Japan International Cooperation Agency (JICA)

Data Collection Survey on Energy Efficiency Sector in the Republic of Uzbekistan

Final Report

March 2023

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Energy Conservation Center, Japan

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【list of abbreviations】

Acronyms	English
ADB	Asian Development Bank
EBRD	European Bank for Reconstruction and Development
IBRD	International Bank for Reconstruction and Development
IEA	International Energy Agency
WB	World Bank

Abbreviations of national institutions

Acronyms	English
AoS	Agency of Statistics
EMR	Electricity Market Regulator （Uzbekistan）
JSC	JSC Uzbekhydroenergo
JSC CHP	JSC Combined Heat and Power
JSC NEG	JSC National Electric Grids
JSC REN	JSC Regional Electric Networks
JSC TPP	JSC Thermal Power Plant
MDHCS	Main department of Housing and Communal Services
MIFT	Ministry of Investment and Foreign Trade
MIIT	Ministry of Investment, Industry and Trade
MoC	Ministry of Construction
MCCS	Ministry of Construction and Housing and Communal Services
MoE	Ministry of Energy
MoED&PR	Ministry of Economic Development and Poverty Reduction
MoF	Ministry of Finance
MoHCS	Minister of Housing & Communal Service

MoT	Ministry of Transport
MoWR	Ministry of Water Resources
NIRES	National Scientific Research Institute of Renewable Energy Sources (Uzbekistan)
SCEEP	The State Committee of the Republic of Uzbekistan on Ecology and Environmental Protection
SCS	State Committee on Statistics

Other abbreviations

Acronyms	English
AEC	Asia Engineering Consultant
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BAT	Best Available Technology
BR	Biennial Report
C/P	Counterpart
CAREC	Central Asia Regional Economic Cooperation Program
CCGT	Combined cycle gas turbine
CGS	Cogeneration Systems
CHP	Combined Heat and Power
CIS	Commonwealth of Independent States
COP	Coefficient of Performance
ECCJ	The Energy Conservation Center, Japan
EER	Energy Efficiency Ratio
EMS	Energy Management System
EV	Electric Vehicle
FS	Feasibility Study
GACMO	Greenhouse Gas Abatement Cost Model

GCF	Green Climate Fund
GDP	Gross Domestic Product
GEFF	Green Economy Financing Facility
GHG	Greenhouse Gas
GT	Gas turbine
GTS	Green Technology Selector
HGT	HUDUD GAZ TAMINOT
HPP	Hydro Power Plant
IE	International Efficiency
IEC	International Electrotechnical Commission
IMF	International Monetary Fund
ISO	International Organization for Standardization
JICA	Japan International Cooperation Agency
LED	Light Emitting Diode
MEPS	Minimum Energy Performance Standard
METI	Ministry of Economy, Trade and Industry
NDC	Nationally Determined Contributions
NEGU	National Electricity Grid of Uzbekistan
OECD	Organisation of Economic Co-operation and Development
OTTV	Overall Thermal Transfer Value
PAL	Perimeter Annual Load
PCKK	PACIFIC CONSULTANTS CO., LTD.
SCOP	Seasonal Coefficient of Performance
SEER	Seasonal Energy Efficiency Ratio
SDG	Sustainable Development Goals
SME	Small and medium-sized enterprises
SRMI	Sustainable Renewables Risk Mitigation Initiative

TCFD	Task Force on Climate-related Financial Disclosures
TES	Total Energy Supply
TFC	Total Final Consumption
TN VED	Commodities Classification Code of the Foreign Economic Activity
TOR	Terms of Reference
TPP	Thermal Power Plant
UJICY	Uzbek-Japan Innovation Center of Youth
UNDP	United Nations Development Programme
USA	United States of America
USD	United States dollar
UZTEST	Uzbek Center for Scientific Testing and Quality Control
ZEB	Net Zero Energy Building
ZEH	Net Zero Energy House

The exchange rate used in this report has been converted using the Central Bank of Uzbekistan's exchange rate as at 31 January 2023, 1 Uzbekistan sm (UZS) = 0.000088 US dollars (USD).

Chapter 1 Study Summary

1.1 Background of the Study

The Republic of Uzbekistan, with the largest population in the Central Asian region (approximately 34.1 million), has experienced continued economic growth, driven by strong government-led resource development and increased exports of natural gas, gold, and cotton—the country's main export products—as well as the effects of ongoing public investment. Securing a stable energy supply is important to maintain steady economic growth, and to this end, the introduction of high-efficiency thermal power plants was planned. The introduction of combined cycle gas turbine plants (CCGTs) was initiated mainly with the support of JICA and the Asian Development Bank (ADB). At the same time, the introduction of gas turbines (GTs) for JSC Combined Heat and Power is underway, and a cumulative total of about 20 CCGTs/GTs are planned for installation, as well as the construction and modernization of 32 hydroelectric power plants.

Meanwhile, a presidential decree in May 2015 listed "development of renewable energy sources," "utilization of solar energy," "introduction of energy conservation equipment," "production automation systems to achieve energy savings," and "high energy efficiency through energy conservation building structures" as items to be addressed to reduce energy consumption. Furthermore, various measures were implemented, such as the discontinuation of the sale of incandescent light bulbs exceeding 40 watts; the introduction of high-efficiency lighting in residential and public facilities; and the introduction of high-efficiency boilers for heating in government institutions and ministries.

In December 2016, the newly elected President Mirziyoyev took office, promoting a policy of openness to foreign countries and a major review of the domestic political system. In May 2017, "Uzbekistan's Development Strategy 2017–2021" (PP3012) specified efforts to reduce energy consumption and save energy ("energy conservation").

Furthermore, in February 2019, the Ministry of Energy (MoE) was established to promote energy policy, and the Department for Energy Efficiency and Energy Conservation became responsible for energy conservation administration (PP4142). This was followed by the Presidential Decree PP4422 in August 2019, which clarified policies regarding the introduction of energy conservation technologies and renewable energy development until 2022 and the issuance of the Country Operations Business Plan (2020–2022) (PP4563) in January 2020. However, the government of Uzbekistan, in the aforementioned Presidential Decree PP4422, recognizes that the organizational work of ministries, departments, and enterprises is inadequate and needs to be improved, as the methods of managing energy loss in the heat supply system (hot water and steam supply network) have not been comprehensively compiled as an energy conservation policy.

To promote energy policy, securing and increasing the efficiency of supplied energy is also important. The introduction of CCGT/GT facilities is still ongoing, but the authority for the practical implementation of policies to curb energy consumption and increase efficiency is divided among the responsible ministries in each economic sector. However, policy integration through the establishment of the MoE has only just begun, and it is assumed that past energy data has been treated as domestic statistics for each sector. In order to promote effective and efficient energy conservation measures, it is considered necessary to review the energy statistics data collection system for Uzbekistan, such as heat and electricity. In addition, the greenhouse gas (GHG) inventory of Uzbekistan shows that GHG emission from the energy sector exceeded 75% as of 2017. The country needs to effectively deploy energy conservation measures to promote climate change countermeasures as indicated in its Nationally Determined Contributions ("NDC"). The energy data of Uzbekistan, compiled by the International Energy Agency (IEA), also needs to be reconfirmed in detail, including the source of the data.

With the above background, JICA decided to conduct this study in order to contribute to the promotion of energy efficiency and conservation policies in Uzbekistan, by the energy efficiency and conservation administrative organization, for the purpose of collecting statistical data, understanding the status of data collection and problem analysis, identifying priority areas of energy efficiency and conservation policies, and collecting information to draft a road map for energy efficiency and conservation policy promotion.

1.2 Purpose of the Study

This study was conducted mainly to collect statistical data on energy consumption, which is necessary to promote energy conservation policies in Uzbekistan, understand the status of data collection and analyze problems, identify priority areas for energy conservation policies, and collect information to create a roadmap for promoting these policies.

1.3 Policy of the Study

1.3.1 Subject of the Study

The study was conducted with the MoE as the main counterpart ("C/P"). It focused on policies that would promote energy conservation on the demand side to achieve a better supply–demand balance. Note that this study targets energy conservation on the energy demand side and does not cover the energy supply side, and the entire Uzbekistan was covered. The study had the following limitations:

(1) Energy consumption data from private companies—other than electric utilities, the gas

industry, etc., under the jurisdiction of the MoE—was limited because the companies sometimes did not disclose the data.

(2) This study mainly considered energy efficiency and conservation measures on the energy demand side but did not include electricity in the energy conversion sector; instead, it considered district heat supply systems.

(3) Owing to COVID-19, travelling to Uzbekistan at the beginning of the study was difficult, and even after arriving there, the restrictions on movement within the country limited the activities to the city of Tashkent.

1.3.2 Method of the Study

Given the lack of data reported by businesses and factories regarding energy statistics and household survey data in Uzbekistan, this study was conducted to identify the energy supply–demand situation in the country, while referring to international data from the IEA and other sources and then identify issues in priority sectors in which energy conservation should be promoted, based on an understanding of energy consumption by sector. Thereafter, the energy conservation technologies of Japan applicable to each sector were examined considering the local environment and IEA recommendations; the environment, including incentives to promote energy conservation technologies in each sector, was examined; and priority measures were proposed. In addition, we identified issues in acquiring energy statistics data in Uzbekistan and made proposals to resolve them. Based on these, we concluded with recommendations to promote energy conservation policies in Uzbekistan. Moreover, we paid attention to the perspective of decarbonization when proposing priority measures.

In addition to desk research and interviews with relevant entities, including C/P, the study also included the collection and analysis of information obtained from a simplified energy efficiency and conservation audit and estimates based on sample surveys in market research, as shown below, in order to understand the current status and issues of energy efficiency and conservation in local industrial facilities and the diffusion of energy efficient products in the market.

- Simplified energy efficiency and conservation audit: The operation and equipment status of energy-intensive facilities (three factories) were confirmed through on-site surveys, and the current status of energy efficiency and conservation, issues, and areas for improvement were clarified.
- Market survey: Interviews were conducted with consumer electronics mass merchandisers and manufacturers' agents in the market, particularly regarding the efficiency, price, and sales volume of residential air conditioners, in order to understand

the diffusion status of high-efficiency equipment.

- Household awareness survey questionnaire: A web-based survey was conducted among general households, and 102 responses were received to confirm energy conservation awareness, energy conservation behavior, the use of energy conservation equipment, etc.
- Demonstration experiment: Through a comparison experiment on energy consumption between existing non-inverter air-conditioner products and inverter air-conditioner products with high-energy conservation performance that are widely used in Uzbekistan, the effectiveness of the latter was verified.

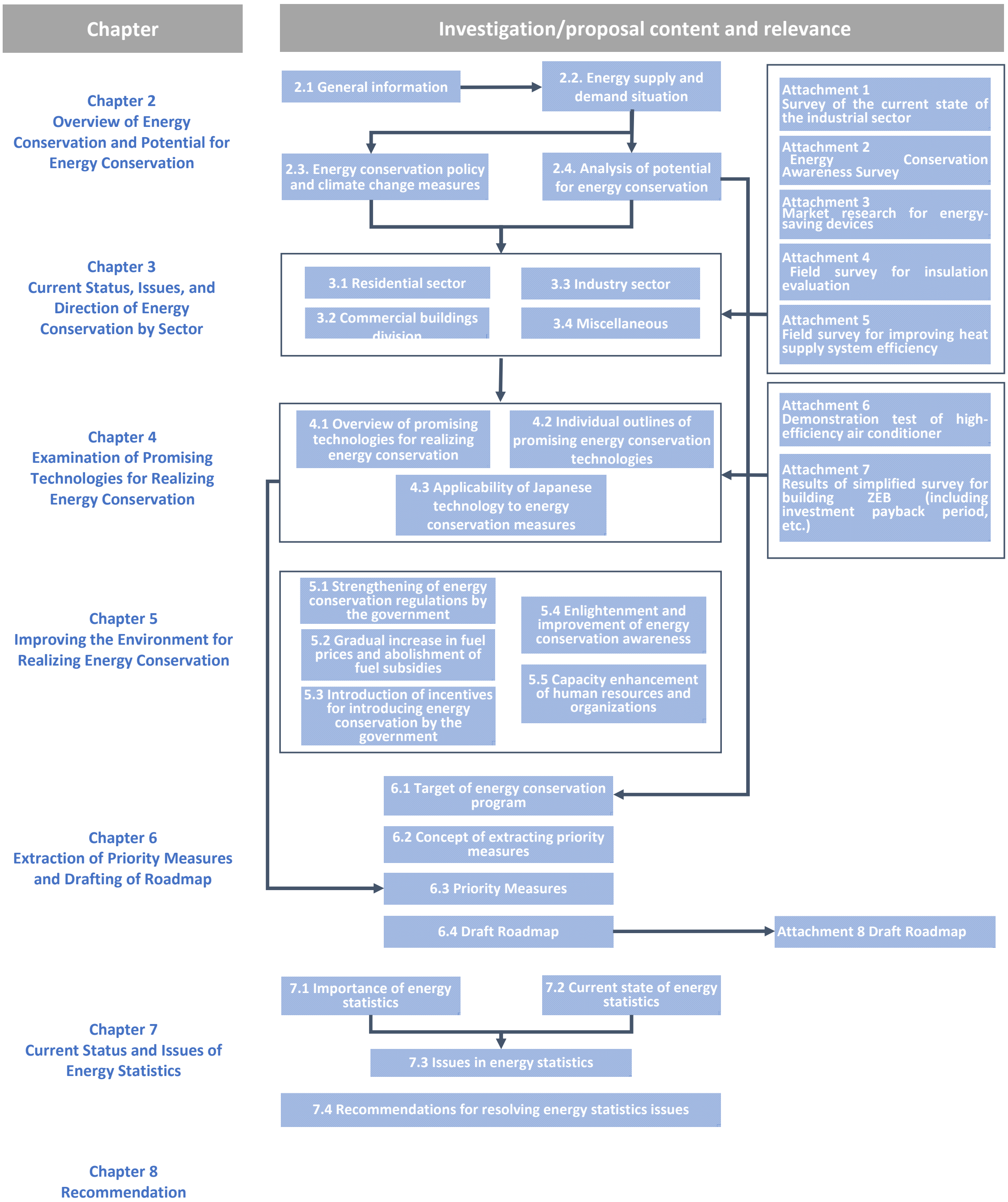
Technical details of the results of these studies are provided in the Appendix. The main contents and items of the study are shown in Table1-1, and their relationship to the chapter structure of this report is shown in Figure 1-1.

Table 1-1: Study summary

Chapter	Contents	Main study items
2	Overview of energy conservation and potential for energy conservation	• Organizing energy supply-demand status • Organizing energy efficiency and climate change measures • Analysis of energy conservation potential and identification of areas where energy conservation should be promoted
3	Current status, issues, and direction of energy conservation by sector	• Assessing energy consumption by sector (residential, commercial buildings, industry, agriculture, transportation, etc.) and analyzing issues
4	Examination of promising technologies for realizing energy conservation	• Identification of promising technologies for energy conservation by sector • Overview of promising energy-conservation technologies and examination of their superiority (e.g., demonstration experiments of energy conservation performance of high-efficiency air conditioners, examination of the conversion of buildings to net zero energy buildings (ZEB), etc.) • Study on the applicability of Japanese energy conservation technologies

Chapter	Contents	Main study items
5	Improving the environment for realizing energy conservation	• Study on strengthening energy conservation regulations • Study on introduction of incentives for energy efficiency and conservation • Study on abolition of fuel subsidies, etc. • Study on raising awareness and educating the public on energy conservation • Consideration of human resources and organizational capacity development
6	Extraction of priority measures and drafting of roadmap	• Study on target areas for energy conservation promotion in Uzbekistan • Examination of energy conservation potential including cost-effectiveness • Summary of priority measures • Discussion of proposed roadmap
7	Current status and issues of energy statistics	• Current energy statistics • Issues in energy statistics • Recommendations for resolving energy statistics issues
8	Recommendation	• Recommendations for promoting energy conservation policies

Source: JICA survey team



Source: JICA survey team

Figure 1-1 Relationship between the study implementation flow and chapter structure

(1) Overview of energy conservation and potential for energy conservation

Energy production and primary energy supply were analyzed by resource based on the IEA energy balance. Regarding energy consumption, we analyzed the final energy consumption by sector and by resource. Based on these results, an energy balance diagram was created to provide an overall picture of the energy supply–demand balance in Uzbekistan, and sectors and energy resources with great potential for energy conservation were selected. As a result, we considered energy conservation in the demand and supply of heat to be effective and analyzed the current status and issues involved. In addition, the country's energy-related policies and measures were reviewed, and its energy conservation policies, competent authorities, and implementation status were summarized.

(2) Current status, issues, and direction of energy conservation by sector

For the residential, commercial building, and industrial sectors that should be targeted for energy conservation, we considered the final energy consumption status of each sector in more detail and summarized the current status and issues of energy efficiency in order to examine the direction of energy conservation. To understand the current situation, the efficiency of heat sources used in homes for heating and hot water supply, as well as the insulation of windows, exterior walls, etc., was sorted and analyzed through questionnaires to households, market surveys of high-efficiency equipment, etc. In the industrial sector, we also attempted to understand energy efficiency by conducting questionnaires with energy suppliers and consumers. From these surveys, issues for energy conservation promotion were extracted, and the direction of energy conservation to be implemented in Uzbekistan was indicated.

(3) Examination of promising technologies for realizing energy conservation

This section outlines promising technologies, such as heat pumps, high-efficiency air conditioners, enhanced insulation, and ZEH (Net Zero Energy House)/ZEB, that can be applied to achieve energy conservation in residential buildings, commercial buildings, and industrial sectors where energy savings should be promoted, as discussed in the previous section, and shows the superiority of such technologies along with the potential for applying Japanese technologies. For high-efficiency air conditioners, a demonstration experiment was conducted in the city of Tashkent to compare and evaluate the energy conservation efficiency with and without inverters, and the superiority of inverter air conditioners was analyzed. The introduction of ZEB was studied using the Gas Public Corporation building, where a simple energy efficiency and conservation audit was conducted, as a case study.

(4) Improving the environment for realizing energy conservation

The study included an analysis of issues and measures in terms of several aspects: the institutional aspect, such as energy conservation standards to promote energy-saving technologies necessary for promoting energy conservation in Uzbekistan; the financial aspect, such as government incentives to introduce energy conservation, in addition to the optimization of fuel prices and fuel subsidies; and the aspect of the strengthening of systems and capacities for promoting energy conservation.

(5) Extraction of priority measures and drafting of roadmap

The study of an energy conservation program that summarizes the sectors and measures that should promote energy conservation measures in the country, the contribution of the measures to improve energy efficiency, and the promoters of the measures. Based on the results of the previous sections, the commercial buildings, residential, and industrial sectors were selected as targets for promoting energy conservation measures, and seven priority measures to be implemented in these sectors were examined along with their energy conservation potential and cost-effectiveness. The three most important measures are (1) the conversion from gas boilers to heat pumps, (2) the spread of high-efficiency air conditioners, and (3) the strengthening of building insulation. The promotion of ZEB, a comprehensive approach that combines building energy conservation measures with the use of on-site renewable energy was also proposed. In addition, a draft roadmap summarizing the results of the above study was prepared and shared with the MoE of Uzbekistan and other related ministries and agencies, as well as international organizations at the "Energy Efficiency Seminar" held on January 31, 2023.

(6) Current status and issues of energy statistics

We reviewed the legal framework and systems for energy statistics in Uzbekistan and conducted interviews and questionnaires with relevant organizations in charge of energy statistics to understand the current situation and identify issues. By comparing the Pilot Fuel and Energy Balance published by the Agency of Statistics (AoS), starting in 2019, with the energy balance of the Uzbekistan published by the IEA, we identified issues in energy statistics and proposed improvements.

(7) Recommendation

The study team made recommendations on the technical and financial cooperation expected to JICA for the efficient and economical use of natural gas resources, etc., which are necessary for the stable supply of energy and electricity, the basis of economic and social development in Uzbekistan.

1.4 Structure to Conduct the Study

The study was conducted by a JV structure consisting of PACIFIC CONSULTANTS CO., LTD (PCKK); the Energy Conservation Center, Japan (ECCJ); and Asia Engineering

Consultant (AEC).

Table 1-2 Structure1 to conduct the study

No.	Identity	Belong to	(in) charge (of an area of responsibility, but not necessarily supervision of staff)
1	Akifumi Nishihata	PCKK	Project Manager/Energy conservation policy (1)
2	Daiki Nose	PCKK	Deputy Project Manager/Energy conservation policy (2)
3	Akira Ishihara	ECCJ	Energy conservation technology (1)
4	Masaru Inada	ECCJ	Energy conservation technology (2)
5	Motohiro Washimi	ECCJ	Energy conservation technology (3)
6	Atsushi Takahashi	ECCJ	District Heat Supply System
7	Hisafumi Ojima	ECCJ	Energy Conservation Demonstration Experiment (1)
8	Teruo Hosokawa	PCKK	Energy Conservation Demonstration Experiment (2)
9	Hiroyuki Sakai	AEC	Statistics/Data Management
10	Takashi Saito	AEC	Organizational Systems and Human Resource Development
11	Yasuko Arakawa	PCKK	Economics & Finance

Source: JICA survey team

1.5 Study Period

The study was conducted between February 2021 and March 2023.

1.6 On-the-spot Investigation

The field survey was conducted under the following structure and schedule.

Table 1-3 Field Survey Implementation Schedule

No.	Field Survey Schedule	Field Survey Team
1	May 26-June 10, 2021	Nishihata, Ishihara, Inada, Sakai, Saito, Arakawa
2	November 12 - November 28, 2021	Nishihata, Takahashi, Kojima, Hosokawa (~21st)
3	March 23 - March 31, 2022	Nishihata, Inada, Takahashi, Kojima
4	May 18 - May 26, 2022	Nishihata, Hosokawa (~22nd), Sakai, Saito
5	July 27-August 4, 2022	Nishihata
6	October 26-November 3, 2022	Nishihata, Ishihara, Kojima, Hosokawa

7	December 14 - 22, 2022	Nishihata, Nose, Sumi, Takahashi, Kojima, Hosokawa
8	January 25 - February 2, 2023	Nishihata, Ishihara, Sakai

Chapter 2 Overview of Energy Savings and Energy Savings Potential

2.1 General Information

2.1.1 Social and economic conditions and development plans

(1) Social and economic conditions

Uzbekistan has a land area of 447,400 square kilometers, which is approximately 1.2 times that of Japan, with a population of 33.5 million, approximately a quarter that of Japan. The capital city is Tashkent, and Sunni Islam is the principal religion. The official language is Uzbek, although Russian is also widely spoken. The currency is the soum (UZS), introduced in 1996.

Uzbekistan's status as a doubly landlocked country means that it is surrounded by other landlocked countries, making it necessary to cross two borders in order to reach the sea. As a result, trade with foreign countries is mainly reliant on road and rail transportation, with air transportation being the exception. This limitation in transportation options not only restricts the volume of trade, but also results in higher transportation costs. The main industries are primary industries[1], such as mining (uranium, gold, crude oil, natural gas, etc.), as well as industries such as cotton farming and food processing. The country has the largest population in Central Asia. According to the National Statistics Agency, the urban-rural population distribution is approximately 50%, but Tashkent's population density is 6,597.5 /km2, which is higher than those of other regions (9.5-772.7/ km2) (Figure 2-1). Looking at the population structure, the working-age population is expected to see a continuous increase up to 2050 (Figure 2-2). Thus, a stable supply of energy and electricity is necessary as the foundation for advancing economic and social development in the continuous demographic bonus or demographic dividend period. However, aging energy infrastructure and the record low temperatures due to a cold spell in January 2023 have led to a temporary stoppages of gas, electricity, and district heat supplies.

Table 2-1 Basic Data

(Data) item	Contents
Official name of the country	Republic of Uzbekistan
Population	34.4 million (2022 UN Population Fund)
land area (of a country,	447,400 square kilometers

[1]Iqtisodiy faoliyat turi bo`yicha sanoat mahsulotlarini ishlab chiqarish (Production of industrial products by type of economic activity), STATISTIKA AGENTLIGI https://stat.uz/uz/rasmiy-statistika/industry-2 accessed February 15, 2023

continent, etc.)	
Capital city	Tashkent
Ethnic groups	Uzbek 84.3%, Tajik 4.8%, Kazakh 2.4%, Karakalpak 2.2%, Russian 2.1% (National Statistical Committee of Uzbekistan, 2021)
Religion	Primarily Sunni Muslim
Head of the state	President Shavkat Mirziyoyev (5-year term, re-elected October 2021)
Prime Minister	Abdullah Alipov.
Key industries	Cotton textile industry, food processing, machine building, gold, oil, natural gas
GDP	69.2 billion dollars (2021: IMF)
Per capita GDP	US$2,002 (IMF, 2021)
Real GDP growth rate	7.4% (2021: IMF)

Source: Ministry of Foreign Affairs website (February 3, 2023) https://www.mofa.go.jp/mofaj/area/uzbekistan/data.html

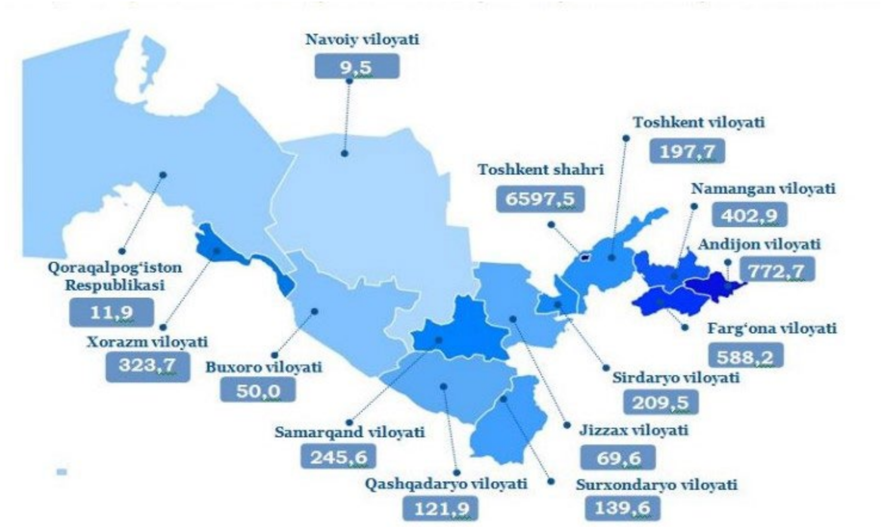


Figure 2-1 Population Density by Region (persons/km^2) in Uzbekistan

Source: Risolalar (Brochure) 2022 yil, STATISTIKA AGENTLIGI https://stat.uz/images/uploads/demografiya-zb08_02_2023.pdf

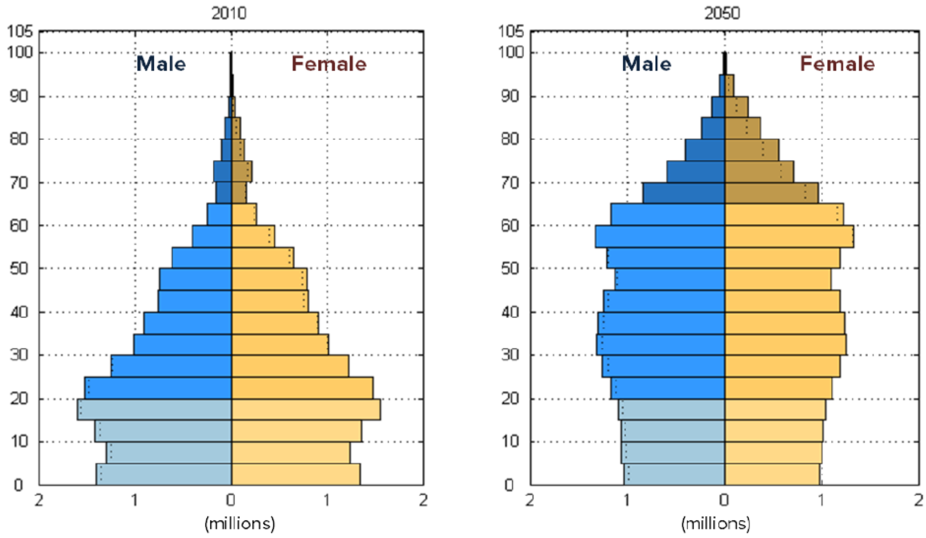


Figure 2-2 Population Composition by Age and Sex in Uzbekistan (2010 and 2050)

Source: International Conference on Population and Development Beyond 2014, United Nations Population Fund https://www.unfpa.org/sites/default/ files/resource-pdf/FINAL_Uzbekistan.pdf

(2) Development plan

Uzbekistan was once a part of the Soviet Union, but since gaining independence following the collapse of Soviet Union in December 1991, the country has undergone the following economic and structural reforms:

Before independence, Uzbekistan mainly engaged in agricultural production such as the cultivation of cotton, vegetables, and fruits using the freshwater resources of the Aral Sea basins.

- ◆ Reform of government structures based on UP60 "New National Development Plan 2022~2026" etc.

Deepening democratic reform and modernization, reforming administrative systems, improving organizational and legal infrastructure for public services, strengthening the roles of parliaments and political parties through the improvement in e-government systems, enhancing the quality and efficiency of public services, social control, and fostering the role of civil society institutions and media.

- ◆ Reforming the judicial system.

Strengthening the independence of the judiciary, protecting the rights and freedom of citizens, improving legislation in the administrative, criminal, civil, and economic sectors, enhancing the effectiveness of crime-fighting systems, ensuring the principle of competition through trials, and improving legal aid and legal services.

- ◆ Economic development and liberalization.

Strengthening macroeconomic stability, maintaining high economic growth rates, improving international competitiveness, modernizing and intensively developing the agricultural sector, continuing institutional reforms to reduce state intervention in the economic sector, developing small and medium-sized enterprises (SMEs) and private entrepreneurship, developing integrated and balanced socio-economy between regions and local governments, and actively attracting foreign investment in the local economy through improving the investment climate.

◆ Development of education, social security, and public infrastructure.

Gradual increase in employment and population, enhancing social security and health systems for citizens, improving women's social and political activities, achieving goals and executing plans for the construction of affordable housing, developing education in the fields of culture, science, literature, arts, and sports, and facilitating local youth policies.

◆ Strengthening nation's independence and sovereignty.

Creating a charter for security around the country, ensuring stability and good relations with neighboring countries, strengthening the country's international image, ensuring security, interstate harmony, and religious tolerance.

2.1.2 Natural Environment

(1) National land

Uzbekistan is located in Central Asia between 37 to 45 degrees north, with 78.8% of the land being plains and the remaining 21.2% foothills. Approximately 80% of its land is semi-desert or desert, with mountain ranges in the southeast and east.[2] The Amu Darya River runs northwest from the western edge of the Tien Shan mountains to the border between the southern part of Uzbekistan and Turkmenistan. Together with Aydar Lake in the central part, the river is used for agricultural irrigation in the south-central region. The Amu Darya River used to reach as far as the Aral Sea and was utilized for freshwater fisheries, but its area was greatly reduced after the freshwater resources in the Aral Sea basins started to be utilized for cotton cultivation.

[2] Uzhydromet https://hydromet.uz/ru/node/41 (Accessed on Feb 15 in 2023)

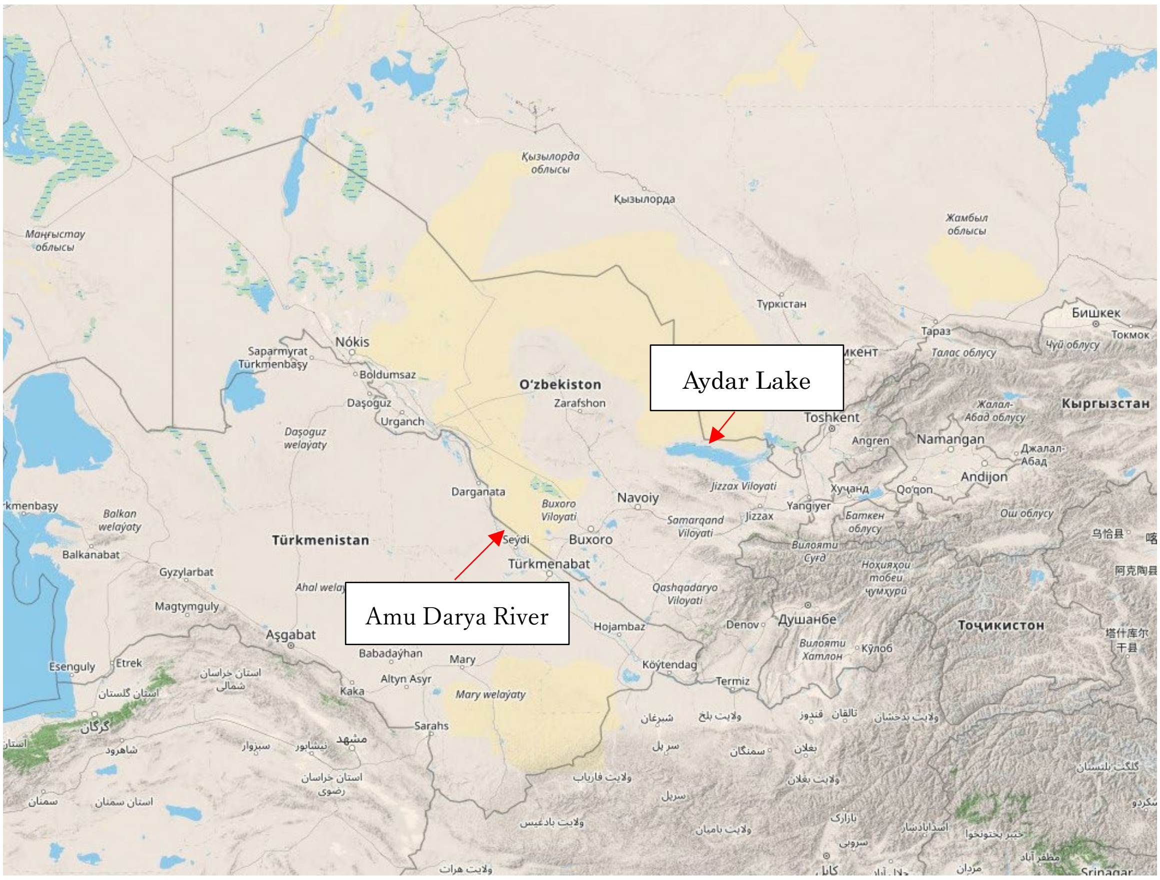


Figure 2-3 Uzbekistan Topography

Source: OpenStreetMap contributor https://www.openstreetmap.org/ with additions by the research team

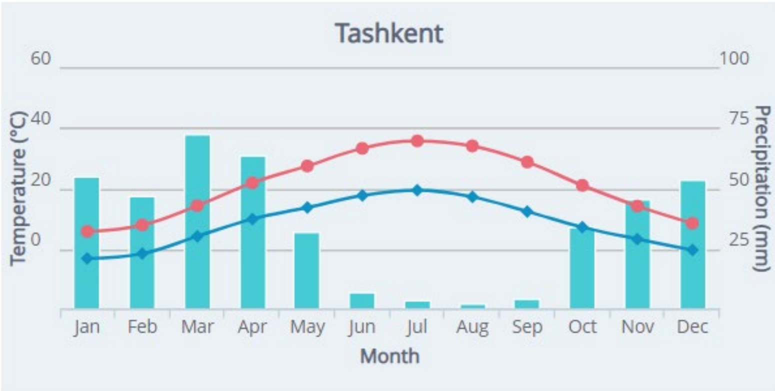
(2) Climate

The climate in Uzbekistan is classified as continental, and characterized by large diurnal and seasonal variation of air temperature.[3] Tashkent records its highest monthly average temperature (35.7°C) in July, but the difference between daytime and nighttime is large, with the lowest temperatures at dawn being around 20°C. The rainy season lasts from October to May, followed by a dry season with low rainfall from June to September (Figure 2-4). Regional variations in precipitation in Uzbekistan vary widely, with the western regions receiving less than 100 mm of precipitation per year, while the eastern and southeastern regions can reach 800~900 mm per year.

A comparison of the climates of Tokyo and Tashkent shows that despite Tashkent's latitude being the same as that of Hakodate, the average temperatures are approximately the same.

[3] Climate Change Knowledge Portal for Development Practitioners and Policy Makers: Uzbekistan https://climateknowledgeportal.worldbank.org/country/uzbekistan/climate-data-historical accessed February 17, 2023

Tashkent has low humidity in summer due to tropical air from the dry continent (approximately 40%[4], compared to approximately 70-80% in Tokyo). Therefore, the internal energy of the air is considerably lower, around 60% that of Tokyo.



Month	Mean Daily Minimum Temperature (°C)	Mean Daily Maximum Temperature (°C)	Mean Total Precipitation (mm)	Mean Number of Precipitation Days
Jan	-3.1	5.8	54.5	13.7
Feb	-1.5	7.9	46.8	12.3
Mar	4.2	14.3	72.3	13.8
Apr	9.9	21.8	63.6	12.9
May	13.7	27.4	32.0	10.2
Jun	17.7	33.2	7.1	5.1
Jul	19.4	35.7	3.5	2.9
Aug	17.2	34.0	2.0	1.9
Sep	12.4	28.7	4.5	3.2
Oct	7.2	21.0	34.1	8.1
Nov	3.3	14.2	45.0	10.2
Dec	-0.3	8.5	53.4	12.8

Figure 2-4 Characteristics of Tashkent's Climate

Source: World Meteorological Organization: Tashkent https://worldweather.wmo.int/en/city.html?cityId=115 accessed February 15, 2023

2.2 Energy Supply and Demand

2.2.1 Energy Balance Analysis

Figure 2-5 shows an energy balance based on IEA 2020 data. It describes the overall energy supply-demand balance in Uzbekistan, illustrating the flows of energy types from primary energy supply in the top row, energy conversion in the middle row, and energy consumption

[4]Weather & Climate: average humidity in Tashkent https://weather-and-climate.com/average-monthly-Humidity-perc,tashkent,Uzbekistan February 2023 Accessed February 15, 2023

in the bottom row. Uzbekistan's primary energy supply is approximately 45 Mtoe, 98.5% of which is dependent on fossil fuels. Approximately 90% of fossil fuels are domestically produced natural gas. The residential sector is the largest final energy consumer (approximately 40%), with the consumer sector (residential and commercial buildings) and the industry accounting for approximately 70% of the total. These three sectors consume 80% of the natural gas supplied to the country. Together with the heat supplied by district heat supply facilities built in urban areas during the former Soviet Union era, this overview shows a high ratio of energy to heat use.

The following is an analysis of the energy supply and energy consumption, by energy source and by sector, to identify priority areas to achieve energy savings.

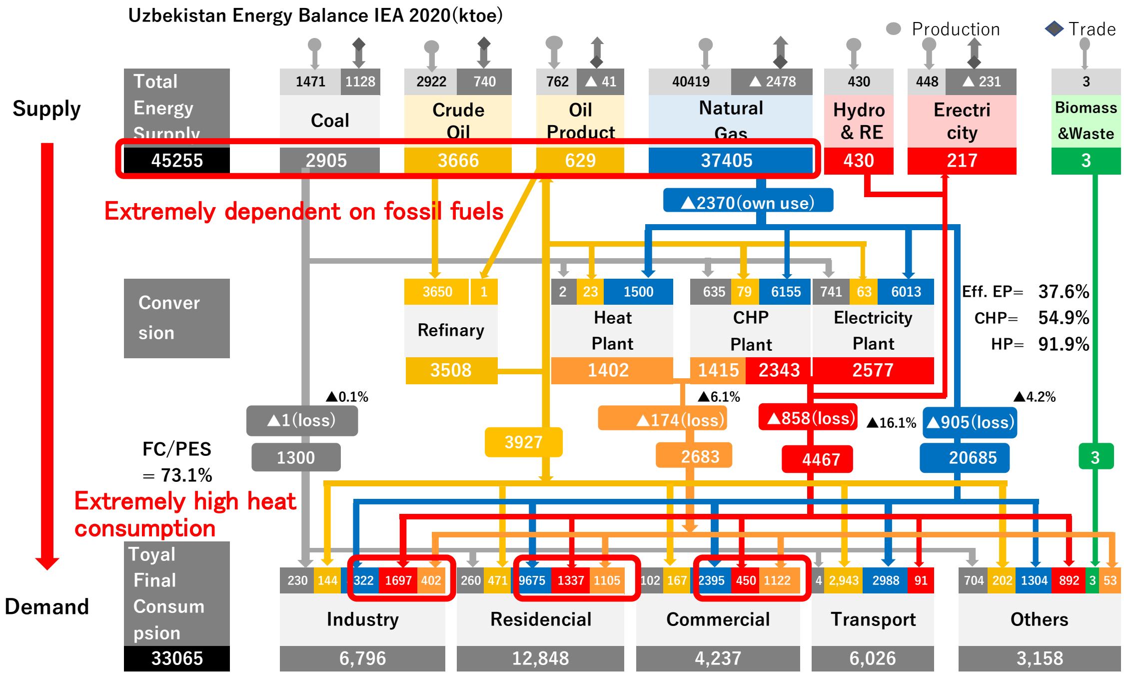


Figure 2-5 Uzbekistan 2020 Energy Balance

Source: Prepared by the study team based on IEA Energy Balance Data.

(1) Energy Supply Status

Primary energy production and domestic primary energy supply in Uzbekistan were shown below including the results of comparisons of domestic primary energy supply per nominal GDP.

1) Primary Energy Production

The volumes and percentages of primary energy production by resource in Uzbekistan for 2018-2020 based on the IEA Energy Balance are shown in Table 2-2 and Figure 2-6. Natural gas accounts for 90% of the total, which is a condition that lasts for more than a decade, as shown in Figure 2-7. However, in 2020, natural gas production was significantly lower than in 2018 and 2019, with domestic supply decreasing by approximately 7% and natural gas exports plummeting from 9,931 ktoe to 2,478 ktoe. This is because of the policy change to prioritize domestic supply as natural gas production declines. According to an IEA study[5], natural gas reserves will be depleted within 20 years if it is produced and used at the current paces, increasing the need to conserve natural gas resources and improve efficiency of use.

Table 2-2 Trends in Primary Energy Production (IEA)

Primary Energy Production	2018		2019		2020	
	ktoe	Ratio	ktoe	Ratio	ktoe	Ratio
Coal	1,478	2.7%	1,439	2.6%	1,471	3.3%
Natural gas	50,159	90.9%	49,297	90.5%	40,419	89.3%
Crude oil	3,048	5.5%	3,163	5.8%	2,922	6.5%
Electricity(Hydro,RE)	507	0.9%	560	1.0%	430	1.0%
Total	55,197	100.0%	54,459	100.0%	45,245	100.0%
Year on year ratio	—		98.7%		83.1%	
Natural gas export (within natural gas production)	12,112	-	9,931	-	2,478	-

Source: Prepared by JICA research team based on IEA Energy Balance

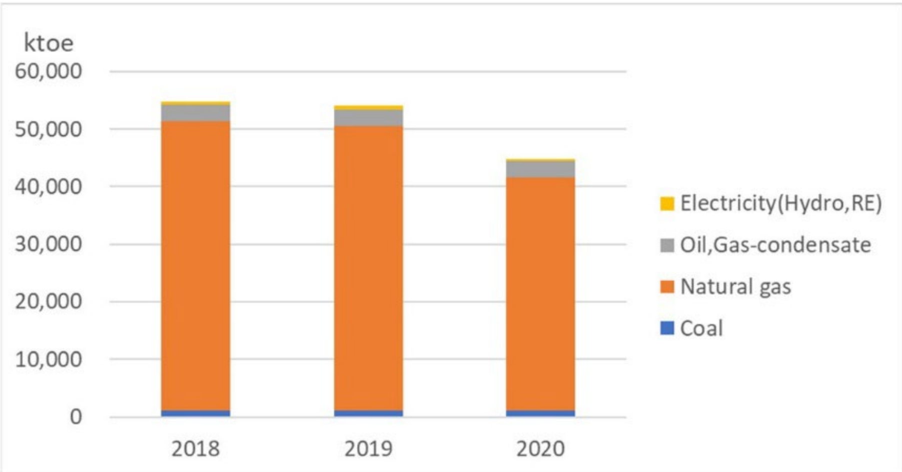


Figure 2-6 Trends in Energy Production

Source: Prepared by JICA research team based on IEA Energy Balance

5 Uzbekistan 2022 Energy Policy Review (IEA, June 2022)

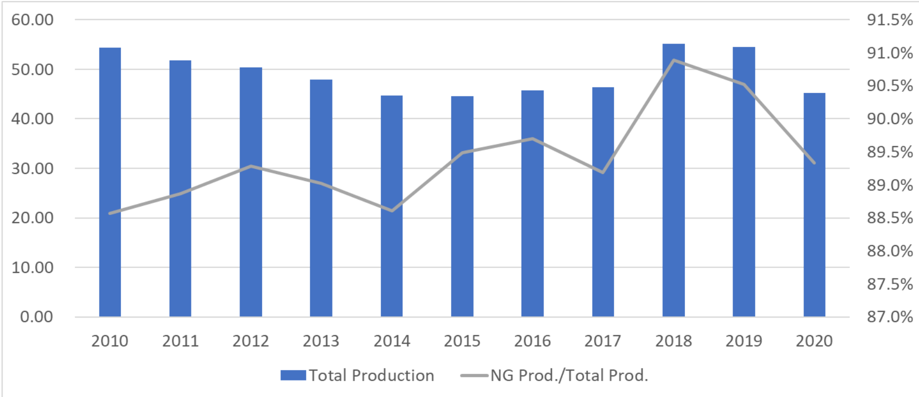


Figure 2-7. Natural Gas as a Percentage of Total Energy Production Over the Past Decade

Source: Prepared by JICA research team based on IEA Energy Balance

2) Domestic Primary Energy Supply (Total Energy Supply; TES)

Table 2-3 and Figure 2-8 show the status of domestic energy supply (TES) in Uzbekistan. The main source is domestically produced natural gas, which accounts for 85% in 2018, 86% in 2019, and 83% in 2020. Natural gas also accounts for 85% of the fuel supplied to power plants and combined heat and power (CHP) facilities. The 2020 TES is approximately 2 Mtoe (4%) less than the 2019 TES. The decline in natural gas supply mainly caused the decrease in TES in 2020.

Table 2-3 Trends in Primary Energy Supply (IEA)

Total Energy Supply	2018		2019		2020	
	ktoe	Ratio	ktoe	Ratio	ktoe	Ratio
Coal	2,442	5.3%	2,086	4.4%	2,905	6.4%
Natural gas	39,373	84.9%	40,365	85.8%	37,405	82.7%
Crude oil	4,257	9.2%	3,851	8.2%	3,666	8.1%
Hydro	507	1.1%	556	1.2%	430	0.9%
Elec. Import-export	-34	-0.1%	113	0.2%	217	0.5%
Oil Products	-157	-0.3%	87	0.2%	629	1.4%
Total	46,393	100.0%	47,061	100.0%	45,255	100.0%
Year on year ratio	―		101.4%		96.2%	

Source: Prepared by JICA Study Team based on IEA Energy Balance

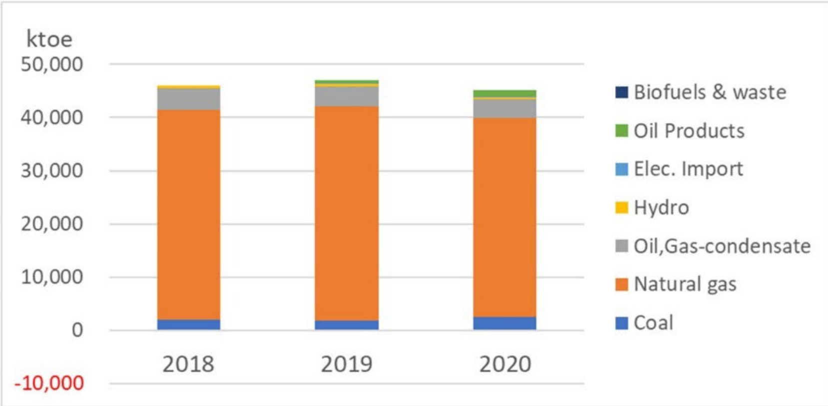


Figure 2-8 Trends in Primary Energy Supply (IEA)
Source: Prepared by JICA Study Team based on IEA Energy Balance

3) TES Per Nominal GDP

Figure 2-9 and Table 2-4 show the results of the study team's estimates of TES per nominal GDP in 2018. UN data were used for nominal GDP and IEA data for TES. Uzbekistan has the highest result with 920 ktoe/bUS$ compared to the global average of 166 ktoe/bUS$, which highlights the extremely high needs for energy conservation.-

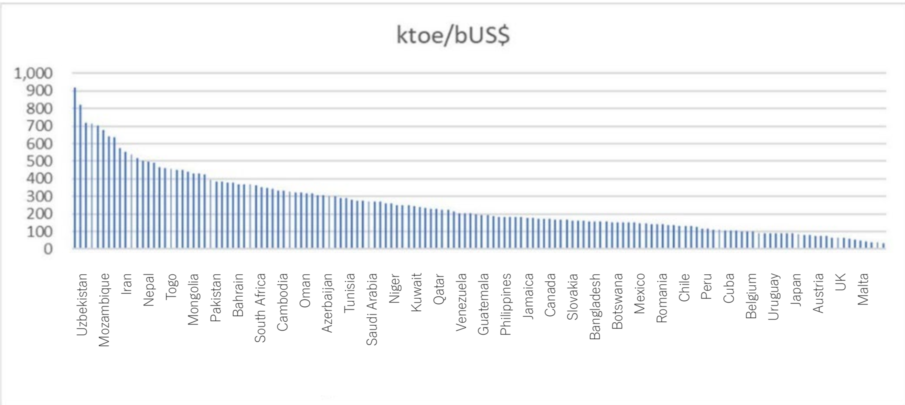


Figure 2-9 Comparison Based on TES 2018 Data Per Nominal GDP
Source: Nominal GDP: UN Statistics, Primary Energy Supply (TES): Prepared by JICA research team based on IEA

Table 2-4 Top 10 TES/Nominal GDP Countries

Ranking	Country	ktoe/bUS$	Ranking	Country	ktoe/bUS$	Country	ktoe/bUS$
1	Uzbekistan	920	6	Turkmenistan	679	Japan	86
2	North Korea	821	7	Congo	640	World	166
3	Trinidad and Tobago	719	8	Syria	635		
4	Ukraine	714	9	Iran	575		
5	Mozanbīku	703	10	Kyrgyzstan	551		

Source: Nominal GDP: UN Statistics; Primary Energy Supply (TES): Prepared by JICA research team based on IEA

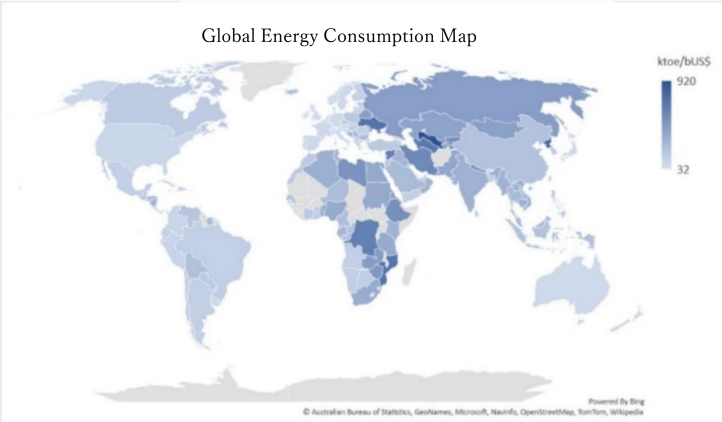


Figure 2-10 TES/Nominal GDP in the Word
Source: Nominal GDP: UN Statistics; Primary Energy Supply (TES): Prepared by JICA research team based on IEA

(2) Energy Consumption (Primary Energy Consumption by Sector and Type)

The status of the final consumption of domestic energy supply on the demand side is reviewed by sector and energy sources to determine which energy sources are consumed the most in which sectors.

1) Total Final Consumption (TFC)

① Final energy consumption by sector

As shown in Table 2-5 and Figure 2-11, the final energy consumption (TFC) of Uzbekistan is approximately 33 Mtoe according to the IEA's Energy Statistics 2020. Of these, the sector that consumes energy the mot is residential, using 39% of the total. The second largest is industrial (20%), followed by transportation (18%), commercial buildings (13%), and others (10%). This ranking has not changed in recent years, with the three consumer sectors (residential, commercial buildings) and industry accounting for 72% of the total.

TFC shows an increasing trend, reflecting the economic development of Uzbekistan. There was a 1.7% increase in 2019 compared to 2018, with growth in the industrial sector and commercial buildings sector and a decrease in residential sector. The TFC still increased by approximately 10% in 2020 from 2019, but the situation is quite different, with a declining trend in industry sector and a significant increase in the residential sector. In 2020, the COVID-19 pandemic is considered having a significant impact on the economy and social life of Uzbekistan. This could affect energy consumption trends in the country, so the trends in 2021 and beyond should be closely monitored.

Table 2-5 Final Energy Consumption Trends by Sector (IEA)

Total Final Consumption	2018		2019		2020	
	ktoe	Ratio(%)	ktoe	Ratio(%)	ktoe	Ratio(%)
Industry	6,500	22.0%	7,190	24.0%	6,796	20.6%
Residential	11,230	38.1%	10,776	35.9%	12,848	38.9%
Commercial & public services	3,618	12.3%	4,063	13.5%	4,237	12.8%
Transport	5,801	19.7%	5,924	19.7%	6,026	18.2%
Other	2,358	8.0%	2,045	6.8%	3,158	9.6%
Total	29,507	100.0%	29,998	100.0%	33,065	100.0%
Year on year ratio	―		101.7%		110.2%	

Source: Prepared by JICA Study Team based on IEA Energy Balance

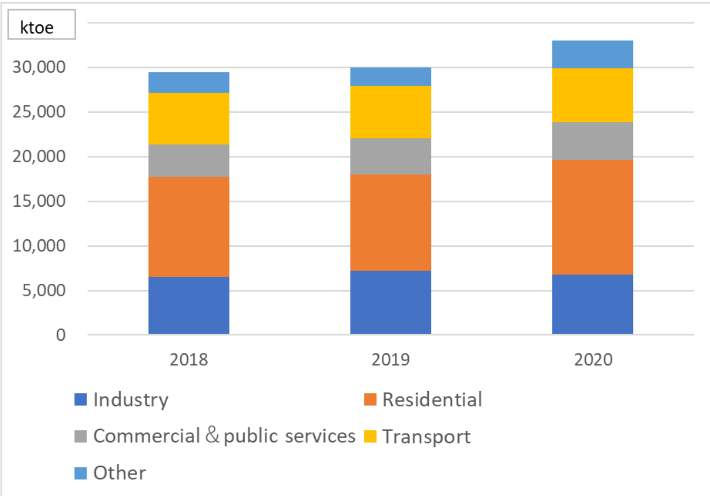


Figure 2-11 Final Energy Consumption Trends by Sector (IEA)
Source: Prepared by JICA research team based on IEA Energy Balance

Table 2-6 shows final energy consumption by sectoral energy source in the IEA for 2020. Focusing on energy by sector in the table, all sectors are highly dependent on natural gas, with 75% for residential sector, 64% for industrial sector, and 57% for commercial buildings sector. The industrial sector is characterized by a relatively high dependence on electricity (25%) and a high dependence on heat (27%) in the commercial buildings sector. The other sector with high electricity consumption is considered to be the agricultural sector that uses irrigation pumps.

As for the heat supply, Figure 2-5 on the energy balance shows that the ratio of fuel input into boilers in district heat supply facilities to the amounts of heat produced, and the ratio of the amounts of heat produced to the final heat consumption in both the CHP facilities and the district heat supply facilities' boilers are a little over 90%. However, considering the fact that most of the equipment continues to be used from the Soviet Union era, and has high efficiency losses and heat losses, and that there is a lack of measurement data, it is highly likely that the actual situation is not accurately indicated. The results of a preliminary diagnosis of the heat supply system suggest that actual efficiency and heat losses may be higher than reported.

Table 2-6 Final Energy Consumption by Sector and Energy Source (IEA, 2020)

Total Final Consumption (ktoe)	Coal	Oil products	Natural gas	Biofuels and waste	Electricity	Heat	Total	Ratio (%)
Industry	230	144	4,322		1,697	402	6,796	20.6%
Residential	260	471	9,675		1,337	1,105	12,848	38.9%
Commercial and public services	102	167	2,395		450	1,122	4,237	12.8%
Transport	4	2,943	2,988		91		6,026	18.2%
Others	704	202	1,304	3	892	53	3,158	9.6%
Total	1,300	3,927	20,685	3	4,467	2,683	33,065	100.0%
Industry	3.4%	2.1%	63.6%		25.0%	5.9%	100.0%	
Residential	2.0%	3.7%	75.3%		10.4%	8.6%	100.0%	
Commercial and public services	2.4%	4.0%	56.5%		10.6%	26.5%	100.0%	
Transport	0.1%	48.8%	49.6%		1.5%		100.0%	
Others	22.3%	6.4%	41.3%	0.1%	28.2%	1.7%	100.0%	
Total	3.9%	11.9%	62.6%	0.0%	13.5%	8.1%	100.0%	

Source: Prepared by JICA research team based on IEA Energy Balance

② Evaluation of TFC by primary energy conversion

Table 2-7 and Figure 2-12 show the final energy consumption by sector when electricity and heat are converted to primary energy from the final energy consumption shown in Table 2-5 and Figure 2-11. The conversion method is indicated below.

For the latest 2020 IEA data, the conversion ratios are 2.74 times for electricity and 1.14 times for heat. After its value is converted to that of primary energy, the final energy consumption is approximately 41 Mtoe, which is 1.25 times higher than before conversion. The ranking by sector remained unchanged from before the conversion, with residential sector 37% (1.20 times), industrial sector 24% (1.44 times), transportation sector 15% (1.03 times), commercial buildings sector 13% (1.24 times), and other 11% (1.47 times). The conversion results are shown in the bar graph in Figure 2-13. The large conversion factor for electricity indicates that the industrial sector and other sectors (agriculture), which have high electricity consumption ratios, account for a higher percentage. However, as already mentioned, the industrial and consumer sectors still take up a large portions of primary energy consumption (74%).

【Calculation of Primary Energy Conversion Factors for Electricity and Heat】

Calculate primary energy conversion factors for electricity and heat based on the data in the energy balance table.

1) Primary energy conversion factor for electricity

Primary energy conversion factor for electricity = input energy for power generation / amount of electricity supplied

Based on IEA 2020 data

■Electricity supplied = (EP, CHP, hydro, RE, etc.) + import excess －self-consumption

－ transmission and distribution losses

= EP generation and hydroelectricity (3,200 ktoe) + CHP generated electricity (2,518 ktoe) + RE, etc. (0 ktoe)

+ import excess (217 ktoe) －self-consumption (368 ktoe) －losses (858 ktoe)

= 4.709ktoe

■Energy input = Energy input for EP and CHP (coal, petroleum products, natural gas)

－CHP heat production

= EP input energy (7,464 ktoe) + CHP input energy (6,870 ktoe)

－CHP generated heat (1,415 ktoe)

=12,919ktoe

Energy input (12,919 ktoe) / Electricity supply (4.709 ktoe) = 2.74

■Primary energy conversion factor for electricity is 2.74.

EP: Electricity Plants

CHP: Combined Heat and Power

RE and so forth: Solar power generation, wind power generation, waste to power and BIO-fuel power generation, etc.

2) Primary energy conversion factor for heat

Primary energy conversion factor for heat = input energy for heat production / heat supply

Based on IEA2020 data

■Heat supplied = Heat generated by CHP (1,415 ktoe) - Heat loss transferred (174 ktoe)

=1,241ktoe

■ Energy input = equivalent heat value (1,415 ktoe) of fuels used in CHP (coal, petroleum products, natural gas).

■Energy input (1,415 ktoe) / heat supply (1,241 ktoe) = 1.14

The conversion factor of heat to primary energy is 1.14.
The same conversion factor is used for heat from heat supply plants.

Table 2-7 Final Energy Consumption Trends by Sector after Converted to the Primary Energy

Primary energy equivalent TFC	2018		2019		2020	
	ktoe	Ratio(%)	ktoe	Ratio(%)	ktoe	Ratio(%)
Industry	8,739	23.4%	9,943	25.7%	9,808	23.8%
Residential	13,299	35.5%	13,039	33.8%	15,331	37.2%
Commercial & public services	4,477	12.0%	5,017	13.0%	5,179	12.6%
Transport	6,000	16.0%	6,248	16.2%	6,183	15.0%
Other	4,909	13.1%	4,376	11.3%	4,717	11.4%
Total	37,424	100.0%	38,622	100.0%	41,218	100.0%
Year on year ratio	—		103.2%		106.7%	

Source: JICA study team, based on IEA data, using JICA-Net Library "Energy Balance Diagram Creation and Data-based Energy Efficiency Policy Analysis Methodology".

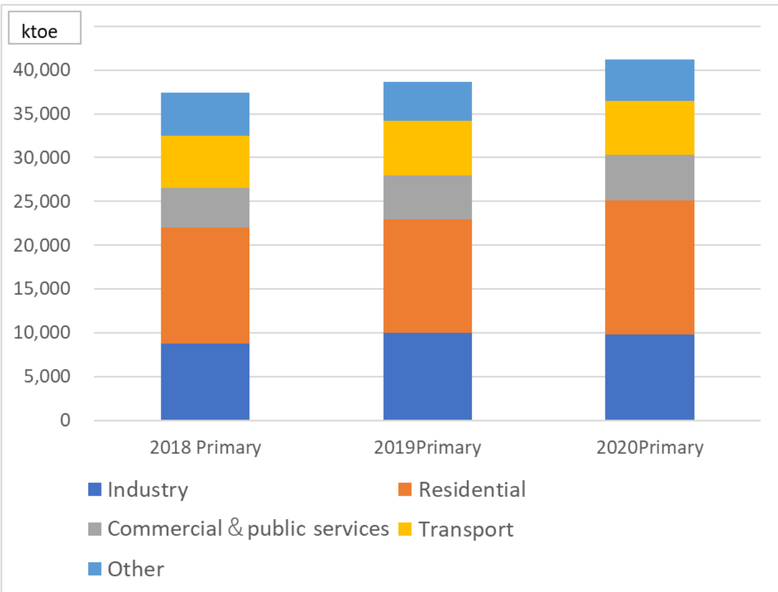


Figure 2-12 Final Energy Consumption Trends by Sector Converted to Primary Energy
Source: JICA study team, based on IEA data, using JICA-Net Library "Energy Balance Diagram Creation

and Data-based Energy Efficiency Policy Analysis Methodology".

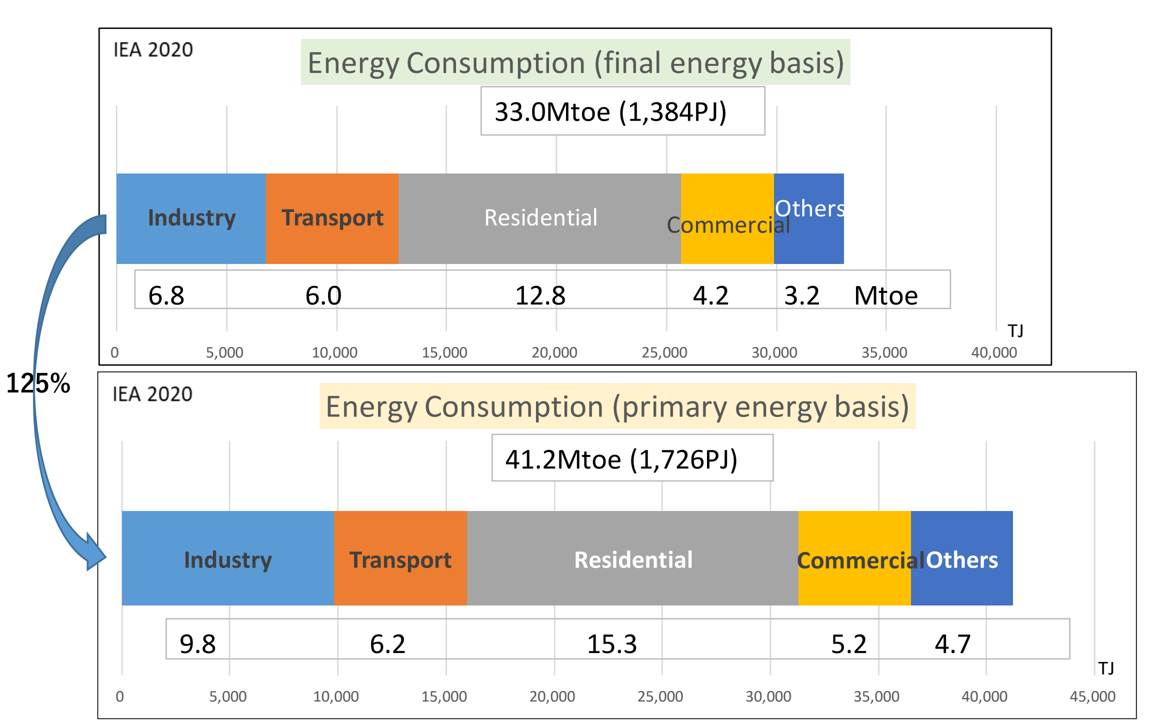


Figure 2-13 Primary Energy Equivalent Energy Consumption by Sector

Source: JICA study team, based on IEA data, using JICA-Net Library "Energy Balance Diagram Creation and Data-based Energy Efficiency Policy Analysis Methodology".

Table 2-8 shows the results of the distribution of 2020 final energy consumption by sector and energy source converted to primary energy. The share of electricity has increased significantly from 14% to 30%, and the share of natural gas is 50%, petroleum products 10%, heat 7%, and coal 3%.

Table 2-8 Energy Consumption by Sector and Energy Source Converted to Primary Energy

Primary energy equivalent (ktoe)	Coal	Oil products	Natural gas	Electricity	Heat	Total	Ratio (%)
Industry	230	144	4,322	4,653	459	9,808	**23.8%**
Residential	260	471	9,675	3,667	1,260	15,331	**37.2%**
Commercial and public services	102	167	2,395	1,235	1,279	5,179	**12.6%**
Transport	4	2,943	2,988	249		6,183	15.0%
Others	704	202	1,304	2,446	61	4,717	11.4%
Total	1,300	3,927	20,685	12,251	3,059	41,218	100.0%
Industry	2.3%	1.5%	**44.1%**	**47.4%**	**4.7%**	100.0%	
Residential	1.7%	3.1%	**63.1%**	**23.9%**	**8.2%**	100.0%	
Commercial and public services	2.0%	3.2%	**46.2%**	**23.9%**	**24.7%**	100.0%	
Transport	0.1%	47.6%	48.3%	4.0%		100.0%	
Others	14.9%	4.3%	27.7%	51.9%	1.3%	100.0%	
Total	3.2%	9.5%	50.2%	29.7%	7.4%	100.0%	

Source: Created by the JICA Study Team, based on IEA data, using JICA-Net Library "Energy Balance

Diagram Creation and Data-based Energy Efficiency Policy Analysis Methodology".

Figure 2-14 shows the breakdown of consumption by energy source in each sector. Table 2-8 shows that natural gas, electricity, and heat account for approximately 95% of the total in the consumer (residential and commercial buildings) and industrial sectors, and Figure 2-14 shows that these three sectors together account for 74% of the nation-wide total, indicating that the promotion of energy conservation is particularly important.

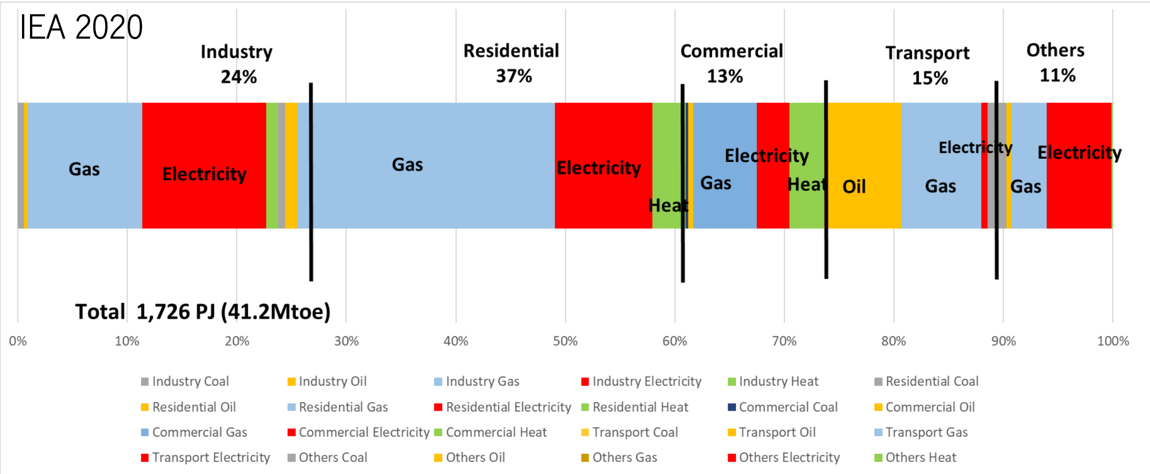


Figure 2-14 Distribution of energy consumption by sector and energy source, converted to primary energy

Source: JICA study team, based on IEA data, using JICA-Net Library "Energy Balance Diagram Creation and Data-based Energy Efficiency Policy Analysis Methodology".

Since the majority of fuels for electricity and heat are natural gas, comparisons were also made for the use of natural gas. For the comparisons, final energy consumption converted to primary energy was used. The comparison method was that after natural gas consumption was calculated and aggregated, shares of natural gas used for electricity and heat production by sector and percentages of the sector total was calculated. The results are shown in Table 2-9. Natural gas accounts for 91% of total consumption in the residential sector, 89% in the industrial sector , and 90% in the commercial building sector. That means in all these sectors, natural gas accounts for approximately 90%, confirming once again that the three sectors are extremely dependent on natural gas and that energy conservation is essential in these sectors.

Table 2-9 Percentage of sector-specific natural gas use in primary energy-equivalent final energy consumption

	Sector Total (Mtoe)	Total N.G. in sector (Mtoe)	N.G.Ratio in sector (%)
Industry	9.8	8.7	88.5%
Residential	15.3	14.0	91.0%
Commercial	5.2	4.6	89.6%
Transport	6.2	3.2	51.7%
Others	4.7	3.4	72.6%
Total	41.2	33.9	82.2%

Source: JICA study team, based on IEA data, using JICA-Net Library "Energy Balance Diagram Creation and Data-based Energy Efficiency Policy Analysis Methodology".

③ Final energy consumption by energy source

Figure 2-16 shows Table 2-6 with trends by energy source and final energy consumption, with natural gas being the largest, accounting for 62.6% in 2020. This is followed by electricity (13.5%), petroleum products (11.9%), heat supply (8.1%), and coal (3.9%). Solar and wind power, which are renewable energies, do not appear in the statistics at this time. However, there are plans to increase their share to 25% by 2026 by constructing 4 GW wind power, 4 GW solar power, 868 MW hydroelectric power plants, etc., based on Presidential Decree UP-60, and since these plans will accelerate in the future, the figures will probably be included in statistics in the future. According to the MoE concept note (see section 2.3.1), electricity demand is expected to increase with economic development and improved living standards, reaching 1.9 times the 2018 level by 2030, as shown in Figure 2-15. Among them, residential sectors are expected to increase significantly by 1.8 times, and economic sectors including industry and business services are predicted to go up by 2.2 times.

From the viewpoint of energy sources, in Uzbekistan, it is important to conserve natural gas resources through the improvement of power generation efficiency and the increase in the ratio of renewable energy, in the power generation sector where the natural gas consumption is the largest. At the same time, it is essential for the consumption side to take energy conservation measures and to introduce renewable energy in the residential, industrial, and commercial building sectors, where energy consumption is expected to increase in the future.

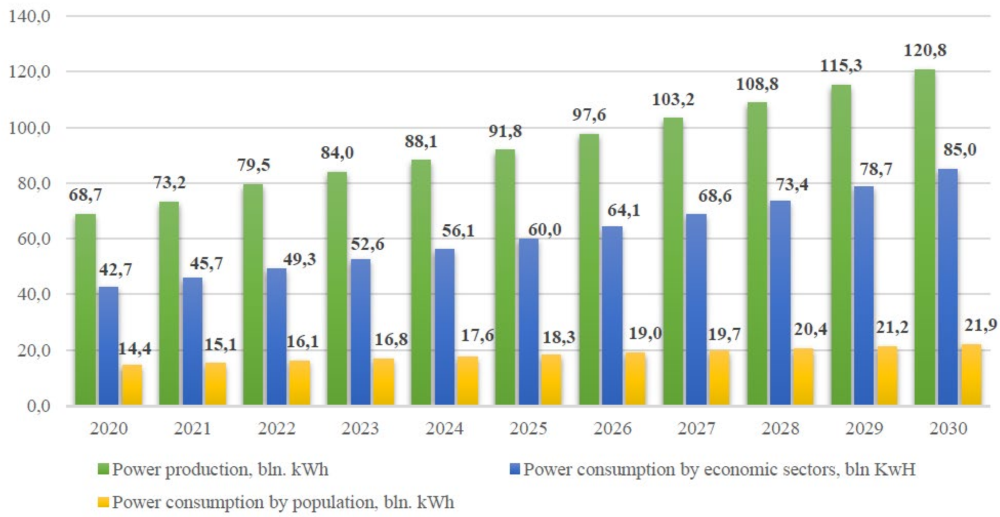


Figure 2-15 Electricity Generation and Consumption Outlook to 2030

Source: Concept Note, MoE, 2021

Table 2-10 Trends in Final Energy Consumption by Energy Source Converted to Primary Energy

Primary energy equivalent TFC (ktoe)	2018		2019		2020	
	ktoe	Ratio(%)	ktoe	Ratio(%)	ktoe	Ratio(%)
Coal	835	2.2%	774	2.0%	1,300	3.2%
Natural Gas	17,643	47.1%	18,229	47.2%	20,685	50.2%
Oil Products	3,703	9.9%	3,577	9.3%	3,927	9.5%
Electricity	12,143	32.4%	12,748	33.0%	12,254	29.7%
Heat	3,101	8.3%	3,294	8.5%	3,059	7.4%
Total	37,424	100.0%	38,622	100.0%	41,225	100.0%
year on year ratio			103.2%		106.7%	

Source: JICA Study Team, based on IEA data, using JICA-Net Library "Energy Balance Diagram Creation and Data-based Energy Efficiency Policy Analysis Methodology".

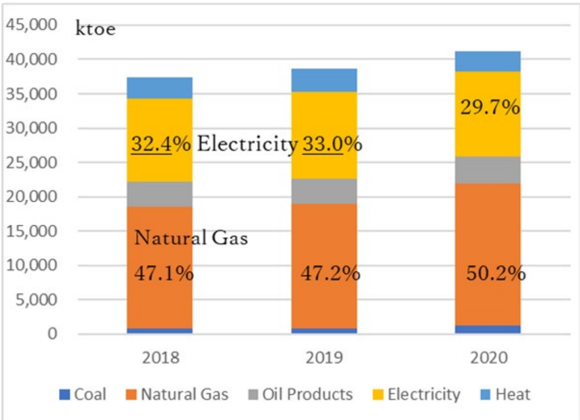


Figure 2-16 Trends in Final Energy Consumption by Energy Source: Converted to Primary Energy

Source: JICA Study Team, based on IEA data, using JICA-Net Library "Energy Balance Diagram Creation and Data-based Energy Efficiency Policy Analysis Methodology".

(3) Greenhouse Gas Emissions

The most recent official greenhouse gas (GHG) inventory for Uzbekistan is the GHG inventory from the country in 2017, as shown in the 2021 First Biennial Update Report of the Republic of Uzbekistan ("BR"). According to this, GHG emissions in 2017 were 189.2 million tCO2e, with the energy sector accounting for 76%, industrial process and product use (IPPU) for 5%, agriculture, forestry, and other land use for 18%, and waste for 1% (Figure 2-17)[6]. According to BR, four of the top five largest GHG emitting subsectors in Uzbekistan are energy related. Methane emissions leaking from facilities and equipment (approximately 47.18 million tCO2e) and fuel-derived CO2 emissions from the energy industry and manufacturing, construction, and housing (approximately 65.91 million tCO2e) are particularly significant, together accounting for approximately 60% of the country`s GHG emissions (Table 2-11). The reason for the large emissions from the energy sector is thought to be that Uzbekistan consumes natural gas produced in their own country for delivery, power generation, and heat use with aging facilities, and natural gas leakage occurs in delivery and low energy efficiency facilities are used in natural gas consumption. The trend of GHG emissions in the country over the past 20 years shows an increasing trend, and a look at CO2 emissions by fossil fuel shows that CO2 emissions from natural gas are outstandingly large, and CO2 emissions from the electricity and heat industry sectors are the largest (Figure 2-18, Figure 2-19, Figure 2-20).[7]

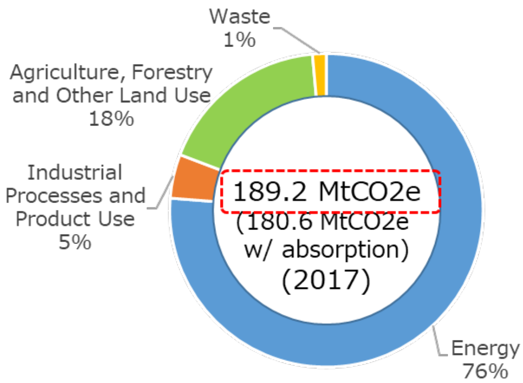


Figure 2-17 Greenhouse Gas Inventory for Uzbekistan (2017)
Source: Prepared by the Study Team based on the First Biennial Update Report of The Republic of Uzbekistan (Government of Uzbekistan, 2021).

[6] First Biennial Update Report of The Republic of Uzbekistan (Government of Uzbekistan, 2021) https://unfccc.int/sites/default/files/resource/ FBURUZeng.pdf, accessed July 16, 2022.

[7] Hannah Ritchie, Max Roser and Pablo Rosado (2020) - "CO_2 and Greenhouse Gas Emissions". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions' [Online Resource]

Table 2-11 Top 5 Greenhouse Gas Emissions (ktCO2e) in Subsectors in the Greenhouse Gas Inventory of Uzbekistan (2017)

Sector	Subsector	ktCO2e	Main GHGs
Energy	Natural gas	47,185.2	CH4
Energy	Power generation (gas-fuel)	27,557.8	CO2
Energy	Processing industry and construction (gas fuel)	20,838.2	CO2
Agriculture, forestry and land use	Rumination	19,446.3	CH4
Energy	Residential sector (gas fuel)	17,521.8	CO2

Source: Prepared by the Study Team based on the First Biennial Update Report of The Republic of Uzbekistan (Government of Uzbekistan, 2021).

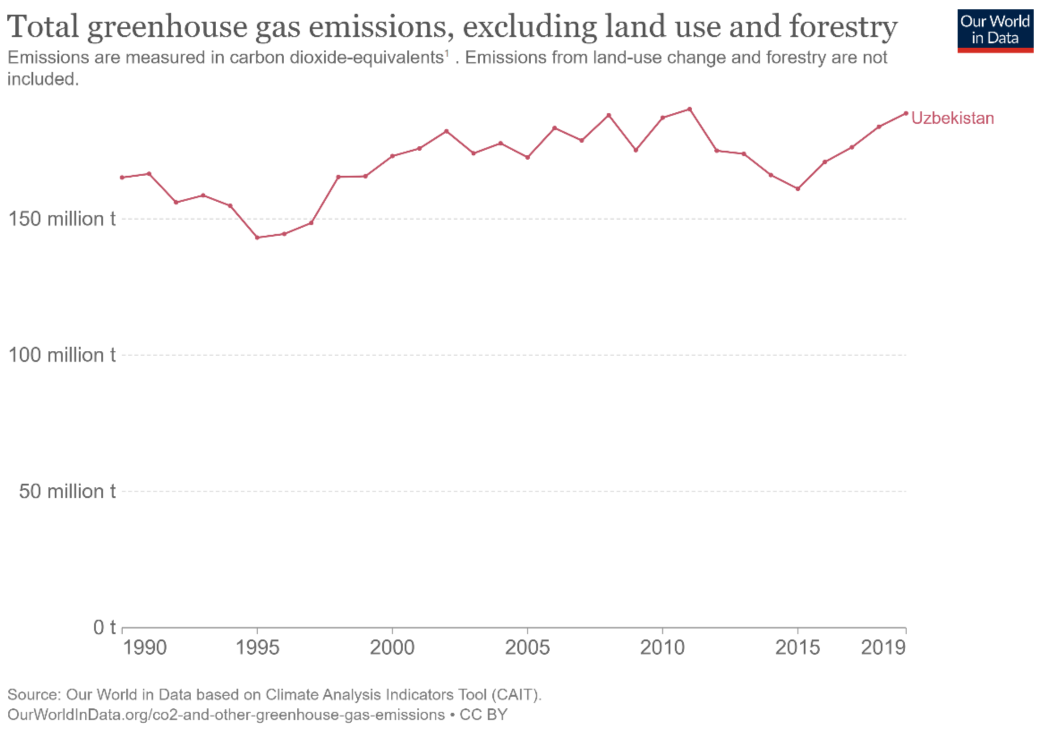


Figure 2-18 Change in Greenhouse Gas Emissions over Time in Uzbekistan (1990-2019)

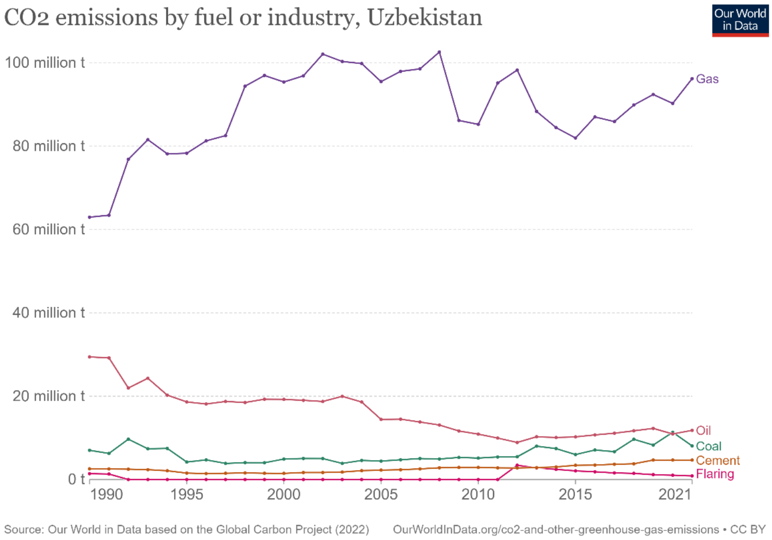


Figure 2-19 Secular Change in CO2 Emissions in Uzbekistan (1990-2019)

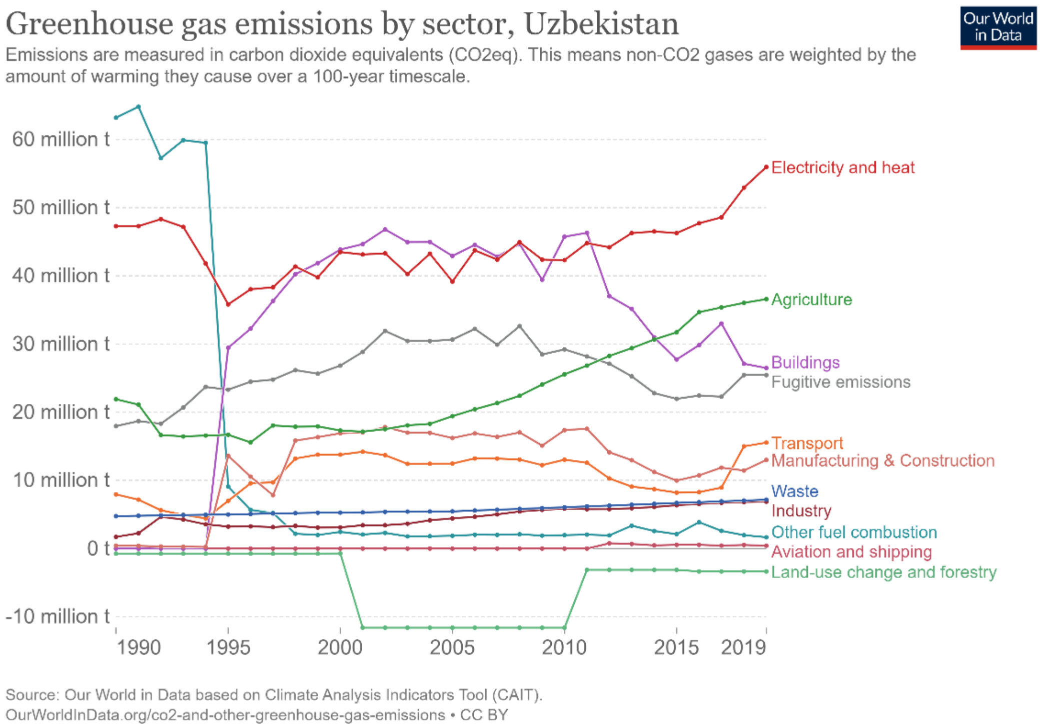


Figure 2-20 Secular Change in Greenhouse Gas Emissions by Sector for Uzbekistan (1990-2019)

2.2.2 Demand and Supply of Heat

It was noted that natural gas consumption by the residential sector, commercial building sector, and industrial sector is assumed to be high, and that its use is for heating and other heat applications. This section provides a background to Uzbekistan`s high heat demand in these sectors.

(1) Demand and Supply of Heat in Uzbekistan

In Uzbekistan, the heat supply situation is characterized by a combination of district heat supply facilities and individual gas boilers, which are used to provide heat for residential, commercial, and industrial buildings. In addition, aging, low-efficiency gas boilers, a remnant of the Soviet era, account for a large proportion of the total.

Meanwhile, the proportion of heat demand satisfied by district heat supply in total heat demand is not large. For example, in Tashkent, the service area of district heat supply facilities is mainly in the old city center and does not cover the entire city.

(2) Comparison of Heat Use in Japan and Uzbekistan

It was mentioned in 2.2.1 that the TES per nominal GDP in 2018 was large at 920 ktoe/bUSD in Uzbekistan, compared to a global average of 166 ktoe/bUSD and 86 ktoe/bUSD in Japan. The main reason is believed to be the large amount of energy used to meet the heat demand in Uzbekistan's residential, commercial building, and industrial sectors.

For reference, according to the Energy White Paper (2021) by the Agency for Natural Resources and Energy, electricity accounts for 53% of energy use in commercial buildings in Japan, more than the 47% for fuel and heat.

2.3 **Energy Conservation policies and Climate Change Measures**

2.3.1 Energy Conservation Policy

Considering the energy situation, the government of Uzbekistan has recently recognized the need for energy efficiency and has launched various energy conservation policies and initiatives. Therefore, the policies on energy efficiency and conservation were summarized to understand their policies on energy efficiency and conservation and their implementation status.

(1) National Policies, Development Plans, Regulations, etc.

1) National Policies, Development Plans, Regulations, etc.

The green economic development policy of the Uzbekistan is based on Presidential Decree PP 4477 of 2019, as shown in the table below.

Table 2-12 Presidential Decree PP4477

Legal system name	Strategy for the Transition to a Green Economy (2019-2030)
Year of entry into force	October 2019
summary	(1) Policy and Legislation The following basic policies are enforced by Presidential Decree PP4477 "2019-2030 Green Economy Policy" of October 2019. ・ Promote the adoption of green technologies and the transition to a green economy to ensure the adoption of green technologies and the fulfillment of the obligations of the Paris Agreement with a long-term perspective ・ Advancing the economy's energy efficiency and natural resource consumption through modernization of technology and development of financial mechanisms ・ Support implementation of pilot projects through national incentives, development of public-private partnership mechanisms, and enhanced cooperation with international financial institutions ・ Encourage investment in education and strengthen cooperation with key foreign educational institutions and research centers ・ Targets compared to 2010 are shown below ✓ 10% reduction in greenhouse gas emissions per unit of GDP ✓ 20% improvement in energy efficiency ✓ Renewable energy ratio of at least 25% of total electricity generation ✓ Installation of drip irrigation technology on up to 1 million hectares and a 20-40% yield increase of crops grown. Increase average productivity of basic agricultural products by 20-25%. (2) Promotion System ・ According to Presidential Decree PP4477 "2019-2030 Green Economy Policy" of October 2019, measures to promote the green economy will be implemented under the following structure ✓ Interdepartmental consultation by the Interdepartmental Council to develop an action plan for the implementation of the strategy for the following year (usually in November) ✓ The Ministry of Economic Development and Poverty Eradication oversees the promotion of the green economy and coordinates the activities of responsible ministries and departments. Modernize industrial infrastructure through the use of environmentally friendly

	technologies and industrial processes. ✓ The Ministry of Energy will improve energy efficiency indicators and develop renewable energy sources. The Energy Efficiency Division has been established in the Ministry of Energy, which is responsible for power generation, electricity supply, and gas supply, and is in charge of planning and promoting energy management policies. ✓ Other ministries will be responsible for ministry-specific tasks. For heat supply, the MoHCS and the Tashkent Municipal Housing and Public Services Department, which is responsible for heat supply in Tashkent, will manage energy consumption standards and energy efficiency improvement measures. The Ministry of Construction is responsible for insulation standards in construction.

2) Policies on Energy Efficiency and Energy Conservation

Uzbekistan's policy on energy conservation is based on Presidential Decree PP4422 and Presidential Decree PP4779, as indicated below. Improvements to the national statistical system, including energy statistics, are also based on Presidential Decree PP 4796. PP4422 indicates the target of a 25% share of renewable energy by 2030 and the provision of subsidies for the introduction of energy-saving technologies, while PP4779 states reduction targets by energy source and the establishment of an energy conservation fund.

Table 2-13 Presidential Decree PP4422

<table>
<tr><td>Legal system name</td><td>Measures to promote development for energy efficiency</td></tr>
<tr><td>Year of entry into force</td><td>August 2019</td></tr>
<tr><td>summary</td><td>・ By 2030, the share of renewable energy will be at least 25% (hydro: 11.2%, solar: 8.8%, wind: 5.0%) of the generation capacity (MW).
<table>
<tr><td>increment</td><td>2019</td><td>2020</td><td>2021</td><td>2022</td><td>2023~2030</td></tr>
<tr><td>hydraulic power</td><td>24.1</td><td>119.8</td><td>204.5</td><td>42.2</td><td>1,487.6</td></tr>
<tr><td>sunlight</td><td>-</td><td>-</td><td>300</td><td>400</td><td>4,300</td></tr>
<tr><td>wind power</td><td>-</td><td>-</td><td>-</td><td>100</td><td>1,600</td></tr>
</table>
Unit: MW
・ 36 programs for high-efficiency systems, renewable energy
・ Recommended measures
✓ High-efficiency heating systems, including installation of the latest</td></tr>
</table>

	heat pump systems ✓ Phased installation of photovoltaic and solar water heating systems ✓ Installation of double-paned window units with high thermal insulation efficiency ✓ LED light source combined with touch sensor ✓ Replace non-standard gas burners with the latest high-efficiency gas burners ✓ Installation of photovoltaic and solar hot water systems in state institutions, administrative buildings of organizations, and infrastructure facilities ・ Subsidizes 30% of the cost of individual acquisition of solar photovoltaic, solar water heating, and energy-efficient gas burner equipment

Source: Prepared by the survey team based on Lex UZ HP

Table 2-14 Presidential Decree PP4779

Legal system name	Plan to improve the efficiency of energy use in the economy
Year of entry into force	July 2020
summary	The planned energy reductions are as follows

	Year 2020	Year 2021	Year 2022	total amount
Gas (mil.m3)	982	743	870	2,595
Electricity (mil.kwh)	907	1501	855	3,263
Petroleum (ton)	5,483	5,816	5,257	16,556

・ In the Roadmap for Energy Efficiency Improvement (Implementation Program), 29 programs are listed.

・ Conduct energy audits for companies with large energy consumption

・ Creation of a fund to be financed by 5% of the net profits of companies in the oil, gas, and energy sectors, among other sources. Funds will be used to

✓ Energy-efficient technologies and renewable energy

✓ Conduct energy audits

✓ Improved building insulation

✓ Preparation of FS for energy efficiency projects

✓ Establishment of a training center and training of professionals for energy efficiency improvement and renewable energy development

Source: Prepared by the survey team based on Lex UZ HP

Table 2-15 Presidential Decree PP4796

Legal system name	Measures for further improvement and development of the national statistical system
Year of entry into force	August 2020
summary	Improvement efforts are to be pursued in a number of sectors, including improving quality and reliability, transparency, and openness with regard to national statistics, and improving existing methodologies based on international recommendations and guidelines. With regard to energy statistics, the report states that there is no complete information that gives a complete picture of the country's energy sector and that the statistical data is insufficiently reliable. Annex 1 and Annex 2 of the same resolution describe efforts for improvement.

3) Power Development Plan

Uzbekistan‘s power supply development plan is developed based on the MoE concept note.

The concept note summarizes the current electricity supply and demand situation and challenges, then forecasts electricity demand through 2030, and presents plans for power source development, including thermal power, hydroelectric power, and renewable energy.

Table 2-16 MoE Concept Note

Legal system name	MoE policy to ensure electricity supply in 2020-2030
Year of entry into force	April 2020
Outline	It has the following plans to enhance its power generation capacity Electricity demand response capacity is expected to be greatly enhanced by 2030, allowing the country to respond to the demand-side shift to electricity. Current facility issues include - Low power generation efficiency (25-35%) - Aging power transmission and substation

- Low consistent efficiency.
- Lack of automation and digitalization in the power generation sector

Dimensions listed

(i) Available power generation capacity: 12.9 GW

(ii) Winter and summer load

- Peak winter 10.4 GW (2019), variance 2.3 GW

Summer peak 9.4 GW (2019), variance 2.6 GW

Demand Trends and Outlook for 2030

- Power generation growth rate (2012-2019) 2.6% per year
- Expected increase in electricity consumption (by 2030): approx. 6-7 %.
- Projected consumption in 2030: 120.8 TWh (1.9 times higher than in 2018)
- Per capita consumption forecast for 2030: 2,665 kWh / year (71.4% increase compared to 1,903 kWh in 2018)
- Shortage relative to demand approx. 9.4
- Electricity imports and exports: will balance and reach 6 TWh/year by 2030.
- Peak maximum power forecast: 20.9 GW (2030) 10.4 GW (winter 2019)

(iv) Development of thermal power generation sector

- 13 projects planned for 2020-2030
- TPP capacity to be installed 14.7 GW (by 2030)

70.7 bln kWh generated in 2030 (1.3 times the 2018 level)

TPP 5.9 GW to be deactivated due to obsolescence (until 2030)

(5) Power generation from renewable energy sources

- Construction target: 3 GW wind, 5 GW solar

6) Development of hydroelectric power generation

- 2030 HPP capacity 3.8 GW, electricity generation 13.1 TWh

(7) Total generation capacity: 29.2 GW (including 4.4 GW of peak load capacity)

Power generation 120.8 TWh

Natural gas TPP: 13.4 GW (45%) 70.7 TWh (58.5%)

Coal-fired TPP: 1.7 GW (5.9%) 13.1 TWh (10.8%)

Hydro: 3.8 GW (13.1%) 9.9 TWh (8.2%)

Wind: 3 GW (10.4%) 8.6 TWh (7.1%)

Solar: 5 GW (17.3%) 18.0 TWh (14.9%) (1000 MW of storage)

NPP: 2.4 GW (8.3 %)

Consumer-owned generation: 0.6 TWh (0.5%)

Plan for installation of power generation equipment

categor	type	Location	Number of	Total	Constructio

y			installations	capacity (MW)	n period
TPP	GT (50-100MW) Peak load compensation	as regulating power plants	2	200-300 x2 Future: 1200 total	2021-2023
TPP		Syrdarya	2	650-750 x2 Future: Total 2600-3000	2023-2024
TPP	CCGT	Navoi as No3	1	650	2023-2024
TPP		Navoi as No4	1	650	2024-2025
TPP		Talimarjan as No.3,4	2	Total 900 or more	2023-2024
TPP	CCGT Planning Phase	Kashkadarja or Surkhandarja		1300	2025-2026
TPP	coal-fired thermal power generation	Angren.	1	150	pending
TPP	Modernization of existing coal-fired power generation	Novo-Angren No.1-5		Capacity increase 330	pending
	13 Projects Newly established 6 Expansion of existing TPPs6 Novo-Angren Modernization 1			increase 3800 4100 330	2020-2030
CHPP	GT	Ferghana	1	17	2020
CHPP	GT	Tashkent	2	54	2022

	Wind power	100-500MW	Karakalpakistan Navoi		Target Total 3000	2020-2030
	Solar power	100-500MW	Djizzak Samarkand Surkhandarya other regions		Target Total 5,000	2020-2030 Total capacity 600 MW and 800 MW Start from
	Hydro power	62 projects			1537	2020-2030

Source: summarized from the MoE concept note (https://minenergy.uz/en/lists/view/77), with additional information obtained by the study team

4) Regulatory Policies related to Energy Conservation

Regulations on energy conservation in Uzbekistan include Presidential Decree PP2912 on heating in housing complexes and the resolution of the Cabinet of Ministers No86 on the Energy Efficiency Labeling System.

Uzbekistan`s energy conservation certification label is similar to the EU label, in part because it is used as a common regulation for imports and exports with five neighboring countries (Russia, Kyrgyzstan, Armenia, Kazakhstan, and Belarus). The calculation of energy efficiency, which determines the rank of the energy efficiency label, follows a similar method to that used for EU labels, with the Uzbek Agency for Technical Regulation carrying out standardization and certification of product quality and energy efficiency. Although there are no subsidies or other energy efficiency and conservation measures through the Energy Efficiency Labeling system, there is a tax incentive for the promotion of renewable energy use (Presidential Decree No. 4422; see "2) Policies on Energy Efficiency and Conservation"), which was jointly developed by the MoE and MIFT. If we assume the formulation of policies for the promotion of energy-efficient products using energy efficiency labeling, the organization in charge of formulating such policies would be the MoE or MIFT, not Uzbek Agency for Technical Regulation, which is mainly in the business of certifying products.

Table 2-17 Presidential Decree PP 2912

Legal system name	Heat supply system development program for 2018-2022
Year of entry into force	April 2017

Summary	In accordance with PP 2912 of 2017, which states that new multi-family dwellings are not permitted without the installation of a separate heating system or a high-efficiency local boiler house, the following policies are in place regarding the use of heat for heating and hot water in new buildings and multi-family dwellings. · Individual buildings and apartment complexes will not install centralized district heat supply piping but will install individual boilers. · Boilers will be natural gas boilers, but electric boilers will be used for boilers to be installed at heights above the 9th floor due to insufficient pressure.

Source: Prepared by the survey team based on Lex UZ HP

Table 2-18 Hearing Information on MoC's Insulation Policy

Legal system name	-
Year of entry into force	-
Summary	Insulation Regulations
	According to the MoC, high standards are required for insulation in new multi-family housing. The current implementation measures for insulation are as follows ・ Thermal insulation standards ✓ Priority was given to preventing condensation until 2011, and in 2012, insulation standards for walls, windows, and roofs were set and applied to new buildings. The calculation criteria for heating calorific values are being reviewed. The exterior walls are double layered with spacing to allow for temperatures up to 70°C. Insulation is installed on the exterior and the use of bricks is prohibited. ・ building application ✓ Submit energy conservation plans and energy use per square meter. The certificate will be issued with four ranks according to its level. ・ design standard ✓ Model designs include 11 schools, 7 sports centers, 3 kindergartens, and 7 medical facilities. The walls are made of gas blocks and sandwich panels. As a design standard for housing, one room in a 3LDK or two rooms in a 4LDK should have 3 hours of sun exposure. ・ energy conservation standards

	✓ Standards for pumps, air conditioning, and lighting apply. ・ New Construction and Renovation ✓ Take energy conservation measures for 2,000 new construction and renovations per year. The renovation, which will be carried out under the state budget, will introduce insulation measures. The existing standard nine-story Soviet-era building has poor insulation, especially on the sides.

Source: Prepared by the survey team based on Lex UZ HP

Table 2-19 Decree No. 86

Legal system name	Measures to introduce into the Republic a system of mandatory energy marking and certification of sold household appliances, new buildings and facilities
Year of entry into force	April 2015
Summary	Energy Conservation Labeling Regulations
	For energy-saving labeling, 18 categories of appliances are regulated. The energy efficiency label ranks begin with grades A+++ through G, followed by G in 2017, F in 2018, E in 2019, and D in 2020, with low-efficiency appliances being banned from the market.

Source: Prepared by the survey team based on Lex UZ HP

(2) Pricing Policy (fuel, electricity, gas, hot water rates)

1) Fuel Price

Gas prices are set for each consumer as follows. Household use is kept low by policy (Table 2-20). The production of chemical products using the gas yields an added value of 3,000 UZS (0.27 USD) (per m3). In addition, residential gas prices vary by region (Table 2-21).

Table 2-20 Gas Prices by Demand

Consumer	Price (UZS/m3)	USD
family	380	0.0334
power generation plant	660	0.0580
private-sector business	1000	0.0088

Source: survey team from June 2021 MoE interviews.

The currency unit (UZS) is converted to USD using the Central Bank rate of Uzbekistan as of 31 January 2023 (1 UZS = 0.000088 USD).

Table 2-21 Residential Gas Prices by Region

Area	Price (UZS/m3)	USD

Tashkent City	380	0.03334
Andijan, Jizzakh, Kashkadarya, Samarkand	226-227	0.0199 — 0.0200
Other areas	209	0.0184

Source: E-kommunal website as of July 2021

The currency unit (UZS) is converted to USD using the Central Bank rate of Uzbekistan as of 31 January 2023 (1 UZS = 0.000088 USD).

2) Electricity Price

Electricity rates are divided between business and residential customers. The electricity price for households is 295 UZS/kWh (0.0265 USD/kWh) in all regions (E-kommunal site as of July 2021), While that for businesses, including factories is 450 UZS/kWh (0.0405 USD/kWh) (from survey questionnaire; as of July 2021).

3) Hot Water Price

Domestic hot water prices vary by region.

Table 2-22 Hot Water Prices for Households by Region

area	Price (UZS/m3)	USD
Tashkent City	5242	0.4613
Bukhara	2868	0.2524
Jizzakh	3456	0.3041
Navoi	1683	0.1481
Namangan	3220	0.2834
Samarkand	3534	0.3110
Fergana	3174	0.2793
Khorezm	4415	0.3885

Source: E-kommunal website as of July 2021

The currency unit (UZS) is converted to USD using the Central Bank rate of Uzbekistan as of 31 January 2023 (1 UZS = 0.000088 USD).

For heating hot water rates that are not determined by a calorimeter, the rate is usually determined per m2 of floor area.

4) Fee System

Rates are determined by the Ministry of Finance ("MoF") and rate increase revisions are implemented.

Over the period 2010-2018, heat prices have increased 3-4x, depending on the region, and electricity prices for households have increased an average of approximately 14% per year (based on analysis of the 2019 METI survey report and website data). Although gas rates vary by supplier, no policy has been adopted to change such pricing.

5) Usage Measurement

As for the installation status of meters, all electricity and gas usage meters have been installed, and as for heat usage meters, all heat meters have been installed for corporations, and all flow meters have been installed for apartment complexes. Note that detached houses are exempt from heat use measurement because they use natural gas. See Table 7-9 in Chapter 7 for details.

6) Fee Collection

For electricity, a meter-based prepaid system is used. See Table 7-9 in Chapter 7 for details.

(3) Organizational Structure for Energy Conservation-Related Policies and Legislation

Based on the field survey, we can generally summarize policies, institutions, and organizations related to energy as follows

① Energy Pricing Policies and Decisions

The Cabinet Decision： Decree No. 310 (April 13, 2019) stipulates that energy prices are to be determined by the Inter-Ministerial Customs Committee of the Cabinet Office. This applies to electricity generation, heat, distribution, gas, and oil prices, as well as fees for their sale and transportation. The Inter-Ministerial Customs Committee is chaired by the Minister of Finance and consists of the Ministers of Economic Development and Poverty Reduction, Energy, Housing and Public Services, and Transportation, as well as the Deputy Minister of Finance and the Chairman of the Antitrust Committee. The procedure for determining prices is set forth in Decree 964 (dated Dec 3, 2019). Organizations that supply, transport, and sell energy, such as power generation, heat supply, and gas companies, should apply to the competent ministries (such as the Ministry of Energy and the Ministry of Housing and Communal Services,) . The Ministry of Finance will confirm the contents of the application after coordination among the relevant ministries and agencies and approval by the Inter-Ministerial Customs Committee and will notify the details of the decision.

② Energy Conservation Policy

Uzbekistan's energy conservation policy is based on "Introduction of Energy-saving Technologies and Development of Renewable Energy Sources" (PP4422; August 2019) and "Reducing Industrial Energy Dependence through Energy Efficiency Improvements and Resource Recycling" (PP4779; July 2020).

The organization and main roles of each ministry are listed below.

1) Ministry of Energy (MoE)

Uzbekistan`s government decided to implement organizational changes in 2019 to radically improve the energy management system, and the MoE was established (UP 5646, P4142). The MoE is staffed by the energy sector, the oil and gas and other fuels sector, and the finance and pricing sector. The Department of Energy Efficiency and Energy Conservation is responsible for energy conservation and is positioned as the department responsible for the overall administration of energy conservation. This reorganization included the reorganization of the electric power industry organization (PP4249), clarification of the responsibilities and authorities of the energy inspection agencies Uzneftegazinspektsiya (oil and gas) and Uzenergoinspektsiya (electricity), and the inspection of electricity and gas consumption measurement equipment (No520 Measures to organize inspection activities to control the use of oil and gas and electricity). However, at present, the inspection certification responsibility and authority for heating calorimetry are unclear.

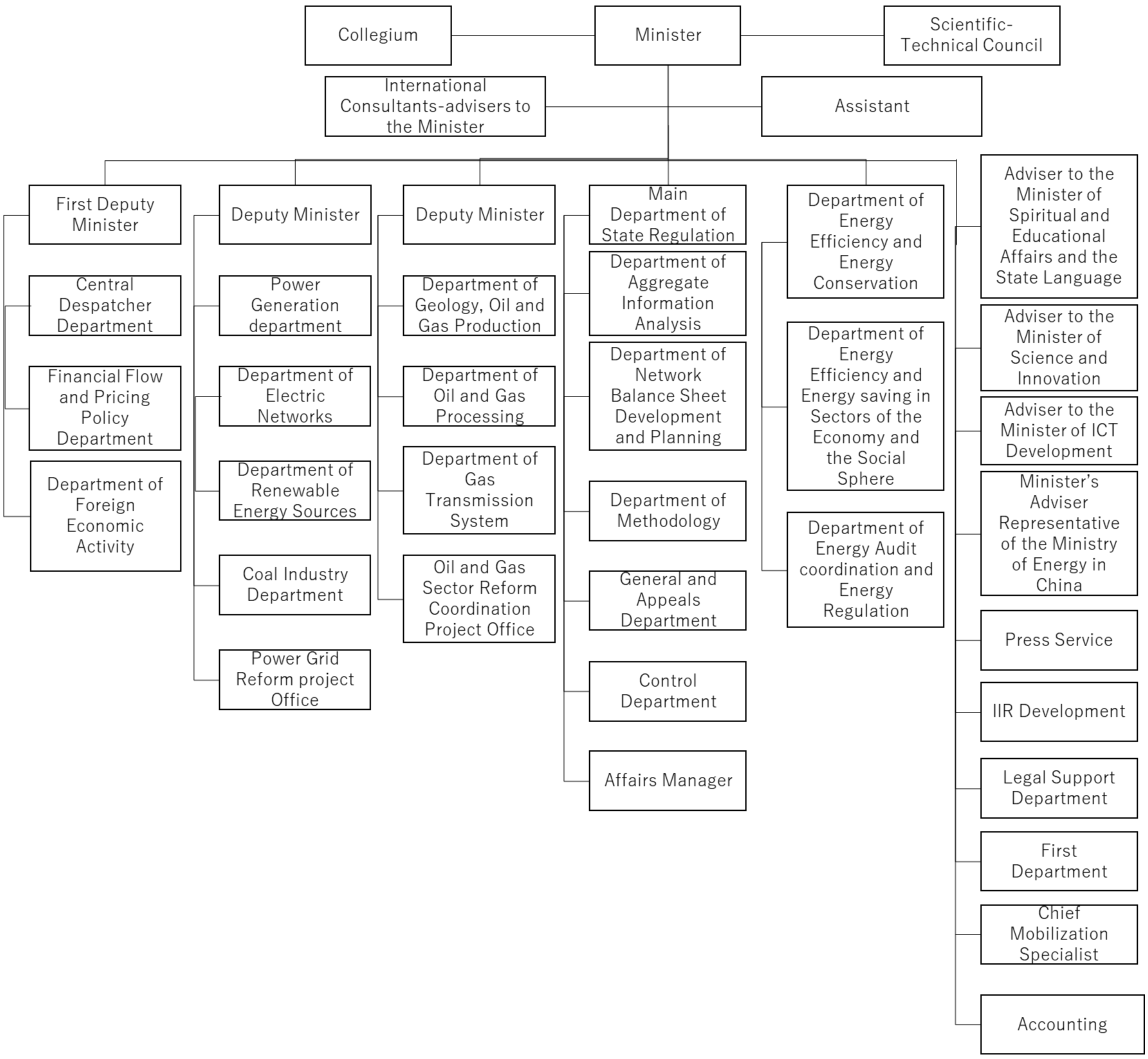


Figure 2-21 Department of Energy Organization Chart

Source: prepared by the study team based on Uzbekistan's decree (Decision of MoE No. 54, on April 9, 2021)

2) Related Organizations of the Energy Conservation Scheme

① Uzbek Agency for Technical Regulation (formerly UZSTANDARD)

The energy efficient labeling system is an energy-related legal system, and UZSTANDARD used it to fulfill its responsibilities as the agency in charge. In July 2021, the organization was reorganized and became the Uzbek Agency for Technical Regulation, an organization under the Ministry of Investment and Foreign Trade (MIFT).

The former UZSTANDARD has been in charge of administration related to product certification, including energy conservation devices, as an agency implementing product certification (No. 1458). In 2015, it was involved in determining the methodology for determining energy efficiency parameters based on international standards (No491), defined the hierarchical classification of energy efficiency labels (O'zDSt 3017), and determined export tariff codes (TN VED) (No86, No860). However, the certification and inspection of energy conservation under the Uzbek Agency for Technical Regulation are not carried out due to a lack of organization, personnel, and equipment in inspection bodies such as UZTEST (Uzbek Center for Scientific Testing and Quality Control). As such, it is not checked whether the target equipment conforms to the energy efficient label affixed.

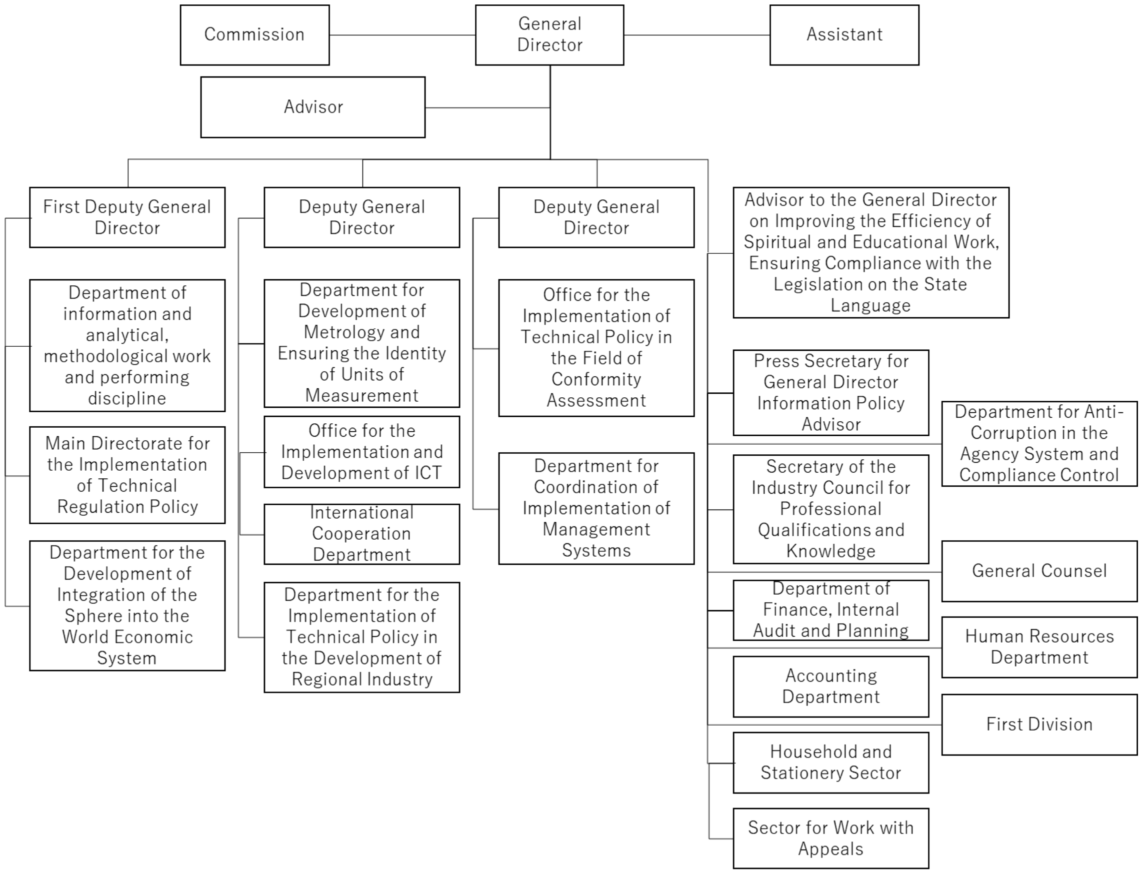


Figure 2-22 Organization of the Uzbek Agency for Technical Regulation

Source: prepared by the study team based on the Uzbekistan's decree (Decision of President PP-5133, on June 2, 2021)

② Ministry of Housing & Communal Services (MoHCS/MJKO)

While the MoHCS oversees the heat consumption of houses, buildings, etc. throughout the country, the local and city governments are responsible for administrative practices such as electricity, gas, and heat supply.

In the MoHCS, priority has been given to policies to secure drinking water supply, but electricity, gas, and heat supply in rural and remote areas is still inadequate in some areas, and the MoHCS is working to improve this situation. Therefore, energy efficiency and conservation policies are expected to be further steps in the future.

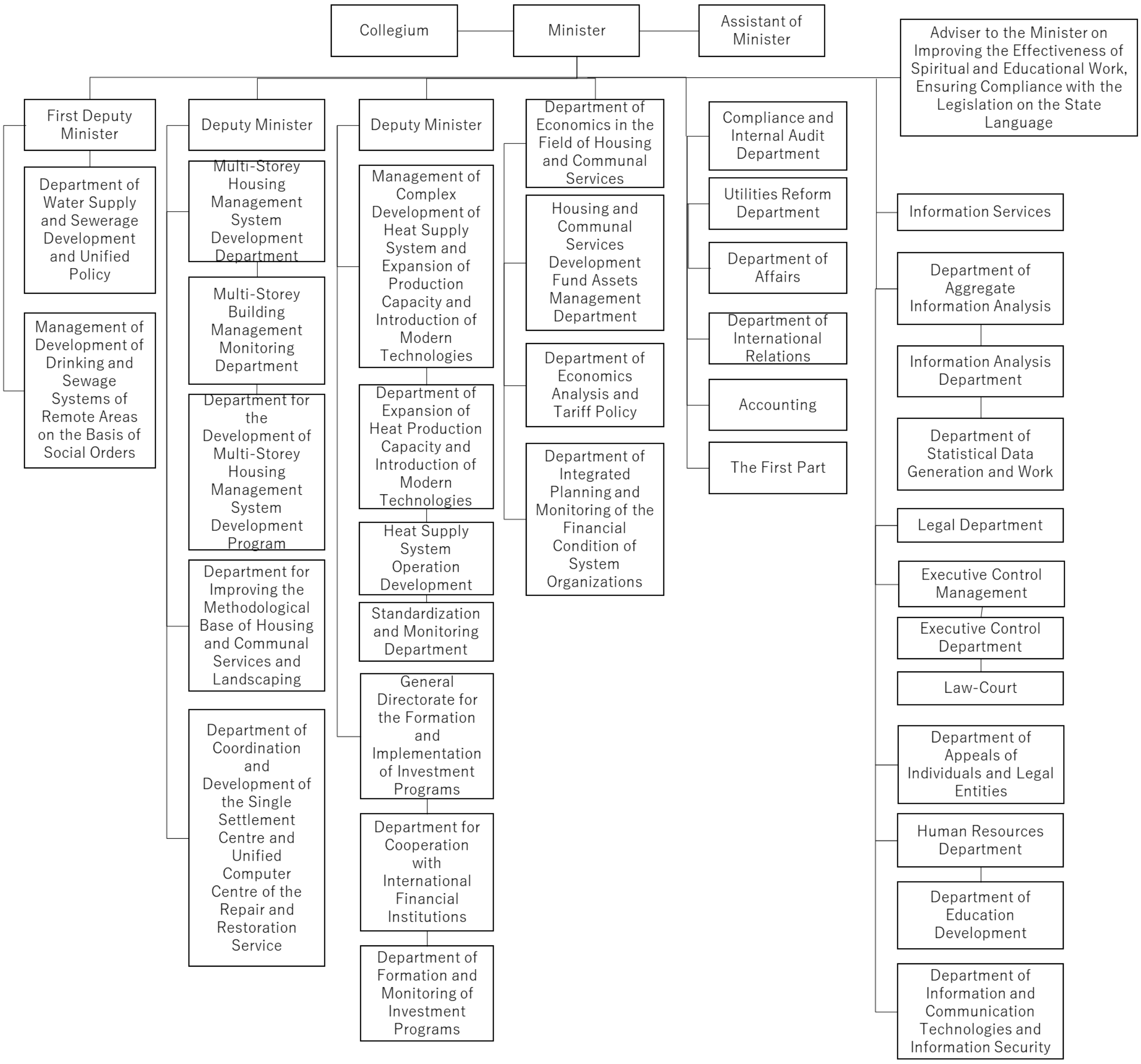


Figure 2-23 Organization of the Ministry of Housing and Public Services

Source: prepared by the study team based on the Decree of Uzbekistan (Decision of MJKO No103, on April 12, 2021)

③ Heat Supply Department of Tashkent City Hall (Residential Sector: MDHCS)

MDHCS owns JSC Teploenergo (TOSHISSIQQUVVATI) and Tashkent Heating Center (Tashkent issiqlik markazi), which manage and operate 13 large boiler rooms and 216 small boiler rooms in the city, and they supplies 90% of the city's heat demand to consumers. The remaining 10% purchases heat from the Tashkent CHP/TashTETSU, which is part of JSC TPP. Negotiations are currently underway to install cogeneration systems in four boiler rooms by Belgium's Stone City Energy. However, MDHCS and Teploenergo/Tashkent Heating Center do not have experience or technology in power generation. As a result, it will be decided in future negotiations whether the cogeneration facilities will be owned by City Hall or JSC TPP. The 'improvement in the heat supply system and financial recovery of heat supply enterprises'

(PP4542; December 2019) plan calls for modernizing the heat supply system and introducing resource-saving technologies. Additionally, closed heat supply systems are planned to improve calorimetry and reduce losses during transport to consumers. This will improve calorimetry that clarifies thermal energy contained in hot water for heating heat supply and the proportion of losses in transport to the consumer. In parallel to this, the installation of heat meters will be promoted by the " improvement in the heat supply system in the city of Tashkent " (PP4543; December 2019).

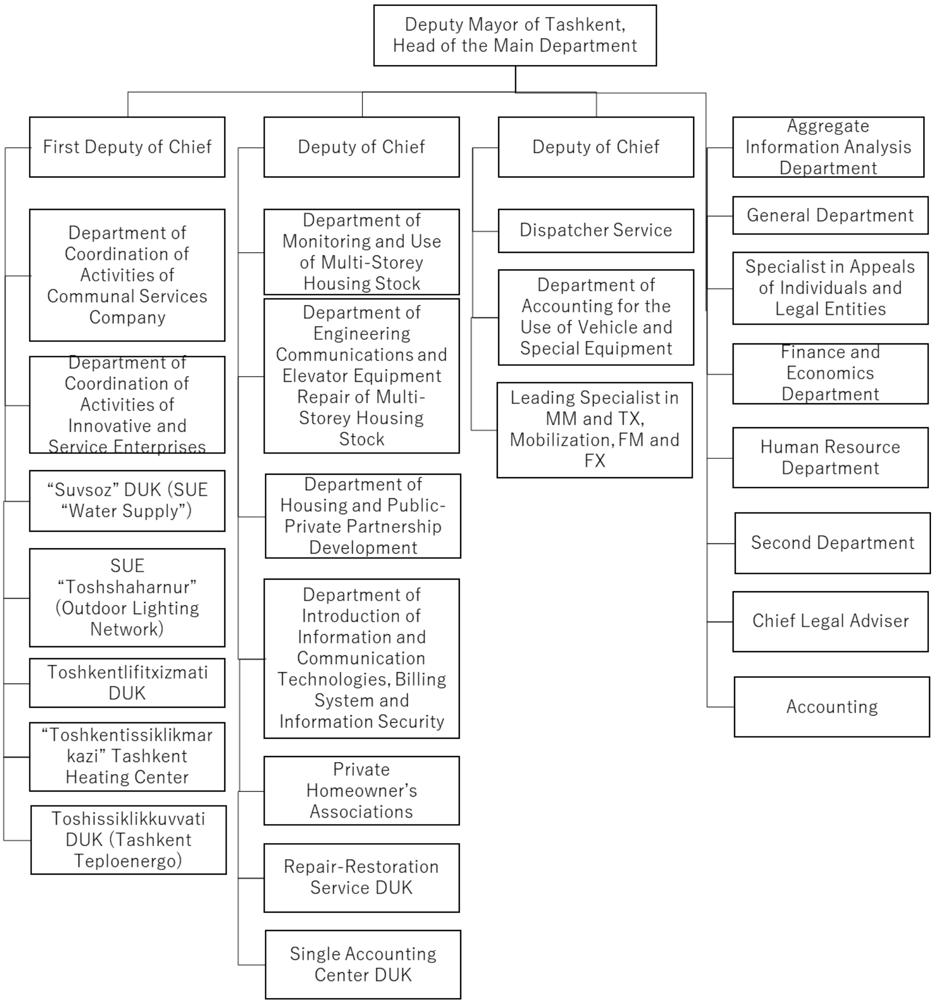


Figure 2-24 Organization of the Heat Supply Department of Tashkent City Hall

Source: prepared by the research team based on Uzbekistan's decree (Decision of the Mayor of the Tashkent city No. 1842, on 21 December 2018)

④ Ministry of Economic Development and Poverty Reduction (MoED&PR)

The Ministry oversees industrial sector activities, conducts energy audits of large energy consuming companies, and promotes initiatives related to green energy, but relies heavily on other ministries, such as Uzbek Agency for Technical Regulation for technical standards related to the installation of high-efficiency energy equipment, MoHCS for heat supply, and the Ministry of Construction (MoC) for building insulation.

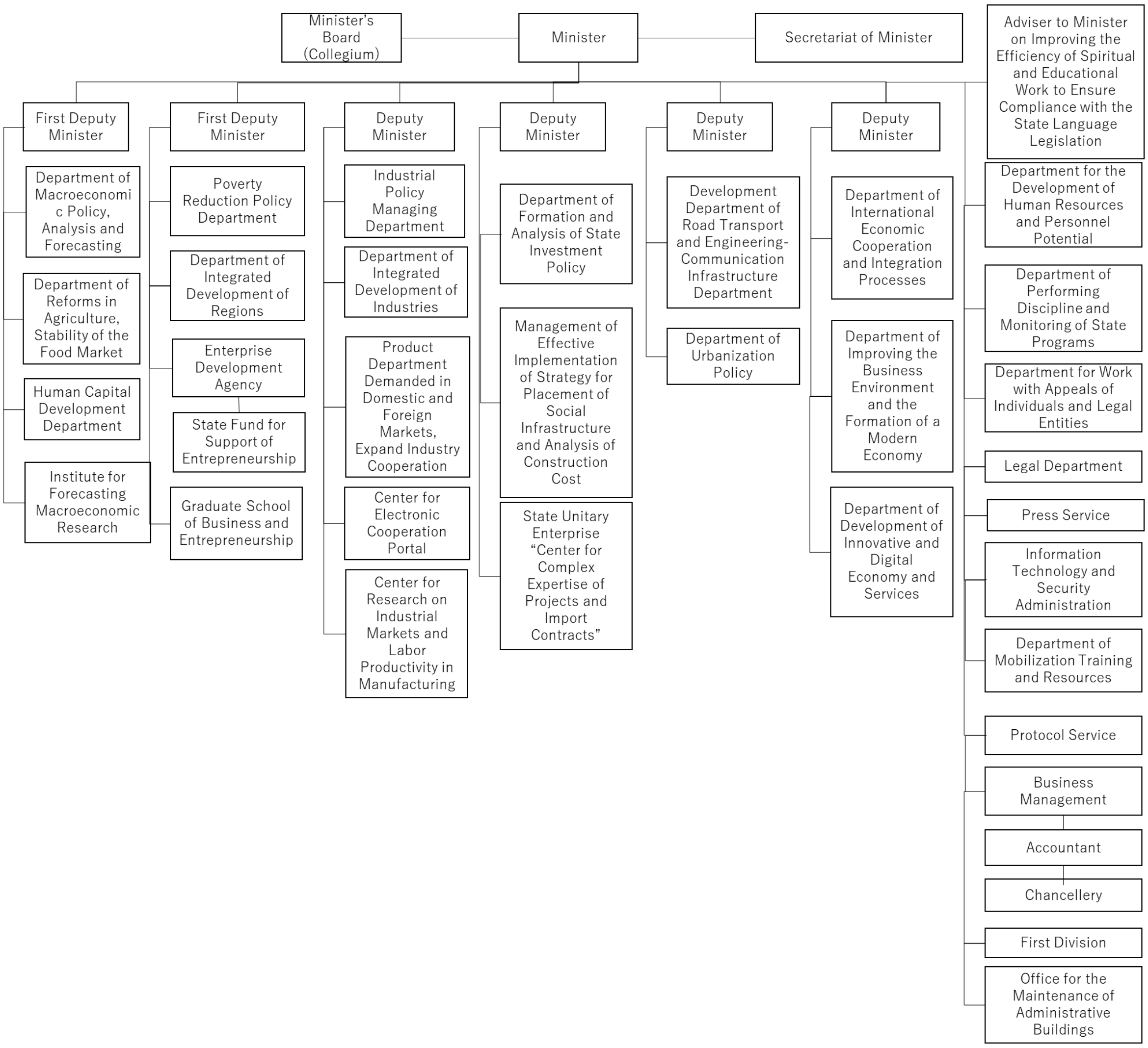


Figure 2-25 Organization of the Ministry of Economic Development and Poverty Eradication

Source: prepared by the study team based on the Uzbekistan's decree (Decision of President PP4653, on March 26, 2020)

⑤ Ministry of Construction (MoC)

The organization of the MoC has not changed significantly from the 2018 organizational chart, but there was a partial revision in May 2021, with the retirement of a deputy minister and a reduction in staff headcount.

One of the tasks related to energy conservation is building insulation, but until 2011, buildings were not designed with insulation in mind. Insulation design has been incorporated into buildings since 2011, and there are now A-D energy conservation standards in accordance with international standards. The country has internationally low energy prices for electricity and gas, and this has prevented the spread of energy-efficient buildings. Energy-efficient construction is mandated and implemented for public service facilities such as schools and hospitals, and the Center for Regulation in Construction conducts research on energy-efficient construction.

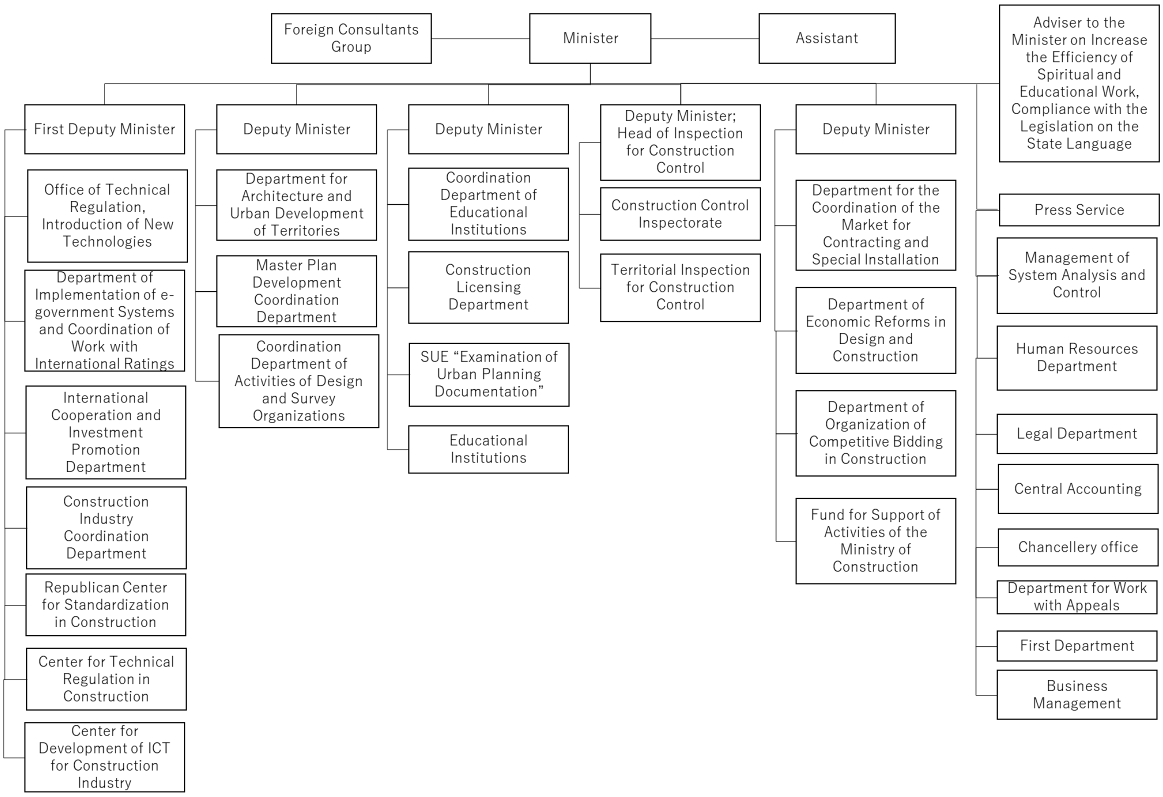


Figure 2-26 Organization of the Ministry of Construction

Source: prepared by the study team based on the Decree of Uzbekistan (Decision of President PP3646, on April 2, 2018)

⑥ The Agency of Statistics (AoS;formerly SCS)

In Uzbekistan, the AoS is the sole authorized agency for the production of national statistics, as stipulated by the Law Approximately Official Statistics (August 26, 2020). Thus, the AoS is responsible for the entire process, from data collection to production and publication, while the other ministries cooperate in data collection and use the aggregated data. An organizational chart of AoS is shown below.

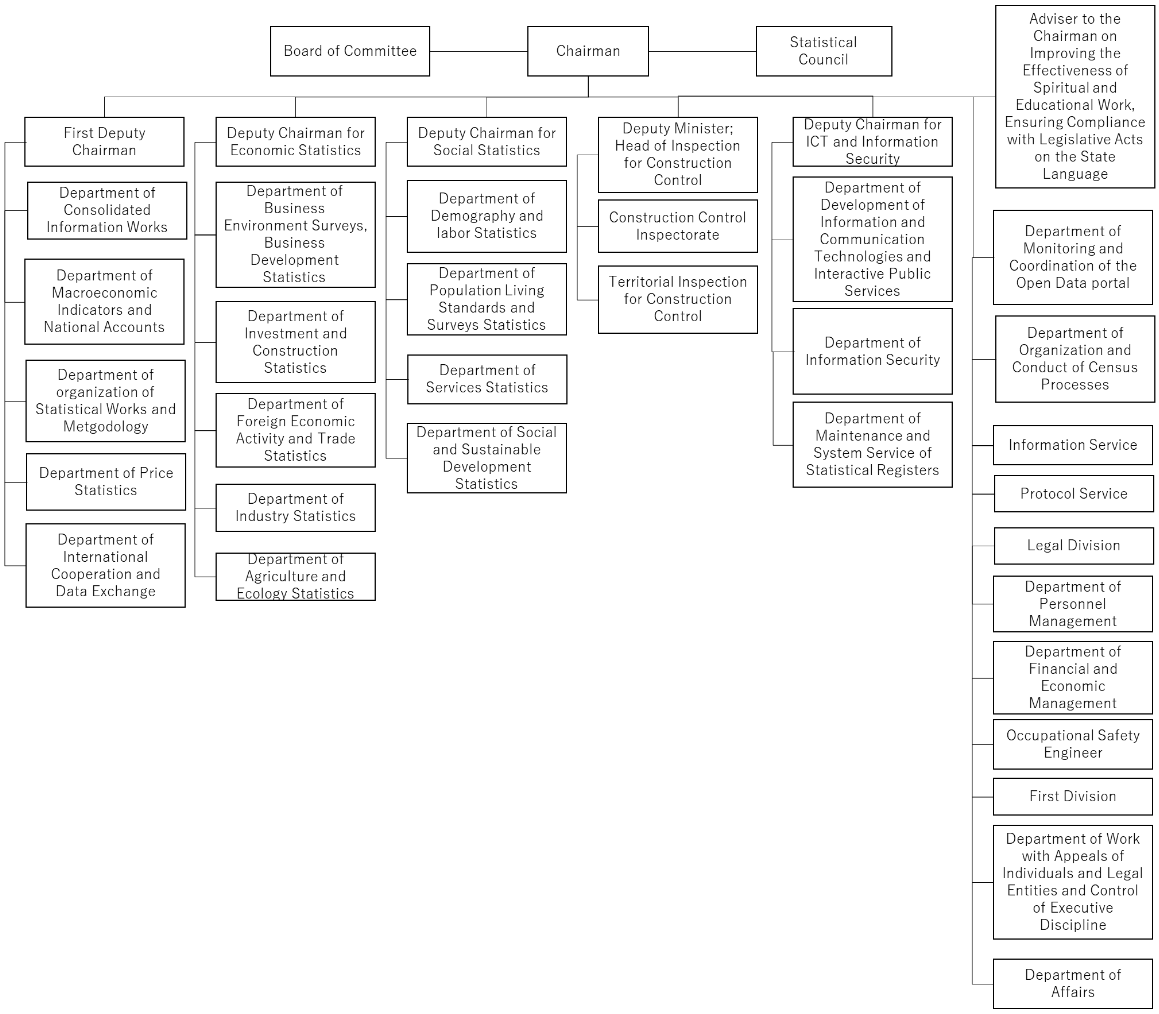


Figure 2-27 Organization of the National Statistics Commission

Source: prepared by the study team based on Uzbekistan's Decree (https://www.stat.uz/en/approximately/structure ; PP4796 Aug. 3, 2020)

2.3.2 Climate Change Measures

(1) Nationally Determined Contribution (NDC)

As shown in 2.2.1(3), GHG emissions in Uzbekistan were 189.2 million tCO_2e in 2017, with methane emissions leaking from facilities and equipment (approximately 47.18 million tCO_2e) and fuel-derived CO_2 emissions in the energy industry, manufacturing, construction, and consumer use (approximately 65.91 million tCO_2e) being particularly significant and together accounting for approximately 60% of Uzbekistan's GHG emissions. In terms of CO_2 emissions per GDP on a 2017 PPP basis, Uzbekistan has a low energy productivity of 0.473 kg in 2019, approximately 2.3 times that of Japan's 0.205 kg, although this is a significant decrease from 1.578 kg in 1990.[8]

Uzbekistan has revised its Nationally Determined Contribution for 2021, with a climate action goal of a 35% reduction by 2030 compared to 2010 GHG emissions per unit of GDP, with reduction targets in energy, agriculture, land use/forestry, and waste.

Table 2-23 Summary of Mitigation Measures in Uzbekistan's NDC (2021)

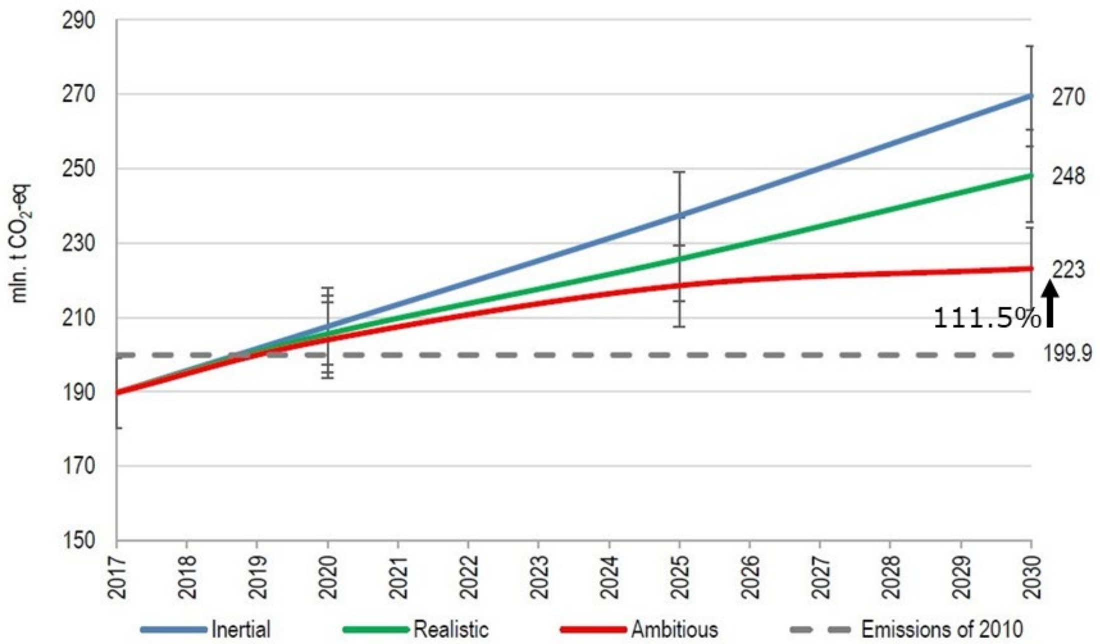
long-term goal	Reduce specific greenhouse gas emissions per GDP by 35% by 2030 from 2010 levels.
base year	2010
Target year	2020-2030
Target GHG	CO2, CH4, N2O, HFC
related organizations	・ The revised NDC was prepared by the Center of Hydrometeorological Service (Uzhydromet) and UNDP and an interagency working group. ・ MoE and MoEDP will develop a National Low-Carbon Development Strategy.
Related Laws and Policies	・ Law of the Republic of Uzbekistan "On Ratification of the Paris Agreement" (No. ZRU-491 dated 02.10.2018) • Law of the Republic of Uzbekistan "On the Use of Renewable Energy Sources" (ZRU-539 dated 21.05.2019) • Decree of the President of the Republic of Uzbekistan "On Approval of the Concept of Environmental Protection of the Republic of Uzbekistan until 2030" (UP-5863 dated 10.30.2019) • Resolution of the President of the Republic of Uzbekistan "On Approval of the Strategy for the Transition of the Republic of Uzbekistan to a Green Economy for 2019-2030" (PP-4477 dated 04.10.2019) ・ Resolution of the Cabinet of Ministers of the Republic of Uzbekistan "On Measures to Implement the National Goals and Targets in the Field of Sustainable Development until 2030" (PKM-841 dated 20.10.2018)
Major mitigation measures planned	
energy	・ Increase the share of renewable energy in power generation to 25 ・ Introduce energy-saving technologies in the industrial, construction, and agricultural sectors
traffic	・ Introduce alternative fuels

[8] World Development Indicators (World Bank) https://databank.worldbank.org/reports.aspx?source=2&series=EN.ATM.CO2E.PP.GD.KD &country=UZB 2, 2023, accessed February 1, 2023

agriculture	・	Improving agricultural productivity
waste	・	Improve municipal waste management systems
forest	・	Expand forest area

Source: Updated Nationally Determined Contribution (Republic of Uzbekistan, 2021) https://unfccc.int/sites/default/files/NDC/2022-06/Uzbekistan _Updated%20NDC_2021_EN.pdf

In its BR submitted to the UN in 2021, Uzbekistan used the GHG Abatement Cost Model (GACMO) to project GHG emissions (CO2, CH4, and N2O) to 2030 based on GHG emissions in 2019. According to the report, even under the most ambitious scenario, which is the most emission-reducing scenario for 2030, GHG emissions are projected to increase by 111.5% in absolute terms from 2019.[9]



Inertial: Current GHG emission and energy consumption trends will continue.
Realistic: Mitigation measures in progress or scheduled to be implemented for which funding has been committed will reduce the rate of increase in GHG emissions.
Ambitious: Realize the full reduction potential of the energy sector with international support.

Figure 2-28 Projected GHG Emission Pathways for Uzbekistan

(2) Status of GCF Project Implementation

In Uzbekistan, a total of four projects (two mitigation and two adaptation) are being implemented as of the end of January 2023 under the Green Climate Fund (GCF). The national accreditation body is headed by Mr Badriddin Abidov, Deputy Minister of the Ministry of

[9]First Biennial Update Report of The Republic of Uzbekistan (Government of Uzbekistan, 2021) https://unfccc.int/sites/default/files/resource/ FBURUZeng.pdf, accessed July 16, 202.

Investments and Foreign Trade of the Republic of Uzbekistan. The following is a summary of two mitigation projects in progress.[10]

Table 2-24 Summary of GCF Projects (Mitigation) in Uzbekistan

FP140	
Title	High Impact Programme for the Corporate Sector
Approval Date / Estimated Completion	August 2020 / September 2029
Accreditation Agency	European Bank for Reconstruction and Development (EBRD)
Target countries	Uzbekistan, Kazakhstan, Jordan, Morocco, Tunisia, Serbia, Armenia
Total GHG emissions avoided	17.22 million tCO2e (18-year project period)
Cost	US$1 billion (US$258.03 million for GCF, including US$5.53 million in grants)
Summary	Target energy-intensive industries, agribusiness, and the mining sector to build low-carbon growth pathways by promoting the adoption of high-impact technologies for climate change mitigation and facilitating behavioral changes at the corporate governance and management levels.
Uniform resouce locator	https://www.greenclimate.fund/project/fp140
FP163	
Title	Sustainable Renewables Risk Mitigation Initiative (SRMI) Facility
Approval Date / Estimated Completion	March 2021 / April 2033
Accreditation Agency	International Bank for Reconstruction and Development (IBRD)
Target Countries	Uzbekistan, Botswana, Central Africa, Kenya, Mali, Namibia
Total GHG emissions avoided	89 million tCO2e (25-year project period)
Cost	US$1.6 billion (US$280 million for GCF of which US$84 million is grant aid)
Summary	Support renewable energy technology development, public investment in power sources and grids, and the use of renewable energy investment

[10]Green Climate Fund: Uzbekistan https://www.greenclimate.fund/countries/uzbekistan, accessed January 31, 2023

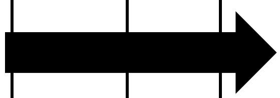
	risk mitigation instruments to facilitate access to affordable, reliable, and sustainable renewable energy, moving to a low-carbon and sustainable development path.
Uniform resource locator	https://www.greenclimate.fund/project/fp163

2.3.3 Support of Other Donors

(1) European Bank for Reconstruction and Development (EBRD)

The European Bank for Reconstruction and Development (EBRD), in cooperation with the MoE, has developed recommendations and a roadmap for achieving 2050 decarbonization in the energy sector, with particular recommendations for the five items listed in Table 2-25, along with a timeline for action, and an energy mix for achieving decarbonization shown in Figure 2-29. The energy mix presented by the EBRD recommends that efforts be made to modernize existing natural gas-fired power generation by 2030, new natural gas-fired power generation be phased out, the use of renewable energy technology be expanded after 2030, and natural gas-fired power generation be used in tandem with renewable energy sources.

Table 2-25 EBRD Recommendations for Achieving Carbon Neutrality in Uzbekistan's Electricity Sector in 2050[11]

		1-2 y	3-5y	5y~.
1. Infrastructure improvements				
Summary	Continued development of efficient, low-carbon generation infrastructure and grids.			
Contents	Continue the reform of the grid to improve the efficiency and low-carbon generation sources and to accommodate the massive introduction of renewable energy as indicated in the Ministry of Energy Concept for 2020-2030. In particular, natural gas-fired power is also expected to play a role in adjusting the fluctuations of renewable energy. National grid interconnection to distribute and absorb renewable energy variability will also play an important role.			

[11]Prepared by the Study Team based on A carbon-neutral electricity sector in Uzbekistan: Summary for policymakers (Ministry of Energy of the Republic of Uzbekistan, 2021).

			1-2 y	3-5y	5y~.
	Organizations concerned (involved)	Ministry of Energy (MoE)			
2. establishment of a framework for promoting renewable energy					
	Summary	Implement regulatory and institutional reforms to promote renewable energy development.			
	Contents	Implement regulatory and institutional reforms to enable and support the development of renewable energy resources and mobilize domestic and foreign investment in renewable energy, which will also contribute to the creation of green jobs. It is important to decarbonize the energy sector by revising the legal framework regarding the governance of energy-related state-owned enterprises and also to promote the participation of the private sector.			
	Organizations concerned (involved)	MoE / State Commission for the Protection of Ecology and Environment (SCEEP) / Electricity Market Regulator (EMR) / Ministry of Finance (MoF) / Ministry of Investment and Trade (MIFT)			
3. subsidy reform and carbon pricing					
	Summary	Elimination of programs and subsidies that support highly carbon-intensive energy sources and the creation of fair competition through the development of a final carbon pricing system.			
	Contents	Phasing out subsidies for carbon-intensive energy and introducing compensation for affected businesses. Gas should be fully liberalized to show the true cost to the market. Finally, carbon pricing was introduced.			
	Organizations concerned	MoE/SCEEP/MoF/MIFT/Ministry of Economic Development and Poverty Reduction (MoDPR)			

			1-2 y	3-5y	5y~.
	(involved)				
4. awareness campaign to create public support					
	Summary	Ensure social acceptability and sustainability of the changes being introduced.			
	Contents	Support the social acceptability and sustainability of the transformation through measures to protect consumers vulnerable to energy prices (e.g., compensation for price increases, subsidies for energy efficiency and renewable energy installations, transparency in electricity prices, and refund of revenues from carbon pricing).			
	Organizations concerned (involved)	MoE/SCEEP/MoDPR			
5. environmental protection					
	Summary	Protect the environment in terms of mitigating climate change and improving resilience and reducing other adverse environmental impacts.			
	Contents	Monitor the project's impact on biodiversity and the environment and improve environmental laws. Climate risk assessment and disclosure in line with TCFD recommendations is important for understanding climate change impacts on power generation assets.			
	Organizations concerned (involved)	MoE/SCEEP/MIFT			

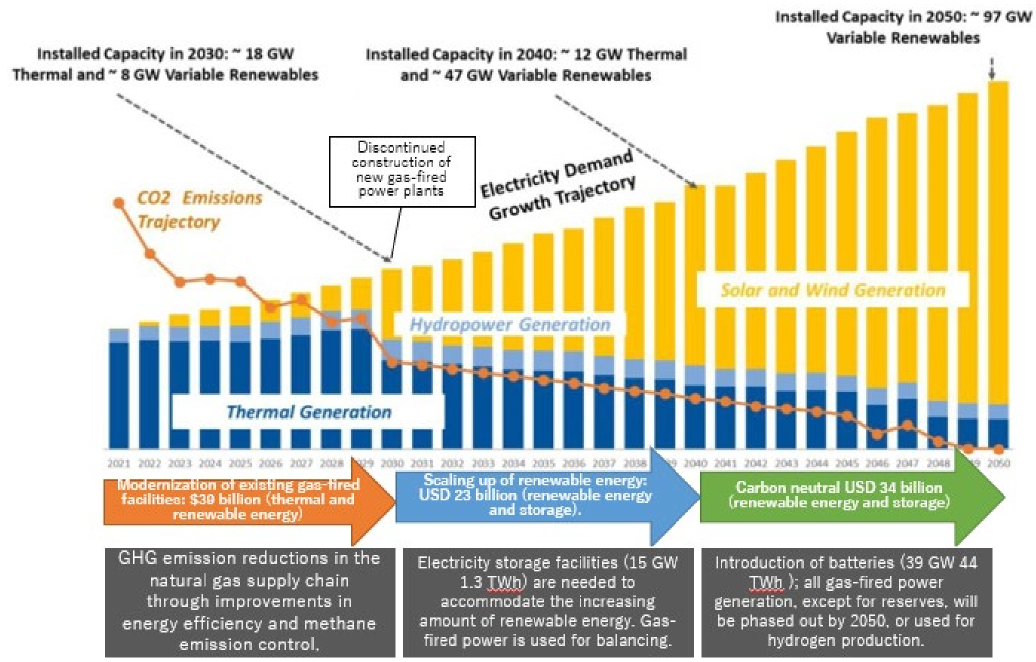


Figure 2-29 Change in Power Generation Mix and CO2 Emissions under Carbon Neutral Scenario[12]

(2) Asian Development Bank

In May 2019, ADB approved a new "Country Partnership Strategy" for Uzbekistan covering the period 2019-2023, which sets "private sector development," "reducing economic and social disparities," and "promoting cooperation and integration among regions" as strategic areas. The Country Operations Business Plan (October 2020), covering the period 2021-2023, calls for a total of $2.473 billion in loans over the same period, of which $710 million will go to the energy sector. In addition to solar and wind power generation, the program includes an energy sector renovation assistance program. Projects related to heat supply include structural reform of the gas sector and support for SCADA implementation, and as of January 31, 2023, the following were listed, but there were no projects directly related to district heating and cooling improvements.

[12]Additions made by the research team based on A carbon-neutral electricity sector in Uzbekistan: Summary for policymakers (Ministry of Energy of the Republic of Uzbekistan, 2021).

Table 2-26 ADB Development Projects for Uzbekistan's Energy Efficiency and Gas and Heat Supply Sectors

Title.	Regional: Fostering Expanded Regional Electricity and Gas Interconnection and Trade under the CAREC Energy Strategy 2030
No.	54019-001
Status	Active
Target Countries	Total 11 countries including Uzbekistan
type	Technical Assistance
budget	2,900,000 USD
Period	July 15, 2020 - December 31, 2023
summary	To support the implementation of the Central Asian Regional Economic Cooperation (CAREC) Energy Strategy 2030 to achieve the long-term vision of a reliable, sustainable, resilient, and reformed regional energy market by 2030, the following four items will be implemented ・ Preparatory work for the establishment of a new regional power transmission cooperation association ・ Implement market reforms and strengthen the government's ability to attract investors ・ Establish a financing vehicle for green energy ・ Establish a Women-in-Energy program to increase women's participation in the energy sector
Background/Issues	The energy sector in the CAREC region is at a critical juncture, influenced by factors as diverse as the increase in renewable energy for climate protection, private sector involvement, as well as improved political relations in the region. Energy Ministers of the CAREC region signed a Ministerial Declaration in Tashkent on September 20, 2019, adopting a joint long-term vision for the regional energy sector and committing to implement the "CAREC Energy Strategy 2030". The strategy includes, among other things, an action plan for the next 10 years, and this TA will support its implementation. The following challenges exist in implementing the energy strategy ・ Although the benefits of cross-border energy connections are mutually recognized, the electricity and gas pipeline networks are still planned separately. ・ Lack of government control and competition for energy companies in the CAREC region has led to inappropriate energy pricing and subsidies, inefficient operations, and deteriorating energy

	infrastructure. ・ Investment needs for energy infrastructure in the CAREC region, excluding China, by 2030 are expected to be USD 400 billion, but private investment is lacking.
uniform resouce locator	https://www.adb.org/projects/54019-001/main

Title.	Support for Innovation and Technology Partnerships in Asia and the Pacific - Energy Sector High-Level Technology Application (Subproject 2)
No.	52307-003
Target Countries	Total of 12 Asia-Pacific countries including Uzbekistan
Status	Active
Period	October 1, 2019 - September 30, 2022
type	Technical Assistance
summary	The project objectives are as follows ・ Increased use of clean energy for heating and cooling ・ Building efficient renewable energy-based microgrids ・ Improved energy demand management
Background/Issues	In ADB's Strategy to 2030, support for the energy sector, including electrification, expansion of renewable energy, and improvement of energy efficiency, is essential for achieving the SDGs. In Central Asia, heat demand for heating is high in winter, but the use of renewable energy for heat demand for heating is less developed than the electrification of electricity generation and transportation with renewable energy.
uniform resouce locator	https://www.adb.org/projects/52307-003/main

Title.	Gas Transmission Network Modernization and Efficiency Enhancement Project
No.	52322-001
Target countries	Uzbekistan
Status	Proposed
Type	Loan
Budget	300 million USD
Period	To be determined (concept paper approved on January 28, 2019)
Summary	The proposed project will address the following three items in the gas

	sector for the efficient use of natural gas ・ Upgrade gas supply network ・ Uzbekneft gas O&M capacity enhancement ・ Strengthening Uzbekneftegas' corporate management capacity
Background/issues	Natural gas is the most important energy source in Uzbekistan, with the gas sector accounting for 20% of the country's tax revenue and 18% of GDP. The residential sector is the largest consumer of natural gas (42%). Such a gas sector has the following challenges ・ To secure natural gas supplies in a sustainable manner for the future. ・ Loss of natural gas and lack of safety due to aging natural gas supply network built over 50 years ago. ・ Lack of capabilities to measure, monitor, and centrally control natural gas supply and demand, which exacerbates the cost of maintaining the gas supply network and increases operational risks. ・ Loss of export opportunities due to poor quality natural gas transportation infrastructure. ・ Deterioration of Zbekneftegas' business due to inappropriate natural gas pricing and tolling.
Uniform resource locator	https://www.adb.org/projects/52322-001/main

Title.	Uzbekistan: Preparing Sustainable Energy Investment Projects
No.	52322-002
Status	Active
Target Countries	Uzbekistan
type	Technical Assistance
budget	3,375,000 USD
Period	January 28, 2019 - December 31, 2023
summary	This TA prepares for the implementation of the following successor projects. ・ Gas Sector Development Program ($750 million) ・ Electricity Distribution Network Modernization Program ($300 million) ・ District Energy Transmission and Distribution Enhancement Project ($200 million)
Background and Issues	The government of Uzbekistan has developed a national vision, "Uzbekistan 2030," which states that modernization of the gas supply network is an urgent

	issue. Reforms in the energy sector promote institutional and governance reforms involving the separation of upstream, midstream, and downstream functions of the energy sector, and the setting of appropriate natural gas and electricity prices.
uniform resouce locator	https://www.adb.org/projects/52322-002/main

Title.	Uzbekistan: Preparation of Gas Infrastructure Modernization in Uzbekistan
No.	52322-003
Status	Closed
Target Countries	Uzbekistan
type	Technical Assistance
budget	225,000 USD
Period	December 27, 2019 - August 11, 2021
summary	This small-scale TA provides preparatory support for the implementation of a SCADA system in the gas sector in Uzbekistan.
Background/Issues	SCADA is a standard operating method for gas transmission systems, enabling real-time monitoring of the status of gas transmission infrastructure. SCADA can optimize the operation of the gas transportation system and maximize revenues from gas transportation. Uzbekistan's gas sector has not implemented SCADA and has been slow to modernize its gas transportation network.
uniform resouce locator	https://www.adb.org/projects/52322-003/main

Title.	Uzbekistan: Digitize to Decarbonize - Power Transmission Grid Enhancement Project
No.	52322-04
Status	Proposed
Target Countries	Uzbekistan
type	Loan
budget	130 million USD
Period	December 27, 2019 - August 11, 2021
summary	This project aims to support low-carbon and green economic development by

	・ Strengthening the reliability and stability of the power grid ・ Improved operational efficiency and monitoring and control systems ・ Reduction in the number of power outages ・ Reduction of power transmission losses ・ Strengthening Corporate Governance of Joint-Stock Company (JSC) National Electricity Grid of Uzbekistan (NEGU)
Background/Issues	Electricity demand in Cambodia is increasing at an annual rate of approximately 4%-5%, and the government is considering phasing out inefficient thermal power plants and introducing renewable energy sources. Many of Uzbekistan's power grids and substations were built 30 to 50 years ago and face the following challenges ・ Maintenance, such as replacing parts of aging substations, is becoming increasingly difficult, and failures pose the risk of reduced reliability of the power supply and system shutdowns. ・ SCADA is not installed in the power transmission and distribution network, and it takes a long time to detect and respond to problems in the power grid. ・ JSC NEGU maintains and manages the power grid, and the company's creditworthiness needs to improve in order to secure investment in renewable energy from the private sector.
Uniform resource locator	https://www.adb.org/projects/52322-004/main

(3) World Bank (WB)

In 2022, the WB approved a new "Country Partnership Framework" (May 2022) for Uzbekistan covering the period 2022-2026, with "inclusive private sector employment growth," "improved human capital," and "improved livelihoods and resilience through environmentally sustainable growth" as high-level targets. Projects related to energy conservation and gas and heat supply include the projects shown in Table 2-27, such as the creation of an environment to promote investment in energy efficiency in buildings and the modernization of the electricity and district heat supply networks.

Table 2-27 WB support projects for energy conservation and gas and heat supply sectors in Uzbekistan

Title.	Clean Energy for Buildings in Uzbekistan
No.	P176060
Status	Active
Target Countries	Uzbekistan
type	Loan
budget	USD 185.9 billion
Period	June 24, 2022 - December 29, 2028
summary	The goal is to improve energy efficiency in public buildings and strengthen the regulatory framework for investment in clean energy in buildings.
Background/Issues	In the "c" countries, natural gas accounts for 86% of total primary energy consumption, more than 80% of electricity generation sources, and 82% of GHG emissions are related to natural gas. The building sector accounts for the largest share of final energy consumption, mostly for heating. In public buildings, energy consumed for heating accounts for about 70%. The buildings are generally in poor condition, have inadequate insulation, use outdated boilers and hot water systems, and are energy inefficient. On the other hand, investments in energy efficiency face the following challenges ・ In general, financing loans to public building managers and other customers is difficult to obtain due to short terms, lack of collateral, and low credit ratings. Many banks are not familiar with clean energy investments in buildings and lack the capacity to conduct due diligence. ・ Public building managers lack the funds to cover development costs such as energy audits and feasibility to implement clean energy investments. ・ Lack of technical capacity in government agencies, banks, and the private sector to finance energy efficiency. ・ Lack of information and awareness about the benefits and need for investment in clean energy has hindered the spread of energy efficiency improvements. There is also a lack of statistical information on building typologies.
uniform resouce locator	https://projects.worldbank.org/en/projects-operations/project-detail/P176060

Title.	Electricity Sector Transformation and Resilient Transmission
No.	P171683
Status	Active
type	Loan
budget	427 million USD (including 47 million USD in grants)
Period	June 25, 2021 - January 31, 2028
summary	The project aims to enable large-scale renewable energy deployment by enhancing the capacity of NEGU and improving the capacity and reliability of the transmission system. The project consists of four elements. ・ Digitalization of the power transmission sector by strengthening power system control and distribution and modernizing the telecommunications network ・ Strengthening of the electric power grid through modernization and expansion of the power transmission network, etc. ・ Strengthening NEGU's capacity ・ Electricity Market Development
Background/Issues	Although Uzbekistan's energy intensity has decreased by about 45% over the past 15 years, energy use per GDP is 3.1 times higher than the average for the European and Central Asian region. Old transmission and distribution infrastructure results in high power losses, estimated at 20%, hindering the spread of renewable energy. The "c" countries have set a goal of making the electricity sector carbon neutral by 2050, and since the promotion of renewable energy is a priority, it is necessary to modernize the electricity grid and strengthen the capacity of relevant institutions to achieve this goal.
uniform resouce locator	https://projects.worldbank.org/en/projects-operations/project-detail/P171683

Title.	District Heating Energy Efficiency Project
No.	P146206
Status	Active
Target countries	Uzbekistan
Type	Loan
Budget	140 million USD
Period	January 25, 2018 - December 31, 2024
Summary	The purpose of the project is to improve the efficiency and quality of

	heating and hot water services in the cities of Andijan, Bukhara, Chirchik, Samarkand and the Sergeli district of Tashkent within "U". The project consists of the following two elements ・ Upgrade district heating and cooling systems, including installation of gas meters and recovery of older boilers and heat transport pipes ・ Strengthening project management capacity of MHCS, Kommunkhizmat Agency (Communal Services Agency) and district heating and cooling companies, etc.
Background/Issues	District heating in the "c" countries is one of the sectors with high natural gas consumption. District heating services have traditionally been provided by public companies under the umbrella of local governments, many of which have been transferred to the MoHCS, which was established in 2017. The largest district heating system in the country is located in Tashkent, accounting for about 78% of the country's total district heating services. Most district heating services were developed between 1950 and 1970, and while energy efficiency has declined, lack of investment in infrastructure modernization has further degraded district heating services. The main issues are as follows ・ Heat rates below cost recovery levels ・ Percentage of low heat rates collected ・ Loss of heat and hot water due to aging heat supply network ・ Lack of operational capacity
Uniform resouce locator	https://projects.worldbank.org/en/projects-operations/project-detail/P146206

Chapter 3 The Current State of Energy Conservation and its Challenges and Direction by Sector

This chapter provides a more detailed analysis of final energy consumption in both the consumer and industrial sectors, which were identified as target areas for energy consumption in Chapter 2. The chapter also examines the current status of energy efficiency and the challenges that need to be addressed to promote energy conservation. Finally, the chapter presents recommendations for the future direction of energy conservation in Uzbekistan.

3.1 Residential sector

3.1.1 Final energy consumption

Total final consumption: Table 3-1 indicates the breakdown of consumption in the residential sector from 2018 to 2020 by resource. The residential sector accounted for the largest percentage of total final consumption (TFC) of energy.

Table 3-1 The Breakdown of Energy Consumption in the Residential Sector by Resource (2018-2020/Equivalent of Primary Energy)

Reidence	2018		2019		2020	
	ktoe	ratio	ktoe	ratio	ktoe	ratio
Coal	471	3.5%	290	2.2%	260	1.7%
Natural Gas	8,002	60.2%	7,577	58.1%	9,675	63.1%
Oil Products	509	3.8%	571	4.4%	471	3.1%
Electricity	3,089	23.2%	3,242	24.9%	3,668	23.9%
Heat	1,229	9.2%	1,357	10.4%	1,260	8.2%
Total	13,299	100.0%	13,039	100.0%	15,334	100.0%

Source: This table has been created by the JICA study team based on IEA Energy Balance 2020

Natural gas represented around 60% of the sector's total, electricity and heat occupied around 24% and a little less than 10%, respectively, and the rest was accounted for by oil products and coal. In 2020, the amount of energy consumed by the residential sector was huge, at 15,334 ktoe, a little more than 30% of total final energy consumption in the country (41,218 ktoe, 2020).

In Uzbekistan, there is currently no data on final energy consumption by use, and therefore, the uses of energy are unknown. For this reason, the author attempted to estimate consumption by use while referring to past investigative data on final energy consumption in Japan. As Figure 3-1 shows, the majority of sources of energy for heating and hot water supply consist of kerosene, gas, and LPG. Therefore, it is estimated that in Uzbekistan a large percentage of heat, coal, oil products, and natural gas is consumed as fuel for boilers, which are used for heating and hot water supply, and as fuel for kitchens.

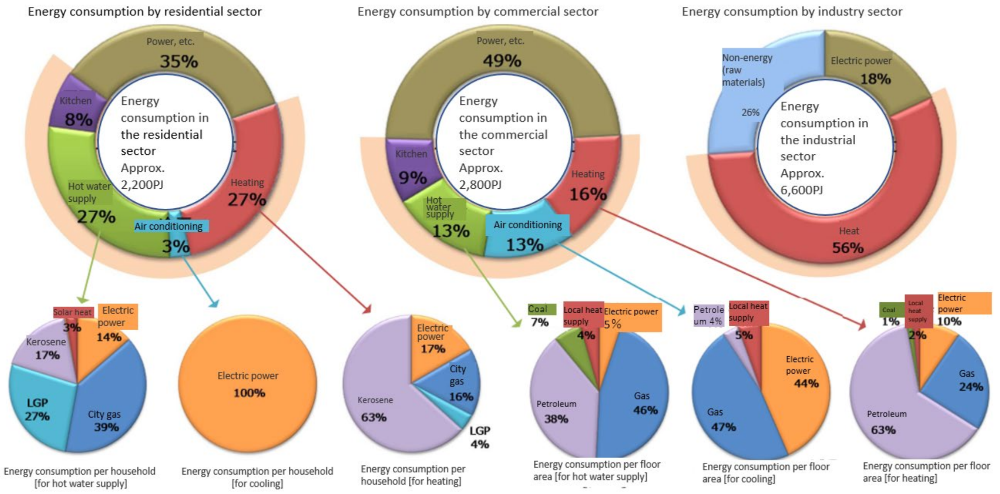


Figure 3-1 Energy Consumption by Use

Source: "Effective Utilization of Heat," Agency for Natural Resources and Energy, April 17, 2015

Among the categories shown in Figure 3-1 , the energy consumed by motive power, which includes the power used to operate home appliances and other devices, is classified as power consumption. If the sum of electricity used for motive power (35%) and electricity used in the breakdown of heat consumption by energy source (heating power (27*17%) + cooling power (3%) + hot water supply power (27*14%)) equals the total of power consumption, it is understood that about one-fourth of power consumption is used for heating and hot water supply (heat consumption). In Uzbekistan, heat consumption can be estimated by assuming that one-fourth of the total energy consumption is used for heating purposes. Using the energy consumption data for 2020 provided in Table 3-1 as an example, the estimated heat consumption can be calculated using the following formula. Based on this calculation, it is estimated that heat consumption accounts for approximately 80% of total energy consumption.

Heat consumption (ktoe) = Heat supply (1,260) + Coal (260) + Oil products (471) + Natural gas (9,675) + Electricity (3,668 × 0.25) = 12,583 = 82% (12,583/15,334)

Furthermore, as indicated in Figure 3-1 , heating and hot water supply represent the greater part of heat consumption, and it is considered that Uzbekistan also has a structure similar to this, and it is estimated that most of the heat consumption is used for heating and hot water supply.

In this report, the author attempted to estimate from data available in Japan, but in Uzbekistan, in order to clarify the target of energy conservation in the residential sector, it is important to first make the uses of energy consumed and the breakdown of amounts clear, and then clarify the target of energy conservation so that energy efficiency is improved. In particular, it is necessary to investigate energy consumption for heat-using equipment such as heaters and hot water suppliers by limiting objectives to particular ones.

In 2021, items related to energy consumption were added in the household survey conducted by the State Committee of Statistics (SCS). Since the survey looks at the types of energy consumed in houses (answers are chosen from among thirteen choices), amounts used, costs, types and floor area of houses, number of rooms, heating methods, heating periods, countermeasures against power failures, etc. in detail, it is expected that the results will be used for not only analyses and statistics of household survey data but also energy measures in the residential sector. For more detailed investigations, it is recommended to refer to the Energy Efficiency Index of the International Energy Agency (IEA).

The following section presents the survey method used for the Survey of the Actual Condition of Energy Consumption in the Residential Sector, which was conducted by Japan's Agency for Natural Resources and Energy, as an example of surveys to obtain the actual condition of energy consumption by use.

[Reference: Survey method used for the Survey of the Actual Condition of Energy Consumption in the Residential Sector]

(1) Example of methods to estimate TFC in the residential sector

- Choose families to be surveyed using a percentage of regional distribution close to that found by the Census, and survey the same families four times a year: spring, summer, autumn, and winter.
- Set a basic energy consumption unit for household equipment that uses electricity, gas, kerosene, and solar heat, investigate the number of pieces of equipment used in each family, capacity, and frequency of use (such as the length of time and the number of times), and seek annual energy consumption for each piece of equipment by multiplying the figures thus obtained.
- Consider the sum of energy consumption for each piece of equipment as annual energy consumption for each household.
- Estimate the total energy consumption by prefecture by weighting for the house structure and the number of household members based on the Census for totalization.

In addition to energy data, the following data are needed to use indicators of residential energy consumption. In the case of heating, it is efficient to compare and evaluate energy consumption using indicators such as energy consumption per floor area and consumption per house.

- Heating and cooling: Floor area of each house, number of family members, number of houses, types of houses, etc.

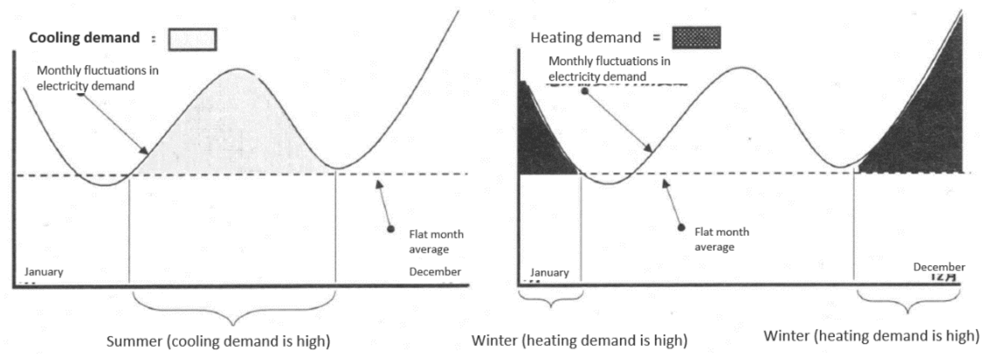
- Hot water supply: Population, number of houses, etc.
- Cooking: Population, number of houses, etc.
- Lighting and other home appliances: Population, number of houses, number of pieces of equipment, etc.

(Reference: IEA Energy Efficiency Indicators Fundamentals on Statistics)

(2) Estimation method based on seasonal fluctuations in TFC in the residential sector

- Choose families to be surveyed using a percentage of regional distribution close to that found by the Census, and survey the same families four times a year: spring, summer, autumn, and winter.
- Estimate energy consumption by air-conditioning systems (heating demand and cooling demand) by considering increases in demand in the season during which such systems are used as demand for air-conditioning based on monthly energy consumption patterns (seasonal fluctuations) and other factors.

  Estimate energy consumption for uses other than air-conditioning using the use of equipment and basic units and then distribute the remaining balance to particular uses (Refer to Figure 3-2).
- Estimate the total energy consumption by prefecture by weighting for the house structure and the number of household members based on the Census for totalization.

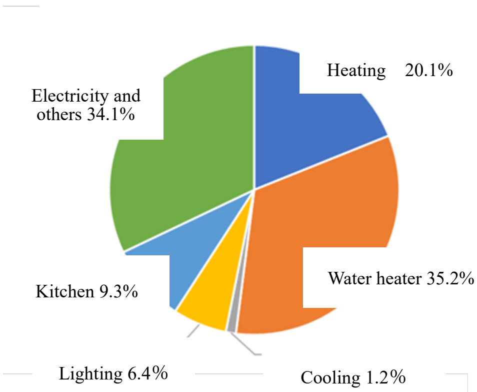


	Heating	Cooling	Water heater	Kitchen	Power and others
Electric power	Estimated based on seasonal variations in electricity demand		Estimated based on late-night electricity consumption	Estimated based on unit for use	Residual
City gas	Estimated based on seasonal variations in city gas demand	-	Residual	Estimated based on unit for use	-
Propane gas	Estimated based on seasonal variations in propane gas demand	-	Residual	Estimated based on unit for use	-
Kerosene	Estimated based on seasonal variations in kerosene demand	-	Residual	-	-
Solar heating	-	-	Estimated based on unit for use	-	-

Figure 3-2 Analysis Method Based on Seasonal Fluctuations in Houshold Energy Consumption

(3) IEA Energy Efficiency Indicators Fundamentals on Statistics presents many examples of surveys of energy consumption by use in the residential sector in various countries of the world (management data, surveys, measurements, and modeling).

Energy consumption by purpose of



Energy consumption by device

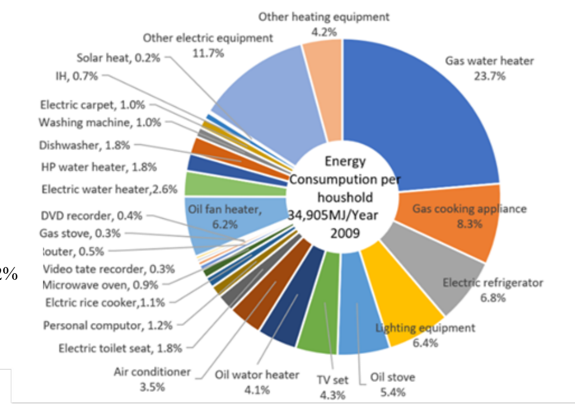


Figure 3-3 Example of Ad-hoc Survey on Household Energy Consumption

Source: The above has been created by the JICA study team based on the Agency for Natural Resources and Energy's 2009 questionnaire survey of 10,000 households "The Actual Condition of Energy Consumption in Families."

3.1.2 Energy efficiency situation and challenges

(1) Current state

As indicated in Section 3.1.1, heating accounts for approximately 80% of the energy consumed in residential buildings in Uzbekistan, with the majority of it used for space heating and hot water supply. Heat supply is provided through regional heat supply facilities as well as individual boilers installed in homes. While existing apartment buildings are connected to the regional heat supply network, newly built apartments rely on gas or electric instantaneous water heaters for hot water supply. Similarly, independent houses use gas boilers for heating and hot water supply.

To improve energy efficiency in heat use, the author conducted a survey to determine the efficiency levels of heat sources and supply equipment used in apartment buildings and independent homes. While the preliminary survey included an assessment of the efficiency of regional heat supply facilities, this survey focused on improving energy conservation on the demand side and did not cover improvements in efficiency on the regional heat supply side. Details of the survey of regional heat supply efficiency can be found in Attachment 5.

The survey also assessed the efficiency of air conditioning for cooling during summer, as well as the heat insulation of buildings to increase heating and cooling efficiency. The analysis involved on-site visits, questionnaires, and interviews to gather information on the sales and adoption of high-efficiency equipment, including their types, models, and heat insulation.

The results and discussions of the surveys and analyses are presented in the Attachment, and this section provides a summary of the key findings.

1) Use of heat supply and cooling

① Use of heating and hot water supply

Statistical data were not available that enabled the author to grasp the overall use of heating and hot water supply equipment and its efficiency in Uzbekistan, but the use of heating and hot water supply was estimated from the 102 replies received in the household questionnaire survey. The results showed that regional heat supply facilities or gas boilers were used for heating and hot water supply and confirmed that gas was the source of heat used for heating and hot water supply. Approximately 40% of households that replied that they used their own gas hot water supplier instead of regional heat supply facilities used a combi-boiler. In addition, some families replied that the efficiency of the combi-boiler was around 30-50%, an indication that there were still families that used an old gas boiler with low energy efficiency.

② Use of cooling

Since statistical data on the overall use of cooling and its efficiency were unavailable, the use of cooling in the Uzbekistan was estimated from the 102 replies received in the household questionnaire survey and the interviews responses in the market. The survey results revealed three key points:

- About 80% of families owned air-conditioning systems. The performance level was about 60% for Class A[1], and about 77% for Class A and higher. This indicates that Class A models were widely used.
- Inverter air-conditioning systems were owned by about 26% of families. According to interviews in the market, the percentage of inverter air-conditioning systems sold was around 30%, indicating that inverter air-conditioning systems were spreading.
- The number of home-use air-conditioning systems sold tended to rise in summer for the purpose of using them for cooling. The proportion of home-use air-conditioning systems sold in summer to those sold in winter was around 5:1.

The aforementioned data indicates that air-conditioning equipment rated as Class A or higher is widely used, and inverter air-conditioning systems are rapidly gaining popularity, with a current ownership rate of approximately 26%. However, compared to Japan's 100% market penetration rate for inverter air-conditioning systems, there is still room for growth in Uzbekistan. The sales of air-conditioning systems tend to peak during the summer months when cooling is required. Therefore, there is potential for further energy efficiency improvements if high-efficiency air-conditioning systems are utilized for heating during the winter season by encouraging a shift from gas to electricity. High-efficiency air-conditioning systems, in this case, refer to heat-pump inverter air-conditioning systems, which are discussed in detail in Chapter 4. Heat pumps, which use electricity as their power source, can generate a significant amount of energy using only a small amount of electricity, thereby enabling more efficient use of natural gas than gas boilers. Furthermore, inverter air-conditioning systems maintain the temperature at a specific level, resulting in fewer temperature fluctuations and lower energy consumption, leading to greater energy conservation. Consequently, replacing traditional air-conditioning systems with inverter systems reduces the amount of electricity consumed for cooling in summer, and using these air-conditioning systems in winter as well leads to energy conservation because heat-pump technology makes it possible to convert natural gas to heat more efficiently than gas boilers.

2) Heat insulation

Since statistical data on the overall heat-insulation performance in Uzbekistan were

[1] Following the EU standards, Uzbekistan uses the standards for the labelling of energy-saving air-conditioning systems from Class G to A+++. A comparison of Class A and Class A+++ indicates that according to the author’s calculations, Class A+++ air-conditioning systems are expected to bring about 30% higher energy conservation effects. Details are described in Chapter 5.

unavailable, heat insulation in the country was estimated from the 102 replies received in the household questionnaire survey and the on-site surveys. The results of the questionnaire survey revealed three key points:

- In terms of window types, nearly half of houses had single-layer glass windows, and windows had no heat-insulating property among about 75% of houses.
- A little more than half of external walls were made of bricks, and external walls had no heat-insulating property among about 75% of houses.
- Roofs had no heat-insulating property among about 62% of houses.

This suggests that there are factors for improvement in terms of the heat insulation of housing.

The following section presents one example of external walls, windows, and rooftops confirmed in the on-site survey. The on-site survey inspected two apartment houses and one public building (which housed Uzbek-Japan Innovation Center of Youth (UJICY), an educational institution annexed to Tashkent State Technical University). Since the inside of rooms in the apartment houses could not be confirmed by entering them because people lived there, what was observed at UJICY is used for reference. The survey made it clear that as confirmed at UJICY, there was room for improvement of windows and external walls in terms of heat insulation.

① Heat insulation of external walls

As shown in Figure 3-4 , bricks with a low heat transmission coefficient were used for the inside of the external wall surface. The surface of the wall was covered with gypsum plaster, and the inside of the wall consisted of a mortar finish and an unsealed air layer. Gypsum boards were affixed to the internal surface of the wall.

The results of calculating the heat transmission coefficient, an indicator of heat insulation, from the structure of external walls analyzed in the on-site survey are indicated in Table 3-2 . The heat transmission coefficient for the external walls is 2.0718 (W/m2-K). The result obtained was that, in terms of heat insulation, the building of UJICY was better than an ordinary ferroconcrete building. However, there is room for improvement, including sticking heat-insulating materials to further increase heat insulation.

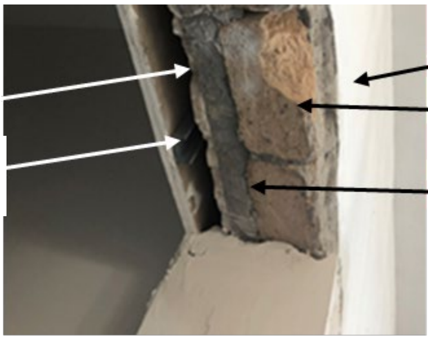


Figure 3-4 The Structure of External Walls (UJICY's Building)
Source: JICA study team

Table 3-2 The Calculation of Heat Transmission Coefficients for External Walls

Materials (from the outside)	Thickness (mm)	Thermal conductivity (W/mK)	Heat transfer resistance (m2K/W)
Gypsum plaster	20	1.6	0.0125
Brick	100	0.64	0.1563
Mortar	30	1.6	0.0188
Unsealed air layer	40	-	0.0700
Gypsum board	12	0.17	0.0706
Heat transmission coefficient (unit: W/m2-K)			2.0718

Source: JICA study team

② Heat insulation of windows

Windows used multi-layered glass, and the heat transmission coefficient for window glass was estimated at 4.07 (W/m2-K)[2]. Multi-layered glass has higher heat insulation than single-layer glass (whose heat transmission coefficient is 6.4 (W/m2-K): the lower the heat transmission coefficient, the higher heat insulation is) but does not have as high a heat insulation as eco-glass (whose heat transmission coefficient is lower than 2.33 W/m2-K), which is highly heat-insulating. It can be said that there is room for further improvement of heat insulation. The heat transmission coefficient for windows is 4.07 (W/m2-K), considerably larger than the above-mentioned heat transmission coefficient of 2.0718 (W/m2-K) for external walls, indicating that windows allow more heat to flow in and out. Therefore, it is estimated that the inflow and outflow of heat due to differences between the atmospheric temperature and the room temperature occur mainly through windows.

Furthermore, there are concrete eaves above windows in the upper part of the external wall, preventing sunlight from entering the room. These eaves are designed to block sunlight

2 Based on the information published by the Flat Glass Manufacturers Association of Japan on its website

in summer, however with windows occupying 55% of the area of external walls cold air can come in through the window glass in winter. Therefore, it is estimated that this has a considerable impact on heating.

Figure 3-5 The External Appearance of the Building (Left), Window Glass (Center), and the Inside of the Room (Right)

Source: JICA study team

③ Rooftops

Since bricks cannot be laid on the rooftop of the building, the rooftop was estimated to consist of 30 centimeters of concrete. In this case, the heat transmission coefficient was calculated at 2.92 (W/m2-K).

These findings indicate that there is potential to improve the heat insulation of external walls, windows, and rooftops, despite the fact that external walls already exhibit a certain level of heat insulation.

(2) Challenges for the residential sector and improvement of energy efficiency

The following section analyzes challenges for the residential sector and discusses ways to improve energy efficiency.

1) Challenges for heating and hot water supply and improvement of energy efficiency

Apartment houses and independent houses that did not receive heat supply from regional heat supply facilities used individual gas boilers, and some of them used inefficient gas boilers. Therefore, improvements to energy efficiency can be expected by replacing these gas boilers with heat pumps. As mentioned above, heat pumps can obtain a large amount of energy using a small amount of energy, making it possible to convert energy to heat more efficiently than gas boilers converting natural gas to heat. For this reason, houses that use gas boilers can improve their energy efficiency by replacing the boilers with heat pumps.

Since apartment houses that receive heat supply from regional heat supply facilities lose much energy in the route of supply from the facilities, improvements in of energy efficiency can be expected by shifting from the use of regional heat supply facilities to a distributed system of electric heat supply to independent houses, thus changing the source of heat from gas to electricity. There is room for improvement in terms of heat loss at regional heat supply facilities and in their hot water supply piping as well as the efficiency of the facilities, but these are not issues to be addressed in improving the energy efficiency of the demand side, the subject of this survey; they are challenges for the supply side, and therefore, they are not mentioned in this report.

2) Challenges for cooling and improvement of energy efficiency

Air-conditioning systems are used mainly in summer, and inverter air-conditioning systems are spreading, but their market penetration rate is still around 26%, lower than the world standard. As described earlier, since inverter air-conditioning systems are highly effective in conserving energy, improvement of energy efficiency can be expected in the future by spreading inverter air-conditioning systems.

3) Challenges for walls and windows and improvement of heat insulation

Heat-insulation can be improved by further increasing the heat insulation for houses of which certain heat-insulating measures have been taken for the external walls, and it can be improved by replacing the materials used for houses lacking in heat insulation with heat-insulating ones. Improvements in heat-insulation can also be expected by using multi-layered glass because single-layer glass is used for windows.

3.1.3 Direction of energy conservation

This section outlines the recommended approach for energy conservation in the residential sector, considering the challenges described above. To improve energy efficiency, two types of conservation measures should be pursued: those that are applicable to all houses and those that should be considered according to the types of housing. The following section provides specific recommendations for energy conservation measures, while identifying the types of housing for which these measures are most appropriate.

(1) Introduction of heat pumps

This measure should be taken chiefly for apartment houses that do not receive heat supply from regional heat supply facilities and independent houses.

The government policy is that newly built apartment houses shall not use regional heat supply facilities in accordance with the Presidential Order PP2912 and that individual heat supply equipment shall be installed for them. In that case, it is effective to cover heat supply for heating and hot water supply with heat-pump high-efficiency air-conditioning systems and heat-pump hot water suppliers.

If gas supply pipes are not available in independent houses, including newly built ones, heat-pump systems can be an effective option for heat supply equipment. In cases where independent houses use hot water suppliers but have access to gas supply pipes, replacing them with high-efficiency combi-boilers can be a temporary measure to minimize heat loss from hot water tanks until they transition to heat pumps.

(2) Replacement by high-efficiency air-conditioning systems and their use for heating

This measure should be taken for all types of housing.

Since air-conditioning systems are used for cooling at all types of housing, irrespective of whether they are collective or independent, it is effective to replace existing air-conditioning systems with high-efficiency ones that have a higher level of energy conservation performance. High-efficiency air-conditioning systems refer to heat-pump air-conditioning systems with inverter functions. Currently, constant-speed air-conditioning systems without inverter functions are widely used for cooling purposes. Therefore, it is recommended to replace these constant-speed systems with high-efficiency air-conditioning systems that have inverter functions to improve energy efficiency.

In addition, even greater energy efficiency can be expected by changing the heating of newly built apartment houses and independent houses that do not receive heat supply from regional heat supply facilities from gas hot water suppliers to high-efficiency air-conditioning systems.

(3) Increasing the heat insulation of external walls, roofs, and window glass

This measure should be taken for all types of housing.

Energy conservation effects can be expected by sticking hard urethane boards to the wall surface in order to increase the heat insulation of external walls. In order to increase the heat insulation of roofs, it is effective to spray heat-insulating materials to or install them on the back of the ceiling

For windows, energy conservation effects can be expected by replacing single-layer glass with multi-layered one. It is also effective for energy conservation to use Low-e glass, which is coated with a metal film to reflect infrared rays from the inside of the room.

(4) Shift to zero energy houses (ZEH)

It is effective to not only take the above-mentioned measures into account, but to also introduce ZEH, which utilize these measures in multiple ways in the future. Such measures should be taken mainly for independent houses.

(5) Prevention of heat loss and efficiency improvement for regional heat supply facilities.

The desirable basic policy is for existing apartment houses that receive heat supply from regional heat supply facilities to shift from the use of such facilities to the introduction of heat pumps, an independent heat supply device, but one possible short-term way of improvement is to take measures such as adopting a closed system and preventing heat loss at the heat receiving part of the equipment while these houses receive heat supply from regional heat supply facilities.

Improvement of the efficiency of regional heat supply facilities is not mentioned in this report because it involves energy conservation measures on the supply side rather than those on the demand side, which this survey targets. However, the author conducted a survey on the subject because it was necessary to grasp the current state of regional heat supply facilities in order to analyze the demand for and supply of heat in Uzbekistan. Details of the survey are described in Attachment 5.

(6) Other measures

Other energy conservation measures for general houses include changing to LED lighting, replacing existing refrigerators with high-efficiency ones, using water-saving shower heads, and setting a lower room temperature for heating.

3.2 Commercial Buildings Sector

3.2.1 Final energy consumption status

Table 3-3 shows the breakdown of energy consumption by resource from 2018 to 2020 in the commercial buildings sector, which accounts for approximately 13% of total energy consumption.

The target commercial buildings are public and private business buildings, and the breakdown of energy consumption by resource is fuel (natural gas, petroleum products, coal) 51%, heat supply 25%, electricity 24%. Overall energy consumption during the three years is on an upward trend. It is considered that energy is mainly used for heating, hot-water supply, kitchens, etc., that use heat, and air conditioners, lighting and office equipment, facilities equipment, etc., that use electricity.

As in the residential sector, the total of fuel and heat supply is 80%, which shows the ratio of heat use is very high. It is desirable to investigate the breakdown of usage, however, based on the cases in Japan and other countries, it is expected that main usage of energy is for heating, followed by hot-water supply, etc.

Table 3-3 Breakdown of Energy Consumption by Resource in the Commercial Buildings Sector (2018-2020)

Commertial and Public service	2018		2019		2020	
	ktoe	ratio	ktoe	ratio	ktoe	ratio
Coal		0.0%		0.0%	102	2.0%
Natural Gas	2,030	45.3%	2,280	45.4%	2,395	46.2%
Oil Products	13	0.3%	157	3.1%	167	3.2%
Electricity	1,128	25.2%	1,201	23.9%	1,236	23.9%
Heat	1,306	29.2%	1,378	27.5%	1,280	24.7%
Total	4,477	100.0%	5,017	100.0%	5,180	100.0%

Source: Prepared by the JICA study team based on the IEA Energy Balance 2020.

3.2.2 Energy efficiency status and challenges

(1) Current status

Although we were unable to obtain statistical data on the heat supply and thermal insulation in the commercial buildings sector of Uzbekistan as a whole, we estimated the energy efficiency of the commercial buildings sector in the Uzbekistan based on the results of the field study conducted. The commercial buildings surveyed included hospitals, elementary and junior high schools, hotels, and HUDUD GAZ TAMINOT (HGT) offices. The architectural style of the HGT building can be seen in many new buildings constructed under the urban planning project in the former Soviet Union after many buildings collapsed during the 1996 earthquake. This architectural style is widely used in Tashkent. Although the sample size is small, we believe that this study has provided some generalizable results on the status of heat utilization and thermal insulation.

1) Heat supply and cooling status

① Usage status of heating and hot-water supply

- Of the facilities surveyed, hospitals and elementary and junior high schools that received hot water from district heat supply facilities for heating were unable to regulate the temperature of the radiators for the hot water, so the room temperature was controlled by introducing outside air.
- In HGT offices, where we were able to check energy consumption details, gas consumption for heating was extremely high. Heat pump air conditioning was not used, and hot water produced by gas-powered water heaters was circulated throughout the office buildings. The thermal efficiency of gas water heaters during continuous combustion is estimated to be 80%, but in reality, frequent intermittent combustion is performed. Also, the furnace is air-cleaned before re-firing to prevent explosions

caused by unburned gas in the furnace, which cools the inside of the furnace. Therefore, the actual efficiency is estimated to be lower.

② Usage status of cooling systems

The cooling systems identified during the field survey were fan-coil units in hotels and packaged air conditioners installed in each room of HGT offices. The packaged air conditioners were of the constant-speed type with low efficiency.

2) Thermal insulation status

- Double-glazing is partially used for windows in hospitals and schools, but many of them use single-glazed windows.
- The field study identified walls made of bricks with concrete on the outside and constructed of concrete on the outside and mortar on the inside. Although the walls were 500 mm thick, thermal insulation was not very good with no thermal insulation materials applied.
- Some buildings use simple thermal insulation on hot water pipes as a measure to insulate equipment for receiving hot water from district heating facilities, but uninsulated piping was also seen in some buildings.

(2) Issues and energy efficiency improvements

1) Issues related to heating and hot-water supply and energy efficiency improvement.

Heat is supplied by district heating or stand-alone gas boilers, but in some cases the pipes are not equipped with thermal insulation, and outside air is introduced without temperature control, resulting in inefficient use of heat. In addition, the thermal efficiency of heating with gas boilers is considered to be less than 80%, which is not very energy efficient. Improvements in district heating are not mentioned here, but energy efficiency improvements can be expected for heating with gas boilers by replacing independent gas boilers with heat pumps.

2) Issues related to cooling and energy efficiency improvement

Packaged air conditioners for buildings were of the constant speed type with low efficiency. As detailed in the efficiency evaluation in Attachment 6, cooling performance is about 50% less efficient than high-efficiency air conditioners, and energy efficiency improvements can be expected through the widespread use of high-efficiency air conditioners in the future.

3) Problems with walls and windows and thermal insulation improvement

Windows use double-glazing only partially. Single-glazing was used in some buildings, and there were many walls without thermal insulation. It is possible to enhance thermal insulation by replacing all single-glazed windows with double-glazed ones. Thermal insulation can be improved by attaching thermal insulation materials.

3.2.3 Direction of energy conservation

(1) Introduction of heat pumps

Currently, newly constructed public facilities and commercial buildings are adopting independent boilers. By changing the power source from natural gas to electricity and adopting heat pump air conditioning, further energy savings can be expected. Installation of gas boilers in large buildings tends to be avoided for safety reasons, and instead, the demand for multi-air conditioners for building use is increasing in Uzbekistan in recent years. It is important to expand the introduction of heat pumps not only to new buildings but also to buildings that are being renovated. Details of the technology are provided in Chapter 4.

(2) Upgrading to high-efficiency air conditioners and use for heating

When updating existing air conditioners, it is effective to replace low-efficiency constant-speed type air conditioners with high-efficiency air conditioners. As mentioned above, high-efficiency air conditioners refer to air conditioners equipped with a heat-pump inverter with higher energy-saving performance. High-efficiency air conditioners can be used not only in summer, but also in winter instead of heating with gas boilers, which is expected to contribute to further energy efficiency improvement.

(3) Enhancing thermal insulation of walls, roofs, and windows

While some buildings, such as hospitals and schools, had a certain level of thermal insulation measures for their windows and walls, there were buildings with single-glazing windows or no thermal insulation materials on walls. It is important to strengthen the thermal insulation of walls, roofs, and windows.

As with existing residential complexes, as a basic direction, it is desirable to shift from the use of district heating facilities to the introduction of heat pumps as independent heat supply systems. However, as short-term improvement measures, while heat is being supplied from district heating facilities, it would be necessary to take measures such as enhancing thermal insulation on hot water piping for district heating facilities.

(4) Promoting Zero Energy Buildings (ZEBs)

As in the residential sector, it is effective in the commercial building sector to comprehensively utilize measures such as heat pumps and high-efficiency air conditioners and introduce ZEBs powered by renewable energy sources. The details of the ZEB concept are provided in Chapter 4.

3.3 Industrial Sector

3.3.1 Final energy consumption status

A breakdown of energy consumption by resource from 2018 to 2020 in the industrial sector, which accounts for approximately 24% of energy consumption, is shown in Table 3-4 .

Natural gas makes up 45 to 52％ energy consumption in the industrial sector. Combined with other fuels, approximately 50% is estimated to be for heat utilization. Although heat supply accounts for approximately 5%, it is on an increasing trend with industrial development. There was economic stagnation in the first half of 2020 due to the effects of COVID-19; however, the economy has recovered since then[3]. It is expected that electrification will progress with economic development and that power consumption in the economic field (industrial, business) in 2030 will be 2.2 times that of 2018.

In the industrial sector, the proportion of electricity is approximately 40%, which is slightly higher than 20% in major sectors, including the residential and commercial building sectors. Electricity has a broad range of applications, including power, heating, and measurement control. Since it is possible that the demand for electricity increases with industrial development, it is important to pay attention to the energy efficiency of electric equipment.

Although the scale of energy consumption in the industrial sector is large, the demand is mostly from corporations, and therefore it is easy to trace consumption data. In addition, even though there are various processes for each industry, it is believed that the energy efficiency for each industry can be traced by utilizing the data from the system for collecting energy data from corporations, called the Integrated Information System, promoted mainly by the Ministry of Energy (MoE）(described in detail in Chapter 7). It is desired to conduct a detailed survey by narrowing down the targets to industries with large energy consumption, to clarify the targets for which countermeasures should be applied, like the Current Survey of Energy Consumption in Japan.

[3] Based on JETRO Business News.

Table 3-4 Breakdown of energy consumption by resource in the industrial section (2018-2020)

Industry	2018		2019		2020	
	ktoe	ratio	ktoe	ratio	ktoe	ratio
Coal	88	1.0%	274	2.8%	230	2.3%
Natural Gas	4,535	51.9%	4,877	49.0%	4,322	44.1%
Oil Products	108	1.2%	116	1.2%	144	1.5%
Electricity	3,503	40.1%	4,181	42.0%	4,654	47.4%
Heat	504	5.8%	494	5.0%	459	4.7%
Total	8,739	100.0%	9,943	100.0%	9,810	100.0%

Source: Created by the JICA study team based on IEA Energy Balance 2020

3.3.2 Current status of energy efficiency and issues

No statistical data that makes it possible to grasp the status of energy efficiency in all industries could be obtained for the energy efficiency status of the industrial sector in Uzbekistan. Therefore, the energy efficiency status in the industry sector was estimated based on a questionnaire survey conducted on resource-intensive industries, energy supply industries, and other industries.

(1) Current status of factories and improvement measures

From the results of the questionnaire survey, it has become clear that there is room for improvement in the energy efficiency of boilers and pumps in the steel, cement and quarrying, gas refining, chemical, and mining industries, which are resource-intensive industries. In particular, in the chemical industry, the use of boilers is necessary; therefore, efficiency improvements of boilers or comprehensive efficiency improvements of heat supply facilities, including cogeneration systems and heat pumps, are needed.

Additionally, there are areas for improvement in other industries' factories, which were also included in the field survey. Some of the improvements that can be made include the following:

Table 3-5 Field survey target list and survey results

Target name	Industry	Date and time	Survey results
Zelal Textile	Textile Dyeing	2021 Nov 23	・ Two flue and smoke tube steam boiler units are installed for heating dyes. However, maintenance and management of the facilities including steam pressure setting and pressure control were not implemented, and the insulation material on the steam header and piping had partially peeled. ・ There is room for improvement in operation

			management and maintenance, energy control, and thorough insulation of boilers.
Natural Juice	Food (Juice manufacturing)	2021 Nov 24	・ There is room for improvement in areas such as insulation of the steam system and preheating of boiler water supply.
Asl Oyna	Glass bottle manufacturing	2022 Mar 28	・ An air preheater that preheats air for city gas combustion by exhaust gas is installed in the heating furnace for melting glass. The exhaust gas temperature after thermal collection exceeds 500°C, and heat efficiency is not great. Since this exhaust gas was diffused into the atmosphere from the chimney, heat loss was extremely large. ・ Further heat recovery from exhaust gas is required. There was a plan for heat recovery facilities.

Source: JICA study team

(2) Policies for energy management and their implementation statuses

From the results of the field survey, it has been clarified that the implementation of energy management is most advanced in the chemical industry in Uzbekistan, and there are many cases of energy management based on ISO50001. On the other hand, in other sectors, business operators with low interest in energy efficiency, business operators that implement energy management, and business operators that have no interest in energy management but have technological interests in energy efficiency were observed.

Therefore, implementation of energy management by means such as placement of energy managers is effective. The energy management implementation status in Uzbekistan is summarized in Table 3-6 .

Table 3-6 Policies regarding energy management and their implementation statuses in Uzbekistan

Item	Policy and implementation status
Identification of business operators	Targets of energy audit (newly built and renovated buildings and companies with the annual energy resource consumption greater than 2,000 tons of standard fuel or 1,000 tons of motor fuel = resource-intensive industries) are specified in the

	Resolution of the cabinet of ministers No. 164. In addition, companies for which energy audit should be conducted (285 companies in resource-intensive industries) are specified in PP4779.
Periodical reporting to the government	It is implemented. Moreover, the implementation plan for the Integrated Information System for collecting energy data of companies is being advanced, led by the MoE (the details of the Integrated Information System are described in Chapter 7).
Energy Manager System	None. Although there are personnel responsible for energy management, it is not mandated.
Energy diagnosis	Energy audit is mandated in PP4779.
Follow-up system	None.
Guidelines (benchmarks)	No benchmarks are provided as a policy.
Guidelines (improvement rate)	1.5 times increase in energy efficiency as a long-time improvement goal (2030).
Energy Management System (EMS), guidelines (implementation items)	Identification of companies applying ISO50001.

Source: JICA study team

3.3.3 Direction of energy conservation

From the results of the field survey, improvement of energy management, updates to high efficiency boilers, and efficiency improvement of motor power use can be considered as recommendations for energy conservation. The specific examples are shown below.

(1) Spread of energy management

In the industrial sector, promoting energy management is essential to drive efficiency improvement. One effective approach is to conduct an energy conservation diagnosis to identify equipment with low efficiency in the field and prioritize their updates. As energy management is not yet widely implemented in Uzbekistan, it is necessary to promote its adoption. The implementation status and proposals for enhancing and promoting energy management in Uzbekistan are summarized in Table 3-7 .

Table 3-7 Proposals for enhancement and promotion concerning energy management

Item	Currently implemented policy and its implementation status	Proposals for enhancement and promotion	Notes
Identification of	Companies for which	Add large-scale offices	The current target is

business operators	energy audit should be conducted have been identified in PP4779.	and holes to the identified companies	companies with a standard fuel consumption of 2000 t/year.
Periodical reporting to the government	It is implemented. Moreover, the implementation plan for the Integrated Information System for collecting energy data of companies is being advanced	–	Results of the Integrated Information System are expected.
Energy Manager System	None. Although there are personnel responsible for energy management, it is not mandated.	Implementation of the energy manager appointment system.	Persons in charge in the companies to whom feedback from the government is given will be clarified.
Energy audits	Energy audits are mandated in PP4779.	Development of experts in energy audits and diagnosis.	
Follow-up system	None.	Monitoring, benchmarks, feedback based on improvement targets.	
Guidelines (benchmarks)	No benchmarks are provided as a policy.	Implementation of benchmarks	
Guidelines (improvement rate)	1.5 times increase in energy efficiency as a long-time improvement goal (2030).	Ask companies to create improvement plans for long-term targets.	
EMS, guidelines (implementation items)	Identification of companies applying ISO50001.	Mandating the basic implementation items for specified companies.	Mandatory implementation and voluntary implementation are carried out simultaneously to spread energy management.

Source: JICA study team

(2) Updating boilers

1) Reduction of steam load by utilization heat pumps

It appears that approximately half of the exiting boilers operating in the industrial sector are approaching their time for replacement; therefore, it is effective to replace them with more efficient boilers. They can also be replaced not only with high-efficiency boilers but with heat pumps.

When low-temperature waste hot water with a temperature of 35 ℃ to 65 ℃ can be used, heat pump systems that generate steam with a temperature of 120 ℃ using this (waste hot water) as the heat source can be used.

For food factories and textile factories that use hot water, it is recommended to replace low-efficiency boilers with heat pumps for hot water. Additionally, for situations where cooling and heating are required in close proximity with a similar amount of heat, using a heat pump to satisfy both requirements through heat transfer is a highly effective method.

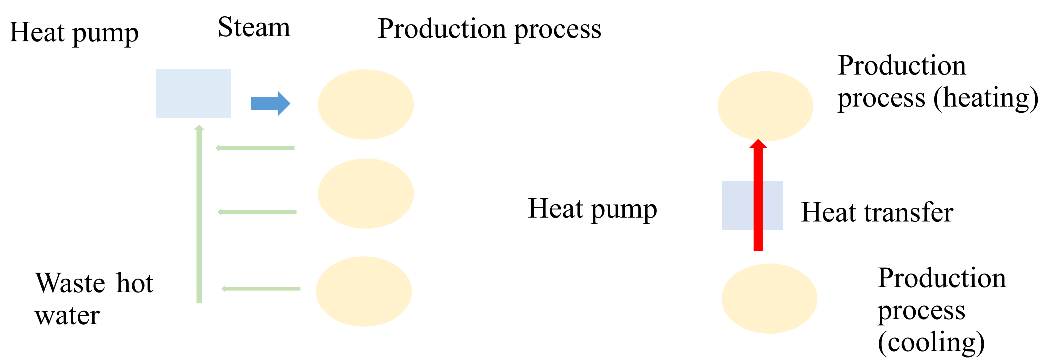


Figure 3-6 Application of a heat pump (left: steam generation, right: heat transfer between production processes)

Source: JICA study team

2) Improvement of the operation method

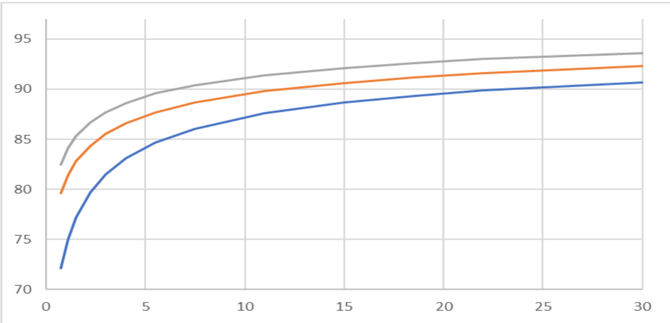
To conserve energy in boilers, it is recommended to implement basic measures such as preheating the feedwater with exhaust heat, optimizing the air ratio, and enhancing the thermal insulation of the steam header and control valves.

(3) Improvement of efficiency in electricity use

Among the large pumps currently installed in Uzbekistan, some have deteriorated in efficiency and are at excess capacity. Therefore, increasing efficiency in pump usage is one possible energy conservation measure.

In the industrial sector, the power consumption of pumps can often be reduced by 20 to 30% by means such as efficiency improvement of the drive motor, changes in the flow rate, and improvement of control. In circulation pumps, in which the effects of flow rate adjustments are large, the efficiency rate tends to be high, while it is lower in force pumps.

As for efficiency improvement of the drive motor, the efficiency improvement effect shown in Figure 3-7 can be obtained by a change from IE1 (Standard Efficiency) to IE3 (Premium Efficiency).



Horizontal axis: motor output kW

Vertical axis: energy efficiency %

From the bottom:

IE1 Standard Efficiency

IE2 High Efficiency

IE3 Premium Efficiency

Figure 3-7 Efficiency difference by motor grade

In the example of 7.5 kW, power consumption decreases by 4.4%. Therefore, updating pumps in the industrial sector should be undertaken as part of the energy conservation activities of individual companies.

3.4 Other (Agriculture Sector)

In sections 3.1 to 3.3, issues and directives are presented for consumer and industrial sectors, to increase energy saving. Further, 3.4 and 3.5 show the summary of similar surveys conducted in sectors that are not the targets of energy saving.

3.4.1 Final Energy Consumption

Table 3-8 shows the breakdown of energy consumption by resource from 2018 to 2020 for the agriculture sector, which accounts for 3 to 5% of the total energy consumption. Electricity consumption is the largest in all years: approximately 97% in 2018 and 2019, and approximately 87% in 2020. The primary use of this electricity consumption is by irrigation pumps used to deliver irrigation water.

Table 3-8 Breakdown of Energy Consumption by Resource in Agriculture Sector (2018 to 2020)

Agriculture/Forestry	2018		2019		2020	
	ktoe	ratio	ktoe	ratio	ktoe	ratio
Coal		0.0%		0.0%	15	0.6%
Natural Gas	37	0.9%	21	0.6%	259	10.3%
Oil Products	3	0.1%	4	0.1%	3	0.1%
Electricity	4,100	97.6%	3,623	97.6%	2,171	86.5%
Heat	61	1.5%	66	1.8%	61	2.4%
Total	4,202	100.0%	3,713	100.0%	2,509	100.0%

Source: Prepared by JICA study team based on IEA Energy Balance 2020

3.4.2 Energy efficiency status and challenges

Most of the approximately 5,000 irrigation pumps in the country under the jurisdiction of the government were installed during the Soviet era, and thus their efficiency and performance have declined significantly over time. Therefore, there is an critical need to reduce power consumption by replacing them with high-efficiency pumps.[4]

In 2018, Torishima Pump Mfg. Co., Ltd. conducted an experiment under JICA's Dissemination, Demonstration, and Business Development Project "Collaboration program with the private sector for disseminating Japanese technology for efficient and economical pump to assist water resource sector in Uzbekistan." The experiment compared the efficiency of a high-efficiency volute pump with an existing double-suction volute pump and found that the high-efficiency volute pump can save approximately 30% of energy.

Similar results were also obtained from a market survey. Compared to the double-suction volute pump (D type), which made up 70% of government-managed pumps, the new type of pump was found to be 30% more energy efficient.

3.4.3 Directives for energy conservation

Based on the aforementioned situation, replacing old irrigation pumps is necessary to enhance energy efficiency in the agriculture sector. While the systematic upgrading of aging and inefficient irrigation water pumps and motors has been conducted in compliance with Presidential Decree PP3012, it is crucial to maintain the systematic upgrading of equipment, and reduce water consumption in accordance with Presidential Decree PP60.

[4] Collaboration program with the private sector for disseminating Japanese technology for efficient and economical pump to assist water resource sector in Uzbekistan: Final Report, JICA, issued by Torishima Pump Mfg. Co., Ltd. in April 2018

3.5 Other (Transportation and Traffic Sector)

3.5.1 Final Energy Consumption

Table 3-9 shows the breakdown of energy consumption by resource for 2018 to 2020 in the transportation and traffic sector, whose TFC accounts for 18-20% of the total. Total of natural gas and petroleum products accounts for 91-95% of the total, which are considered fuels for trucks, passenger cars, etc. The consumption of natural gas and oil products is almost 50-50. Electricity consumption is estimated to come from rail and pipelines. However, this may increase in the future as electric vehicles become more common. Overall, energy consumption is on the rise.

Table 3-9 Breakdown of Energy Consumption by Resource in Transportation and Traffic Sector (2018 to 2020)

Transport	2018		2019		2020	
	ktoe	ratio	ktoe	ratio	ktoe	ratio
Coal	3	0.0%	2	0.0%	4	0.1%
Natural Gas	2,857	47.6%	3,289	52.6%	2,988	48.3%
Oil Products	2,818	47.0%	2,454	39.3%	2,943	47.6%
Electricity	322	5.4%	501	8.0%	250	4.0%
Heat	0	0.0%	0	0.0%	0	0.0%
Total	6,000	100.0%	6,248	100.0%	6,184	100.0%

3.5.2 Current Status and Issues in Energy Efficiency

As mentioned in the previous section, the energy consumption of the transportation and traffic sector in Uzbekistan is dominated by automobile fuel consumption, which is highlighted here.

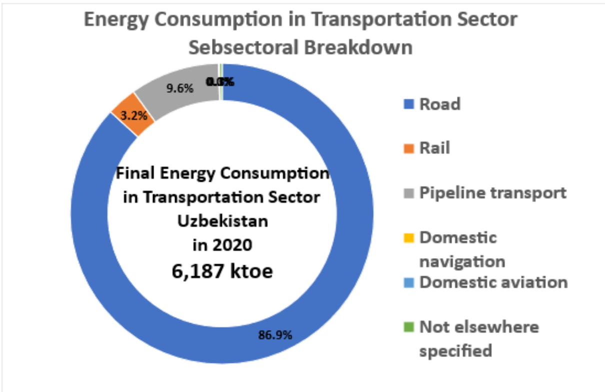


Figure 3-8 Final Energy by Transportation Mode in Transportation Sector

Source: Prepared by JICA study team based on IEA data.

One characteristics of the diffusion of automobiles in Uzbekistan that must be kept in mind, is that compressed natural gas vehicles (CNG vehicles) are widely used. According to an article from the online news service Uzdaily.com, 65% of privately owned automobiles in Tashkent are natural gas automobiles. This is followed by gasoline vehicles (25%), propane vehicles (8.4%), and diesel vehicles (2.2%). This is partly due to the fact that the government strongly promoted the conversion from gasoline to natural gas vehicles. This was to reduce environmental damage; however, it was mainly motivated by the intentional low-price policy for natural gas, as discussed in the "Uzbekistan 2022 / Energy Policy Review" of IEA. Although actual vehicle fuel economy statistics are not available, the Review points out that this low-price policy has encouraged the purchase of larger, less fuel-efficient automobiles. Another issue is that the country has no fuel standards for automobiles.

3.5.3 Direction of energy conservation

The transportation and traffic sector mainly consumes energy through fuel consumption by automobiles, with 65% of that fuel being natural gas. To reduce energy consumption, it is advisable to consider switching from natural gas to electricity as a source of automobile fuel. Presidential Decree UP60 also highlights initiatives for the production and widespread use of electric vehicles (EVs), and the shift towards EVs for transportation vehicles is a global trend. Therefore, promoting the use of EVs is advisable.

Chapter 4 Examination of Promising Technologies to Achieve Energy Conservation

To realize the direction of energy conservation in the residential, commercial buildings, and industrial sectors as indicated in Chapter 3, this chapter examines promising technologies that can be applied to achieve the goal. First, 4.1 shows the list of promising technologies in each sector. Next, 4.2 provides an overview of each promising technology and describes the technologies that can be specifically applied in Uzbekistan; the advantages of such technologies over conventional technologies; and the significance of implementing such technologies in Uzbekistan.

4.1 List of Promising Technologies to Achieve Energy Conservation

The energy conservation technologies applicable to each sector are summarized below.

Table 4-1 Promising technologies to achieve energy conservation

Target Sectors	Promising Technologies to Achieve Energy Conservation
Housing Sector	• Introduction of heat pumps • Installation of high-efficiency air conditioners • Reinforcement of building insulation (windows, walls, roofs) • Introduction of ZEH • Introduction of LED lighting
Commercial Buildings Sector	• Introduction of heat pumps • Installation of high-efficiency air conditioners • Reinforcement of building insulation (windows, walls, roofs) • Introduction of ZEB • Introduction of LED lighting
Industrial Sector	• Energy Management • Improvement of efficiency of drive motors

Source: Prepared by the JICA study team

4.2 Overview of Promising Energy-conservation Technologies

This section provides an overview of each promising technology and describes the specific technologies that would be appropriate to implement in Uzbekistan, as well as the advantages of such technologies.

4.2.1 Conversion of Gas Boilers to Heat Pumps

(1) Overview of heat pump technology

A heat pump is a system that pumps thermal energy from a low temperature to a high temperature heat source by providing energy from outside. It can obtain a large amount of thermal energy by providing a small amount of input energy. This energy-conserving technology is widely used in cooling and heating fields, such as air conditioners, refrigerators, water heaters, and dryers.

In the heat cycle of a heat pump, when a gaseous refrigerant is compressed by an electric compressor, the refrigerant transforms from a gas to a liquid and releases latent heat of condensation to the surrounding environment. This latent heat of condensation is used as a heat source for heating. When the liquid refrigerant is instantly depressurized to atmospheric pressure, it transforms to a low-temperature liquid owing to adiabatic changes. When a liquid refrigerant evaporates at low temperatures and transforms to a gas, it removes the latent heat of evaporation from its surroundings. This latent heat of evaporation is used as a heat source for cooling.

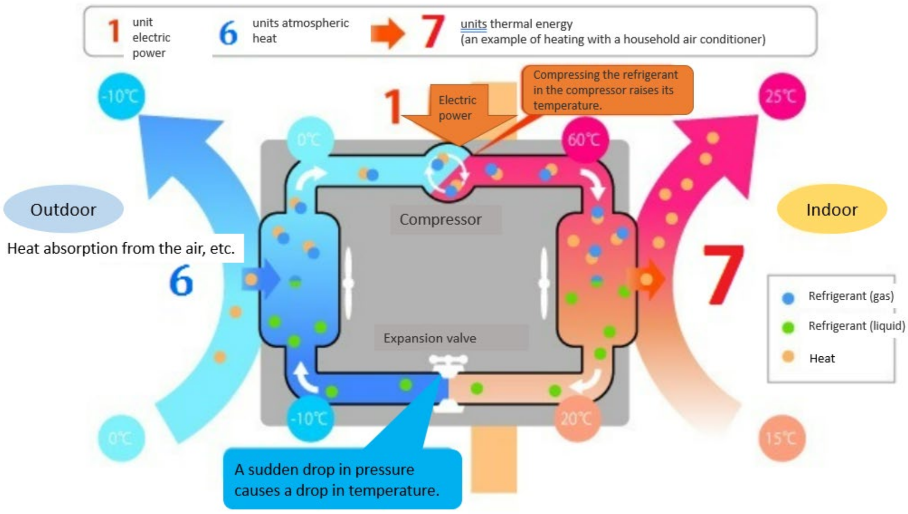


Figure 4-1 Mechanism of a heat pump

Source: Heat Pump and Thermal Storage Center of Japan. "What is a Heat Pump?" https://www.hptcj.or.jp/study/tabid/102/Default.aspx (see 2023-1-29)

As mentioned above, using heat pumps can generate more thermal energy than consumed energy input. Thus, it is considered a more efficient use of energy. For example, the coefficient of performance (COP) of current high-efficiency heat pump air conditioners is 3.0 to 3.5. The COP is the ratio of the amount of heat pumped from the ambient (kW) to the power consumption of the compressor (kW). Accordingly, a heat pump with a COP of 3.0 means it produces three times as much heat output as the power input. In addition, inverter technology, which has been given much attention in recent years, can greatly help improve efficiency at intermediate loads. Conventional constant-speed types operate on and off during intermediate loads, which cause a large current flow when the motor starts and stops. Even if the COP is high, the performance cannot be fully demonstrated. However, by continuously controlling the motor speed with inverter technology, continuous operation is possible, even at intermediate loads, to maintain a high COP.

As mentioned in Chapter 3, in Uzbekistan, a huge amount of energy is used for heating, hot water supply, and other heat applications, and as using more efficient heat supply facilities contributes significantly to energy conservation, it would be desirable to convert the gas-based heat supply currently used in housing complexes and detached houses to electricity-based heat pumps.

For example, for the residential sector, heat pump room air conditioners and heat pump hot water supply could replace the gas boilers used for heating and hot water supply. In residences with central heating, such as apartment complexes, heating and cooling with a central chiller utilizing the existing hot and cold-water piping may be considered.

A central chiller is a centrally controlled air conditioner that integrates equipment called a chiller (chilling unit), which circulates water or liquid in a single location in a building. The chilled or hot water produced by the chiller is supplied to each room through piping, and the chilled or hot water flowing from the piping is generally used to get cold or hot air using an air conditioning unit called a fan coil unit. As radiator heating is common in Uzbekistan, it is conceivable that existing radiators (radiant panels) could be used to provide heating instead of fan coil units. However, radiant panels require high temperatures (about 60° C), whereas the hot water produced by chillers is about 40° C. Therefore, it is considered more realistic to use fan coil units to supply heating rather than radiators.

When a central chiller is used, as the chilled water produced by the chiller is circulated in the system, a separate heat pump hot water supply may be installed for hot water supply.

Figure 4-2 Heat pumps (room air conditioners and hot water heaters) for residential use-

Source: Heat Pump and Thermal Storage Center of Japan. "Heat Pump and Thermal Storage Products." https://www.hptcj.or.jp/family/tabid/156/Default.aspx#case01 (see 2023-1-29)

For commercial buildings and public buildings, multiple air conditioners and a central chiller/heaters are applicable. As mentioned above, while a central chiller/heaters manage heat sources in one location using a central management system, multiple air conditioners for buildings have heat sources on each floor or zone and can individually operate multiple indoor units of different capacities with a single outdoor unit. For small buildings, although the service life is shorter than that of central systems, multiple air conditioners for buildings are effective because of their small investment scale and easy maintenance. For large buildings, both multiple air conditioners for buildings with a small investment scale and a central chiller/heaters with a long service life can be applied. Central chillers/heaters are generally heat pumps commonly used in large facilities, and as noted above, existing cold and hot water piping in the building can be used as long as the system is repairable. Thus, heat supply for air conditioning applications in commercial buildings is desirably replaced by heat pumps. As hot water use is relatively low, solar water heaters can be used to provide hot water for water heating purposes, while the installation of heat pump hot water supply could be an option if there is a shortage in terms of quantity.

Figure 4-3 Heat pumps for commercial buildings (left: central chiller, right: multiple air conditioner for buildings)

Considering the above, the heat pump equipment suitable for residential and commercial buildings in Uzbekistan can be organized as follows:

Table 4-2 Heat pump technology suitable for each target facility-

department	Target Facilities		Heat pumps suitable for each target facility
Residential Sector	individual housing		Heating and cooling: Room air conditioner Hot water supply: heat pump hot water supply (Eco-Cute)
	housing complex		Heating and cooling: Central chiller Water heater: heat pump hot water supply (Eco-Cute)
Commercial Buildings Sector	Small building		Heating and cooling: Multiple air conditioners for buildings
	Large building	new	Heating and cooling: Multiple air conditioners for buildings / Central chiller/heaters
		existing	Heating and cooling: Central chiller/heater

Source: Prepared by the JICA study team

(2) Advantages of heat pumps

1) High heat conversion efficiency

As described above, heat pumps have a high energy conserving effect because they can obtain a large amount of heat energy from a small amount of energy input. Figure 4-4 compares the overall thermal efficiency of heating and the hot water supply method, namely, the electric heat pump, gas boiler, and district heat supply facility, referring to general parameters based on Japanese conditions and other factors. The heat output in each case was compared with the heat value of the natural gas to be supplied being 100. In the case of electric heat pumps, once the gas is converted to electricity and then transmitted, the power generation efficiency of gas-fired power plants, transmission and distribution losses, and the COP of electric heat pumps are considered. In the case of gas boilers, only the thermal efficiency of the boiler is considered, as the gas is used as it is. In the case of district heat supply facilities, once the water is made into hot water, it is supplied to each heat-receiving facility via a transport pipeline. Therefore, the thermal efficiency of boilers at district heat supply facilities, the heat loss in transport pipelines, and the heat loss in hot water radiators are considered.-

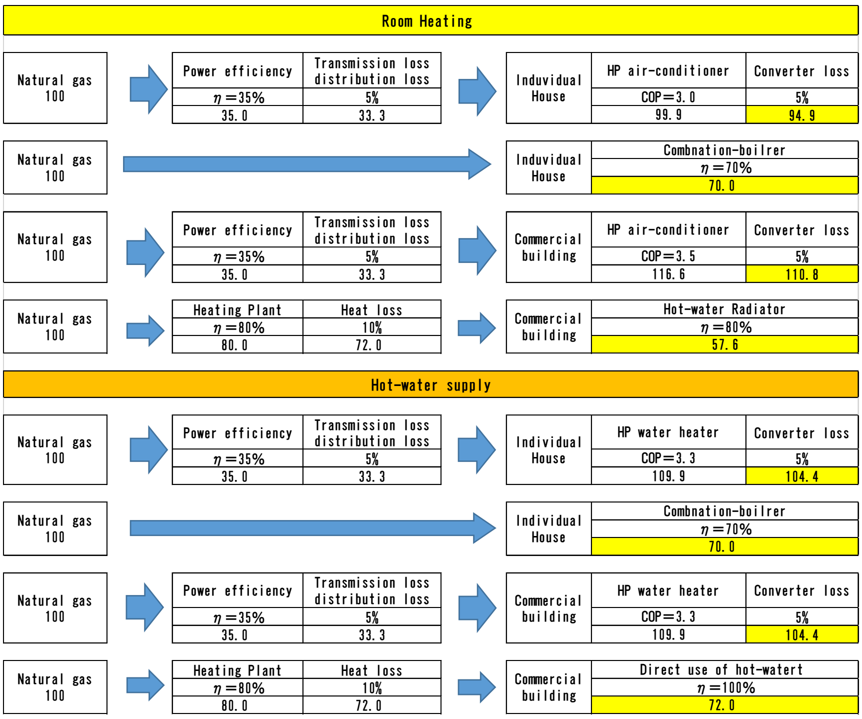


Figure 4-4 Heat efficiency for each heat conversion device when natural gas consumption is set at 100

(Losses and efficiencies are based on general parameters, such as Japanese conditions.)

To summarize, in the case of the electric heat pump, the heat output for heating (high-efficiency air conditioner) ranged from 94.9 to 110.8 and that for hot water (heat pump hot water supply) was 104.4, compared to 100 for natural gas, indicating that natural gas can be efficiently converted into heat. Meanwhile, the output heat rate of gas boilers and district heat supply ranged from 57.6 to 72, so it is clear that heat pumps have a relatively larger available output heat rate and thermal efficiency. Therefore, in order to effectively use the thermal energy of natural gas to provide heating and hot water, the use of heat pumps instead of gas boilers and district heat supply facilities is considered the Best Available Technology (BAT).

2) High global expectations and potential for decarbonization

As countries work to address climate change, heat pumps are attracting increasing attention worldwide owing to its high energy efficiency, as shown in 1) above. According to the IEA's World Energy Outlook 2022, more than half of the CO_2 reductions in the heating and cooling and hot water supply sectors that can be expected in 2050 are assumed to come from heat pump technology, and there are high expectations for the CO_2 reduction effects by heat pump technology. In response to this trend, the global market for heat pumps for water heating is expanding by more than 50% per year.

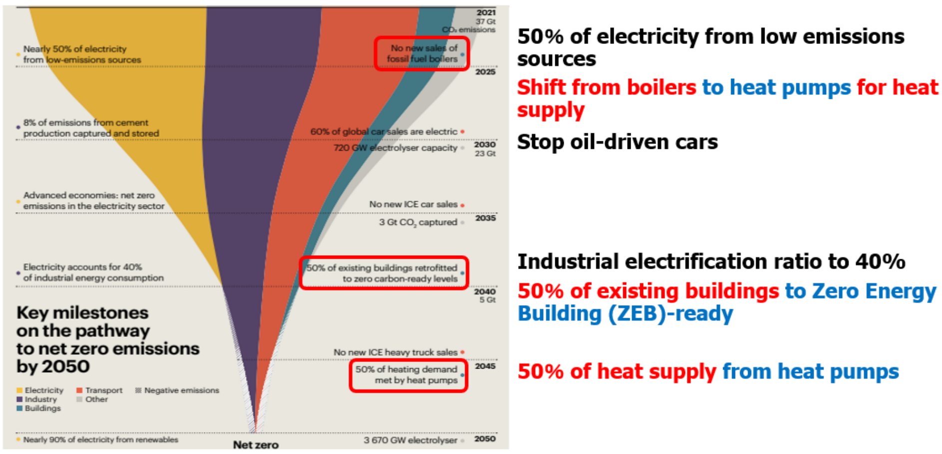


Figure 4-5 Milestones for achieving net zero emissions by 2050

Source: IEA "World Energy Outlook 2022."

The high potential of heat pumps for decarbonization is illustrated in Figure 4-6. Figure 4-6 compares the CO_2 emissions per MJ of heat from each heat supply system. While a city gas boiler emits about 0.057 kg of CO_2 per MJ, a heat pump with a COP of 7.0 emits 0.018 kg of CO_2 per MJ, about 1/3 of the CO_2 emissions of a gas boiler. The CO_2 reduction effect will be even more pronounced if the power source for the heat pumps is changed from gas-fired power generation to power generation from renewable energy sources in the future. Moreover, in the case of power generation from renewable energy sources, CO_2 emissions can be reduced to as close to zero as possible. This is also in line with the government's policy of the Uzbekistan which has been actively trying to introduce renewable energy in recent years. In its Strategy for the Transformation to a Green Economy 2019–2030, the government of Uzbekistan has set a policy of increasing the share of renewable energy in the overall power supply mix to at least 25% by 2030, also aiming for a 35% reduction in greenhouse gas (GHG) emission intensity per GDP compared to 2010 levels.

As described above, the CO2 reduction effect of heat pumps is significant, and it is highly advantageous to promote the introduction of heat pumps in the country from the perspective of the global trend toward decarbonization and the synergistic effect with renewable energy in Uzbekistan.

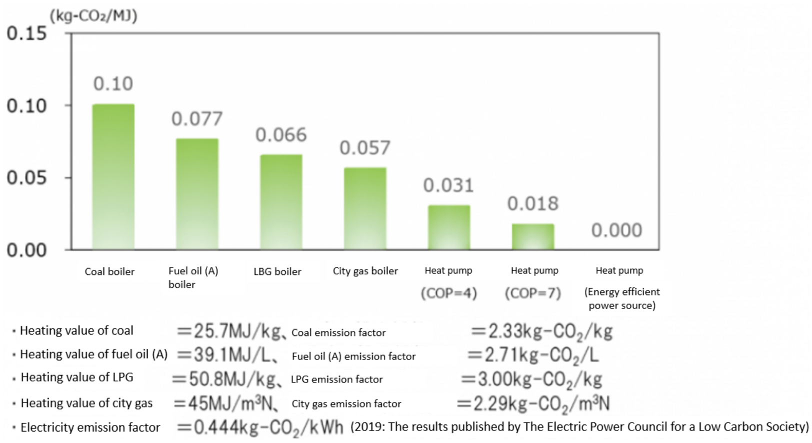


Figure 4-6 CO2 emissions per MJ of heat from each heat supply system

Source: Journal of the Japan Society of Mechanical Engineers, "Special Feature: The Road to Carbon Neutrality: From the Perspective of Energy Conservation," Joint Project of the Institute of Electrical Engineers of Japan, "Expectations for Heat Pumps toward the Decarbonization Era," Heat Pump and Thermal Storage Center Foundation, March 2022.

4.2.2 Installation of High-efficiency Air Conditioners

(1) High-efficiency air conditioners overview

High-efficiency air conditioners are defined here as heat-pump type air conditioners with inverter functions. An inverter is a frequency converter, a technology that controls voltage, current, and frequency. An air conditioner equipped with an inverter can produce cool (warm) air in a short time by controlling the motor of the compressor, which is the heart of the air conditioner, with an inverter device, and speeding up the rotation speed of the pump motor. When the room is hot (cold), the inverter circuit allows the motor to rotate at a high speed to quickly cool (warm) the air in the room and then maintain the coolness (warmth) by operating at a constant speed. An air conditioner without an inverter can only perform a simple ON/OFF operation, stopping operation when the temperature reaches the set temperature and starting operation when the temperature rises (or falls in the case of heating), whereas an air conditioner with an inverter can properly adjust the temperature, thus reducing power consumption by more than 50%, compared to a conventional non-inverter air conditioner.[1]

The Energy Efficiency Ratio (EER) is an indicator of the performance of air conditioners and refrigeration units. EER is defined as the cooling capacity of the unit divided by its rated power consumption (kW/kW), describing the maximum performance of the unit under rated operating conditions. On the other hand, the aforementioned inverter technology is used to control the motor speed under a given intermediate load. This is not a technology to improve EER, as it enables continuous operation rather than inefficient on/off operation. Therefore, new indicators such as the Seasonal Energy Efficiency Ratio (SEER) and the Cooling Seasonal Performance Factor (CSPF) have now been applied as indicators to evaluate improvement in energy efficiency through inverter technology. The CSPF is commonly used in Japan, while the SEER is adopted in Europe by the European Commission. As the SEER calculation method is complex, its detailed description will not be given in this report, but the concept is as follows. First, the outdoor temperature conditions are set at several stages and an operating time is configured for each condition in a way that reflects the actual usage conditions. Considering the operating time, the EER for each condition is then measured and a weighted average value is calculated to get the SEER. kWh/kWh is used for the unit of measure. SEER is thus an energy efficiency indicator that reflects actual operating conditions and is suitable for indicating the performance of air conditioners and refrigeration units.

A similar evaluation indicator is also available for heat pumps, with the Seasonal Coefficient of Performance (SCOP) being adopted by the European Commission. This is the equivalent of the Heating Seasonal Performance Factor (HSPF) used in Japan. The SCOP is an indicator that represents the actual conditions of use, while the Coefficient of Performance (COP) represents the maximum performance of a heat pump.

[1] Daikin Industries, Ltd. "Why Inverter Air Conditioners Save Energy." https://www.daikin.co.jp/csr/information/lecture/act01 (see 2023-01-29)

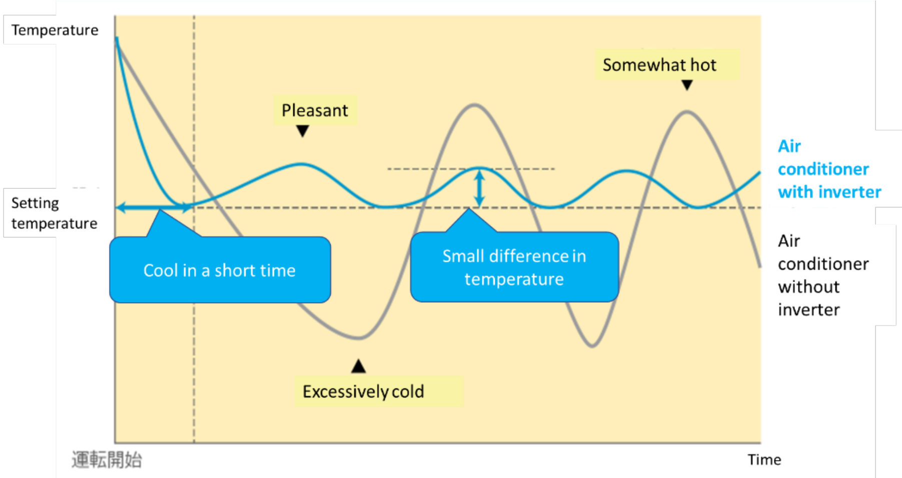


Figure 4-7 Comparison of temperature change between air conditioners with and without inverters

Source: Daikin Industries, Ltd. "Daikin's Initiatives," https://www.daikin.co.jp/csr/information/lecture/act01 (see 2023-1-29)

(2) Advantages of high-efficiency air conditioners

In order to demonstrate whether similar energy-saving effects can be achieved in Uzbekistan, comparative demonstration experiments were conducted between inverter-equipped air conditioners and non-inverter-equipped (constant-speed type) air conditioners during summer (May to July) and winter (December to March), when cooling and heating demand is high. Details of the demonstration experiment are described in Appendix 6. The results of the experiment showed that, compared to the constant-speed type air conditioner, the inverter-equipped air conditioner was about 50% more efficient in summer and about 30% more efficient in winter in terms of power consumption. Figures 4-8 and 4-9 show the results of the demonstration experiment. The bar graph shows energy consumption and the line graph shows EER (energy efficiency: the higher the value, the higher the efficiency). In winter, humidity and enthalpy (internal energy of outdoor air) are higher than in summer, and more heat energy is obtained from the outdoor air, resulting in lower compressor power consumption, and therefore, higher EER. Comparing the inverter type and constant-speed type, the performance difference in EER is 1.78 times higher in winter, on average. Meanwhile, although EER is lower in summer than in winter, owing to lower humidity and enthalpy, the performance difference with the constant-speed type is 1.9 times better than the performance difference in winter. Comparing power consumption, the average power consumption of the inverter type is 0.53 times lower than that of the constant-speed type, almost half the power consumption.

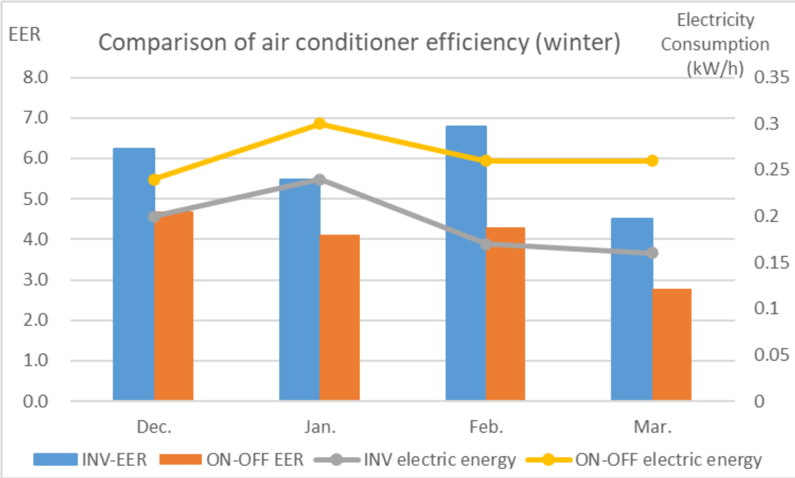


Figure 4-8 Comparison of air conditioner efficiency (winter)

Source: Prepared by the JICA study team

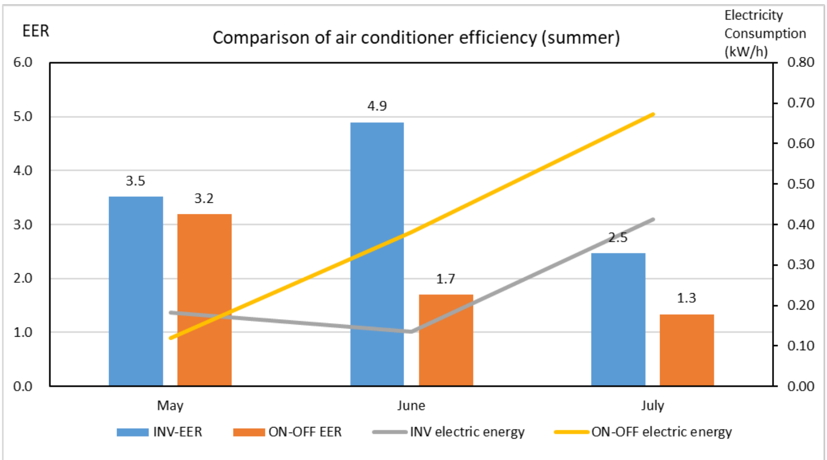


Figure 4-9 Comparison of air conditioner efficiency (summer)

Source: Prepared by the JICA study team

As described above, the superiority of inverter-equipped air conditioners over conventional constant-speed type air conditioners was confirmed in Uzbekistan. According to the household questionnaire survey and market hearing survey described in Chapter 3, almost 30% of households have inverter-equipped air conditioners, and the sales ratio in the market is about 30%, so energy-saving effects can be expected from the widespread use of inverter-equipped air conditioners.

4.2.3 Enhanced Thermal Insulation

(1) Insulation technology overview

Insulation means reducing the transfer of heat between the inside and outside of a building through walls, floors, roofs, windows, etc. To reduce heat transfer, the parts of a building in contact with the outside air, such as floors, exterior walls, and roofs, should be wrapped, without gaps, with materials to improve insulation.

The thermal insulation performance of a building is indicated by the "average heat transfer coefficient (UA value)," which is calculated by dividing the amount of heat that escapes from the inside of the building, to the outside, through the floor, exterior walls, roof (ceiling), and openings by the area of the building envelope. The smaller this value is, the more difficult it is for heat to escape and the more energy efficient the building is.

In order to improve the insulation of the building as a whole, it is important to improve the insulation at building openings. Among these, windows have the largest heat flow in and out, with approximately 60% of indoor heat escaping through windows in winter and 70% of indoor heat entering through windows in summer, so strengthening window insulation is particularly important. To improve the thermal insulation of windows, the window glass can be changed from single-pane to double-pane (see Figure 4-10), or double-paned with an interior window.

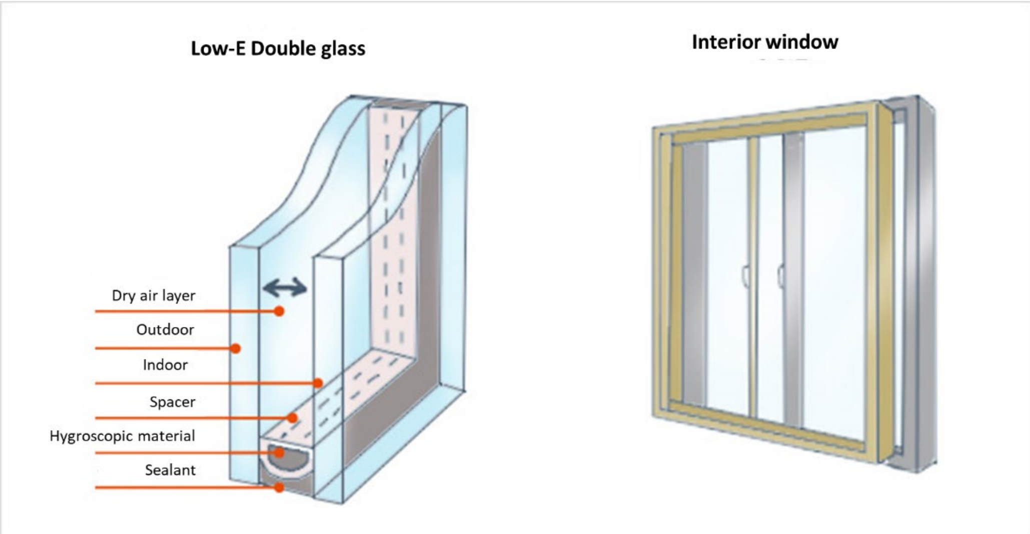


Figure 4-10 Example of window insulation measures

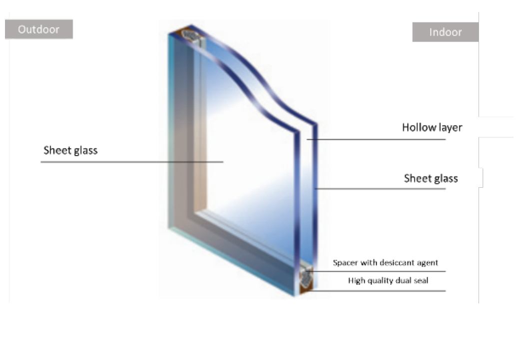
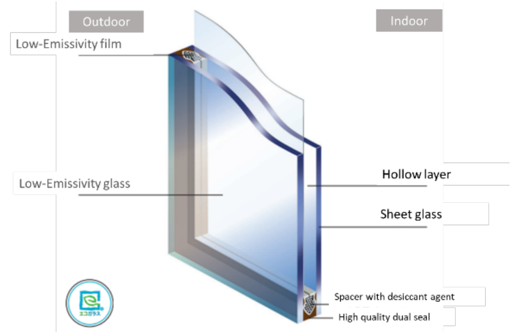
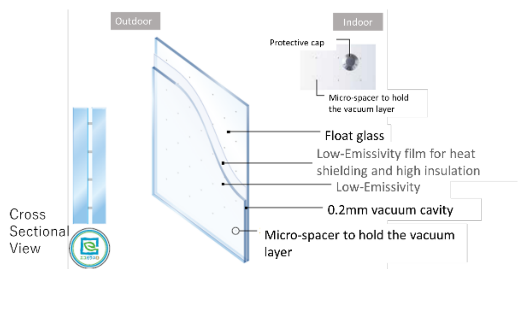
Source: Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry, "Energy Conservation by Residential Buildings."
https://www.enecho.meti.go.jp/category/saving_and_new/saving/general/housing/ (See 2023-2-1)

However, according to the results of the field survey, the window type in Uzbekistan is not a sliding door system like in Japan, but has butterfly doors in a wooden frame, which makes installing an internal window difficult. Replacing it with double-glazing windows is more realistic, as the window frame can be used as is.

There are several types of insulating glass, as shown in Table 4-3, and it is desirable to introduce Low-E glass and vacuum glass, which have higher thermal insulation properties. By using vacuum glass, the insulation performance can be expected to be approximately four times that of single-layer glass and twice that of ordinary double-glazing.

Other techniques, such as spraying rigid polyurethane foam or attaching rigid polyurethane boards, can be applied to strengthen the insulation of roofs and exterior walls.

Table 4-3 Types and overview of double-glazing glass

Types of insulating glass	Performance Overview
	Double-glazing glass Glass that has a hollow layer between two sheets of glass with a metal component called a spacer. The hollow layer is filled with dry air, which prevents heat transfer and improves thermal insulation performance by sandwiching air with lower thermal conductivity than the glass.
	Low-E double-glazing glass (Eco glass) It is a type of insulating glass, consisting of glass coated with a special metallic film called Low-E film, which reflects heating heat to increase the heat-retaining effect of the interior.
	Vacuum glass (Eco glass) It is a type of Low-E glass but differs in that the space between the two sheets of glass is a vacuum. It has a higher heat-retaining effect, and has a better insulation effect than Low-E glass because heat transfer hardly occur.

Source: Nippon Sheet Glass Co.

"Double glazing" https://glass-wonderland.jp/cms/wp-content/uploads/2019/05/2021_s02-060.pdf (see 2023-2-1)
"Low-E double glazing glass." https://glass-wonderland.jp/cms/wp-content/uploads/2019/05/2021_s02-052_220418.pdf (see 2023-2-1)
"Ultra-High Insulation Vacuum Glass" https://glass-wonderland.jp/cms/wp-content/uploads/2019/05/2021_s01-016_0928.pdf (see 2023-2-1)

(2) Superiority of thermal insulation technology

As mentioned above, replacing single glazing with double glazing (Low-E glass or vacuum glass) can generally achieve a fourfold improvement in insulation performance. In order to determine whether similar results could be obtained in Uzbekistan, we confirmed the structure and specifications of windows in typical apartment buildings and public buildings during a site visit survey and estimated the thermal transmittance and heat balance when replacing the current window glass with double-glazing glass. As shown in Table 4-4, it was found that the insulation effect almost doubled from 6.4 W/m2-K to 3.5 W/m2-K when double-glazing was used, and almost tripled from 6.4 W/m2-K to 1.9 W/m2-K when low-E glass with higher insulation performance was used, and heat loss was reduced by 210 MW/year and 326 MW/year, respectively (see Attachment 4 for survey details).-

Table 4-4 Estimated thermal transmittance and heat loss due to enhanced window insulation

	status quo	multi-layered glass (e.g., double or triple glazing)	Low-E glass
thermal transmittance	6.4[2]	3.5	1.9
heat loss	463	253	137

Source: Prepared by the JICA study team

Similarly, the thermal transmittance and heat loss of the ceilings and exterior walls were also estimated for the current situation and for the case of insulation reinforcement (blowing insulation material on the ceiling and attaching rigid urethane board to the walls). It was found that the thermal transmittance insulation effect increased from 2.92 W/m2-K to 0.4 W/m2-K, about 7.3 times, when the insulation material was sprayed on the ceiling, and from 2.07 W/m2-K to 0.56 W/m2-K, about 3.7 times, when rigid urethane board was attached to the wall surface, and the heat loss was reduced by 147 MW/year and 346 MW/year, respectively.

Table 4-5 Estimated thermal transmittance and heat loss from reinforced ceiling insulation

	status quo	Blowing insulation on ceiling (100mm)
Thermal transmittance (W/m2-K)	2.92	0.4
Heat loss (MW/year)	170	23

Source: Prepared by the JICA study team

[2]The current thermal transmittance is based on the thermal transmittance of single-layer glass published by the Japan Flat Glass Manufacturers Association.

Table 4-6 Estimated thermal transmittance and heat loss due to enhanced insulation of exterior walls-

	status quo	Rigid urethane board affixed to wall (30mm)
Thermal transmittance (W/m2-K)	2.07	0.56
Heat loss (MW/year)	474	128

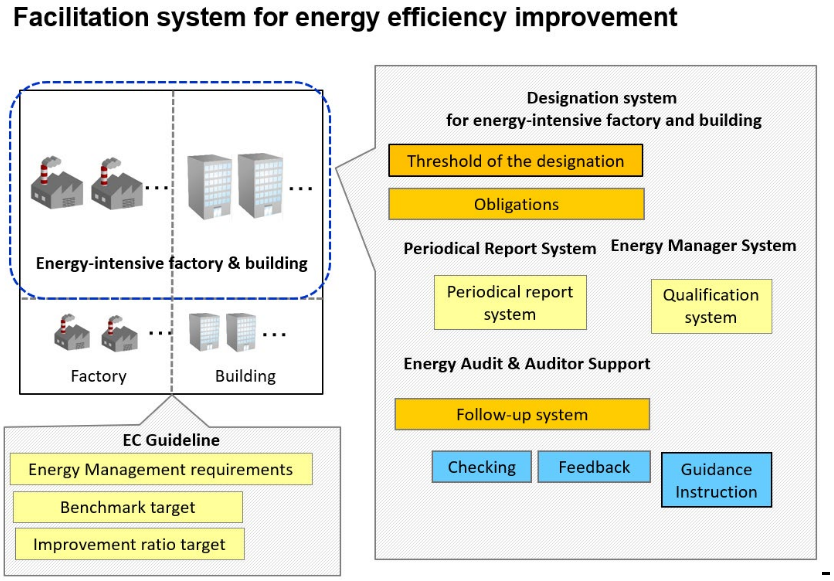
Source: Prepared by the JICA study team

The above estimation results also revealed that the energy-saving effects of insulation reinforcement (double-layered windows, blowing insulation on ceilings, and attaching insulation to exterior walls) are significant in Uzbekistan, so it is highly advantageous to promote insulation reinforcement in the country.

4.2.4 Energy Management (ISO 50001)

(1) Energy management overview

Energy management refers to corporate, individual, and community activities to visualize energy use in corporate offices, buildings, factories, homes, and communities, and to use energy efficiently. Specific activities include the visualization of energy consumption through the introduction of an EMS (Energy Management System), the use of renewable energy, and energy conservation through adopting high-efficiency equipment. For corporate activities in particular, an effective measure is the introduction of ISO 50001 (EMS), an international standard issued by the International Organization for Standardization (ISO) in 2011, which aims to manage and continuously improve the energy used by companies and other entities. ISO 50001 is a standard that specifies the requirements for establishing a management system that enables the systematic implementation of activities to set policies, objectives, and targets; develop plans; establish procedures; and control activities regarding energy use. It aims to improve energy efficiency and other related performance metrics in the system, as a whole, leading to reductions in energy costs and GHG emissions.



Source: Compiled by the Energy Conservation Center

Figure 4-11 The functions required to implement the EMS and promote energy efficiency improvements

As mentioned in Section 3.3 (Industrial Sector) of Chapter 3, no benchmarks or energy manager systems have been implemented in the energy management implementation status, and therefore, the implementation of benchmarks and energy manager systems in the energy efficiency improvement promotion system is required (as shown in Figure 4-11). It is considered to be particularly effective for Uzbekistan to initiate the implementation of the benchmark and energy manager system. Below is an overview of the benchmarks and the energy manager system.-

1) Benchmark

Benchmarking, in this context, is a system that evaluates the energy efficiency and conservation status of businesses using a common index for each industry to promote energy efficiency and conservation efforts with the aim of achieving a target (target standard) for each business.

By setting numerical values, individual factories and buildings can set targets to achieve in order to improve energy efficiency.

As Uzbekistan does not currently have a benchmarking system and has not defined the fields to be benchmarked or the indicators common to the industries, the benchmarks under Japan's Energy Conservation Law are considered, as listed in Table 4-7, with reference to the "Benchmarking System in Japan" (Appendix). The proposed sectors and indicators are listed in Table 4-7. In the steel and cement fields, the number of plants in Uzbekistan is small, so the Japanese figures may be used as a reference.-

Energy efficiency data comparisons in the consultative bodies of companies in each sector are needed to establish benchmark indicator values. In the case of the gas refining and transportation sectors, comparisons can be made for each plant of the same company.

Table 4-7 Target sectors and proposed indicators for benchmarking in Uzbekistan

draft plan for a field	Benchmark Indicator Proposal	Comparative study for benchmarking
gas refining	Energy consumption per refinery volume	Comparative study of each plant in Uzbekneftegaz
chemical fertilizer	Energy consumption per product	Comparative study of various chemical fertilizer plants
vehicle maintenance	Energy consumption per unit serviced	Comparative Study of Vehicle Maintenance Companies
gas transport	Energy consumption per volume transported	Comparative study of each plant in Uztransgaz

Source: Prepared by the JICA study team

2) Energy manager system

The energy manager system is defined in Japan's Act on the Rational Use of Energy as a person who maintains energy-consuming facilities, improves energy use methods, and monitors energy use with respect to the rational use of energy. Energy managers play a central role in understanding energy efficiency and improving energy efficiency in a company. They also assist management responsible for energy efficiency in developing energy efficiency improvement goals, creating improvement plans, and managing energy management organizations.[3]

By designating an energy manager, the government will clarify its direction to the company and who is responsible for providing feedback in the company. Specific energy manager training methods are discussed in detail in Chapter 5.

In Uzbekistan, the energy management systems of businesses are not well established. Therefore, significant energy-saving effects can be expected by promoting energy management through measures such as the benchmarks and energy manager system described above and by promoting energy conservation and renewable energy in the planned activities of each business. Currently, large businesses that are subject to energy audits (diagnostics) are identified in the industrial and energy supply sectors. It would be highly

[3]Article 11 of the Act on the Rational Use of Energy

effective if energy management is implemented starting with large businesses that consume large amounts of energy.

It is also desirable to consider lowering the standard energy consumption in the future and expanding the range of eligible businesses to include medium-sized businesses.

(2) Introduction and effectiveness of energy management

As mentioned above, energy management is a global standard activity that has been standardized by the ISO, and countries are achieving reliable energy savings through the implementation of energy management. In Japan, through thorough energy management based on the Act on the Rational Use of Energy, the actual status of energy conservation activities at businesses has been monitored, and steady improvements in energy efficiency have been implemented by providing guidance to businesses whose energy conservation efforts are judged to be insufficient. As a result, Japan has achieved significant results, including a 40% improvement in energy efficiency over the past 40 years, when GDP has increased by approximately 2.4 times, and has succeeded in achieving both energy conservation and economic growth.

Therefore, it is considered effective as an energy conservation measure to build a stronger energy management system by introducing benchmarks and an energy manager system in Uzbekistan. In particular, the following two measures in Uzbekistan are fostering the groundwork for promoting energy management, and if energy management is promoted in this country, it is expected to be highly effective in conserving energy.

1) Establishment of a comprehensive information system

In implementing energy management, it is important to grasp the actual status of energy consumption. Only by understanding the status of energy consumption, can industries set target levels of energy conservation for each industry and for energy efficiency improvement in each business, and then, the energy manager system can function by establishing benchmarks as described above. In Japan, the energy consumption status of business operators can be ascertained through periodic reports submitted by specified business operators designated under the Energy Conservation Law, etc. In Uzbekistan, the Ministry of Energy (MoE) is also taking the lead in developing a mechanism (comprehensive information system) to monitor the energy consumption status of large-scale businesses. The details of the integrated information system are described in Chapter 7. The system is based on the Presidential Resolution PP4779, which is a plan and measure to improve energy efficiency and a system to collect the energy consumption status of large companies on the consumption side, with the aim of improving the efficiency and quality of energy management. Currently, in Uzbekistan, the energy consumption of enterprises is monitored by the SCS as part of the energy statistics data collection, but the accuracy of the data is poor, and data are not collected by use, such as for heating, boilers, CGS (cogeneration), etc., or by product line, and the information is not sufficient to analyze energy conservation policies (see Chapter 7 for a discussion on energy statistics issues). Therefore, there is a move to develop a comprehensive information system under the MoE lead, separate from the energy statistics of the SCS. The system is currently under development, but once it is fully operational and can accurately assess the energy consumption of large-scale businesses, it will collect information that will serve as the basis for implementing energy management, and could be a catalyst for the spread of energy management.

2) Establishment of a human resources training course in energy auditing (diagnostics) at Tashkent Polytechnic University

A stepping stone to the introduction of the energy manager system was the establishment of a human resources training course in energy audits (diagnostics) at Tashkent Polytechnic University. The course aims to train highly qualified professionals in the field of energy efficiency and conservation in Central Asia and to find a scientific base for this purpose. The course is designed to teach the basics of energy audits (diagnostics) in industry and industrial companies. Specific suggestions for human resource development will be discussed in detail in Chapter 5, but this type of educational institution promoting human resource development for energy audits (diagnostics) could be a facilitating factor for the introduction of an energy manager system.

4.2.5 Conversion of buildings to ZEB/ZEH

(1) Overview of ZEB/ZEH

ZEB/ZEH stands for Net Zero Energy Building / Net Zero Energy House and refers to buildings that aim to reduce the annual primary energy balance they consume to zero while achieving a comfortable indoor environment.

Although energy consumption cannot be completely reduced to zero because of the inevitable human activities in buildings, it is possible to reduce energy consumption to net zero by reducing energy consumption through energy conservation and generating energy for use through energy creation. However, the concept of ZEB is broad, and the energy efficiency of a building is evaluated and defined as “ZEB ready” with energy efficiency increased to 50% or more, “Nearly ZEB” with energy efficiency increased to 75% or more, or “ZEB” with virtually zero fossil energy consumption by renewable energy. Specifically, “ZEB” is defined as a building that uses renewable energy to offset fossil energy consumption to virtually zero. The ZEB concept, along with green certification, is useful as a design goal for buildings and, along with energy conservation obligations in construction, is a powerful means of promoting energy conservation in buildings.

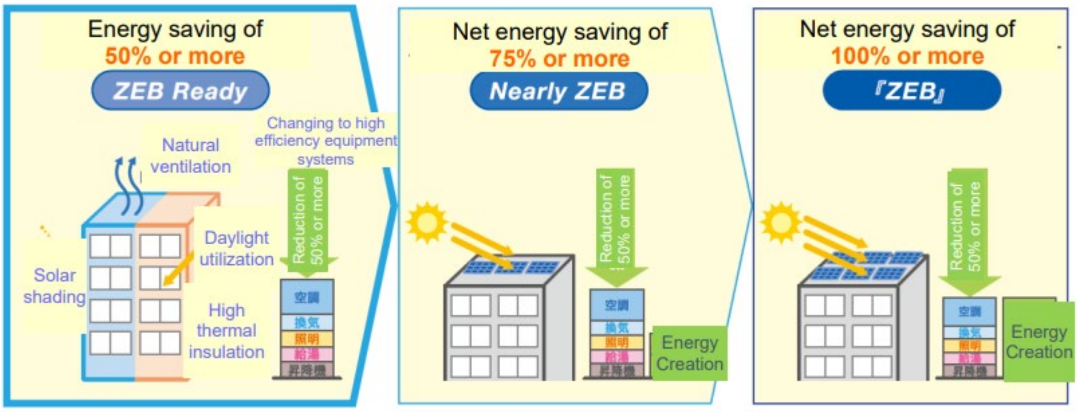


Figure 4-12 Concept of ZEB

Source: METI (Japan)

The results of the field survey in Uzbekistan revealed that the insulation of the buildings was poor. Therefore, as shown in Table 4-8, it is considered realistic to achieve ZEB in stages based on the ZEB concept of maximizing the use of passive technologies—such as insulation, which are relatively easy to introduce—and overlapping active technologies to improve the efficiency of facilities to conserve energy. The shortfall is then covered by the introduction of renewable energy. Regarding the technologies to be introduced in each specific step, it is necessary to introduce the required technologies after diagnosing the building conditions individually. In this study, the case of two buildings of the Gas Public Corporation (HGT: HUDUD GAZ TAMINOT), whose headquarters and branch offices were subjected to a simple diagnosis during the field survey, were used as examples to examine ZEB conversion. The following are specific measures for each step.-

Table 4-8 Direction of ZEB conversion

step	Items for consideration
1	Reinforcement of building insulation Window glass ⇒ Double-glazing, low-e glass, vacuum glass, double-paned windows, plastic sash External walls ⇒External insulation (attaching insulation to external walls), internal insulation (attaching insulation to internal walls) Ceiling ⇒ Attachment of heat insulating material, solar radiation measures
2	Installation of high-efficiency equipment (energy-saving measures for lighting and other energy-consuming equipment) Lighting ⇒ Introduction of high-efficiency LED lighting, appropriate illuminance management (introduction of illuminance control lighting), and Lights off by motion sensors Hot water ⇒ For showers: Solar heat utilization, exhaust heat utilization, heat pump water heater ⇒For beverages: gas stove ⇒ vacuum electric pot
3	Introduction of new air conditioning system a) Cooling system (heat pump) Electric heat pumps (high-efficiency inverter air conditioners (heat pump chillers (water/air-cooled), packaged air conditioners, turbo chillers, screw chillers) Gas heat pump (compressor driven by gas engine) Absorption chillers (heat pumps driven by heat, GENELINK (low-temperature use of waste heat/solar heat) Air conditioning using water vaporization heat Free cooling (e.g., closed-type cooling towers) (b) Heating system Air conditioning with high-efficiency heat pumps Air-cooled heat pump chiller/heater (building circulation with hot water) Packaged air conditioners Gas boiler (circulation by hot water) Solar heating (building circulation of hot water collected by solar heating) Example in Japan: Headquarters of Shizuoka Gas (awarded energy conservation target) (Heat accounts for 67% of the energy used for air conditioning, and Tashkent has only about two weeks of rainfall per year, making it favorable for solar thermal applications.)
4	Use of renewable energy Consider using renewable energy sources to provide the electrical energy that must ultimately be used. In addition, to cope with fluctuating renewable energy, the installation of energy storage facilities will be considered.

Source: Prepared by the JICA study team

Specific measures for each step are described below.

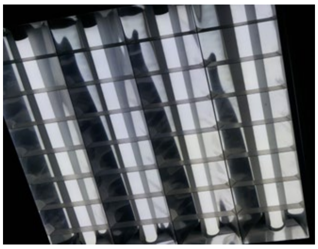
1) Step 1: Reinforce building insulation

Measures to strengthen heat insulation include the application of rigid polyurethane boards to exterior walls, the use of double-glazed windows with vacuum glass, etc., as the windows had single-layered glass. These techniques have already been described precisely in this chapter and are, therefore, omitted in this section.

2) Step 2: Install high-efficiency equipment

① High-efficiency lighting equipment

As LEDs are currently only partly used, LED lighting will be installed in areas where LED lighting is not used, and LEDs with higher energy-saving effects will be installed in areas where LED lighting is used.



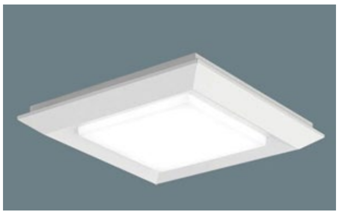


Figure 4-13 Energy-saving measures for lighting facilities (left: Current LED lighting, right: High-efficiency LED (Proof)

② Installation of solar heat supply equipment

Currently, solar and gas-fired hot water systems are used in parallel, but a more efficient solar hot water system will be installed. The possibility of installing a solar hot water system should be considered based on the strength of the roof. If the roof is not strong enough, it is necessary to consider a system in which the heat storage tank is placed separately and hot water is circulated between the heat storage tank and the solar panels.

Figure 4-14 Appearance of water heaters (left: gas water heater, right: solar water heater)

Source: JICA study team photo

3) Step 3: Install a new air conditioning system

Currently, air conditioning equipment accounts for a considerable amount of energy consumption, and it is difficult to achieve ZEB simply by updating to high-efficiency equipment. Moreover, packaged air conditioners are used for cooling and hot water boilers for heating, but heating and cooling systems using renewable energy sources should be considered whenever possible. Therefore, the possible air conditioning systems are divided into cooling and heating systems and organized as follows.

① Consideration of a cooling system

i) Heat pump systems (packaged air conditioners, multiple air conditioners for buildings, heat pump chiller/heaters, etc.)

Currently, the building uses constant-speed packaged air conditioners, with energy-saving labeling level C. By replacing these with high-efficiency air conditioners of the inverter type, a power consumption reduction of 20–30% is expected. However, as they consume a large amount of electricity, they require a large area for the installation of solar panels.

ii) Water vaporization thermal cooling

As a cooling system that uses the vaporization heat of water, it is an environmentally friendly energy-saving facility with a simple structure and does not use refrigerants, such as chlorofluorocarbons. However, the equipment cost is high owing to the large size of the cooler in the water evaporation section, the huge size of the equipment, and the fact that the equipment is not mass-produced. Therefore, in Japan, they are often used for the primary cooling of introduced outdoor air.

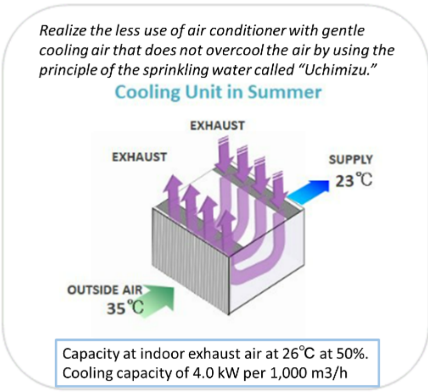


Figure 4-15 Water vaporization heat system cooler

Source: From Earth clean Tohoku Web

② Consideration of heating systems

i) Heat pump system (packaged air conditioner and multiple air conditioners for buildings)

Currently, a gas-fired hot water boiler is used to produce hot water at 50° C, which is circulated through the building. Energy consumption can be reduced to about 1/3, as EER 3.5, if air-cooled heat pump chiller/heaters are replaced. However, unlike gas hot water boilers, they do not function efficiently without having a constant hot water temperature and constant temperature difference. Therefore, we believe it is necessary to create a system that can respond to fluctuations in outdoor air quality by collecting heat with supplemental solar thermal panels.

ii) Use of solar heat

Recently, evacuated-tube solar water heaters are becoming more widespread, making it possible to produce 50° C hot water even in winter. However, as renewable energy is highly variable and it is difficult to provide a stable energy supply, a thermal storage function and a backup function, such as CGS, are necessary.

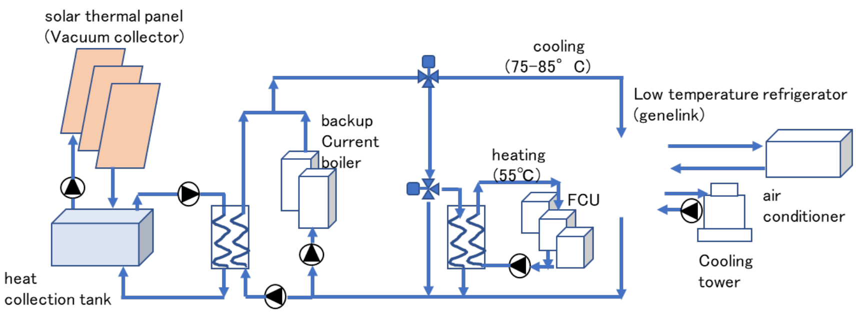
4) Step 4: Use of renewable energy

After strengthening insulation, upgrading to high-efficiency equipment, and converting air conditioning equipment to heat pumps, the power source itself must be converted to renewable energy, and the energy supplied must also be clean in order to ultimately realize ZEB.

Based on the above, the measures necessary to realize ZEB in HGT's head office and branch office buildings, which were the subject of this study, are summarized in Tables 4-9 and 4-10.

Table 4-9 Proposed ZEB measures in the head office building

step	countermeasure item	Specific Methods
1	Building insulation effect	External insulation of exterior walls (30 mm insulation) Roof insulation (50 mm insulation) Window insulation (vacuum glass, low-e glass)
2	Introduction of high-efficiency equipment	High-efficiency LED lighting, solar water heaters
3	Introduction of new air conditioning system	Heat pump chillers, solar panels (heating), water cooling Fan Convector
4	Use of renewable energy	Solar power generation + energy storage system



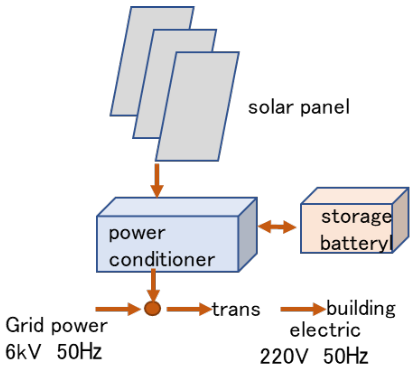
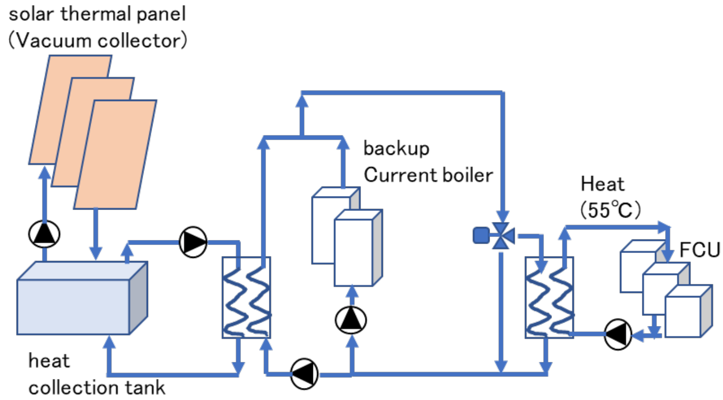


Figure 4-16 Overview of proposed ZEB conversion of headquarters building2

Table 4-10 Proposed ZEB measures at branch offices

step	countermeasure item	Specific Methods
1	Building insulation effect	External insulation of exterior walls (30 mm insulation) Roof insulation (50 mm insulation) Window insulation (vacuum glass, low-e glass) Gap ventilation measures (addition of a windbreak room)
2	Introduction of high-efficiency equipment	No measures (LED lighting has already been installed throughout the building)
3	Introduction of new air conditioning system	Building air conditioner (for cooling) Solar water heater + heat storage tank (for heating) Fan convectors (for heating)
4	Use of renewable energy	Solar power generation (electricity is grid-connected)



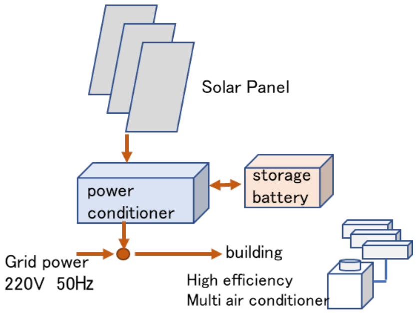


Figure 4-17 Overview of proposed ZEB conversion at branch office

(2) Advantages of ZEB/ZEH

1) Large natural gas reductions

The electricity energy savings for HGT's headquarters and branch offices, which were considered for ZEB conversion in this study, are shown in Tables 4-11 and 4-12 below. ZEB is achieved by reducing thermal and electrical energy by strengthening insulation, installing high-efficiency equipment, and changing the air conditioning system, as well as using renewable energy to cover the electrical energy that cannot be reduced.--

Table 4-11 Effects of ZEB conversion in the head office building

step	countermeasure item	ZEB Effect	
		effect item	Energy (GJ/year)
1	External insulation (walls and roof) Window insulation	Heating energy reduction (heat) Increase in cooling energy (electricity)	759 -45
		subtotal	
2	Hot water heater High-efficiency lighting	Solar thermal panel installation (heat) Introduction of high-efficiency LEDs (electricity)	252 15.3
	subtotal	subtotal	
3	Solar water heater Chilled water heat pump Fan Convector	Heating energy reduction (heat) Cooling energy reduction (electricity) (EER: 1.15⇒ 3.5)	202 330
	subtotal	subtotal	
4	Solar panel installation	Electricity Energy Reduction	441
total			1,954

Source: JICA study team

Table 4-12 Effects of ZEB conversion in branch office buildings

step	countermeasure item	ZEB Effect	
		effect item	Energy (GJ/year)
1	External insulation (walls and roof) Window insulation	Heating energy reduction (heat)	730
3	Solar thermal panels ... Birmingham	Heating energy reduction (heat) Cooling energy reduction (electricity) (EER: 1.15⇒ 3.5)	263 42
	subtotal	subtotal	
4	Solar panel installation	Electricity Energy Reduction	68
total			1, 103

Source: JICA study team

These two buildings were evaluated to see if they could be certified as ZEB according to the Japanese ZEB evaluation method. According to the Ministry of the Environment's website, ZEB is to be assigned to buildings that achieve energy savings of 50% or more of the current energy consumption for buildings with a total floor area of 10,000 m2 or more. Although the buildings do not satisfy the total floor area, the results of the evaluation are shown in Figures 4-18 and 4-19. The headquarters building achieved Nearly ZEB in the third step and satisfied ZEB in the fourth step. The branch office satisfied ZEB Ready in the first step. These figures show that there is a large energy reduction in building insulation, indicating a significant effect. The effect of insulation is particularly noticeable in buildings like branch offices, where thermal energy consumption is greater than electrical energy consumption.

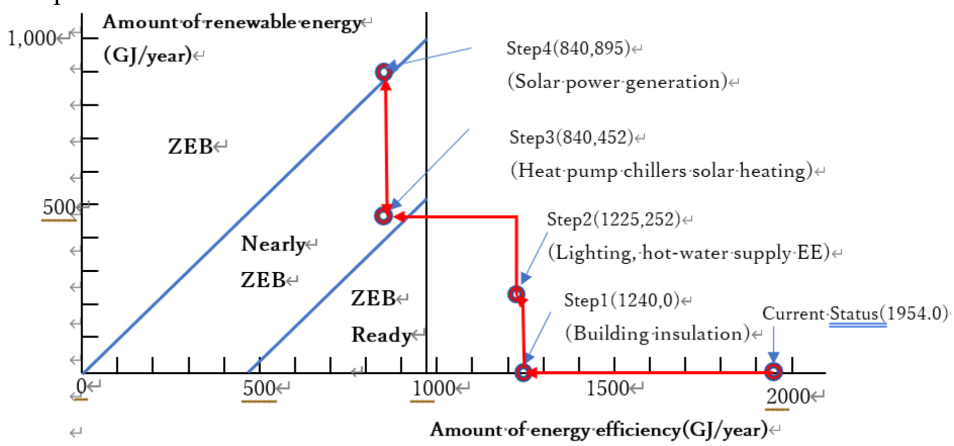


Figure 4-18 ZEB rating of head office building

Source: JICA study team

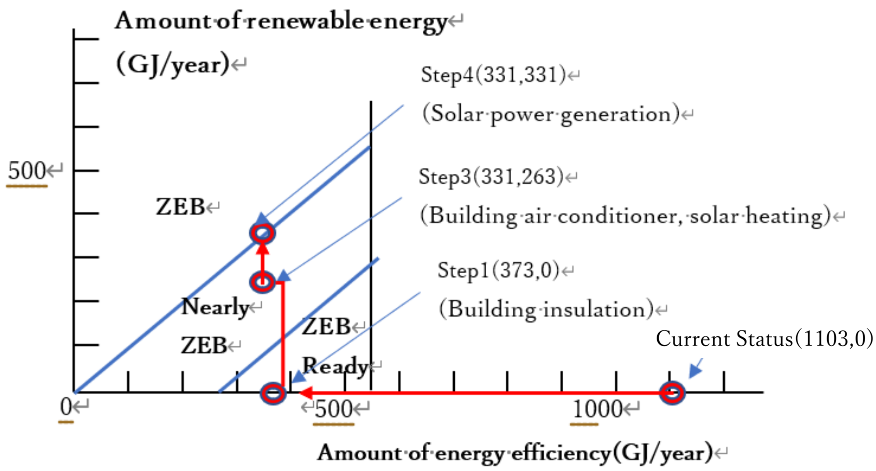


Figure 4-19 ZEB evaluation of branch office (#8)

Source: JICA study team

As mentioned above, in order to promote ZEB, it is necessary to diagnose the condition of each building individually and then implement ZEB conversion measures appropriate for each building. However, as the two HGT buildings surveyed in this study have the typical structure and building specifications of public buildings in Uzbekistan, ZEB conversion is considered possible for other buildings as well. Therefore, the promotion of ZEB in Uzbekistan is highly advantageous for the country, as it is expected to have a significant natural gas reduction effect.

2) Global trends in ZEB promotion

As described in the section on the advantages of heat pumps, the IEA's World Energy Outlook 2022 states that the development and electrification of renewable energy sources, as well as improvements in energy efficiency, will be important milestones for the world to achieve zero emissions by 2050. The goal is to make 50% of existing buildings ZEB ready by 2040, and the conversion of buildings to ZEB is positioned as a global priority.

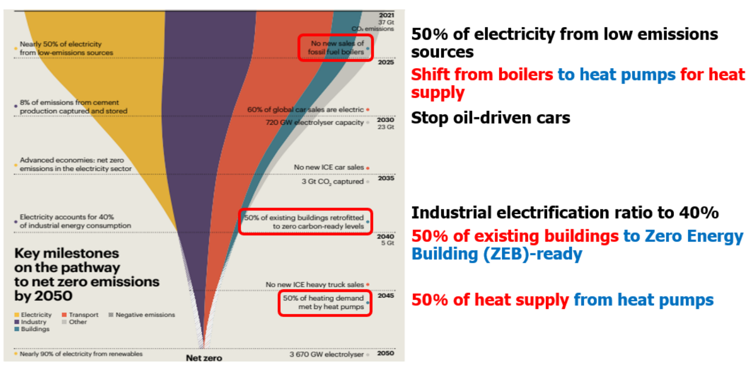


Figure 4-20 Milestones for achieving net zero emissions by 2050 (reiterated)

Source: IEA "World Energy Outlook 2022."

In addition, according to the IEA's Energy Technology Perspectives 2020, unless much of the existing capital stock (home heating systems, cars, aircraft, buildings, transportation infrastructure, industrial equipment, etc.) are retired early (or measures are taken to reduce emissions from those capital stocks), they will continue to be used for decades, resulting in a lot of CO2 emissions. The IEA estimates that cumulative global CO2 emissions by the time the existing capital stock and capital stock currently under construction cease operations will have reached approximately 750 Gt, which exceeds the amount of emissions allowed to achieve net zero emissions by 2050. Therefore, it is important for existing buildings to be retrofitted or renovated for insulation and energy efficiency.

In this way, the IEA also recommends the promotion of ZEB, including for existing buildings, in order to realize a decarbonized society. The promotion of ZEB is a global trend that should be shared by the world. In Japan, the shift to ZEB/ZEH has been progressing rapidly in recent years, and the Ministry of the Environment; the Ministry of Land, Infrastructure, Transport and Tourism; and the Ministry of Economy, Trade and Industry have been playing a central role in the promotion of ZEB/ZEH by creating a roadmap for the spread of ZEB. In this vein, the Japanese public and private sectors collaborated to establish an international standard for Japan's ZEB methodology in order to disseminate it to other countries, and ISO/TS23764 was established in September 2021. It is expected that the technical specifications will be used to promote policies and measures for the spread of ZEB in each country in the future.

In light of this global trend, the conversion of buildings to ZEB is an energy-saving measure that should be actively promoted in Uzbekistan, which has set a goal of reducing GHG emissions by 35% from the 2010 level by 2030.

3) Packaged with renewable energy

The promotion of ZEB is also consistent with the direction of the renewable energy policy promoted by Uzbekistan. The government of the country has set a policy to increase the share of renewable energy to more than 25% by 2030. It is actively promoting the introduction of renewable energy through preferential policies for the introduction of solar and wind power generation facilities, as well as several projects for the introduction of renewable energy with international donor agencies. According to the IEA, Uzbekistan has high potential for renewable energy, of which solar energy has particularly great potential. The gross potential of solar energy is estimated at 2,134 x 103 PJ, which is calculated to be almost four times the country's primary energy consumption in 2022.[4]

Thus, in Uzbekistan, ZEB combined with on-site solar power generation is considered to

[4]IEA "Solar Energy Policy in Uzbekistan: A Roadmap" (2022)

be highly worth promoting.

Table 4-13 Renewable energy potential in Uzbekistan

Renewable Energy Sources	gross potential	technological potential
hydraulic power	385 PJ	8 PJ
wind power	92 PJ	17 PJ
sunlight	2134 × 103 PJ	7411 PJ
geothermal	2805 × 103 PJ	13 PJ
total amount	4940 × 103 PJ	7507 PJ

Source: IEA "Solar Energy Policy in Uzbekistan: A Roadmap" (2022)

4.2.6 Others (Introduction of LED Lighting and the Establishment of Motor Standards)

In addition to the promising technologies mentioned above, other technologies that may be effective in promoting energy conservation include the introduction of LED lighting and the regulation of standards for industrial motors. As these technologies have not been investigated or examined in detail in this study, a brief overview of the technologies concerned and their applicability to Uzbekistan will be provided.

(1) Introduction of LED lighting

LEDs, or Light Emitting Diodes, are said to consume about 20% of the power of incandescent bulbs, 30% of fluorescent bulbs, and 25% of mercury lamps, so energy savings can be expected by replacing existing non-LED bulbs or LEDs with higher energy-saving performance.

In addition, LEDs have a lifespan of more than 20 times longer than incandescent bulbs and three times longer than fluorescent bulbs, require fewer replacements, and reduce CO2 emissions from manufacturing and sales, which is why they are becoming increasingly popular worldwide as the movement toward decarbonization accelerates. Globally, LED sales have increased significantly in recent years, from a market share of about 5% in 2013 to more than half of global lighting sales in 2021.

Under this trend, the Minimum Energy Performance Standard (MEPS) framework, which defines minimum energy consumption efficiency standards in Uzbekistan, has been introduced in 2016 for home appliances. It covers 18 product groups, including washing machines and refrigerators, as well as lighting and air conditioners. MEPS is combined with a labeling program based on an A–G class rating system, with A being the most efficient and G being the least efficient.

Uzbekistan national government banned the sale of incandescent lamps of 40W or higher in 2017 and banned the import and sale of household appliances of rank G, F, and E from 2017, 2018, and 2019, respectively; in Presidential Resolution PP4422, it stipulated that D-class appliances shall also be subject to a ban on sale and import starting from 2019, and inefficient equipment are introduced to be phased out.

Efforts to promote LEDs are also underway, with public buildings constructed after 2020 required to install energy-efficient gas heating systems and lighting systems with sensors integrated with LEDs.

Thus, the introduction of LEDs is in line with the policy of Uzbekistan, and as the government of the country is voluntarily promoting the spread of LEDs, it is desirable to promote energy conservation by further improving the environment, including strengthening labeling regulations and raising awareness through public relations activities.

(2) Introduction of motor standards regulations

Motors are used in various types of equipment in the industrial sector, such as pumps, compressors, and blowers, and according to IEA statistics, 46% of the world's electricity is consumed by electrical machinery or electric motors. Therefore, a large energy-saving effect can be expected by promoting the spread of high-efficiency electric motors.

Motor efficiency is specified by the International Electrotechnical Commission (IEC) in IEC60034-30 as one of four classes: IE1: standard efficiency, IE2: high efficiency, IE3: premium efficiency, and IE4: super efficiency. However, it is possible to reduce energy costs by increasing the efficiency of motors. For example, as shown in Figure 4-21, if a motor with 11 kW output is used for 15 years with 4000 operating hours each year, the life cycle cost is 96.7% of the operating cost (electricity price) and about 2.3% of the initial cost (purchase price), so the longer the motor is operated, the more the electricity price accounts for most of the cost. The higher the energy saving effect is manifested, the greater the economic benefit will be.-

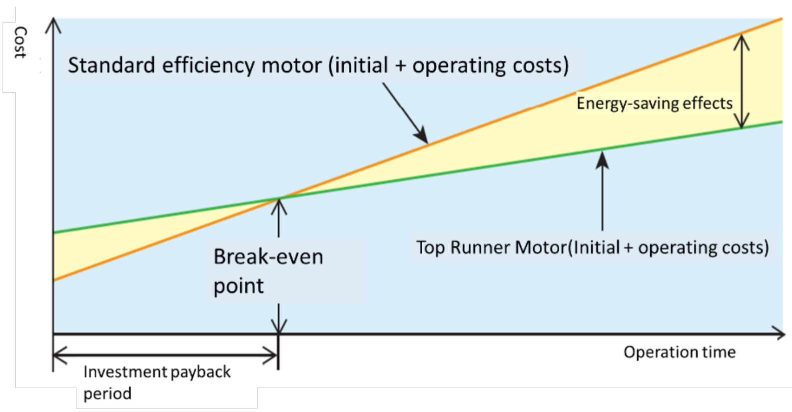


Figure 4-21 Comparison of economic efficiency between standard efficiency motors and high

efficiency motors-

Source: "Top Runner Motors for Global Environmental Protection and Energy Conservation," Japan Electrical Manufacturers' Association https://www.jema-net.or.jp/jema/data/S5238(20211220).pdf (2023 See -2-1)

As mentioned in Chapter 3, as Uzbekistan has not introduced energy performance standards for industrial equipment, such as pumps and motors, it would be effective to introduce international standards from the IEC and prohibit the use of motors with IE2 or lower.

4.3 Applicability of Japanese Technology to Energy Saving Measures

The product areas discussed in this chapter, such as high-efficiency air conditioners, heat pumps, and double-glazing glass, are all areas in which Japanese companies hold the top share of the global market and are world leaders in energy-saving technology, but Japan's presence in the Uzbekistan market is not strong. For air conditioners and other home appliances, in addition to local companies, such as ARTEL, many imports come from China, Korea, Turkey, and other countries. In Uzbekistan, the high quality and performance of Japanese products are well recognized, and even slightly higher prices appeal to the wealthy, but they lose their presence in the volume zone where the public is motivated to buy. With the outbreak of the war in Ukraine, Russia's influence has been reduced, and the Central Asian region has become a kind of vacuum zone, which can be seen as an opportunity for Japanese companies to enter Uzbekistan.

Below is an overview of the Uzbekistan market for high-efficiency air conditioners, heat pumps, and double-glazing glass.

(1) High-efficiency air conditioner

The market size of room air conditioners in Uzbekistan is about 230,000 units per year (half of which are estimated to be sold in Tashkent), 85% of which are non-inverter types. Chinese manufacturers, such as GREE, and Korean manufacturers, such as Samsung and LG, dominate the market, while ARTEL, a local company, is a major player in the heating and cooling business. If energy-saving awareness among buyers increases as the labeling system becomes more widespread, Japanese products with superior inverter technology and higher quality can be expected to increase their market share. Among the Japanese manufacturers, Daikin, which was used as a test machine in the demonstration test of inverter air conditioners in this study, is active with a sales agency agreement with a local company in Uzbekistan. Although other manufacturers, such as Panasonic, Mitsubishi Electric, and Hitachi, can be found on the e-commerce webpage of Uzbekistan, we could not find any Japanese products on display at the electronics retail stores that we visited during our field work in Tashkent.

Figure 4-22 Air conditioners on display at an electronics retailer in Tashkent (above)

Figure 4-23 Exhibits at Daikin distributors in Tashkent (below)-

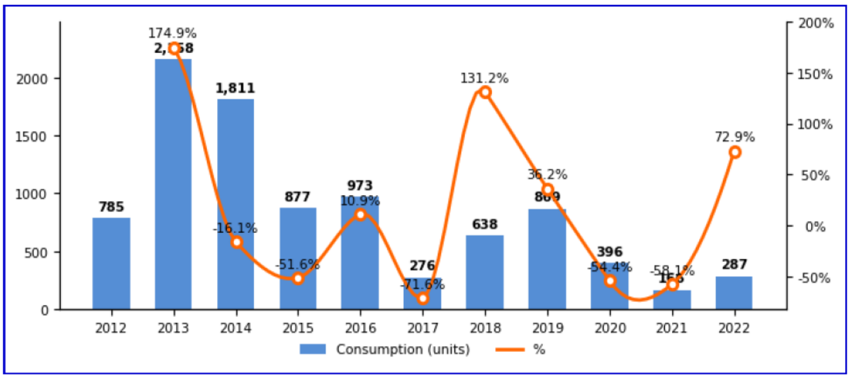
(2) Heat pump

The global heat pump market was valued at US$6.04 billion in 2020 and is expected to continue to grow at a rate of nearly 10%. However, in Uzbekistan, according to statistics using AI, a private research company, the number of heat pumps sold, other than air conditioners, was 396 units in 2019 before Covid-19, with a market value of US$900,000. The figure is very small because it does not include air conditioning units, which are considered to be primarily for hot water heating purposes. According to the firm's machine learning-based forecasting model, the compound annual growth rate (CAGR) of the market until 2030 is 4.0%.

As Uzbekistan has no domestic production of heat pumps, it relies entirely on imports, with the main import sources being France (48%), China (30%), Luxembourg (17%), and Turkey (6%) in terms of volume in 2022. In value terms, France accounted for 62% of total imports at US$517,000. Luxembourg is in second place with US$141,000 (17%), followed by China and Turkey.

Japanese manufacturers, such as Daikin, Panasonic, and Mitsubishi Electric, are increasing their presence in the Western market as global players. In particular, in recent years, these companies have been strengthening capital investment in Eastern Europe with the aim of expanding the European market and may also consider expansion into Central Asia via Eastern Europe.

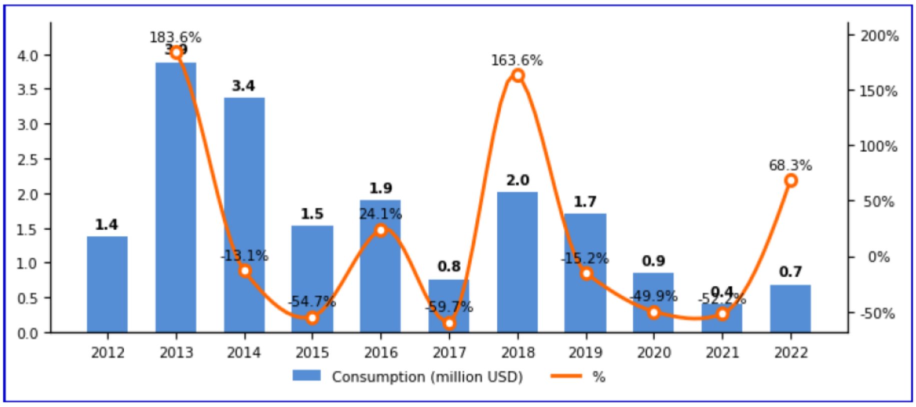
(units, % y-o-y)



Source: *IB AI Platform*

Figure 4-24 Sales of heat pumps in Uzbekistan

(million USD, % y-o-y)



Source: *IB AI Platform*

Figure 4-25 Sales of heat pumps in Uzbekistan

(3) Multi-layered glass (e.g., Double or triple glazing)

Four of the top 11 companies in the glass industry are Japanese companies. The top company in the world is AGC, which holds 2.9% of the global market share, followed by Saint-Gobain (France) in second place and Corning (US) in third; in fourth place is Nippon Sheet Glass, which has acquired Pilkington (UK) and is seeking overseas market expansion.

A search for "glazing" on the Green Technology Selector—an online shopping-style platform offered by the European Bank for Reconstruction and Development (EBRD) under the Green Economy Financing Facility (GEFF)—returns 307 products from 15 companies. Seven of these companies are from Ukraine; 184 products are made there. Twenty-two domestic Uzbekistan products are registered by IMZO (c), while 12 foreign products are registered by Guardian (U.S.) and 11 by Saint-Gobain (France). From Japan, Nippon Sheet Glass has registered five products under the Pilkington brand name. However, Japan's latest Low-e double glazing products are not registered.

Source：deallab.info/glass-industry/

Figure 4-26 World market share of the glass industry

Source: deallab.info/glass-industry/

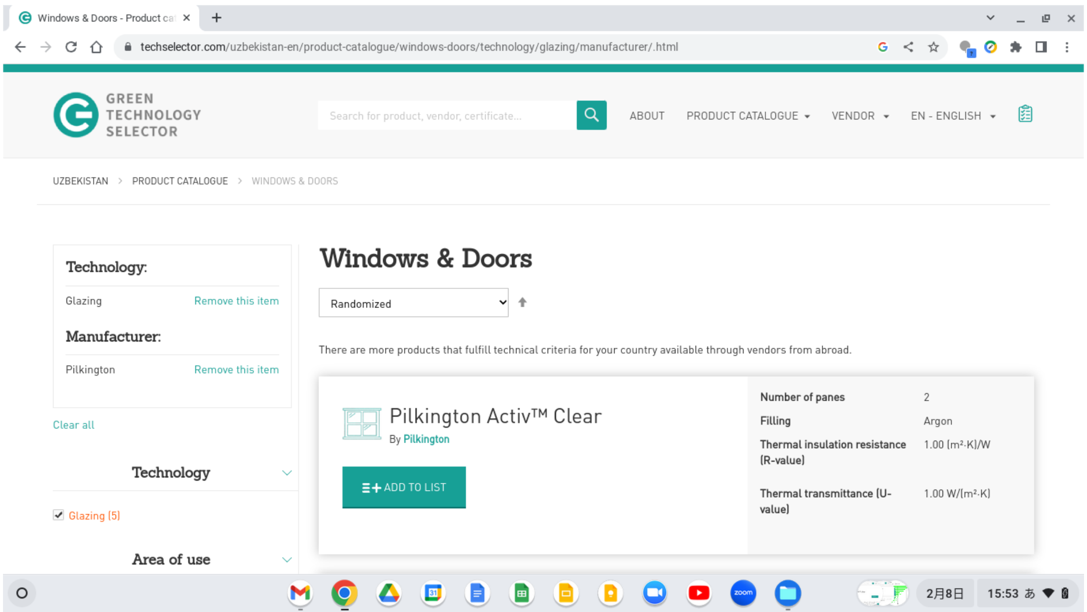


Figure 4-27 Green technology selector search screen for Nippon Sheet Glass (Pilkington)-

Source: JICA study team

Table 4-14 Number of flat glass products registered in the green technology selector

Manufacturer	country	Number of products
Glas Trösch	Ukraine	144
StekloMir	Kazakhstan	41
IMZO	Uzbekistan	22
Gurdian Glass	USA	21
Sisecom Glat Glass	Turky	19
Stekloplast	Ukraine	16
PARITET	Ukraine	12
SAINT-GOBAIN GLASS	France	11
Pilington	Japan	5
Climascrceen	Ukraine	4
Vikonda	Ukraine	4
Ekran Viknovit	Ukraine	3
Stark.	Armenia	3
Vesnyanka	Ukraine	1
Строй Дизайн PV	Kazakhstan	1
total amount		307

Source: JICA study team

(4) Towards the development of Japan’s technologies

Uzbekistan's status as a doubly landlocked country means that it is surrounded by other landlocked countries, making it necessary to cross two borders in order to reach the sea. As a result, trade with foreign countries is mainly reliant on road and rail transportation, with air transportation being the exception. This limitation in transportation options not only restricts the volume of trade, but also results in higher transportation cost. For example, relatively heavy products such as air-conditioners are usually transported from Turkey by truck on the road. There is no option for rail transport from Turkey, and air transport is rarely undertaken due to high costs. In addition, tariffs are extremely high in Uzbekistan, when importing overseas products of the same type as those supplied by domestic manufacturers such as ARTEL. This is one of the obstacles faced by foreign manufacturers in developing their technologies in this country.

The high quality of Japanese technology and products is also recognized in Uzbekistan. It is therefore desirable to overcome factors affecting product prices, such as transport costs and high tariffs, and to provide products that can be purchased by the general public. To achieve this goal, it is inadequate for overseas manufacturers to sign distributorship agreements with local companies in Uzbekistan and then export their products. Instead, it is considered essential to establish production locations by forming joint ventures with local companies, make aggressive capital investments and increase their presence in the Central Asian market.

Chapter 5 Creating an Environment Conducive to Energy Conservation

Chapter 4 presented the promising technologies applicable to Uzbekistan to promote energy conservation, but institutional, financial, human, and organizational environment improvements are also needed to promote the diffusion of these technologies. Therefore, this chapter examines the institutional, financial, human, and organizational improvements necessary to promote energy conservation.

5.1 Tighter Government Energy Conservation Regulations (Labeling Regulations for Domestic and Imported Products and Mandatory Insulation)

5.1.1 Tighter Energy Conservation Standards and Labeling Regulations

The energy conservation standards and labeling set for energy-consuming equipment, such as air conditioners, have been effective in raising consumer awareness and prohibiting the sale of low-efficiency products. As mentioned in Chapter 2, Uzbekistan has started an energy efficiency labeling system in 2016, and encouraging the purchasing of new high-efficiency equipment while further promoting the labeling system is necessary.

Table 5-1 below shows the EU's energy-saving labeling standards for air conditioners. Uzbekistan follows the EU's standards, that is, products are classified from G to A+++. Comparing the performance of the A and A+++ classes, a calculated energy saving effect of about 30% can be expected. As mentioned in Chapter 3, a survey of households was conducted to determine the current state of energy efficiency in the residential sector; it revealed that Class A products will be the mainstream in 2021–2022, an improvement over the B–C products that were the mainstream five years ago. The goal should be to improve this to A++ or higher in the future.

Table 5-1 Energy efficiency classes for air conditioners

Energy efficiency classes for air conditioners

Energy Efficiency Class	SEER	SCOP
A+++	SEER ≥ 8,50	SCOP ≥ 5,10
A++	6,10 ≤ SEER < 8,50	4,60 ≤ SCOP < 5,10
A+	5,60 ≤ SEER < 6,10	4,00 ≤ SCOP < 4,60
A	5,10 ≤ SEER < 5,60	3,40 ≤ SCOP < 4,00
B	4,60 ≤ SEER < 5,10	3,10 ≤ SCOP < 3,40
C	4,10 ≤ SEER < 4,60	2,80 ≤ SCOP < 3,10
D	3,60 ≤ SEER < 4,10	2,50 ≤ SCOP < 2,80
E	3,10 ≤ SEER < 3,60	2,20 ≤ SCOP < 2,50
F	2,60 ≤ SEER < 3,10	1,90 ≤ SCOP < 2,20
G	SEER < 2,60	SCOP < 1,90

Source: EU energy labelling

As the renewal cycle for equipment such as air conditioners is expected to be about 10 years, raising the energy efficiency standards for new purchases can be expected to produce significant energy savings in about 10 years. In addition, the use of air conditioners is increasing in Uzbekistan; therefore, further strengthening energy conservation standards is important.

To strengthen energy efficiency standards, it will be important to subsidize equipment with higher energy efficiency classes and to strengthen the government's certification and testing laboratory system as well as its capacity to improve the accuracy of energy efficiency labeling values, which will be discussed in detail in this chapter, in section 5.5.

It is important to promote the purchase of equipment with higher energy efficiency classes, while at the same time prohibiting the sale or importation of equipment with lower standards. Currently, in Uzbekistan, as discussed in Chapter 2, the sale and import of Class D equipment is prohibited, and it is desirable to expand the scope of similar regulations.

5.1.2 Stricter Insulation Regulations

The Ministry of Construction (MoC) of Uzbekistan explained that it has introduced high thermal insulation performance standards for new homes. However, as noted in Chapter 2, it was difficult to confirm compliance with specific numerical and global standards. In the future, when considering the promotion of net zero energy buildings (ZEB), global standards should be introduced for the evaluation of insulation performance of the building envelope, in addition to the energy efficiency standards for air conditioners as described in section 5.1.1. Perimeter Annual Load (PAL) and Overall Thermal Transfer Value (OTTV) are used to evaluate the insulation performance of the building envelope. In Japan, PAL is applied to non-residential buildings, but it requires very complicated calculations. In contrast, OTTV—an indicator of the thermal performance of the building envelope proposed by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)—can be calculated relatively easily. OTTV has been introduced in Singapore and many other countries in Southeast Asia, and the introduction of OTTV in Uzbekistan should be considered.

5.2 Abolition of Low Tariff and Inducement Policy for Natural Gas

A major impediment to energy efficiency for consumers is government subsidies for natural gas and pricing mechanisms.

Table 5-2 Comparison of main energy retail unit prices (tariffs) on a heat rate basis5-2

For single-family homes, gas is priced at 10.03 UZS (0.0009 USD) /MJ compared to 81.94 UZS (0.0072 USD) /MJ for electricity, making the gas tariff on a calorific value basis very low, less than 1/8th of the electricity tariff. Energy tariffs cannot be compared side-by-side because they include primary to secondary energy conversion efficiency and transmission and distribution costs. In particular, for electricity tariffs, when the power source composition is mainly thermal power generation, a power generation efficiency of 33% is about three times higher than that of fossil fuel-based secondary energy, when compared on a calorific value basis. Even discounting this, it can be said that the gas tariffs in Uzbekistan are set unusually low. For example, assuming that the energy consumption efficiency (COP) of a heat pump is 3.0 and the efficiency of a gas boiler is 80% relative to the higher heating value, the ratio of the electricity rate to the gas rate is 81.94/3/ (10.03/0.8) = 2.17.

For commercial buildings, a similar calculation yields 125.0/3/ (17.42/0.8) = 1.91, which is still about 1/2 the cost of electricity for gas. It is clear that these very cheap gas tariffs are discouraging consumers from upgrading to energy-efficient equipment.

Meanwhile, the unit price of the hot water tariff for district heat supply on a calorific value basis is 1/2.6 to 1/3.2 of the electricity tariff, and if the efficiency of electricity dispatch is 35% and the energy efficiency of the heat supply system is 70%, the ratio of electricity to hot water tariff is 1/2 using simple calculation. Although slightly cheaper for regional hot water, the rates are considered to be mostly reasonable.

In addition, when converting electricity tariffs into Japanese yen, 295 UZS (0.0260 USD)/kWh for consumer use is 3.4 yen/kWh and 450 UZS (0.0396 USD)/kWh for industrial use is 5.25 yen/kWh, which means that they belong to the lowest electricity tariff group in the world, but they are not abnormally low.

By reviewing the very low pricing of these natural gas tariffs, policies may be needed to encourage consumers to purchase energy-efficient equipment and direct them to energy-efficient electricity.

Table 5-2 Comparison of main energy retail unit prices (tariffs) on a heat rate basis

	energy source	Energy Retail Price (Tariff)	Heat-based energy unit price (UZS (USD)/MJ)
detached house	electricity	295 UZS/KWh	81.94 (0.0072)
	natural gas	380 UZS/m3	10.03 (0.0009)
housing complex	electricity	295 UZS/KWh	81.94 (0.0072)
	natural gas	380UZS/m3	10.03 (0.0009)
	district heating	131 UZS/Mcal	31.29 (0.0028)
Business Building	electricity	450 UZS/KWh	125.0 (0.0110)
	natural gas	660 UZS/m3	17.42 (0.0015)
	district heating	162 UZS/Mcal	38.7 (0.0034)

Source: JICA study team

*Calculation conditions

- Natural gas calorific value (high): 37.89 MJ/m3, IEA Natural Gas Information 2022 Edition/Database Documentation
- Heat value of electricity: 3.6 MJ/KWh
- Gas and electricity tariffs are based on IEA Uzbekistan 2022 Energy Policy Review
- Unit heat value of district supplied hot water: Converted to heat value assuming a temperature difference of 40°C for a hot water price of 5242 UZS/m3 (apartment building) and 6480 UZS/m3 (commercial building).
- The METI report has the unit heat rate for 2018 at 100 sUZS/Mcal, which is the same level as the projected rate of increase.
- The currency unit (UZS) is converted to USD using the Central Bank rate of Uzbekistan as of 31 January 2023 (1 UZS = 0.000088 USD).

5.3 Consideration of Introducing Incentives for Energy Conservation Promotion

5.2

Therefore, in this section, we examine the financial incentives necessary for consumers to make the initial investment in energy conservation, that is, the initial investment required to implement energy conservation measures, such as adopting high-efficiency equipment and reinforcing insulation. Specifically, the economic feasibility of investing in energy conservation under the current energy unit price was evaluated, and for investments that were determined not to be economically rational, the necessity of subsidies to change the energy unit price or to ensure economic rationality was examined. We then organized and discussed what kind of incentive system would be needed if assistance were required.

5.3.1 Economic Evaluation of Energy Conservation Investments

(1) Economic evaluation methods

In this section, we will evaluate the economics of consumers' energy-conserving investments. In the analysis, in order to promote energy-conserving investments, especially in the consumer sector (residential sector and commercial buildings sector), which has high energy use, we conducted an economic evaluation of the promising technologies presented in Chapter 4, namely, high-efficiency air conditioners, heat pump water heaters, and thermal insulation reinforcement in the residential sector. In addition, in the commercial building sector, an economic evaluation was conducted as a comprehensive package of ZEB. As a result, for investment targets that were determined not to be economically rational, some kind of fiscal policy was considered necessary for the need to promote them from the perspective of energy efficiency and conservation benefits. Therefore, estimates were also made regarding the degree of price change and the degree of subsidy required if the energy unit price is changed and the government provides fiscal incentives. The assumptions used in the calculations are as follows.

- The economic evaluation was conducted using the Simple Payback Period.
- The payback period was determined by the following equation

  Payback period = investment in energy conservation ÷ energy conservation benefits
- Investment in energy conservation is the amount of initial investment costs incurred in implementing energy conservation measures, such as replacing existing equipment with high-efficiency equipment and strengthening insulation. Considering the service life of the existing equipment, it shall be replaced with high-efficiency equipment at the time of its renewal. The price difference between high-efficiency equipment and existing equipment is used as the investment cost for energy conservation.
- As there are two patterns of heat utilization for heating and hot water supply: a) using independent boilers for each building and b) supplying heat from the district heat supply, the study was divided into two patterns.
- In case a) above, replacement with a high-efficiency air conditioner is defined as the price difference between replacing a gas boiler with a high-efficiency air conditioner for heating applications and replacing a low-efficiency air conditioner with a high-efficiency one for cooling applications. In case b), as district heat supply constitutes social infrastructure, and no investment cost is incurred by consumers, the entire installed price of the equipment when replaced with high-efficiency air conditioners is used as the investment cost for energy conservation.

- For water heaters, in the case of a), the price difference when replacing a gas boiler with a heat pump water heater, and in the case of b), for the same reason as above, the entire equipment installation price when replacing a heat pump water heater is used as the energy efficiency investment cost.
- For insulation reinforcement, the entire cost invested is considered as the investment cost for energy conservation, including the price difference for replacing low-insulation glass with high-insulation glass and the new, additional cost for attaching insulation to walls and ceilings. The cost per square meter of insulation reinforcement was calculated as the initial investment cost.
- The prices for high-efficiency air conditioners were applied to the general market prices in Uzbekistan obtained from the market survey conducted in this study. However, as heat pump water heaters and insulation materials are not available in Uzbekistan, the sales prices for those in the Japanese market were used as reference.
- The energy conservation benefit is the accumulated amount of reduction in utility costs (electricity, gas, and hot water rates) per year and it was calculated by the following equation:

  The energy conservation benefit = Annual utility cost before the investment in energy conservation (Amount of annual energy consumption x Energy unit price) – Annual utility cost after the investment in energy conservation (Amount of annual energy consumption x Energy unit price) .
- If the heat that a user can get is comparable in terms of heating and cooling, the existing equipment was compared to the high-efficiency equipment per room in the building (amount of annual energy consumption, price). In other words, one unit of an existing gas boiler (heating) and one unit of a low-efficiency air-conditioner (cooling) were compared to one unit of a high-efficiency air-conditioner (heating and cooling). Since a gas boiler is generally used to supply both heat and hot water, one-third of the price of the gas boiler is used as the price of heat when comparing only the heat.
- The following pre-requisites are used to calculate the annual energy consumption:
  - Heat efficiency of gas boiler: 0.7 (already set), 0.9 (newly set)
  - Heat loss from radiator: 0.2, heat efficiency of radiator: 0.8
  - Primary energy conversion: 3.6 MJ/kWh、4.2 MJ/Mcal
  - Heat from natural gas: 34.2 MJ/m^3
  - A gas boiler, district heat supply, and heat pump water heater that have the comparable heat level of 17 GJ/year are used to compare to calculate the energy consumption for hot water supply.

- Heating is assumed to be used in the winter for 4 months, and the amount of energy consumption per 1 m^2 for 4 months during the winter is calculated to evaluate the effectiveness of reinforcement of insulation.

- Cooling is assumed to be used in the summer for 3 months.
- Under the above prerequisites, the results of the amount of annual energy consumption under each energy conservation measure（m^3/y: Natural gas, kWh/y: Electricity, Mcal/y: Hot water）are shown in Table 5-5.
- By focusing on the two HGT, HUDUD GAZ TAMINOT buildings inspected in the field survey that was conducted to study the potential of ZEB, the economic evaluation of ZEB is based on the investment required to convert each building to ZEB and the resulting reductions in gas and electricity consumption as energy-conserving investments and benefits. Details on the cost-effectiveness of ZEB are provided in Attachment 7.
- The discount rate is not considered in the cash flow obtained from future energy conservation benefits.
- Currency units were converted to USD using the rate of the Central Bank of the Uzbekistan as of January 31, 2023 (1 UZS = 0.000088 USD).
- The service life was set based on the average number of years of use based on the results of consumption trend surveys and other surveys in Japan. As the reference service life for attaching insulation to ceilings and exterior walls was not clear, it was set at 30 years, the same as that for window glass. For ZEB, 50 years was set as the general actual service life of the building.

Energy conservation		(Machine's) service life
High-efficiency air conditioner		15 years
Water heater		15 years
Thermal Insulation Enhancement	Insulating glass (Low-E glass)	30 years
	Attachment of insulation to ceiling and exterior wall surfaces	30 years
ZEB		50 years

(2) Assessment results

1) Economic efficiency of various energy-conserving investments

Under the above conditions, we conducted an economic evaluation of the replacement of low-efficiency air conditioners with high-efficiency ones, gas boilers with heat-pump water heaters, and existing windows with double-glazing ones, as well as the reinforcement of insulation by attaching heat insulating materials. Summary of the economic evaluation and the details of calculation are shown in Table 5-3, Table 5-4 and Table 5-5.

In the case of a change from a gas boiler and a low-efficiency air conditioner, the investment cost is lower to replace the gas boiler and low-efficiency air conditioner with a high-efficiency air conditioner that provides heating and cooling in a single unit, therefore, the price difference of replacement with a high-efficiency air-conditioner was negative (-28 USD). Although heating by gas boiler (winter-time) and cooling by low-efficiency air-conditioner (summer-time) are mainly used at this moment, it is possible to gain the energy conservation benefit and reduce the initial investment cost by converting to high-efficiency air-conditioners for heating and cooling. As a result, the payback period is minus 2.1 years. In the case of the switch from district heat supply, the payback period was 3.4 years. Assuming that the useful life of the air conditioners is 15 years, the results show that in both cases the investment payback is realized within the useful life.

The replacement of gas boilers with heat pump water heaters resulted in no return on investment owing to the lack of energy efficiency benefits, while switching from district heat supply to heat pump water heaters showed 184.6 years.

As the unit energy cost of gas is very low in Uzbekistan, switching from gas boilers to heat pump water heaters shows a negative energy conserving benefit. With the current conversion efficiency, the difference in energy bills cannot be made up by improving equipment efficiency alone. For gas boilers, the annual energy bill will still be lower, making it difficult to recoup the investment. In such cases, even if the government grants full subsidies for the equipment installation costs, consumers will not be able to enjoy economic benefits, even if the equipment is energy-conserving. To ensure the economic rationality of heat pump water heaters, it will be necessary to change the pricing of the unusually low energy unit price for natural gas.

The payback period for insulation reinforcement was found to be 31.3 years for the conversion to double-glazing (Low-E) glass and 12.5 years for the application of insulation to walls and ceilings, both within the useful life of the building.

The payback period for converting the gas utility buildings surveyed on ZEB for the HGT, HUDUD GAZ TAMINOT was 39 and 99 years, respectively. If the useful life of a ZEB is 50 years, the result is that the HGT, HUDUD GAZ TAMINOT's branch offices can invest, but the HGT, HUDUD GAZ TAMINOT's headquarters will not be able to recover its investment within the useful life of the ZEB. Although the payback period will vary depending on the building to be converted to ZEB, it can be said that without some financial measures, ZEB conversion through investment by businesses may not become widespread.

However, if the government invests in ZEBs, and the income from exporting the natural gas reductions obtained from the investment is viewed as an energy conservation benefit, the payback period is 10 to 23 years, allowing for payback within the useful life of the project. Therefore, the government will need to make policy decisions on whether to grant subsidies and other financial measures to developers, or whether the government itself will make investments to promote ZEB conversion. The economic evaluation in the case of government investment will be discussed in detail in Chapter 6. In order to consider the introduction of incentives such as subsidies to businesses in energy conservation investments that result in no economic rationality, the extent of the subsidies required will need to be discussed, which will be done in the following section.

Table 5-3 Economic evaluation of each energy-saving measure

Energy conservation measure	Improvement plan	Investment in energy conservation (USD)	Energy Saving Benefit (USD)	Simple investment Payback period (Year)	Possibility of investment payback
Heating and cooling efficiency improvement	Gas boilers and low-efficiency air conditioners → high-efficiency air conditioners	-28	13	-2.1	Yes
	District heat supply, low-efficiency air conditioners → high-efficiency air conditioners	132	39	3.4	Yes
Hot water supply efficiency improvement	Gas Boiler → heat pump water heater	1,672	-11	No return on investment expected	No
	District heat supply →. heat pump water heater	2,288	12	184.6	

Thermal Insulation Enhancement	Single Layer Glass -> Conversion to multi-layered glass (Low-E)	55	2	31.3	Yes
	Installation of insulation in ceilings and exterior walls	8	0.6	12.5	Yes
ZEB	Gas Public Corporation ① (Head office) Above measures + introduction of renewable energy (see Attachment 7 for details)	422,590	4,235	99.8	No
	Gas Public Corporation (2) (Branch office) Above measures + introduction of renewable energy (see Attachment 7 for details)	78,630	2,036	38.6	Yes

Source: JICA study team

Table 5-4 The detailed results of the calculations for economic evaluation of each energy-saving measure5

			Price（USD）		Annual energy consumption		Energy unit cost		Annual energy cost		Annual cost savings		payback period	
energy-saving measures	Form of supply	Current (upper, middle)、After (bottom)		Price difference	Total	Unit		/Unit		Unit		Unit		Unit
Air conditioning	Individual gas boiler	a.Boiler（heating）	160	c-(a+b)	505.3	m3	0.0334	USD/m3	17	USD	(a+b)-c			
		b.Low-efficiency air conditioners (cooling)	572		936.0	kWh	0.0260	USD/kWh	24	USD		USD	-2.12	year
		c.High-efficiency air conditioners (cooling & heating)	704	-28	1,080.0	kWh	0.0260	USD/kWh	28	USD	13			
	District heat supply	a.District heat supply（heating）	0	c-(a+b)	3,702.9	Mcal	0.0115	USD/Mcal	43	USD	(a+b)-c			
		b.Low-efficiency air conditioners (cooling)	572		936.0	kWh	0.0260	USD/kWh	24	USD		USD	3.39	year
		c.High-efficiency air conditioners (cooling & heating)	704	132	1,080.0	kWh	0.0260	USD/kWh	28	USD	39			
Hot water supply	Individual gas boiler	a.boiler	616	b-a	710.1	m3	0.0334	USD/m3	24	USD	a-b	USD	-158.92	year
		b.Heat pump hot water supply	2,288	1,672	1,320.0	kWh	0.0260	USD/kWh	34	USD	-11			
	District heat supply	a.District heat supply	0	b-a	4,047.6	Mcal	0.0115	USD/Mcal	47	USD	a-b	USD	184.61	year
		b.Heat pump hot water supply	2,288	2,288	1,320.0	kWh	0.0260	USD/kWh	34	USD	12			
Thermal insulation	-	a.Single Layer Glass	8	b	72.2	m3	0.0334	USD/m3	2	USD	a-b	USD	31.32	year
		b.double-glazing (Low-E) glass	55	55	19.2	m3	0.0334	USD/m3	1	USD	2			
		a.No insulation	0	b	24.9	m3	0.0334	USD/m3	1	USD	a-b	USD	12.46	year
		b.Introduce thermal insulation	8	8	6.7	m3	0.0334	USD/m3	0	USD	0.61			
ZEB	-		0		1,328.7	m3	1.7000	USD/m3	2,259	USD				
			0		625.3	m3	3.1600	USD/m3	1,976	USD	4,235	USD	99.79	year
		HGT（HQ）	422,590	422,590	0.0	m3	0.0000	USD/m3	0	USD				
			0		992.7	m3	1.7000	USD/m3	1,688	USD				
			0		110.3	m4	3.1600	USD/m4	349	USD	2,036	USD	38.62	year
		HGT（Brunch）	78,630	78,630	0.0	m3	0.0000	USD/m3	0	USD				

Source: JICA study team

Table 5-5 The detailed results of calculation of annual energy consumption for each energy-saving measure

Items to compare	Equation for the calculation of annual energy consumption
Gas boiler (Heating)	1.2 kWh(Output)*(1/0.9)*(1/0.8)*3.6*(1/34.2)*24 h*30 days*4 months
District heat supply (Heating)	1.2 kWh*(1/0.8)*3.6*1/4.2（MJ/Mcal）*4months
Low-efficiency air-conditioner (Cooling)	1.3 kWh(3-month average output)*24 h*30 days
High-efficiency air-conditioner (Heating and cooling)	Cooling: 0.7 kWh(3-month average output)*24 h*30 days Heating: 0.8 kWh(4-month average output)*24 h*30 days
Gas boiler (Hot water)	17,000 MJ(Heat)*(1/0.7)*(1/34.2)

District heat supply (Hot water)	17,000 MJ(Heat)*1/4.2（MJ/Mcal）
Heat pump water heater	110 kWh(Monthly average output)*12 months
Single glass	6 W/㎡ K×20 K *(1/0.7)*3.6*(1/34.2)
Double（Low-E）glass	1.6 W/㎡ K×20 K*(1/0.7)*3.6*(1/34.2)
No insulation	2.07 W/㎡ K×20 K*(1/0.7)*3.6*(1/34.2)
With insulation	0.56 W/㎡ K×20 K*(1/0.7)*3.6*(1/34.2)

2) Consideration to ensure economic rationality

In the previous section 1), replacement with high-efficiency air conditioners and insulation reinforcement may spread autonomously to some extent by educating people about economic rationality even without financial incentives, as the investment payback is possible within the service life in both cases.

However, without some financial measures, heat pump water heaters and ZEB conversion will not be economically rational for investors under the current circumstances, and it is highly likely that they will not be widely used. Therefore, regarding the financial measures necessary to promote the use of heat pump water heaters and ZEBs, sensitivity analyses were conducted on the degree of increase in the unit energy price of natural gas, which is currently set at an abnormally low price, and on the degree of subsidy and other financial incentives, respectively.

① Sensitivity analysis on natural gas energy unit prices

A sensitivity analysis on natural gas energy unit costs was conducted to verify the changes in costs required to achieve economic rationality for heat pump water heaters and ZEB conversion. The results are listed in Table 5-4.Table 5-6 Results of the sensitivity analysis of natural gas energy unit prices assuming the gas cost becomes eight times higher than the current cost5-5

It was found that the unit cost of natural gas energy would need to be six times higher than the current unit cost to pay itself back within the service life of 15 years for heat pump water heaters. As for ZEB conversion, it was found that it would be difficult to recover the investment for some buildings unless the gas unit cost becomes three times higher than the current cost.

In Table 5-4, in addition to the case of investment payback over the useful life, the results of the sensitivity analysis of natural gas energy unit prices are introduced to the study assuming the gas unit cost becomes eight times higher than the current cost. As mentioned in Table 5-2, the energy price of natural gas is currently set at about 1/8th the price of electricity, and therefore, if the price is raised to the same level as the electricity price (i.e., if the unit energy price of natural gas is increased to eight times the current price). The results of the trial calculations are also presented.Table 5-6 Results of the sensitivity analysis of natural gas energy unit prices assuming the gas cost becomes eight times higher than the current cost5-5

Table 5-6 Results of the sensitivity analysis of natural gas energy unit prices assuming the gas cost becomes eight times higher than the current cost

	Necessary Cost Increase of Natural Gas to have Payback within Useful Life	Payback period in case gas cost increased to the same level as electricity rates (8 times higher than the current cost)
heat pump water heater	six times	10.7 years
Conversion to ZEB (HGT, HUDUD GAZ TAMINOT, Head Office)	three times	21.1 years
Conversion to ZEB (Gas Public Corporation and branch offices)	Recoverable at the current energy unit price	Recoverable at the current energy unit price

Source: JICA study team

② Results of the sensitivity analysis of subsidies

In addition to the sensitivity analysis of unit energy costs, a sensitivity analysis was also conducted on the level of subsidy needed for ZEBs to spread. Heat pump water heaters were excluded from the sensitivity analysis of the subsidy because Table 5-3 shows that even if the full installation cost is subsidized, economic rationality cannot be ensured owing to their low unit energy cost. Simulation results are shown in Table 5-5.Table 5-3 Economic evaluation of each energy-saving measure5-3Table 5-7 Results of the sensitivity analysis of subsidies5-

The result was that ZEB conversion requires a subsidy of about 50% of the investment cost to achieve a return on investment in 50 years, the life of the building.

Table 5-7 Results of the sensitivity analysis of subsidies

	Payback of investment over useful life	Payback of investment within 1/2 of the useful life
Conversion to ZEB (HGT, HUDUD GAZ TAMINOT, Head Office)	50% of	75% of
Conversion to ZEB (Gas Public Corporation and branch offices)	Recovery of investment possible without subsidies	Recovery of investment possible without subsidies

Source: JICA study team

(3) Consideration

The replacement of low-efficiency air conditioners with high-efficiency ones and strengthening insulation is expected to spread autonomously from the viewpoint of economic rationality, and it is important for the government to focus on proactive public relations and awareness activities to promote the understanding of economic rationality.

From the viewpoint of energy conservation, the promotion of water heaters is necessary. However, as economic rationality cannot be ensured at the current energy unit price, it is necessary to take measures under the comprehensive energy policy, such as raising energy unit prices or promoting measures to increase the primary energy conversion efficiency of electricity, as will be described in Chapter 6.

In addition, government subsidies and other incentive measures are needed for ZEB conversion, as it may not become widespread if energy prices remain at the current level. However, as will be explained in more detail in Chapter 6, when investments are made through government spending, the export of the price-reduced natural gas makes the investment economically rational for the government. Therefore, it is conceivable to start with the ZEB conversion of public facilities through government spending, and then to spread it to the private sector while introducing subsidies and other incentive measures. The government needs to make a policy decision as to whether to precede ZEB conversion with government investment or promote incentive measures for private sector operators, while considering economic rationality as a policy. An evaluation of the economic rationality for government investment will be described in Chapter 6.

5.3.2 Incentive design

5.3.1

(1) Type and summary of fiscal incentive measures

1) Subsidiary aid

The subsidy program provides partial or full payment of costs when companies take the necessary measures to conserve energy, such as replacing existing equipment with the latest energy-conserving equipment. As the enactment of the "Law Concerning the Rational Use of Energy" (Energy Conservation Law) in 1979, energy conservation has become a national issue in Japan, and the government has actively taken measures to support energy conservation. One of the main measures is the subsidy system, which offers a wide variety of subsidy programs in various ministries.

2) Preferential taxation

Preferential taxation is a system that provides tax incentives, such as reductions or exemptions of corporate enterprise tax, income tax, and fixed asset tax, for the acquisition of specific energy-conserving equipment, etc.

In Japan, the program began in the 1970s as an economic stimulus measure to encourage companies to accelerate capital investment. Since 2000, the program has expanded to the consumer sector with the creation of tax breaks for the purchase of fuel-efficient vehicles and energy-saving renovations of homes.

3) Low-interest loans

Low-interest loans are special loans that are used to finance the construction of new or additional facilities with high MoC. In Japan, a loan program to promote the effective use of energy was established in the 1970s for energy-conserving investments, such as the use of waste heat recovery by large corporations, which was later extended to small and medium-sized enterprises.

(2) Advantages and disadvantages of various fiscal incentive measures

Subsidies, low-interest loans, and tax incentives each have advantages and disadvantages. For example, while subsidies are more pervasive because they are accessible to all, the government incurs the administrative costs of administering and managing the subsidies. For low-interest loans, as the implementing entity is the financial institution, the government's burden of operation and administration is reduced, while expenses on the part of the financial institution are added to the interest rate. For households and small businesses, it may be difficult to obtain financing for the initial investment costs, thereby limiting eligibility. In addition, while tax incentives, like subsidies, are accessible to all, their economic impact is difficult to measure.

Table 5-8 Arrangement of advantages and disadvantages of fiscal incentive measures

type	Advantages	demerit
subsidiary aid	Accessible to all and easy to spread the system	Administrative costs are borne by the government
low-interest loans	Low operating and administrative costs on the part of the government	Expenses on the part of the financial institution are added to the interest rate. Eligibility is limited due to the loan approval process.
tax break	Accessible to all and easy to disseminate	Difficult to measure economic impact

Source: JICA study team

(3) Case studies in Japan

In Japan, since the enactment of the Energy Conservation Law in the 1970s, a variety of measures have been implemented to promote energy conservation, including subsidies, preferential taxation, and low-interest loans. This section summarizes the main fiscal incentive measures implemented in Japan by the industrial and consumer sectors covered by this study.

1) Summary

In Japan, the Ministry of Economy, Trade and Industry (METI) is primarily responsible for providing subsidies, low-interest loans, and tax incentives to the industrial and consumer sectors.

Table 5-9 Fiscal incentive programs in Japan

type	Industrial Sector	Consumer Sector	
		Commercial Buildings Division	Housing Division
subsidiary aid	Applicable	Applicable	Applicable
low-interest loans	Applicable	Applicable	Applicable
tax break	Not Applicable (Ended in 2021)	Applicable	Applicable

Source: Prepared by the JICA study team

2) Overview of various incentive targets

① Industrial sector

The following subsidies, interest subsidies, and other measures are provided to the industrial sector. In addition to subsidies for hardware, such as capital investment, subsidies are also provided for software, such as subsidies for the cost of conducting energy conservation assessments and proposing operational improvements based on these assessments for small and medium-sized enterprises. There were also measures that allowed businesses that acquired energy-conserving equipment to receive special depreciation and other tax benefits, but these measures ended in 2021.

Table 5-10 Examples of subsidy programs for businesses

Measure name	Advanced Energy Conservation Investment Promotion Support Project
Eligible Businesses	Support is provided for the following four projects related to upgrading to equipment with high energy consumption efficiency at factories and business sites. ① Advanced projects: Energy-conserving investments that introduce advanced energy-conserving equipment, etc. that have high technology and energy-conserving performance and are expected to expand their introduction potential in the future. ② Tailor-made projects: Equipment renewal and process renovation, including the introduction of custom-built equipment that requires individual design, and energy conservation efforts by multiple businesses in collaboration. ③ Designated equipment installation projects: Renewal to specific utility equipment, production equipment, etc. with high energy-conserving performance, such as air conditioners and refrigerators ④ Energy management business: Efficient and effective energy conservation efforts through EMS control and operational improvements by concluding energy management support services with energy management companies.
Target group	Businesses and sole proprietors operating in Japan
Subsidy rate	(1) Small and medium-sized enterprises, etc.: within 10/10; large enterprises and others: within 3/4 (2) Small and medium-sized enterprises, etc.: within 10/10, large enterprises and others: within 3/4

	(3) Set by facility type and performance (capacity, etc.) (4) Small and medium-sized enterprises, etc.: within 1/2, large enterprises and others: within 1/3 (消去理由：元の表は転記借用と思われ＊記号見当たらず)
Subsidy Limit	Maximum amount: 1.5 billion yen/year, Minimum amount: 1 million yen/year Maximum amount: 100 million yen/year, Minimum amount: 200,000 yen/year ⑤ Upper limit: 100 million yen/year, lower limit: 1 million yen/year
Management	METI (Ministry of Economy, Trade and Industry)

Source: JICA study team

Table 5-11 Examples of interest subsidy programs for businesses

Measure name	Interest subsidy for investment in energy-conserving equipment
Eligible Businesses	The program provides partial subsidies of loan interest to businesses that receive loans from private financial institutions, etc. for the cost of design, installation, construction, etc. of facilities if any of the following apply. (1) Projects that newly construct or add energy-conserving facilities with high energy consumption efficiency (2) Projects that newly install or add energy-conserving equipment, etc. and improve the energy consumption intensity of the entire factory or business site by 1% or more. (3) Projects related to energy conservation efforts through the use of cloud services at data centers, introduction of EMS, etc.
Target group	Private enterprises, etc.
Subsidy rate	Up to 1%, interest subsidy period up to 10 years
Subsidy Limit	10 billion yen/business
Management	METI (Ministry of Economy, Trade and Industry)

Source: JICA study team

② Consumer sector (commercial buildings sector)

For the commercial building sector, the company mainly provides support for demonstrations to promote ZEB.

Table 5-12 Examples of subsidies for the commercial buildings sector

Measure name	ZEB Demonstration Project
Eligible Businesses	• Subsidies are available for the following expenses required for large buildings (new construction: 10,000 m2 or more, existing construction: 2,000 m2 or more) to obtain certification for energy efficiency and conservation performance evaluation: Nearly ZEB, ZEB Ready, or ZEB Oriented. • Design cost, construction cost, equipment cost (air conditioning, hot water supply, lighting, ventilation, energy storage system, BEMS, etc.)
Target group	Building owners, ESCO companies, leasing companies, etc.
Subsidy rate	Within 2/3 of eligible expenses
Subsidy Limit	Up to 500 million yen/year
Management	METI (Ministry of Economy, Trade and Industry)

Source: JICA study team

③ Consumer sector (residential sector)

For the residential sector, the Ministry of Economy, Trade and Industry (METI), the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), and the Ministry of the Environment are collaborating to implement subsidy programs to support residential energy conservation, such as improving residential insulation and installing high-efficiency water heaters. In addition, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT)-led program offers low-interest loans for energy-efficient housing, such as ZEH, as well as mortgage tax breaks. In addition, each municipality provides subsidies for the purchase of energy-conserving home appliances (refrigerators, air conditioners, lighting, televisions, etc.) that meet certain standards under energy-conserving labels.

Table 5-13 Examples of subsidies for the residential sector

Measure name	Residential Energy Conservation 2023 Campaign (1) Children's Eco-Home Support Project, (2) Advanced Window Renovation Project, (3) Hot Water Supply Energy Conserving Project)
Eligible Businesses	① Acquisition of new housing with high energy-conserving performance at the ZEH level and energy-conserving renovation of housing ② Replacement with energy efficient glass, installation of interior windows, and replacement of exterior windows

	③ Installation and replacement of residential fuel cells, combined electric heat pump and gas instantaneous water heaters, and heat pump water heaters
Target group	Acquirers of new homes and remodeling contractors
Subsidy rate	Determined according to the performance level of energy conservation to be applied
Subsidy Limit	(1) 1 million yen per dwelling unit (50,000-600,000 yen for remodeling) (2) 50,000-2,000,000 yen per dwelling unit (3) 50,000-100,000 yen/unit per dwelling unit (apartment house). Maximum of 2 units.
Management	(1) Ministry of Land, Infrastructure, Transport and Tourism; (2) Ministry of Economy, Trade and Industry and Ministry of the Environment

Source: JICA study team

Table 5-14 Examples of tax incentives for the housing sector

Measure name	housing loan tax reduction
Eligible Businesses	New construction and renovation of low-carbon housing and ZEH-level energy-efficient housing, acquisition of new housing such as energy-efficient standard-compliant housing, and ordering of renovation work
Target group	Persons who construct or renovate a residence in which they reside
Subsidy rate	Deduction from income tax of 0.7% of the balance of the mortgage loan each year for up to 13 years (10 years for existing houses) for the acquisition of the house and the land on which the house and the land on which the house is built are located
Subsidy Limit	As above. Borrowing limits are determined based on housing type.
Management	Ministry of Land, Infrastructure, Transport and Tourism

Source: JICA study team

(4) Fiscal incentive measures implemented in Uzbekistan

The following section reviews the fiscal incentive measures implemented in Uzbekistan, by its governments and international donor agencies, for the country's industrial and consumer sectors, and then summarizes the status of implementation of each of these measures.

1) Summary

Table 5-15 Summary of the implementation of fiscal incentive programs in

Uzbekistan5-13

Table 5-15 Summary of the implementation of fiscal incentive programs in Uzbekistan

	Industrial Sector	Consumer Sector	
		Commercial Buildings Division	Housing Division
subsidiary aid	EBRD	EBRD	Uzbekistan government
low-interest loans	Uzbekistan Government, World Bank, EBRD	Uzbekistan Government, EBRD	Uzbekistan Government UNDP*.
tax break	Uzbekistan government	Not implemented	Not implemented

Source: JICA study team

2) Overview of various incentives

The measures implemented by each agency and the consideration of their suitability for Uzbekistan are organized as follows.

① Industrial sector

i) Government of Uzbekistan

There seems to be many fiscal incentive measures implemented by the Uzbekistan government on its own, specifically for the industrial sector. However, the government provides subsidies, low-interest loans, and tax incentives for individuals and corporations to install energy-conserving and renewable energy equipment.

Table 5-16 Summary of fiscal incentive measures under Presidential PP 220

laws and ordinances	Additional measures for the introduction of energy-conserving technologies and the development of low-power renewable energy sources
Decree no.	PP 220, Council of Ministers Resolution No. 568
Year of enactment	September 2022
Summary	・ Low-interest loans: individuals (consumers) can make interest-free installment payments for three years when purchasing equipment for solar power generators, wind turbines, and solar water heaters (renewable energy) produced in Uzbekistan. The interest will be financed at the expense of the Off-Budget Intersectoral Energy Efficiency Fund (hereafter referred to as the Energy Efficiency Fund) under the jurisdiction of the Ministry of Energy (MoE). ・ Consumers who have paid the full cost of purchasing and installing

	subsidized renewable energy equipment will be subsidized for a portion of the cost. ・ Subsidized consumers may purchase renewable energy equipment directly at domestic retail facilities, including e-commerce, by paying in installments or at the final retail price minus the subsidy. ・ Tax incentives: 50% reduction in corporate and property taxes for 3 years for corporations whose main activity is the production of photovoltaic, wind power plants, and small hydroelectric power plant installations
Eligible Businesses	Photovoltaic generators, wind power generators, solar water heaters
budget	100 billion UZS (approx. 1.2 billion yen) * Budget for the installation of personal renewable energy sources
terms	The subsidy rate for each facility is based on the "standard calculation value" set by the government and is set according to the capacity of the facility to be installed.
implementor	Off-budget inter-sectoral energy conservation fund under MoE jurisdiction (energy conservation fund)
status of implementation	The number of users of the system increased steadily. With the increase in the number of users, the supply side system is becoming unable to keep up, and increasing the number of manufacturers on the supply side is a future challenge.

Source: Prepared by the JICA study team based on PP220, Ministerial No. 568, and hearing information

Table 5-17 Summary of fiscal incentive measures under Presidential PP 4422

laws and ordinances	Accelerated measures in the development of renewable energies, introduction of energy-saving technologies, and improvement of energy efficiency in economic and social sectors
Decree no.	PP4422
year of enactment	August 2019
summary	・ Subsidies for solar panels, solar water heaters, and 30% of the cost of replacing low-efficiency gas stoves with high-efficiency gas stoves for private residences ・ Interest subsidies on loans from commercial banks for the purchase of renewable energy equipment, energy efficient gas stoves and boilers, and other energy efficient equipment by individuals and corporations
Eligible Businesses	Purchase and installation of renewable energy equipment, high efficiency boilers and gas burners

budget	unknown
terms	・ Auxiliary Solar power up to 3 million UZS Solar water heaters up to 1.5 million UZS Gas burner appliances up to 200,000 UZS ・ Subsidized interest payments Individuals: the portion of the loan not exceeding UZS 500 million for individuals that exceeds the policy rate. However, not to exceed 8 percentage points Corporate: portion of the loan not exceeding UZS 5 billion, also not exceeding 5 percentage points
implementor	MoE
status of implementation	Although we have not been able to confirm the implementation status of the subsidy program, according to the interview information, the challenge for consumers to invest in energy-saving equipment is the lack of initial investment funding. Therefore, this subsidy scheme, in which subsidies are granted after the equipment is purchased, is not very popular.

Source: Prepared by the JICA study team based on PP4422 and interview information

■ Status of implementation

The subsidy for the purchase of renewable energy and solar thermal power, which began in 2022, is well underway, with the program's rollout beginning with the subsidy for renewable energy and high-efficiency gas combos, as well as boilers for individuals, under PP 4422, which was enacted in 2019 and enhances the payment scheme for individual consumers.

ii) International donor agency (World Bank)

The World Bank has been providing two-step loans to the industrial sector for energy-saving capital investments since 2010. A summary is given below.

Table 5-18 Summary of two-step loans to industries implemented by the World Bank

case name	Energy Efficiency for Industrial Enterprises (EEIE)
implementation period	2010-2024
Objective.	Improve energy efficiency of industrial enterprises (IEs) by designing and establishing financing mechanisms for energy efficiency investments.
Business Overview	described outside the table
Eligible Businesses	・ Energy system investments related to boiler upgrades and fuel conversions, use of cogeneration facilities, compressed air systems,

	electric drive systems such as electric chillers, machinery, lighting, etc., heat piping (steam, water) and related equipment ・ Production technology investments related to equipment, machinery, and facility improvements and upgrades Investments in the use of waste heat and waste materials associated with the utilization of waste heat (hot gases, liquids, and solids) and the combustion of combustible waste (gases, liquids, and solids), where this can effectively control harmful pollution.
project budget	332.5 million USD
loan terms and conditions	・ The maximum loan amount is USD 10,000,000 for individual beneficiaries and USD 30,000,00 for consolidated beneficiary groups. The sub-borrower will co-finance an amount equivalent to 20% of each sub-project cost.
target group	Industrial enterprises such as brick manufacturing, textiles, electrical equipment manufacturing, and food processing
implementing agency	・ Ministry of Economic Development and Poverty Reduction (MoED&PR), Asia Alliance Bank, ASAKA Bank, Uzpromstroybank, National Bank of Uzbekistan, Hamkorbank, Invest Finance Bank
status of implementation	description outside the table

Source: JICA study team

■ Business overview

The two-step loan project involves the World Bank providing financing to local banks in Uzbekistan, then the local banks provide loans for energy-saving capital investments in industrial industries. The World Bank only finances the project, and the actual operations, such as loan procedures, are carried out by local banks according to the manual.

The implementation scheme of the project is shown in Figure 5-1. The World Bank signs a Financing Agreement with the MoF, then the funds are provided to each PB through the MoF. In addition, the World Bank enters into separate Project Agreements with PBs, whereby the World Bank identifies the loan recipient, approves the loan, determines the loan terms (interest rate, repayment, grace period, etc.), and confirms that the burden of the loan risk lies with the PB. The funds provided by the MoF to the MoEDPR are mainly for capacity building related to energy efficiency and conservation, and only have a coordinating role between the World Bank and the PBs. The Bank is not involved in the flow of funds related to the two-step loan, such as the Project Agreements and the Financing Agreements.Figure 5-1 Scheme diagram for industrial two-step loans5-1

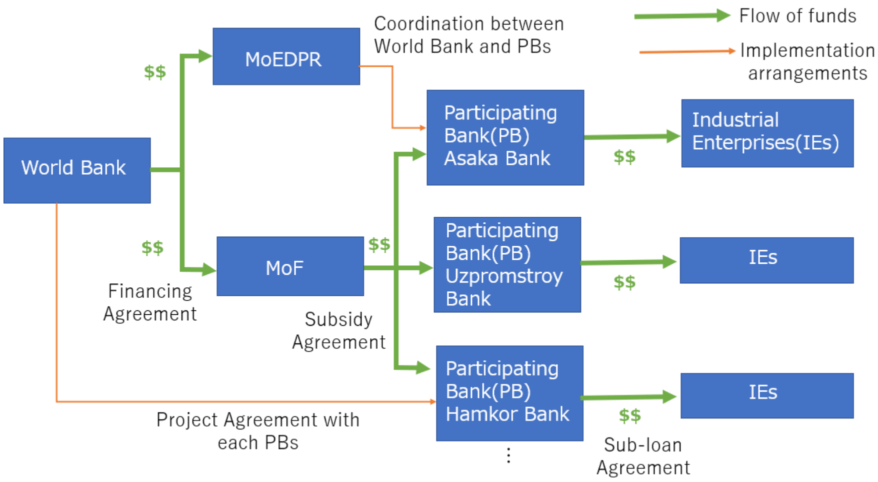


Figure 5-1 Scheme diagram for industrial two-step loans

Source: JICA study team, based on World Bank data

■ Status of implementation

The project is progressing well. The achievement status against the targets, as of April 2022, is shown in Table 5-17. The majority of the loan recipients were companies in the oil and gas, chemical, and cement industries.Table 5-19 Progress of industrial two-step loan business5-17

Table 5-19 Progress of industrial two-step loan business

valuation index	level of achievement	Actual result as of April 2022	Target value (January 2023)
Leverage amount of EE investment	140%.	285,000,000USD	201,000,000USD
energy-conservation	70% (of the total)	438,000MWh	613,000MWh
CO2 reduction	58%	730,713t	1,269,000t
Number of IEs benefited	91%.	64 companies	70 companies
Amount of sub-loan to SME	87%	26,000,000USD	30,000,000USD

Source: JICA study team, based on World Bank data

The project is scheduled to end in 2024; its continuation after that has not yet been determined. However, as the Uzbekistan government's support requirements for the energy efficiency and conservation sector are high, and other international donor agencies are also interested, it is possible that these agencies may execute loans even after the World Bank's loans are completed.

iii) International donor agency (EBRD)

The EBRD offers a two-step loan called the Green Economy Financing Facility (GEFF). A summary is given below.

Table 5-20 Summary of corporate (including industrial sector) two-step loans by the EBRD

case name	Green Economy Financing Facility (GEFF)
implementation period	2018-2023
Objective.	Promote investment in green technologies that reduce corporate greenhouse gas emissions and in climate change adaptation and mitigation technologies
Business Overview	described outside the table
Eligible Businesses	・ Small-scale projects that use high-performance equipment and materials selected by the green technology selector. (Technologies listed in the GTS range from air conditioning, heat pumps, window and door insulation, boilers, lighting, motors, pumps, etc.)-a) ・ Other large projects (energy, water efficiency, renewable energy projects)-b)
working budget	60 million USD
loan terms and conditions	The maximum amount for “Eligible Projects" is as follows a) Up to USD300,000 b) Up to USD5 million Successful projects are also eligible to receive additional incentives (10% of the borrowing amount for energy efficiency PJTs and 20% of the borrowing amount for renewable energy projects) if they are certified through a post-project verification process.
target group	・ Private companies, sole proprietorships, or other legal entities wishing to invest in qualified technologies ・ Vendors of equipment and materials listed in the green technology selector (GTS) ・ Green" technology manufacturers listed in the green technology selector (GTS) that plan to maintain or expand the "green" part of their business
implementing agency	Ipak Yuli Bank, HAMKOR BANK, SQB, UzPSB
status of implementation	described outside the table

Source: JICA study team

■ Business overview

The GEFF is a two-step loan through which the EBRD provides funds to local banks, which in turn lend to local SMEs (Small- and medium-sized enterprises); it operates through a network of more than 170 local financial institutions in 28 countries. In Uzbekistan, the project started in 2018.

As the EBRD's projects are targeted at the private sector, and funds are lent directly to local banks, Uzbekistan government is not involved in the GEFF as a counterpart. A diagram of the GEFF's business scheme is shown in Figure 5-2.Figure 5-2 Scheme diagram of the GEEF5-2

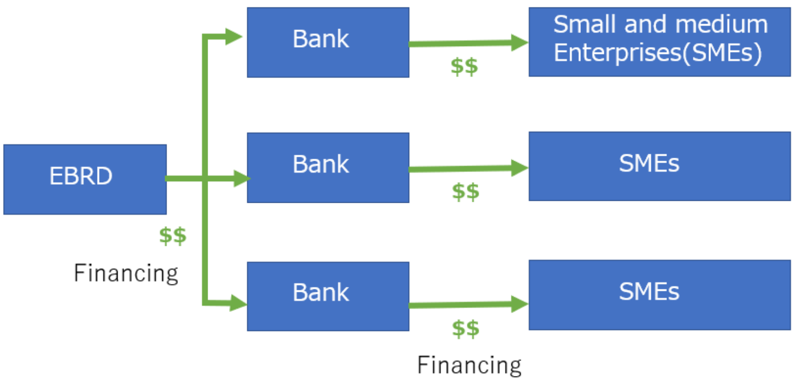


Figure 5-2 Scheme diagram of the GEEF

Source: Prepared by JICA study team based on the EBRD materials

The Green Technology Selector (GTS) is an online platform that provides companies with information on products and vendors offering high-performance technologies by country and product category. The information is provided in a format similar to a product catalog. Those who wish to obtain financing can do so by identifying the products eligible for financing from the GTS and applying to the bank. In addition, as the products listed in the GTS satisfy the EBRD's screening requirements, the local banks that provide loans can execute those loans without additional screening for products listed in the GTS.

To be listed in the GTS, products must be able to achieve a 20% energy conservation regardless of the manufacturing country. In addition, if a loan for a technology not listed in the GTS is desired, the loan will be determined after an individual review by an expert.

■ Status of implementation

Financing began in 2018, and as of December 2022, USD 45 million in loans have been executed or approved. Progress is on track, with the entire USD 60 million to be financed by 2023, when the project is scheduled to be completed. The average loan amount per loan project is approximately USD 0.1mil, and approximately 2,000 loan projects have been executed to date.

The interest rate of the loans varies from bank to bank, for example, for SQB, the average is 22%, although it varies depending on the policy rate of the central bank of Uzbekistan, and the loan term is 5 years. A total of 121 loans have been executed from the start of operations in 2020 to 2022. Loan recipients include the manufacturing, agriculture, transportation, and telecommunications sectors. For the manufacturing sector, loans are provided for inverter-type motors and boiler improvements, the transportation sector for EVs, and the construction sector for insulation materials.

This project is scheduled to end in 2023, but there are plans to roll out a new scheme, GEFF, from 2024, expanding the target to the residential sector. As it is the goal of the EBRD to eventually manage its loan operations solely with private funds, the next phase will reduce the percentage of incentives, as opposed to the current incentive system, which adds 10–20% to loans.

② Consumer sector (commercial buildings sector)

i) Government of Uzbekistan

Although there do not appear to be any fiscal incentive measures implemented by the Uzbekistan government on its own, specifically for the commercial building sector, it has implemented an energy efficiency renovation project for public facilities with support from the World Bank. In addition, the incentive measures under Presidential PP 4422 are available to individuals and businesses, which can receive subsidies and low-interest loans for the purchase of renewable energy equipment and high-efficiency boilers and gas burners.

ii) International donor agency (World Bank)

For the commercial buildings sector, the World Bank has implemented projects aimed primarily at improving energy efficiency in public facilities.

Table 5-21 Summary of the World Bank's energy efficiency and conservation promotion projects for public facilities

case name	Clean Energy for Buildings in Uzbekistan
implementation period	2022-2028
Objective.	・ Promote clean energy investment in public buildings ・ Environmental and market development for EE investment
Business Overview	description outside the table
working budget	185.9 million USD

target group	Public facilities (kindergartens, childcare facilities, public elementary, middle, and high schools, dormitories, student dormitories, vocational schools (sports and cultural facilities, etc.), central, regional, and municipal hospitals, regional clinics, and related administrative facilities)
Eligible Businesses	・ Retrofits to reduce building heat demand (e.g., insulating building walls, roofs, and basements, replacing inefficient windows, doors, and light fixtures) ・ Upgrading to heating systems that provide less heat load with clean energy such as air source heat pumps, pellets, geothermal, etc., or to more efficient gas/electric boilers ・ Applies to on-site renewable energy generation if economic rationality is recognized.
implementing agency	MoE Off-Budget Intersectoral Energy Conservation Fund (Energy Conservation Fund)
status of implementation	described outside the table

Source: Prepared by JICA study team

■ Business overview

In this project, the World Bank funds will be provided to the Energy Conservation Fund through a sovereign loan to the MoF, and the Energy Conservation Fund will hire a construction company and enters into a turnkey contract that includes all services, such as detailed design, construction, operation and maintenance (one year), and verification measurements. The utilities that receive this service reimburse the energy conservation costs resulting from it to the Energy Conservation Fund. Such a funding mechanism, called Energy Efficiency Revolving Funds, has the advantage of guaranteeing the sustainability of the financing of energy efficiency investments. Repayment by beneficiaries also improves ownership, accountability, and the quality of energy management by beneficiaries, making energy cost reductions more likely to be sustained and encouraging energy efficient behavior. For governments, it is also a motivation to invest in energy conservation because they do not only receive a report on the amount of energy saved in their utilities as a result of energy conservation investments but also know the costs that will be returned through energy conservation. Figure 5-3 shows the scheme of the project.Figure 5-3 Scheme of the Energy Efficiency Revolving Funds for public facilities5-3

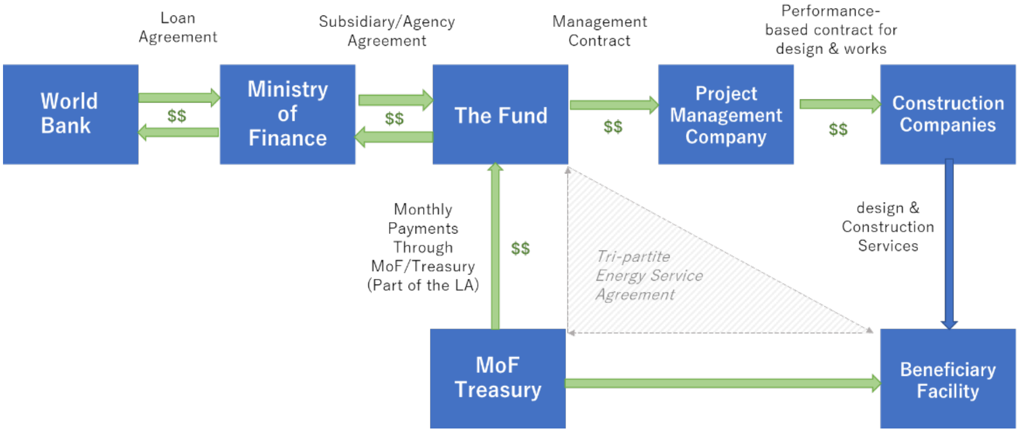


Figure 5-3 Scheme of the Energy Efficiency Revolving Funds for public facilities
Source: JICA study team, based on World Bank data

■ Status of implementation

The project is scheduled to have a Financing Agreement signed in January 2023 (as of December 2022). The Uzbekistan government is preparing to issue a Presidential Decree to be signed. The World Bank is conducting a feasibility study so that the project can be implemented immediately after signing. For example, the World Bank is investigating clean technology options applicable in Uzbekistan, such as heat pumps + photovoltaics and gas boilers, as well as ZEB. An energy audit has also been conducted and investment targets have been identified for the first year of the project. The relevant ministries (Ministry of Health, Ministry of Education, and Ministry of pre-school) provided information on 800 buildings, of which 250 were subjected to energy audits by German consultants, and 45 buildings were identified for investment in the first year. The procurement documents are expected to be ready around January and February 2023.

③ Consumer sector (residential sector)

i) Government of Uzbekistan

The financial incentive measures for the residential sector offered by the Uzbekistan government are implemented under PP 220 and PP 4422, described in Tables 5-14 and 5-15, respectively. Subsidies and low-interest loans are provided for the purchase of renewable energy equipment and high-efficiency boilers and gas burners.Table 5-16 Summary of fiscal incentive measures under Presidential PP 2205-14Table 5-17 Summary of fiscal incentive measures under Presidential PP 44225-15

ii) International donor agency

Information on financial incentive measures targeted at the housing sector by international donor agencies was not available during this survey.

(5) Directions and issues in designing incentive programs

Financial incentive measures for industry have been implemented smoothly, with the World Bank and the EBRD taking the lead in providing low-interest loans and granting subsidies for a wide range of energy-conserving equipment, and the local banks that serve as implementing agencies have established an implementation flow.

The following are directions for future implementation of incentive programs in Uzbekistan and issues to be considered:

1) Direction of incentive system design

- As incentive programs offered by the Uzbekistan national governments and international donor agencies are already in place in both the industrial and consumer sectors, it is effective to improve support for the (1) introduction of high-efficiency air conditioners, (2) strengthening of the insulation of walls and windows, and (3) introduction of heat pumps, while utilizing existing programs, rather than designing and introducing new programs.
- Financial incentive measures for industry are led by the World Bank and the EBRD, which provide low-interest loans and grant subsidies for a wide range of energy-conserving equipment and have established an implementation flow of local banks as implementing agencies. It would be desirable for the industrial sector to be included within a market financing scheme, with governments and international donor agencies providing the source of financing.
- Financial incentive measures for the consumer sector could utilize the schemes for energy-conserving equipment and renewable energy facilities implemented by the Energy Conservation Fund. The current subsidies, which cover solar panels and solar water heaters, could be expanded to include high-efficiency air conditioners and heat pumps. The scheme offers the option of subsidies or three-year, interest-free installment payments, making it easy for consumers who cannot finance the initial investment costs to purchase the product. It is clear that high-efficiency air conditioners and insulation reinforcement can be economically viable to some extent, even under the current unit energy prices, but to ensure their widespread use, they should be made eligible for subsidies.
- For ZEB conversion, a similar project in Uzbekistan is the World Bank's Clean Energy for Buildings in Uzbekistan. The World Bank's projects are targeted at public buildings, and no financial incentive measures for ZEB conversion of commercial buildings have been implemented. Therefore, there is room for the Uzbekistan government to consider implementing a subsidy program.

2) Issues in designing incentive programs

- If the MoE were to take the lead in implementing financial incentive measures, the Energy Saving Fund, which is currently an agency that implements subsidy projects for consumers and businesses, could be a candidate for the implementing agency. However, as the Fund is a new organization, established in 2020, strengthening the capacity of its staff is necessary. An overview of the Energy Conservation Fund and its activities is provided at the end of this section.
- As subsidies for ZEB conversion require proof of ZEB certification, developing Uzbekistan's domestic certification bodies, etc., in parallel is necessary.
- While subsidies can be widely disseminated to consumers and are an immediate tool, the system needs to be designed in such a way that it does not favor only those segments of the population that have easy access to the system.

3) Potential Japanese contributions to the implementation of incentive measures and issues to be considered

In the case of implementing the above-mentioned incentive measures, we summarized whether Japan could contribute or not and the issues to be considered.

- As for industry, the existing support schemes implemented by international donor agencies could be utilized, including the co-financing of the World Bank and the EBRD projects and the registration of Japanese energy-saving equipment in the EBRD's GTS.
- Regarding the consumer sector, the existing Energy Conservation Fund scheme could be used to provide funds to the Energy Conservation Fund so that high-efficiency air conditioners and heat pumps would also be eligible for subsidies.
- As the World Bank has adopted a financially sustainable and effective mechanism called Revolving Funds to support ZEB conversion, Japan needs to consider financial sustainability and the use of existing mechanisms when supporting ZEB conversion. As the awareness of ZEB is still considered low in Uzbekistan, a possible approach would be to first convert specific buildings to ZEB as a showcase to raise awareness of ZEB conversion, as was done in this survey for the HGT, HUDUD GAZ TAMINOT, before financial incentive measures are taken.

Reference: Off-budget inter-sectoral energy conservation fund (Energy Conservation Fund, hereafter) under the jurisdiction of the MoE.
The Energy Conservation Fund is a fund under the MoE for energy conservation and energy efficiency, established by Ministerial Resolution (No. 640) in October 2020 under Presidential Decree PP 4779. The main objectives and activities of the Energy Conservation Fund are as follows:

Purpose of Establishment

Attract and finance investments to implement energy efficiency projects in the economic and social sectors and in households.

Primary Role

- Co-financing of projects with commercial banks or international or foreign financial institutions.
- Providing preferential financing in cooperation with banks for the installation of the latest energy-conserving technologies and renewable energy equipment in production processes, public facilities, and households in the economic sector.
- Financial assistance to manufacturers of energy-efficient and energy-conserving technologies, equipment, and materials.
- Priority lending to producers of fuel and energy resources and consumers who use them in the implementation of measures to improve energy efficiency and conserve energy.
- Financial and technical support for the implementation of energy audits (diagnostics) in the economic and social sectors.
- Use of credit lines and other financial mechanisms, such as credit guarantees to commercial banks in the framework of energy efficiency projects.
- Support for training and retraining of experts in the field of energy conservation, energy efficiency, etc.

Funding Source

- 5% of net income of companies in the oil, gas, and power sector is allocated.
- Revenue from the application of higher tariffs to companies for excessive energy consumption.
- 20% of the amount of economic sanctions imposed for violations related to the use of fuel and energy resources.
- Grants and loans from international financial institutions and funding from donor agencies.
- Income from the management of the fund's assets.

Activity

- Its activities include subsidizing the installation of renewable energy equipment, as shown in Table 5-14, as well as serving as a counterpart to the World Bank’s project to promote energy conservation for public facilities, as described in Table 5-19.Table 5-16 Summary of fiscal incentive measures under Presidential PP 2205-14Table 5-21 Summary of the World Bank's energy efficiency and conservation promotion projects for public facilities5-19
- Table 5-16 Summary of fiscal incentive measures under Presidential PP 2205-14
- Table 5-17 Summary of fiscal incentive measures under Presidential PP 44225-15

・ Table 5-21 Summary of the World Bank's energy efficiency and conservation promotion projects for public facilities5-19
Source: JICA study team, based on Ministerial Resolution No. 640 and hearing information.

5.4 Raise awareness and increase energy conservation

In order to promote energy conservation, educating and raising awareness of energy conservation is also important. We conducted an awareness survey of households to ascertain the current status of energy-saving behavior and awareness at home.

5.4.1 Current status of consumer awareness of energy conservation

In this study, a questionnaire survey of households was conducted to ascertain the current status of energy-saving behavior and awareness at home. A total of 102 responses were received from households across the country. Details of the survey results are provided in the Appendix 3; the current section describes the energy-saving behavior and awareness of households that were identified.

- About 90% of households are interested in energy efficiency and conservation, and about 95% of households implement some kind of energy efficiency and conservation activity in their daily lives.
- All households believe that education on energy conservation is important, with about 45% of households citing it as a facilitating factor. Other factors promoting energy conservation included government dissemination of information on energy conservation and incentives for energy conservation.
- In terms of the knowledge of individual energy-conserving devices, about 77% of households either did not know about heat pump technology or had heard of it but did not know the details. About 80% of the households either did not know about or did not use water-saving showerheads. However, about 65% of the households indicated that they have knowledge of energy-saving labeling.
- Regarding the use of heating, about 73% of the households heated all rooms evenly, and about 28% indicated that they heated only the rooms that needed heating. When asked if it is possible to use air conditioners as heaters, about 55% of the respondents answered that it is not possible (or that they do not use air conditioners as heaters).[1]
- About 35% of the respondents, or about 35% of the total, answered 24.6°C as the most common heating temperature setting.

[1]This response includes cases in which the air conditioner is not powerful enough to be used as a heater, as well as cases in which the air conditioner is not used as a heater in the first place.

Although this was a limited survey of 102 households, and the results do not represent the situation in Uzbekistan as a whole, it was clear that most households indicated that they were interested in energy conservation, but lacked the knowledge of specific energy-saving technologies, such as heat pump technology and water-saving showerheads. Moreover, many households recognized that education and public relations activities are important to promote energy conservation.

Regarding energy-saving behavior, as described in Chapter 3, it is clear that the majority of households use central heating with gas boilers and do not have individual room heating practices. Raising awareness of the use of individual room heating is also important to promote the spread of high-efficiency air conditioners.

5.4.2 Measures to raise awareness of energy conservation

(1) How to promote energy conservation education

In order to increase consumer awareness of energy conservation, publicity and awareness-raising activities regarding the energy-conservation effects of electricity, gas, and electrical equipment are required. Beginner-level education in energy conservation should also be enhanced and, if necessary, this should be linked with energy conservation incentive programs to increase general consumers' awareness of energy conservation. The education related to this PR and awareness activity is positioned as basic training that should be provided to new and existing personnel of energy consuming companies, as well as the related ministries and agencies, before they acquire expertise in energy efficiency and conservation. It is important for the MoE to take the initiative in promoting energy conservation public awareness and basic education activities.

(2) Awareness-raising activities to promote behavior change

In Uzbekistan, most households use gas boilers for central heating in winter. There is little awareness of using air conditioners for heating in winter, even though they are more energy efficient than gas boilers. Therefore, it is important to promote the use of high-efficiency air conditioners in winter, as well as in summer. As the shift from conventional radiator heating to high-efficiency air conditioners conflicts with the conventional lifestyle, government-led activities to actively promote awareness of the benefits of the shift are considered necessary to popularize high-efficiency air conditioners.

A case study of Hokkaido, Japan can be used as a reference in this regard. In Hokkaido, kerosene heaters and central heating are the mainstream, and according to a survey conducted by the Hokkaido Government in 2021, only about 20% of households use air conditioners as their main heating source in winter. Hokkaido produces 1.5 times more greenhouse gas emissions in the residential sector than the rest of Japan, with heating and hot water supply being the main sources of emissions. Specifically, Hokkaido and private electric power companies are cooperating in a campaign to encourage conversion to high-efficiency air conditioners by offering a drawing for gifts of energy-efficient appliances to Hokkaido residents who purchase high-efficiency air conditioners.[2]

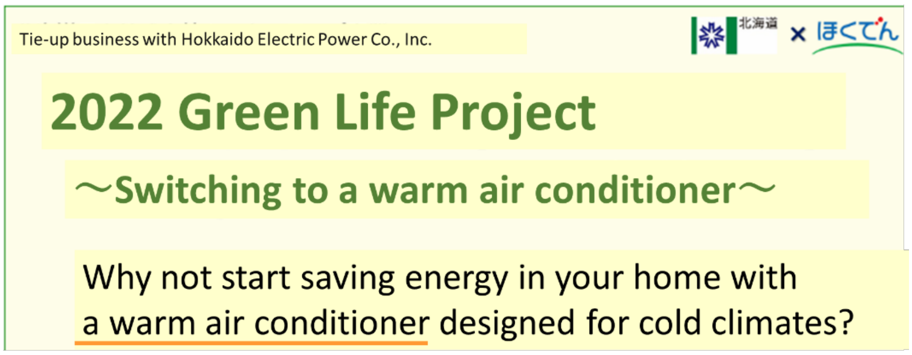


Figure 5-4 Examples of activities to promote the replacement of high-efficiency air conditioners by Hokkaido

Source: "Hokkaido x Hokuden 2022 Green Life Project," Hokkaido https://www.pref.hokkaido.lg.jp/ks/zcs/2022glpj.html (see 2023-2-1)

Following the project to promote behavioral change toward a decarbonized society in Hokkaido, Uzbekistan should conduct public awareness surveys and analysis, as well as promote government-led information dissemination and public relations activities in the media and marketplace.

5.5 Strengthening human and organizational capacity

Presidential Decree UP5646 of February 1, 2019, issued instructions to the Prime Minister of the Cabinet regarding energy administration, while Presidential Decision PP4142 of the same day determined measures regarding MoE organization and activities. Based on these series of directive decisions, the energy supply sector related to oil, gas, electricity, and heat was reorganized, and the MoE was given overall control over energy, including energy conservation.

The MoE’s Department of Energy Efficiency and Energy Conservation, which is the primary focus of this study, is positioned as the lead organization for promoting energy conservation in Uzbekistan. However, there are only a small number of personnel assigned to this task. Energy conservation-related work across a wide range of sectors, including energy consumption, is carried out with the cooperation of various ministries and

[2] "FY2021 Grant Project for Measures in Power Supply Location Areas: Report on Commissioned Work for Promoting Behavioral Change Toward a De-Carbon Society," Jyukankyo Research Institute, February 2022.

organizations. The creation of energy policies, master plans, etc., as well as policies, need to be compiled from the perspective of both energy supply and consumption. Information aggregation and coordination from related ministries and organizations, especially in the energy consumption sector, is extremely important in the policy-making and implementation process, but is difficult with the current organizational personnel and structure.

Therefore, in order to create a master plan and to implement and promote energy conservation improvement measures, it is necessary to further strengthen the coordination system between the Department of Energy Efficiency and Energy Conservation, which is the driving force, and the related ministries and organizations, as well as the human resources of each of them. In this section, we propose measures to strengthen the organization and human resources in accelerating and promoting energy conservation.

5.5.1 Reinforcement of the system for energy conservation promotion

Technical standards for energy consumption are currently highly dependent on the relevant sector ministries, but they are not integrated and managed by them. At present, the MoE does not have an adequate information aggregation system. In order to comprehensively promote energy policy in the future, the MoE's Department of Energy Efficiency and Energy Conservation should be the starting point for energy conservation administration initiatives, and the MoE should take the lead in the promotion of energy efficiency and conservation. In addition, as it is necessary to strengthen the organizations related to energy efficiency and conservation in each of the relevant ministries and organizations, as well as the organizational structure for cooperation with the MoE, the following improvement measures for the MoE-led energy efficiency and conservation promotion system, and for strengthening the organizations related to energy efficiency and conservation, are proposed.

(1) Ministry in charge of energy conservation administration

A summary of the relevant ministries and organizations, as well as their statuses by industry sector, is provided below.

① Industrial sector (MoED&PR)

The MoE conducts energy audits for organized companies with an annual energy consumption of 2,000 toe (ton oil equivalent) or more, while the energy consumption of companies with less than 2,000 toe is controlled by the MoED&PR. Presently, the MoE does not conduct audits of companies with less than 2,000 toe, so it does not have detailed information on the energy consumption of the industrial sector. The MoE should take the lead in strengthening the industrial sector's energy consumption control system. The related energy audit system is described in section 5.5.2.

② Construction division (MoC)

The MoC is responsible for building permits and certifications for building insulation structures (energy efficiency) for buildings and other structures. The issue is how to share energy efficiency and conservation information with the MoE. Although the criteria for insulation approval are classified into three categories (listed below), MoC building permit approval is not based solely on energy efficiency, as building location conditions and other factors are also items for review.

- Design to prevent building damage due to low temperatures, with -14°C (as a target)
- Criteria to promote energy efficiency and conservation in government and public facilities (subject to public budget availability)
- Standards that can appeal to energy conservation (energy conservation appeal standards by private sector base)

In addition, the Center for Regulation in Construction, an agency external to the MoC, is conducting research on even more effective insulation techniques. In order to efficiently promote energy conservation in buildings, promoting comprehensive energy conservation measures, including the installation of thermal insulation, as well as lowering heat and power consumption. Further, strengthening research institutes to improve energy conservation technologies in the building sector seems important. However, the MoE has not been able to conduct research on energy-saving technologies for buildings, which is under the jurisdiction of the MoC. In order to coordinate the overall energy policy, a person in charge with expertise in energy conservation in the building sector should also be placed within the MoE to strengthen coordination with the MoC and the Center for Regulation in Construction.

③ Private sector (electrical equipment, etc.; formerly UZSTANDARD)

The Uzbek Agency for Technical Regulation under the MIFT (formerly UZSTANDARD) is in charge of energy-conserving label certification for electrical equipment. Although Korea has begun to provide support for energy efficiency and conservation capacity measurement equipment, as well as devices for energy efficiency and the conservation labeling of electrical equipment, this study has not confirmed whether there is sufficient support for human resource development for the use of the measurement equipment. Checking the situation and considering support for human resource development is necessary.

In order to promote energy-conserving labels, the MoE should cooperate with the Agency for Technical Regulation to restructure the labeling system into an Uzbekistan version and accelerate human resource development.

④ Heat consumption sector (MoHCS)

The heat supply is managed by the local government's housing department, with information compiled by the Ministry of Housing and Public Services (MoHCS). Heat consumption information is also compiled by the MoHCS and is described in section (2) (iii) below.

(2) Organization in charge of energy supply

In order to clarify the progress of energy conservation and the initiatives of energy conservation administration, including the preparation of energy policy, it is important to grasp the amount of energy supply in terms of fuel, electricity, and heat, as well as to determine the degree of energy conservation promotion. The various organizations within the MoE are responsible for energy supply-related tasks. The Department of Energy Efficiency and Energy Conservation needs to strengthen cooperation with these organizations to coordinate policy development and implementation.

① Fuel supply (MoE Oil and Gas Reform Coordination Project Office)

The Oil and Gas Reform Coordination Project Office of the MoE is in charge of fuel supply and is reforming the organization, structure, and operations of fuel supply in cooperation with the departments related to oil and gas production, refining, and transportation. Related corporate entities, such as JSC Hududugazta'minot, should strengthen the energy conservation promotion system under the supervision of the MoE.

② Electricity supply (MoE project office for reforming the power sector)

The MoE's project office for reforming the power sector is in charge of electricity supply. This department, which was inaugurated at the end of 2021, works with organizations and corporate entities related to power generation, transmission, and distribution in the electric power sector to promote reforms in the organization, structure, and operations of electric power supply. Basically, the related companies, such as the thermal power generation company, JSC TPP, along with its affiliated power generation companies; the hydroelectric power generation company, JSC Uzbekhydroenergo; the transmission company, JSC NEG; and the power distribution company, JSC REN, should voluntarily promote energy conservation. The installation of electricity smart meters has been increasing up to 98% coverage, and it is expected that the development of electricity consumption and loss data will be reflected in the MoE's electricity sector development strategy.

③ Ministry in charge of heat supply (MJKO)

The heat supply is managed by the local government's housing department, with information compiled by the Ministry of Housing and Public Services (MJKO). District heat supply stations are managed by local government departments in charge of heat supply; however, the information on boiler operation and management records are not standardized. It is important to improve the system of the Ministry of Housing and Public Services and the housing and public service departments of each local government by, for example, strengthening boiler operation management and sharing operation records.

Owing to insufficient individual heat energy measurement equipment, heat supply and heat consumption are managed by estimates from fees; therefore, the accuracy of the aggregated data is low. The Ministry of Housing and Public Services needs to promote the development of heat consumption measurement equipment and the unified management of heat supply and consumption data, etc.

(3) Organization overseeing energy conservation

At present, it is difficult for the personnel structure of the Department of Energy Efficiency and Energy Conservation to manage the entire energy efficiency and conservation administration to grasp the entire energy efficiency and conservation administration in the wide range of technical fields. The system to practically supervise the entire energy administration of Uzbekistan's operational departments has not been established.

In order to strengthen and promote energy efficiency and conservation administration and to manage and supervise all the industrial sectors subject to energy efficiency and conservation in the future, establishing an organization that oversees all the technical fields is necessary. Further, it is desirable to establish an external organization of the MoE and assign experts and personnel in each technical field. It is also important to (1) establish a system that serves as the starting point for all energy conservation initiatives, (2) keep track of the status of energy supply and consumption in each sector along with the implementation of energy conservation policies, and (3) compile this information for the benefit of the MoE's energy policy development and implementation promotion.

5.5.2 Establishment of an Education Implementation System to Raise Energy Efficiency and Conservation Awareness, Train Energy Efficiency and Conservation Managers, and Establish Training Guidelines

Education content regarding energy conservation vary widely depending on the target audience. Based on the situation in Uzbekistan, the necessary subject-specific education and training and organizational systems should be discussed. It goes without saying, public awareness training for general consumers is elementary knowledge and is positioned as a fundamental part of the training guidelines.

(1) Human resource development

1) Training of energy personnel in the government and business organizations

Many staff members responsible for energy conservation work in the government and should have a comprehensive knowledge of energy audits and management. Currently, energy audits by the government are conducted by government officials with an appropriate academic background and relevant experience. Regarding private-sector organizations, the human resources related to energy management will be important to promote energy conservation in the future. As mentioned in section 4.2.4(2)2), education on energy audits (diagnostics) has been provided, and human resource development is underway at Tashkent Technical University; however, a certification system for energy management for those with field experience, as well as practitioners, has not yet been established.

① Human resource development related to fuel and electric energy supply

Professional training and education on fuel and power by the various departmental organizations is functioning well. JSC Hududugazta'minot is mainly responsible for the specialized education and human resource development regarding fuel, while JSC TPP, JSC NEG, and JSC REN are responsible for electricity generation, transmission, and distribution, respectively.

② Human resource development for heat supply

As mentioned in section 5.5.1(2), each housing department of the local government is in charge of professional training and education on heat supply. However, ensuring consistency and uniformity in content is difficult. There is no unified recording system for boiler operation records and heat energy consumption. The MoE should take the lead in implementing a specialized training system for energy conservation related to heat supply. An institution that specializes in education and training is needed, as the MoE's staffing is limited presently.

To promote energy conservation in heat supply, it is important to make boiler operation records mandatory and clarify the management status of heat energy consumption. For reference, Table 5-20 provides an overview of boiler engineer qualifications in Japan related to boiler operating records and thermal energy consumption.Table 5-22 Summary of boiler engineer certifications in Japan5-20

Table 5-22 Summary of boiler engineer certifications in Japan

Qualification Classification	Target boiler Approximate heat transfer area	Target Facilities and Equipment	Remarks
Special Boiler Engineer	500m2 or more	Large-scale heat consumption equipment	Large factory
1st class boiler Engineer	25 m2 to 500 m2	Medium Heat Consumption Facilities	Office/Hospital
Second Class Boiler Engineer	Less than 25m2	General manufacturing	Heating and hot water supply

		facilities	
Boiler handling Persons who have completed technical training	Less than 3m2	Small scale boiler	hot-water supply, etc.

Source: Japan Boiler Association; https://www.jbanet.or.jp/license/division/boiler-chief/から表に整理

2) Human resource development related to energy audits and management

The MoE manages audits on energy consumption in the industrial sector, while the MoED&PR keeps track of energy consumption below 2,000 toe. In order for the MoE to have a complete picture of energy consumption, unifying the qualifications of energy managers and grasping the status of energy management is required. For reference, Table 5-21 shows the qualification system for energy managers in Japan.Table 5-23 Business categories and obligations subject to energy management5-21

Table 5-23 Business categories and obligations subject to energy management

classification			obligation	
The business's classification	Annual energy use (Oil Equivalent)	type of industry	Managers to be appointed	Documents to be submitted
	3,000 kl or more	Mining, manufacturing, electricity supply, gas supply, heat supply	Energy - Manager (Energy Manager)	Periodic report on energy use in designated form Medium- to long-term plan for rationalization of energy use
The first kind specified business operator		Industries other than those listed on the left Examples; hotels, hospitals, schools	Energy - Manager (Persons who have completed the energy manager training course)	
the second kind specified business operator	1,500 kl to ~3,000 kl	All industries		
Other	Less than 1,500 kl			

Source: Agency for Natural Resources and Energy, Energy Conservation Portal Site; https://www.enecho.meti.go.jp/category/saving_and_new/saving/enterprise/factory/classification/index.html# Organized in table from HEADER

3) Creation of human resource development training guidelines

To promote the spread of energy efficiency and conservation, it is important to (1) promote the certification of energy conservation personnel across many technical fields and (2) develop a qualification certification system that includes education and training in the latest energy efficiency and conservation technologies for those in practice and those with field experience.

It is necessary to develop training guidelines and promote the establishment of Uzbekistan's domestic energy efficiency and conservation qualification system in order to develop human resources and education implementation systems in the government and private companies.

The categories of energy conservation personnel include the fields of energy auditing and energy management, listed in section (1). Although the fields are different, there are many similarities in the training content related to institutional and technical aspects. Education and training in audit (diagnostic) practices and business techniques is required for energy audits (diagnostics).

(2) Organizational system

A comprehensive organizational structure is needed for public information and awareness activities related to energy consumption and energy conservation, as well as for the development of administrative officials, managers, and private-sector human resources, covering a wide range of technical fields. It is recommended that an Uzbekistan version of the Energy Conservation Center should be established under the supervision of the MoE to serve as a one-stop comprehensive organization to promote energy conservation. As an implementation procedure for the establishment of the organization, it is appropriate to (1) utilize the training course on energy audits (diagnostics) at Tashkent University of Technology, while organizing the existing organizations for each industrial sector and technological field, (2) promote the establishment of an energy manager system, as described in section 4.2.4(1)2), and (3) gradually integrate them as an energy conservation center.

Chapter 6 Selection of Priority Measures and the Preparation of a Draft Roadmap

6.1 Energy Conservation Program Eligibility

The energy efficiency and conservation program will be Uzbekistan's country program that summarizes the sectors and measures that should be prioritized to promote energy efficiency in the country, the percentage of energy efficiency improvement (contribution) of the measures, and the promoters of the measures.

Figure 6-1 shows the percentage of energy consumption by sector and energy source, using petroleum units (toe), based on the energy statistics for Uzbekistan mentioned in Chapter 2. The figure shows that natural gas consumption for heat supply (shown in blue and green) in the residential, industrial, and commercial building sectors currently accounts for the largest share of primary energy consumption in Uzbekistan.

Based on the considerations up to Chapter 5, it is believed that the curtailment of natural gas and heat consumption in the residential, industrial, and the commercial building sectors, as well as the electrification of these sectors, would be advantageous for promoting energy conservation in Uzbekistan. This chapter mainly discusses measures that should be prioritized in these sectors.

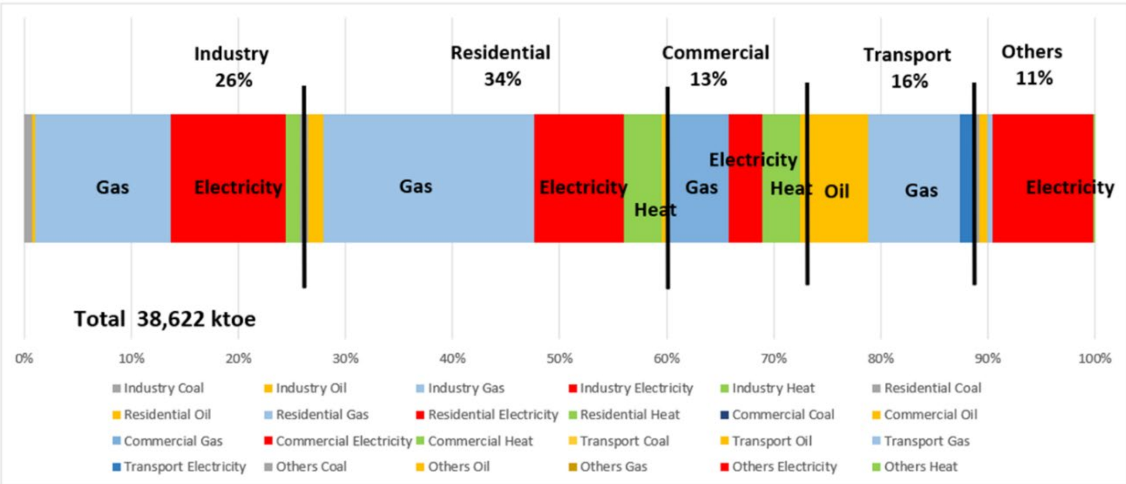


Figure 6-1 Percentage of energy consumption by sector and energy source using toe evaluation (recapitulated)

Source: Prepared by the JICA study team based on the latest data from the IEA

6.2 Energy Conservation Programs and Priority Measures

(1) Prioritized sectors and measures

The sectors and measures to be prioritized in energy efficiency programs must conform to Uzbekistan's policies toward energy efficiency, as well as to the global trend toward net zero emissions in 2050, as advocated by the IEA and others and shown in Chapter 4.

Presidential Decree No. PD-60 on the Development Strategy of the "New Uzbekistan" for the period 2022–2026 sets a target of a 20% improvement in socioeconomic energy efficiency and, along with the expansion of renewable energy, specifically notes the importance of improving energy efficiency in the commercial and residential building sectors.

In addition to energy efficiency improvements, the IEA includes the development of renewable energy sources and electrification as important milestones on the path toward 2050 net zero emissions, as shown in Figure 6-2. Key milestones also include the switch from boilers to heat pumps for heat supply by 2025 and having 50% of existing buildings as Zero Energy Buildings (ZEB) by 2040.

In the economic evaluation of each energy efficiency and conservation measure in Uzbekistan shown in Chapter 5, the conversion from gas boilers to heat pumps, the installation of building insulation and the promotion of ZEB were mentioned, although the introduction of incentives for energy efficiency and conservation were taken into consideration.

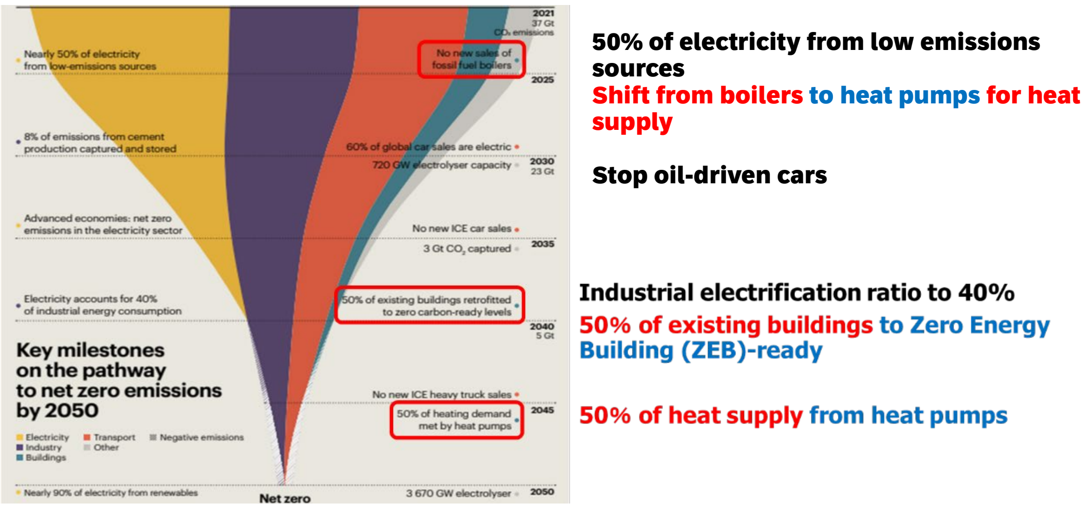
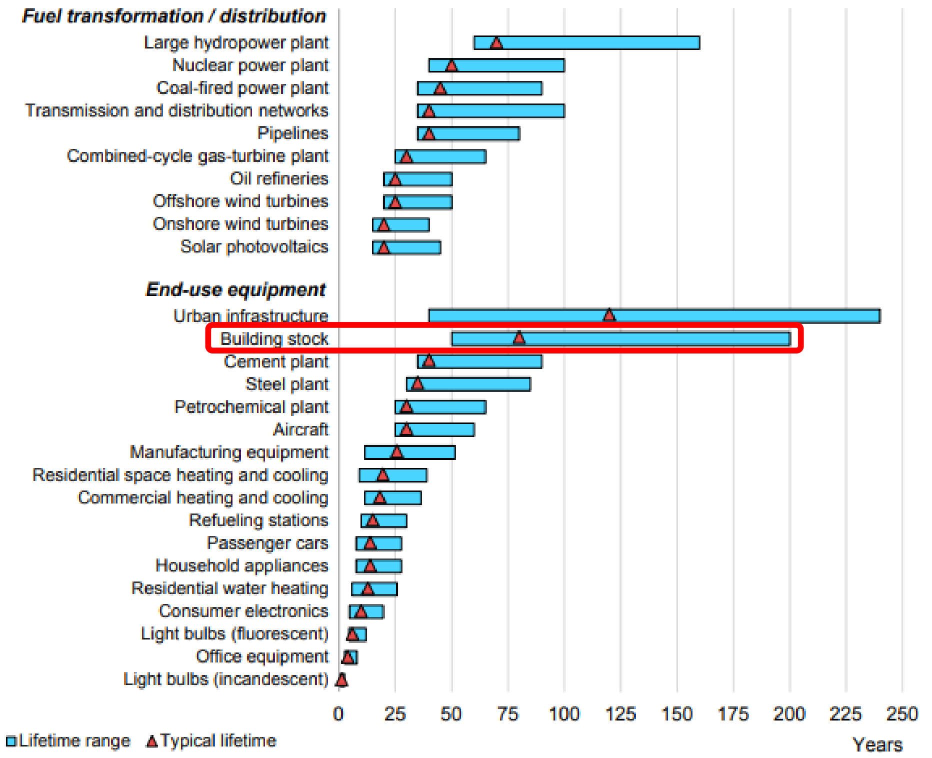


Figure 6-2 Milestones for achieving net zero emissions by 2050 (recapitulated)

Among the energy efficiency measures for buildings (commercial and residential), insulation measures are especially effective because their effects last for the lifetime of the building. In addition, the impact of lowered energy consumption on aging, inefficient buildings is also significant. Figure 6-3 shows the average life expectancy of the main assets in the energy sector. Urban infrastructure, building stock, large hydroelectric power plants, etc. have very long useful lives, at least 50 years, and up to 200 years for buildings. Hence, replacing these buildings with cleaner, more efficient ones will take a long time.



Notes: The red markers show expectations of average lifetimes while the blue bars show typical ranges of actual operation in years, irrespective of the need for interim retrofits, component replacement and refurbishments. "Buildings" refers to building structures, not the energy consuming equipment housed within. Examples of "urban infrastructure" assets include pavement, bridges and sewer systems.

Figure 6-3 Typical life of major energy sector assets

Source: IEA "Energy Technology Perspectives 2020."

Based on Uzbekistan's national policies and global trends (mentioned above), measures to improve energy efficiency in the building sector are of high importance, and are particularly urgent for new buildings, as the impact will be long-lasting. As indicated in Chapter 3, the consumption by energy source in the commercial building sector and the residential sector in Uzbekistan is dominated by natural gas and heat supply, so the following three policies should be considered as important priority measures for energy efficiency.

① Replace aging, inefficient gas boilers with heat pumps

② Promote higher efficiency in air conditioners, which are typical heat pump-integrated equipment

③ Promote building insulation and ZEB (regarding ZEB, start with public buildings, as they are easier for the government to promote, then move to commercial and residential buildings in stages)

In the industrial sector, the main measures involve businesses themselves improving energy efficiency through their business activities. As 75% of power consumption in factories is assumed to come from industrial motors, conversion to high-efficiency motors (IE3 or higher) is considered to be a highly effective energy conservation measure.

Therefore, a measure that should be promoted by the Uzbekistan government in the industrial sector is the establishment of an energy management system enabling each industry to monitor a target for energy consumption per unit.

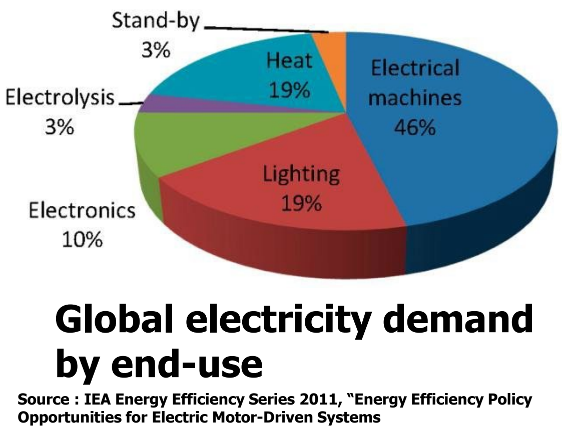


Figure 6-4 Electricity demand applications (global average)
Source: IEA "Energy Efficiency Policy Opportunities for Electric Motor-Driven Systems"

(2) Contribution to the energy efficiency improvements in Uzbekistan

Figure 6-5 shows the estimated trends in future energy efficiency improvements based on energy statistics for Uzbekistan. If final energy consumption (TFC) is estimated to increase at an annual rate of 3.7% from now until 2026 (red line in the figure) and gross domestic product (GDP) is estimated to grow at an annual rate of 5.4% (blue line in the figure), TFC per GDP (TFC/GDP) could decrease by 6.3% from 2022 to 2026, meaning that energy efficiency per GDP could be improved 'naturally' by around 6.3%.

However, the above 6.3% is not sufficient to achieve Uzbekistan's energy efficiency improvement target of 20% by 2026. Additional measures are needed.

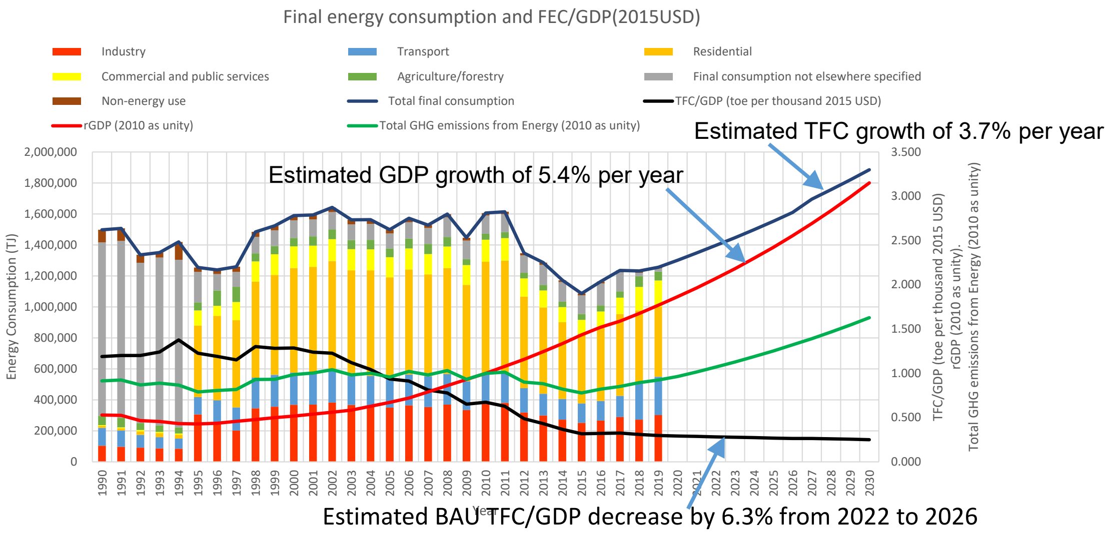


Figure 6-5 Typical life of assets owned by major energy sector

Source: IEA "World Energy Statistics and Balances."

Figure 6-6 shows an estimated breakdown of the contributions required in each sector to achieve Uzbekistan's energy efficiency improvement target of 20% per GDP. If it is estimated that the reduction of losses in other sectors that contribute to achieving the target, that is, the power sector (generation, transmission, and distribution), is about 3% based on the MoE Concept Note, and the efficiency improvement associated with the above GDP growth is about 6%. The contribution of energy conservation programs (energy efficiency improvement) is estimated to be at least 10%.

The combined contributions from measures such as increased renewable energy generation, future ZEB, and electric vehicles (EV) will increase the possibility of achieving Uzbekistan's goal of 20%.

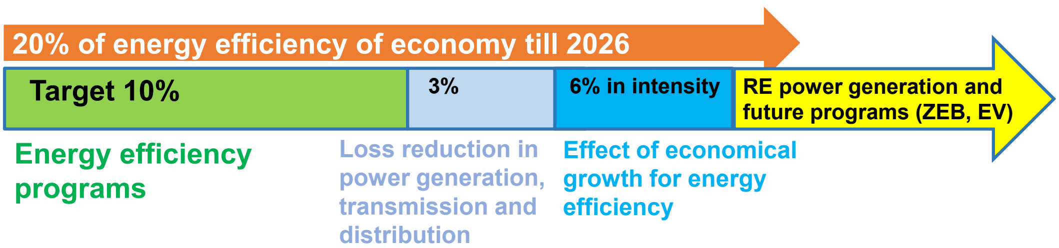


Figure 6-6 Contribution of each sector to achieve Uzbekistan's energy efficiency improvement target of 20%

Source: Prepared by the JICA study team

(3) Energy conservation program

Table 6-1 summarizes the sectors and measures that should be prioritized in the energy conservation program, the percentage of energy efficiency improvement (contribution) of the measures, and the promoters of the measures.

The seven priority measures are expected to make a certain degree of contribution (ratio of energy conservation potential of each priority measure to primary energy consumption of all sectors) and have realistic cost-effectiveness (payback period). In addition, owing to the need to introduce government subsidies, ZEB conversion is promoted as the fourth measure, as it is a comprehensive and developmental form of the first three measures.

In order for Uzbekistan's Ministry of Energy (MoE) to take the lead in promoting this energy conservation program, it will be necessary to collaborate with the newly restructured Ministry of Construction and Public Services (MCCS), among others.

Below is an explanation of the priority measure implementation. Details on the energy conservation potential and cost-effectiveness of each measure are organized in section 6.3.

① Convert heat supply equipment from gas boilers to heat pumps. Heat pumps are powered by clean renewable electricity, resulting in zero CO2 emissions. The IEA has also identified the conversion as a global priority. According to the energy balance of Uzbekistan, heat is currently supplied mainly from inefficient gas boilers (heating and hot water). In the current gas-fired power supply, the energy conservation and decarbonization benefits of converting heat supply facilities are limited. The government efforts to promote renewable energy could further enhance the decarbonization benefits in the future.

② Replace air conditioners and other products with high-efficiency models in the commercial buildings and residential sectors. Energy conservation standards for appliances and other products need to be strengthened by the Standardization, Metrology, and Certification Agency (Uzstandard). The demonstration test conducted at Tashkent University of Technology (Appendix 6) has also confirmed the effectiveness of the strengthened standards, and the IEA also recommends the use of high-efficiency inverters for air conditioners.

③ Promote the insulation reinforcement of windows, walls, roofs, etc. in the commercial buildings and residential sectors. The MCCS needs to enforce stricter regulations governing building insulation performance.

④ Develop ZEB certification standards, etc. for the future promotion of net ZEB. Owing to the long lifetime of buildings, as social capital stock, the IEA has also recognized this as a top priority. International standards for ZEB (ISO/TS23764) were established in 2021, and this became a global trend. In Uzbekistan, considering the large potential for photovoltaic power generation, the goal is to promote ZEB by combining energy efficiency measures with on-site photovoltaic power generation.

⑤ Promote the introduction of high-efficiency LED lighting fixtures. The IEA also recommends this as a reliable energy conservation measure. While a certain degree of diffusion has been achieved in Uzbekistan, further diffusion should be promoted. Cooperation between the MoE and the Standardization, Metrology and Certification Agency (Uzstandard) is required.

⑥ Strengthen the monitoring and control activities of energy consumption by large energy consumers in the industrial sector (e.g., factories). Results regarding this measure have been achieved in many countries, including developed countries. International standards (e.g., ISO 50001) should be used for energy management activities. Based on the energy consumption data reported by operators, it is important for the MoE, the Ministry of Investment, Industry and Trade (MIIT), and the Agency of Statistics (AoS) to work together to produce comprehensive energy statistics to develop and evaluate energy conservation policies for the entire country.

⑦ Promote the use of higher efficiency (energy efficiency class from IE1 to IE3) motors in MCCS in factories and irrigation pumping stations. The Ministry of Water Resources, which manages various water supply projects in the country, can contribute to reducing electricity consumption through the modernization of pumping stations for irrigation and other uses.

Table 6-1 Recommended energy conservation program

No.	Priority measures	Outline of Implementation	contribution	cost effectiveness effect	government assistance necessity	timeline **2020 2030 2040 2050**	promoter
1	Conversion from gas boilers to heat pumps (and further to use of renewable electricity)	➢ Subject: Commercial Buildings and Residential Buildings ➢ Description: Conversion from gas to electricity for heat supply facilities (heating and hot water) using heat pumps.	1 to 2 %	7.4 to 22.2	High		➢ MoE ➢ MIIT
2	Diffusion of high-efficiency air conditioners	➢ Subject: Commercial Buildings and Residential Buildings ➢ Description: Improvement of energy efficiency class of heating and cooling air conditioners.Transition from gas boiler heating to high-efficiency air conditioner heating	0.5%	5.2	High		➢ MoE ➢ MIIT ➢ Uzstandard
3	Reinforcement of building insulation (windows, walls, roofs)	➢ Subject: Commercial Buildings and Residential Buildings ➢ Contents: Doubled-glass, etc. for windows, insulation board, etc. for walls	1 to 3%	4.8 to 9.4	High		➢ MoE ➢ MCCS
4	Realization of ZEB/ZEH in the future	➢ Subject: Commercial Buildings and Residential Buildings ➢ Description: Combination of building energy conservation and on-site renewable energy	2.5 to 5%	10.2 to 22.7	High		➢ MoE ➢ MCCS
5	Widespread use of high-efficiency LED lighting	➢ Subject: Commercial Buildings and Residential Buildings	0.5%	6.9	Less		➢ MoE ➢ Uzstandard

		➢ Description: Improvement of energy efficiency class of LED lighting fixtures					
6	Establishment of an energy management system	➢ Target: Large energy consumers mainly in the industrial sector (factories, etc.) ➢ Description: Operational improvement and capital investment (renewal of aging boilers and industrial furnaces, etc.)	1.5%	4.2	High		➢ MoE ➢ MIIT ➢ AoS
7	High efficiency industrial motors	➢ Subject: Industrial Sector ➢ Description: Mandatory improvement of motor energy efficiency class.Modernization of irrigation pumping stations	0.5 to 1.5%	5.6	Less		➢ MoE ➢ MIIT ➢ MoWR
Total Contribution			7.5 to 14% (average around 10%)				

Source: Prepared by the JICA study team

6.3 **Details of priority measures**

The effectiveness of heat pumps, as indicated in the priority measures discussed in section 6.2, will be examined in section 6.3.1, along with their relationship to the efficiency of the power supply. The effectiveness of other priority measures will be discussed in section 6.3.2 onwards.

The numerical basis for effectiveness is the energy conservation potential. The primary energy consumption reduction potential was used as Uzbekistan's country-wide effect. Cost-effectiveness (payback period) was also estimated in terms of the feasibility of each measure.

6.3.1 Conversion from gas boilers to heat pumps

(1) Power supply efficiency and heat pumps

Although the effectiveness of heat pumps is clear from the studies in Chapter 4, the efficiency is greatly affected by the efficiency of the power supply, and therefore, the transition in the efficiency of the power supply must be considered. The efficiency of the power supply in Uzbekistan can be assumed in Table 6-2. It is assumed that the efficiency of the power supply will increase significantly in the future, thereby greatly reducing the conversion factor of electricity consumption to primary energy.

This change could significantly increase the benefits of electrification. Therefore, for heat pumps, systematically advancing the penetration rate is recommended, considering future improvements in power supply efficiency.

Table 6-2 Assumed primary energy conversion factors for electricity

Year	Conversion Coefficient Value	Source for Calculation
2020	2.74	Calculated from IEA Energy Balance 2020
2030	1.6	Ratio of thermal power generation: 58% (MoE concept note). Thermal power generation efficiency: 40% (survey team assumption) Transmission and distribution loss: 8.85% (MoE concept note)
2040	1.1	Ratio of thermal power generation: 41% TFC growth rate: 3.7%/year (Extended growth rate through 2030 according to concept note) Power supply to support increased TFC: Assuming 100% RE

		Power generation efficiency: 40%（applying 2030 assumption) Transmission and distribution loss: 8.85% (applying 2030 plan)

Source: Prepared by the JICA study team based on the IEA Energy Balance, MoE Concept Note, etc.

(2) Variation of the overall energy efficiency of heat pumps depending on power supply conditions

There are differences in efficiency between the overall energy efficiency of heat pumps, gas boilers, and district heat supply, as shown in Table 6-3.

Table 6-3 Comparison of overall energy efficiency (heat pumps as 1; large numbers are more efficient)

Primary energy conversion rate of electricity	Case A: 1.1 (2040)		Case B: 1.6 (2030)		Case C: 2.74 (2020)	
Thermal applications	heating	hot-water supply	heating	hot-water supply	heating	hot-water supply
heat pump	1	1	1	1	1	1
High-efficiency boiler	0.25	0.4	0.36	0.58	0.62	0.99
District Heat Supply	0.13	0.21	0.19	0.31	0.33	0.53

Consideration condition: SCOP 4 for heating heat pumps

SCOP 2.5 for heat pump water heaters

Efficiency of high-efficiency boilers 0.9

Primary energy conversion factor for use of supplied heat 2.07 (assuming DHP)

Source: Prepared by the JICA study team

The efficiency difference itself does not imply investment efficiency, as the equipment cost of a heat pump is greater than that of a high-efficiency boiler. Uzbekistan is improving the efficiency of their power supply systems. As shown in Table 6-3, heat pumps will have a significant efficiency advantage after 2030 and will be essential for the country. Increasing the penetration of heat pumps now is required, as it is assumed that the cost-effectiveness of using heat pumps will increase in the future owing to the constrained supply and rising prices of energy (especially natural gas).

(3) Heat pumps for air conditioning in commercial buildings

The issue of converting from heat supply as commercial buildings to heat pumps for air conditioning energy sources is discussed in this section.

Energy conservation potential of heat pumps in commercial buildings

Assuming that the heat supply system is changed to a heat pump, the energy conservation potential is calculated based on the heat value. The following are the parameters of the study.

- COP4 for heat pumps; primary energy coefficient for power supply is 2.7; and primary energy coefficient for heat supply is 2.07
- Conversion of heat supply systems to heat pump systems in buildings
- 66% of the heat consumption of the project building is 1147 ktoe (IEA 2018) (sorted with other effects)
- Penetration rate target: 40

Under these conditions, the energy conservation potential of replacing the supplied heat from the heat supply system with heat pumps can be calculated using the respective efficiency and primary energy conversion factors, as follows.

1147 x 0.66 x (2.07-2.7/4) x 0.4 = 422 ktoe/y

(4) Cost-effectiveness of heat pumps for air conditioning in commercial buildings

Of the cost-effectiveness, effectiveness addresses the benefits generated by the energy conservation potential. The energy conservation potential is evaluated using primary energy, and in Uzbekistan, the reduction of natural gas use is considered. Benefits are defined as the those resulting from the reduction of natural gas. The price of natural gas is evaluated here according to the steady-state international price of natural gas, which is 2000 UZS/m3 (0.176 USD/m3). Using the calorific value of natural gas of 34.2 MJ/m3, the energy conservation potential can be converted into a year's worth of benefits by multiplying by 2.44 b-UZS/ktoe (0.215 m-USD/ktoe).

In this section, the notation is simplified as follows.

UZS: Uzbekistan’s currency unit, USD: U.S. currency unit

As of January 31, 2023, 1 UZS = 0.000088 USD (Central Bank of Uzbekistan).

h: hours, d: days, M: months, y: years, person: number of persons

b: billion, m: million

m3: cubic meter of natural gas

m2: area in building (square meters)

The cost-effectiveness index values are as follows, with the denominator and the numerator in the same monetary unit.

(Cost-effectiveness) = (cost)/(benefit for one year)

The smaller this number is, the more likely it is to be implemented. If this number is less than 10, it means that the benefits for 10 years exceed the costs invested. The actual feasibility of implementation depends on the allocation of funds to the cost, the presence or absence or degree of interest, and where the benefits and costs are incurred.

The conclusion is that the implementation possibility is sufficient, as the effect lasts longer than 15 years in normal cases and longer than 10 years in short cases.

Estimated expenses will be net expenses and will not include expenses related to securing funds and interest.

As the diffusion rate is a coefficient on the size of the measure, both in terms of effectiveness and cost, the calculation assumes that it does not affect the cost-effectiveness figures, which in reality may change owing to lower costs when implemented on a large scale, interference with the effectiveness of the measure, and other factors.

The cost-effectiveness of heat pumps in commercial buildings is as follows and can be implemented.

Calculated based on heat value. The primary energy reduction effect for the winter heat generation capacity of a 100-kW heat pump chiller [100 kW x 24 h x 120 d/y x 3.6 MJ/kWh (1.04 TJ/y)] is (2.07 - 2.7/4) times, which is 1.45 TJ/y.

Also add effects to be used during the summer months as effects. The primary energy reduction owing to improved efficiency is multiplied by (2.7/1.5-2.7/4), which is 0.29 TJ/y, compared to the summer cold generation capacity of 100 kW x 8 h x 90 d/y x 3.6 MJ/kWh (0.26 TJ/y).

Assuming an operating load factor of 0.85 for these totals of 1.74 TJ/y, the primary energy reduction effect is 1.48 TJ/y, and its monetary equivalent is 1.48 TJ/y / 41.8 (TJ/ktoe) x 2.44 (b-UZS/ktoe) = 0.087b-UZS/y (0.0077m-USD/y)). Meanwhile, the cost of a 100-kW heat pump chiller is 0.5 b-UZS (0.044 m-USD) x 1.3 (installation cost), which is divided by 0.087 b-UZS/y (0.0077 m-USD/y) to obtain a cost-effectiveness ratio of 7.4.

(5) Energy conservation potential of heat pumps in residential buildings

As energy consumption in residences is high, and the primary energy demand is thermal energy, such as hot water and gas, the applicability of heat pumps is significant.

Gas boilers and district heat supplies could theoretically be replaced by heat pumps (HP). The energy conservation potential was estimated, as shown in Table 6-4. The future potential represents 19.5% of the current energy consumption (oil equivalent) of Uzbekistan.

Table 6-4 Energy conservation potential of heat pumps in residential buildings (million toe)

	Hot-water supply			Heating			Total
	Conversion from	Conversion from heat	Subtotal	Conversion from	Conversion from heat	Subtotal	

	gas consumption to HP	supply to HP		gas consumption to HP	supply to HP		
Case C	0.03	0.19	0.22	2.57	0.27	2.84	3.06
Case B	1.22	0.28	1.50	4.33	0.33	4.66	6.16
Case A	1.74	0.32	2.06	5.08	0.35	5.43	7.49

Cases A, B, and C correspond to the 2040, 2030, and 2020 conditions in Table 6-2, respectively.

The ratio of thermal energy consumption in housing is 0.3 for hot water supply and 0.7 for heating

Target energy: Residential energy consumption (primary energy) in 2020

Source: Prepared by the JICA study team

The figures in Tables 6-3 and 6-4 are based on the following calculations.

Let the conditions of the study be as follows. For gas, the primary conversion factor is 1.

α : Primary conversion factor for electricity

β : Primary conversion factor for district heat supply

f: SCOP for water heating or heating

g: Efficiency of high-efficiency boilers

E: Energy consumption of the subject (primary energy)

E1: Net energy consumption of the subject

Calculating primary energy use from E1, electricity: E1/f x α, high-efficiency boiler: E1/g, and district supplied heat: E1 x β. Therefore, when electricity is set as 1, the efficiency of high-efficiency boiler: g x α/f and district supplied heat: $\alpha/(\beta$ x f) as the ratio of these reciprocals. The potential for electricity conversion can be calculated from the difference in efficiency, as follows: high-efficiency boiler → electricity: $E(1-g \times \alpha/f)$, local supply heat → electricity: $E(1-\alpha/(f \times \beta))$.

(6) Realizing the energy conservation potential of heat pump air conditioning in residential buildings

Based on section (5) above, if the air conditioning of the house is completely converted to heat pumps, an energy conservation potential of 5430 ktoe (oil equivalent) can be finally realized in around 2040, which is equivalent to 14.1% of Uzbekistan's national energy consumption (oil equivalent).

This potential can be moved toward long-term realization by promoting the following measures.

① Widespread use of high-efficiency air conditioners and heating with air conditioners (see section 6.3.2)

② Reinforcement of building insulation (see section 6.3.3)

In addition, if heat pump water heating is installed in all the houses in a housing complex or in a particular area, and at the same time, and if the housing complex or area is intensively insulated and high-efficiency air conditioning is deployed, significant benefits can be realized.

(7) Realization of the energy conservation potential of heat pump water heating in residences

From section (5) above, assuming that heat pump water heaters are installed in all houses, a maximum energy conservation potential of 2060 ktoe (oil equivalent) can be realized, which is equivalent to 5.4% of Uzbekistan's national energy consumption (oil equivalent). This should be promoted as one of the future goals of social infrastructure development by the government.

Considering this goal, priority should be given to introduction in the following areas where introduction can be easily promoted in a unified manner, while such introduction areas should be expanded successively.

① By converting all the homes and buildings in a district heat supply target that belong to the same system to heat pump water heating, that district heat supply can be converted to heating operation for winter heating only.

② Install heat pump water heating in all dwellings within a housing complex. At the same time, the housing complex will be provided with the necessary insulation and high-efficiency air conditioning. In this way, the gas system of the housing complex would not need to be operated as a reserve system for emergencies.

It is estimated that although heat pumps for hot water supply have high potential for energy conservation, realizing cost-effectiveness will take a long time considering the current level of international natural gas prices.

It is recommended that the government should address this issue in view of infrastructure development; public facilities or commercial buildings are appropriate in this regard.

The price of natural gas is assumed to be 2000 UZS/m3 (0.176 USD/m3) in this study; however, a rise in the market price will be advantageous in terms of the national account. According to a trial calculation, if the market price increases to 8000 UZS/m3 (0.704

USD/m3), the 10-year benefits of natural gas abatement are expected to be equal to the cost of installation.

However, there may be cases in which the applicability of a limited subject should be considered on an individual basis. In the following two cases, the cost-effectiveness is about 20, and supportive measures by the government, as social infrastructure development, are considered necessary for the profitability of the user.

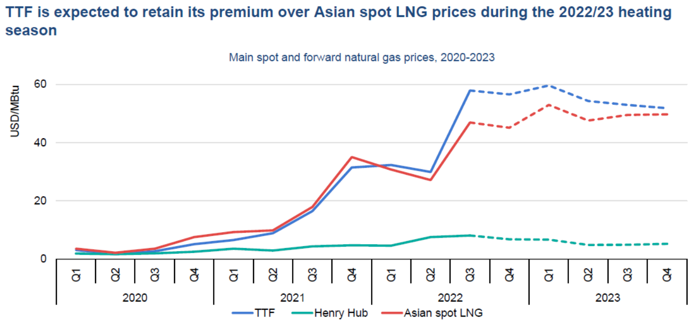


Figure 6-7 Trend of the natural gas prices in the international market

Source: IEA “Gas Market Report, Q4-2022”1

Applicability of heat pumps for hot water supply

1. Replacing an aging low-efficiency boiler in a detached house

Currently, boilers with low efficiency are used in detached houses, without being updated. For the detached houses, the following primary energy benefits are estimated if the boiler and hot water supply were completely replaced with high-efficiency air conditioners, for air conditioning, and heat pump hot water supply, for hot water.

Target ratio 5%; efficiency of the current boiler 65%; primary energy coefficient of electricity 2.7; heating SCOP 4.6 (A2+ class) for high efficiency air conditioner; inverter air conditioner assumed; annual average SCOP 3.3 for heat pump for hot water; heat generation 17 GJ/y for heat pump for hot water for cooking 10%. Assumption for air conditioning: water heating energy ratio of 7:3.

Amount of natural gas to be reduced: 36 ktoe/y natural gas.

Increased electricity (oil equivalent): air conditioning energy 9.6 ktoe/y, hot water supply energy 5.7 ktoe/y.

Energy conservation potential: 20.7 ktoe/y, benefits 50.5 b-UZS/y (4.44 m-USD/y)

Cost: 17,000 heat pumps for water heating corresponding to 7 ktoe/y of hot water heat rate.

Total cost: 1122 b-UZS (98.7 m-USD) as 5 high efficiency air conditioners (40 m-UZS (3520 USD)) per heat pump for water heating (26 m-UZS (2290 USD)).

Cost effectiveness: 22.2

2. When a heat pump water heater is installed in a housing complex connected to a district heat supply, and the heat from the district heat supply is used only for heating.

Assumed for 5% of the 1079 ktoe/y of the residential heat supply. Primary energy coefficient of 2.7 for electricity; primary energy coefficient of 2.07 for heat; annual average SCOP of 3.3 for the heat pump for hot water; 17 GJ/y of heat generated by the heat pump for hot water; and a hot water energy ratio of 30%.

Reduction in natural gas used at heat supply plants to be reduced: 33 ktoe/y.

Increased electricity (oil equivalent): 13 ktoe/y increase compared to 16 ktoe/y of hot water energy.

Energy conservation potential: 20 ktoe/y, benefits 48.8 b-UZS/y (4.29 m-USD/y).

Cost: 39400 heat pumps for water heating required for 16 ktoe/y. 1024 b-UZS/y (90 m-USD).

Cost effectiveness: 21.0

The cost-effectiveness of installing heat pump water heaters in commercial buildings will be calculated in the same way as for apartment buildings.

6.3.2 Diffusion of High-efficiency Air Conditioners

Air conditioners are a type of heat pump, and both the heating and cooling aspects should be considered as functions of high-efficiency air conditioning.

Currently, the demand for air conditioners as cooling systems is increasing. Although the increase in energy-using equipment puts a strain on the energy supply, it is considered an essential part of the increased lifestyle benefits associated with economic growth.

The efficiency of air conditioners is enhanced by technological developments. The demonstration tests conducted in this study (Appendix 6) also specifically demonstrated the efficiency of high-efficiency (inverter) air conditioners. Therefore, it is necessary to shift to high-efficiency air conditioning equipment while ensuring cost rationality.

In section 6.3.1, the start of full application of heat pumps, including water heating, in residential buildings is estimated to be around 2030. The system in which air conditioners are used for heating, and heat pumps are used for hot water supply, in residences is estimated to prevail. This system could be promoted as mandatory in building standards.

Low-efficiency air conditioners have low heating efficiency and are inferior to high-efficiency boilers or heat supplies. High-efficiency air conditioners are essential equipment for heat pump heating with air conditioners; the transition to high-efficiency air conditioners should be promoted considering this.

If a high-efficiency air conditioner is already equipped, it can be used as a partial heat pump air conditioning system in a residence because it does not involve a new investment. It is appropriate to implement this measure in newly constructed housing complexes where insulation is guaranteed, and air conditioning loads are low.

High-efficiency air conditioners have a wide range of applications. The effects of the measures implemented at this time are evaluated here as part of this project; they may enjoy even greater effects in the future.

Energy conservation potential from the spread of high-efficiency air conditioners

1. Higher efficiency air conditioner models purchased

Subject: Based on IEA data, the share of air-conditioned electricity consumption in the residential sector (residential) is assumed to be 10% (from a Japanese case study) of the 1169 ktoe of electricity consumed.

Provide incentives to select inverter air conditioners with higher air conditioning efficiency standard (labeling) values at the time of purchase.

Effectiveness rate of 25%: 10% improvement of one rank above the standard air conditioner efficiency value + 15% effect of inverter installation.

Demonstration tests have shown that it is 50% more effective in summer and 80% more effective in winter.

Penetration rate: 50% (30% new purchase increase, 20% replacement).

Primary energy conversion factor for electricity.

Energy conservation potential: 44 ktoe/y (117 x 0.25 x 0.5 x 3)

2. Use of high-efficiency air conditioners for heating

Subject: Heat consumption 1079 ktoe/y in the residential sector (residential) based on IEA data.

As the subject of the study is an apartment complex, heat consumption is the target of the calculation. When boilers are installed in new construction sites owing to building regulations, heat can be evaluated in natural gas. However, heat from air conditioners will be once evaluated in electricity, then natural gas. Therefore, the target amount is ascertained from the net heat consumption, which is not converted to primary energy.

Assumed penetration rate: 30% for new construction, 50% for high-efficiency air conditioners in new construction, and 50% for implementation in eligible conditions. In order to increase the implementation ratio of this matter, it is desirable to implement it as administrative guidance rather than a voluntary matter for the dwellers.

Effect: The heating SCOP of the air conditioner to be utilized shall be 4.5. Heating standards for air conditioners are A+ 4.0-4.6, A+ + 4.6~5.1, and A+ + + 5.1 or higher in SCOP, and a SCOP level of 4.5 can be achieved, on average, for A+ or higher air conditioners.

It is assumed that new apartment complexes are equipped with gas boilers, which are used for heating and hot water supply according to building regulations. Therefore, gas boilers are used for comparison in the calculation of energy conservation potential. If the primary energy conversion factor for electricity is 3, and the primary energy conversion factor for gas boilers is 1.1, an effect due to the factor of (1.1-3/4.5) =0.43 is generated.

This item assumes the installation of a high-efficiency air conditioner. It should be noted that this is a matter of operational choice, that is, which of the already equipped heating energy equipment should be used, and is an operational effectiveness evaluation, not an investment effectiveness evaluation.

The subject of this item should be well insulated. In buildings with low insulation and high heating energy use, the effect of high-efficiency air conditioning can be significant, but there are many situations in which heating with high-efficiency air conditioning is insufficient, reducing the reliability of heating with high-efficiency air conditioning.

Although the application was targeted at apartment buildings, it is equally effective for single-family dwellings designed with high thermal insulation and equipped with high-efficiency air conditioners. With proper information provided by the government, the effects of high-efficiency air conditioning should occur in such cases as well.

Snowfall in January 2023 in Uzbekistan resulted in a significant drop in temperatures. This was the first time in decades that the supply of natural gas was in short supply, which interfered with the local heat supply and caused a sudden increase in the use of low-efficiency electric heaters, resulting in power and gas outages. The regular allocation of power supply capacity to heating by high-efficiency air conditioners diversifies the heating supply system and contributes to the stability of the energy supply in winter.

Energy conservation potential: 35 ktoe/y (1079 x 0.3 x 0.5 x 0.5 x 0.43)

The cost-effectiveness of promoting high-efficiency air conditioners is as follows and can be implemented.

1. Higher efficiency air conditioner models purchased

Incentives were assumed to subsidize 30% of the price difference based on A, but other subsidy methods are possible. The price difference for one rank is about 50 USD. The number of subsidized units is assumed to be 3.25 million (about 40% of the total number of households).

The incentive is 553b-UZS ($48.6mUSD). The benefit of the 44ktoe effect is 107.5b-UZS (9.46m-USD). The ratio of the two is 5.2 as a cost-effectiveness ratio.

2. Use of high-efficiency air conditioners for heating

As the installed air conditioners are used, no new investment costs are incurred.

6.3.3 Reinforcement of Building Insulation (windows, walls, roofs)

The effectiveness of building insulation is clear from the studies in Chapter 4. The insulation implementation policy can be considered from the aspect of standards and the aspect of insulation reinforcement through investment, while the reinforcement of insulation in new construction or major renovation should proceed by obligation through construction standards.

Energy conservation potential of reinforcing building insulation

1. Setting the penetration rate Assume that building insulation standards will be strengthened and applied to new construction and major renovations. Assume a penetration rate of 15%. 2. For business buildings 40% of the heat consumption of 1147 ktoe/y (IEA 2018) in commercial buildings is assumed to be insulated. Composition of heat dissipation: windows 0.42, walls 0.42. Improvement ratio: windows 3.5 → 1.6 (multi-layer → low-e), walls 2.07 → 0.56 (insulation). Primary energy coefficient of heat supply 2.07. Energy conservation potential: windows 27 ktoe/y, walls 44 ktoe/y. 3. In the case of an apartment complex It is assumed that 40% of the total (6424 ktoe/y) of the 1079 ktoe/y residential heat consumption (oil equivalent of IEA 2018) and the net heat consumption of 5345 ktoe/y for the collective housing portion of the 8002 ktoe/y residential gas consumption (both IEA 2018) will be subject to insulation. The primary energy conversion factor for the weighted average of heat and gas to net heat consumption is 1.5. Composition of heat dissipation: windows 0.4, walls 0.5. Improvement ratio: windows 6 to 3.5 (multi-layer single layer to multi-layer), walls 2.07 to 0.56 (insulation). **Energy conservation potential: windows 210 ktoe/y, walls 97 ktoe/y** 4. For a detached house We assume that 50% of the 496 ktoe/y of net heat consumption for the detached house portion of the residential gas consumption of 8002 ktoe/y (both IEA 2018) is subject to insulation. The primary energy conversion factor for net heat consumption is 1.37. Composition of heat dissipation: windows and roof 0.45, walls 0.55. Improvement rate: windows and roof 0.6 (windows 6 to 3.5, roof 3 to 0.5), walls 2.07 to 0.56. **Energy conservation potential: windows and roofs 14 ktoe/y, walls 21 ktoe/y**

The cost-effectiveness of strengthening building insulation is as follows and can be implemented.

1. For business buildings Window: the target area for 1 TJ is 1000 GJ / 0.727 GJ/m2 (70 W/m2 x 24h x 120d), the unit

cost of the measures is 0.63 m-UZS/m2 (55 USD/m2) (low-e), and the effectiveness is 0.055 b-UZS/TJ (4840 – USD/TJ) (1.6/3.5 x 2.07 x 2. 44÷41.87).

Wall: the area covered for 1 TJ is 1000 GJ / 0.428 GJ/m2 (41.4 W/m2 x 24h x 120d), the unit cost of the measure is 0.086 m-UZS/m2 (7.6 USD/m2), and the effectiveness is 0.088 b-UZS/TJ (7740 USD/TJ) (1.51/2.07 x 2.07 x 2.44÷ 41.87).

Cost-effectiveness: by weighted average of targeted heat release:

(0.63/0.727 + 0.086/0.428)/ (0.055 + 0.088) = 7.4

2. In the case of an apartment complex

Window: the target area for 1 TJ is 1000 GJ / 1.246 GJ/m2 (120 W/m2 x 24h x 120d), the unit cost of the measures is 0.387 m-UZS/m2 (25 USD/m2), and the effectiveness is 0.036 b-UZS/TJ (3170 USD/TJ) (2.5/6 x 1.5 x 2.44 / 41.87).

Wall: the area covered for 1 TJ is 1000 GJ / 0.428 GJ/m2 (41.4 W/m2 x 24h x 120d), the unit cost of the measure is 0.086 m-UZS/m2 (7.6 USD/m2), and the effectiveness is 0.064 b-UZS/TJ (5630 USD/TJ) (1.51/2.07 x 1.5 x 2.44÷ 41.87).

Cost-effectiveness: by weighted average of targeted heat release:

(0.387/1.246 + 0.086/0.428 x 1.25)/ (0.036 + 0.064 x 1.25) = 4.8

3. For detached houses

Windows and roofs: the target area for 1 TJ is 1000 GJ / 0.933 GJ/m2 (90 W/m2 x 24h x 120d), the unit cost of the measures is 0.815 m-UZS/m2 (71.7 USD/m2), and the effectiveness is 0.048 b-UZS/TJ (4220 USD/TJ) (2.7/4.5 x 1.37 x 2.44÷ 41.87).

Wall: the area covered for 1 TJ is 1000 GJ / 0.428 GJ/m2 (41.4 W/m2 x 24h x 120d), the unit cost of the measure is 0.086 m-UZS/m2 (7.6 USD/m2), and the effectiveness is 0.058 b-UZS/TJ (5100 USD/TJ) (1.51/2.07 x 1.37 x 2.44÷ 41.87).

Cost-effectiveness: by weighted average of targeted heat release:

(0.815/0.933 + 0.086/0.428 x 1.22) / (0.023 + 0.043 x 1.22) = 9.4

6.3.4 Realization of ZEB/ZEH in the Future

The development of ZEB for the future is an important issue in Uzbekistan. Its energy conservation potential is such that if all buildings were ZEB ready or higher, more than 50% of the energy consumption of commercial buildings could be saved. In practice, the primary, long-term target is considered to be about 20%, to be promoted in stages. In this case, the target value corresponds to 1000 ktoe/y in the 2020 IEA energy balance (oil equivalent).

If the same approach is taken for ZEH in detached houses, the target would be 160 ktoe/y. Here, the natural gas energy consumption of the entire detached house is estimated to be about 8% of the natural gas energy and thermal energy consumption of the entire house. As the scale of energy consumption of detached houses is small, the potential is also small.

In Uzbekistan, many people live in apartment complexes. Although the scale of energy consumption in apartment buildings is considerably larger than that of commercial buildings and detached houses, apartment buildings are not the primary target of ZEB because of their high energy consumption density and the limited space available for installing photovoltaic power generation. Rather than setting ZEB targets for apartment buildings, it is considered effective to promote energy conservation that is equivalent to ZEB-ready by building up individual measures, such as reducing thermal energy consumption of natural gas and heat by promoting individual energy conservation measures, such as heat pumps, insulation, and high-efficiency air conditioners.

Regarding ZEB, this study examines ZEB conversion for the case of two commercial buildings (see Chapter 4 and Appendix 7).

The estimated cost-effectiveness of the project is 10.2 to 22.7 years (national basis) (Appendix 7); however, as buildings are used for a long time, it is desirable to create an implementation model for the future.

Note that the cost of insulation is expected to be significantly lower for new construction than renovation. Therefore, it is recommended to expand the examples of public buildings to increase awareness and promote ZEB-level insulation through building standards.

6.3.5 Widespread Use of High-efficiency LED Lighting

The widespread use of LED lighting is an important global issue, and Uzbekistan has already widely adopted LEDs by banning the sale of incandescent bulbs over 40 W (2017). However, the use of high-efficiency LED lighting is a future challenge in Uzbekistan, as LED efficiency is improving in terms of technology.

Energy conservation potential of high efficiency LEDs

Target: Electricity for lighting in residential and commercial buildings

Residential: 1169 ktoe (Residential electricity in IEA 2018)

Commercial building: 427 ktoe (Commercial electricity in IEA 2018)

Lighting ratio of 27%: 13.4% of households and 30% of commercial buildings are illuminated in Japan (2009). 1/0.7 is used for the weighted average, considering the high air conditioning ratio in Japan.

Penetration rate: Assumed 50% replacement with high-efficiency LEDs.

Effect of upgrading from low-efficiency LEDs to high-efficiency LEDs: 50.

Estimation of curtailed payments by setting the highest Japanese standard, bulb-based LEDs: Daylight, daylight white, white: 43%; warm white, light bulb color: 61%.

From the above, the energy conservation potential is 108 ktoe.

The cost-effectiveness of increasing the efficiency of LEDs is as follows and can be implemented.

Estimated at 20W LED specification.
Assumed cost: 93k-UZS (8.18 USD).
Effect: Assumed improvement cost equivalent to electricity used:
20Wx3hx30dx12Mx3 (primary energy conversion factor) x 3.6 (kJ/kWh) = 233 kJ.

Benefit: 230 ÷ 41.87 (ktoe/TJ) × 2.444 (b-UZS/ktoe) = 13.4 k-UZS.

Cost effectiveness: 6.9
Total cost: 108 (ktoe) x 2.444 (b-UZS/ktoe) (0.215 m - USD/ktoe) x 6.9 = 1822 b-UZS (160 m - USD).

6.3.6 Establishment of an Energy Management System

Energy efficiency measures in the industrial sector will be considered in three aspects: energy efficiency by operators, standards for equipment, and large-scale measures for process and recovery cycles. This study will address the first two as measures to be implemented and strengthened on a regular basis, but the last point should also be addressed, separately, when Uzbekistan builds production plants and energy supply and transportation facilities, and their processes and recovery cycles are verified from an energy efficiency perspective.

The basis for energy efficiency in business sectors is to have an autonomous energy management system, under which they share goals with the government and make the improvement potential a reality. Uzbekistan's measures to establish such a system are underway and should be continued and strengthened (see Chapter 4). It is also necessary that there should be a government support system in terms of investment to help businesses become more energy efficient (see Chapter 5).

Energy conservation potential through the establishment of energy management systems in the industrial sector

The energy conservation potential existing in the factory will be made apparent by the following methods.
(1) Establish energy management in factories
(2) Identify energy conservation targets and realization methods through energy conservation audits

The scale of possible energy conservation is assumed to be about 10% of energy consumption, based on the findings in Japan of energy efficiency and conservation audits, general findings on energy efficiency and conservation potential, and the findings of the questions and answers in the "Ugoku" factory. However, the investment period for thermal energy consumption tends to be longer than that for electricity energy conservation, assumed about 2%, mainly for operational improvements. The on-site survey of local factories confirmed that there is room for energy conservation, but the scale of the effect is not yet clear.

(3) Implement energy conservation with the energy manager as the key person

(4) Grant the necessary funds to projects that do not require investment or have a payback period of 3 years or less.

Energy conservation potential is 500 ktoe/y, breakdown: electricity 400 ktoe, natural gas 100 ktoe (10% of 2018 IEA energy consumption for electricity and 2% for natural gas) vs. oil equivalent (electricity 3).

The cost-effectiveness of establishing an energy management system in the industrial sector is as follows and can be implemented.

Energy management costs

Personnel costs for energy management personnel training and implementation

Target: Managers 2000 person

Training cost: 2M

Implementation cost: 30% of 36M load

Labor cost: 0.7b-UZS/y/person (0.062m-USD/y/person), 147b-UZS/y (129m-USD)

Energy management investment cost: 3x 122b-UZS/y (108m-USD/y)

Total cost: 5140b-UZS/y (452m-USD/y)

Total effect: 122b-UZS/y (108m-USD/y)

Cost effectiveness: 4.2

6.3.7 High Efficiency Industrial Motors

Regarding the standards for equipment, one effective technology is efficiency standards for motors (see Chapter 4). This mandates the efficiency of new motor facilities, and because it is implemented by obligation, its cost is intrinsic, not an investment.

For the industrial sector, in addition to the above, there are other measures, such as improving the efficiency of steam and hot water systems and the heat recovery performance of industrial furnaces, the promotion of which could also result in energy efficiency for the industry.

Energy conservation potential of high-efficiency industrial motors

(1) Standardization

Establish a standard for high-efficiency motors for the industrial sector. IE3 (use of premium efficiency) to be mandatory. Note that the European standard allows the use of IE2 when an inverter is installed, and as IE2 + inverter is usually recognized as more efficient and reasonable than IE3, that method can also be used. However, the estimation of energy conservation and cost-effectiveness is done here under IE3 conditions.

(2) General-purpose motors subject to the mandate

AC induction motors used in equipment, excluding the following

Heat resistant

Used in ships and offshore structures

Used in liquids

Explosion-proof specifications for use in oil and gas plants

Items that are used infrequently, such as gate opening/closing

Items used in cryogenic environments

For vacuum pumps

(3) Target quantity and effect

Subject field power 4000 ktoe: oil equivalent to 2018 IEA industry power consumption (electricity 3)

Motor share of electricity 75%: Composition in Japan

Energy consumption reduction rate of 7.4% (calculated in Japan: average based on capacity configuration)

Penetration rate 50% (100% high efficiency for new construction, 10-year renewal rate assuming 20-year service life)

Energy conservation potential is 110 ktoe/y

The cost-effectiveness of building industrial motors with higher efficiency is as follows and can be implemented.

(1) Incremental manufacturing cost of motor per kW: 4m-UZS (352USD) from 40% increase (Japan estimate)

The incremental manufacturing cost is borne by the supplier in the first instance, but is transferred as a cost to the purchasing plant through the equipment sales price.

(2) Annual benefit calculation per kW: 4.8h/dx20d/Mx12M=1150h, unit cost 630 UZS (0.055USD), 0.72b-UZS/y (0.063m-USD)

(3) Cost effectiveness

5.6 from the ratio of (1) and (2)

6.4 **Roadmap Proposal**

The draft roadmap (Attachment 8), summarizing the results of the studies up to section 6.3 above, was prepared and shared with the relevant ministries and agencies, including the MoE of Uzbekistan, and international organizations at the "Energy Efficiency Seminar" held on Tuesday, January 31, 2023 at the venue of the National Scientific Research Institute of Renewable Energy Sources, under the Ministry of Energy.

Chapter 7 Current Status and Issues of Energy Statistics

7.1 Importance of Energy Statistics

7.1.1 Importance of Energy Statistics in Energy Conservation Policy

Official energy statistics are critical in formulating energy policies related to energy security, energy mixture, energy conservation, Sustainable Development Goals (SDGs), and the green economy. Figure 7-1 is an energy balance table showing production, imports and exports, energy conversion, transportation, consumption, etc. by energy source. This information, including the current status of energy related matters and the transition status covering the entire country, is extremely important for policy makers because it can be used to plan energy and environmental policies and to evaluate their effectiveness.

The United Nations and the International Energy Agency (IEA) recommend that countries around the world produce and disclose their energy balance tables in the same format. They also request countries to submit their energy data to the IEA. The IEA compiles and publishes global energy-related information from various countries. By using the energy information published by the IEA, countries can compare data among themselves and manage the progress and targets of their energy and environmental policies. The provision of statistical information is essential for countries to fulfill their goals regarding greenhouse gas reduction and other responsibilities. The release of data is also expected to advance research on energy and environmental issues by making the data more accessible both to policy makers and to researchers.

IEA ENERGY BALANCE 2020 UZBEKISTAN ktoe												
		Coal	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Wind, solar, etc.	Biofuels and waste	Electricity	Heat	Total
		ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
Total Enegy Supply	Production	1471	2922	0	40419		430		3			45245
	Imports	1128	740	762	0					448		3078
	Exports	0	0	-41	-2478					-231		-2750
	International marine bunkers	0	0	0	0							
	International aviation bunkers	0	0	-114	0							-114
	Stock changes	306	5	21	-535							-204
	Total energy supply	2905	3666	629	37405		430		3	217		45255
Conversion	Statistical differences	-211		106	223					-242	41	-83
	Electricity plants	-741		-63	-6013		-430			3200		-4047
	CHP plants	-635		-79	-6155					2518	1415	-2937
	Heat plants	-2		-23	-1500						1402	-123
	Gas works											
	Oil refineries		-3645	3508								-137
	Coal transformation	-8										-8
	Liquefication plants											
	Other transformation											
	Energy industry own use	-7	-4	-146	-2370					-368		-2895
	Losses	-1	-17	-4	-905					-858	-174	-1959
Total Final Consumption	Total final consumption	1300	0	3927	20685				3	4467	2683	33065
	Industry	230		144	4322					1697	402	6796
	Transport	4		2943	2988					91		6026
	Residential	260		471	9675					1337	1105	12848
	Commercial and public services	102		167	2395					450	1122	4237
	Agriculture / forestry	15		3	259					791	53	1122
	Fishing	0			0							0
	Non-specified	689		53	1045				3	101		1890
	Non-energy use			145								145

Figure 7-1 Uzbekistan's 2020 energy balance table

Source: Prepared by the JICA study team based on the IEA Energy Balance Data

In promoting energy policies and energy conservation policies, accurate energy statistics based on reliable data are essential for understanding the current situation, setting baselines for goals, and measuring the progress and achievement of measures. The statistics data should also be used as an indicator to evaluate energy consumption and usage efficiency at the sectoral or more disaggregated level. However, the current status is recognized as inadequate by the Ministry of Energy (MoE) and others in Uzbekistan's national government.

With regard to improving energy statistics, in December 2019, the World Bank and the National Statistical Commission (SCS) of Uzbekistan jointly issued the "National Strategy for Development of Statistics of the Republic of Uzbekistan for 2020–2025." In addition, the improvement of energy statistics was specified in Presidential Decree PP4796, dated August 3, 2020, "Measures for Further Improvement and Development of the National Statistical System," and improvement activities are underway by the SCS. The MoE is working to strengthen cooperation with the SCS in order to unify the energy balancing work handled by the SCS, as well as improve accessibility to the collected information. The MoE is also trying to develop a system for collecting energy consumption information to promote energy efficiency in the economy and industry.[1]

Since the SCS became an organization under the direct control of the President and changed its name to The Agency of Statistics in a reorganization in January 2023, this report uniformly describes its name as the AoS.

7.2 Current Energy Statistics

7.2.1 System for Compiling Energy Statistics

(1) Legal framework

The AoS is the sole authorized agency for the development of national statistics in Uzbekistan, according to the Law About Official Statistics (August 26, 2020). Thus, for energy statistics as well, the AoS is responsible for the entire process from data collection to development and publication, while the other ministries cooperate in data collection and are users of the aggregated data. However, in practice, other ministries collect and distribute data within their range of jurisdiction. From this point, the AoS and each related ministry are considered the primary producers of official statistics, while other ministries provide a variety of data within their capacity.[2]

1World Bank and SCS, "National Strategy for the Development of Statistics of the Republic of Uzbekistan for 2020 - 2025 " 2019.12

2Under Japan's Statistics Law, the Statistics Bureau of the Ministry of Internal Affairs and Communications (MIC) is responsible for the statistics that cover the entire country and ministries (e.g., the Population

Statistical information is to be provided to state agencies, autonomous bodies, legal entities, international organizations, and the general public in the manner prescribed. Statistics can be viewed on the Open Data page of the AoS website or through the Open Data Portal.[3,4]

The method of data collection, including survey targets, questionnaires, reporting frequency, etc., is to be discussed with the competent ministries, and the MoE also holds discussions once a year. However, the report by the World Bank points out that the discussions are not sufficient. In fact, according to the interviews conducted during the field survey, information from the AoS is not easily retrieved owing to reasons such as confidentiality even though other ministries make requests. However, some respondents said that the situation has been improving since around 2020.[5]

The administrative body in charge of the energy sector is the MoE, which was established in February 2019 as a separate entity from the Ministry of Economy, Trade and Industry. According to the amended law "On the Rational Use of Energy" (July 14, 2020), the MoE is positioned as a specially authorized national agency in the field of the rational use of energy. It is given the role of implementing a unified national policy to improve energy efficiency and promote energy conservation in government institutions, economic sectors, and social sectors. The Law includes a section on "Organization of Statistical Observations on Energy Production and Consumption," and the integrated information system that the MoE is trying to develop, referred to in (2)2) in the next section, is considered a part of this. Under Japanese Statistics Law, the concept of responsibility sharing differs in that the Statistics Bureau of the Ministry of Internal Affairs and Communications (MIC) is responsible for statistics that cover the entire country and ministries (e.g., the Population Census), while statistics in areas under the jurisdiction of each ministry and agency are the responsibility of each ministry (e.g., the Agency for Natural Resources and Energy is responsible for comprehensive energy statistics and the Survey of Petroleum Consumption, etc.).[6,7]

Census). However, each ministry and agency is responsible for statistics in areas under its jurisdiction (e.g., the Agency for Natural Resources and Energy is responsible for comprehensive energy statistics and the Current Survey on Petroleum Consumption). They have different approaches to the division of responsibility.

[3]https://stat.uz/en/

[4]https://data.gov.uz/eng

[5]Same as footnote 1.

[6]UP-5646 Republic of Uzbekistan, Measures for the Periodic Improvement of the Fuel and Energy Industry Management System (February 1, 2019).

[7]Law 628 "On the Rational Use of Energy" "c" Amendment and Addition to the Law of the State Republic of Japan (July 14, 2020)

(2) Policies and strategies for energy statistics

1) Activities to improve energy statistics in accordance with Presidential Resolution PP4796, "Measures to further improve and develop the national system of statistics" (August 3, 2020)[8]

In December 2019, the World Bank and the AoS (SCS) jointly issued the "National Strategy for Development of Statistics of the Republic of Uzbekistan for 2020–2025," a comprehensive review of national statistical activities and recommendations for improvement. The report recommends improvements in energy statistics, including the incorporation of international indicators, the strengthening survey of residential final energy consumption, and cooperation with data providers adopting their requests.[9]

Subsequently, the Presidential Decree PP 4796 established items for the improvement of national statistics until 2025. PP 4796 is positioned to promote improvements in the quality and reliability of the overall national statistical information produced by the AoS (SCS), improvements in transparency, and improvements by following international recommendations and guidelines. With regard to energy statistics, it is harshly assessed that "there is currently no complete information that reveals a complete picture of the country's energy sector." This indicates that the reliability of statistical data is considered inadequate. Regarding energy statistics, the Annex describes efforts to improve them, the main points of which are as follows (note: these efforts are ongoing).

- Improvement in existing methods of energy statistics based on the UN and IEA standards.
- Collection of proposals from ministries and agencies for better information on energy efficiency and energy consumption. Addition of energy consumption questions to household surveys and publication of results.
- Improvement of statistical indicators for high quality energy balance formation.
- Identification of missing indicators in energy statistics. Formation of indicators based on the UN standards.

2) MoE activities in accordance with the Resolution of the President PP4779 "About additional measures to reduce fuel energy dependence branches of the economy from fuel-energy products by increasing energy efficiency economy and activities available resources"

The MoE, in accordance with the Resolution of the President PP4779, aims to establish an "Integrated Information System" to collect and process energy consumption and

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[8]PP4796 Resolution of President of the Republic of Uzbekistan "On measures to further improve and develop the national system of statistics of the Annex 1-V-6 Improvement of energy statistics (August 3, 2020) (Document 4)
[9]World Bank, SCS, "National Strategy for the Development of Statistics of the Republic of Uzbekistan for 2020 - 2025 " (December 2019)

management information to improve the energy efficiency of enterprises.[10]

Table 7-1 Functional requirements for an integrated information system as indicated in the Decree of the President PP4779

Table 7-2 Purpose of the integrated information systems

The system has been in trial operation for electric power companies since March 2022. The original plan was to seek collaboration and cooperation from related ministries and agencies to expand the program to large companies. However, as of January 2023, the expansion of operations has been halted owing to a lack of development engineering capacity. The MoE is expected to reissue its development policy.

The Resolution of the President stipulates that in this system various related bodies will collaborate to create an automated integrated information system, such as the MoE, the Ministry of Economic Development and Poverty Reduction, the State Tax Committee, the AoS, and the Ministry for Department of Information Technology and Communications. The Resolution also stipulates that this system will be commissioned and integrated with e-government by the end of 2021 to provide the necessary information on production volumes, financial indicators, and other necessary information across sectors, among other provisions.

The Resolution of the President also stated that energy resource conservation targets were set for 2020–2022 for 25 energy and energy-intensive industries, mainly under the jurisdiction of the MoE. A low map was also set with a roadmap listing 29 items for energy efficiency improvements and energy conservation. Furthermore, energy audits were established for 285 energy-intensive companies.[11]

Table 7-1 Functional requirements for an integrated information system as indicated in the Decree of the President PP4779

[Excerpt] 9. The Ministry of Energy, the Ministry of Economic Development and Poverty Reduction, the State Tax Committee, the National Statistics Commission, and the Ministry for Department of Information Technology and Communications: a) Develop a technical task to create an automated integrated information system for the Ministry of Energy within three months. ・ Analysis and forecasting consumption volume of fuel and energy in large-scale companies and other sectors of the economy. ・ Simplified mechanism for providing the identification numbers of energy producers

[10]PP4779 About additional measures to reduce dependence branches of the economy from fuel-energy products by increasing energy efficiency economy and activities available resources (July 10, 2020)
[11]Companies consuming more than 2,000 tons of standard fuel or 1,000 tons of motor fuel per year in fuel and energy resources

(large consumers) via the internet and sending the corresponding reports on the energy generated (consumed) in electronic format. ・ Automated collection, systematization, and analysis of accounting data on generated (consumed) energy; and determination of energy efficiency for large-scale industrial enterprises ・ Creation of a secure trading platform for online reverse auction trading in the renewable energy sector. b) Ensure commissioning of the trial operation of the unified information system and its integration with e-government by the end of 2021, and providing cross-sectoral electronic exchange of necessary information such as production volumes and financial indicators. c) Implement a mechanism for mandatory energy audits of energy intensive enterprises based on analytical data obtained from the unified information system.

Source: Excerpt from the Decree of the President PP4779

Table 7-2 Purpose of the integrated information systems

2.4 Purpose of the system The main objectives in creating this system are:	
(a)	To form a single information space in the field of energy conservation and energy efficiency.
(b)	To analyze energy resources consumed by consumers for further planning and action to improve energy efficiency.
(c)	To improve efficiency and quality of management in the field of energy conservation.
(d)	To obtain and further update information from primary sources to improve the quality of information and describe statistical details.
(e)	To enhance openness and transparency of information in the area of energy efficiency and conservation.

Source: Excerpt from "Integrated Information Systems" TOR

7.2.2 Current Status of Energy Statistics Data Collection

(1) Data collection system for energy statistics

Collecting energy statistics is a difficult task that involves collecting and compiling a vast amount of data scattered across a variety of sectors to create an energy balance. The most important aspect of compiling an energy balance table is how to collect the vast amount of data efficiently and accurately. Table 7-3 summarizes where and what data the AoS and MoE collect. The table shows related items presented in each section.

Table 7-3 Current status of the data collection system for energy statistics

Main Study Item		Data location	AoS	MoE
Primary energy production and supply Energy Conversion Energy Transportation	Monthly and annually By energy type Production amount, supply amount, self-use amount, losses, storage, etc.	Energy industry	Data collection for energy statistics Table 7-5	As a regulatory agency, require the energy industry to report energy information and data Table 7-4
Energy consumption (e.g., industrial, transportation, commercial buildings)	Annually Sales amount by energy type and by sector			
	Monthly for large companies, annually for non-large companies Consumption amount by energy type	Company（Large companies 807, small to medium companies approx. 5000） Table7-6 Nonprofit organizations, national government agencies	Data collection for energy statistics Table 7-5 (Consumption)	Information provided by AoS. Currently developing "Integrated Information System Table7-1, Table7-2
Energy consumption (residential)	Annually Sales amount by energy type and by sector	Energy industry	Data collection for energy statistics Table 7-5	As a regulatory agency, require the energy industry to report energy information and data Table 7-4
	Monthly consumption amount, monthly purchase cost Starting in 2021 By energy type (including biofuels)	Survey conducted as part of a household survey: sampling of 10,000 households nationwide Table 7-7	Data collection for energy statistics	Information provided by AoS
Remarks			Reporting energy statistics to the IEA as a national statistical agency	Automatic collection system for smart meter metering is in operation for gas and electricity

Source: Prepared by the JICA study team

As the agency in charge of energy statistics, the AoS collects the necessary data across all sectors covering energy production and consumption.

Surveys for the energy industry are limited in scope, including production, supply, conversion, transportation, and supply. Thus, they are considered full surveys.

The number of survey targets on the energy demand side is huge; therefore, it is difficult to survey all of them. It is necessary to process the supply data obtained from the energy industry and the aggregate data from demand side surveys of companies, corporations, etc., by cross-checking them to avoid duplication.

The 807 enterprises in the industry cover 85−90% of the industry, and the 5,000 small and

medium-sized enterprises cover above a certain size, as shown in Table 7-6. It is estimated that coverage is high for all enterprises, corporations, and public institutions. However, whether coverage or expansion estimates are made was not determined.

Regarding residential consumption, smart meters and automatic collection systems for electricity and gas have been available for all consumers from 2021. Full-year data became available from 2022. The household survey is a sampling survey of 10,000 households, 833 households x 12 months. It is a highly valuable source of information because it is tied to energy consumption data, with attribute data on region, housing type, and area. The AoS is interested in using the expanded estimates from the household survey for its statistics, with reference to the smart meter data shown in Table 7-7. Other petroleum products, coal and other fuels, and heat supply are reported by each energy industry. Table 7-9 shows the installation of meters for electricity, gas, and heat, which are the source of energy consumption data.[12]

The MoE, as the regulator of the energy industry, is able to obtain detailed information on the management of the energy industry. However, the MoE depends on the AoS for information regarding the demand side. General enterprises, representing the demand side, are obliged to respond to AoS surveys. However, there is no mechanism that requires regular reporting to the MoE. Detailed data on consumption, including the breakdown by business category, purpose of use, etc., is necessary for the study and planning of energy conservation policies. For such purposes, a separate survey is required. An example of this is the "integrated information system" targeting industry.

As there are a huge number of end consumers of energy, obtaining accurate data for each type of energy requires a great deal of ingenuity and effort, including the development of relevant laws and systems. In addition, privacy protection must be taken into consideration these days.

(2) Energy data collection by the MoE

As the Ministry in charge of energy administration, the MoE has established a mechanism to collect general energy management information from energy companies and related organizations in order to compile supply data for the various energy sources used by the government. This mechanism is independent from the AoS, and the information is not publicly available. As the energy industry is state-owned, it is required by law to report periodically to the State Asset Management Agency. Energy-related data included in the report are also reported to the AoS and the MoE. According to the questionnaire survey to the MoE, shown in Table 7-4, periodical reports are conducted on items such as manufacturing, transportation, and retail.[13]

The MoE aims to establish a new data collection system through an integrated information system. Data on energy imports and exports are collected by the AoS, the MoE, and the Customs Department. The AoS also provides registration information such as the number of households and enterprises which are essential for the energy statistics.

[12] Automated electricity metering and control system (ASKUE); Automated system for accounting and control of natural gas (ASKUG).

[13] Law 207 Implementation of Criteria for Evaluating the Performance of Joint Stock Corporations and Other Entities in the Stock of the State (August 28, 2015)

Table 7-4 Major reporting items for the Energy Industry

Industry		Data
Electricity	Power plant	Fuel consumption, output/supply, generation efficiency, power in plant
	Power system	Transmission and distribution losses, power in substations
	Retail	Sales volume (kWh), value-based sales figures
Natural gas	Manufacture	Supply, self-used gas for production facilities
	Transport	Transportation losses, self-used energy by transportation facilities
	Retail	Sales volume and value-based sales figures
Petroleum products	Manufacture	Supply, self-use
	Retail	Sales volume and value-based sales figures
Coal	Manufacture	Supply, self-use
	Retail	Sales volume and value-based sales figures
Heat	Manufacture	Fuel consumption, supply
	Transport	Self-used energy of heat transport facilities
	Retail	Sales volume and value-based sales figures

Source: Prepared by the JICA study team based on a questionnaire to the MoE

To promote energy conservation, it is important to understand information on the demand side, specifically, what kind of energy is used for what purpose. However, the MoE has not yet established a mechanism to collect demand-side information directly from end users and is still dependent on the AoS.

(3) Collection of energy statistics data by the AoS

1) Reporting form for the AoS energy data collection

Each year, the AoS provides a reporting form for collecting data to produce national statistics. The format for 2021 was determined by the "SCS Solution." The reporting forms, which relate to energy production to consumption for the preparation of energy statistics, are selected from all the available forms, that is, from Form 1 to 109, as shown in Table 7-5.[14] They are related to industrial, residential, and commercial buildings.

The company or corporation that prepares each type of report is determined, and the AoS distributes and collects these forms in an electronic manner to the target organizations. Each state has a local AoS organization, and statewide information may be collected via local organizations. Table 7-5 does not include household surveys. In addition, monthly reports

[14]Resolution of the State Statistical Commission of the Republic of Uzbekistan on the Approval of the State Statistical Report for the Year 2021 (February 9, 2021)

are required to large enterprises, and data not listed in the table below are also collected and used.

Table 7-5 List of data collection reports related to energy statistics for 2021 as defined by the AoS (formerly SCS)

Classification	Report number and title	Reporting frequency	Reporting party/organization	Main survey items
Conversion	22 Thermal energy supply	Annually	Heat Supply Corporation for residential (Excluding small, medium, and micro businesses)	Consumption volume of fuel and electricity, Production volume of heat, and Heat loss
Production Supply Transportation	24 Fuel Supply and Sources	Annually	JSC "Uzbekneftega".	Production volume of gas, Exports and imports volume of gas, and Supply volume of gas to consumers (businesses, organizations, residences)
		Annually	Oil company	Production volume of crude oil, Exports and imports volume of crude oil, and Shipment volume of petroleum products
		Annually	JSC "Uzbeknefko" JSC "Chargunkmee"	Production volume of coal, and Shipment volume of coal products
Transportation	65	Annually	Main pipeline transportation company for gas and oil	Transportation volume of gas and oil using pipeline, and Distance of travel
Production Supply	26 Production and distribution of	Annually	JSC "Uzbekneftega"	Input volume of oil and gas condensate,

Transportation	oil and gas condensate			and Production and loss volume of petroleum products
Conversion Transportation	27 Supply Sources and Distribution of Electricity	Annually	Power generation and distribution companies (except for the 28 JSCs)	Volume of generated power, Volume of imported power, and Consumption volume of electricity (by region and sector)
Conversion Transportation	28 Supply Sources and Distribution of Electricity	Annually	JSC "Electric Network" JSC "Regional Electricity Networ" JSC "Thermal Power Plan" JSC "Hydroelectric Power Plan"	Consumption volume of fuel at power plants, Generated volume of electricity, on-site electricity, Power volume at transmission end, Transmission losses, On-site power consumption for power plants, Incoming power from grid interconnection, and Supply volume to industrial and residential sectors.
Transportation	52 Use of liquefied natural gas	Annually	Regional organization of JSC "Uztransga".	Number of apartments and houses using natural and liquefied gas, Supply volume of natural gas and liquefied gas to consumers (categorized by urban

				and rural areas)
Consumption	25 Receipt, consumption, and waste of fuel and energy	Annually	For-profit organizations (excluding small and medium enterprises) nonprofit organization Central bureaus of government (insurance, education)	Used volume of raw material, Used volume of non-energy, and Consumption volume of electricity, heat, petroleum products, gas coal, coal products, firewood, oil and gas condensate

Source: Prepared by the JICA study team based on the AoS (SCS) HP

General companies and other entities on the energy demand side are obliged to respond to the AoS survey. However, there is no mechanism to require regular reporting to the MoE. The MoE is aiming to establish a new data collection system through an integrated information system.

As energy industry sales data includes sector-specific information, data quality should be improved by comparing demand-side statistical data with sales data of electricity, gas, and heat. However, no such reciprocal use exists.

2) Status of data collection of total energy consumption by sector

The status of energy data collection in the industrial and residential sectors is shown in Tables 7-6 and 7-7, based on the results of interviews with relevant organizations.

In Uzbekistan, all registered companies are subject to be surveyed in the commercial building sector. Thus, it seems that the survey is conducted in accordance with the industry. The survey sheets published by the AoS target the fields of primary energy supply and energy conversion, and are accompanied by a table to fill in the distribution by region (1 republic, 12 states, and 1 city). This means the AoS may obtain data by region.

For the energy consumer category, the business classification of the industrial sector in the AoS pilot table differs from the business classification used by the IEA. This is because the AoS follows the industry classification used at the time of registration of the legal entity in Uzbekistan. While it is not a problem that the industrial classification can take a country-specific form depending on the country's industrial structure, it is necessary to convert the classification to the internationally recommended industrial classification when reporting to the IEA.

Table 7-6 Status of energy data collection in the industrial sector (manufacturing, construction, and non-fuel mining)

Subject	All enterprises including large companies and small and medium-sized enterprises registered in Uzbekistan Large companies: 807 companies (accounting for 85-90% of energy consumption in the industrial sector) small and medium-sized enterprises: Approximately 5,000 enterprises (The number may include commercial and public service companies.)
Reporting frequency	Large company: Monthly Small and medium-sized enterprises: Annually
Reporting items	Fuel consumption: Volume of consumed, purchased, sold, and inventory changes, etc. by fuel type (22 types) Heat ：Volume of purchased, consumed, sold, etc. Power consumption ：Volume of purchased, consumed, sold, etc.
Comments from the Ministry of Energy, MDE on data reliability and utilization	Large companies have personnel with energy management skills. However, small and medium-sized enterprises have “scarce human resource” and often make errors in filling out reports. In the “Integrated Information System”, under development, will be able to check errors by recording both the physical amount of energy, and the purchase amount. In addition, annual reporting causes delays in response. It is recommended to make the reporting frequency 4 semesters to improve efficiency of follow-up. Referring to Japanese “The Current Survey of Energy Consumption” method may help collecting energy information by imposing reporting requirements on companies.
Classification among large companies, SMEs, and micro firms	Classification by average of annual number of employees per industry as shown in the table in Cabinet Decision N275. The number of persons for classification varies depending on the type of industry.[15]

Source: Prepared by the JICA study team based on interviews with the MoE and AoS, June 2021

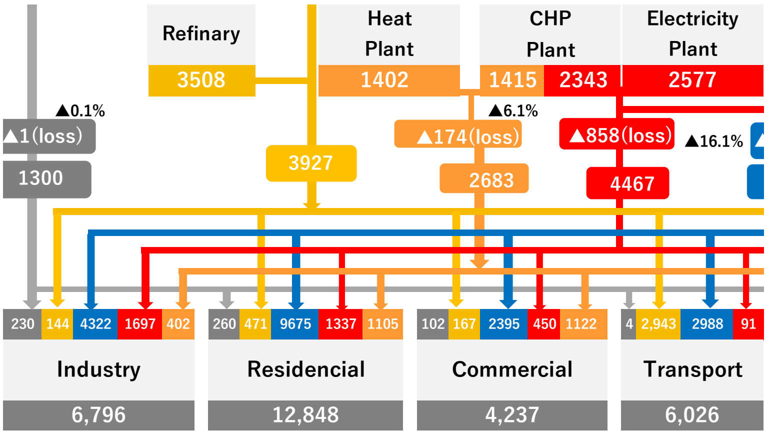
[15]Law 275 - Measures for the Transition to the International System of Classification of Types of Economic Activities (August 24, 2016)

Table 7-7 Energy data collection in the residential sector

Subject	10,000 households per year (distributed by apartment buildings, detached houses, and region)
Reporting frequency	833 households/month x 12 months (A nationwide sampling survey from 206 clusters)
Reporting items	Consumption volume of electricity, gas, fuel, and heat. Below are the interviewed items at related bodies. ・ Periodically reported data from the selling organization is used for electricity, gas, and heat. ・ For the heat supply, there are meters for hot water supply. However, meters have not yet been installed for heating heat. Then, the consumed volume and amount per household are calculated based on the number of square meters of the room and the number of people in the household. ・ In Tashkent, the demand is based on the amount of heat supplied by the heat supply plant. ・ Fuel consumption volume for individual boilers is based on data from fuel distributors. ・ Fuels in rural areas are researched by examining the SCS questionnaire, such as wood, animal and plant origin fuels. ・ Items on energy consumption will be added to the "household survey" from 2021 to improve data accuracy.
AoS Comments	・ The number of households sampled is determined by a specialized department that surveys general households. ・ The methodology for the extended estimation was conducted under the guidance of UN experts. ・ Electricity and gas sales organizations submit data once a year and report data broken down by department. Comparisons are also made on region-by-region basis. ・ New apartment buildings and detached houses are using individual boilers. The shipment data for residential fuel which is periodically reported by fuel suppliers are used. ・ Various fuels are used in rural areas. Data will be collected on 13 types of fuels (electricity, heat, gas, petroleum, coal, livestock and poultry dung, cotton stalks, corn grass, sawdust, etc.) by having them fill out a form provided by AoS. Since a large value of 8,002 ktoe of natural gas consumption was listed in

the Residential column of Total Consumption in the 2018 Energy Balance Table, the data source was checked with SCS.

- "As of 2018, there was a gas company under the MoE called Ustrangas. The data shows the amount of gas transported by that gas company to residential customers by state. The transported amount was based on supplier side data, not demand side meters. When the meters are spread to the general houses in the future, we would like to refer to that data and process the statistical numbers from the sampling survey with expanded estimates."



Energy Flow Diagram (prepared by JICA study team based on IEA 2020) (excerpt)

- Of the housing units in Uzbekistan, those receiving hot water and heating hot water from the heat supply system are almost exclusively in apartment buildings in Tashkent that are not newly built (most were built in the former Soviet Union era). Since the population ratio of Tashkent is approximately 8% (2.68 million/ 34.56 million), it is assumed that more than 90% of the population has individual boilers, etc. and uses natural gas, coal, kerosene, or some other fuel to obtain hot water heating, which would result in the above trend.

Source: Prepared by the JICA study team based on interviews with the AoS, the MoHCS, and Tashkent city, June 2021

(4) Current status of the installation of metering instruments and automatic control systems

As the number of objects to be metered on the demand side is extremely large, it is necessary to develop smart meters for accurate metering and an automatic data collection system. Table 7-9 shows the Resolution of the President (PP) and Decree of the President (UP), as well as the laws and regulations regarding the installation of metering and automatic control and accounting systems for electricity, gas, and heat (for hot water and for hot water for heating purposes) on the demand side. For the current status of the installation of measuring instruments, information obtained from interviews with the MoE, MoED&PR, MoHCS, and City of Tashkent is shown in Table 7-9.

In the press release by the Ministry of Investment, an announcement about electricity meters was made: the Automatic System for Electricity Metering and Control (ASKUE) will be installed to all 7.3 million subscribers in 2021. An announcement about gas meters was also made: modern electronic gas meters will be installed for all consumers, that is, more than 3.5 million, free of charge, in 2021. This will be implemented as a part of the implementation of the Automated System for Accounting and Management (ASKUG).

While all automatic metering and collection systems for electricity and gas have been installed, no progress has been made in heat metering, except for institutional customers.

Table 7-8 Major decree of the President and the Resolution of the President on the development of electronic metering and automatic control and accounting systems for electricity, natural gas, and heat supply

Number	Approval Date	Upper: Title / Lower: Main purpose
UP5278	2017.12.12	Reform of the national public service system.
		Establishment a policy of electronic, online, and one-stop access to public services.
UP5761	2019.7.9	Financial stabilization of the fuel and energy industry
		Development of automatic control and accounting systems for electricity. Accomplishment of AMR coverage of 100% by the end of 2020. AMR: Automated electricity metering and control system
UP6010	2020.6.18	Additional measures to improve the sales mechanism for natural gas and electric energy.
		Sales and consumption will be handled by local electric and natural gas supply companies to ensure completeness and timeliness of payments. Implement installation of an automated system for natural gas to monitor and process accounting for customers in all categories by the end of 2021.
PP4840	September 24, 2020	Additional measures for the implementation of an automated system of natural gas management and accounting.
		Install metering equipment at defined locations such as regional boundaries and entrances to large consumption areas.

		System implementation will be completed by August 1, 2021.
PP4542	2019.12.2	Additional measures to improve the heat supply system, and financial improvement of heat suppliers.
		Introduction of the latest resource-saving technologies (modernization of boilers, insulated pipes, etc.), replacement of measuring instruments, automatic accounting systems, shifting to closed systems in a phase manner, etc. (No deadline specified.)
PP4543	2019.12.2	Measures for further improvement of the heat supply system in Tashkent.
		Introduction of the latest resource-saving technologies (boiler modernization, insulated pipes, cogeneration, etc.), replacement of measuring instruments, automatic accounting system, shifting to closed systems in a phase manner, etc. (No deadline specified.)

Source: Prepared by the JICA study team based on Lex UZ HP

Table 7-9 Installation of electricity, gas, and heat metering devices

Demand Type	Electricity	Gas	Heat
Institutional customers	All installed	All installed	- Heat meters are installed for all customers.
Apartment buildings	All installed	All installed by August 2021 (Prepaid smart meters)	- Hot water meters (flow meters) are installed for all customers. - Meters for hot water for heating are not currently available. - Currently, the sent out amount is used as the demand. - As for new apartment buildings, individual boilers are chosen due to lack of supply and expense, so research on fuel consumption is required.
Detached house	All installed	All installed by August 2021 (Prepaid smart meters)	- Since they use individual boilers (not covered by the heat supply system). Thus, research on fuel consumption is required. - In remote area, there are variety of biofuels. No meter is available for such case. This will be researched through AoS survey form (13 fuel types).

Source: Prepared by the JICA study team based on interviews with the MoE, MoHCS, and MoED&PR, June 2021

7.2.3 Current Status of Energy Balance

The energy balance of Uzbekistan was prepared and published by the IEA until 2017 based on the data submitted by the AoS through the joint questionnaire by the IEA/Eurostat/UNECE, which was to report annual energy. However, since 2018, the AoS, with the guidance of experts from the UN, IEA, and other organizations, has been preparing the “Pilot Fuel and Energy Balance table,” which is reported to and published by the IEA. Pilot tables have been created for the three years from 2018 to 2020. All of them can be downloaded from the Open Data (Industry) site on the AoS website. Figure 7-2 shows the Pilot Fuel and Energy Balance Table for 2019.

The AoS recognizes the problem of accuracy in energy balance tables owing to difficulties in data collection. According to interviews with the AoS, it has been promoting improvement activities for compiling the energy balance with a loan from the World Bank. Revisions on the energy balance are being made in accordance with the World Bank’s instructions. For the 2019 and 2020 editions, advice was also received from IEA experts. Energy statistics are to be released at the end of August every year; however, the release has been delayed since 2020.

The IEA has also published an Energy Balance Table for Uzbekistan, as shown in Figure 7-1. However, that was with revised contents. The factor of the revision may be because the classification of statistics recommended by UN and IEC is different from that the AoS used for domestic data collection. The IEA Country Notes and Sources, which explain the preparation of the energy balance, state that fuel inputs and emissions for electricity and heat plants are estimated by the IEA Secretariat.[16]

The Decree of the President PP4796 states that “there is currently no complete information on energy statistics that reveals a complete picture of the country’s energy sector.” The improvement activities are in the process of incorporating the aforementioned World Bank recommendations.[17]

[16]International Standard Industrial-l Classification of All Economic Activities (ISIC) (2019)
[17]PP4796 Resolution President of the Republic of Uzbekistan "On measures to further improve and develop the national system of statistics of the on measures to further improve and develop the national system of statistics of the Republic of Uzbekistan "Annex 1-V-6 Improvement of energy statistics (August 3, 2020) (Document 4)

PILOT FUEL AND ENERGY BALANCE OF THE REPUBLIC OF UZBEKISTAN 2019
(1000 tons of oil equivalent)

		Coal	Natural gas	Oil, including gas condensate	Motor gasoline	Diesel fuel	Fuel oil	Liquefied petroleum gases	Kerosene	Coke	Other types of petroleum products	Nuclear energy	Electric power	Heat energy	Total
Total Enegy Supply	Production	1154.5	49306.6	3010.9	-	-	-	-	-	-	-	-	557.0	-	54028.9
	Import (+)	574.5	-	666.5	4.2	73.9	125.5	-	-	0.04	227.9	-	290.6	-	1963.2
	Export (-)	-	-9933.2	-	-	-	-	-	-	-	-	-	-177.7	-	-10111.0
	Change in residuals (+, -)	69.2	999.0	6.6	55.0	3.3	3.4	1.5	4.8	-	-	-	-	-	1142.8
	Total primary energy supply (=)	**1798.2**	**40372.3**	**3684.0**	**59.2**	**77.3**	**128.9**	**1.5**	**4.8**	**0.0**	**227.9**	**-**	**669.8**	**-**	**47023.9**
Conversion	Transfers	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Statistical discrepancy	-	-	0	-	-	-	-	-	-	-3.8	-	-2.0	-0.06	-5.9
	Power plants	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Heat and power plants	-974.7	-12294.7	-	-	-1.5	-207.8	-	-	-	-	-	4736.0	1414.9	-7327.8
	Heating plants	-0.5	-1741.1	-	-	-0.9	-33.5	-	-	-	-	-	-510.9	1779.0	-507.9
	Gas plants	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Oil refineries (chemical) plants	-	-	-3662.7	1088.4	1071.9	212.9	914.4	171.1	20.0	205.4	-	-	-	21.5
	Transformation of coal (briquette and house furnaces)	-112.9	-	-	-	-	-	-	-	-	-	-	-	-	-112.9
	Gas-to-liquid and coal liquefaction	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Other (conversion and processing of fuel)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Own use by the energy sector	-0.8	-7026.8	-4.7	-	-6.4	-17.0	-16.4	-	-	-2.1	-	-331.8	-	-7406.0
	Losses	-15.9	-880.7	-16.6	-4.7	-0.6	-	-0.5	-	-	-	-	-72.7	-179.3	-1170.9
Total Final Consumption	**Total consumption**	**693.4**	**18628.8**	**-**	**1143.0**	**1139.8**	**83.5**	**899.0**	**176**	**20.1**	**427.4**	**-**	**4658.2**	**3014.5**	**30883.6**
	Industrial sector	**240.5**	**4877.7**	**-**	**1.8**	**55.4**	**14.3**	**2.8**	**3.1**	**20.1**	**14.0**	**-**	**1458.9**	**429.2**	**7117.9**
	Mining and quarrying	0.8	107.6	-	0.03	5.6	0.00	-	-	-	-	-	43.8	24.2	181.9
	Chemical (except petrochemical) industry	-	1897.3	-	0.87	8.3	0.0	1.1	0.50	-	14.0	-	311.6	44.2	2277.9
	Metallurgical industry	10.8	572.5	-	0.3	27.6	4.8	-	0.1	20.1	-	-	674.3	208.1	1518.6
	Non-metallic mineral products	224.2	1163.8	-	0.03	7.6	8.7	-	0.4	-	-	-	86.5	9.8	1500.9
	Mechanical engineering	0.0	48.8	-	0.06	0.8	0.8	0.1	0.1	-	-	-	28.3	8.5	87.4
	Food industry, production of beverages and tobacco products	0.4	351.2	-	0.011	1.0	0.1	0.6	0.46	-	-	-	39.3	67.4	460.4
	Pulp and paper and printing industry	0.1	27.2	-	-	0.0	-	-	0.422	-	-	-	3.9	4.6	36.1
	Textile and leather industry	1.3	254.6	-	-	3.47	0.05	-	-	-	-	-	191.6	21.2	472.2
	Other industries	2.9	454.8	-	0.5	1.1	-	1.0	1.0	-	-	-	79.8	41.2	582.5
	Transport sector	**2.9**	**3289.8**	**-**	**981.8**	**1082.7**	**0.1**	**382.2**	**147.8**	**-**	**-**	**-**	**181.9**	**-**	**6069.2**
	Railways	2.9	-	-	2.0	82.5	0.1	-	1.5	-	-	-	125.5	-	214.6
	road transport	-	2762.1	-	978.7	1000.2	-	382.2	-	-	-	-	-	-	5123.2
	other types of transport (water, air, urban electric)	-	-	-	1.1	-	-	-	146.3	-	-	-	2.7	-	150.1
	Transportation by pipelines	-	527.7	-	-	-	-	-	-	-	-	-	53.7	-	581.4
	Road transport services	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Other	**450.0**	**10061.7**	**-**	**159.40**	**1.6**	**69.1**	**512.6**	**25.0**	**-**	**60.2**	**-**	**3017.4**	**2585.4**	**16942.4**
	Population	318.7	7578.4	-	-	-	0.5	510.2	0.5	-	-	-	1159.0	1178.8	10746.0
	Construction	1.8	-	-	-	-	-	-	-	-	60.2	-	35.7	-	97.7
	Commercial enterprises and government agencies	117.3	2280.2	-	159.30	-	0.1	-	24.5	-	-	-	427.4	1197.1	4205.9
	Agricultural industry	11.7	21.0	-	0.10	0.9	-	2.4	0.005	-	-	-	1294.8	57.0	1387.8
	Fishery	0.0	0.4	-	-	-	-	-	-	-	-	-	-	-	0.4
	Unspecified other sectors	0.5	181.8	-	-	0.7	68.5	-	-	-	-	-	100.6	152.5	504.6
Non-Energy Use	**Non-energy use**	**-**	**399.5**	**-**	**-**	**-**	**-**	**1.3**	**-**	**-**	**353.2**	**-**	**-**	**-**	**754.0**
	in industry / transformation-processing / fuel energy	-	199.8	-	-	-	-	1.3	-	-	353.2	-	-	-	554.3
	including chemicals / petrochemicals	-	199.8	-	-	-	-	-	-	-	-	-	-	-	199.8
	in transport	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	in other sectors	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Figure 7-2 Uzbekistan Pilot Fuel and Energy Balance Table for 2019, from the AoS (SCS)
Source: AoS HP

7.3 Issues in Energy Statistics (Results of Energy Balance Analysis)

7.3.1 Issues of the AoS Pilot Fuel and Energy Balance

As national energy statistics are a synthesis of a large number of statistical data, each statistic must be sufficiently reliable throughout the process of data measurement, collection, and tabulation. In order to create an annual energy balance sheet, data from the various areas of energy production, conversion, and consumption must be collected, compiled, and tabulated, including verification of unit conversions, missing, duplicate, and balance. The study of the contents of the Pilot Fuel and Energy Balance for 2018, 2019, and 2020 revealed the following issues with the quality of the statistical data. The relevant sections of the balance table and comments are shown in Figure 7-4. These may affect the reliability of the energy index.

(1) Issues arising from data reliability

1) Transmission and distribution losses

Transmission and distribution losses were 858 ktoe in IEA 2020, which is significantly more than in the AoS Pilot: 32 ktoe. The AoS data shows a transmission and distribution loss ratio of 0.6%, which deviates significantly from the MoE Concept Note of approximately 15%.

According to the 2019 UN Energy Statistics Compilers Manual, transmission and distribution losses are typically 7–15%. This is quite peculiar compared to the percentage range of Japan, the USA, and Germany, that is, about 5–6%. If the loss rate were only for the transmission portion, it would be 2.7% in the MoE concept note and around 2% in the Japanese example. If many power plants were in close proximity to demand areas, and there was little or no long-distance transmission, transmission and distribution losses could be negligible. However, this is not the reality in such facilities. Therefore, the data is considered erroneous.

2) Heat

The total fuel supplied to heat plants in 2020 was reduced to 30% of the fuel supplied in 2019. A 70% decrease in one year is unlikely to be a normal decrease. In addition, all data of the thermal energy is the same figure as the previous year, making it difficult to consider them statistically.

3) Natural gas

The on-site consumption of natural gas is significant at 6,634 ktoe (13% of production) in 2018 and 7,035 ktoe (14% of production) in 2019. It decreases significantly to 2,371 ktoe (6% of production) in 2020. According to the explanation from the AoS, such energy is consumed by gas companies in gas mining and gas processing. However, this needs to be scrutinized closely. If a change in the definition of a statistic results in a change in the statistical data, the changed contents and duration should be clearly noted.

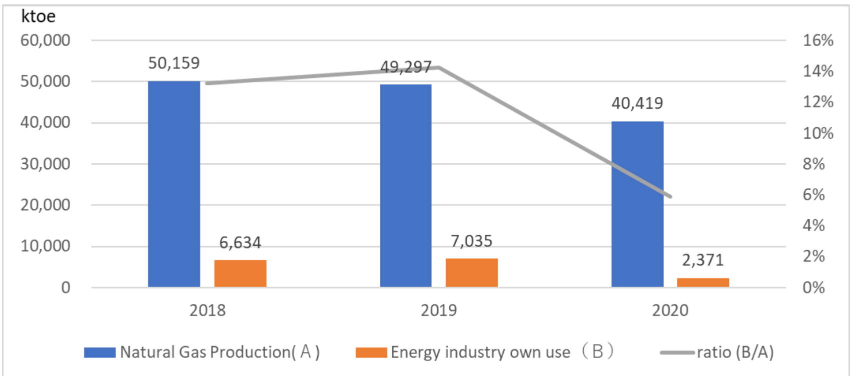


Figure 7-3 Transition of natural gas producers' on-site consumption

Source: Prepared by the JICA study team based on the IEA Energy Balance

4) Natural gas consumption in the residential sector

Natural gas consumption in the residential sector is considerably high, accounting for more than 70% of the sector's consumption and approximately 40% of the country's total consumption. The annual fluctuations have been extremely high in recent years: 8,002 ktoe in 2018, 7,577 ktoe in 2019, and 9,675 ktoe in 2020. It is necessary to confirm the data collection details, such as checking the supply and sales data sources to date, estimations based on household survey data starting in 2021, and referring to collected data through smart meter and automatic data collector.

Table 7-10 Transition of final energy consumption in the residential sector

	2,018 ktoe	2,019 ktoe	2,020 ktoe
Coal	471	290	260
Natural Gas	8,002	7,577	9,675
Oil Products	509	571	471
Electricity	1,169	1,159	1,337
Heat	1,079	1,179	1,105
Total	11,230	10,776	12,848

Source: Prepared by the JICA study team based on the IEA Energy balance

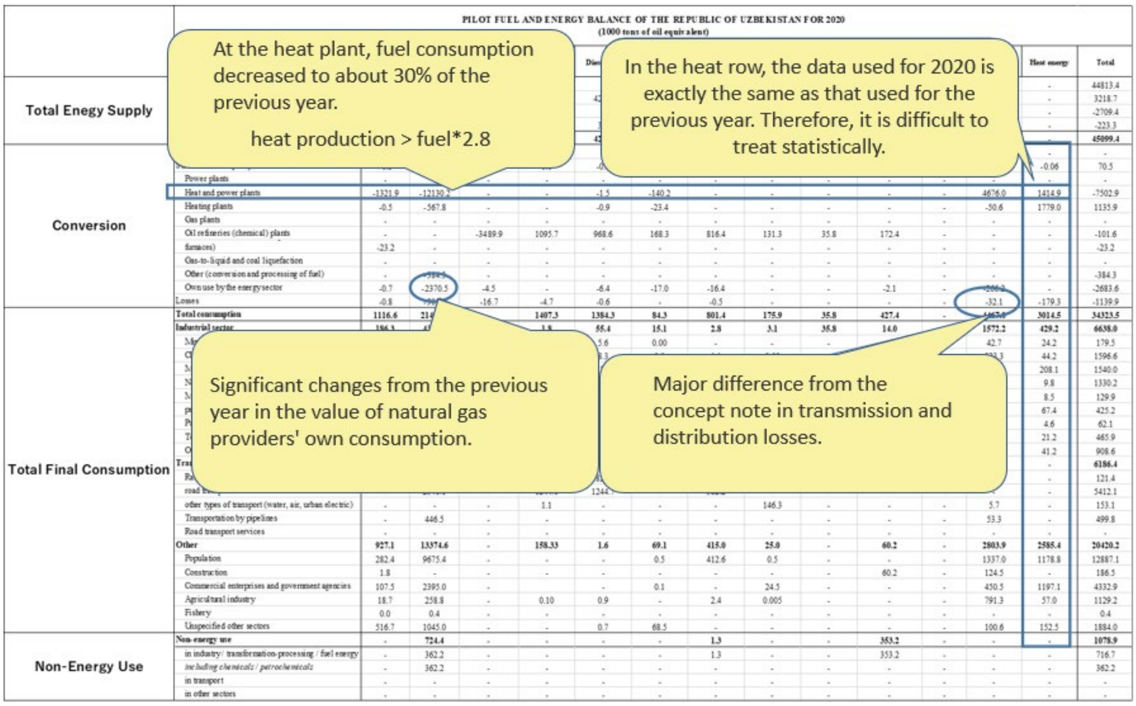


Figure 7-4 Issues in the Uzbekistan Pilot Fuel and Energy Balance 2020

Source: AoS HP

(2) Issues related to data in the residential sector

1) Development of data by purpose of use

The residential sector is the largest energy consuming sector, accounting for approximately 40% of total final energy consumption (TFC). However, the data source of energy consumption in the residential sector, which is necessary to develop energy conservation policies, is not sufficient, as it is not found anywhere other than the data reported by energy suppliers to the AoS.

To examine the energy conservation of houses, more detailed data than the energy balance table is required, such as a breakdown of heating, cooling, hot water supply, cooking, home appliances, etc. by purpose of use, and a breakdown of heat demand in a house by equipment, etc. Even though the detailed data is required, such data is not yet available. Therefore, it is recommended to proceed with the acquisition and development of application-specific data by referring to the recommendations of the IEA and the examples of Japanese initiatives shown in Chapter 3.[18] The same is true for the commercial buildings sector.

2) Utilization of household survey data

The improvement in accuracy was attempted by adding energy related items to the survey items of the household survey from 2010. The study team is currently consulting with IEA experts on how to make expanded estimates from sampling data and how to reconcile with the existing supply and sales data from energy companies.

As the household survey includes information on region, housing type with area, and family composition, etc., it is expected to utilize the data for analysis by energy source, by attribute, etc.

3) Actual energy consumption of heat supply is unknown

There is no metering of end-use heat consumption at the end of the apartment buildings with heat supply. Therefore, the actual end-use energy consumption and heat transfer losses are yet to be quantified. An example of energy flow from a heat supply station to an apartment building is reported with a simple measurement for apartment and school buildings, as shown in Attachment 5. Such data should be used as a reference for the future strengthening of measurements related to heat consumption in apartment buildings and other buildings.

4) Maintenance of biomass data

In the household survey, survey items cover electricity, gas, heat, and other fuels used as biomass energy, including cotton stalks and livestock excrement. However, biogas is not included. Biogas can be derived from traditional sources, such as plants and animals, or from urban waste. However, the IEA report points to a lack of data on biomass utilization. A credible study on the use of biomass for housing in rural areas is required.[19]

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18 IEA, Energy Efficiency Indicators Essentials for Policy Making
(https://iea.blob.core.windows.net/assets/135d18c1-7640-4918-ad53-c093130f
2513/Energy_Efficiency_Indicators_Essentials_for_Policy_Making.pdf

19 IEA, Uzbekistan 2022 Energy Policy Review.

(3) Differences in business classifications for power generation between the AoS and IEA

In Uzbekistan, the business classification at the time of company registration does not include the IEA classification of "Electricity plant" and "CHP Plant". Therefore, as shown in Table 7-11, thermal power plants and combined heat and power plants are included in the category "Heat and power plant" and heat supply plants are included in the category "Heating plant." The energy conversion part related to electricity generation and heat production is the unique classification of Uzbekistan.

It is not a problem that the classification codes are country-specific depending on the country's industrial structure. However, as mentioned above, the IEA secretariat estimates fuel inputs and emissions for thermal power generation and CHP when preparing Uzbekistan's energy balance. Therefore, when reporting to the IEA, the AoS should convert its data to the recommended international industrial classification.

In addition, the status of thermal power generation, Uzbekistan's main power source, is difficult to understand from the country's domestic energy statistics. Thus, it would be better to devise a method of presentation in consultation with the IEA.

Table 7-11 Differences in the business classification of thermal power plants, combined heat and power plants, and heat supply plants between the IEA and Uzbekistan

IEA	Uzbekistan
Electricity Plants	Heat and power plants
CHP plants (Combined heat and power plants)	
Heat plants	Heating plants

Source: JICA study team

7.3.2 Challenges of the MoE

Interviews and a related literature survey were conducted on the challenges of the MoE regarding energy statistics in Uzbekistan.

As mentioned above, the MoE is the government agency in charge of national energy administration. It has a scheme to collect management information from energy companies and related organizations in order to compile supply data and other information, classified by energy source, for government use. This scheme is independent of the AoS, and the information is not publicly available. For electricity and gas, the installation of smart meters for consumers and automatic data collection systems are almost completed. In addition, the data is being collected from electricity and gas retailers. Data on the production and supply of fuels, such as oil and coal, are also collected from the industry. Data on the heat supply and demand side is obtained from the MoHCS and AoS, if required. However, the demand side data, which is important for promoting energy conservation, relies on the AoS. It led the status that the information is not sufficient for analyzing energy conservation policies. According to this situation, the MoE and the AoS have established a forum for exchanging information starting in 2022. Furthermore, a standing committee, Acceleration Team, has been established within the government, with the participation of ministries and agencies involved in statistical data, such as energy supply and demand balance, etc. The Acceleration Team has been discussing the standardization of energy statistics production methods, etc.

The following issues are related to the energy statistics of the MoE of Uzbekistan, which were organized based on the literature survey and interviews.

- ✓ The MoE faces the challenge of not having an accurate energy statistics system for each sector on the energy demand side. Improvements are required in terms of data collection methods and other related matters.
- ✓ The challenge is how to collect data on energy consumption, which currently relies on the AoS, accurately and efficiently, to improve the quality of energy statistics.
- ✓ The beta version of the "Integrated Information System," which collects energy consumption data through online research for large companies in the industrial sector, has been under a test operation with electric power companies since March 2022. However, the expansion of its application has been halted owing to the lack of development engineering capacity. The company development policy is currently under review of the plan.
- ✓ There is currently no database for compiling and analyzing data after it has been collected. (Therefore, the MoE is interested in the background and process of database construction for the "Survey of Petroleum Consumption in Japan," targeting the industrial sector. The database is being constructed by the Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry of Japan).

7.4 Activities and Recommendations to Resolve Issues in Energy Statistics

Data on energy is foundational and essential for energy policy makers to understand policy priorities, evaluate the implementation of measures, and establish a PDCA cycle. Establishing a system for collecting accurate data and using that data is a fundamental approach to promoting energy conservation.

Continuous improvements of the energy statistics system should be made for data collection. In particular, the importance of the enhancement of metering and data collection in the heat supply sector has been recognized.

7.4.1 Collection, Aggregation, and Management of Energy Data by the AoS

In accordance with the Resolution of the President 4796 of 2020, the AoS (SCS) has been working on improving energy statistics and other activities following international practices. It is required to continue this work. Selected items are 1) to develop an energy balance based on the UN and IEA recommendations and suggestions, 2) to add a section on energy consumption to the household survey and publish the results, and 3) to identify missing indicators and reflect them in the reporting format.[20]

In addition to the above, to improve energy statistics data, the legal stance of the AoS needs to be strengthened against companies, and others reporting data. Currently, when anomalies are found in the data, it is virtually impossible to instruct companies and other entities to correct the reported data because it must be proven that the data is incorrect. The AoS needs to improve the current situation in which it does not have the authority to enter companies nor the provision to penalize them.

7.4.2 Jurisdiction of Energy Statistics by the MoE

The data necessary to develop an energy strategy should be collected, managed, and analyzed responsibly by the government agency in charge of energy, or its related agencies. In fact, in Japan and other OECD countries, the energy database and energy statistics are compiled by the government agency in charge of energy or its related agencies that have expertise in the field and easy access to energy industry data. The MoE should be in charge of such roles in Uzbekistan, as is the case in OECD countries.

Energy statistics, currently under the jurisdiction of the AoS (formerly SCS), should be placed under the jurisdiction of the MoE, including the database. This requires strengthening human resources, organization, and information systems.

In addition, as mentioned in section 7.3.1, the MoE must have a scheme to ensure consistent accuracy in the series of data measurement, collection, and tabulation processes required to compile energy statistics. In order to establish a new scheme accurately and promptly, support would be required, such as dispatching experts in energy statistics from Japan.7.3.1

7.4.3 Development of a Data collection System for Energy Consumption (Integrated Information System)

The original plan for the Integrated Information System was to begin operating the system for large companies and expand it gradually to small and medium-sized companies and other departments. However, the expansion of operations has been halted owing to a lack of development engineering capabilities and other factors. Therefore, the MoE is expected to reissue its development policy. The following items need to be considered at an early stage, prior to the full-scale operation of the system.

- Terminal entry procedures to ensure accuracy

20PP4796 Resolution President of the Republic of Uzbekistan "On measures to further improve and develop the national system of statistics of the Republic of Uzbekistan" Annex 1-V-6 Improvement of energy statistics (August 3, 2020)

- Strategies to avoid and detect simple errors in the input process
- Ensure the sustainability of the database (policy for updating and operation and maintenance of the system)
- How to incorporate the system with other databases, including coordination between organizations

On the system development, technical study on above mentioned items is the issue. The interviews with Uzbekistan officials in the survey revealed that energy statisticians in Uzbekistan are highly interested in the data collection scheme used by Japan for its comprehensive energy statistics, periodic reporting system based on the Energy Conservation Law, residential energy consumption survey cases, etc. Therefore, it would be effective for Japan to provide support for the "Survey of Current Consumption of Petroleum" by assisting with capacity building regarding the legal background of the system design and the database construction process." Table 7-12 lists the relevant materials provided to date.

Table 7-11: Information sharing on the Japanese practices related to efficient data collection and management

Following items were translated to Russian and shared by July 2021. Such information sharing was to response the request to know how Japanese scheme works and what laws, articles, and systems are used to collect energy consumption data periodically from many enterprises. The scheme means the "Statistic Survey on the Current Status of Petroleum Consumption" which the Japanese Agency for Natural Resources and Energy conducted for industrial sectors, and the "Periodic Reporting System for Specified Business Operators" under the Energy Conservation Law. (1) Survey of Petroleum Consumption in Japan - Explanation on outline and basis of laws and ordinances - Excerpts from the Annual Report (Table of Contents, Users Guide, Survey Form) - Survey Rules - Instruction on Completion of Survey Form (2) Periodic Reporting System for Specified Business Operators under the Act on the Energy Conservation Law Excerpts from legal articles related to mandatory periodic reporting to companies - Act on Rationalizing Energy Use (Energy Conservation Law) Designation of Specified Business Operators and Periodic Reporting - Order for Enforcement of the Act on Rationalizing Energy Use Energy Consumption for Designation as a Specified Business Operators - Ordinance for Enforcement of the Act on Rationalizing Energy Use Deadlines of periodic reporting, Conversion method to "Energy Consumption with Crude Oil Equivalent", etc.

Source: Prepared by the JICA study team based on the website of the Agency for Natural Resources and Energy

7.4.4 Collection of Detailed Energy Consumption Data for the Residential Sector

The residential sector is the largest energy consuming sector, accounting for approximately 40% of TFC, and is a top priority area for energy conservation measures. Understanding energy consumption by use, such as heating, hot water, cooling, and cooking, will help to identify priority targets. If the energy consumption of each piece of equipment used in the same application is identified, efficiency improvement targets can be set according to the room for the technological development of each piece of equipment.

As such data is currently not available, and the household survey does not include detailed questions by use, it is recommended to conduct a detailed survey particularly for residential energy consumption. For the detailed survey, it is recommended to refer to the IEA's Energy Efficiency Indicators and the example of the Japanese energy consumption survey of the residential sector, shown in Chapter 3.

The residential energy consumption survey is expected to be used to analyze trends by attributes, as the survey is tied to consumption data by energy source and attributes, such as region, housing type, and housing area. In addition to electricity, gas, and heat, the survey covers the use and purchase costs, including free acquisition, of 13 items, such as cotton stalks, livestock waste, and other biomass. However, it does not include biogas, for which IEA Report 18 pointed out a lack of data. It is hoped that a reliable survey on residential biomass use in rural areas will be conducted in the future.[18]

7.4.5 More Efficient Energy Data Collection

It is very important for policy makers to obtain the necessary energy consumption data directly from energy end-users through surveys. However, this is expensive and not easy. Therefore, it is recommended to develop human resources with the know-how to conduct surveys efficiently and economically, and to develop contractors.

7.4.6 Accuracy Improvement of Energy Measurement on the Demand Side

The target regarding the coverage of energy consumption meters is 7 million residences and 0.4 million businesses. It is necessary to automate energy measurement and tabulation with smart meters in order to measure data accurately. The status of the installation of metering equipment for electricity, gas, and heat supply is shown in Table 7-9.

Regarding heat supply to residences, plans for heat meters and automated systems have not progressed well owing to budget constraints. Additionally, there are many factors that reduce efficiency and require large amounts of money to address, such as the modernization of old boilers, the repair and renewal of deteriorated heat pipes, and closed-cycle systems. It seems that this situation is the reason why it is difficult to accurately grasp the consumed volume and efficiency of use.

For the metering of hot water supply on the residential side, it is decided to continue current metering to conduct a simple measurement of flow rate only, not calorimeter. Thus, the situation continues to be difficult from the perspective of energy management. In many cases, the heat supply for heating is charged by floor area and the number of occupants, and metering itself is not performed.

Therefore, due to the low accuracy of the measurement data for the whole system of heat supply, the actual demand and heat transfer losses of the produced heat are not identified separately. The demand and heat transfer losses are reported as an estimation. The district heat supply systems consume a large amount of natural gas, approximately 4% of the domestic gas supply. In order to properly evaluate the actual heat efficiency of the entire system, it is important to promote the installation of heat meters and enhanced metering, including the automatic collection of meter data, with reference to the results of the simple measurement at apartment buildings, as shown in Attachment 5.

Chapter 8 Proposal

In this chapter, seven priority measures were derived starting with Uzbekistan's energy consumption ratios by sector and source. The priority measures were based on energy conservation potential, the cost-effectiveness (payback period) of energy conservation measures, international trends, and knowledge obtained through field surveys and demonstration experiments. These were shown in Table 6-1 in Chapter 6, "Recommended Energy Saving Programs". Three measures are given the highest priority, such as: (1) conversion of existing gas boilers to heat pumps; (2) diffusion of high-efficiency air conditioners, and (3) strengthening of buildings' heat insulation. As a comprehensive measure that incorporates these three, ZEB/ZEH in commercial buildings and residential sectors is recommended. Implementing these measures for energy conservation will enable a 10% improvement in energy efficiency by 2026 at the earliest. Combination with energy conservation effects in other sectors, such as the reduction of losses in the power sector, natural decrease in energy consumption intensity due to economic development, may enable the achievement of the 20% energy efficiency improvement target in Decree of the President No. UP-60.

On the other hand, it is obvious that the implementation of measures and the realization of their effects will require the proactive efforts of the Uzbekistan government based on the results of this study. Especially in Uzbekistan, domestic energy prices for gas and electricity are suppressed by energy subsidies. Since gas is set at extremely low prices, the economic efficiency (payback period) of energy conservation investments by energy consumers is not always ensured. Such an environment is not conducive to energy conservation without proactive government support. In general, the solution to such an issue is to ensure the economic rationality of energy conservation investments through the optimization (raising) of energy prices by eliminating government subsidies that are driving down domestic energy prices. However, this is a very sensitive issue politically in Uzbekistan, partly due to the historical background. Therefore, there is a high probability that consumers will not naturally invest in energy conservation according to market principles. For the diffusion of energy conservation, government intervention is essential to enhance energy conservation investment, i.e., by providing incentives such as subsidies and tax exemptions.

This study found that even when the economics of energy efficiency investments at the consumer level cannot be secured, there are cases where sufficient cost-effectiveness can be achieved at the national level, partly due to the recent surge in global natural gas prices. In other words, it should be noted that even if the Uzbekistan government provides financial support to consumers through subsidies and tax exemptions to create an environment for investment in energy conservation, the expense can be fully recovered at the national level by exporting the natural gas reduced through the measures. From this perspective, the following is a summary of the seven priority measures that require government assistance.

Table 8-1 Required Items to Implement Energy Conservation Programs

No.	Priority measures	Requirements	Necessity of government assistance	
1	Conversion from gas boilers to heat pumps (and more efficient power supply, use of renewable electricity)	➢ Budgetary measures to support government subsidies, etc. ➢ Educational activities to raise public awareness of energy conservation ➢ Optimization of energy subsidies	High	➢ MoE ➢ MCCS ➢ MIIT
2	Diffusion of high-efficiency air conditioners	➢ Budgetary measures to support government subsidies, etc. ➢ Educational activities to raise public awareness of energy conservation ➢ Facility development and introduction of equipment to strengthen the functions of certification bodies for energy conserving equipment	High	➢ MoE ➢ MCCS ➢ MIIT ➢ Uzstandard
3	Reinforcement of buildings' heat insulation (windows, walls, roofs)	➢ Budgetary measures to support government subsidies, etc. ➢ Educational activities to raise public awareness of energy conservation	High	➢ MoE ➢ MCCS
4	Realization of ZEB/ZEH in the future	➢ Budgetary measures to support government subsidies, etc. ➢ Conducting demonstration experiment by the government at public facilities, and educational activities to raise public awareness of energy conservation ➢ Facility development and introduction of equipment to strengthen the functions of certification bodies of ZEB/ZEH ➢ Optimization of energy subsidies	High	➢ MoE ➢ NIRES ➢ MCCS
5	Diffusion of high-efficiency LED lighting	➢ Educational activities to raise public awareness of energy conservation	Less	➢ MoE ➢ MIIT ➢ Uzstandard

		➢ Facility development and introduction of equipment to strengthen the functions of certification bodies of energy conserving equipment		
6	Establishment of an energy management system	➢ Strengthening the legal system and scheme for cooperation among relevant ministries and agencies ➢ Exercise political leadership to drive industry (especially energy-intensive industries) ➢ Facility development and introduction of equipment to strengthen the functions of the institutions implementing the program ➢ Training and capacity building of personnel who can take charge of system implementation	High	➢ MoE ➢ MIIT ➢ AoS
7	High-efficiency industrial motors	➢ Educational activities to raise awareness of energy conservation to factories and pumping stations, etc. ➢ Facility development and introduction of equipment to strengthen the functions of certification bodies of energy conserving equipment	Less	➢ MoE ➢ MIIT ➢ Uzstandard ➢ MoWR

The evaluation of economic potential at the national and consumer levels conducted in this study is based on a simplified estimation. Detailed research and methodological design is required to implement the measures. Additionally, government of Uzbekistan's proactive approach is required. Further, for effective implementation of energy conservation measures, it is important to establish a policy-making process that reflects the effects of measures in the next set of measures by implementing the PDCA cycle (plan, do, assess, and improve).

As energy conservation efforts in Uzbekistan are still in their early stages, support from international aid agencies, including JICA, is important for the design and implementation of the measures. Therefore, it is proposed to have the implementation of a demonstration project for ZEB conversion as a technical cooperation project by JICA. The reason is that it is a comprehensive measure covering the three highest priority issues listed above and provides useful data for the implementation of each measure. Thus, the proposal is of a high priority. In addition, this study also estimated the economics of ZEB conversion for HUDUD

GAZ TAMINOT (HGT) offices. However, the energy conservation benefits are large at the national level but not necessarily at the consumer level. Therefore, in order to support ZEB conversion as a policy in the future, it is essential to conduct detailed surveys through demonstration experiments to verify the economic feasibility of ZEB conversion as well as to elaborate the government support measures. The next step of the demonstration experiment is to expand the scope to public facilities for which the government can bear the cost of ZEB conversion. The next step is to promote ZEB conversion in the commercial building sector, in addition to public facilities, by establishing subsidies and other government support programs. Meanwhile, information on incentive design should be collected to facilitate the future diffusion and deployment of ZEB in the residential sector. From the perspective of accelerating energy conservation, consideration should be given to proceeding with the above steps in parallel. For the implementation structure, it is recommended to position the Ministry of Energy (MoE) and its National Institute for Renewable Energy Systems (NIRES) as the main counterparts, while also collaborating with the Ministry of Construction and Public Services (MCCS) and the Ministry of Investment, Industry, and Trade (MIIT), among others. The demonstration project is also expected to have an educational effect on the public as consumers, who will learn the benefits of reduced utility costs and improved living environments, and will be motivated to invest in energy conservation.

As for the JICA project, it is proposed to promote the establishment of an energy management system in the industrial sector in addition to the elaboration of measures through the aforementioned ZEB demonstration. The energy management system is a measure to promote energy conservation, and it is to provide each industry with targets like energy consumption intensity as a benchmark, and to support activities toward achievement. However, it is considered effective to work in combination with the development of human resources for energy managers and personnel for assessments and audits. Because understanding the energy consumption and insulation status of buildings are essential skills for ZEB conversion.

Thus, in Uzbekistan, it is necessary to start with the aforementioned activities while promoting other energy conservation programs and priority measures in parallel. As budgetary measures are required to achieve these goals, it is suggested that financial support be provided to the governments of Uzbekistan through JICA cooperation and co-financing with international financial institutions like WB and ADB. In particular, scaling up through financial cooperation is important in promoting ZEB/ZEH for public facilities, commercial buildings, and residences based on demonstration experiments promoting the replacement of equipment in the industrial sector found through the energy management system. For this purpose, financial cooperation, such as structuring two-step loans in cooperation with local financial institutions (Asakabank, Uzpromstroy Bank, etc.) will be an effective option.

In order to promote energy conservation in Uzbekistan, it is also important to promote the advanced energy conservation technology and energy conservation equipment possessed by Japanese companies through these projects. However, at present, tariffs on imports of the same type of products from abroad that can be supplied by domestic manufacturers (e.g., ARTEL) are extremely high. This is a barrier for foreign manufacturers wanted to expand their business to Uzbekistan. To encourage the import of materials and equipment from companies with advanced energy conservation technology, including Japanese manufacturers, it would be beneficial to implement preferential tariff measures. It is important to pursue proactively with a view to disseminating and deploying Japan's technology and experience in energy conservation to the neighboring countries of Uzbekistan.

Appendix

Attachment 1: Survey of the Current Status of the Industrial Sector

Attachment 2: Survey of Energy Conservation Awareness

Attachment 3: Market Survey of Energy Conservation Equipment

Attachment 4: Field Survey for the Evaluation of Thermal Insulation

Attachment 5: Field Study for the Efficiency Improvement of the Heat Supply System

Attachment 6: Demonstration Experiment of High-Efficiency Air Conditioners

Attachment 7: Brief Survey of the Transformation of Buildings to ZEB (including payback period for business operators)

Attachment 8: Draft Roadmap

Table of Contents

Appendix 1: Survey of the Current Status of the Industrial Sector

1. Purpose of the Survey

A site visit survey and questionnaire survey were conducted to understand and identify the status of energy consumption and energy conservation in the industrial sector.

2. Site Survey

2.1. Summary of the Site Survey

A site survey was conducted at factories in Tashkent to identify the status of energy consumption in the industrial sector. The findings of the survey are presented below. Some points were discovered that can be studied for improvement. This indicates the potential for the improvement of energy efficiency through specific energy conservation activities.

Table 1: List of field survey sites

Name of factories	Type of business	Date	Outline of surveyed points
Zelal Textile	Textile Dyeing	November 23, 2021	Confirmation on room for improvement in operation and maintenance of boilers, energy management, thermal insulation, etc.
Natural Juice	Food (juice product manufacturer)	November 24, 2021	Confirmation of room for improvement in heat insultation of steam system, preheating of supply water for boilers, etc.
Asl Oyna	Glass Bottle Manufacturing	March 28, 2022	Heat recovery of exhausted gas is required. A heat recovery facility is under planning.

Source: JICA study team

2.2. Results and Study of the Site Survey

2.2.1. Zelal Textile (textile and dyeing factory)

The following information was obtained from the site survey at the factory.

- This factory dyes and patterns cotton fabrics manufactured in Turkey.
- Steam is used to sterilize, sanitize, dye, and dry cotton clothes.
- Two boilers, flue and smoke-tube boilers, are installed to heat dyestuff. However, little maintenance is performed on the equipment, such as steam pressure setting and air pressure adjustment. The insulation material of the steam header and pipes was partially peeled off.

Source: Photos by the JICA study team

Figure 1: Pictures of Zelal Textile (textile and dyeing factory)

Study on the potential for energy conservation

Operational improvements, including the management of operating rates and air ratios, should be addressed by employing qualified people for energy management at factories. The possible improvement measures for energy conservation are listed below.

Steam: Reinforcing the thermal insulation of the steam header and control valves. Reduction in steam pressure.

Boiler: Preheating of water supply for boilers. Optimizing air ratio by installing an economizer for the exhaust gas.

Compressed air: Make temperature of air supply lower. No. 4 Compressor is driven by an inverter to control flow volume.

Installation of a cogeneration system: The amount of gas and electricity costs are commensurate with the system. Thus, the introduction of the system will be efficient.

Energy management: Monitoring of energy intensity. Installation of electricity demand monitoring equipment.

Heat transfer: Possibility of heat transfer with the adjacent plant: brick firing plant.

2.2.2. Natural Juice (juice product manufacturer)

The air conditioning system was installed at the office section. The boiler was used for sterilization. The factory stated that it is currently constructing a wastewater septic tank.

Study on the potential for energy conservation

The possible improvement measures for energy conservation are listed below.

Steam: Reinforcing heat insultation of the steam header and control valves. Reduction of steam pressure.

Boiler: Preheating the boiler feed water by installing an economizer for the exhaust gas. Optimization of air ratio.

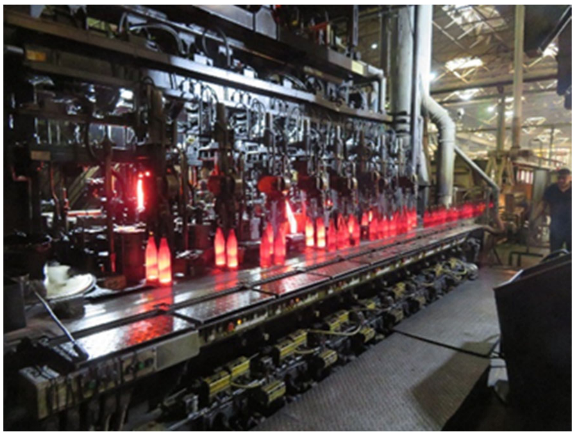
Compressed air: Make temperature of air supply lower.

Energy management: Monitoring of energy intensity. Installation of electricity demand monitoring equipment.

2.2.3. Asl Oyna (glass bottle manufacturer)

The status of energy usage was surveyed at a factory that mainly manufactures beer bottles from silica sand and recycled glass by using a 1250 °C furnace. The heating furnaces for melting glass are equipped with air preheaters, which use waste heat to heat up the air to burn city gas. However, the temperature of the exhaust gas after heat recovery is 500 °C or higher.

A new type of heating furnace under construction is planned to recover waste heat by using regenerative burners. Significant energy savings were being promoted.




Source: Photo by the JICA study team

Figure 2: Pictures of Asl Oyna (The left picture shows a bottle casting line, and the right one shows an air preheater installed in flue)

Study on the potential for energy conservation

As mentioned above, energy conservation measures have been taken, such as the installation of an air preheater. However, the exhaust gas after heat recovery is still high. Thus, the thermal efficiency is considered not sufficient. Waste heat after heat recovery—in the exhaust gas overs 500 °C— is always dissipated into the atmosphere from the stack. This results in extremely high heat loss.

In Japan, energy conservation is being promoted by reducing bottle weight, repeated use of bottles, and standardizing bottle specifications (size and shape). In addition, aluminum cans are used for beverages, such as beer, owing to their recyclability and low manufacturing energy consumption. Such structural conversion is considered as one of the energy saving measures.

3. Questionnaire Survey

3.1. Summary of the Questionnaire Survey

In order to ascertain the potential for energy conservation and the status of its implementation, a questionnaire survey was conducted. The questions on the questionnaire and the subject of the survey are indicated below. Some energy suppliers were included in the responses.

Questionnaire items

- Name and size of factory or office
- Energy consumption and production
- Condition of facilities (boiler, heat recovery system, etc.)
- Availability of target goal for energy efficiency improvement
- Status of energy management

Questionnaires were sent out to

- Relevant factories and offices through the MoE's energy conservation department.

3.2. Status of Responses

The responses are shown in Tables 2, 3, and 4.Table 2: Energy-intensive industriesTable 4: Other industries

Table 2: Energy-intensive industries

Field	Number of responses	Notes
Iron and steel	1	Bar mill with electric furnace: 1
Soil, stone and cement	1	Focus on the cement related part in the data from an office which also runs metal refining plant.

Gas refining	7	Includes responses from several JSC Uzbekneftegaz.
Chemical	7	Comprehensive chemical materials: 1, Tire: 1, Soda ash: 1, Chemical fertilizer: 4
Mining	3	Coal: 2, Gold and Uranium: 1

Source: JICA study team

Table 3: Energy supply industry

Field	Number of responses	Notes
Power generation	7	
Gas transportation	8	Including responses from several offices of JSC Uztransgaz.
Heat supply	1	

Source: JICA study team

Table 4: Other industries

Industrial field	Number of responses	Notes
Flour milling and compound feed	16	
Automobile	18	
Machine	1	Mining equipment 1
Power distribution equipment	2	Control equipment: 1, Bonding wire: 1
Irrigation	5	Water supply sector: 5
Fats and oils	1 association 22 companies	Response contains only company list and boiler list.
Vehicle maintenance	12	

Source: JICA study team

3.3. Summary of Results

Table 5 shows the potential for energy conservation, estimated based on the responses from the energy-intensive industries; the target goals for the improvement of energy efficiency are stated in the responses. Table 5: Analysis results

Table 5: Analysis results

Field	Number of responses	Estimated potential of energy conservation	Targeting goals of improvement of energy efficiency
Iron and steel	1	30 %	Mentioned the goal of PP4779.
Soil, stone and cement	1	20 %	Not stated.
Gas refining	7	Insufficient information	Representative responses mentioned the goal of PP4779.
Chemical	7	5-15 %	Improvement plans are developed annually.
Mining	3	10 %	One response mentioned the goal of PP 4779.

Source: JICA study team

3.4. Analysis by Sector

The analysis of the energy conservation status, potential for energy conservation, and any further energy conservation measures was conducted for energy-intensive sectors, such as iron and steel, as well as for sectors responded much information. The calorific value of electric power was converted to 9.97 MJ/kwh, which is the value used in Japan, to facilitate an easy comparison with energy consumption in Japan. For the calorific value of natural gas, 35.7 MJ/m3 was used, which was stated in Uzbeksteel's response. A conversion factor of 45.5 GJ/ton was used for diesel and fuel oil, as a typical value.

3.4.1. Iron and Steel

One response was obtained (Uzbeksteel). Based on the responded data, energy consumption intensity was estimated to be 9.40 GJ/product ton of electricity consumption and 3.46 GJ /product ton of natural gas consumption (12.86 GJ/product ton in total). This figure is considerably higher than 5.8 GJ/ton, which is the Energy Conservation Law benchmark value for electric furnace plants in Japan (distribution values range from 5.3 to 9.1, with the denominator being a mixture of steelmaking tons and rolling tons). Based on the comparison between 12.86 and 9.1, it is assumed that a 30% energy saving can be achieved by measures involving the implementation of equipment. Estimated energy conservation measures are listed below.

- As there is no special mention about waste heat recovery, it is assumed that an energy saving of approximately 30% can be achieved for natural gas by enhancing waste heat recovery.

- In Japan, measures to reduce the energy consumption of heating furnaces are used by direct rolling. Depending on layouts and equipment related measures, this technology may be applicable.
- Although the efficiency of the current boiler is not known, an improvement in efficiency of approximately 10% is possible by updating to a new facility with enhanced waste heat recovery.
- For electric power, improving the efficiency of arc furnaces results in a reduction of approximately 6–7% from 450 kwh/ton and a reduction in pump power of approximately 30%. Moreover, replacement plans have already been prepared for some of the pumps. In addition, it is necessary to consider the installation of converters into the drive units and the reduction of power consumption through operation plans.
- The responses states that there are an energy management organization and guidance on energy conservation. It is desirable to ascertain whether energy conservation measures for individual facilities and energy conservation through operation plans is actually being implemented.

3.4.2. Soil, Stone, and Cement

One response was obtained, from JSC Almalyk mining and smelting plant. Although the response included multiple business sectors, the cement related part is listed so that it can be analyzed; it will be analyzed in comparison to the Japanese benchmark values. Based on the response, production is estimated at 1.94 Mt. Estimated consumption is 4.24 GJ/product ton in total, consisting of 1.22 GJ/product ton of electricity and 3.02 GJ/product ton of natural gas. Note that the electricity consumption used for this analysis is set on the sum of the direct consumption of the cement process and the estimated consumption of the ancillary equipment (22% of the total). Considering the benchmark value under the Energy Conservation Law for cement works in Japan, 3.891 GJ/product ton, there appears potential for improvement. In terms of heat input, the natural gas consumption of 3.02 GJ/product ton is 20% higher than the heat input level of 2.5 GJ/product ton for cement plants in Japan, and it is assumed that there is potential for energy conservation as well.

As for the energy conservation measures, further waste heat recovery is considered effective and important, as waste heat recovery is described only for copper and zinc smelting processes, but not for cement. It is also necessary to verify whether the process includes an energy-efficient dry type facility. Although the efficiency of the current boiler is not known, there is potential for an improvement in efficiency of approximately 10% by updating to a new facility with enhanced waste heat recovery.

3.4.3. Gas Refining

Responses were obtained from seven offices (in JSC Uzbekneftegaz). No information on process configuration, equipment, etc. was provided in the responses. The results of efficiency improvement plans which is specifically implemented are currently in place are 0.35% for electricity and 1.15% for fuel gas, leaving a gap between the goal of 1.5 times energy efficiency. It seems necessary to consider process-oriented considerations, such as leakage; renewal of the boiler, motor, and pump; and waste heat recovery.

Electricity consumption in summer is 19% higher than that in winter. It is estimated that the ratio of cooling energy to electricity consumption is high. Accordingly, the operating efficiency of the chiller should be checked. The unit cost of gas, according to the responses, is very small at 295 uzs/km3. Therefore, it seems difficult to achieve reductions in gas consumption at JSC Uzbekneftegaz through economic efficiency. Thus, a top-down approach is required to set reduction targets.

The seven offices that responded are all from the same company. Thus, their energy consumption per throughput should be compared internally. Comparisons are easier if the information on processing conditions are internally shared with in a company.

3.4.4. Chemical

Responses were obtained from three chemical sectors, other than fertilizers: soda ash, tires, and comprehensive chemical materials. The energy saving potential is listed separately for each of the production items, as they are different.

■Soda ash

The plant is new, having been installed in two phases, in 2006 and 2016. The boiler efficiency of 85% has room for improvement. Steam consumption is estimated to be 454,500 tons in total, based on the responses, 36,000 tons/month x 12 months/year for production facilities, and 22,500 tons/year for room heating. The natural gas required for this heat value is 41,937 km3 assuming a boiler efficiency of 0.85, which accounts for 50% of the natural gas consumption. The steam requirement is considerably lower, on average, compared to the total boiler capacity of 159 t/h x 0.8 (anticipated maintenance) x 24h x 365d = 1,114,000 tons in terms of calorific value. Natural gas accounts for 83% of the energy consumption at the plant. Therefore, the enhancement of boiler efficiency is particularly important for energy conservation. Considering the low boiler load, an improvement of approximately 10% of the boiler energy is expected.

■Tires

It is a newer plant, and the boiler operating efficiency is high. However, the average load on the boiler is low, thus there may be room for improvement.

■Comprehensive chemical materials

As a factory implementing ISO 50001, it is considered appropriate to visualize energy consumption trends for each workshop so that management and employees can recognize them, and to require thorough energy management in each workshop. Boiler operating efficiency varies from boiler to boiler, and it is recommended to conduct an energy audit of boiler facilities to investigate the potential for improvement in order to replace low efficiency boilers. In addition, heat recovery by the combustion of off-gas and installation of waste heat boilers have been partially implemented. The possibility of these expanded installations of these installations should be considered.

3.4.5. Chemical Fertilizer

Four responses were obtained. Although the potential for energy conservation varies from case to case, it is estimated that there is room for energy conservation in the range of 5–15%. The efficiency of the boiler and steam occupies an important position in energy conservation at chemical plants. If there is sufficient heat demand, sharing heat supply between cogeneration and boilers can also be effective.

3.4.6. Gas Transport

Responses were obtained from eight offices of JSC Uztransgaz in each region. The amount of transportation and energy consumption varies widely among them. Thus, it is desirable to standardize the indicators of transportation volume, transportation distance, etc., and to conduct activities to compare energy efficiency. If such activity is conducted in each office of Uztansgaz, useful indicators could be obtained.

3.4.7. Flour Milling and Compound Feed

Responses were obtained from 16 factories. Descriptions about target goals for energy efficiency improvement are lacking, and it is estimated that there is room for improvement activities of approximately 5–15%. As the production process in flour milling and compound feed mills primarily uses electricity and is primarily an on-site activity, it is desirable to promote improvement activities through on-site energy management.

3.4.8. Water Transmission for Irrigation

Five responses were received. The business office itself has stated the importance of the replacement of low-efficiency pumps. Such old type pumps should be replaced with more efficient pumps. This is because energy consumption in the water delivery sector is largely dependent on pump performance. It is desirable to make a list of large pumps and their efficiencies. From a national perspective, low efficiency pumps should be prioritized for renewal.

3.4.9. Vehicle Maintenance

Twelve responses were obtained. Vehicle maintenance is a field of machining, which consumes mainly electricity. Thus, low-efficiency, electricity-using equipment is required, such as compressors, conveying equipment, etc. Some enterprises are planning to renew their equipment, but others are not considering this; therefore, it is desirable to promote renewal plans.

Regarding energy management, while some enterprises are proactive by following ISO 50001, others are not concerned at all. It seems essential to raise the include level of energy management entirely in the sector.

Regarding the evaluation of energy efficiency, some responses include a reference energy consumption per unit depending on the contents of the wagon repair. Such information can be used to compare the actual power consumption of each wagon repair at every enterprise to evaluate the efficiency of each site's equipment and operations.

Appendix 2: Survey of Energy Conservation Awareness

1. Purpose of the Survey

As basic information for the drafting of the roadmap, a survey was conducted on the current status of energy conservation activities and awareness at home, aiming to ascertain the potential for energy conservation created by a change in the lifestyle of citizens toward energy conservation activities.

2. Survey Contents

The table below shows the interview items developed for the four major topics; they were organized as a questionnaire.

Note that, based on the preliminary survey, apartment buildings are highly likely to receive their hot water from the district heat supply. However, in detached houses, the hot water is produced by the boilers installed in each house. The utility expenses for the former housing complex would include hot water and hot water for heating, in addition to electricity and gas. However, the latter does not require hot water or hot water for heating, and the energy required for the boiler is provided by gas or electricity. The utility expense in Uzbekistan is electricity, gas, and hot water in descending order. Based on the above, utility expense was also surveyed, as listed in the table below.

Table 6: Details of the energy efficiency and conservation survey for households

survey item	Contents
Energy-conservation activities at home	Interview about any other actions that lead to energy conservation in the home . For example , the temperature setting of the air conditioner and their daily clothing
Status of Home Appliance Usage	Survey on the number of home appliances for the household, the year of purchase, and future plans for purchasing home appliances.
Use of energy efficiency labels	Survey awareness of energy efficiency labels and status of use , such as whether they refer to energy efficiency labels when purchasing home appliances.
Utility expenses, etc.	Investigate actual utility expense. In addition, given that utility costs are highly dependent on housing type, we will also ask about housing type is also interviewed in order to understand the relationship between utility expense and the diffusion of energy-efficiency equipment.

Source: JICA study team

3. Survey Method

The survey was created using Google forms. The URL of the Google form was posted to several Telegram groups to solicit responses. Incentives were paid to those who participated in the survey; responses were received from 102 people. The survey questions are shown in the table below. This method was used because it was not possible to request responses from specific counterparties through the government of Uzbekistan. As the survey team did not narrow down the list of counterparties, it is expected that the distribution range of respondents has a certain degree of randomness.

Table 7: Survey questions

No.	Questions
Research on building information	housing type
	Age of building
	Type of exterior wall
	Window type
	Availability of Wall insulation
	Availability of Roof insulation (question only for detached houses)
Survey on Air Conditioners	Number of air conditioners
	Percentage of inverter air conditioners
	Grade of air conditioner
	Grade of air conditioner for next purchase
	Will you buy an inverter air conditioner for the next purchase?
	In case of there are general performance air conditioners and high-efficiency air conditioners when high-efficiency air conditioners have lower running costs
	The performance of the air conditioner I am considering purchasing is A. If a subsidy is available for the same type of A+ air conditioner to support 20~30% of the price difference between A+ and A, would you like to purchase an A+ air conditioner
Survey on Energy Conservation Awareness	Are you interested in energy conservation?
	Do you think energy conservation education is important?
	What do you think it is important to promote energy conservation?
	Do you know heat pump technology?
	Do you take energy conservation actions in your daily life?
	About heating in winter

	About loungewear in winter
	Do you know the energy conservation label?
Survey on energy equipment at home (Other than air conditioners)	Hot water supply, District heating, or boiler
	Do you use a combi boiler ?(only for those who answered boiler in the previous question)
	Efficiency of the boiler (only for those using a boiler)
	Age of boiler installation (only for those using a boiler)
	Is a hot water meter installed?
	In winter, do you use air conditioner in addition to district heat supply and heating hot water for heating using boiler ?
	About water-saving showerheads

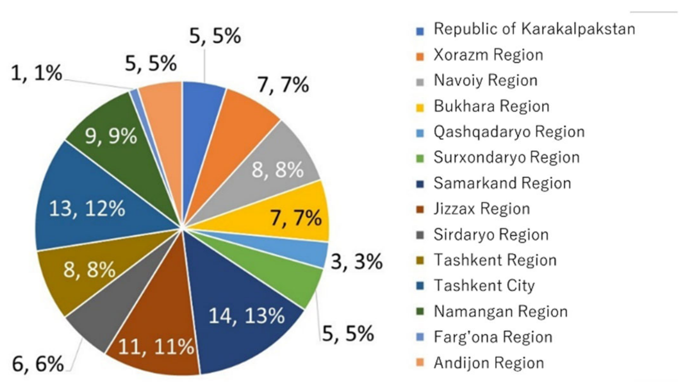
Source: JICA study team

4. Results of the Survey

4.1. Distribution of Respondents

The figure below shows the regional distribution of respondents. Sixty percent of the respondents live in urban areas and 40% in other areas, while 60% live in detached houses and 40% in apartment buildings. Thus, it can be said that most of the respondents live in detached houses.

Respondents' residences are widely distributed throughout the region, as shown in Figure 3.Figure 3: Distribution of Respondents' Residences1



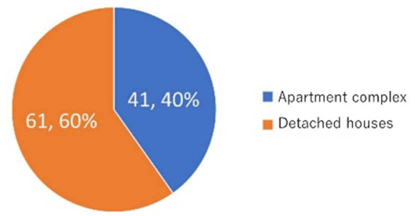
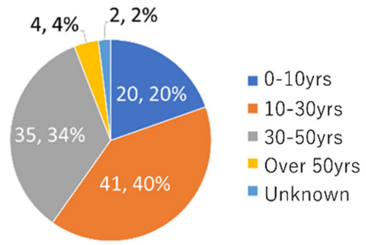
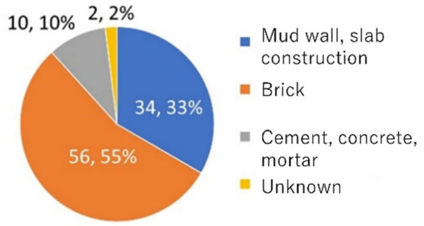
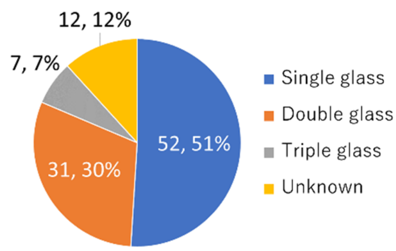
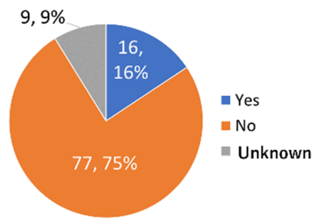
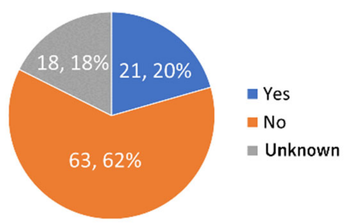
Source: JICA study team

Figure 3: Distribution of Respondents' Residences1

4.2. Results of the Survey on Building Information

Details of the survey results are shown in Table 8.

Table 8: Results of the survey on building information

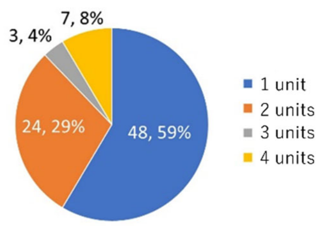
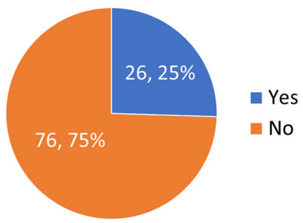
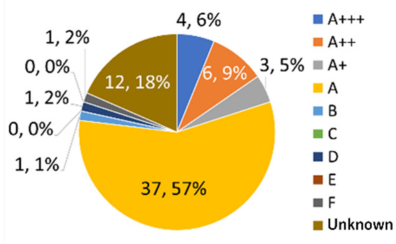
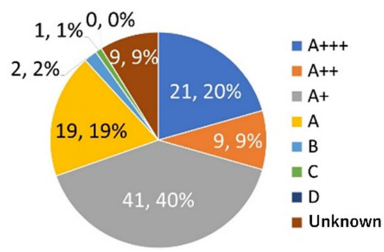
Questions	Answer.	Responses (Graph)
Type of housing	Apartment complexes: 41 cases, 40%. Detached houses: 61 cases, 60%.	
Age of Building	0-10 years: 20 cases, 20%. 10-30 years: 41 cases, 40%. 30-50 years: 35 cases, 34%. More than 50 years: 4 cases, 4%. Unknown: 2 cases, 2%.	
Type of exterior wall	Mud walls and slab construction: 34 cases, 33%. Brick: 56 cases, 55%. Cement, concrete and mortar: 10 cases, 10%. unknown: 2 cases, 2%.	
Type of window	Single-glass: 52 cases, 51%. Double-glass: 31 cases, 30%. Triple-glass: 7 cases, 7%. unknown: 12 cases, 12%.	
Whether the walls are insulated or not	Yes: 16 cases, 16%. No: 77 cases, 75%. unknown: 9 cases, 9%.	
Whether the Roof insulation or not (only for detached houses)	Yes: 21 cases, 20%. No: 63 cases, 62%. unknown: 18 cases, 18%.	

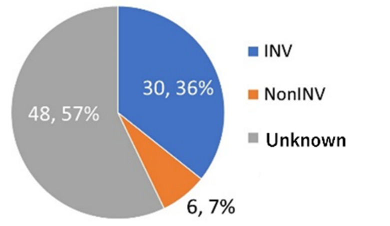
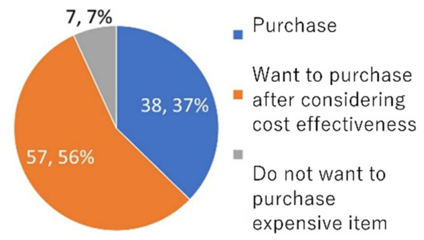
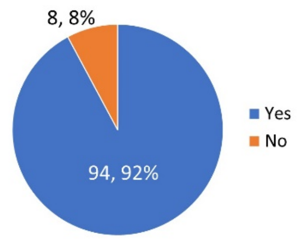
Source: JICA study team

4.3. Results of the Survey on Air Conditioners

Details of the survey results are shown in Table 9.

Table 9: Results of the survey on air conditioners

questions	Answer.	Responses (Graph)
Number of air conditioners	1 unit: 48 cases, 59%. 2 units: 24 cases, 29%. 3 units: 3 cases, 4%. 4 units: 7 cases, 8%.	
Percentage of inverter air conditioners	Yes: 26 cases, 25%. No: 76 cases, 75%.	
Grade of air conditioner purchased	A+++: 4 cases, 6%. A++: 6 cases, 9%. A+: 3 cases, 5%. A: 37 cases, 57%. B: 1 case, 1%. D: 1 case, 2%. F: 1 case, 2%. unknown: 12 cases, 18%.	
Desired Grade of air conditioner for the next purchase	A+++: 21 cases, 20%. A++: 9 cases, 9%. A+: 41 cases, 40%. A: 19 cases, 19%. B: 2 cases, 2%. C: 1 case, 1% yet to consider: 9 cases, 9%.	

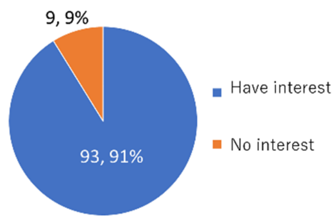
Will you buy an inverter air conditioner for the next purchase?	INV: 30 cases, 36%. Non-INV: 6 cases, 7%. unknown: 48 cases, 57%.	
In case there are general performance air conditioners and high-efficiency air conditioners, when high-efficiency air conditioners have lower running costs	Purchase: 38 cases, 37%. Want to purchase after considering cost-effectiveness: 57 cases, 56%. Do not want or reluctant to purchase expensive items: 7 cases, 7%.	
If subsidy is available for the same type of A+ air conditioner to support 20% ~30% of the price difference between A+ and A.	Yes: 94 cases, 92%. No: 8 cases, 8%.	

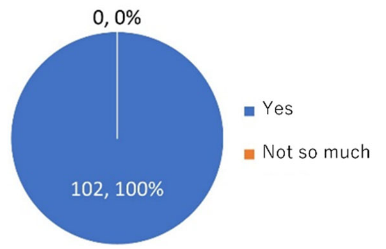
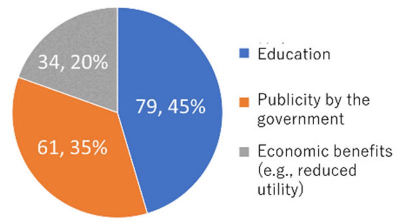
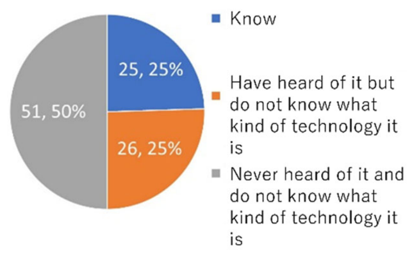
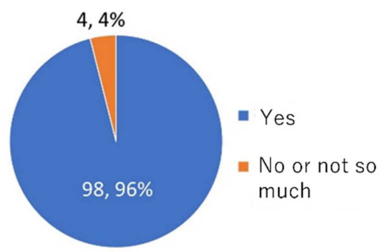
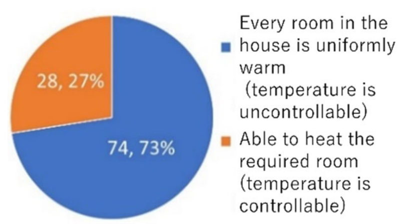
Source: JICA study team

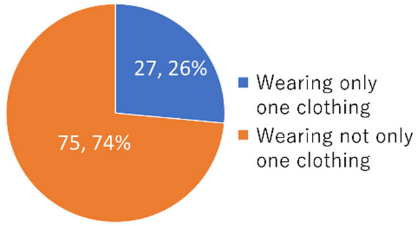
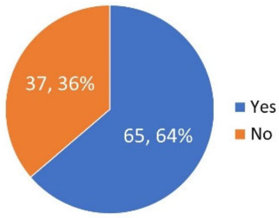
4.4. Results of the Survey on Energy Conservation Awareness

Details of the survey results are shown in Table 10.

Table 10: Results of the survey on energy conservation awareness

questions	Answer.	Responses (Graph)
Are you interested in energy conservation?	Have Interested: 93 cases ,91%. N0 interest: 9cases, 9%.	

<table>
<tr>
<td>Do you think energy conservation education is important?</td>
<td>Yes: 102 cases 100%.
Not so much: 0cases, 0&</td>
<td>
</td>
</tr>
<tr>
<td>What do you think is important to provide energy conservation to?</td>
<td>Education: 79 cases ,45%
Publicity by the government: 61 cases, 35%
Economic benefits (e.g., reduced utility costs): 34 cases, 20%.</td>
<td>
</td>
</tr>
<tr>
<td>Do you know heat pump technology?</td>
<td>Know: 25 cases ,25%.
Have heard of it but do not know what kind of technology: 26 cases, 25%
Never heard of it and do not know what kind of technology it is: 51 cases ,50%.</td>
<td>
</td>
</tr>
<tr>
<td>Do you take energy conservation actions in your daily life?</td>
<td>Yes: 98 cases, 96%.
NO or Not so much: 4 cases, 4%.</td>
<td>
</td>
</tr>
<tr>
<td>About Heating in winter</td>
<td>Every room in the house is uniformly warm (temperature is controllable): 74 cases, 73%.
Able to heat the required room (temperature is controllable): 28 cases, 27%.</td>
<td>
</td>
</tr>
</table>

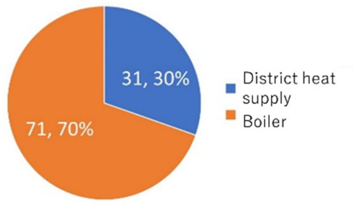
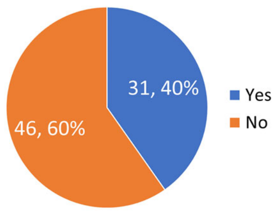
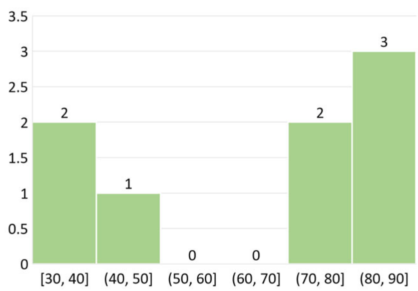
About loungewear in winter	Wearing only one piece of clothing: 27 cases, 26%. Wearing not only one piece of clothing: 75 cases, 74%.	
Do you know the energy conservation label?	Yes: 65 cases, 64% No: 37 cases ,36%	

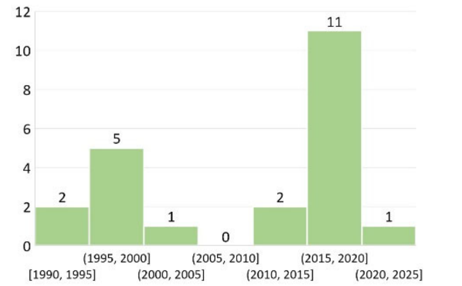
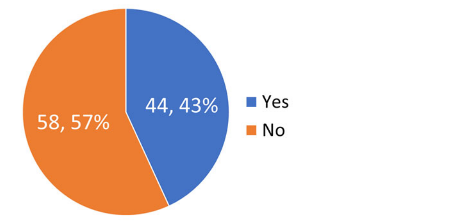
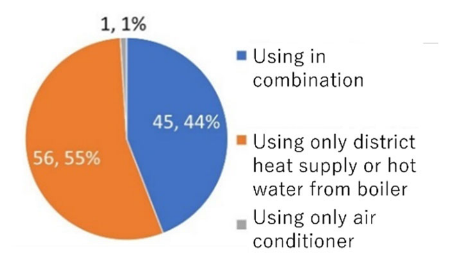
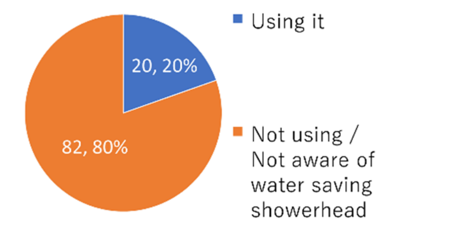
Source: JICA study team

4.5. Results of the Survey on Home Energy Appliances (other than air conditioners)

Details of the survey results are shown in Table 11.

Table 11: Result of the survey on home energy appliances (other than air conditioners)

questions	Answer.	Responses (Graph)
Hot water supply, District heat supply, or boiler	District heat supply: 31cases, 30% Boilers: 71 cases, 70%	
Do you use a combi boiler? (Only for those who answered boiler in the previous question)	Yes: 31 cases ,40% No: 46 cases, 60%	
Efficiency of boiler (Only for those using a boiler)	30-40%:2 cases 40-50%: 1 case 70-80%: 2 cases 80-90%: 3 cases	

Age of boiler after installation (only for those using a boiler)	1990-1995: 2 cases 1995-2000: 5 cases 2000-2005: 1 case 2010-2015: 2 cases 2015-2020: 11 cases 2020-2025: 1 case	
Is a hot water meter installed?	Yes: 44 cases, 43%. No: 58 cases, 57%	
In winter, do you use air conditioner in addition to district heat supply or heating hot water from boilers?	Using in combination: 45 cases, 44%. Using only district heat supply or only heating hot water from boilers :56 cases ,55%. Using only air conditioner: 1 case, 1%.	
About water saving showerheads	Using: 20 cases ,20%. Not using/not aware of water saving shower heads: 82 cases, 80%	

Source: JICA study team

5. Analysis of the Survey Results

5.1. Indications from the Survey Results on the Building

The results of the home survey confirmed the following three main issues, indicating that there is room for improvement in the heat insulation performance of homes.

- Half of the window types (51%) are single-glass.
- Walls are not equipped with insulation in 75% of the houses.
- More than 60% of detached houses do not have roof insulation.

5.2. Indications from the Survey Results on Air Conditioning

A summary of the results of the survey is shown below. The survey results indicate that air conditioners with class A performance are widely used. Regarding future air conditioner purchases, many respondents want air conditioners with higher performance, or inverters. Many respondents claimed that they would consider the running costs. In addition, many respondents indicated that they would choose higher efficiency air conditioners if a subsidy program was available. Thus, it seems that a subsidy program may be worth considering as a way to promote the spread of high-efficiency equipment.

- More than half of the households (51%) owned one air conditioner.
- 23% of households do not own an air conditioner, and 26% own two or more.
- Grade A or higher accounted for 77% of purchased air conditioners.
- About 1/4 of the respondents (26%) have inverter air conditioners.
- The desired grade of air conditioners for the next purchase is A+ for 40% of the respondents, A+++ for 20%, and A for 19%.
- More than half of the respondents were not sure if they would purchase an inverter air conditioner for their next purchase. When asked to choose only from inverter or non-inverter air conditioners, 84% said they would like to purchase an inverter air conditioner.
- If there are typical performance air conditioners and high-efficiency air conditioners, and high-efficiency air conditioners cost less to run, 37% said they would purchase them, and 56% said they would consider cost-effectiveness and purchase them.
- More than 90% of respondents indicated that they would purchase A+ if they could enjoy a subsidy for 20% to 30% of the price difference between A+ and A.

5.3. Indications from the Survey Results on Energy Conservation Awareness

Overall, it can be said that respondents have a certain awareness of energy conservation. The result also shows that publicity by the government is important. This can be the basis for drafting energy conservation policies.

5.3.1. Indications from Survey Results on Energy Equipment in household.

5.4. Overall, the results show that there is room for improvement in boilers used in households and room to promote the use of water saving shower heads. It is desirable to reflect these findings in specific energy conservation policies.

Appendix 3: Market Survey of Energy Conservation Equipment

1. Purpose of the Survey

A market survey was conducted to obtain information that is useful in studying measures to promote the deployment of high-efficiency equipment, such as air conditioners, in the market. The results will be used to recommend measures to promote more energy-efficient air conditioners in the future.

2. Contents of the Survey

Uzbekistan's energy efficient labeling system, one of its energy conservation measures, was announced on April 9, 2015, in Resolution No. 86 of the cabinet meeting. This system has been in effect since January 2016. The equipment that receives labelling and the operational status of the system are shown in Table 12.

Table 12: Status of Uzbekistan's energy efficient labeling system

Item	Status
Equipment to be labeled	Home appliances - refrigerator-freezers - washing machines - household dishwashers - electric cookers - air conditioners - lighting fixtures - TVs, electric water heaters - microwave ovens
Standard	There are various standards for energy consumption efficiency of each equipment. The standard was put into operation in 2016, as a similar standard to EU Energy Label; and it has no revision since then.
Operation of standards	Prohibits lower standards in a phase manner. D was prohibited in 2020.
Certification Body	NA
Subsidy Programs Related to the	NA

Leveling	

Source: JICA study team

The energy efficient labeling system is effective in promoting improvements in the energy efficiency of equipment. Strengthening this system is necessary in order to promote the spread of high-efficiency equipment to households. Therefore, in order to identify areas that should be strengthened under the system, an interview survey was conducted on the sales performance and diffusion status in the market, as well as on the types and models of high-efficiency equipment for households.

3. Survey Method

3.1. Surveyed Equipment

The main focus of this survey was residential air conditioners. Information was also collected on refrigerators and boilers.

3.2. Scope of the Survey

Considering the sales situation in Uzbekistan, a survey was conducted at retailers and other dealers. There are two types of retailers: consumer electronics retailers and privately owned electronics shops. The consumer electronics retailers are large-scale stores or chain stores, located in close proximity to, or in the same building as, large-scale shopping centers. The privately owned electronics shops are operated in a parcel where many stores are located.

3.3. Interview Items

The survey focused on the following items.

(Sales status)

Classification, power consumption, efficiency class, price, and sales volume

(Diffusion factors)

Sales trends, energy conservation labels, usefulness of inverters, and the use of air conditioners as heaters

4. Results of the Survey

The results obtained from the survey are summarized below.

4.1. The sales status and status classification of residential air conditioners are shown in Tables 13 and 14, respectively.

Table 13: Sales of residential air conditioners

Type of store	Type of products	Classification	Power consumption		Ranks	Average prices(som)	Sales quantity	Ratio of INV
			Heating	Cooling				
MALIKA	Mainstream products	18	1500	1640	A	6,500,000	–	–
(privately-owned store)	High-efficiency products	18	1410	1580	A or above	8,000,000	–	
IDEA	Mainstream products	12	1200	1085	A	7,000,000	500	30%
(electronics mass retail store)	High-efficiency products	12	1099	1000	A or above	8,000,000	100	

Table 14: Classification of residential air conditioners

区分	単位	индекс（インデックス）						
Маркировка（分類）	BTE（BTU）	05	07	09	12	18	24	30
Производительность（能力）	кВт（kW）	1.5	2.0	2.5	3.5	5.5	7	9

Source: Prepared by the JICA research team

4.2. Sales Trends of Air Conditioners

Sales trends are as follows:

- The sales of residential air conditioners are increasing, at both general dealers and mass merchandisers. Energy efficient labeling began in 2016, and sales have more than doubled since then.
- Home air conditioners are sold mostly during the summer season. Comparing summer and winter sales figures, the ratio is about 5:1. However, in January and February, sales trend is not a good time for sales in the overall consumer electronics market.
- Reasons for the increase in the sales of residential air conditioners include the summer heat wave due to climate change, the economic development of Uzbekistan, and the introduction of installment payment systems at large retailers.

4.3. Performance of Air Conditioners Sold

The energy conservation performance of air conditioners sold is indicated below.

- As for energy efficiency classes, around 2016, when energy efficiency labeling was launched, most products were B or C, but now A or higher are the norm.
- In the past, inverter air conditioners were not sold, but now, they are on the rise.
- The distributors commented on the lack of reliability of air conditioner performance for

Uzbekistan domestic models. This suggests that an appropriate certification system should be considered.

5. Analysis of Survey Results

Based on the situation in the market, the following considerations were made.

Based on Static Control Solution data, as shown in Table 15, the diffusion rate of air conditioners was 40% in 2020. Considering the room for improvement and of recent market, the seals number will trend to increase.

Table 15: Number of air conditioners per 100 households (SCS statistics)

Provision of the population with durable goods (the number of goods per 100 households)

(based on the results of sample surveys of households)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	january-december 2020
Conditioners	19	20	27	29	30	32	34	34	35	39	40

Source: Prepared by the JICA Study team

Regarding the sales performance of air conditioners, the most popular efficiency class was B or C in 2016, when the energy efficiency labeling began. However, in 2021 and 2022, Class A was the most popular. The efficiency class of residential air conditioners sold is rising. Class A+ equipment is not currently widespread; however, they are available for purchase.

Therefore, a future policy consideration would be to replace popular equipment with more energy efficient versions.

The sales ratio of inverter air conditioners to total sales is currently approximately 30%. Therefore, there is room to promote the widespread use of inverter air conditioners.

The above indicates that while the use of air conditioners is expected to increase in the future, there is also a high possibility of transitioning customers to high efficiency air conditioners.

The performance of each class of residential air conditioners is shown in Table 16. Comparing the performance of Class A+++ with A, former type can be expected to save 30% or more of energy, and further energy conservation can be expected by shifting to inverters. The survey highlighted the room for future improvements in the efficiency of air conditioners.Table 16: Classes of residential air conditioners

Table 16: Classes of residential air conditioners

Energy efficiency classes for air conditioners

Energy Efficiency Class	SEER	SCOP
A+++	SEER ≥ 8,50	SCOP ≥ 5,10
A++	6,10 ≤ SEER < 8,50	4,60 ≤ SCOP < 5,10
A+	5,60 ≤ SEER < 6,10	4,00 ≤ SCOP < 4,60
A	5,10 ≤ SEER < 5,60	3,40 ≤ SCOP < 4,00
B	4,60 ≤ SEER < 5,10	3,10 ≤ SCOP < 3,40
C	4,10 ≤ SEER < 4,60	2,80 ≤ SCOP < 3,10
D	3,60 ≤ SEER < 4,10	2,50 ≤ SCOP < 2,80
E	3,10 ≤ SEER < 3,60	2,20 ≤ SCOP < 2,50
F	2,60 ≤ SEER < 3,10	1,90 ≤ SCOP < 2,20
G	SEER < 2,60	SCOP < 1,90

Source: EU energy labelling

5.1. Other Information Obtained from the Survey

Table 17 and Table 18 show information on household refrigerators and household boilers, respectively. Energy efficient models of refrigerators are currently being sold, although they are not the mainstream models. As Table 19 shows, the effect of high-efficiency class labelling on household refrigerators is significant, indicating that the policy to promote high-efficient appliances may result in much improvement.Table 17: Efficiency classes and prices of residential refrigeratorsTable 18: Selling prices of residential boilersTable 19: Efficiency of residential refrigerators by class

Table 17: Efficiency classes and prices of residential refrigerators

Store	Model	Power consumption (W)	Efficiency class	Average price (UZS)	Average Price (USD)
MALIKA (private owned store)	Mainstream sales models	299,000	A	6,000,000	540
	energy conservation model	256,000	A++	8,000,000	720
IDEA (Chain store for consumer	Mainstream sales models	286,000	A	5,000,000	450
	energy conservation	233,000	A++	8,000,000	720

electronics)	model				

Source: JICA study team

Table 18: Selling prices of residential boilers

store	Power consumption (W / Вт)	Price (UZS)	Price (USD)
MALIKA (private owned store)	20000	3,500,000	315
	26000	6,770,000	609
	24000	7,500,000	675
IDEA (chain store for consumer electronics)	28000	9,198,000	828

Source: JICA study team

Table 19: Efficiency of residential refrigerators by class

Energy efficiency class	Energy Efficiency Index
A+++ (most efficient)	$EEI < 22$
A++	$22 \leq EEI < 33$
A+ (e.g., A+)	$33 \leq EEI < 42$
A	$42 \leq EEI < 55$
B	$55 \leq EEI < 75$
C	$75 \leq EEI < 95$
D	$95 \leq EEI < 110$
E	$110 \leq EEI < 125$
f	$125 \leq EEI < 150$
G (least efficient)	$EEI \geq 150$

Source: Table in EU energy labelling

Appendix 4: Field Survey for the Evaluation of Thermal Insulation

1. Purpose of the Survey

In order to study the measures to improve energy efficiency in apartments, interviews and field surveys were conducted on the heat insulation performance of building walls and pipes. The results of this study will be used to analyze the heat insulation rate of residences and to recommend measures to improve heat insulation performance.

2. Survey Summary

A field survey, arranged by the MDHGS, was conducted on two apartment buildings receiving centralized heat supply. The survey included the visual inspection of the exterior and the piping areas receiving heat supply in the basement floor. A summary of the buildings studied is shown in Table 20 (Building A has nine stories, and Building B has 12 stories). As the survey is based on the observations of human-occupied houses, the presented dimensions are rough estimates.

Table 20: Outline of the surveyed properties

Outline of Building A	9-story building, 90 households Width: 50 m, Height: 30 m, Depth: 15 m, Total floor space per household: 75 m2 Exterior surface area, sum of front and back : 50 m x 30 m x 2 sides = 3,000 m2 Side: 30 m x 15 m x 2 sides = 900 m2 Rooftop surface/underground surface: 15 m x 50 m = 75 m2 Window area: 931 m2 (24% of wall area)
Building B Outline	12-story building, more sophisticated type than Building A. Dimension details are unknown since the survey was conducted in the twilight.

Source: JICA study team

As mentioned above, as this field survey was conducted on human-occupied houses, it was difficult to conduct precise inspections and measurements, which would have required the destruction of parts of the houses. Therefore, the current condition of the building was clarified by supplementing the information so as not to deviate too much from the actual condition, for example, by using analogies from information obtained in other surveys conducted in this project for the interior of the wall. Based on the results, an analysis was made regarding energy efficiency improvements to develop recommendations.

3. Survey Results and Analysis

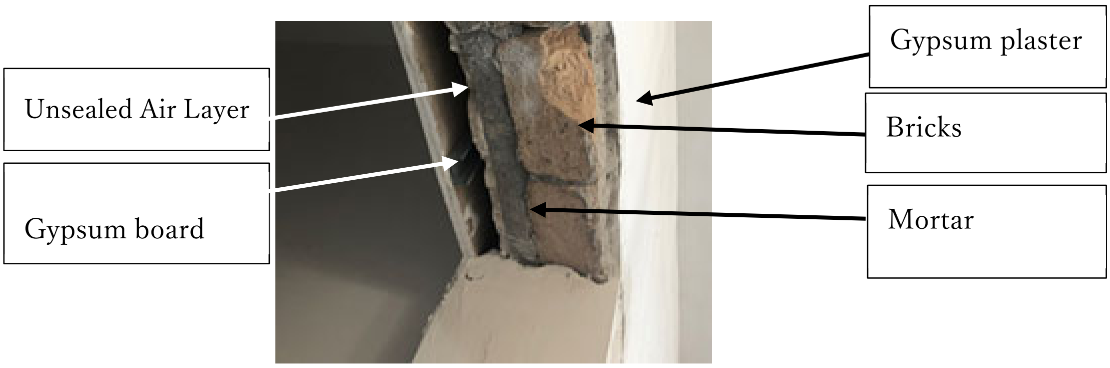
3.1. Analysis of Heat balance

The insultation of the entire building was determined based on the information obtained from the inspection survey. The factors of the heat balance were also ascertained and assumed. The results of calculating the air conditioning load based on these factors will be analyzed to create recommendations for energy efficiency improvements.

3.1.1. Insulation and the Structure of Apartments

1) Insulation and structure of apartment buildings

The wall structure reference information is from an apartment under construction at the Uzbekistan-Japan Youth Innovation Center (UJIYC), where an air conditioning demonstration experiment was conducted.



Source: Photo by the JICA study team

Figure 4: Wall structure (UJICY building)

The internal structure of the wall is shown in Figure 4. The heat insultation performance is improved by using bricks, which have a low heat transfer coefficient. The surface has gypsum plaster, and the internal part was finished with cement. There was an air layer inside, and the room side of the wall was finished with gypsum board. Table 21 shows the results of calculating the heat transfer coefficient, an index of insulation based on the wall structure identified during the field survey. The heat transfer coefficient of the walls was 2.0718 (W/m2K), indicating that the heat insulation was better than that of typical reinforced concrete buildings. The use of thick bricks also has a heat storage effect. This helps to mitigate the effects of temperature fluctuations in a climate like Uzbekistan's, where temperatures fluctuate considerably.

Table 21: Calculation of the heat transfer coefficient of the walls

Materials (from outside)	Thickness mm	Heat conductivity W/mK	Heat transfer resistance m2K/W
gypsum plaster	20	1.6	0.0125
brick	100	0.64	0.1563
mortar	30	1.6	0.0188
unsealed air layer	40	-	0.0700
gypsum wallboard	12	0.17	0.0706
Heat transfer coefficient U W/ m2K			2.0718

Source: JICA study team

2) Structure and heat insultation of windows

The windows have single-layer glass, and the heat transfer coefficient is expected to be 6.4 W/m2-K (according to public information from Japan Flat Glass Association website). This figure is considerably higher than that of the wall surface. It is presumed that windows are the main routes for the inflow and outflow of heat owing to the difference in temperature between the inside and outside of buildings. However, considering the harsh winters, the ratio of window glass area is much smaller than that in Japan, at 24% of the exterior wall (eyeball measurement). In addition, a veranda and eaves were installed on the window side. The structure was designed so that solar radiation would not directly enter the room, considering the effects of summer sunlight.

3) Structure and heat insulation of the roof top of the building

As the roof top of the building cannot be loaded with bricks, owing to structural constraints, a concrete surface with a thickness of 30 cm was added (estimated by visual measurement). In this case, the heat transfer coefficient was calculated to be 2.92 (W/m2K).

4) Structure and heat insulation of the ground surface of the building

The basement area of the building is a utility area, with pipes for heat supply, water piping, etc. However, it is essentially a space. The ground surface of the first floor was made entirely of concrete, with an estimated thickness of 50 cm from the exterior. The heat transfer coefficient in this case was calculated to be 2.14 (W/m2K). As the underground part is heated by heat dissipation from the hot water pipes, it is excluded from the heat balance. The bare steel pipes for hot water and heating piping are installed inside the building; however, they are fixed to the bricks. Thus, heat from the pipes was assumed to be dissipated to the outside air.

3.1.2. Air conditioning load and heat balance

In order to examine the air conditioning capacity suitable for Uzbekistan, the air conditioning load was examined for apartment building A, in which a field survey was conducted. The examination was conducted with the heat insulation figures assumed above. As the building has an external insulation structure, the heat balance was calculated for the entire building. Following shows the calculated results and the air conditioning capacity suitable for the following conditions where the field survey was conducted this time.

As a precondition for the study, the air conditioning was set at 25 °C in summer, from June to August, and 25 °C in winter, from November to April. Based on the building's exterior appearance, it was estimated that all units have air conditioners. Calculations were conducted for the heat balance through wall surfaces and windows, as well as the heat dissipation from internal heat generation, such as human bodies and electrical equipment. The following sections show each value and the conditions for the calculation.

1) Heat balance from outside to building

i) Heat balance through wall surface

Size of wall area: 2,969 m2 (front + back (3,000 m2) + sides (900 m2) - window area (931 m2))

Table 22: Heat balance through wall surface

Period	Month	Temperature Celsius	Difference of temperature between inside and outside of the building	Exterior surface area (m2)	Heat transfer coefficient (W/m2K)	Heat balance (MWh/ month)
summer	June	25.5	0.5	2,969	2.0718	2.3
	July	27.6	2.6			11.9
	August	25.6	0.6			2.7
	subtotal					17
winter	November	8.8	16.2	2,969	2.0718	71.7

	December	4.1	20.9			95.6
	January	1.4	23.6			104.5
	February	3.2	21.8			90
	March	9.3	15.7			71.8
	April	15.9	9.1			40.3
	Subtotal					474

Source: JICA study team

ii) Heat balance through the rooftop of the building

Size of rooftop area: 750 m2

Table 23: Heat balance from the roof of the building

Period	Month	Temperature Celsius	Difference of temperature between inside and outside of buildings	Exterior surface area (m2)	Heat transfer coefficient (W/m2K)	Heat balance (MWh/month)
summer	June	25.5	0.5	750	2.92	0.8
	July	27.6	2.6			4.2
	August	25.6	0.6			1
	subtotal					6
winter	November	8.8	16.2	750	2.92	25.5
	December	4.1	20.9			34
	January	1.4	23.6			38.5
	February	3.2	21.8			32
	March	9.3	15.7			25.5
	April	15.9	9.1			14.4
	Subtotal					170

Source: JICA study team

iii) Heat balance through windows

Size of window area: 931 m2

Table 24: Heat balance through windows

Period	Month	Temperature Celsius	Difference of temperature between inside and outside of buildings	Window area (m2)	Heat transfer coefficient (W/ m2K)	Heat balance (MWh/month)
summer	June	25.5	0.5	931	6.4	2.2
	July	27.6	2.6			11.5
	August	25.6	0.6			2.7
	Subtotal					16
winter	November	8.8	16.2	931	6.4	70
	December	4.1	20.9			92.7
	January	1.4	23.6			104.7
	February	3.2	21.8			87.3
	March	9.3	15.7			69.7
	April	15.9	9.1			39
	Subtotal					463

Source: JICA study team

2) Internal heat generation

i) Heat generated by human bodies

Summer: 5 persons/household x 90 households x 60% (occupancy rate) x 116 W/h (light work) x 24 h/day x 90 days/

(Summer) = 68 MWh/building in summer

Winter: 5 persons/household x 90 households x 60% (homeownership rate) x 116 W/h (light work) x 24 h/day x 181/

(Winter) = 136 MWh/building in winter

ii) Heat generated by electrical equipment

The electricity consumption per household in Japan, 4.17 MW/year—surveyed by the Ministry of Land, Infrastructure, Transport and Tourism—was used as a reference.

Summer: 4.17 MWh/year/households / 12 months x 3 months x 90 households/building = 94 MWh/building in Summer

Winter: 4.17 MWh/month/households / 12 months x 3 months x 90 households/building = 188 MWh/building Winter

3) Calculation of air conditioning load based on the heat balance of the entire building

i) Heat balance of the whole building in summer

Air conditioning load = heat generated by human bodies + electricity consumption + heat flow from outside the building through walls, rooftop, and windows

(68 MWh/building + 94 MWh/building + 17 MWh/building + 6 MWh/building + 16 MWh/building)

= 201 MWh/building

ii) Heat balance in winter

Air conditioning load = heat dissipation from outside the building through walls, roof, and windows - heat generated by human bodies - electricity consumption

(474 MWh/building + 170 MWh/building + 463 MWh/building - 136 MWh/building - 188 MWh/building)

= 783 MWh/building

iii) Entire building

The air conditioning load in summer and winter is calculated to be 201 MWh and 783 MWh, respectively. The air conditioning load per household is shown below.

Air conditioning load in summer: 1 kW/h (201 MW/building / 90 households / 3 months / 30 days / 24 h/day)

Air conditioning load in winter: 2 kW/h (783 MW/building / 90 households / 6 months / 30 days / 24 h/day)

3.1.3. Result of analysis

To cover the air conditioning load in winter with air conditioners, the air conditioner to be selected needs to have a capacity of 3.6 or 4.2 kW based on a load factor of 60% (2 kW/h/0.6 = 3.4 kW), including defrosting, and taking temperature fluctuations.

To cover the air conditioning load in summer with air conditioners, an air conditioner with a capacity of 1.2 kW/h will be sufficient based on a load factor at 80% (1 kW/h/0.8 = 1.2 kW). In Japan, the minimum capacity for air conditioners is 2.2 kW because of the high load for dehumidification in summer. However, 1.2 kW and 0.9 kW air conditioners are available in Tashkent, where humidity is low. An air conditioner purchased exclusively for summer use cannot be the main heating source for winter because its capacity is significantly different from that of a winter air conditioner. It seems essential to have air conditioners with a capacity of 3.6 kW or higher for year-round air conditioning use.

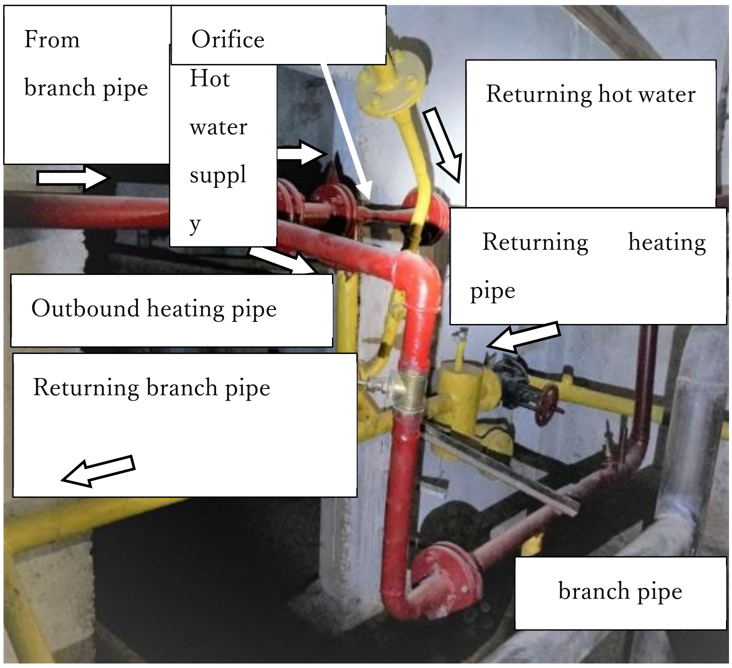
3.2. Analysis of thermal loss

The field survey results indicated that heat loss from piping was occurring. Based on this, the following sections present an analysis and recommend improvement measures.

3.2.1. Piping condition and mechanism based on the results of the field survey

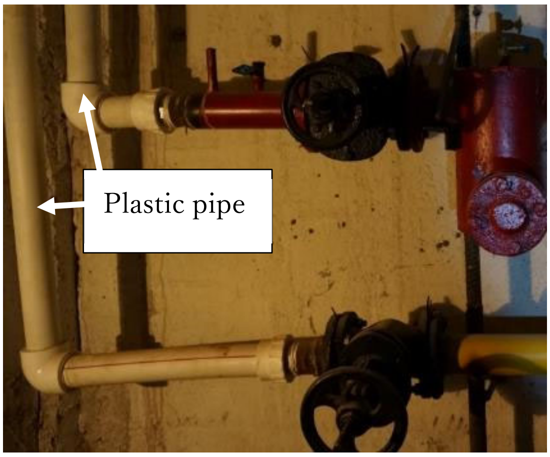
As shown in Figures 5, 6, and 7, hot water from the heat supply station is supplied through the basement by pipes that branch out from the main building. The hot water pipes from the branch pipe to the building, colored in red, branches out into hot water and heating in the middle of the route. The heating pipes run around the inside of the building and connect to the return branch pipes. The hot water pipes are partially with orifice, and unused hot water is recirculated by the negative pressure of the orifice. When there is little usage, like at night and during vacant hours, the recirculation serves to prevent freezing. The remaining hot water is returned to the heat supply station via branch pipes.

The steel pipes and branch pipes in the building currently have no heat insultation. Heat insultation is planned to be installed at the residents' expense. Apartment building B had already been upgraded with plastic piping.



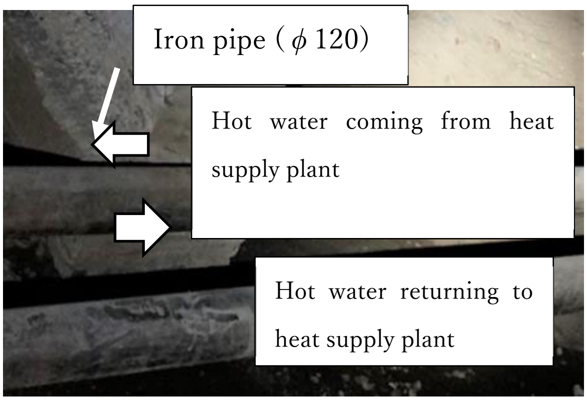
Source: Photo by the JICA study team

Figure 5: Flow and mechanism of hot water from heat supply station (pipes in basement)



Source: Photo by the JICA study team

Figure 6 Plastic pipes at Building B



Source: Photo by the JICA study team

Figure 7: Branch pipe outbound and return pipes

3.2.2. Situation of Heat Loss from Pipes

Since the conditions including distance and hot water temperature cannot be determined for the branch pipes. The heat loss from the steel pipes in the building is calculated.

[Precondition]

Length of the pipes for hot water supply: 960 m/building (round trip across the width and up the height of the building)

Hot water temperature: 60°C (estimated from the outgoing temperature: 71°C and the return temperature: 56°C based on interviews at the heat supply station)

Ambient temperature of the pipes: 25°C

Table 25: Calculation of heat loss from the pipes in the building

No	Name	Size	Straight pipe equivalent length (m/piece)	Volume (Pieces)	Dissipated heat per meter (W/m)	(MJ/m-h)	Heat Dissipation (MJ/h)
1	Flanged globe valve	20A	1.06	90	36	0.13	12.5
2	Flange	20A	0.46	180	36	0.13	10.8
3	Pipes	20A	960.0	-	36	0.13	313.4
						Total Thermal Loss	337

Source: JICA study team

For the natural convection heat dissipation from the steel pipe, a value of 36 W/m at an ambient temperature of 25°C was used from the "Standard practice for thermal insulation works, JIS A9501." The above results show the following values for heat dissipation from the hot water and heating pipes.

Heat dissipation from hot water pipes:
337 MJ/h x 24h/day x 365 days/year = 2,952 GJ/year = 820 MW/year
Heat dissipation from pipes for heating:
337 MJ/h x 24h/day x 6 months/year x 30 days = 1,456 GJ/year = 404 MW/year

Taking the sum of the above calculated results, it is estimated that 1,224 MW/year of heat dissipation is occurring in the piping system in the building. The overall heat balance for the entire apartment, including the centralized heat supply building, the independent heat supply building, and the individual heat supply buildings, is shown in Table 26.

Table 26: Heat balance of the entire apartment

No	Housing Type	Number of buildings (houses)	Loss from pipes (MW)	Heating energy (MW)	Hot water energy (MW)	Total amount (TW)
1	Centralized	15,120	1,224	783	549	37.7

	heat supply					
2	Independent Heat Supply	5,588	245	783	549	8.8
3	Individual heat supply	17,674	-	783	549	22.6
	Total amount					69.1

*1: The piping condition of the independent heat supply type is assumed to be fully retained. The 20A piping insulation ratio is 80% according to the JIS, and the independent heat supply is assumed to be 245 MW (1,224 x 20%). These assumptions were made, as no field survey was conducted.

*2: Hot water energy was calculated separately for showering and dishwashing.

Shower: 82 L/time x 5 persons x 90 households x 365 days/year x (45°C - 15°C) = 469 MW/year

Dish washing, and others: 70 L/day x 90 households x 365 days/year x (45°C - 15°C) = 80 MW/year

The total heat value of 69.1 TW will be 249,000 TJ in TJ equivalent. This is approximately 70% of the total gas consumption of the residential sector (352,547 TJ).

Source: JICA study team

3.2.3. Investigation into heat loss sources

The heat loss is largely due to heat dissipation from the building and thermal piping. Based on the figures obtained from the analysis on heat balance in the previous section, each heat loss source and loss amount is shown in Table 27.

Table 27: Heat loss breakdown

Heat dissipation loss from building		Heat dissipation loss from pipes	
Surface of a wall	474MW/year	Pipes for hot water	820 MW/year
Surface of Rooftop	170 MW/year	Pipes for heating	404 MW/year
Windows	463 MW/year		
Subtotal	1,107 MW/year	Subtotal	1,224MW/year

Source: JICA study team

3.2.4. Improvement plan

The main measures involve thermal insulation and heat retention:

① Double-glazing window glass

- Two layers of clear glass can provide a reduction of 210 MW/year.

  (Calculation method)

  Heat transfer coefficient: 6.4 ⇒ 3.5 (W/m2-K)

  Heat loss: 463 MW/year ⇒ 253 MW/year

- A reduction of 326 MW/year can be achieved by using low-e glass coated with a metallic film that reflects indoor infrared rays.

  (Calculation method)

  Heat transfer coefficient: 6.4 ⇒ 1.9 (W/m2-K)

  Heat loss: 463 MW/year ⇒ 137 MW/year

(2) A reduction of 147 MW/year can be achieved with a blowing insulator, with a thickness of 100 mm into the ceiling of the top floor, or affixing insulation boards.

(Calculation method)

Heat transfer coefficient: 2.92 ⇒ 0.4 (W/m2-K)

Heat loss: 170 MW/year ⇒ 23 MW/year

(3) A reduction of 346 MW/year can be achieved by affixing rigid polyurethane board, with thickness of 30 mm, to the brick surface of the walls.

(Calculation method)

Heat transfer coefficient: 2.07 ⇒ 0.56 (W/m2-K)

Heat loss: 474 MW/year ⇒ 128 MW/year

(4) Retention of pipes

Regarding the plastic pipes, which are currently being implemented in Building B as a retentive measure, the wall thickness is quite thin (at 5 mm by eye measurement); therefore, it is not expected to be very effective in retention.

The material is polypropylene (PP-R) with a thermal conductivity of 0.25 W/mK. Assuming a thickness of 5 mm, the radiant heat dissipation will be 27.4 W/m.

Heat radiation: 36 ⇒ 27.4 W/m

Heat loss: 1,224 MW/year ⇒ 932 MW/year

Effect: 292 MW/year, which is a 24% reduction in heat dissipation from the current situation.

It is possible to maintain an 80% heat retention efficiency by installing an insulator around the pipes with a thickness of 20 mm, based on the JIS.

In the case of heat retention efficiency being improved by 80%:

Heat loss: 1,224 MW/year ⇒ 245 MW/year

Effect: 979 MW/year

Therefore, the effect would be greater if the current steel pipe were wrapped with a thicker layer of heat insulation.

In addition to the above four improvement measures, preventing heat loss by improving the piping configuration is possible. The specific improvement measures are shown below.

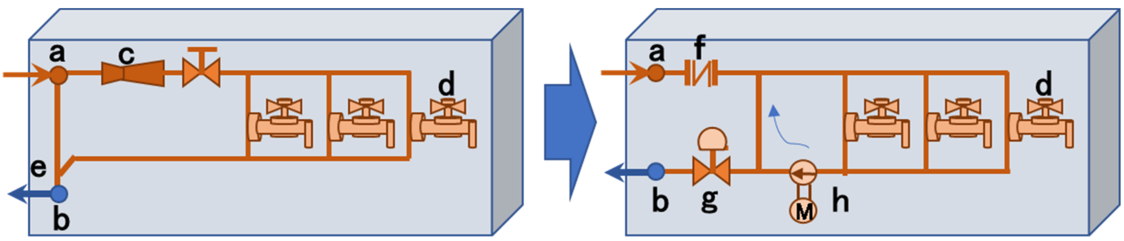
(5) Improvement of hot water piping configuration

The current piping system for hot water supply to the apartment building is shown in Figure 8. The hot water coming from the heat supply station is branched at point "a" into a bypass pipe and a pipe going to the inside of the building. An orifice, marked as "c," is installed at the entrance of the pipe going into the building to prevent freezing at night during the winter. However, it is not functionally useful.Figure 8: Piping for hot water supply in an apartment building

The return pipes should be connected to the low-pressure part of the orifice. However, they are connected at an angle to the bypass pipes, marked as "e," and the returned hot water is being suctioned. Hot water flowing in the bypass pipe is returned directly to the heat supply station without going into the building, routing from point "a" to "b," resulting in energy loss. To reduce these losses, it is recommended to reconfigure the piping to eliminate the bypass pipes and circulate hot water through the building by means of a circulation pump and bimetal valve (specified in the next paragraph).

The piping reconfiguration involves removing the orifice and valve at point "c," installing a check valve at point "f," and installing a circulation pump at point "h" to circulate hot water through the building. Then, a bimetal valve should be installed in the discharge section from the building at point "g." This enables the efficient use of the heat from the heat supply plant by returning the hot water that was circulated through the building and cooled to less than 45°C.

Image of Current supply piping and Piping after improvement



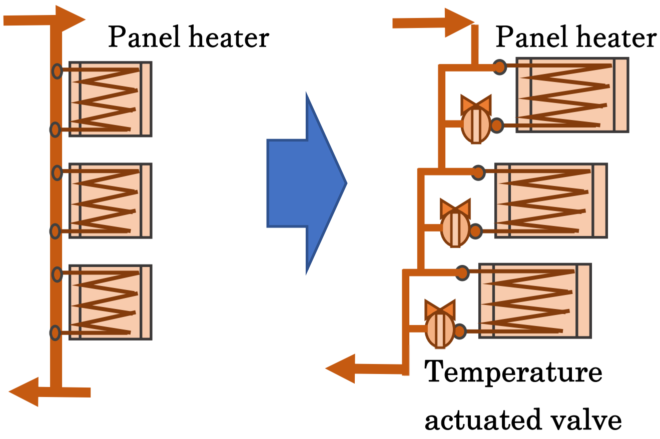
Source: Illustrative examples of field observations (prepared by the JICA study team)

Figure 8: Piping for hot water supply in an apartment building

(6) Improvement of radiator piping for heating in the building

The normal piping of radiators for heating consists of two pipes, one for the outbound and one for the return. However, the current piping in the house uses one pipe. This mixes the outbound and return hot water. The temperature is too high for the upstream radiators, and the lower as the downstream radiators. This decreases the efficiency of the radiators.

As shown in Figure 9, energy conservation can be achieved by improving the way pipes are connected. T-piping should be added at the entrance of the radiator heater panel so that the total pressure, static pressure plus dynamic pressure, is applied. The piping structure of the outlet section remains almost the same, except for a butterfly valve using bimetal that should be installed in the middle. This enables uniform heating because the butterfly valve prevents hot water from flowing unless the temperature goes below a certain level.



Source: Illustrative examples of field observations (prepared by the JICA study team)

Figure 9: Improvement in the piping for heaters

4. Evaluation of Building Insulation and Recommendations

Based on the survey and analysis results shown above, this section presents an analytical discussion of heat insulation in housing, including both detached houses and apartments, in the following order.

① Identification of the type and amount of energy used in the household sector in IEA data.

② Confirmation of the number of detached houses and housing units of apartments.

③ Confirmation of the required heat value obtained from the frame performance.

④ Comparison of the energy used in the household sector in IEA data with the heat requirements determined from the frame performance of a detached house and an apartment building (when the apartment building is not supplied from the district heat supply).

⑤ Comparison of the heat energy of apartment buildings between household sectors in IEA data and the heat requirements determined from the performance of the frame of an apartment.

⑥ Recommended measures for detached houses and apartment buildings.

4.1. Identification of the type and amount of energy used in the household sector in IEA data

The data for the household sector in IEA 2018 data are as follows.

Household sector (unit: ktoe)
Natural gas: 8,002
Heat (hot water): 1,079
Electricity: 1,169
Petroleum products: 509
Coal products: 471

4.2. Confirmation of the number of detached houses and housing units of apartment buildings

The actual number of detached houses could not be determined from the SCS website. Therefore, it was estimated based on the number of apartment buildings found on the Uzbekistan news website (KUN.UZ) and the ratio of detached houses to apartment buildings on the SCS website. The calculated figure is shown in Table 28.

Table 28: Numerical information on various houses

No.	Type	Number
(1)	Number of apartment buildings	38,382 buildings
(2)	Number of buildings provided centralized heat supply	15,120 buildings, 39.4%
(3)	Number of buildings with independent supply heat source	5,588 buildings, 14.6%
(4)	Number of buildings with individual heat supply	17,674 buildings, 46%

Source: Prepared by the JICA study team based on information from https://kun.uz/en/61105041

It is understood that number (3) and (4) in Table 28 do not receive hot water from the district heat supply. For the points that hot water for heating and hot water supply are fueled by gas those are considered to be the same as detached houses.

It is required to seek SCS for confirmation on above information. However, it is still in approaching process and yet to have responses. It should be noted that this analysis may be subject to change according to the responses.

The ratio of detached houses to apartment buildings as per the SCS is shown in Table 29.

Table 29: Ratio of detached houses to apartment buildings as per the SCS

Type	Ratio
Apartment buildings	21.5%
Detached houses	77.9%
Others	0.6%

Source: https://stat.uz/en/official-statistics/

Based on the above information, the number of detached houses was estimated to be 139,068.

Statistical data from the SCS indicates that the number of dwellings, total number of apartment buildings and detached houses, is approximately 6.5 million.

Table 30: Number of dwellings by region

Number of residential apartments (houses) by region

(at the end of the year, units)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Republic of Uzbekistan	**5,512,030**	**5,571,042**	**5,629,349**	**5,718,187**	**5,804,059**	**5,796,860**	**5,940,490**	**5,924,275**	**6,074,552**	**6,337,713**	**6,589,931**
Republic of Karakalpakstan	258,964	265,821	266,771	269,288	285,727	288,548	298,813	326,867	326,634	364,400	366,942
regions:											
Andijan	498,989	503,525	509,296	514,483	527,222	534,234	542,539	550,287	555,982	563,342	571,670
Bukhara	299,942	302,017	302,343	302,738	314,784	319,911	324,635	339,121	378,245	410,614	428,548
Jizzakh	185,984	188,582	191,155	194,281	197,188	200,062	202,898	205,545	208,310	213,606	220,102
Kashkadarya	407,804	416,719	420,928	438,874	442,239	481,113	511,314	549,308	574,959	604,882	671,233
Navoi	170,292	171,509	173,782	174,943	176,213	178,449	182,966	198,145	204,511	212,876	217,414
Namangan	508,740	522,295	533,248	550,389	561,731	569,265	585,375	444,622	453,230	485,482	513,433
Samarkand	524,236	529,945	536,034	542,806	550,744	558,687	570,333	590,401	600,570	612,346	623,448
Surkhandarya	359,555	372,518	373,461	375,692	377,893	380,641	383,288	413,149	424,810	437,818	447,955
Syrdarya	148,741	147,129	152,986	154,612	156,785	157,830	152,050	151,957	154,753	158,712	160,173
Tashkent	557,810	552,334	557,401	577,233	580,959	586,158	594,317	604,886	610,015	617,483	687,295
Fergana	666,120	666,355	669,156	670,800	674,951	689,824	701,454	642,560	650,201	654,955	660,266
Khorezm	261,337	263,508	267,427	271,102	271,867	273,449	307,082	318,402	328,268	363,279	368,437
Tashkent city	663,516	668,785	675,361	680,946	685,756	578,689	583,426	589,025	604,064	637,918	653,015

Information of the Cadastral Agency under the State Tax Committee of the Republic of Uzbekistan

Source: https://stat.uz/en/official-statistics/

This figure is considered reasonable given that the total population of Uzbekistan is approximately 35 million, and the average household size is 5 persons.

It is estimated that the average number of households in one apartment building is approximately 170, based on the above ratios of apartment buildings to detached houses and the total number of dwellings in Uzbekistan. The number of each dwelling was estimated, as shown in Table 31.

Table 31: Estimated number of dwellings

	Number of buildings	Number of residences
Houses	139,068	139,068
Apartments	38,382	6,486,558
District Heating	15,120	2,555,280
Individual Heating	5,588	944,372
Others	17,674	2,986,906

Source: JICA study team

4.3. Confirmation of the Required Heat Value Obtained from the House Frame Performance

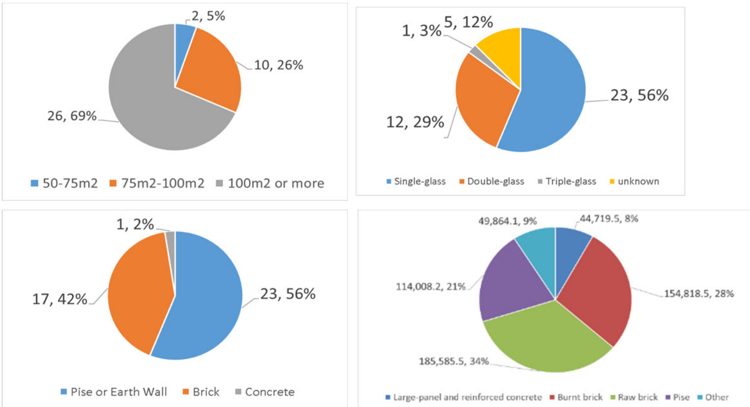
The conditions of the detached houses were set, as shown in Table 32, based on information from the SCS and a questionnaire survey with the households. For the apartment buildings, the same conditions as in section 3.1.1 were set in this report. The technical study methods are also the same as those in section 3.1.1.3.1.1

Table 32: Conditions of detached houses

total floor space	125m2 (10m x 12.5m)
Wall Height	3m
wall area	135m2 (wall area excluding window area: 108m2)
window area	27m2 (approx. 20% of wall area)
Wall thickness	200mm
Roof area	144m2 (total floor area x 1.15)
Specification of walls	Slab and mud wall (heat transfer coefficient: 0.7)
Specification of windows	Single-glass (heat transfer coefficient: 6.4)
room temperature	25°C* (77°F)

*The results of the ENQ survey of households indicated that the room temperature was 24.6°C in winter. Here, the temperature is set to 25°C, the same as the conditions in the apartment buildings.

Source: JICA study team



Source: https://stat.uz/en/official-statistics/

Figure 10: Results of questionnaire survey on the conditions of detached houses

Source: Photo by the JICA study team

Figure 11: Exterior of detached houses

Table 33: Specification of walls for the houses

	Thickness（m）	Thermal Conductivity (W/mK)	Heat Transfer Resistance (m2K/W)
Pise or Earth Wall	0.2	0.7	0.29
Plaster board	0.02	1.6	0.01
Mortar	0.02	1.6	0.01
Thermal Transmittance（W/m2K）			2.15

Source: JICA study team

The specifications of the walls were assumed, as shown in Table 34.

Table 34: Specifications of walls1

	2020				
	Large-panel and reinforced concrete	Burnt brick	Raw brick	Pise	Other
Republic of Uzbekistan	**44,719.5**	**154,818.5**	**185,585.5**	**114,008.2**	**49,864.1**

Source: JICA study team

No data was available for the roof specifications. The U-value was set to 3, determined from the exterior. For walls, roofs, and windows, each U-value was obtained based on the typical indoor and outdoor thermal resistance values, such as climatic conditions and the internal heat generation from human bodies and electrical equipment. For other conditions, the same values as for apartment buildings are applied.

From the above, the heat balance in winter per detached house was 52.4 MWh and per apartment building was 785 MWh.

1 house: total heat balance including walls, windows, and roof - heat generated by human bodies - heat generated by electrical equipment = 52.4 MWh/winter

1 building: Total heat balance including walls, windows, and roof - Heat generated by human bodies - Heat generated by electrical equipment = 785 MWh/winter

Table 35: Heat balance for detached houses

House

Room Temp°C 25

Season	Month	Outside Temp °C	Diff of Room Tems °C	Window Area m2	Thermal Transmittance W/m2K	Heat Balance MWh/month
Winter	Nov	8.8	16.2	108	2.1	2.7
	Dec	4.1	20.9			3.5
	Jan	1.4	23.6			3.9
	Feb	3.2	21.8			3.6
	Mar	9.3	15.7			2.6
	Apr	15.9	9.1			1.5
	Sum					17.9

Season	Month	Outside Temp °C	Diff of Room Tems °C	Window Area m2	Thermal Transmittance W/m2K	Heat Balance MWh/month
Winter	Nov	8.8	16.2	27	3.2	1.0
	Dec	4.1	20.9			1.3
	Jan	1.4	23.6			1.5
	Feb	3.2	21.8			1.4
	Mar	9.3	15.7			1.0
	Apr	15.9	9.1			0.6
	Sum					6.7

Season	Month	Outside Temp °C	Diff of Room Tems °C	Window Area m2	Thermal Transmittance W/m2K	Heat Balance MWh/month
Winter	Nov	8.8	16.2	144	3	5.0
	Dec	4.1	20.9			6.5
	Jan	1.4	23.6			7.3
	Feb	3.2	21.8			6.8
	Mar	9.3	15.7			4.9
	Apr	15.9	9.1			2.8
	Sum					33.4

Winter	Household	Homr rate	Easy Work (W/h)	Days	Hours	Calorific Value/house
House	5	60%	116	180	24	1.5

Winter	Calorific Value (MWh/Year・households)	Period (180days/year)	Calorific Value
Electric Appliances	8.3	0.5	4.2

Heat Balance	52.4

Source: JICA study team

Table 36: Heat balance for apartment buildings

Apartment

Room temp°C 25

Season	month	Outside Temp °C	Diff of Room °C	Wall Area m2	Therman Transmittance W/m2K	Heat balance MWh/month
Winter	11	8.8	16.2	6,000	2.1	145.0
	12	4.1	20.9			187.1
	1	1.4	23.6			211.2
	2	3.2	21.8			195.1
	3	9.3	15.7			140.5
	4	15.9	9.1			81.4
	Sum					960.3

Season	month	Outside Temp °C	Diff of Room °C	Window Area m2	Therman Transmittance W/m2K	Heat balance MWh/month
Winter	11	8.8	16.2	1,800	3.2	67.5
	12	4.1	20.9			87.1
	1	1.4	23.6			98.4
	2	3.2	21.8			90.9
	3	9.3	15.7			65.5
	4	15.9	9.1			37.9
	Sum					447.4

Season	month	Outside Temp °C	Diff of Room °C	Roof Area m2	Therman Transmittance W/m2K	Heat balance MWh/month
Winter	11	8.8	16.2	1,500	2.92	51.1
	12	4.1	20.9			65.9
	1	1.4	23.6			74.4
	2	3.2	21.8			68.7
	3	9.3	15.7			49.5
	4	15.9	9.1			28.7
	Sum					338.4

Winter	Calorific value/household	Number of households	Calorific value/apartment
	1.5	170	255.6

Winter	Calorific value/household	Number of households	Calorific value/apartment
Electric appliance	4.2	170	705.5

Heat balance	785.0

Source: JICA study team

4.4. Comparison of the energy used in the household sector in IEA data with the heat requirements determined from the frame performance of a detached house and an apartment building (when the apartment building is not supplied from the district heat supply)

A usage ratio of natural gas for hot water for heating was assumed (35%). The theoretical value of 96,898 was lower than the actual value of 130,288. Although further analysis is required to determine the reason, detached houses may have less airtight performance than buildings. However, apartment buildings are subject to reductions, even though excess energy may be stored and functioned.

Table 37: Energy data used in the household sector (detached houses)

Theoretical Value

	Number of buildings	Number of residences	Heat balance (MWh/number of buildings)		Heat balance (GWh/winter)	Heat balance (TJ/winter)	Heat balance (TJ/winter)	Amount of Natural gas 94.9%
			House	Apartment				
House	139,068	139,068	52.4		7,282	26,215	26,215	
Apartment	38,382	6,486,558		785.0	30,131	108,471		
District heating	15,120	2,555,280			11,870	42,730		
Individual heatir	5,588	944,372			4,387	15,792	15,792	
Others	17,674	2,986,906			13,875	49,948	49,948	
sum except for apartment supplied by district heating							91,956	96,898

Actual Value（IEA2018）

Residential Sector	ktoe	TJ	Ratio of hot water 35%
Natural gas	8002	372,252	130,288

Source: Prepared by the JICA research team based on IEA 2018 data.

4.5. Comparison of the heat energy used in the household sector in IEA data with the heat requirements determined from the frame performance of apartment buildings (Note: Only apartment buildings with supply from district heat supply)

The comparative overview is shown in Table 38. The efficiency of the district heat supply was considered at 57.6%, assuming the usage ratio of hot water for heating provided by the district heat supply was 55%. The results were similar to those obtained for detached houses and apartment buildings without district heat supply.

Table 38: Energy data used in the household sector (apartment buildings)

Theoretical Value

	Number of buildings	Number of residences	Heat balance (MWh/number of buildings)		Heat balance (GWh/winter)	Heat balance (TJ/winter)	Heat balance (TJ/winter)	Amount of Natural gas 94.9%
			House	Apartment				
House	139,068	139,068	52.4		7,282	26,215		
Apartment	38,382	6,486,558		785.0	30,131	108,471		
District heating	15,120	2,555,280			11,870	42,730	42,730	
Individual heatir	5,588	944,372			4,387	15,792		
Others	17,674	2,986,906			13,875	49,948		
sum supplied by district heating							42,730	45,027

Actual Value（IEA2018）

Residential Sector	ktoe	TJ	Ratio of hot water 55%	Amount of Natural gas 57.6%
Hot water	1079	45167.2	24,842	43,128

Source: prepared by JICA research team based on IEA 2018 data.

4.6. Recommended measures for detached houses and apartment buildings

Based on the previous analysis, it is recommended to improve general energy conservation measures for detached houses and apartment buildings, as shown in Table 39. The conditions after the implementation of the measures were set to the same values as those in the section of apartment buildings.

Table 39: Proposed energy conservation measures in detached houses and apartment buildings

Subject	Plan of countermeasure
room temperature	From 25°C to 24°C
window	Single-glass → Double-glass (U-value: From 3.2 to 1.5)
Detached house (roof)	Reinforced insulation (U-value: From 3 to 0.4) Same as for apartment buildings
Detached house (wall)	Reinforcement of heat insulation (U-value: From 3.4 to 0.5)

Apartment Buildings (roof)	Reinforcement of heat insulation (U-value: From 2.9 to 0.4)
Apartment Buildings (wall)	Reinforcement of heat insulation (U-value: From 2.1 → to 0.5)

Source: JICA study team

The estimate was based on a measure implementation rate of 20 %. The effectiveness of the energy conservation measures is shown in Tables 40 and 41.

Table 40: Effectiveness of energy conservation measures in detached houses and apartment buildings (excluding heat supply stations)

(Unit：TJ)

Value	Ratio of measure	No measure implemented	Room tmp	Windows	Insulation(House)		Insulation(Apartment)		Measure Implemented	Amount of reduction
			25→24°C	single→double	Roof	Wall	Roof	Wall		
Theorical	20%	96,898	94,274	95,910	93,013	94,582	91,018	84,173	74,731	22,166
	Countermeasure effect		97%	99%	96%	98%	94%	87%	77%	23%
Actual	130,288		126,761	128,960	125,065	127,174	122,383	113,178	100,483	29,805

Source: JICA study team

Table 41: Effectiveness of energy conservation measures in apartment buildings (only with district heat supply)

(Unit: TJ)

Value	Ratio of measure	No measure implemented	Room tmp	Windows	Insulation(Apartment)		Measure Implemented	Amount of reduction
			25→24°C	single→double	Roof	Wall		
Theorical	20%	45,027	43,505	44,568	41,389	36,939	30,802	14,225
	Countermeasure effect		97%	99%	92%	82%	68%	32%
Actual	43,128		41,670	42,689	39,644	35,381	29,503	13,625

Source: JICA study team

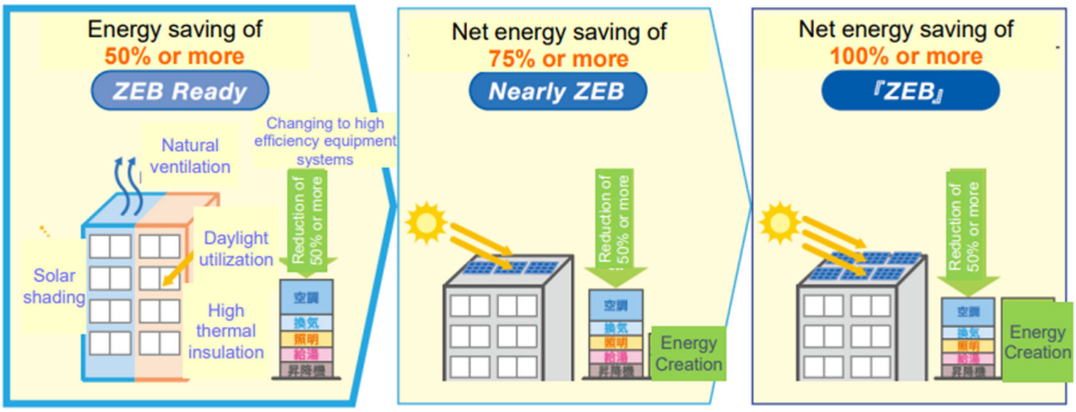
From the above, it was found that optimizing the room temperature setting and strengthening the building frame performance serve as energy conservation measures: It is recommended to improve the heat insulation performance of both detached houses and apartment buildings, as well as to set the indoor temperature setting a bit lower.

Furthermore, the introduction of the Zero Energy Building (ZEB) concept for buildings is recommended as a future improvement measure.

The ZEB concept is defined for complexes as follows.

- "ZEB ready" buildings improve energy conservation performance by over 50%.
- "Nearly ZEB" buildings improve energy conservation performance by over 75%.
- "ZEB" buildings achieve practically zero consumption of fossil-fuel energy by using sustainable energy.

The ZEB concept and green certification are useful design goals for buildings, as they serve as a powerful means to improve energy conservation, especially relevant for those buildings with energy conservation obligations in construction. The details of this study are described in Appendix 7.0



Source: Ministry of Economy, Trade and Industry, Japan

Figure 12: Concept of ZEB

Appendix 5: Field Study for the Efficiency Improvement of the Heat Supply System

1. Purpose of the Survey

In order to understand the situation of district heat supply stations on the supply side, and heat receiving facilities on the demand side, on-site inspections of district heat supply stations, hospitals, elementary and junior high schools, hotels, and apartment buildings in Tashkent City were conducted, as well as on-site surveys to understand the situation of heat loss.

2. Methods of investigation and review

Visits were made to each site for visual observations and on-site interviews. Based on this, improvement measures are to be proposed.

3. Results of the Study

3.1. District Heat Supply Station

There are 10 district heat supply stations in Tashkent. No. 1–9 are heat supply plants built to the specifications of the former Soviet Union, while No. 10 is the newest CHP. During this site visit, two district heat supply stations, No. 1 and 8, were inspected to confirm the status of thermal efficiency. The results of the survey are described below.

- The hot water supplied by the heat supply stations is mainly used for heating in apartment buildings that have a variable element of district heat supply during the course of the day. Currently, an increasing number of households in apartment buildings have their own water heaters that can supply hot water for water heating and heating at the same time.
- White smoke, containing soot from the high chimney (50–60 m) of a natural gas-fired district heat supply plant, was observed on the day of the field survey (Figure 13), indicating that the plant may be emitting slightly more air than the theoretical air volume to avoid incomplete combustion or incomplete combustion in the boiler.Figure 13: Piping and insulation installation at a district heat supply plant
- Based on a control command from the city of Tashkent, the district heat supply station adjusts both the quantity and the temperature of hot water depending on the outdoor air temperature. Hot water supply pumps generally had 630 kW (with flow rate throttling control).
- At district heat supply plants, 5–15% of hot water (PW: Process Water) is consumed in-house to preheat boiler feed water (SW: Supply Water). The efficiency of the district heat supply plant of approximately 90%, relying on the amount of PW consumed on

site, is understandable.

Tashkent City No. 1 combustion air supply fan and gas piping at district heat supply station (Emissions other than water vapor.) The reality of the

the upper illustrationTashkent City No8Insulation of return water piping at district heat supply plant
Lower diagram Insulation of heat-receiving equipment in an apartment buildings Polyethylene-coated aluminum tube(white)

Tashkent City No. 1 combustion air supply fan and gas piping at district heat supply station

Tashkent City No. 1 combustion air supply fan and gas piping at district heat supply station

Source: Photo by the during JICA study team

Figure 13: Piping and insulation installation at a district heat supply plant

Tashkent City No. 8 hot water supply pumps and electric motors for district heat supply plants

Tashkent City No. 8 hot water supply pumps and electric motors for district heat supply plants

Source: Photo by the JICA study team

Figure 14: Hot water supply pumps at district heat supply station

3.2. Heat Receiving System at a Hospital Attached to the MoE

The situation is as follows.

- The heating is provided by receiving hot water from the Tashkent District Heat Supply Station.
- Patient rooms are equipped with air conditioners dedicated to cooling for patients.
- Hospitals are prohibited from using gas for safety reasons.
- The glass windows in the administrative area on the first floor were retrofitted with double glass, while those in the ward area are fitted with single glass.
- Solar hot water panels were installed on the roof of the 4th floor 3-4 years ago for use in water heating. However, they are no longer in use owing to the corrosion of the equipment and piping.
- Radiators that use hot water from the district heat supply are not temperature-controlled, and the room temperature is adjusted by introducing outside air.
- Two power lines are used as power sources to prepare for voltage fluctuations, momentary power outages, and blackouts.
- The temperature of the incoming and outgoing hot water is 60°C and 40°C, respectively. The simple insulation of the incoming hot water pipes reduced the surface temperature from 60°C to 45°C, showing the effectiveness of the insulation.
- Five years ago, a thermometer and flow meter were installed by the district heat supply office in the piping of the hot water receiving system in the first-floor machine room. The measured heat value is metered by Tashkent city officials, enabling the billing of hot water. The temperature measuring instruments are calibrated and maintained annually by the district heat supply office.

Challenges include the need for an independent hot water supply system; the temperature control and reduction of outside air introduction loss by providing flow control functions for radiators; the strengthening of the insulation of district heat supply hot water piping; and the replacement of single-glass windows in hospital rooms with double glass.

Source: Photo by the JICA study team

Figure 15: Hospital calorimetry (thermometer), calorimetry meter, and simple insulation

3.3. Hot Water Receiving Facilities for Tashkent Municipality No. 110 primary and secondary schools

The situation is as follows.

- The heat source equipment was upgraded in 2020. Underfloor heating was installed in the hallways, and double glass was installed in the windows.
- The district heat supply heat source receiving facility in Tashkent is a completely closed system with plate heat exchangers, and all hot water is returned to the district heat supply sections. A calorimeter (Telemote) and expansion tanks are equipped. Incoming temperature is 61°C (red piping), and incoming temperature is 45°C (blue piping). Ten plate heat exchangers have no heat flow-out protection.
- Hot water supply for heating is shut down on weekends, holidays, and vacations; rising utility costs after retrofitting the heat system is the cause.
- Classrooms are warmed by radiators only. No cooling system in summer.
- Ventilation openings on the classroom ceilings provide countermeasures against elevated CO_2 concentrations.
- The classroom temperature is controlled by opening windows and receiving outside air directly.

Challenges include (1) the temperature control and reduction of outside air introduction loss by providing the radiator with a hot water flow control function and (2) insulating the district heat supply hot water piping and the plate heat exchanger piping.

Source: Photo by the JICA study team

Figure 16: Closed system hot water receiving facilities, calorimetric metering equipment, and calorimeters at elementary and junior high schools

3.4. Hot Water Receiving Facility for Tashkent City District Clinic

The situation is as follows.

- Clinics are seen as medical institutions that do not accept surgery or hospitalization.
- Hot water is used for heating and sanitary purposes (hand washing).
- The hot water piping is fully drained and has no return piping to the district heat supply station. A calorimeter is installed. Billing is based on the heat meter readings taken by the Tashkent city officials. Telemonitoring of calorimetry will be implemented in the future.
- In accordance with Presidential Decree 194 (2014), public buildings are required to install heat meters. Each management association can choose whether to install heat meters in apartment buildings; there are no penalties for choosing not to.
- Incoming hot water is 60°C, and outgoing hot water is 40°C.
- The heating device in the reception room is a cast iron radiator with no function to regulate the hot water flow.

Challenges include (1) the temperature control and reduction of outside air introduction loss by providing the radiator with a hot water flow control function and (2) insulating the district heat supply hot water piping and plate heat exchanger piping.

3.5. Hotel Uzbekistan's Hot Water Receiving Facilities

The situation is as follows.

- Built in 1947, it is currently 85% owned by the government. There is a plan for its renovation.
- Hot water is received from a district heat supply plant, and a completely closed system of serpentine heat exchangers is adopted. To supply hot water to 17F, the original

pressure of 0.6 MPa-G is boosted to 0.8 MPa-G by a vertical pump. Use of unit number control.

- All bath and shower hot water is drained.
- Electric water heaters are used heat water, as the use of gas is prohibited for safety control purposes.
- The heating and cooling systems in the guest rooms are equipped with 2-pipe fan coil units. High, medium, and low airflow can adjust the room temperature.
- An electric heat pump heat source unit (4 compressors) supplying 140 kW cold water/130 kW hot water is installed on the ground floor as a backup heat source, mainly for use on cold days after the hot water supply period of the district heat supply station. Refrigerant is 410A, and the outdoor unit has a water sprinkler system.

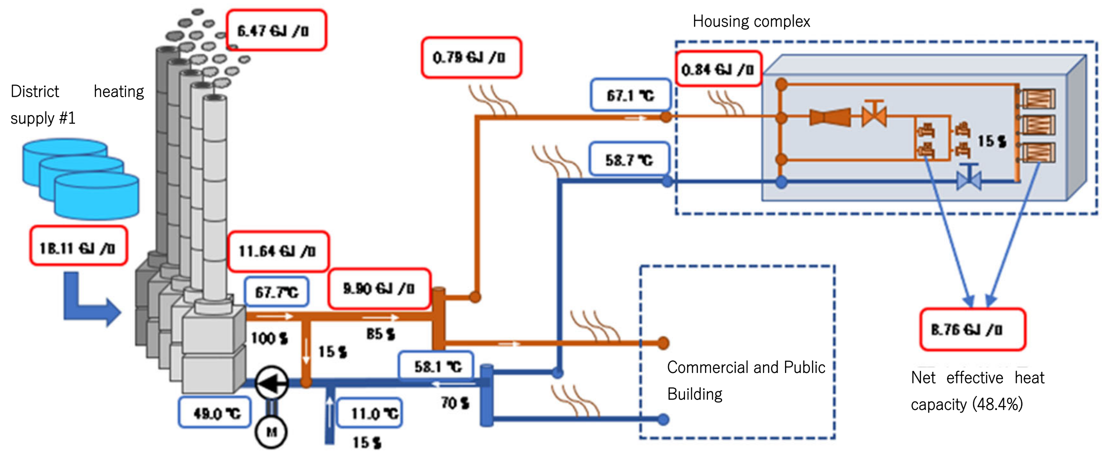
Challenges include upgrading to plate heat exchangers, changing from unit number control to inverter control, changing from electric to electromagnetic cookers, installing sunshade louvers, and periodically cleaning condenser fins.

Source: Photo by the JICA study team

Figure 17: Hotel hot water receiving system, pressure booster pumps, and fan coil unit

4. Overall Energy Efficiency Analysis of the Heat Supply System Based on the Survey Results

Based on a survey of heat supply stations, acquired data provided, field sample surveys of apartment complex piping systems and hot water temperatures, the following findings were obtained as the overall energy efficiency of the heat supply system. The heat flow from the heat supply station to the apartment buildings is shown in Figure 18.



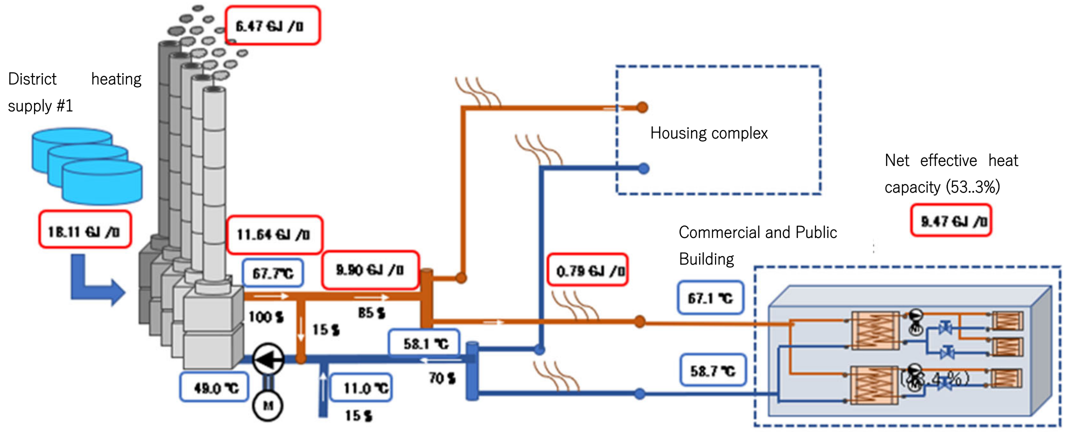
Source: JICA study team

Figure 18: Heat flow from the heat supply station to apartment complexes

The results of the energy flow analysis revealed the following points.

- The efficiency of the boiler at the heat supply station (#1) is 64.3% (according to data from the heat supply station), but the supply water (11° C) consumed in the hot water supply is preheated using heated water, which consumes about 15% of the heat. This is because the replenishment water consumed by the hot water supply is as low as 11° C, which exceeds the boiler's heating capacity.
- The furnace at the heat supply station has a chimney as high as 50 m, which makes it difficult to maintain high pressure inside the furnace barrel, and the water tubes inside the furnace barrel are iron tubes, which are poor heat conductors. As a result, 30% of the waste heat from the chimney is lost owing to high waste heat temperatures of 200° C or higher.
- The main pipes (diameter 500) from the heat supply station are properly insulated, but the branch pipes (diameter 120) occasionally have bare sections, and excluding some exceptions inside the house, the bare iron pipes have little heat insulation. This results in high heat dissipation to the atmosphere owing to heat transfer.

The effective heat rate in the house is 48.4%, which is considered a low-efficiency heat supply system. The heat flow to commercial and public buildings with heat exchangers, such as schools and hotels, is shown in Figure 19.



Source: JICA study team

Figure 19: Heat flow from the heat supply station to schools and hotels with heat exchangers

The heat supply system of schools with heat exchangers is the same as that of apartment buildings up to the building entrance; at the building entrance, the heat is exchanged by a heat exchanger, and a circulation pump is used inside the building to create a building-specific supply system. Therefore, when heat loss in the heat-receiving part is excluded, the efficiency is evaluated to be 53.3% in terms of primary energy, which is a 5% increase in efficiency compared to that of the apartment buildings.

5. Improvement Plan

5.1. District Heat Supply Station

5.1.1. Construction and Operation of District Heat Supply Plants

As shown in the survey results, an increasing number of households are equipped with their own water heaters that can supply hot water for hot water uses and heating at the same time. As a future policy, it is recommended to (1) plan the construction of district heat supply plants only in areas that satisfy the location conditions that minimize the daily fluctuations in hot water supply and (2) reduce the efficiency loss of hot water boilers at partial load and the heat loss from the long pipelines. It is recommended that the fuel consumption of hot water boilers be reduced by minimizing the heat loss from long-distance hot water supply and return piping groups. In addition, the district heat supply stations that are limited to relatively small areas and satisfy the location requirements for low daily fluctuations in hot water supply can be operated efficiently for the part-load operations of hot water boilers. By targeting a limited number of districts at the same time, the heat dissipation losses from hot water supply and return piping can be minimized.

For the construction of district heat supply plants, it is important to consider the equalization of heat demand and profitability in the future. Typical examples of the construction of district heat supply plants in Japan and the reasons of their subsequent integration are described below.

While there are solutions to pollution from flue gas from urban heating boilers, such as the combustion control of individual heating boilers and the installation of dust removal devices in flues, it is now understood that district heat supply is a powerful solution to the problem of air pollution. It was adopted by the Tohoku University Faculty of Engineering, which moved to a former military site in Aobayama, Sendai in 1966, and was the first full-scale district heating system to use a nitrogen-pressurized, high-temperature water supply system, with temperatures ranging from 130–180℃. In 1969, Japan's first district heating and cooling system was constructed in Senri New Town, Osaka. Subsequently, district heating and cooling systems were constructed for the Osaka Expo site, Shinjuku city center and department stores, Narita Airport and Narita New Town, and the city hall and public apartment buildings in Tomakomai, Hokkaido. In June 1972, the Heat Supply Business Law was promulgated. However, the only district heating and cooling facilities being built today are in locations where heat demand can be both equalized and profitable. Only the apartment buildings in the new town and commercial building complexes in the city center have large fluctuations in heat demand during the day and night. This has reduced the operational efficiency of boilers and chillers, resulting in higher costs for heating and cooling, and has led to a situation where independent profitability cannot be improved, leading to a situation in which investors are displaced. District cooling and heating stations are currently operating for complex groups of facilities where heat demand is relatively constant between day and night, regardless of the seasons, such as commercial building groups and large hospitals, and commercial building groups and entertainment facilities.

The following data are assumed to be necessary for effectiveness verification.

- Future demographic projections
- Hot water demand for district heat supply in summer, mid-season, and winter
- Efficiency of candidate heat source equipment for hot water supply, etc.

5.1.2. Control of Proper Air Ratio

As indicated in the survey results, it was considered possible that incomplete combustion or blower air, above the theoretical air volume, was occurring at the district heat supply station. The minimum amount of air required for the complete combustion of fuel is the theoretical air volume. In actual combustion, it is impossible to utilize all the oxygen in the supplied air. When only the theoretical air volume is supplied, fluctuations in the combustion environment caused by the pressure in the water-tube hot water boiler (furnace pressure), among other factors, cause incomplete combustion. Based on the component analysis data of combustion exhaust gas measured in the chimney, boiler operation and management standards regarding the optimum air ratio can be established and operated to implement rational boiler operation and maintenance.

The ratio of the actual air supply to the theoretical air volume is called the air ratio. The appropriate air ratio depends on the type of fuel and the shape of the combustion chamber. The combustion products in the flue gas depends on the chemical composition of the fuel, nitrogen, and excess oxygen not used for combustion. As the excess oxygen concentration in the combustion exhaust gas is independent of the fuel type, the current combustion state can be evaluated by measuring the oxygen concentration in the combustion exhaust gas in the chimney in comparison with the reference value for the air ratio. Furthermore, the air ratio is higher when excess oxygen is high. Water-tube hot water boilers burning at high air ratios heat and exhaust excess air due to high air supply, resulting in higher fuel consumption than necessary. This causes the combustion efficiency of the boiler to decrease. Maintaining the proper air ratio leads to proper fuel consumption, thus reducing the boiler's fuel consumption.

The Law Concerning the Rational Use of Energy (Energy Conservation Law), regulated by Japan's Ministry of the Environment, sets standard and target values for air ratios that vary by fuel type and combustion chamber shape. The air ratio is controlled by measuring the oxygen concentration in the combustion exhaust gas, adjusting the combustion air supply to the appropriate level, and cleaning the burner chips. Although there are no penalties for proper air ratio control, it is recommended that energy managers maintain air ratio standards and targets to ensure economically optimum boiler operation.

Table 42: Standard/target values for air ratio specified in Japan's Energy Conservation Law

Upper: Standard value / Lower: Target value

classification		liquid fuel		gaseous fuel	
		continuous expression	intermittent (intermittence)	continuous expression	intermittent expression
boiler	≧30ton/h	1.10 - 1.25 / 1.05 - 1.15		1.10 - 1.20 / 1.05 - 1.15	
	≧10ton/h	1.15 - 1.30 / 1.15 - 1.25		1.15 - 1.30 / 1.15 - 1.25	
	≧5ton/h	1.20-1.30 / 1.15-1.30		1.20-1.30 / 1.15-1.25	
	＜5ton/h	1.20-1.30 / 1.15-1.30		1.20-1.30 / 1.15-1.25	
Metal melting furnace		1.30/1.05-1.25	1.40/1.05-1.30	1.25/1.05-1.20	1.35/1.05-1.25
Metal heating furnaces		1.25/1.05-1.20	1.35/-	1.25/1.05-1.20	1.35/-
Metal heat treatment furnace		1.25/1.05-1.20	1.30/1.05-1.30	1.20/1.05-1.15	1.25/1.05-1.25

Cement firing furnace	1.30/1.05-1.25	1.30/-	1.30/1.05-1.25	1.30/1.05-1.25

Source: Prepared by the JICA study team based on the criteria for judgment by business operators regarding the rationalization of energy use in factories, etc. (Agency for Natural Resources and Energy).

The following data are expected to be required for effectiveness verification.

- Data on fuel consumption at district heat supply plants under current conditions and after improvements
- Analysis data of the combustion exhaust gas components of the boiler in summer, mid-season, and winter, etc. Both present data and those after improvement.

5.1.3. Control of Heat Supply Linked with Outdoor Air Temperature

The amount of heat supplied can be evaluated as the product of the hot water supply and the temperature difference between the hot water inlet and outlet. When the temperature difference between the inlet and outlet of the supplied hot water is increased by 10%, natural gas consumption increases by a factor of 1.38 (=1.1/0.8) when the water-tube hot water boiler efficiency is 80%. If the temperature difference between the inlet and outlet of the supplied hot water is increased by 10%, the amount of heat loss from the outer surface of the supply piping will also increase by 10%, requiring an additional 1.1 times the fuel consumption to cover the amount of heat loss. The resulting fuel consumption would increase by a factor of 1.50 (= 1.2/0.8). However, when the hot water supply is increased by 10%, the velocity of flow in the supply and return piping also increases by 10%, but the turbulent heat transfer coefficient in the supply and return piping is proportional to the Reynolds number to the 0.8th power, so the heat transfer rate increases 1.08 times. Therefore, the amount of heat dissipation loss from the outer surface of the supply and return piping is only 1.08 times greater. Similarly, if the boiler efficiency is 80%, the fuel consumption to cover the heat release is 1.35 times (=1.08/0.8).

Based on this theory, eliminating the adjustment of the supplied hot water temperature according to the day's outdoor air temperature, which is based on a control command from the city of Tashkent, would reduce the increase in fuel consumption and heat loss from the outer surface of the supply and return pipes, which depends on the temperature difference between the inlet and outlet of the supplied hot water, and achieve energy savings of approximately 15% (=1.50 - 1.35).

However, the actual facility uses a flow throttling control of approximately 630 kW compared to a shaft power of 400 kW (assuming a water pump efficiency of 60%), resulting in not only an excessive facility capacity but also a situation in which no variable water flow rate is employed.

Therefore, it is recommended that the current method of adjusting the amount of supplied heat in response to outdoor air temperature is to adjust only the amount of hot water supply.

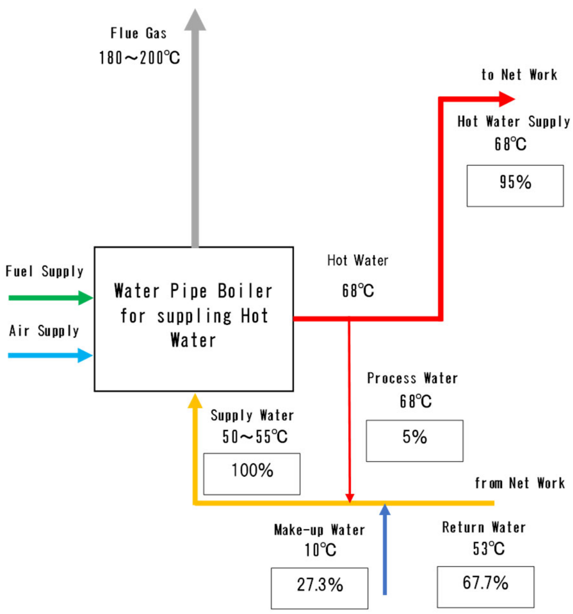
The data needed to verify the effectiveness of the program are expected to include the following.

- Data on fuel consumption, etc. at the current and improved district heat supply stations

5.1.4. Installation of Economizer

When the natural gas, from which sulfur components have been removed, is used as fuel in a boiler, the flue gas does not contain sulfur oxides, so there is no need to maintain the flue gas above 180° C, that is, the acid dew point for sulfur oxides. Therefore, the heat recovery from a combustion exhaust gas temperature of 120° C in the chimney can reduce the self-consumption rate by 5–15%, that is, fuel consumption can be reduced.

A typical material balance at a district heat supply plant is shown in Figure 20. Depending on the economically optimal capacity design of the heat recovery heat exchanger (economizer), if the heat released from the stack to the atmosphere can be recovered to heat the make-up water after chemical treatment, which serves as boiler feed water, to 55° C, there will be no on-site consumption in the district heat supply plant. Table 43 shows the boiler feed water temperatures that could be expected with the introduction of the economizer if the objective is to reduce fuel consumption to produce Process Water equivalent to 5–15% of the current on-site consumption. By heating chemically treated make-up water to 48° C, Process Water consumption is reduced to 5%.Table 43: Boiler feed water (SW) temperatures calculated from typical mass balance



Mass & Energy Balance of the DH in Tashkent

Source: JICA study team

Figure 20: Typical material balance diagram for a district heat supply plant operated by the city of Tashkent

Table 43: Boiler feed water (SW) temperatures calculated from typical mass balance

Name	°C	%	°C
RW	50	55	27.50
MW	15	30	4.50
PW	130	5	6.50
SW			38.50

55%
30～40%
5～15%

Name	°C	%	°C
RW	50	55	27.50
MW	15	40	6.00
PW	130	15	19.50
SW			53.00

Name	°C	%	°C
RW	50	55	27.50
MW	15	40	6.00
PW	130	15	19.50
SW			53.00

Name	°C	%	°C
RW	42	55	23.10
MW	5	30	1.50
PW	80	5	4.00
SW			28.60

55%
30～40%
5～15%

Name	°C	%	°C
RW	42	55	23.10
MW	5	40	2.00
PW	80	15	12.00
SW			37.10

Name	°C	%	°C
RW	50	55	27.50
MW	32	40	12.80
PW	130	10	13.00
SW			53.30

Name	°C	%	°C
RW	50	55	27.50
MW	15	30	4.50
PW	80	5	4.00
SW			36.00

55%
30～40%
5～15%

Name	°C	%	°C
RW	50	55	27.50
MW	15	40	6.00
PW	80	15	12.00
SW			45.50

Name	°C	%	°C
RW	50	55	27.50
MW	48	40	19.20
PW	130	5	6.50
SW			53.20

Name	°C	%	°C
RW	50	55	27.50
MW	5	30	1.50
PW	130	5	6.50
SW			35.50

55%
30～40%
5～15%

Name	°C	%	°C
RW	50	55	27.50
MW	5	40	2.00
PW	130	15	19.50
SW			49.00

Name	°C	%	°C
RW	50	55	27.50
MW	60	40	24.00
PW	130	0	0.00
SW			51.50

Source: JICA study team

In addition, the following data will need to be collected to verify the effectiveness of the project.

- Data on the current fuel consumption and fuel consumption after improvements
- Analysis data on the components of boiler flue gas in summer, mid-season, and winter, as well as the components of boiler flue gas, both present data and those after the introduction of the system.
- Material and energy balance data regarding the boiler, including flue, etc.

By installing a heat exchanger (economizer) that recovers all heat, including latent heat up to 60°C from combustion exhaust gas below 150°C, and preheating chemically treated make-up water to at least 48°C, the amount of heat consumed by the district heat supply plant to preheat make-up water can be reduced. The following is an economizer design methodology, albeit on a different scale, for reference.

Purpose Recover unused combustion exhaust gas sensible and latent heat (total heat) from district heat supply plants to heat make-up water. Composition of equipment Heat recovery heat exchanger that recovers all heat from unused 120–150°C combustion exhaust gas to heat make-up water to 60°C, and associated piping.

Temperature (°C) and mass flow rate (kg/min) of combustion exhaust gas

Composition of combustion exhaust gas

Composition of standard flue gas; the composition of natural gas combustion; and the percentage composition of oxygen, carbon dioxide, nitrogen, and water vapor.

Thermophysical properties of combustion exhaust gas

Constant pressure specific heat kJ/(kg-K), density (kg/m3) and mass flow rate of steam and water in flue gas (kg/min), mass flow rate of dried flue gas (kg/min), and air ratio calculated from the composition of the standard flue gas of natural gas

Condensation and latent heat of combustion exhaust gas

Condensation curve of flue gas and latent heat to be recovered (kJ/s), calculated from the composition of standard flue gas of natural gas

Design specifications of the total heat recovery heat exchangers (Economizers)

Material of heat exchanger (SUS301)

Make-up water inlet/outlet temperature, mass flow rate, specific heat at constant pressure, density, heat exchanged (sensible heat), and pressure loss

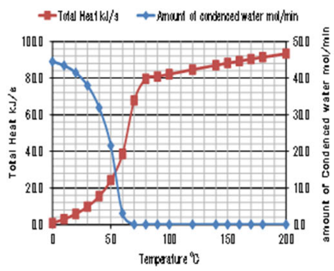
Inlet and outlet temperature and mass flow rate of flue gas, specific heat at constant pressure, density, heat exchanged (sensible + latent heat), and pressure loss

A separate case study, in which the condensation and latent heat of combustion exhaust gases were calculated, is shown in Figure 21.

Amount of condensed water and recovered latent heat calculated from the components of the flue gas

temp. °C	vaper-press. MPa	latent heat kJ/kg	vaper kJ/kg	water kJ/kg	vaper mol/min	condensed mol/min	vaper・water mol/min	flue gas mol/min	vaper KJ/s	water kJ/s	gas kJ/s	total kJ/s
0	0.00061	2,501	2,501	0.00	1.05	44.4861	45.5357	173.259	0.788	0.000	0.0000	0.788
10	0.00123	2,478	2,520	41.99	2.13	43.4061	45.5357	173.259	1.610	0.547	0.8441	3.001
20	0.00234	2,454	2,537	82.60	4.10	41.4388	45.5357	173.259	3.118	1.027	1.6882	5.833
30	0.00424	2,431	2,556	125.40	7.57	37.9670	45.5357	173.259	5.805	1.428	2.5324	9.765
40	0.00738	2,406	2,573	167.20	13.61	31.9214	45.5357	173.259	10.510	1.601	3.3765	15.487
50	0.01233	2,383	2,592	209.00	24.01	21.5244	45.5357	173.259	18.671	1.350	4.2206	24.241
60	0.01995	2,358	2,609	250.80	42.49	3.0463	45.5357	173.259	33.254	0.229	5.0647	38.548
70	0.03166	2,334	2,617	282.60	78.77	0.0000	45.5357	173.259	61.831	0.000	5.9088	67.740
80	0.04741	2,308	2,642	334.40	91.82	0.0000	45.5357	173.259	72.788	0.000	6.7529	79.540
90	0.07011	2,283	2,659	376.20	91.82	0.0000	45.5357	173.259	73.250	0.000	7.5971	80.847
100	0.1014	2,256	2,674	418.00	91.82	0.0000	45.5357	173.259	73.658	0.000	8.4412	82.099
120	0.1978	2,202	2,704	501.80	91.82	0.0000	45.5357	173.259	74.479	0.000	10.1294	84.608
140	0.3615	2,144	2,729	585.20	91.82	0.0000	45.5357	173.259	75.179	0.000	11.8176	86.996
150	0.4761	2,113	2,740	627.00	91.82	0.0000	45.5357	173.259	75.476	0.000	12.6618	88.138
160	0.6181	2,081	2,750	668.80	91.82	0.0000	45.5357	173.259	75.746	0.000	13.5059	89.252
170	0.7921	2,048	2,759	710.60	91.82	0.0000	45.5357	173.259	75.988	0.000	14.3500	90.338
180	1.003	2,013	2,765	752.40	91.82	0.0000	45.5357	173.259	76.176	0.000	15.1941	91.370
200	1.555	1,939	2,775	836.00	91.82	0.0000	45.5357	173.259	76.440	0.000	16.8823	93.322

Condensation curve calculated from the flue gas



Source: Compiled by the Energy Conservation Center

Figure 21: Condensation and latent heat of combustion exhaust gas

5.2. Commercial/Public Buildings

Based on the local desire to install a whole building heating and cooling system, which was identified during the site survey, it is recommended that changing from the conventional centralized heat supply system with heating and hot water to the building's own heat pump heat supply system, which can supply cold and hot water. One advantage of this is the ability to utilize the piping infrastructure of conventional heat supply systems. For new commercial buildings, the introduction of a central air conditioning system can significantly improve efficiency, and for commercial/public buildings, the transition from traditional centralized heat supply systems to building-specific heat systems can significantly improve efficiency.

5.3. Consumer Sector

The results of a comprehensive energy efficiency study of the heat supply system revealed that there are significant losses in the energy supplied from the heat supply station to the homes and buildings where it is ultimately consumed. Therefore, the conversion from a conventional heat supply system to a stand-alone heat system was mentioned to increase the efficiency of thermal energy. Measures to improve the efficiency of heat supply in the consumer sector were proposed as follows.

5.3.1. Conversion from a Semi-Closed System to Completely-Closed System

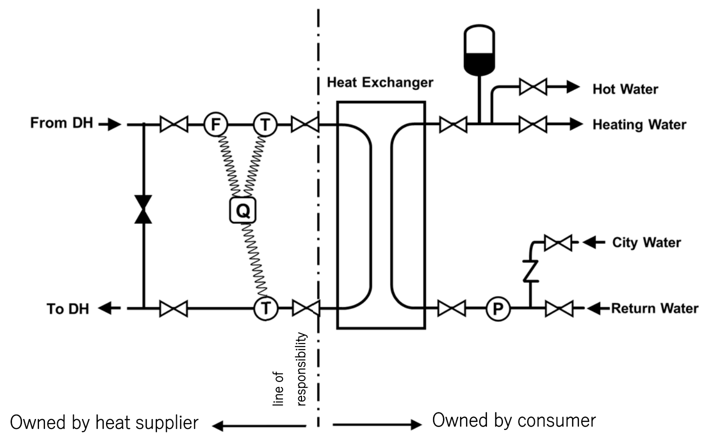
Hot water from the heat supply station is branched into hot water pipes (red) and heating pipes (yellow). As the heating supply is shut off during the summer months, a bypass is added to the heating pipes to return the surplus water to the district heat supply station. As a policy, a planned conversion from a from semi-closed to completely-closed system is currently underway.

Source: Photo by the JICA study team

Figure 22: Hot water piping and return water piping for the heat receiving system in the basement floor of a 9-story apartment building

Currently, the hot water supply from the district heat supply station is directly connected to the heat receiving facilities of the apartment buildings. Independent heat receiving facilities in apartment complexes via heat exchangers allow metering of the amount of hot water heat supplied by the district heat supply station to accurately determine heat demand. It will also lead to a reduction in process losses due to self-consumption, which preheats the low-temperature make-up feed water at 5–15% of the hot water volume produced by the district heat plant. In addition, the adoption of the metering of hot water heat content prevents non-technical losses as a side effect.

Specifically, a heat exchanger can be installed between the hot water supply of the current district heat supply station and the heat receiving facilities of the apartment buildings. The capacity of the heat exchanger depends on the number of households and the average number of persons per household using the target apartment buildings. It is recommended that a calorimeter consisting of a thermometer and a flow meter be installed on the hot water supply side of the district heat supply station to display the measured values and transmit the measured values to the data center at the same time. Based on these individual heat demand quantities, data can be used to determine the amount of heat supplied by the district heat supply station. Suppliers can utilize the data to collect rates based on heat and city water demand by apartment buildings. It is essential to clarify the demarcation point of responsibility for the maintenance of heat exchangers, either on the government side or on the apartment buildings side.



Source: Prepared by the JICA research team

Figure 23: P&I diagram of a completely-closed system for heat receiving equipment in an apartment building

It is assumed that the following data will be needed to verify the effects

- Number of households using the apartment buildings served by the current district heat supply station

- Average number of people per household
- Data on fuel consumption of the district heat supply plant in the current situation and after the improvement, etc.

5.3.2. Adoption of Water-saving Showerheads

In the current semi-closed system, hot water for cooking and showering is not returned from the apartment buildings. To conserve hot water for showers, which is consumed in large quantities, water-saving showerheads are effective. At present, water-saving showerheads are not widely used because they have not been introduced.

The use of water-saving showerheads can reduce the cost of hot water for each household in a mass-consumption apartment building and the amount of hot water supplied by the district heat supply station, that is, the amount of fuel consumed. Advertising the functions and benefits of water-saving showerheads will promote widespread use, and therefore, reduce the amount of hot water consumed by each household, allowing the residents of apartment buildings to enjoy direct cost savings. At the same time, the fuel consumption of the district heat supply plant will be reduced.

Source: Water-saving showerhead catalog

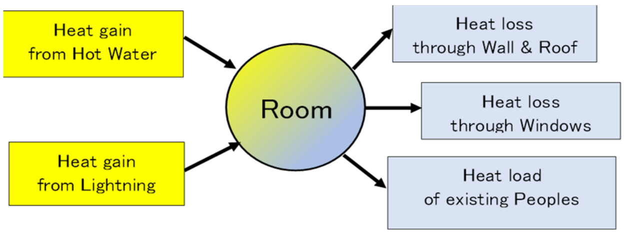
Figure 24: Illustration of water-saving showerhead

The data required to verify the effectiveness of the program include the following.

- Number of households using the apartment buildings served by the current district heat supply station
- Average number of people per household
- Data on fuel consumption of the district heat supply plant in the current situation and after the improvement, etc.

5.3.3. Reduction of Heat for Heating by Utilizing the Heat Storage Effect of the Building Frame

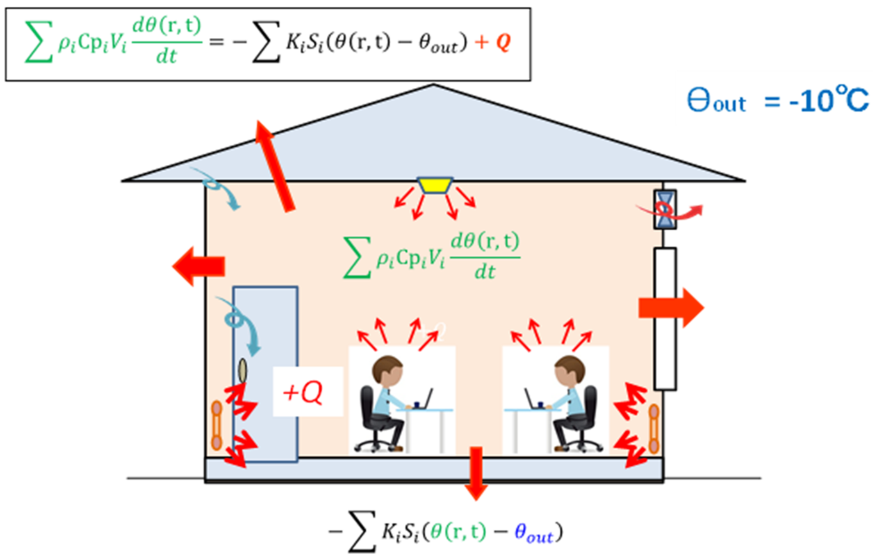
The indoor thermal environment during heating is the amount of heat obtained from the hot water panel heaters and the heat dissipation from the lighting fixtures. The heat gain is determined as the amount of heat that warms the building occupants, fixtures, and building frame and flows through the exterior walls, window glass, and roof surfaces to balance with the amount of heat loss that dissipates to the outside air.



Source: Compiled by the Energy Conservation Center

Figure 25: Heat supply to and emission from a room during heating

When the room is heated on a daily basis, the supplied heat is used for the heating load in the room space and for heat dissipation from the building frame, etc. Room partitions, walls on the corridor side, and floors on the intermediate floors are negligible as heat loads because the building as a whole is maintained at approximately isothermal temperatures. Figure 26 shows the heat storage term for the building and air in the non-steady-state heat transfer equation, the amount of heat dissipated to the outside air through building walls and window glass surfaces, and the amount of heat supplied to the room from the hot water panel heaters.



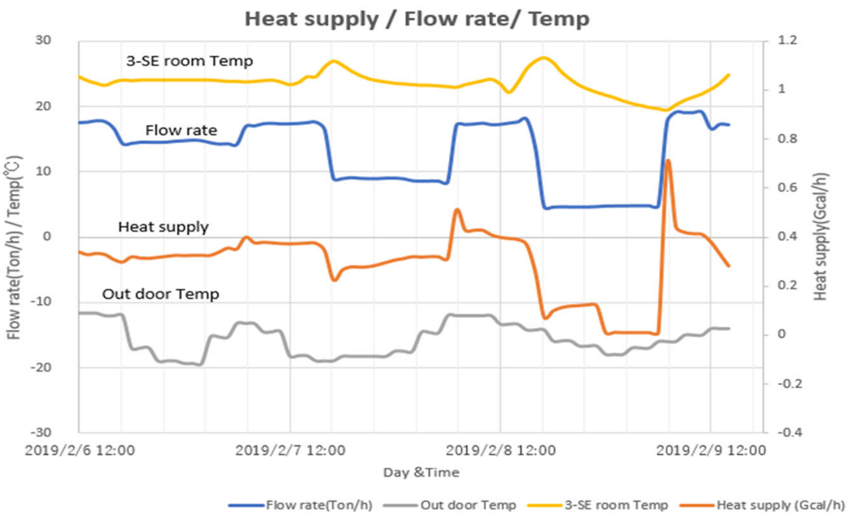
Source: Compiled by the Energy Conservation Center

Figure 26: Differential equations for the numerical analysis of the heat storage effect of the frame, and the physical meaning of each term

The effect due to the heat capacity (ρCpV: density x specific heat at constant pressure x volume) of the exterior walls, which are currently composed of fired brick, concrete, and interior materials, is insensitive in its thermal response to changes in outdoor air temperature and the amount of heat supplied for heating. Depending on the excess or deficiency of the supplied heat, the frame regulates the thermal balance by storing and releasing heat autonomously. The project aims to reduce the fuel consumption of the district heat supply station by reducing the amount of heat supplied for heating by utilizing the autonomous heat storage effect of the building frame, while maintaining the minimum indoor temperature standard for winter among the national standards for the indoor environment.

Figure 27 shows an example of measuring the thermal response characteristics of a building based on changes in the indoor temperature environment over time in response to sudden changes in the amount of heat supplied to the building. An experiment was conducted to reduce the hot water supply starting at 5:00 p.m. and restoring it at 7:00 a.m. the next morning. The actual hot water supply volume was adjusted by closing a dividing valve installed in the inward piping of the hot water receiving facility. The following table shows the temporal trends of indoor temperature as a "response" of indoor temperature to the "stimulus" of adjusting the hot water supply. The temperature in the room on the third floor (orientation: SE), heated with 100% hot water supply, was generally 24.0°C during the daytime, regardless of changes in outdoor air temperature. The room temperature drop was generally less than 1°C when the hot water heat rate was adjusted to 88% and 82% at night. The maximum room temperature drop was 4°C when the hot water heat rate was adjusted to 29%.

It was demonstrated that even if the hot water supply flow rate for heating is reduced during the 12 hours at night, the range of the room temperature drop is small compared to the current set room temperature owing to the heat storage effect of the building frame.



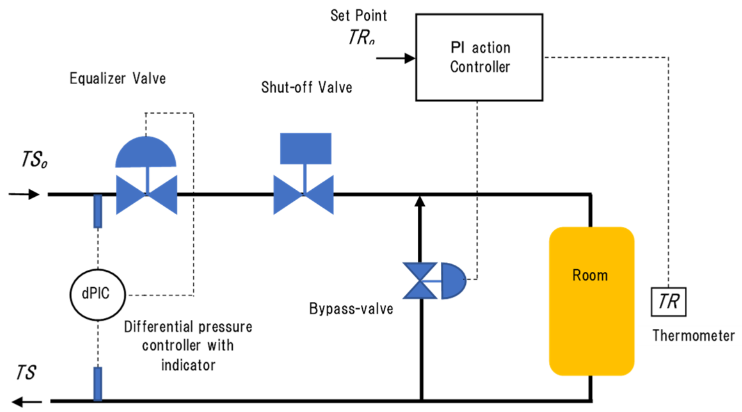
Source: Compiled by the Energy Conservation Center

Figure 27: Heat storage effect of the building frame verified by the indoor temperature change in response to changes in heat supply (flow rate)

A device that automatically controls the flow of hot water for heating, supplied by the district heat supply station, based on the measured values of representative indoor temperatures, can be installed in the heat receiving equipment of each building. The automatic controller consists of an equalizing valve and shutoff valve installed in the hot water supply piping, a bypass valve that returns excess hot water from the return piping to the supply piping, a temperature controller that controls the room temperature, and a thermometer that measures the typical room temperature.

The temperature controller operates to minimize the deviation between the indoor set temperature and the measured indoor temperature. The object of control of the temperature controller is to regulate the supply flow to the heater by adjusting the opening of the bypass valve. The equalization valve operates autonomously to equalize the pressure difference in the piping due to unequal supply and return flow rates by operation by the bypass valve. This automatic controller enables heating at reasonable temperature setpoints in the room, resulting in fuel savings for the district heat plant.

Even if an automatic controller is not installed, an automatic controller can be introduced after verifying the effectiveness of the current hot water flow control valve by manually throttling its opening.



Source: Compiled by the Energy Conservation Center

Figure 28: Automatic controller that adjusts the amount of hot water supplied based on the set room temperature

The data needed to verify these effects are as follows.

- Minimum indoor temperature in winter based on the law and current district heat supply heat supply heat rate and flow rate, indoor temperature of the subject building, and outdoor air temperature
- Heat supply volume of district heat supply, supply flow rate, indoor temperature of the subject building, outdoor air temperature, and data collection in the verification of the thermal storage effect of the building frame.

5.4. Consumption Sector

Improvements in the efficiency of thermal energy in the supply of heat from heat supply plants, and its use, were analyzed and proposed in the previous section. Additionally, from the perspective of the consumption sector, efficiency improvements can be achieved by obtaining heat through electricity. This section investigates this point and suggests improvements.

5.4.1. Efficiency Improvement by Electrification from Natural gas

Currently, 10 kV trunk transmission lines are buried underground and transformed to 400 VAC and 200 VAC at consumption areas to feed power. In the Concept Note for ensuring electricity supply in Uzbekistan in the 2020–2021 report, transmission losses will improve from the current 2.72% to 2.40% in 2025 and to 2.23% by 2030. Distribution losses will also improve from the current 12.47% to 7.9% by 2025 and to 6.5% by 2030. Based on the implementation plans, transmission and distribution losses will improve from the current 15.19% to 10.3% in 2025 and to 8.73% by 2030. Momentary power outages and blackouts have become everyday occurrences. These are the result of excessive power demand, which is mainly caused by inrush currents at the time of the simultaneous startup of electric motors and other equipment. An inverter (thyristor inverter) is a device that converts an AC power source to a DC power source and then from the DC power source to an AC power source of any required frequency. AC motors can employ an inverter soft start, so inrush currents will not occur. In addition, the circuit and functionality to deal with voltage fluctuations in the AC power supply, which is normalized, is retained so that the impact is minimal. As the speed of an AC motor is proportional to the power supply frequency, the speed of the motor can be controlled. Pumps and blowers powered by electric motors driven by inverter power supplies can control flow rate, pressure, and shaft power. Therefore, in electric energy conversion, the inverterization of electric motors leads to energy savings. Heat loss from the hot water supply and return piping at the district heat supply station is currently up to 20°C each. Considering that distribution and transmission losses will be improved in the future, the energy conversion from natural gas to electricity will reduce natural gas consumption.

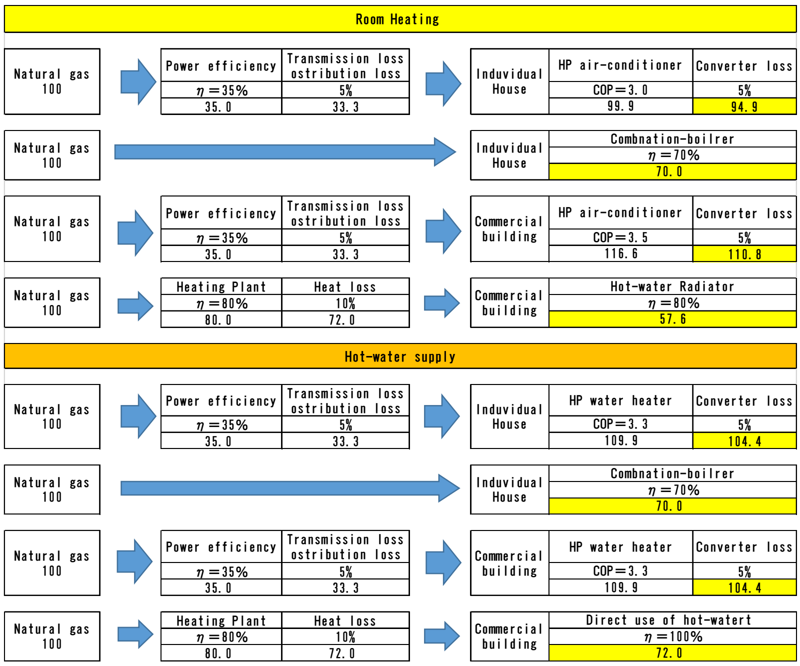
Current hot water boilers fueled by natural gas are heat engines that utilize only the sensible heat possessed by the heated water. A heat pump, in contrast, is a heat engine that pumps thermal energy from a low temperature to a high temperature heat source by providing energy from an external source. In the heat cycle of a heat pump, when a gaseous refrigerant is compressed by an electrically driven compressor, it changes from a gas to a liquid and releases latent heat of condensation to the surrounding environment. This latent heat of condensation is used as a heating heat source. When a refrigerant in a high-pressure state, liquefied by compression, is instantly depressurized to atmospheric pressure, the refrigerant changes to a low-temperature liquid owing to adiabatic change (Joule-Thomson effect). When a liquid refrigerant evaporates at a low temperature and changes to a gas, it removes the latent heat of evaporation from the surroundings. This latent heat of evaporation is used as a cooling heat source.

The coefficient of performance (COP) of current, improved, inverter-equipped heat pump air conditioners is 3.0 to 3.5, as a typical value. The physical meaning of COP is the ratio of the amount of heat pumped from the ambient (kW) to the power consumption of the compressor (kW). A COP 3.0 heat pump is therefore a typical energy conservation device in the field of cold and warm heat applications today, as it produces three times the heat output for the electricity input. Further progress in COP regarding heat pumps is expected in the future owing to improvements in refrigerants and the mechanical efficiency of compressors.

It is recommended that the use of heat pump air conditioners with inverters first, primarily for cooling in the summer months. The installed heat pumps can also be used for winter heating and as a heating system that handles the heat load to maintain the minimum necessary indoor environment by utilizing the heat storage effect of the structure, with a conventional hot water radiator, and handling the variable heat load, thereby reducing the amount of hot water supplied by the district heat supply station.

Figure 29 shows, using an index, a comparison of the amount of heat available for (1) heating, with a heat pump air conditioner using electricity supplied by a natural gas-fired power plant and (2) producing hot water with a heat pump water heater, when the natural gas consumed in combustion is set at 100.

Potential heat energy produced from the natural gas consumption of 100 by some heat



Source: Prepared by the JICA study team based on the above reference materials.

Figure 29: Amount of heat available from each heat conversion device when natural gas consumption is set at 100 (losses and efficiencies are general values referring to the situation in Japan, etc.)

The following data are required for the effectiveness verification.

- Data on energy consumption and the fluctuation range of indoor temperatures for the same set indoor temperature for heat pumps, with and without inverter, and with the same compressor capacity, during the winter period

6. Evaluation of the Effect of Efficiency Measures in the Heat Supply System

Based on the heat balance and management data of the heat supply station, the following findings were obtained regarding the effectiveness of the heat supply related measures in Tashkent. The effects of the measures on the consumption side are converted to supply-side effects according to the consumption area correction rate.

(1) No. 8 improvement of boiler air ratio in DH
Assumed penetration rate 15%
Natural gas reduction potential 1.49%
Natural gas reduction 2,630,000 m3/year
(Reference value: assumed investment amount 1.35 million yen)

(2) Conversion from hot water temperature increase to hot water volume increase in the supply heat rate increase stage, linked to outdoor air temperature and wind speed
Assumed penetration rate 100%.
Gas reduction potential 10.3%
Gas reduction 35,000,000 m3/year
No investment required

(3) Change to a completely closed heat supply system
Assumed penetration rate 10%.
Gas reduction potential 36.3%
Gas reduction: 42,700,000 m3/year
Water supply reduction potential 81%
Water supply reduction 21,600,000 m3/year
(Reference value: estimated investment amount 352 million yen)

(4) Recovery of latent heat by the economizer of combustion exhaust gas and the introduction of make-up feed water preheating
Assumed penetration rate 10%.
Gas reduction potential 27.8%
Gas reduction 32,700,000 m3/year
(Reference value: assumed investment amount 90 million yen)

(5) Connection with incoming equipment: heat insulation of piping equivalent to 65A
Assumed penetration rate 15%
Youth point correction rate 30%/52.3% = 0.57
Gas reduction potential 0.5%
Gas reduction 503,000 m3/year
(Reference value: assumed investment amount 5.28 million yen)

The effects of introducing energy conservation measures on the consumption side are as follows.

(1) Introduction of water-saving showerheads

Assumed penetration rate 15%

Use point correction rate 30%/52.3% = 0.57

Gas reduction potential 35

Gas reduction 2,560,000 m3/year

Water supply reduction potential 35

Water supply reduction 437,000 m3/year

(Reference value: assumed investment amount 93.8 million yen)

(2) Reduction of nighttime hot water supply during winter using the heat storage effect of the frame of a thick-walled building

Assumed penetration rate 30%

Use point correction rate 30%/52.3% = 0.57

Gas reduction potential 20%

Gas reduction 20,100,000 m3/year

(Reference value: estimated investment amount 264 million yen)

(3) Prohibition of opening exterior windows for indoor temperature control during the start and end of the heating season

Assumed penetration rate 30%

Use point correction rate 30%/52.3% = 0.57

Gas reduction potential 2.7%

Gas reduction 5,040,000 m3/year

(Reference value: assumed investment amount 225 million yen)

(4) Conversion from DH water heating to electric HP water heaters for individual water heating

Assumed penetration rate 10%.

Gas reduction potential 36.2% (2030)

Gas reduction 15,500,000 m3/year

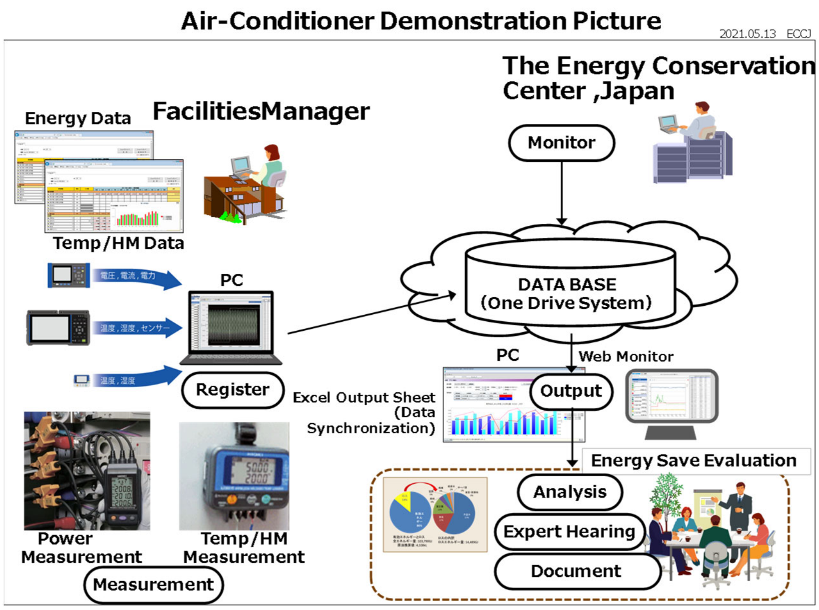
(Reference value: estimated investment amount 7.500 million yen)

Appendix 6: Demonstration Experiment of High-Efficiency Air Conditioners

1. Purpose and Outline of the Demonstration Experiment

Uzbekistan has a harsh desert-like climate with summer temperatures exceeding 40°C (104°F) and winter temperatures reaching as low as -20°C (-40°F). Although the uptake of air conditioners in ordinary households, as a cooling measure, is low, it is expected to grow substantially in the future as incomes rise. Heating systems in Uzbekistan are either centralized based on gas combustion or individual heating systems with individual boilers. However, considering the region's lack of gas infrastructure and the effectiveness of electrification as one of the measures to combat global warming, the widespread use of heat pump heating systems could be an important measure. In particular, the introduction of nuclear power generation and the expansion of renewable energy sources in the future will reduce the consumption of fossil fuel gas, while accurate temperature control by air conditioners will help prevent excessive heating.

Based on the above, in order to obtain information that will contribute to the creation of a roadmap, a demonstration experiment was conducted at the site to measure electricity consumption during cooling and heating, using two actual household air conditioners, one with an inverter system and the other with an ON–OFF control (constant speed type). The data obtained here will be used as basic data for estimating electricity consumption when air conditioners are installed in other facilities and for comparison with the current heat supply system. Specifically, the data obtained from the experiment was used to demonstrate the superiority and energy efficiency of the inverter system and to evaluate the variation in efficiency with air conditioning load. An overview of the demonstration experiment is shown in Figure 30.



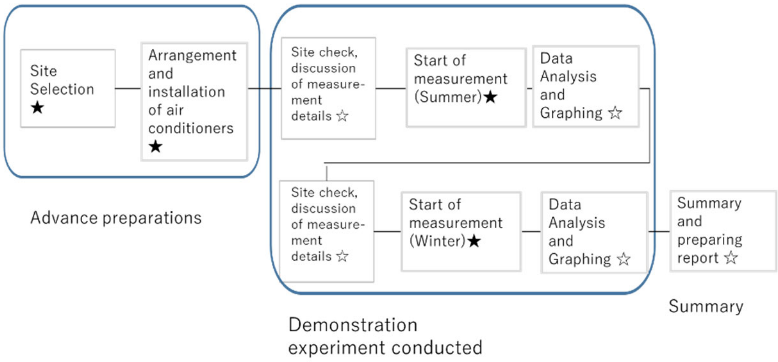
Source: JICA study team

Figure 30: Overview of air conditioner demonstration experiment

2. Methods of the Demonstration Experiment

2.1. Demonstration Process

The demonstration process is shown in Figure 31. At the end of summer and winter measurements, data will be graphed and analyzed to calculate air conditioning load and air conditioning efficiency.



Source: JICA study team

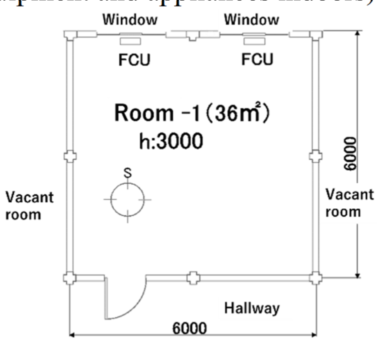
Figure 32: Demonstration process

2.2. Place of Implementation

Two rooms, with a floor area of 36 m2 (see Figure 33), were rented on the third floor of the Uzbek-Japan Innovation Center of Youth (hereinafter referred to as UJICY) at the Tashkent University of Technology; inverter air conditioners and constant-speed type air conditioners were installed in each room for the demonstration tests.Source: JICA study team

Figure 33: Layout of the demonstration laboratory

The study was conducted under conditions that eliminated, as much as possible, human variables (the inflow of outside air owing to the opening and closing of doors and windows, and the operation of electrical equipment and appliances indoors) and outside air fluctuations.



Source: JICA study team

Figure 33: Layout of the demonstration laboratory

Source: Photo by JICA study team

Figure 34: Left: Appearance of UJICY; Center: Condition of doubled-glass; Right: Condition of outer wall of the room

2.3. Acquired Data

The following data were automatically measured every 30 minutes for the two rooms. In addition, the snow accumulation in winter (frost conditions, operating conditions during snowfall) and indoor condensation conditions were checked for fear that these aspects might affect the demonstration.

- Outside air: temperature, humidity
- Indoor: room temperature, humidity, power consumption (air conditioner)

2.4. Demonstration Equipment

2.4.1. Air-conditioning

The selected air conditioner models have high COP performance and are relatively well marketed:

- Inverter air conditioner: DAIKIN ururu & sarara (FTXZ35N+RXZ35N)
- Fixed-speed air conditioner: Gree Pular (GWH12AGB)

Five air conditioners were compared before the final selection. The results are shown in Appendix 1. The outdoor unit was installed in a well-ventilated, snow-free location (see Figure 35).

Source: Prepared by the JICA research team

Figure 36: Air conditioner installation (left: outdoor unit, right: indoor unit)

2.4.2. Measuring Instrument

Table 44 shows the measuring instruments used in this study. Both the temperature/hygrometer and the wattmeter are equipped with internal memory, which has a capacity of more than 180 days considering the 30-minute interval measurement. The temperature/hygrometer is powered by dry cell batteries, and the electricity meter is powered by a battery, making it possible to handle power outages of up to 24 hours.Table 44: Instrument specifications

Table 44: Instrument specifications

Measuring instrument	Manufacturer	Model	Measuring range, accuracy	Memory	Communication function
Thermo-hygrometer	HIOKI E.E. CORPORATION	Data mini temperature and humidity logger LR8514 SensorZ2010	-20~70°C±0.5°C 0 ~80RH±3RH	500000/ch(30 min interval, 180 days)	・Send data to PC manually
Electricity meter		PW3360-91	Voltage: ~600V Current: ~5kA	SD card: 2G	・Send data to PC by TCP-IP cable

2.4.3. Data Acquisition System

Figure 38 shows the data flow and system configuration of the data collection system used in this demonstration experiment.2

Regarding the data flow on the system, for temperature and humidity data, data stored in the internal memory of the thermo-hygrometer is manually collected from the internal memory once a week and sent to the PC.

For power data, the instrument is clamped to a single wire in the power cable of an air conditioner to simultaneously measure voltage and current, and the obtained data is input into a memory card and automatically transmitted to a PC via an intranet. The collected data on the PCs were set up in ONEDRIVE to allow (1) access to the PCs via the Internet and (2) downloading of the data, including data from Japan. The phase was considered when calculating the power consumption.

The data stored in ONEDRIVE will be downloaded from Uzbekistan and Japan for the expert analysis of the data, and the data on the memory cards and internal memory will be siphoned off locally when the summer/winter period passes to check data consistency.

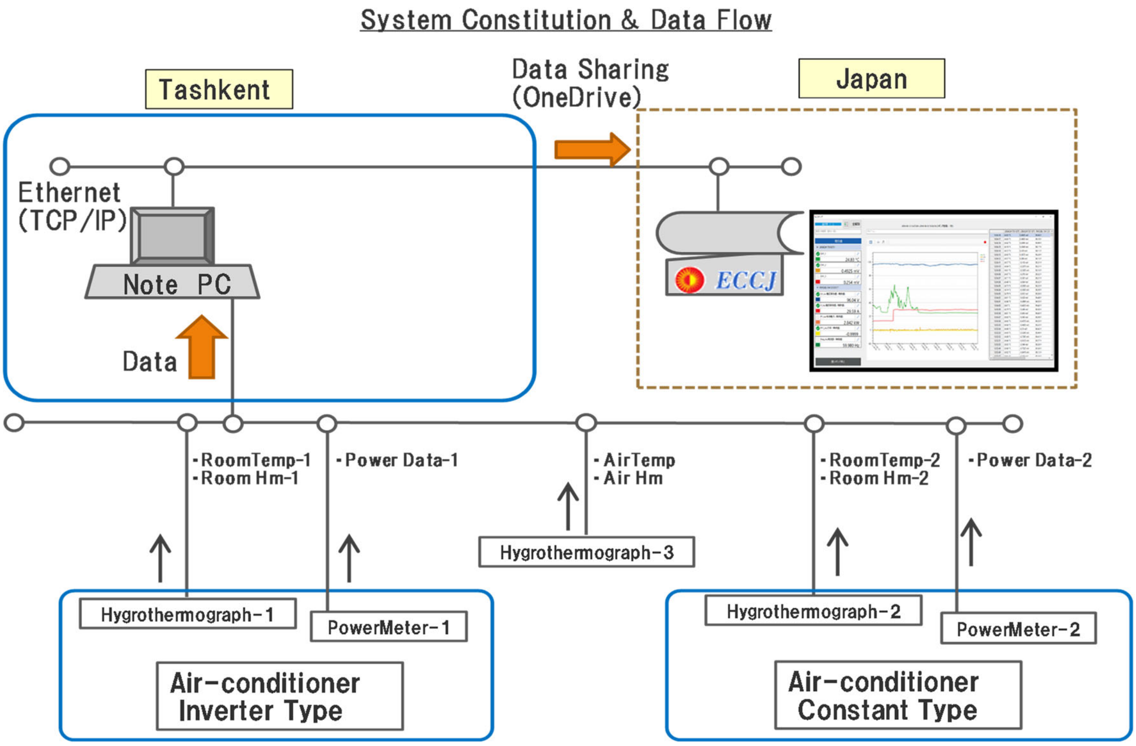


Figure 38: Data collection system configuration

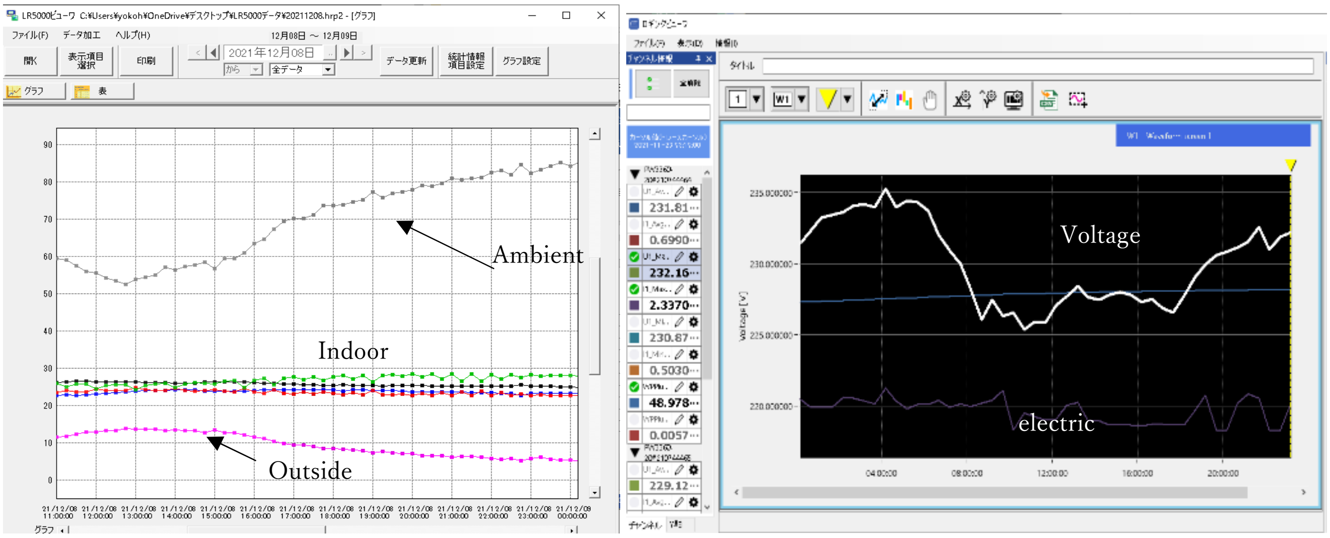


Figure 39: Examples of data collected (left: temperature and humidity data; right: data from the electricity meter)

2.5. Experiment Period

The air conditioners were operated 24 hours/day in both summer and winter, and the data measurement period was as follows.

- Summer months: May, June, July
- Winter months: December, January, February, March

2.6. Actual Conditions

2.6.1. Air Conditioner Temperature Setting

The air conditioners were set at 25°C in summer and 23°C in winter, with the air volume set to automatic.

2.6.2. Wall Insulation

Table 45 shows the results of calculating the heat transfer coefficient based on the materials and thickness of the exterior walls. Bricks were used to improve insulation. As an unsealed air layer is provided on the interior side to enhance thermal insulation, the heat transfer coefficient of the wall was 2.0178 (W/m2-K), which is a better thermal insulation situation than that of an ordinary reinforced concrete building.Table 45: Calculation of the heat transfer coefficient of the walls

Table 45: Calculation of the heat transfer coefficient of the walls

material (located from exterior)	Thickness mm	thermal conductivity W/m2K	heat transfer resistance m2K/W
plaster	20	1.6	0.0125
brick	100	0.64	0.1563
mortar	30	1.6	0.0188
air layer (open)	40	-	0.0700
plaster board	12	0.17	0.0706
thermal transmittance U W/m2K			2.0718

Source: JICA study team

2.6.3. Window Insulation

The site has double-glass windows with a glass spacing of 12 mm, which provides better thermal insulation than single glass, with a heat transfer coefficient of approximately 4.07 (W/m2-K) (from the Japan Flat Glass Association website. However, this is not the performance of Ecoglass in Japan (<2.33). Concrete eaves above the exterior walls of the windows provide a mechanism to prevent solar radiation from entering the building in summer. The window glass area accounts for 55% of the exterior wall area, and in winter, a large amount of cold air is expected to enter through the window glass, and the heating load is expected to be quite large.

2.6.4. Indoor Electrical Equipment

The only other energy consumption in the room, other than LED lighting, was measured by this instrumentation and is considered to be within the range that would not affect the current demonstration experiment.

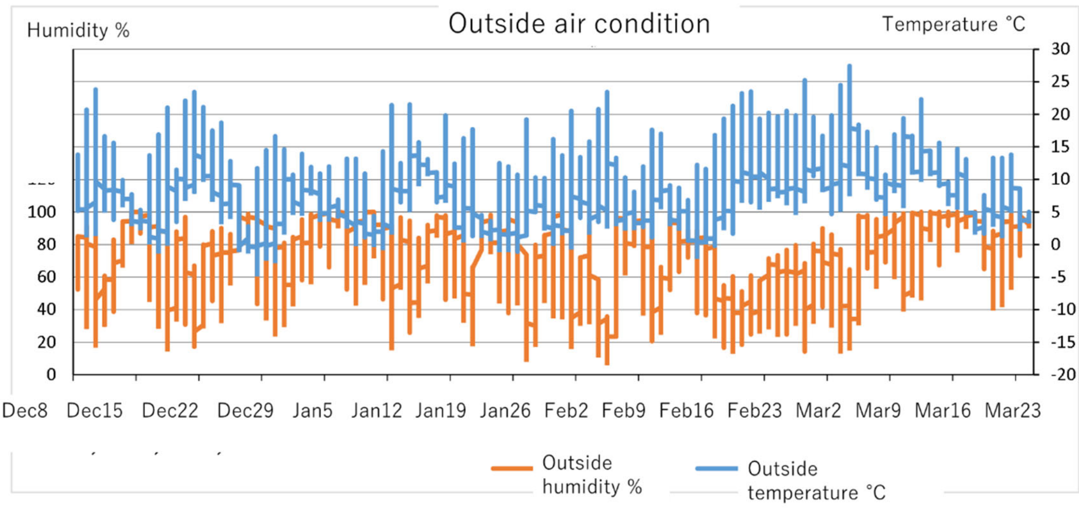
3. Empirical Results

3.1. Winter Season

3.1.1. Outside Air and Room Temperature Conditions in Tashkent

Figure 41 shows the winter temperatures and humidity measurements.3

Winters in Tashkent are rainy, and humidity fluctuates widely within a day. When it rains, humidity becomes 100%, but when the rain stops, humidity drops to 20%, resulting in dry conditions. Therefore, when the weather is dry, the sun shines brightly, and the temperature often rises above 20°C in winter, reaching as high as 27°C. Whereas, the temperature often goes below zero. The temperature fluctuates greatly. The average temperature is 8.4°C, nearly the same as that of Tokyo, but the daily temperature fluctuation is more than 20°C, giving very different from sensible temperature like Tokyo. In March, frequent rainy days bring 100% humidity, and weak sunlight make for cooler and colder temperatures.Table 46: Outdoor and indoor temperature conditions in winter



Source: JICA study team

Figure 41: Winter temperature and humidity conditions in Tashkent4

Table 46: Outdoor and indoor temperature conditions in winter

Table 46: Outdoor and indoor temperature conditions in winter

	Inverter type		ON/OFF type		Outside condition	
	Room temperature	Humidity	Room temperature	Humidity	Temperature	Humidity
	C	%	C	%	C	%
Average	23.4	23.9	22.4	25.9	8.4	69.7
Max.	29.2	49.6	27	46.7	27.4	100
Min.	18.5	10.1	17.8	11.4	-4.4	7.3

Source: JICA study team

3.1.2. Air Conditioner Operation in Winter

A comparison of air conditioner performance by month is shown in Figure 43. Although December–February was sunny, and the temperature was lower than 7°C (45°F), the direct sunlight on the outdoor units had an effect, resulting in higher efficiency, especially during the daytime. The humidity was also high, averaging 70%, and the enthalpy of the outdoor air was high, resulting in EERs of 5.47 to 6.79 for the inverter air conditioning system and 4.12 to 4.68 for the ON–OFF system. In contrast, March was rainy, and the cold rain directly cooled the heat exchanger of the outdoor unit, and frost and ice adhered to it, resulting in a deteriorated efficiency of 4.5 for the inverter system and 2.78 for the ON–OFF system.

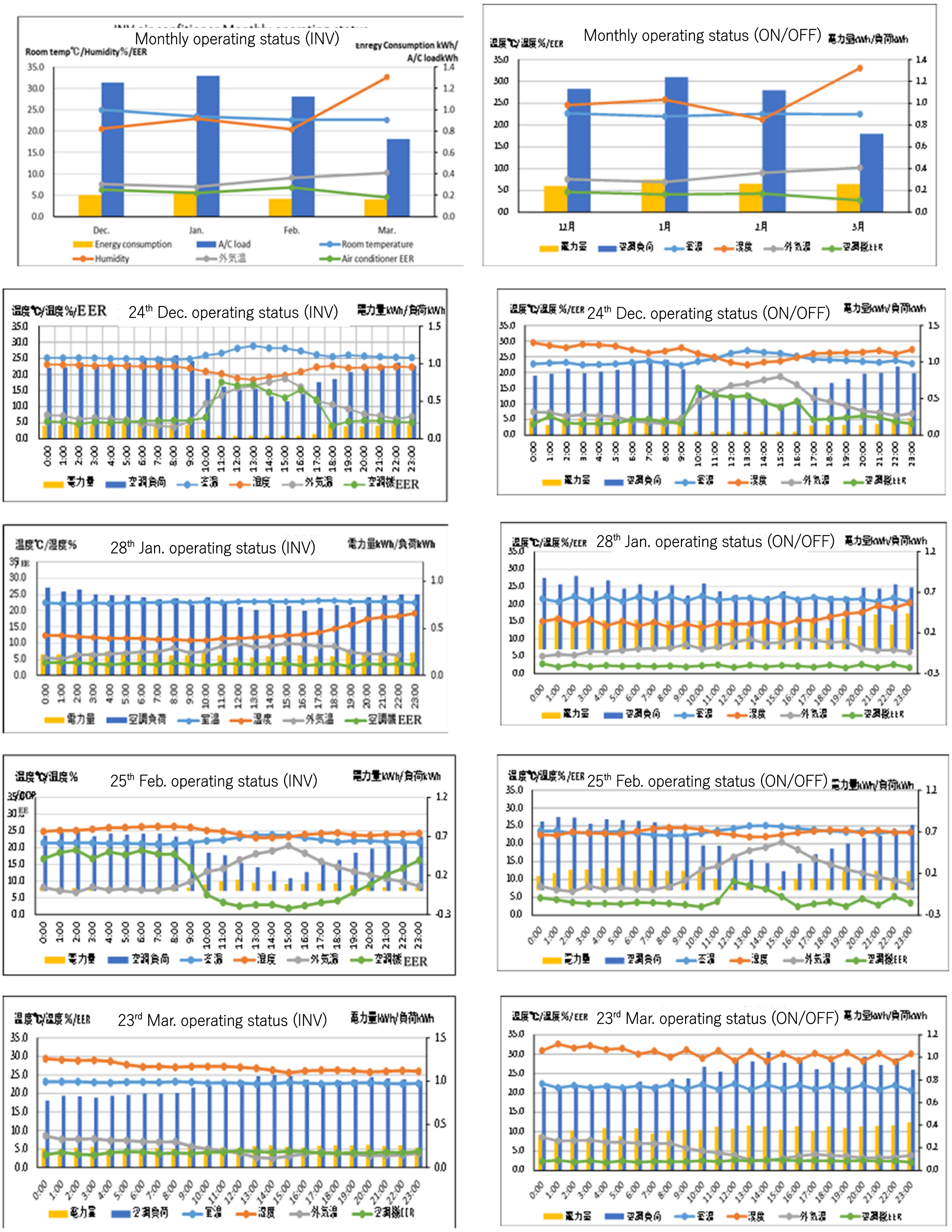


Figure 43: Monthly and daily operation of each air conditioner in winter

Table 47: Performance comparison for air conditioners

			December-21	January-22	February-22	March-22	Ave.
Outside	Temperature	°C	7.6	6.9	9.1	10.3	8.5
	Humidity	%	69.7	74.3	55.8	80.2	70.0
・INV Type							
	Room temperature	°C	25.0	23.4	22.6	22.6	23.4
	Humidity	%	20.5	22.9	20.4	32.6	24.1
	Energy consumptio	kWh/h	0.20	0.24	0.17	0.16	0.19
	A/C load	kWh/h	1.26	1.32	1.12	0.73	1.11
	Air conditioner EER		6.2	5.5	6.8	4.5	5.75
・ON-OFF type							
	Room temperature	°C	22.7	22.0	22.5	22.5	22.4
	Humidity	%	24.6	25.8	21.3	33.1	26.2
	Energy consumptio	kWh/h	0.24	0.30	0.26	0.26	0.27
	A/C load	kWh/h	1.13	1.24	1.12	0.72	1.05
	Air conditioner EER		4.7	4.1	4.3	2.8	3.97
・Comparison							
	Comparison in EER		1.55	1.35	2.50	1.72	1.78
	Comparison in Energy consumption		0.83	0.80	0.63	0.62	0.72

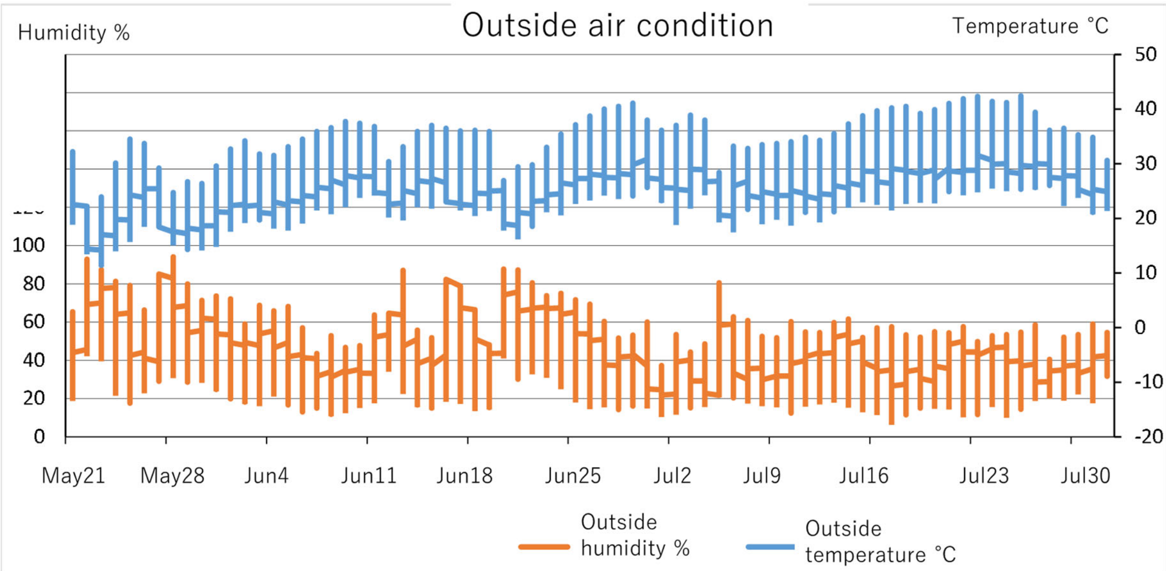
Source: JICA study team

3.2. Summer Season

3.2.1. Outside Air and Room Temperature Conditions in Tashkent

Figure 45 shows the summer temperature and humidity measurements. Tashkent has a desert climate with little or no rainfall in summer. Humidity is around 20% during the day and 60% at night. Temperatures fluctuate considerably even within a single day, reaching over 30°C or even 40°C during the day, but at night the temperature drops to nearly 20°C, making it relatively comfortable and eliminating the need for air conditioning. At a set temperature of 25°C, the air conditioning load is not high until early July.

The room temperature is almost in line with the set value (25°C) for both the inverter system and the ON–OFF system. The room temperature is controllable. However, the maximum indoor temperature of the inverter unit reached 28.7°C, and the maximum indoor temperature of the ON–OFF system reached 28.8°C. The temperature at this time fluctuated rapidly from 34°C at 10:00 to 40°C in 4 hours, indicating that normal, air-cooled packaged air conditioners cannot follow such rapid temperature fluctuations.



Source: JICA study team

Figure 45: Summer temperature and humidity conditions in Tashkent

Table 48: Outdoor and indoor temperature and humidity conditions in summer

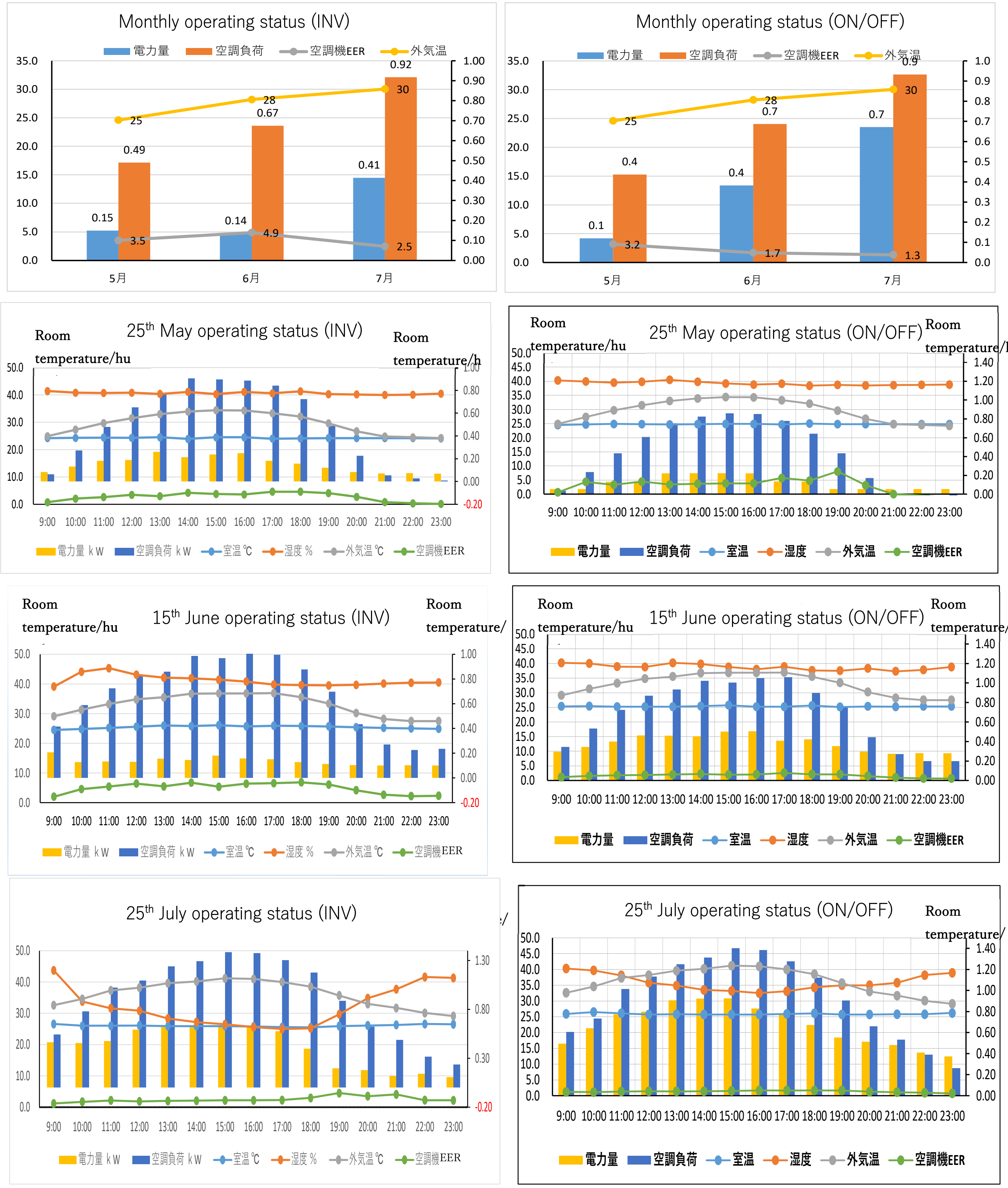
	Inverter type		ON/OFF type		Outside condition	
	Room temperature	Humidity	Room temperature	Humidity	Temperature	Humidity
	C	%	C	%	C	%
Average	25	40.1	25.1	38.6	27.1	40.3
Max.	28.7	54.9	28.8	50.3	41.1	94.1
Min.	23.2	26.5	23.5	24.2	11.4	8.2

Source: JICA study team

3.2.2. Summer Operation of Air Conditioners

The daily and monthly operation of the air conditioners is shown in Figure 47. In May, the outside temperature was 25°C compared to the air conditioning setting temperature of 25°C, resulting in almost no air conditioning load. Under these circumstances, there is little difference between the inverter system and the ON–OFF system; however, the efficiency of the inverter system is worse because of the extra power consumed by the control system.5

As the air conditioning load increases in June and July, both power consumption and EER become better for the inverter system. In July, when the load is particularly heavy, the amount of electricity used per hour is 0.4 kW for the inverter system, which is about 60% of the 0.7 kW used by the ON–OFF system.



Source: JICA study team

Figure 47: Monthly and daily operation of each air conditioner in summer

Table 49: Comparison of air conditioner performance

			May	June	July
	Temperature	°C	24.6	28.2	30.0
	Humidity	%	42.3	40.1	32.8
INV Type					
	Room temperatu	°C	24.3	25.0	25.7
	Humidity	%	40.7	42.3	36.2
	Energy consump	k W	0.15	0.14	0.41
	A/C load	k W	0.49	0.67	0.92
	Air conditioner EER		3.5	4.9	2.5
ON-OFF type					
	Room temperatu	°C	24.7	25.2	25.5
	Humidity	%	39.1	40.5	35.8
	Energy consump	k W	0.12	0.38	0.67
	A/C load	k W	0.44	0.69	0.93
	Air conditioner EER		3.2	1.7	1.3

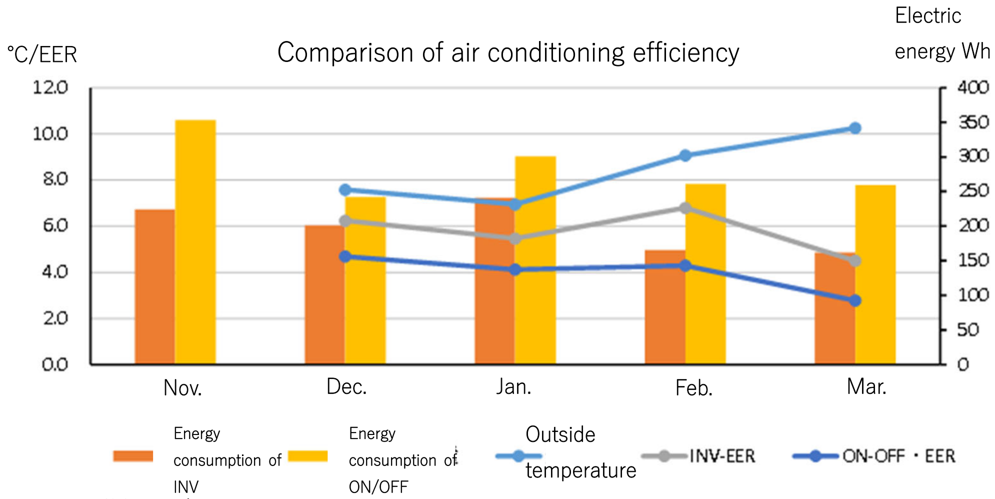
Source: JICA study team

4. Analysis of Empirical Results

4.1. Winter Season

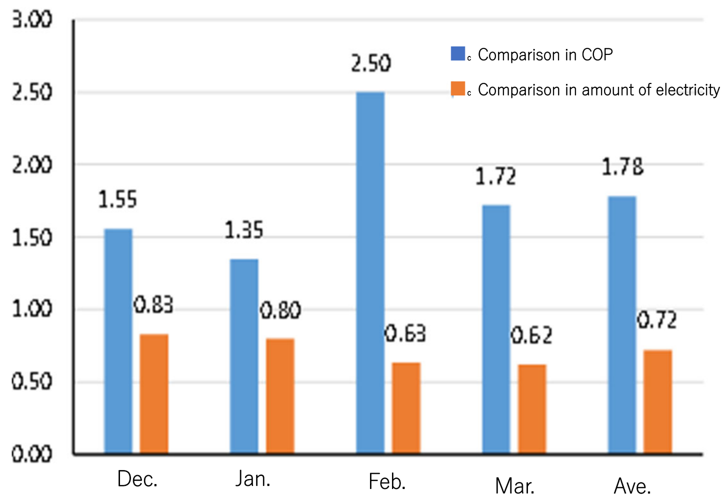
Figure 48 shows an efficiency comparison between inverter and ON–OFF packaged air conditioners in winter, and Figure 49 shows a performance comparison. In this demonstration experiment, as the only impacting factor is a change in climate, the outside temperature and the amount of electricity consumed are nearly linked.

The difference in terms of the electricity ratio was seen in February and March, with the inverter air condition showing a 30% advantage. This difference may be due to differences in defrosting systems, optimization of refrigerant condensation temperatures, and other peripheral technologies, in addition to the inverter system. As for EER, the average performance difference over the winter season was 1.78 times. In addition, the difference of 1°C in room temperature, this time, was due to the performance of the indoor unit's fan, and it is possible that the ON–OFF unit, this time, could not produce enough airflow to equalize the entire room.



Source: JICA study team

Figure 50: Comparison of air conditioner efficiency



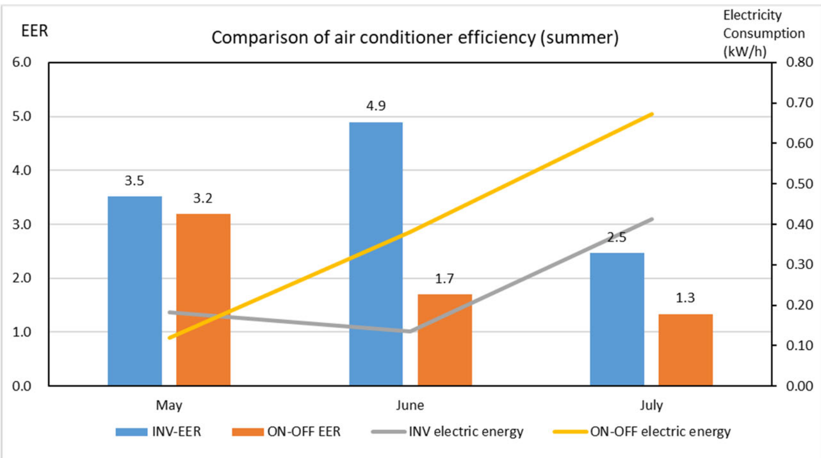
Source: JICA study team

Figure 51: Comparison of air conditioner performance

4.2. Summer Season

4.2.1. Performance Comparison between the Inverter and ON–OFF Air Conditioner

Figure 52 shows a comparison of efficiency between the inverter and ON–OFF packaged air conditioners in summer. The EER ratios range from 1.64 to 2.24, indicating that the inverter system performs 1.9 times better on average. This compares favorably with 1.8 times during the winter season. Comparing power consumption, the average power consumption is 0.45 to 0.61 times higher than that of the previous model, and the average power consumption is 0.53 times higher, almost half. This may be because there is no defrosting effect compared to the winter season, and the inverter system is easier at managing temperature fluctuations.



Source: JICA study team

Figure 52: Comparison of air conditioner performance

Table 50: Comparison results for air conditioners

エアコンの比較結果 2021.06.16 省エネルギーセンター

				インバータ機		定速機		
				1.DAIKIN emura	2.DAIKIN uruu&sarara	3.Gree Bora	4.Gree Pular	5.MEDIA AURORA
	評価項目		unit	FTXJ35MW+RXJ35M (12000BTU/h)	FTXZ35N+RXZ35N (12000BTU/h)	GWH12AAB	GWH12AGB	BEST 12
System data	Cooling Capacity	Min/Nom/Max	k W	/3.5/	/3.5/	-	-	-
	Heating Capacity	Min/Nom/Max	k W	/4.0/	/5.0/	-	-	-
	Power Input	Cooling	k W	0.86	0.66	1.05	0.985	1.09
		Heating	k W	0.99	1.00	0.94	0.985	1.05
	Space Cooling	Energy efficiency class		A++	A+++	A	A	A
		Capacity	k W	3.5	3.5	3.25	3.35	3.25
	Space Heating	Energy efficiency class		A++	A+++	A	A	A
		SCOPIA		4.60	5.73	3.4	3.5	3.81
	Nominal efficiency	EER		4.09	5.3	-	3.4	-
		COP		4.04	5.00	-	3.72	-
Indoor Unit	Fan Cooling	Silent/Low/Med/high	㎥/min	2.9/4.8/7.8/10.9	6.0/6.8/9.6/12.4	9.2MAX	10.0MAX	5.4/7.43/8.4
	Fan Heating	Silent/Low/Med/high	㎥/min	4.1/6.9/9.6/12.4	6.8/7.7/10.2/12.4			
Outdoor Unit	Operation Range	Cooling Ambient Min.～Max.	°CDB	' -10～46	' -10～	-	' ～55	-
		Heating Ambient Min.～Max.	°CDB	' -15～18	' -20～	-	' -15～	-
	Refrigrant	Type		R-32	R-32	R-410	R-410	R-410
		GWP		675.0	675.0	2090	2090	2090
	Power supply	Phase/Frequency/Voltage	Hz/V	1～/50/220～240	1～/50/220～240	1～/50/220～240	1～/50/220～240	1～/50/145～265
Selection				△	◎	○	◎	△

Appendix 7: Brief Survey of the Transformation of Buildings to ZEB (including payback period for business operators)

1. Purpose of the survey and study

This study is a basic study of the implementation of future ZEB demonstrations. In implementing the project, the introduction of high-efficiency equipment and energy conservation technologies from Japan will be considered, as ZEB can fully utilize renewable energy in Uzbekistan, such as solar heat, which is abundant in the country, as it is in a desert area. In this study, the energy consumption intensity analysis tool (ESUM), which can perform thermal analysis, will be used to evaluate the thermal insulation of the existing building and study the possibility of ZEB.

2. Target Building

2.1. Building Selection

From the list of buildings presented by the Ministry of Energy of Uzbekistan, four candidates were selected considering building size, office usage, and publicity to the general public after ZEB, which was strongly requested by the Ministry of Energy. After the site surveys, the headquarters building and branch office (#8) of the Gas Supply Corporation (HGT: HUDUD GAZ TAMINOT) were selected for the project (see Table 51).

HGT's headquarters building was selected because the building is located on a main road and has a bank for paying utility bills in the facility, which will be effective for PR after the ZEB implementation. Although the branch office (#8) is located in a residential area far from the main road, it is used by many members of the public to pay their gas bills, and like the head office building, it is effective in promoting ZEB.

The two buildings selected for this project are robust, traditional buildings with brick encased within the exterior walls and walls more than 50 cm thick. These buildings are more than 40 years old; such buildings are generally widespread in Tashkent. It is believed that aiming for ZEB in such a general existing building is easier than converting a modern building to ZEB because it is easier to take advantage of advanced Japanese technology, and it is easier to horizontally deploy the technology when constructing ZEB in the future.

As for the other two buildings, they were related to the electric supply corporation, but one of them had 12 tennis courts attached to the office and consumed a lot of electricity and thermal energy for the high-ceiling lighting and heating system for the indoor courts, so the amount of energy consumed by the office building was unknown. The other one was a service center; it was not included because a large machine tool was operating in addition to the office, and it was not possible to distinguish its power consumption from that of the office.

Table 51: Conditions in the building

Facility name	Head office building "HGT."	Branch office #8 "HGT."
total floor space	2,742 m2	796 m2
number of story	Four-story building (with basement)	Two-story building (with basement)
appearance		

Source: JICA study team

2.2. Building Information

2.2.1. Various Conditions in the Building

The results of the survey on the various conditions in the building are shown in Table 52.

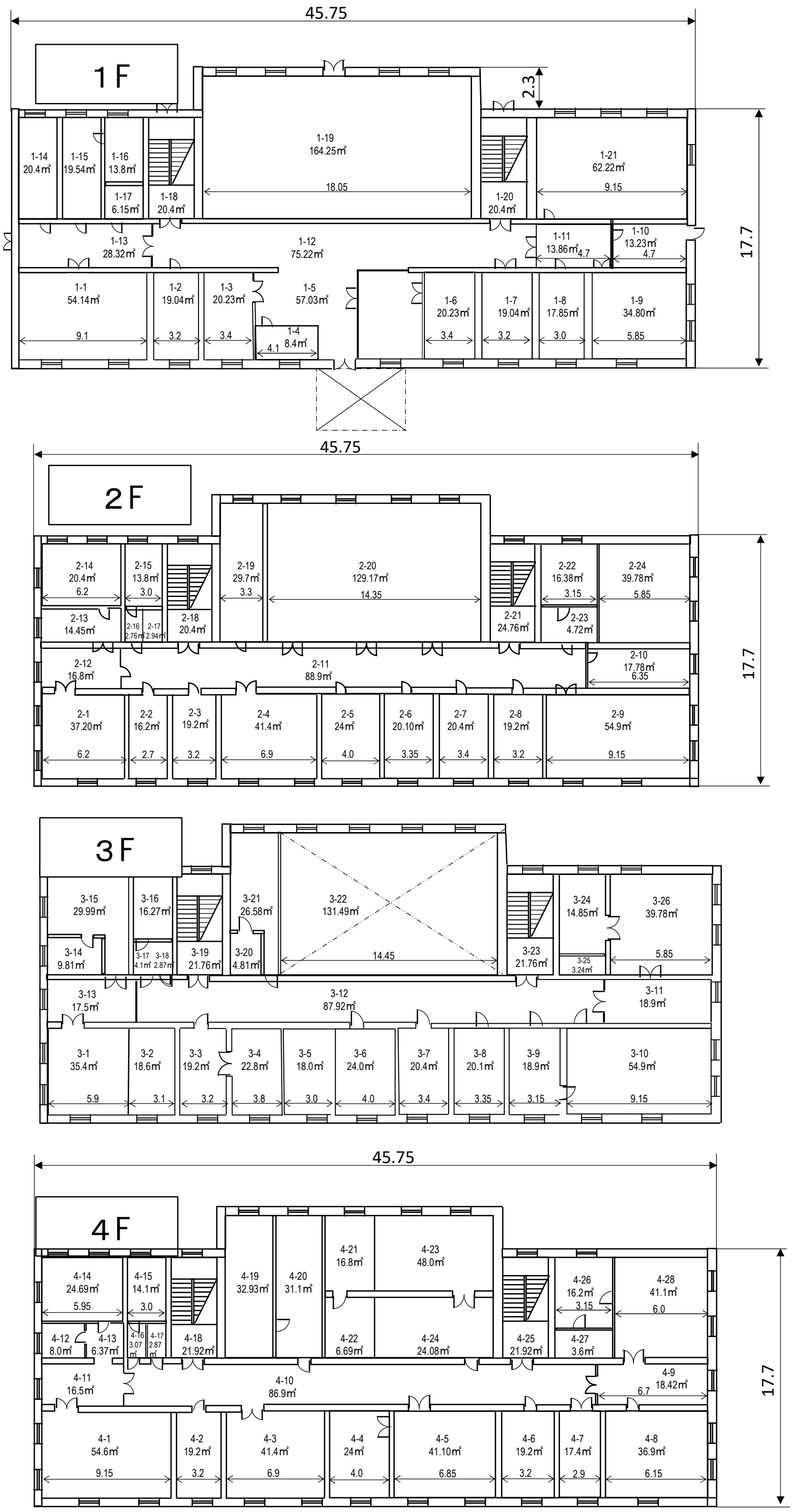
Table 52: Conditions in the building

Head office building		Branch office #8	
No. of people in the office	112 people	No. of people in the office	33 people
Number of PCs	112 units	Number of PCs	33 units
FAX	4 units	FAX	4 units
Printer	33 units (ink jet)	Printer	10 units (ink jet)
IP phone	15 units	IP phone	5 units
Packaged air conditioner	56 units	Packaged air conditioner	6 units
Total lighting capacity	10.3kW	Total lighting capacity	1.2kW

Source: JICA study team

2.2.2. Floor Plan

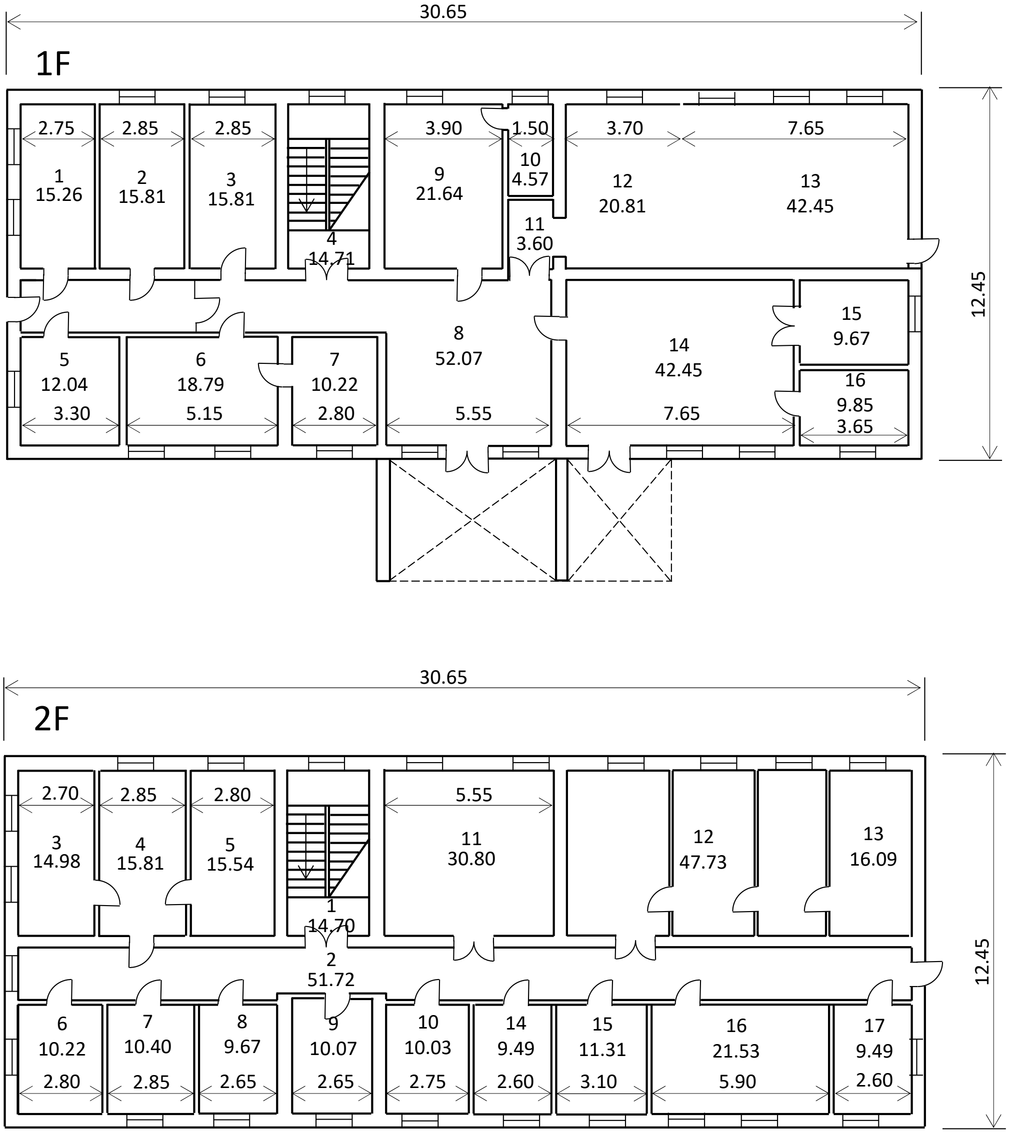
1) Head office building



出典： JICA 調査団

Figure 53: Floor plan of the head office

2) Branch office (#8)



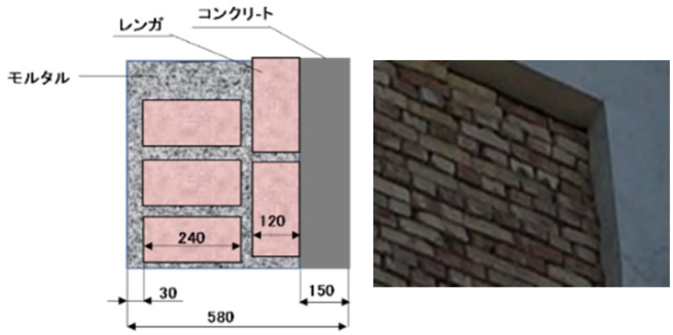
出典： JICA 調査団

Figure 54: Floor plan of the branch office

2.2.3. Building Structure

1) Structure of exterior wall

A schematic of the exterior wall is shown in Figure 55. The wall was built by stacking bricks with mortar, and its outside was covered with concrete with a thickness of 150 mm. The wall thickness is approximately 580 mm, and it is a wall-type structure that serves as the framework for the entire building, instead of columns. The thick walls serve to moderate the large temperature fluctuations inherent in Tashkent's desert climate. However, as no heat insulator has been installed, the heat insulation is not very good, and the thermal transmission coefficient is 1.36 W/m2K. For ZEB, the thermal transmission coefficient needs to be further reduced by affixing a heat insulator.



Source: JICA study team

Figure 55: Structure of the outside wall

2) Structure of the floor

A photograph of the floor viewed from behind the floor is shown in Figure 56. The structure consists of wooden beams passing between the walls, wooden planks placed on top of these beams, and poured concrete. As it is not reinforced, it would be difficult to load large equipment or heavy items, such as bookshelves.

Source: JICA study team

Figure 56: Structure of the Floor (viewed from behind the floor)

3) Structure of the rooftop

The roof consists of a triangular roof frame constructed of steel and wood over a 100 mm thick concrete ceiling, topped with slates. As it is made primarily of slate and wood, placing heavy objects, such as solar panels, on it is not possible. In order to load the panels, the current roof must be removed, heat insulation must be attached, and a steel framework for the solar panels must be installed.

Source: JICA study team

Figure 57: Structure of the rooftop

2.2.4. Status of Energy Consumption

1) Monthly energy consumption (head office building)

Figure 58 shows the monthly energy consumption of the headquarters building of the HGT, HUDUD GAZ TAMINOT, the target of this survey. The building has extremely high gas consumption for heating. The challenge is to reduce the amount of thermal energy required by strengthening the building's heat insulation. The current heating system uses a gas hot water boiler to circulate 50°C hot water throughout the building. The exhaust gas temperature at a stable combustion state is measured to be around 95°C. Based on this, the thermal efficiency during continuous combustion is estimated to be around 80%. However, in reality, intermittent combustion is frequently performed, which entails the furnace being scavenged with cold air before combustion to prevent an explosion due to unburned gas in the furnace at the time of re-ignition. Therefore, the inside of the furnace is cooled down, and the actual efficiency is estimated to be quite low. Gas consumption from May to October, when heating is not used, is used for water heating and other purposes; therefore, thermal energy is required all year round.

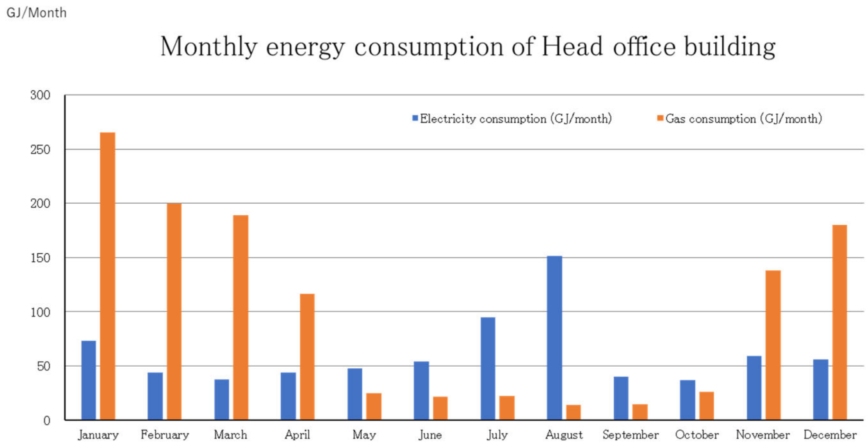


Figure 58: Monthly energy consumption (head office building)

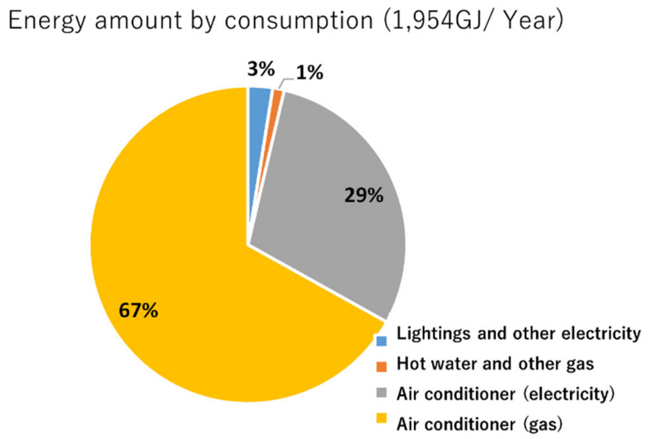
Source: JICA study team

The main reasons for energy consumption are cooling in summer, July and August, and fixed uses, such as lighting and electrical outlets, which are required year-round. In addition, electricity consumption is somewhat higher in winter than in the middle months when air conditioners are not used. However, it can be inferred that air conditioners are used to supplement heating in winter.

2) Energy consumption percentage (head office building)

The amount of air conditioning energy was estimated from the energy consumption in the middle months when air conditioning is not used. The calculated energy consumption percentages by use are shown in Figure 59.

Energy consumed for heating and cooling accounts for 96% of the total energy consumption. The heating energy consumption accounts for 67% of the total energy consumption, particularly in winter when gas is used. These are major challenges for introducing ZEB. During summer, each room is cooled by a pre-installed air conditioner, which is a constant-speed type (C label), and therefore, not very efficient.

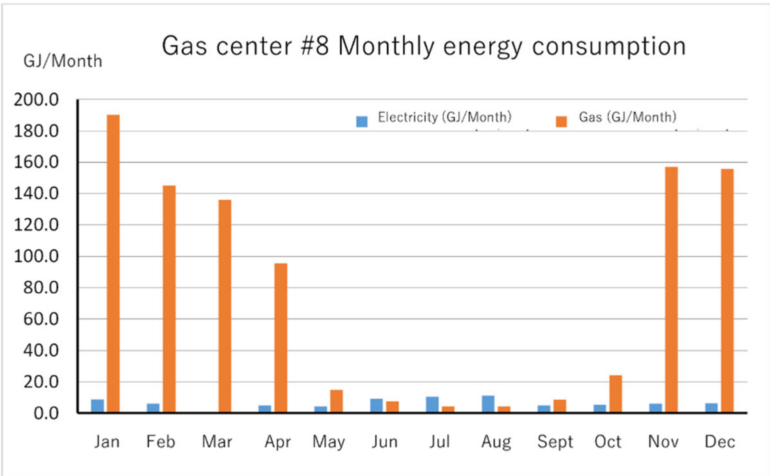


Source: JICA study team

Figure 59: Percentage of energy consumption by use

3) Monthly energy consumption of the branch office

Figure 60 shows the monthly energy consumption of the branch office (#8). Gas consumption is significantly higher than electricity consumption. This trend is more pronounced during the winter months. Moreover, during the winter months, heat from the heating system is thought to be leaking out of the building owing to the non-stop operation of the system and the uninsulated building structure. For ZEB, it is necessary to consider strengthening the building's thermal insulation and introducing a heating system that uses renewable energy, such as solar heat. During summer, the number of people in the room during the day is small (approximately 10), and only 5–6 air conditioners are installed, resulting in significantly lower electricity and gas consumption.



Source: JICA study team

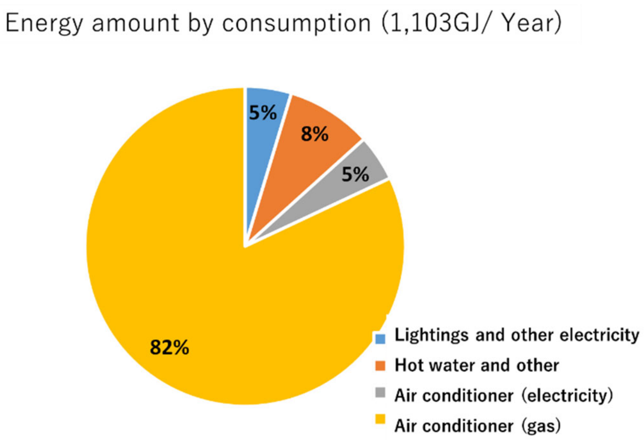
Figure 60: Monthly energy consumption of the branch office (#8)

4) Percentage of energy consumption by use at the branch office (#8)

The percentage of energy consumption by use is shown in Figure 61. Heating accounts for 82% of total energy consumption; the challenge is to strengthen building insulation and effectively use renewable energy sources, such as solar heat.

Regarding lighting, LED lighting has been installed throughout, leaving little room for energy conservation.

A gas stove and an instant hot water heater are installed in the break room, resulting in an energy consumption of 8% for water heating and other purposes; however, as the detailed use is unknown, they are excluded from the energy conservation target in this survey.



Source: JICA study team

Figure 61: Percentage of energy consumption by use

3. ZEB Considerations

3.1. Direction toward ZEB

The traditional building in Tashkent currently consumes a high amount of thermal energy for air conditioning in winter. This is thought to be because the building is not insulated and is generally heated 24 hours a day, so a large amount of heat is dissipated outdoors at night when it is cold. Therefore, as steps to realize ZEB, the first issues to be considered are the implementation of enhanced building insulation and the cessation of nighttime heating. The next step is to minimize the air conditioning load by implementing energy conservation measures, such as upgrading to high-efficiency equipment, followed by the construction of an optimal air conditioning system that takes renewable energy into account. In the last step, the amount of energy that cannot be further reduced is considered in the step of using solar power generation.

Table 53: Direction toward ZEB

step	items for consideration
1. Reinforcement of building insulation	[Window glass] Doubled-glass, Low-e glass, Vacuum glass, Doubled windows, and Plastic sashes [Exterior walls] Exterior insulation (attaching insulation to exterior walls), interior insulation (attaching insulation to interior walls) Ceiling] Attachment of heat insulating material, solar radiation protection
2. introduction of high-efficiency equipment (energy conservation measures for energy-consuming equipment)	[Lighting]Installation of high-efficiency LED lighting, appropriate illuminance management (introduction of illuminance control lighting), lights off using human detection sensors Hot water supply For showers: solar heat utilization, exhaust heat utilization, heat pump water heaters For beverages: gas stove => vacuum electric pot
New air conditioning system	Cooling system heat pump Electric heat pumps (high-efficiency inverter air conditioners (chiller (water/air-cooled), packaged air conditioners) (Turbo chillers, screw chillers) Gas heat pump (compressor driven by gas engine) Absorption chiller (heat pump operated by heat, GENELINK (low-temperature use of waste heat/solar heat)) Air conditioning using water vaporization heat Free cooling (e.g., closed-type cooling towers) Heating system Air conditioning with high-efficiency heat pumps Air-cooled chiller (building circulation by hot water) package air-conditioner Gas boiler (building circulation by hot water) Solar heating (hot water collected by solar heat and circulated in the building) Example in Japan: Headquarters of Shizuoka Gas (awarded the Energy Conservation Grand Prize) (Heat accounts for 67% of the energy used for air conditioning, and Tashkent has only about two weeks of rainfall per year, making it favorable for solar thermal applications.)
4. use of renewable energy	Consider using renewable energy sources to provide the electrical energy that must ultimately be used. In addition, to cope with fluctuating renewable energy, the installation of energy storage facilities will be considered.

Source: JICA study team

The best combination of the study items indicated in the above steps should be considered based on the on-site survey. For Step 4, a rough heat balance was calculated using the Energy Consumption Unit Management Tool (ESUM) published by the Energy Conservation Center, Japan, and the capacity and specifications of the ZEB facilities were determined. Based on the study of equipment capacity, equipment and construction costs should be outlined and the equipment payback period calculated.

3.1.1. Step 1: Reinforcing Building Insulation

1) Reinforcement of exterior walls' insulation for

The exterior walls have what is commonly referred to as a "1.5 brick stack," with 1.5 bricks side by side, but there is no heat insulator, so the heat transfer coefficient is relatively high. The walls are more than 500 mm thick and serve to moderate temperature changes in the outside world through their heat storage effect. As a method of strengthening the insulation of the building, an external insulation structure will be adopted in consideration of the impact on the current office work. The heat transfer coefficient can be improved to 0.49 W/m2K by attaching approximately 30 mm of insulation material to the exterior walls and installing a steel plate for rain protection. This is a 64% improvement over the current situation. The roof has 100 mm of concrete with poor insulation. Therefore, 50 mm of insulation material was attached to improve thermal insulation.

Table 54: Effects of thermal insulation (exterior walls and ceilings)

	Insulation mm	Heat transfer coefficient (W/ m2K)		Rate of improvement
		status quo	After insulation	
outer wall	30	1.36	0.49	64% of
roof	50	4.11	0.505	88%.

Source: JICA study team

2) Reinforcement of window insulation

As single-glass and double-glass windows are used in different rooms, the effect was calculated uniformly assuming the current situation as single glass.

The windows do not slide to open, like in Japan. They have double-hinged wooden frames, which makes it difficult to use double-paned windows. A proposal to introduce vacuum double glazing, a Japanese technology, was considered. The advantage of vacuum double glazing is that only the glass needs to be replaced, with the present window frame left as is, saving time and labor for installation and minimizing the impact on office work.

Table 55: Effects of dual layer window glass

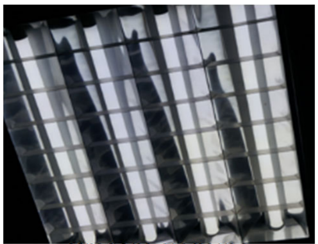
Window	thermal transmittance ratio (W/㎡K)		Improvement rate
	Single-glass	Dounle Low-e glass	
	6.5	1.4	78%

Source: JICA study team

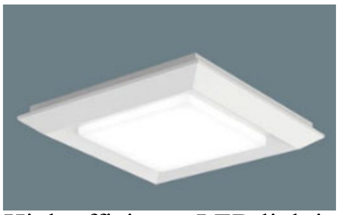
3.1.2. Step 2: Installation of High-efficiency Equipment

1) Energy conserving measures for lighting facilities

LED lighting is used throughout the head office building, and the power load owing to the lighting system is relatively small. The lighting fixtures in the corridors, at 72 W/unit, remain on throughout the day. Energy can be saved by installing high-efficiency LED lighting and motion sensors. Table 56 shows the assumptions used to verify the energy conservation effects of upgrading to high-efficiency LED lighting.Table 56: Assumptions



Present lighting



High-efficiency LED lighting

Source: JICA study team

Figure 62: Energy-saving measures for lighting equipment

Table 56: Assumptions

Item Name	symbol	calculated value	unit	remarks
Current LED power consumption	A	72	W/unit	
Highly Efficient LED Power Consumption	B	20.5	W/unit	Manufacturer's catalog value
number of hours worked	C	1,920	h/year	8h/day x 240 days/year
number of large objects such as cars, computers, etc.	D	43	counter for machines, incl. vehicles	

Source: JICA study team

The energy saving effect of lighting equipment is the difference between the energy consumption of high-efficiency LED lighting and that of the present LED lighting. The present electricity consumption, electricity consumption after improvement, and reduced electricity consumption are shown below.

Current power consumption: A x C x D = 72 W/unit x 1920 h/year x 43 units/1000 = 5,944 kWh/year

Electricity consumption after improvement: B x C x D = 20.5 W/unit x 1920 h/year x 43 units/1000 = 1,692 kWh/year

Reduced electricity consumption: Current electricity consumption - electricity consumption after improvement = 4,252 kWh/year

2) Installation of solar hot water systems

The water heating system in the headquarters building is equipped with solar water heaters, but they are used in parallel with a gas-fired water heating system, which heats the water with gas throughout the day and circulates it throughout the building. In contrast, the branch office uses a solar water heater for showers, which saves more energy.

When installing solar water heaters, it is necessary to consider the strength of the roof to determine whether installation is feasible. If the roof is not strong enough, it is necessary to consider a system in which the heat storage tank is placed separately, and hot water is circulated between the heat storage tank and the solar panels.

Gas water heater (Head office building) Solar water heater (Branch office (#8))

Source: JICA study team

Figure 63: Exterior view of water heater

3.1.3. Step 3: Installation of a new air conditioning system

As air conditioning equipment accounts for a considerable amount of energy consumption, it is difficult to construct ZEB simply by updating to high-efficiency equipment. Currently, packaged air conditioners are used for cooling and hot water boilers for heating, but it is necessary to consider systems that can be adapted for heating and cooling using renewable energy whenever possible. Possible air conditioning systems were examined separately for cooling and heating.

1) Consideration of cooling system

i) Heat pump systems (packaged air conditioners, central air conditioning system for buildings, chillers, etc.)

The heat pump method has already reached the point of technological perfection, to the extent that it has already become a stage of cost competition. Currently, C-label constant-speed packaged air conditioners are used. Replacing these with high-efficiency packaged air conditioners with inverter systems is expected to reduce power consumption by 20–30%. However, as they consume a large amount of electricity, they require a large area for the installation of solar panels.

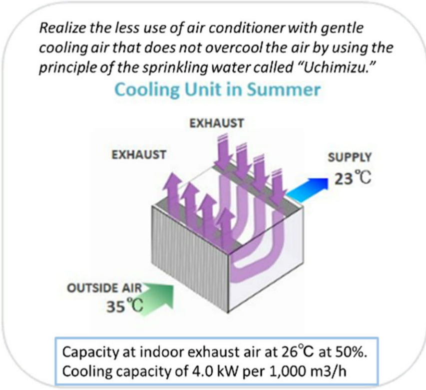
The headquarters building has a roof area of 700 m2. Assuming a 45-degree angle of installation, a 70% installation rate, and a solar power generation efficiency of 1 kW/10 m2, the power generation capacity is estimated to be approximately 35 kW. The estimated annual power generation is about 126 GJ/year, which can cover only 22% of the current electricity energy consumption of 566 GJ for cooling (1954 GJ annual consumption x 29% of cooling energy). ZEB cannot be achieved only by high-efficiency improvements. In summer, humidity is extremely low, and it is necessary to consider improving efficiency in combination with the water vaporization cooling method discussed in the next section.

Meanwhile, the six packaged air conditioners that the branch office presently has should be replaced with appropriate high-efficiency electric heat pumps.

ii) Water vaporization thermal cooling

This system utilizes the vaporization heat of water and has a simple structure. Not using refrigerants, such as chlorofluorocarbons, makes it an environmentally friendly energy conservation facility. In Japan, the system is often used for cooling outside air for ventilation in places where many people gather, such as subway station platforms and department stores.

One of the disadvantages is that the water evaporation part of the cooler is large, making the facility huge, while the COP is high, at around 10. As the object building itself is not designed for efficient natural ventilation, the only option for ventilation is by opening windows. Therefore, it may be effective to consider introducing a water-cooling system as a cooler.



Source: Website of Tohoku Earthclean

Figure 64: Appearance of water cooler

2) Heating system support

i) Heat pump system (packaged air conditioner, central air conditioning system for buildings)

Currently, a gas-fired hot water boiler is used to produce hot water at 50°C, which is circulated through the building.

If replaced with an air-cooled heat pump chiller, energy consumption can be reduced to about 1/3 as COP3. Unlike gas hot water boilers, however, chillers do not function efficiently without a constant hot water temperature and a constant temperature difference. For this reason, it is necessary to create an auxiliary system that can collect heat with supplementary solar thermal panels and make it possible to cope with the thermally fluctuating outside air.

ii) Use of solar heat

Recently, evacuated-tube solar water heaters are becoming more widespread, making it possible to produce 50°C hot water even in winter. However, renewable energy is highly variable and requires a backup heat storage function, such as a heat storage tank.

3.1.4. Step 4: Use of renewable energy

1) Renewable energy

Regarding renewable energy, photovoltaic power generation is recommended for the following reasons.

- It is the most widespread and easiest to procure in the world.
- It is highly feasible considering the cost reduction that will be achieved by its further spread

in the future and that it can adapt to the climate in Uzbekistan without any problem.

2) Electricity storage facilities, etc.

The branch (#8) is supplied by the grid power at 220 V low voltage, and reverse powering is possible owing to its proven track record. For this reason, grid linkage is considered as the easiest and cheapest way of power integration. Meanwhile, the headquarters building received 6,600 V of power (10,000 V even at a local hotel), which was distributed to the building via its own transformers. However, to cope with voltage fluctuations in the grid power, a regulator was installed in the building. The regulator may provide a stable voltage supply in the building area. As solar panels themselves have large voltage fluctuations, storage batteries are considered necessary to absorb the voltage fluctuations and enable consumption in the building in accordance with the ZEB concept.

3.2. ZEB Measures for Buildings

Based on the previous studies, a draft study of the measures for ZEB was developed.

3.2.1. Proposed ZEB Measures for the Head Office Building

The headquarters building faces a major development path; its exterior must be renovated with the appropriate materials. As mentioned above, no insulation is present on the exterior walls and roof, contributing to the increased air conditioning load. Therefore, it is necessary to remove the aluminum exterior material, affix insulation, and install a new exterior material to improve the insulation effect.

High-efficiency LED lighting will replace the 72 W LED lights in the hallway that are lit during business hours. Regarding the hot water supply system, although a solar water heater is installed, the system uses the circulation of a gas from a gas water heater installed in the basement, which loses energy but was excluded because it accounts for only a small percentage of the energy consumption.

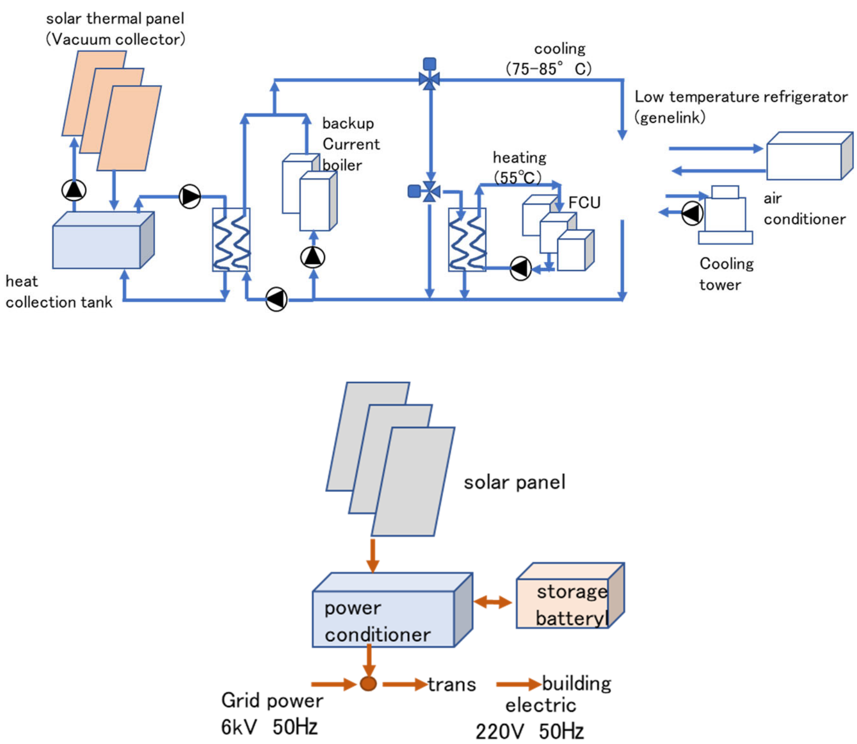
The energy consumption of air conditioning accounts for 96% of the total energy consumption; this must be reduced for ZEB. The proposal involved a combination of a solar water heater and a high-efficiency heat pump.

Electricity consumption that cannot be reduced by the above measures will be addressed by installing solar power generation. Based on the above, the measures to be taken for the head office building (#1) are as follows.

Table 57: Proposed ZEB measures for the head office building

step	countermeasure items	Specific Methods
1	Building insulation effect	External insulation of exterior walls (30 mm insulation) Roof insulation (50mm insulation) Window insulation (Doubled-glass, Low-e glass)
2	Introduction of high-efficiency equipment	High-efficiency LED lighting, solar water heaters
3	Introduction of new air conditioning system	Heat pump chiller, solar panel (heating), water cooling Fan Convector
4	Use of renewable energy	Photovoltaic power generation + energy storage system

Source: JICA study team



Source: JICA study team

Figure 65: Overview of the proposed ZEB measures for the head office building

3.2.2. Branch Office Building #8

Insulation of the exterior walls will be implemented, as they are not insulated in the same manner as the head office building. Further, the branch office will add a windbreak room to address the drafts at the entrances and exits that affect the air conditioning load.

LED lighting is used throughout the building; no energy saving effect from higher efficiency lighting can be expected, so energy saving measures for lighting facilities will not be considered.

Regarding the hot water supply system, a solar water heater is already installed in the office, so it is not the target of this energy conservation measure. The use of gas water heaters will also be addressed in the direction of electrification, as they are used during breaks and are used infrequently.

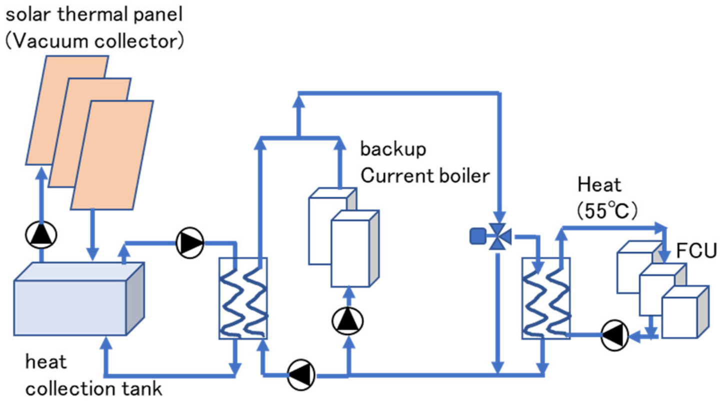
Regarding the air conditioning system, energy consumption for heating is high due to the 24-hour hot water circulation by gas-cooked water heater for heating, while the number of packaged air conditioners installed for cooling is small and extremely low compared to that for heating. For this reason, the use of solar water heaters and thermal storage tanks (backup function) for heating and a central air conditioning system for buildings for cooling will be considered for the air-conditioning system. In addition, the heating system currently uses radiant panels; a fan convector will be installed to increase heating efficiency.

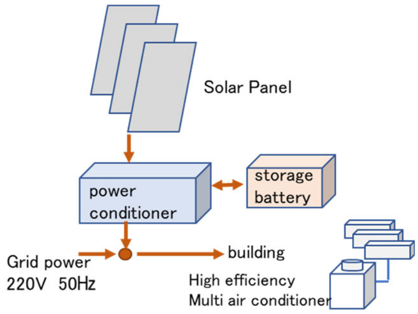
Electricity consumption that cannot be reduced by the above measures will be addressed by installing solar power generation. The ZEB measures at the branch offices are shown below.

Table 58: Proposed ZEB measures for the branch offices

Step	Countermeasure item	Specific Methods
1	Building insulation effect	External insulation of exterior walls (30 mm insulation) Roof insulation (50mm insulation) Window insulation (Doubled-glass, Low-e glass) Gap ventilation measures (addition of a windbreak room)
2	Introduction of high-efficiency equipment	No countermeasures
3	Introduction of new air conditioning system	Central air conditioning system for buildings Solar water heater + heat storage tank Fan Convector
4	Use of renewable energy	Solar power generation (electricity is grid-connected)

Source: JICA study team





Source: JICA study team

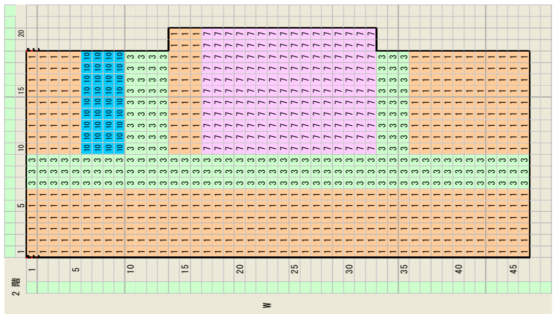
Figure 66: Overview of the proposed ZEB measures for branch office #8

3.3. Evaluation of Heat Balance Using the Energy Consumption Intensity Management Tool (ESUM)

3.3.1. Overview of ESUM

ESUM was developed for the purpose of promoting energy conservation in commercial buildings, as a tool that can predictably calculate the amount of energy used in a building and determine the energy consumption intensity (MJ/m2). It is possible to display and analyze EXCEL-based floor plans by zone and by use, showing the heat load under local environmental conditions (see Figure 68). The specific effects will be estimated by calculating the heat load of the ZEB measures to the current target building at ESUM and to the building studied above.6

No.	部門	ゾーン名		室名	床面積	
1	事務室	1	ﾍﾟﾘﾒｰﾀ		453	
2	事務室	2	ｲﾝﾃﾘｱ			
3	事務室	3	通路・その他		201	
4	電算	4	電算室関連			
5	出入口・ﾛﾋﾞｰ	5	ｱﾄﾘｳﾑ・ﾛﾋﾞｰ・ﾎｰﾙ			
6	出入口・ﾛﾋﾞｰ	6	出入口・風除室			
7	講堂、大会議室	7	講堂		176	
8	飲食店	8	飲食店			
9	ｺﾝﾋﾞﾆ	9	ｺﾝﾋﾞﾆ			
10	その他・共用	10	その他・共用施設		36	
11	屋内駐車場	11	駐車場			
12						
13						

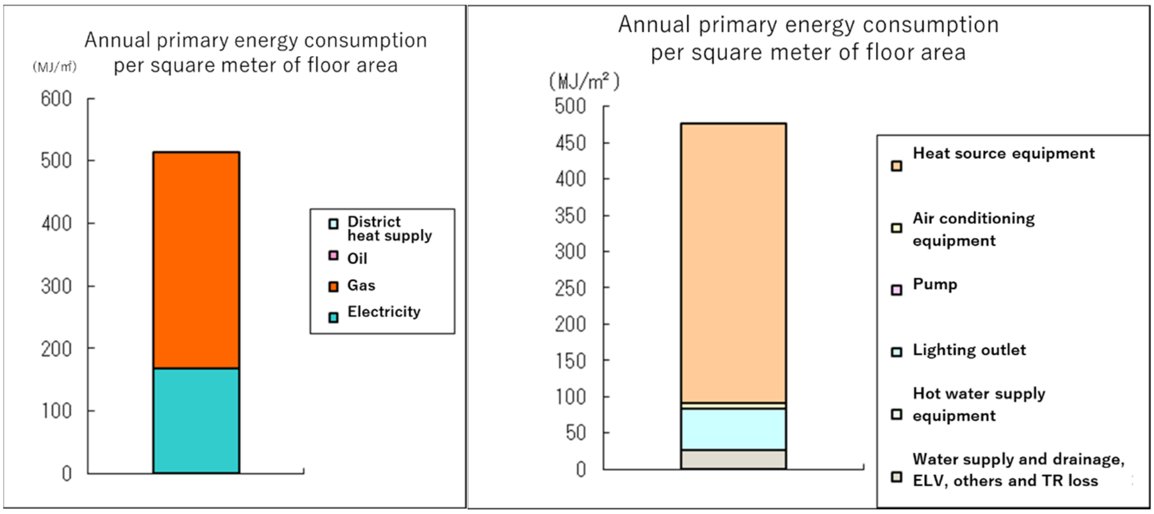


Source: JICA study team

Figure 68: ESUM input screen

3.3.2. Results of the Analysis of the Current Status of the Head Office Building

The results of the ESUM analysis for the headquarters building are shown in Figure 70. The overall energy consumption intensity is approximately 514 MJ/m2, which is less than the average for government office buildings in Japan (1,261 MJ/m2 from the website of the Energy Conservation Center). In winter, the heat load is extremely high due to 24-hour heating, indicating the importance of energy conservation measures related to heating. The current air conditioning load is 877 GJ/year for heating load and 486 GL/year for cooling load, from Figure 72.7Figure 72: Evaluation of air conditioning load and insulation thickness in ESUM



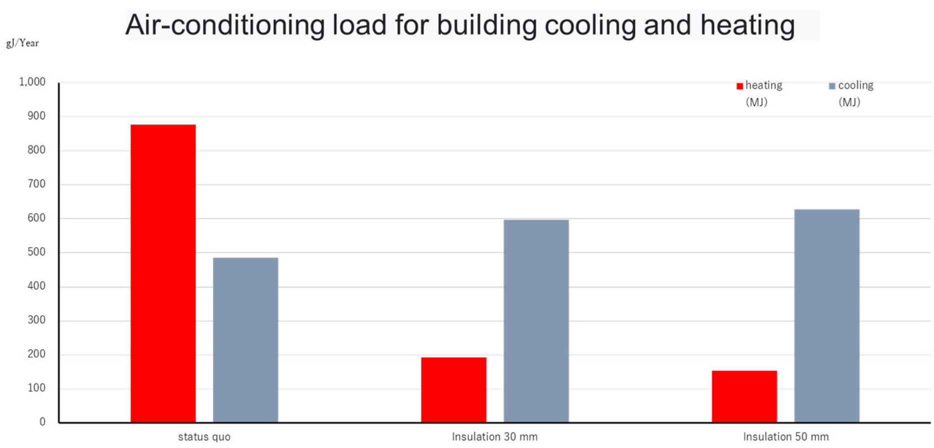
Source: JICA study team

Figure 70: ESUM output screen

3.3.3. Consideration of Heat Requirement by Insulation

Figure 72 shows the results of heat load calculations using ESUM, considering a 30 mm thick insulation attached. As the subject facility has only natural ventilation by opening and closing windows, and ventilation is not considered in the building structure, the heating load in winter is reduced to 200 GJ, or 1/4 of the heat load after insulation, assuming no ventilation in the calculation.8

If the insulation thickness is changed from 30 mm to 50 mm, a further reduction of 20% is possible. The insulation effect on the roof is particularly large, and the effect of reducing the insulation thickness to 50 mm for the roof only is significant. As heat inside the building does not escape to the outdoors owing to the external insulation, the cooling load is increased by the enhanced insulation and the heat storage effect of the bricks in the walls. The heat load is especially large in auditoriums with high crowding, and the introduction of a Japanese air conditioning system, such as a stratified air conditioning system, would be effective.



Source: JICA study team

Figure 72: Evaluation of air conditioning load and insulation thickness in ESUM

3.4. Specifications of Various Equipment (e.g., HVAC Equipment and Solar Panels)

In this section, based on the results of the studies and calculations obtained up to this point, specifications for the installed air-conditioning equipment and solar panels will be discussed. The results of the study will be used for estimated costs.

3.4.1. Air Conditioning

Head office building

Chiller: The estimated air conditioning capacity is 100 kW (18 HP x 2 units) based on the conditions in the air conditioning demonstration test (108 m2, air conditioning capacity 4 kW) and the total floor area of the headquarters building (2,742 m2).

Branch office (#8)

Central air conditioning system for buildings: Currently, only 10 people are present during the day, and only 6 packaged air conditioners are installed, so the estimated air conditioning capacity is 5 HP x 1 unit.

3.4.2. Solar Panel

Head office building

Estimated power consumption: 29 kW

(Chiller 29 kW (100 kW / 3.5 (COP)) x 80% (operating rate) + lighting (10.3 - 4.3) kW)

Based on the local contractor's survey results, the solar panels should be 1 kW/10 m2, and the installation area should be 1.5 times the panel size based on the required 45-degree installation angle. Assuming an installation rate of 70%:

Roof area required for 29 kW capacity is 622 m2 (29 kW / 1 kW /10 m2 x 1.5 / 70%)

Number of panels required: 58 (29 kW / 1 kW /10 m2 / 5 m2/panel)

Branch office (#8)

Approximate power consumption: 6 kW

(Central air conditioning system for buildings (8 HP) 5.7 kW x 80% (utilization rate) + Lighting 1.2 kW)

Required roof area for 6 kW capacity is 130 m2 (6 kW / 1 kW /10 m2 x 1.5 / 70%)

Number of panels required: 12 (6 kW / 1 kW / 10 m2 / 5 m2/panel)

3.5. Estimated Expense

The estimated construction costs required for the above ZEB measures are shown below. In this study, import tax and transportation costs related to the transportation of materials and equipment for ZEB measures were not considered, as they vary depending on the characteristics of the project.

3.5.1. Step 1: Reinforcement of Heat Insulation based on Survey Results of Local Contractors

1) Head office

Installation of window and wall insulation: $205,000
Roof insulation
PV roof installation: $50,000, Total: $255,000

2) Branch office (#8)

Installation of window and wall insulation: $38,000
Roof insulation
Wind-removal room: $5,000, Total: $43,000

3.5.2. Step 2: Installation of High-efficiency Equipment

1) Head office

Lighting cost (survey in Japan): $8,000 ($7,300 + installation cost (10%))
Solar water heater (200 L): $990 ($900 (made in China) + installation fee (10%))

2) Branch office (#8)

3.5.3. Step 3: Installation of High-efficiency Heat Pumps

1) Head office building

Heat pump chiller: $55,000 (18 HP x 2 units) (estimated from similar products in Japan)
Solar thermal system: $40,000 (20 panels + system cost)
Fan conveyor: $21,600 ($360/unit x 60 units)
Total: $116,600

2) Branch office (#8)

Central air conditioning system for buildings: $6,630 (8HP Daikin) + indoor units (4 x 2HP) (survey in Japan)
Solar thermal panels: $20,000 (10 panels + system cost)

3.5.4. Step 4: Installation of Solar Panels (Results of field survey)

1) Head office building

Solar power generation system: $42,000 ($1,500/kW (including storage battery and converter) x 28 kW)

2) Branch office (#8)

Solar power generation system: $5,400 ($900/kW (including converter) x 6 kW)

Table 59: Estimated construction cost (Unit: US$)

step	countermeasure item	(technical) specification	Head office building	Branch office (#8)
1	external insulation	Insulation thickness 30mm	Applicable	Applicable
	Roof insulation	Insulation thickness 50mm	Applicable	Applicable
	Window insulation	Vacuum Low-e Glass	Applicable	Applicable
	Windbreak room	Double doors	N/A-	Applicable
	Subtotal		255,000	43,000
2	High-efficiency LED lighting	Power consumption (72W⇒20.5W)	Applicable	N/A-
	Hot-water heater	Solar water-heater	Applicable	N/A-
	Subtotal		8,990	0
3	Air conditioner (heating/cooling)	Cooling and heating air-cooled chiller	Applicable	N/A-
	Solar water-heater	Vacuum tube method	Applicable	N/A-
	Fan convector	Temperature control method	Applicable	N/A-

	Central air conditioning system for building	High-efficiency inverter type	-	Applicable
	Subtotal		116,600	26,630
4	Solar power (generation)	Monosilicon type	Applicable	Applicable
	Power conditioners, storage batteries	6kV/220v	Applicable	0 (no energy storage)
	Subtotal		42,000	9,000
Total amount			422,590	78,630

Source: JICA study team

3.5.5. Estimation on Step-by-Step ZEB Effect

1) Prerequisite

Gas price: $0.2/m3 (international price)
Gas calorific value: 34.2 MJ/m3
Power generation efficiency: 33.3%.

from the foregoing

Gas unit price: $5.8/GJ
Unit price of electricity: $17.5/GJ

2) Step-by-step investment effect (Head office building)

Table 60: Investment returns on head office building

Step	Countermeasure item	Amount of investment (US$)	ZEB Effect			Return on investment (years)
			Effect item	Energy (GJ/year)	Amount of money ($/year)	
1	External insulation (walls and roof) Window insulation	255,000	Heating energy reduction (heat) Increase in cooling energy (electricity)	759 -45	4,403 -788	70.5
			subtotal		3,615	
2	Hot water heater High-efficiency lighting	990 8,000	Solar thermal panel installation (heat) Introduction of high-efficiency LEDs (electricity)	252 15.3	1,401 268	5.4

	subtotal	8,990	subtotal		1,669	
3	Solar water heater Chilled water heat pump Fan Convector	55,000 40,000 21,600	Heating energy reduction (heat) Cooling energy reduction (electricity) (COP: 1.15⇒3.5)	202 330	1,172 4,477	20.6
	subtotal	116,600	subtotal		5,649	
4	Solar panel installation	42,000	Electricity Energy Reduction	441	7,717	5.4
Total		422,590			18,650	22.7

Source: JICA study team

Table 61: Return on investment for branch #8

Step	Countermeasure item	Amount of investment (US$)	ZEB Effect			Return on investment (years)
			Effect item	Energy (GJ/year)	Amount of money ($/year)	
1	External insulation (walls and roof) Window insulation	43,000	Heating energy reduction (heat)	730	4,234	10.1
3	Solar thermal panels ... Birmingham	20,000 6,630	Heating energy reduction (heat) Cooling energy reduction (electricity) (COP: 1.15⇒3.5)	263 42	1,524 737	11.8
	Subtotal	26,630	subtotal		2,261	
4	Solar panel installation	9,000	Electricity Energy Reduction	68	1,190	7.6
Total		78,630			7,685	10.2

Source: JICA study team

3) ZEB Rating

The evaluation was conducted to determine whether the building could be certified as a ZEB according to the Japanese ZEB evaluation method. According to the information provided on the website of the Ministry of the Environment, ZEB shall be evaluated for buildings that achieve energy savings of 50% or more of the current energy consumption for buildings with a total floor area of 10,000 m2 or more. Although the building under study does not satisfy the total floor space requirement, it was evaluated using the same energy consumption reduction ratio index. The results are shown in Figures 73 and 74. The headquarters building achieved Nearly ZEB in the third step and satisfied ZEB in the fourth step. Branch office (#8) satisfied ZEB Ready in the first step. The figure shows that building insulation has a significant effect. This is particularly noticeable in buildings like the branch office (#8), where thermal energy consumption is greater than electrical energy consumption.

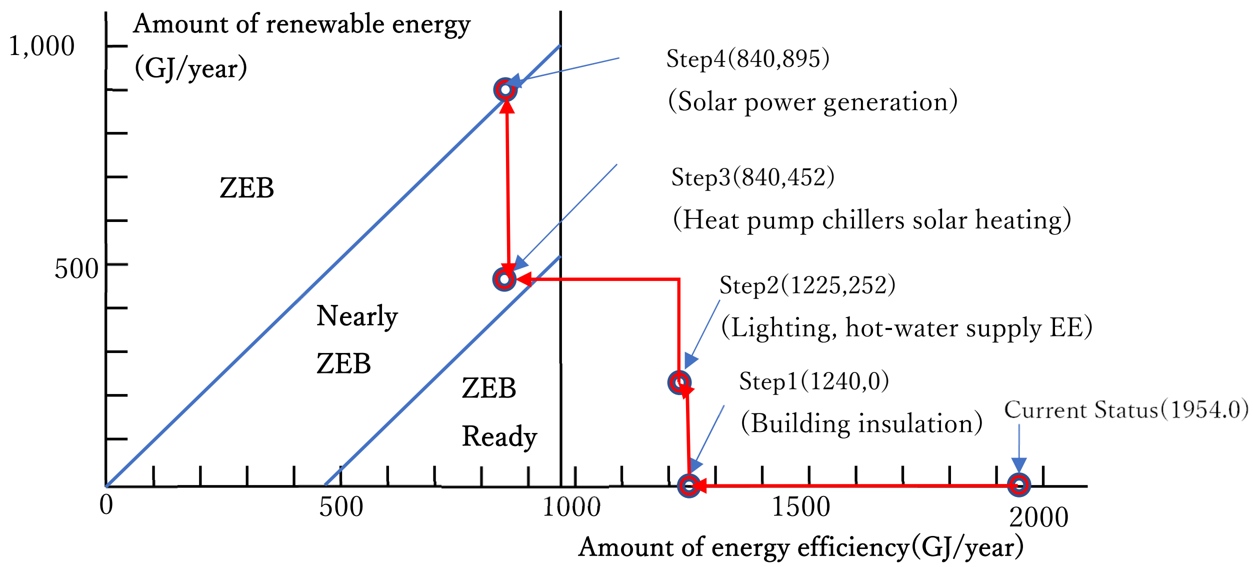


Figure 73: Evaluation of ZEB for the head office building

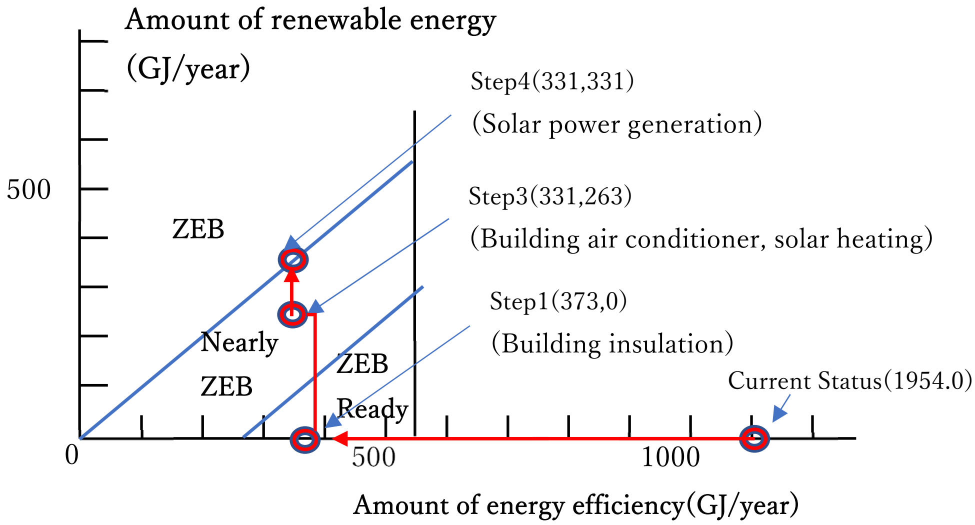


Figure 74: Evaluation of ZEB for the branch office (#8)

3.5.6. Estimated Overall ZEB Effect (national basis, company/individual basis)

1) Prerequisite

Country-based
Gas unit price: $5.8/GJ
Unit price of electricity: $17.5/GJ
Company/individual basis
Gas unit price: $1.7/GJ
Unit price of electricity: $3.16/GJ

2) Estimated effects on a national basis

i) Head office ZEB effect
Gas consumption reduction cost: $7,707/year (1,954 GJ/year x (67% + 1%) x $5.8/GJ)
Electricity consumption reduction cost: $10,942/year (1,954 GJ/year x (29% + 3%) x $17.5/GJ)

Total ZEB reduction: $18,650/year 19948; Investment: $422,590; Payback period: 22.7 years

ii) Branch office (#8) ZEB effect
Gas consumption reduction cost: $5,758 (1,103 GJ/year x (82% + 8%) x $5.8/GJ)
Electricity consumption reduction cost: $1,930 (1,103 GJ/year x (5% + 5%) x $17.5/GJ)

Total ZEB reduction: $7,685/year; Investment: $78,630; Payback period: 10.2 years

3) Estimated effects on a company and individual basis

i) Head office ZEB effect
Gas consumption reduction cost: $2,259/year (1,954 GJ/year x (67% + 1%) x $1.7/GJ)
Electricity consumption reduction cost: $1,969/year (1,954 GJ/year x (29% + 3%) x $3.16/GJ)

Total ZEB reduction: $4,235/year; Investment: $422,590; Payback period: 100 years

ii) Branch office (#8) ZEB effect
Gas consumption reduction cost: $1,687/year (1,103 GJ/year x (82% + 8%) x $1.7/GJ)
Electricity consumption reduction cost: $349/year (1,103 GJ/year x (5% + 5%) x $3.16/GJ)

Total ZEB reduction: $2,036/year; Investment: $78,630; Payback period: 38.6 years