The Sultanate of Oman

Public Authority for Electricity and Water

# Project for Energy Conservation Master Plan in the Power Sector in the Sultanate of Oman

# Final Report

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Tokyo Electric Power Company

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# Abbreviation

| | |
|---|---|
| AC | Air-Conditioner |
| AER | Authority for Electricity Regulation |
| AHU | Air Handling Unit |
| BAU | Business as Usual |
| BEMS | Building Energy Management System |
| BOO | Build Own Operate |
| BST | Bulk Supply Tariff |
| CCGT | Combined Cycle Gas Turbine |
| CDM | Clean Development Mechanism |
| CEC | Coefficient of Energy Consumption |
| CFL | Compact Fluorescent Lamp |
| C/P | Counterpart |
| DisCo(s) | Distribution Company (-ies) |
| DNA | Designated National Authority |
| DPC | Dhofar Power Company |
| DSM | Demand Side Management |
| EC | European Commission |
| EE | Energy Efficiency |
| EE&C | Energy Efficiency and Conservation |
| EER | Energy Efficiency Rate |
| ECCJ | Energy Conservation Center, Japan |
| EHC | Electricity Holding Company |
| EIA | Environment Impact Assessment |
| EMS | Energy Management System |
| ESCO | Energy Service Company |
| EU | European Union |
| F/S | Feasibility Study |
| GCC | Gulf Cooperation Council |
| GDE | Gross Domestic Expenditure |
| GDP | Gross Domestic Product |
| GHG | Greenhouse Gas |
| GPRS | General Packet Radio Service |
| GT | Gas Turbine |
| HCP | Higher Council of Planning |
| HEMS | Home Energy Management System |
| HQ | Headquarters |
| IEA | International Energy Agency |
| IMF | International Monetary Fund |

| | |
|---|---|
| IPCC | Intergovernmental Panel on Climate Change |
| IPP | Independent Power Producer |
| IWPP | Independent Water and Power Producer |
| ISO | International Organization for Standardization |
| JICA | Japan International Cooperation Agency |
| LV | Low Voltage |
| MECA | Ministry of Environment and Climate Affairs |
| MEDC | Muscat Electricity Distribution Company |
| MESL | Minimum Energy Standards and Labeling System |
| METI | Ministry of Economy, Trade and Industry (Japan) |
| MDMS | Meter Data Management System |
| MIS | Main Interconnected System |
| MJEC | Majan Electricity Company |
| MM | Muscat Municipality |
| MOCI | Ministry of Commerce and Industry |
| MOG | Ministry of Oil and Gas |
| MONE | Ministry of National Economy |
| MRMWR | Ministry of Regional Municipalities and Water Resources |
| MV | Middle Voltage |
| MZEC | Mazoon Electricity Company |
| NEEC | National Energy Efficiency and Conservation Center |
| O&M | Operation and Maintenance |
| OCGT | Open Cycle Gas Turbine |
| OES | Oman Electrical Standards |
| OETC | Oman Electricity Transmission Company |
| OPEC | Organization of the Petroleum Exporting Countries |
| OPWP | Oman Power and Water Procurement Company |
| PAEW | Public Authority for Electricity and Water |
| PAL | Perimeter Annual Load |
| PDO | Petroleum Development Oman |
| PoA | Programme of Activities |
| PPA | Power Purchase Agreement |
| PPP | Purchasing-Power-Parity |
| PPS | Power Producer and Supplier |
| QNB | Qatar National Bank |
| RAECO | Rural Area Electricity Company |
| R&D | Research and Development |
| RO | Riyal Oman |
| S/C | Steering Committee |
| SCADA | Supervisory Control and Data Acquisition |

| | |
|---|---|
| SEC | Saudi Electricity Company |
| SEEC | Saudi Energy Efficiency Center |
| SQU | Sultan Qaboos University |
| S/W | Scope of Works |
| ST | Steam Turbine |
| TEPCO | Tokyo Electric Power Company |
| TOU | Time of Use |
| UK | United Kingdom |
| UNFCCC | United Nations Framework Convention on Climate Change |
| VAV | Variable Air Volume |
| VWV | Variable Water Volume |
| WACC | Weighted Average Cost of Capital |
| W/C | Working Committee |
| WTI | West Texas Intermediate |

# Executive Summary

## 1. Introduction

### 1.1 Background of the Study

In the Sultanate of Oman (hereinafter "Oman"), electric power demand has been rising rapidly due to recent rapid economic and population growth. Especially, the promotion of the special economic zone to break the dependency on the oil industry is anticipated to accelerate electric power demand growth.

Although Oman has tried to secure power resources in response to electric power demand growth, the supply-demand balance has worsened recently and was forced to implement planned blackouts. In addition, 90 % of power resources are gas turbine generation using natural gas, which causes the scarcity of the domestic natural gas supply.

In Oman, there hardly any measures on the demand side. Current activities are limited to small scale efforts such as Energy Efficiency and Conservation (EE&C) promotion activities led by the government or by distribution companies. Thus, comprehensive EE&C measures are required in conserving power consumption and load leveling.

Under these circumstances, the Public Authority for Electricity and Water (hereinafter PAEW) which is the counterpart (C/P) needs to establish a national energy efficiency and conservation plan in the power sector and requested that Japan provide research support.

The Project for the Energy Conservation Master Plan in the Power Sector in the Sultanate of Oman (hereinafter the "Study") aims to create an EE&C master plan regarding electric power towards 2023 with objectives to institutionalize EE&C policy in the power sector and promote EE&C including improving efficiency on the demand side and conserving electric power.

### 1.2 Scope and Objective of the Study

The Study will be conducted based on the S/W signed between PAEW and the Japan International Cooperation Agency (hereinafter "JICA") in October, 2011. The Study period is from February, 2012 to February, 2013 and encompasses all of Oman.

The Study is conducted to propose EE&C policy in Oman's power sector and create a master plan regarding electric power towards 2023 in order to promote EE&C including improving power efficiency on the demand side and conserving electric power.

### 1.3 Workflow of the Study

The study team (hereinafter "JICA Study Team") conducts the study according to the workflow shown below.

**1st Phase: Current Situation Analysis**

**1st – 3rd Local Survey**

**Introduction of Japanese EE&C Measures**
- Introduction of Japanese EE&C measures at the workshop (Global measures are partially introduced.)

**Grasping the Current situation of Policy and Measures**

**(Confirmation of Upstream Policy)**
- Energy, natural resources, and power policy, and policy for climate change
- EE&C policy

**(Confirmation of Existing EE&C Measures)**
- Overview, budget, implementation structure etc.
- Electricity tariff system
- Relevant laws and regulations

**(Confirmation of General Information)**
- Social and economic situation, development plan, natural environment, fuel prices etc

**Analyzing Power System**

**(Review of Existing System)**
- Existing power generation structure, power generation amount, generation efficiency
- Power supply and demand, power daily curve
- Power consumption and demand analysis
- Operation of power generation plants
- Generation cost analysis (construction costs, fuel costs, O&M costs etc.)
- Transmission and distribution facility and its losses

**(Review of Future Power Development Plan)**
- Receipt and review of the power demand forecast to 2035
- Receipt of the power development plan etc.

**Market Research for High Efficiency Appliances (JICA Study Team) and EE&C Awareness Survey (Local Consultant)**
- Interview survey to large retail shops
- Procurement of local consultant and supervising the survey

**2nd Phase: Consideration and Proposal on EE&C Measures**

**2nd – 4th Local Survey**

**Discussion Step 1**

**(Coordination of Concepts for Each Measure)**
- Presentation of the concepts of each measure to be implemented in Oman
- Collection of opinions at workshops and analysis of comments

**(Analysis of the Status of Each Measure)**
- Confirmation of the status of measures to be considered in Oman: whether it should be a mandatory program or a voluntary program.

**Discussion Step 2**

**(Consideration of Measure Priorities)**
- Consideration of criteria to decide priorities
- Evaluation of the priorities of EE&C measures

**(Discussion of the Depth of Studying according to the Priorities)**
- Discussion of the depth of studying according to the priorities (mandatory or voluntary program)

**Discussion Step 3**

**(Discussion of Contents of Each Measure and Creating an Implementation Plan)**
- Starting the discussion after clarifying the discussion points according to design process
- Creating an implementation plan with the design items following the design discussion
- Feedback on the market survey results and an awareness survey of the scheme design

**3rd Phase: Creating an EE&C Master Plan**

**4th – 5th Local Survey**

**Creating a Master Plan**

**(Roadmap to Indicate Overall Implementing Policy)**
- Proposal of a roadmap with an overall schedule and milestones
- Proposal of EE&C center as an implementing agency in terms of structure and operation
- Collection of workshop opinions at workshops

**Economic Analysis (Evaluation)**

**(Benefit Estimation)**
- Estimating benefits by EE&C based on demand forecast, unit generation cost, generation efficiency etc.

**(Cost Estimation)**
- Estimating planning and operational costs of each measure and investment costs by the private sector

**(Validation of Each Measure)**
- Validation in consideration with cost-benefits, economic impact (industrial development) etc.

**Proposal of Action Plans and Recommendations**

**(Study Items and Implementation Plan for the Future)**
- Identifying further necessary study items and an implementation proposal
- Capacity building of human resources and its implementation plan etc.

**Work Flow of the Study**

## 2. Proposed EE&C Measures

### 2.1 Outline of the EE&C Measures

Having screened the measures through a simple cost/benefit analysis, this Study proposed the following measures as prioritized measures.

**Outline of the Proposed EE&C Measures**

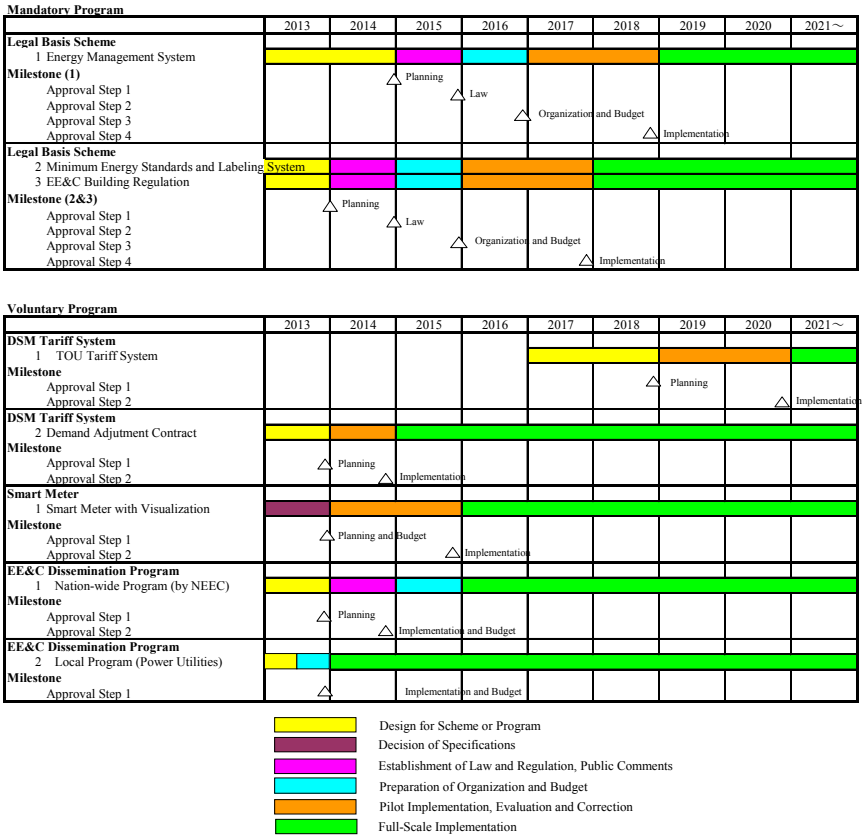
| | Scheme | Summary | Target |
|---|---|---|---|
| 1 | Energy Management System (EMS) | • Periodical reporting system of energy consumption and EE&C plan from designated consumers.<br>• Assignment of Energy Manager (qualified by the national qualification) on site<br>• Mandatory energy audit for designated consumers | • Factories and buildings which use a certain amount of energy consumption (electricity and fuel) in Industry, Commercial and Government sectors |
| 2 | Minimum Energy Standards and Labeling System (MESL) | • Minimum standards for designated products<br>• Display of comparative star according to an efficiency criteria | • AC, Refrigerator & Freezer, Lamp, Washing Machine |
| 3 | EE&C Building Regulation (EBR) | • Permission of construction plan including insulation and energy efficiency equipment | • Buildings and houses which use a certain amount of floor area |
| 4 | DSM Tariff System (DST) | • Demand Adjustment Contact (Discount tariff for power reduction based on the requests from power utilities)<br>• TOU Tariff System (Optional tariff which has high price in peak time and low price in off-peak time) | • Large electricity consumers who wish to apply for these optional tariffs |
| 5 | Smart Meter with Visualization (SM) | • Smart meter with visualization of electricity consumption to improve EE&C awareness of consumers | • All the sectors |
| 6 | EE&C Dissemination Program (EDP) | • Nation-wide dissemination programs (Campaign, subsidy, award, awareness survey, etc.) | • All the sectors |

### 2.2 Implementation Plan of the EE&C Measures

(1) Implementation Plan

The following points were considered for creating the following schedule.

- Each EE&C measure basically implements per the order of the detailed scheme design, pilot implementation and full-scale implementation.
- A new organization, National EE&C Center (NEEC), is proposed to be established for the executing agency for the Energy Management System and the EE&C dissemination programs. NEEC is planned to start in 2016, and prior to that time, PAEW is expected, as a preparatory body, to plan and prepare the scheme and programs.
- The mandatory programs such as Energy Management System, Minimum Energy Standards and Labeling System, EE&C Building Regulation and the establishment of a new organization require a legal basis and a one-year preparation period must be considered.




**Overall Schedule and Milestone**

(2) Estimation of the Governmental Costs (Administration Costs)

The implementation schedule and budget plan of each EE&C measures are proposed as follows (the annual schedule after 2022 is the same as 2021).

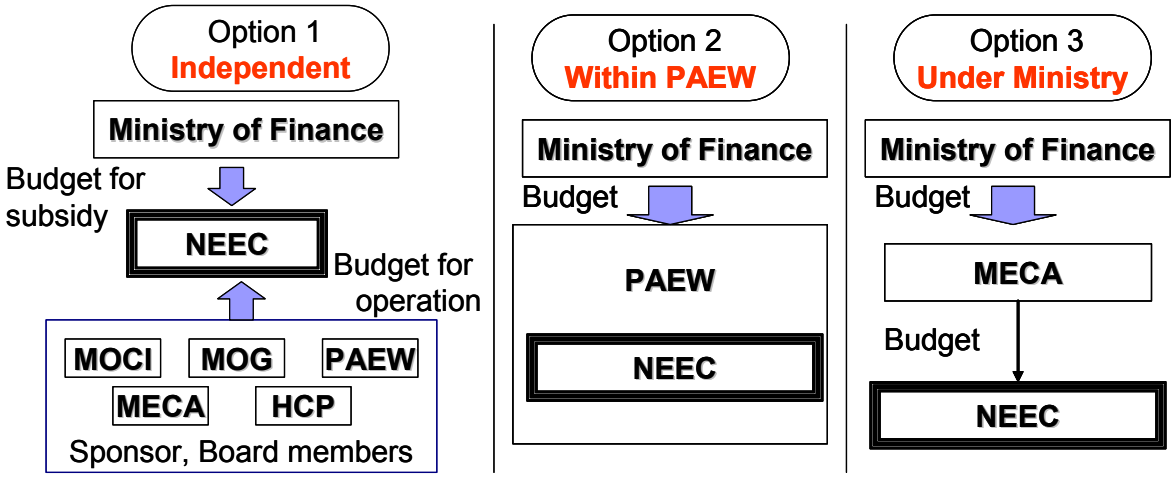
**Implementation Cost of the EE&C Measures** Unit: RO

| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|
| **Energy Management System (EMS)** | | | | | | | | | |
| PAEW | 196,800 | 196,800 | 296,800 | 346,800 | | | | | |
| NEEC | | | | | 110,000 | 110,000 | 117,500 | 117,500 | 117,500 |
| **Minimum Energy Standards and Labeling (MESL)** | | | | | | | | | |
| MOCI | 46,800 | 196,800 | 96,800 | 592,800 | 592,800 | 222,800 | 222,800 | 222,800 | 222,800 |
| **EE&C Building Regulation (EBR)** | | | | | | | | | |
| NCBC | 146,800 | 146,800 | 166,800 | | | | | | |
| Muscat Municipality | | | | 110,700 | 110,700 | | | | |
| All the Municipalities | | | | | | 498,600 | 498,600 | 498,600 | 498,600 |
| MOCI | | | 15,600 | 15,600 | 15,600 | 15,600 | 15,600 | 15,600 | 15,600 |
| **DSM Tariff System (DTS)** | | | | | | | | | |
| AER | 158,600 | 158,600 | 62,400 | | 158,600 | 158,600 | 158,600 | 158,600 | 62,400 |
| **Smart Meter (SM)** | | | | | | | | | |
| EHC | 96,800 | 96,800 | 49,300 | 2,500 | 2,500 | 50,000 | 2,500 | 2,500 | 2,500 |
| **EE&C Dissemination Program (EDP)** | | | | | | | | | |
| PAEW | 46,800 | 66,800 | 46,800 | | | | | | |
| NEEC | | | | 2,318,600 | 1,304,200 | 1,304,200 | 1,304,200 | 1,304,200 | 1,304,200 |
| **Total Cost (without Subsidy)** | 692,600 | 862,600 | 734,500 | 3,387,000 | 2,294,400 | 2,359,800 | 2,319,800 | 2,319,800 | 2,223,600 |
| Subsidy for EMS | | | | | 183,398 | 183,398 | 183,398 | 183,398 | 183,398 |
| Subsidy for MESL | | | | | | 5,250,000 | 5,250,000 | | |
| **Total Cost (with Subsidy)** | 692,600 | 862,600 | 734,500 | 3,387,000 | 2,477,798 | 7,793,198 | 7,753,198 | 2,503,198 | 2,406,998 |

(3) Proposal of a New Implementation Organization

The Study proposed to establish a new implementation agency, National EE&C Center: NEEC, which can manage the targets of electricity and fuel, as an executing agency for the EE&C dissemination programs, subsidy provision, and Energy Management System.

The following three options were proposed as the organization structure.




**Three Options for the Implementation Structure of NEEC**

## 3. Cost Benefit Analysis

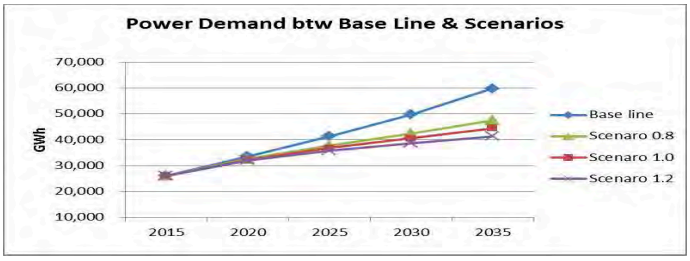
### 3.1 Effect Analysis by EE&C Measure

The proposed EE&C measures are expected to reduce the power demand, peak demand and

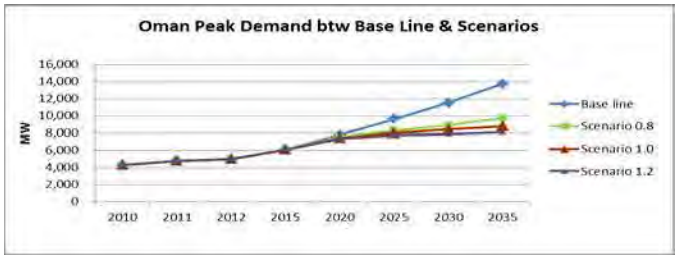
primary energy consumption in the whole Oman as shown in the following estimated scenarios.

**Baseline and EE&C Scenarios**

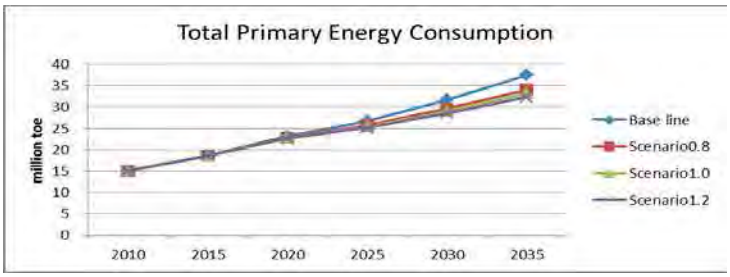
| Scenario Name | EE&C Pre-condition |
|---|---|
| Baseline | EE&C measures are not introduced (forecasted by the JICA Study Team) |
| Scenario 1.0 | EE&C measures are introduced and the impact is 100 % as expected. |
| Scenario 0.8 | EE&C measures are introduced and the impact meets 80 % of the expectations. |
| Scenario 1.2 | EE&C measures are introduced and the impact exceeds expectations. (120 %) |




**EE&C Scenarios in Power Demand (Net)**




**EE&C Scenarios in Peak Demand (Net)**




**EE&C Scenarios in Primary Energy Consumption**

### 3.2 Estimation of Total Costs for the Measures

Additional investment costs and government administration costs for all the measures are summarized as follows.

**Total Costs for All EE&C Measures** **Unit: million US$**

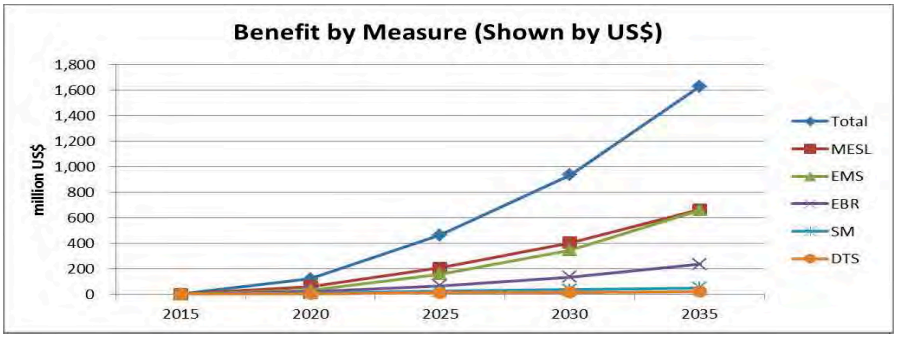
| Measures | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2025 | 2030 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | Investment | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 136.9 | 233.1 | 243.4 | 298.2 | 341.8 | 405.3 |
| | Admi. cost | 1.8 | 2.2 | 1.9 | 8.8 | 6.4 | 20.2 | 20.1 | 6.5 | 5.8 | 5.8 | 5.8 |
| | Total | 1.8 | 2.2 | 1.9 | 8.8 | 6.4 | 157.2 | 253.3 | 249.9 | 304.0 | 347.6 | 411.1 |
| EMS | Investment | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 91.6 | 97.1 | 124.5 | 158.3 | 199.4 |
| | Admi. cost | 0.5 | 0.5 | 0.8 | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| | Subtotal | 0.5 | 0.5 | 0.8 | 0.9 | 0.8 | 0.8 | 92.4 | 97.9 | 125.3 | 159.1 | 200.1 |
| MESL | Investment | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 87.4 | 88.0 | 88.6 | 92.9 | 86.4 | 88.8 |
| | Admi. cost | 0.1 | 0.5 | 0.3 | 1.5 | 1.5 | 14.2 | 14.2 | 0.6 | 0.6 | 0.6 | 0.6 |
| | Subtotal | 0.1 | 0.5 | 0.3 | 1.5 | 1.5 | 101.6 | 102.2 | 89.2 | 93.5 | 87.0 | 89.4 |
| EBR | Investment | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 49.5 | 53.5 | 57.7 | 80.7 | 97.1 | 117.2 |
| | Admi. cost | 0.4 | 0.4 | 0.5 | 0.3 | 0.3 | 1.3 | 1.3 | 1.3 | 1.0 | 1.0 | 1.0 |
| | Subtotal | 0.4 | 0.4 | 0.5 | 0.3 | 0.3 | 50.8 | 54.8 | 59.0 | 81.7 | 98.1 | 118.2 |
| DTS | Investment | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Admi. cost | 0.4 | 0.4 | 0.2 | 0.0 | 0.4 | 0.4 | 0.4 | 0.4 | 0.0 | 0.0 | 0.0 |
| | Subtotal | 0.4 | 0.4 | 0.2 | 0.0 | 0.4 | 0.4 | 0.4 | 0.4 | 0.0 | 0.0 | 0.0 |
| SM | Investment | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Admi. cost | 0.3 | 0.3 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Subtotal | 0.3 | 0.3 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| EDP | Investment | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Admi. cost | 0.1 | 0.2 | 0.1 | 6.0 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 |
| | Subtotal | 0.1 | 0.2 | 0.1 | 6.0 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 |

### 3.3 Estimation of Total Benefits by the Measures

The effects on reduction of consumption of natural gas and crude oil and reduction of construction of power station are converted into monetary effects as follows.

**EE&C Effects by Measure**

| Effects | Unit | 2015 | 2020 | 2025 | 2030 | 2035 |
|---|---|---|---|---|---|---|
| EMS | million US$ | 0 | 30 | 158 | 346 | 660 |
| MESL | million US$ | 0 | 61 | 208 | 404 | 664 |
| EBR | million US$ | 0 | 18 | 65 | 135 | 234 |
| DTS | million US$ | 0 | 3 | 11 | 16 | 22 |
| SM | million US$ | 0 | 7 | 24 | 35 | 50 |
| Total effects of the above | million US$ | 0 | 119 | 465 | 936 | 1,631 |



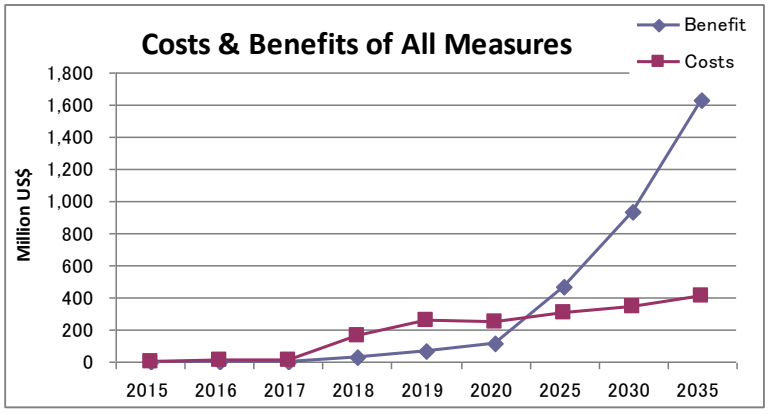

**EE&C Monetary Benefit Trends by Measure (in US$)**

### 3.4 Cost Benefit Analysis for All EE&C Measures

The net benefit is calculated by the expression to subtract the total costs from the monetary benefits. As for the results, the Internal Rate of Return (IRR) for all measures is 25 %, and the Cost & Benefit ratio (B/C ratio) is 2.1 times (2013～2035).

**Cost and Benefit Analysis for All EE&C Measures**

| Items | Unit | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2025 | 2030 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Benefit | million US$ | 0 | 0 | 1 | 4 | 5 | 24 | 64 | 118 | 464 | 935 | 1,630 |
| Investment cost | million US$ | 0 | 0 | 0 | 0 | 0 | 137 | 233 | 243 | 298 | 342 | 405 |
| Admi cost | million US$ | 1.8 | 2.2 | 1.9 | 8.8 | 6.4 | 20.2 | 20.1 | 6.5 | 5.8 | 5.8 | 5.8 |
| Balance | million US$ | -2 | -2 | -1 | -5 | -2 | -133 | -189 | -132 | 160 | 588 | 1,219 |
| IRR | % | 25% | | B/C | 2.1 | times | | | | | | |




**Cost and Benefit towards 2035**

## 4. Recommendation

From the results of the costs/benefit analysis, the proposed EE&C measures are obviously beneficial for Oman. Besides, savings of domestic resources contribute to national energy security. Thus the EE&C policy should be further promoted for the future of Oman.

Out of the proposed EE&C measures, the Minimum Energy Standards and Labeling System (MESL) and EE&C Building Regulation (EBR) are highly recommended because these schemes are expected to be effective in reducing the electricity consumption of air conditioners which occupies about 40 % of total consumption (about 60 % during the summer peak period). In fact, similar schemes have been already adopted or planned to be introduced in the Middle East countries. From this perspective, the implementation of these measures will be prioritized.

The action plans for the preparation and implementation of each EE&C measure were also proposed. To steadily achieve the action plans, PAEW, which was a counterpart of the Study, is expected to continue to play a main role as the driving force. Besides, the proposed EE&C measures are related to some ministries, agencies and companies, and solid coordination between such stakeholders is crucially required. In this Study, cross-sectional Sub-Committees

were established to discuss the EE&C measures and it is expected that the committees will also continue to be involved in the preparation and implementation of each EE&C measure. The JICA Study Team recommended that PAEW together with the Sub-Committees follow up on this master plan even after completion of the Study. .

# Chapter 1 Introduction

## 1.1 Background of the Study

In the Sultanate of Oman (hereinafter "Oman"), electric power demand has been rising rapidly due to recent rapid economic and population growth. Especially, the promotion of the special economic zone to break the dependency on the oil industry is anticipated to accelerate electric power demand growth.

Although Oman has tried to secure power resources in response to electric power demand growth, the supply-demand balance has worsened recently and was forced to implement planned blackouts. In addition, 90 % of power resources are gas turbine generation using natural gas, which causes the scarcity of the domestic natural gas supply.

In Oman, there hardly any measures on the demand side. Current activities are limited to small scale efforts such as Energy Efficiency and Conservation (EE&C) promotion activities led by the government or by distribution companies. Thus, comprehensive EE&C measures are required in conserving power consumption and load leveling.

Under these circumstances, the Public Authority for Electricity and Water (hereinafter PAEW) which is the counterpart (C/P) needs to establish a national energy efficiency and conservation plan in the power sector and requested that Japan provide research support.

The Project for the Energy Conservation Master Plan in the Power Sector in the Sultanate of Oman (hereinafter the "Study") aims to create an EE&C master plan regarding electric power towards 2023 with objectives to institutionalize EE&C policy in the power sector and promote EE&C including improving efficiency on the demand side and conserving electric power.

## 1.2 Scope and Objective of the Study

### 1.2.1 Scope of the Study

The Study will be conducted based on the S/W signed between PAEW and the Japan International Cooperation Agency (hereinafter "JICA") in October, 2011. The Study period is from February, 2012 to February, 2013 and encompasses all of Oman.

### 1.2.2 Objective

The Study is conducted to propose EE&C policy in Oman's power sector and create a master plan regarding electric power towards 2023 in order to promote EE&C including improving power efficiency on the demand side and conserving electric power.

### 1.2.3 Scope of Work

The contents of the scope of work are as follows.

(1) Current Situation Analysis (Phase 1)

(a) Grasping the Current Situation and Identifying Issues regarding the Energy and Power Fields

- Social and economic situation and the development plan
- Natural environment
- National policy on energy and domestic natural energy resources
- Power policy, laws and regulations, organizational structure
- Power development plan
- Power supply and demand situation
- Operational situation of existing power generation plants
- Power consumption analysis (survey of power consumption pattern in the industrial sector, buildings and residential sector)
- Power demand load analysis (survey of power load factor and power demand patterns of the day, season and areas)
- Fuel prices trend
- Electricity tariff system

(b) Grasping the Current Situation and Identifying Issues in the EE&C Field

- EE&C policy, laws and regulations, organizational structure
- Policy on climate change (mitigation measures)
- Current situation under which EE&C measures implemented
- Market survey on the spread of energy efficient equipment
- EE&C awareness survey (local consultant work)

(c) Confirmation of the Power Demand Forecast towards 2035

- Review of the power demand forecast by PAEW and the power load pattern
- Confirmation of forecast conditions

(2) Consideration and Proposal of EE&C Measures (Phase 2)

Regarding the EE&C measures shown below, Japanese cases will be introduced. As for the measures to be implemented in Oman, an outline of the measures, implementation structure, implementation plan etc. will also be proposed.

- Electricity tariff system
  - Introduction of the Japanese electricity tariff system
  - Proposal on the electricity tariff system aimed at EE&C and the peak-cut with the TOU (Time of Use) tariff and demand adjustment contract

- Energy Management System (EMS)
  - Introduction of Japanese energy management system
  - Proposal of the energy management system adjusted for Oman
- Minimum Energy Standards and Labeling System (MESL)
  - Introduction of Japanese minimum energy standards and the labeling system
  - Proposal of minimum energy standards and labeling system adjusted for Oman
- EE&C dissemination activities and the educational system
  - Introduction of Japanese EE&C dissemination activities and EE&C education
  - Proposal of EE&C dissemination activities and the EE&C educational system adjusted for Oman
- EE&C in buildings
  - Introduction of Japanese EE&C technology and EE&C building regulation
  - Proposal of EE&C building regulation adjusted for Oman
- Power meter monitoring
  - Introduction of Japanese power meters and automated monitoring
  - Proposal of power monitoring measures
- Automatic control system of electric appliances
  - Introduction of Japanese automatic control system of building and homes
  - Proposal of automatic control system adjusted for Oman
- EE&C Center
  - Introduction of Energy Conservation Center, Japan
  - Proposal of organizational structure for EE&C Center for Oman

(3) Creating an EE&C Master Plan (Phase 3)

- Comparison among EE&C measures and deciding priorities
- Creating an EE&C roadmap towards 2023
- Proposal of an organizational structure and implementation plan for each EE&C measure
- Consideration of the costs and benefits of each EE&C measure

## 1.3 Implementation Schedule

### 1.3.1 Work Flow of the Study

The study team (hereinafter "JICA Study Team") conducts the study according to the workflow shown below.

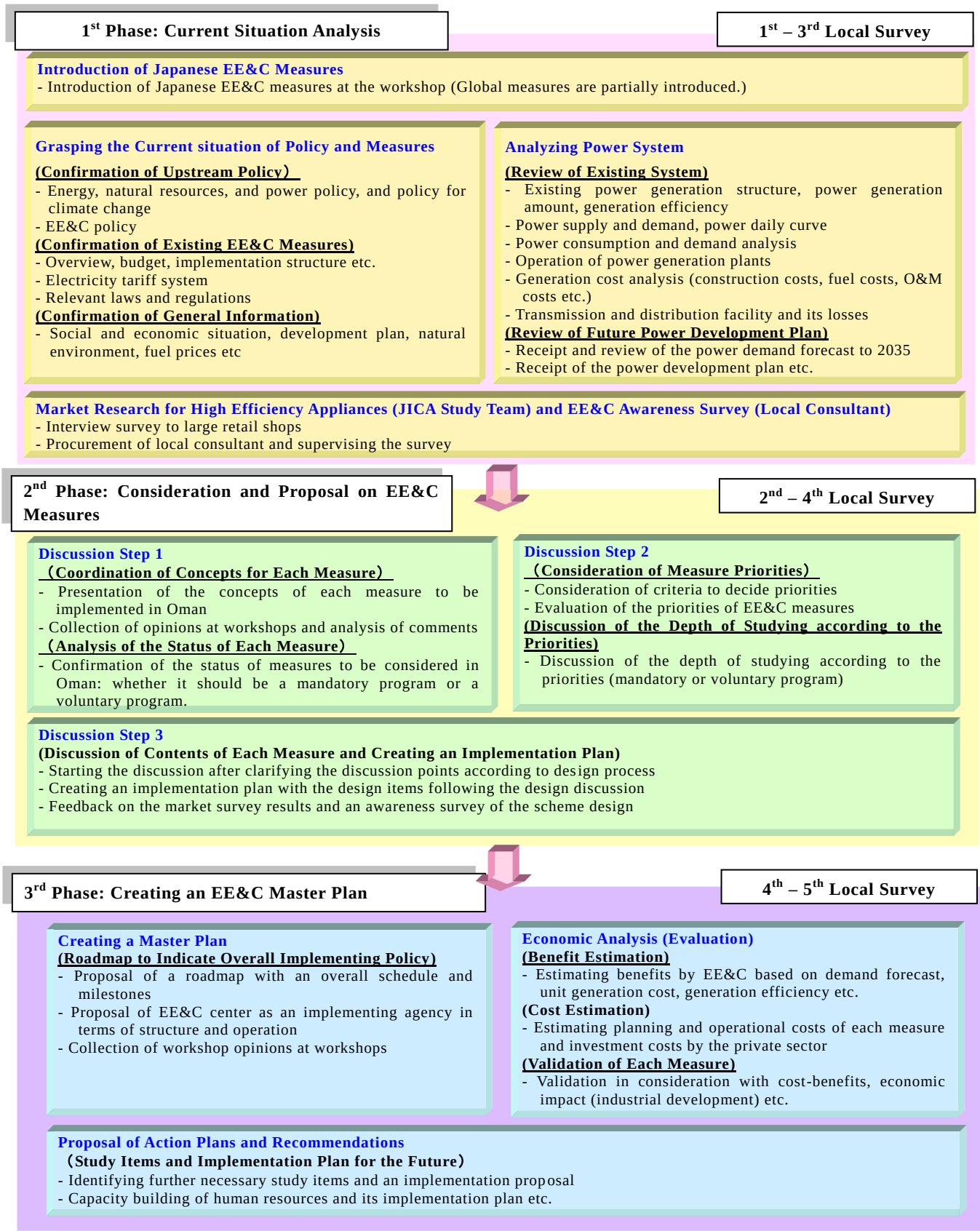



**Figure 1- 1 Work Flow of the Study**

## 1.3.2 Work Schedule

Overall work schedule to conduct the aforementioned work is as follows.

**Table 1- 1 Work Schedule (1/2)**

| | 2012 | 2013 |
|---|---|---|
| **Current Situation Analysis (Phase1)**<br><br>**1. Grasping Current Situation of Policy and Measures**<br>(1) Confirmation of Upstream Policy<br>• Energy, natural resources and power policy and policy for climate change<br>• Confirmation of EE&C policy<br>(2) Confirmation of Existing EE&C Policy<br>• Overview, budget, implementation structure<br>• Electricity tariff system<br>• Relevant laws and regulations<br>(3) Confirmation of General Information<br>• Social and economic situation, development plan, natural environment, fuel prices, power sector structure etc.<br>**2. Analyzing Power System**<br>(1) Review of Existing System<br>• Existing power generation structure, power generation amount, generation efficiency<br>• Power supply and demand, power daily curve<br>• Power consumption and demand analysis<br>• Operation of power generation plants<br>• Generation cost analysis (construction costs, fuel costs, O&M costs etc.)<br>• Transmission and distribution facility and its losses<br>(2) Review of Future Power Development Plan<br>• Receipt and review of power demand forecast to 2035<br>• Receipt of power development plan and power generation cost forecast of the future<br>**3. Introduction of Japanese EE&C Measures**<br>• Introduction of Japanese EE&C measures at a workshop (Global measures are partially introduced.)<br>**4. Market Survey of High Efficient Appliances and EE&C Awareness Survey**<br>• Interview survey to large retail shops<br>• Procurement of local consultant and survey supervision | | |
| **Local Survey** | | |
| **Reports** | Ic/R, It/R, Pr/R, Df/R | F/R |

**Table 1- 2 Work Schedule (2/2)**

| | 2012 | 2013 |
|---|---|---|
| **Consideration and Proposal on EE&C Measures (Phase 2)**<br><br>**1. Discussion Step 1**<br>(1) Coordination of Concepts of Each Measure<br>• Presentation of concepts of each measure to be implemented in Oman<br>• Collection of opinions and analysis of comments<br>(2) Analysis of Status of Each Measure<br>• Confirmation of the status of measures to be considered in Oman: whether it should be a mandatory program or a voluntary program<br>**2. Discussion Step 2**<br>(1) Consideration of Priorities of Measures<br>• Consideration of criteria to decide priorities<br>• Evaluation of the priorities of EE&C measures<br>(2) Discussion of the Depth of Studying according to the Priorities<br>• Discussion of the depth of studying according to the priorities<br>**3. Discussion Step 3**<br>(1) Discussion of Contents of Each Measure and Creating Implementation Plans<br>• Starting discussions after clarifying discussion points according to design process<br>• Creating implementation plans with the design items after the design discussion<br>• Feedback of the market survey results and an awareness survey to the scheme design | | |
| **Creating an EE&C Master Plan (Phase 3)**<br><br>**1. Creating a Master Plan**<br>(1) Roadmap to Indicate Overall Implementation Policy<br>• Proposal of a roadmap with overall schedule and milestones<br>• Proposal of EE&C center as an implementing agency in terms of structure and operations<br>• Collection of opinions at workshops<br>**2. Economic Analysis (Evaluation)**<br>(1) Benefits Estimation<br>• Estimating benefits by EE&C based on demand forecast, unit generation cost, generation efficiency etc.<br>(2) Cost Estimation<br>• Estimating planning and operation costs of each measure and investment costs by the private sector<br>(3) Validation of Each Measure<br>• Validation in consideration with cost-benefit, economic impact (industrial development) etc.<br>**3. Proposal of Action Plans and Recommendations**<br>(1) Study Items and Implementation Plan for the Future<br>• Identifying further necessary study items and implementation proposal<br>• Capacity building of human resources and its implementation plan etc. | | |
| **Local Survey** | | |
| **Reports** | | |

Ic/R It/R Pr/R Df/R F/R

## 1.4 Study Team Structure

The JICA Study Team can be divided into two: one mainly holds discussions with power utilities and the other discusses EE&C measures with relevant governmental agencies. Thus, it consists of two sub-teams, one a power study team and the other an EE&C measures team.

C/P is PAEW and the JICA Study Team discusses matters with the Working Committee (W/C) which is led by PAEW.

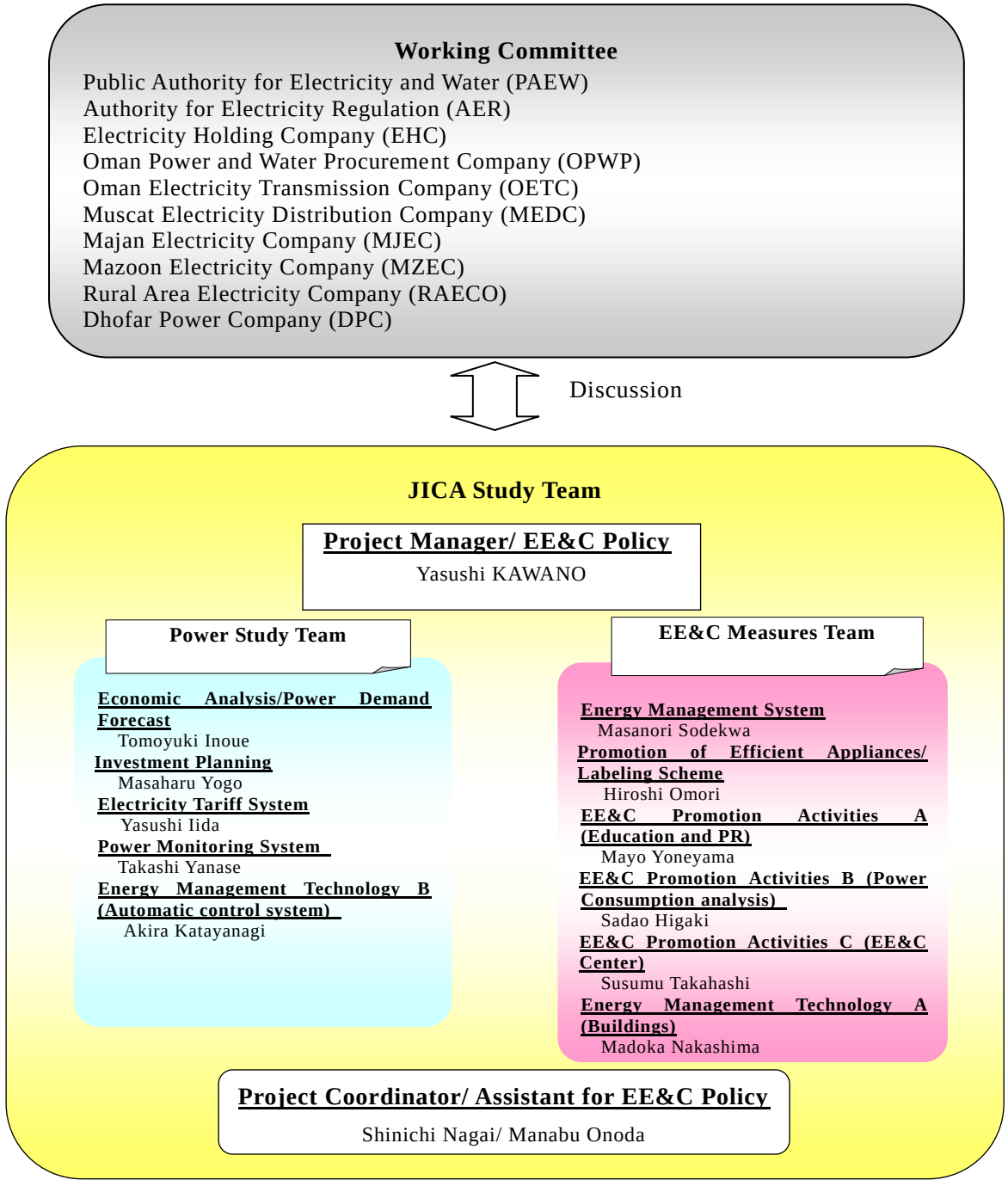



**Figure 1- 2 Study Team Structure**

## 1.5 Basic Approach for Current Situation Analysis

In the current situation analysis, various basic surveys are conducted for studying EE&C measures for Oman. All of the basic surveys collect current data and information, and then the JICA Study Team analyses and provides feedback. This feedback is used for the optimization of each EE&C measure or validation of economic effects. The basic approach is described below.

### 1.5.1 Generation Cost Analysis

(1) Objective

The effects of the energy conservation in the power sector are attributed to the fuel savings and the decrease of the capacity cost of generators. The generation cost is estimated through the basic investigations for the evaluation of the effects of taking the measures for energy conservation.

(2) Methodology

In general, the energy conservation in the power sector can reduce the power energy consumption in the manner of three patterns (Base Down, Peak Shift and Peak Cut) shown in the following figure. Saving energy consumption reduces the fuel consumption of the existing generators. On the other hand, shifting (or cutting) the maximum power outputs of generators during the peak period of time has the effect of reducing future investments into power stations.

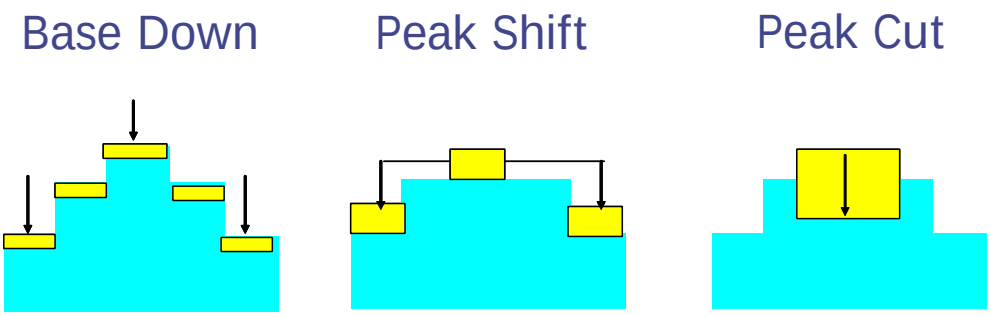



**Figure 1- 3 Patterns of Energy Conservation in Power Sector**

### 1.5.2 Power and Energy Demand Forecasts

(1) Objective

The power and Energy demand forecasts become the basic information used to assume economic merit to implement the EE&C measures. Concerning electricity power, the economic merit is calculated by the forecast in combination with the generation cost analysis result as mentioned above.

In the Study, the baseline amount of electricity and energy consumption (BAU case) is estimated, and then the scenario to achieve EE&C is proposed by estimating the EE&C effect from the additional EE&C measures as the amount of the reduction from the baseline.

In addition, PAEW submits the power demand forecasts (until 2035), and the JICA Study Team reviews it's results and the method and conduct overall energy demand forecasts including electricity.

(2) Method of Demand Forecasts

The following diagram shows the method of Demand Forecasts conducted by the JICA Study Team. Basically, while considering the interrelation based on the following macro-economy block, the energy consumption by sector and by type of energy is estimated in the future. The power demand forecasts are obtained as a part of the overall energy demand forecasts.

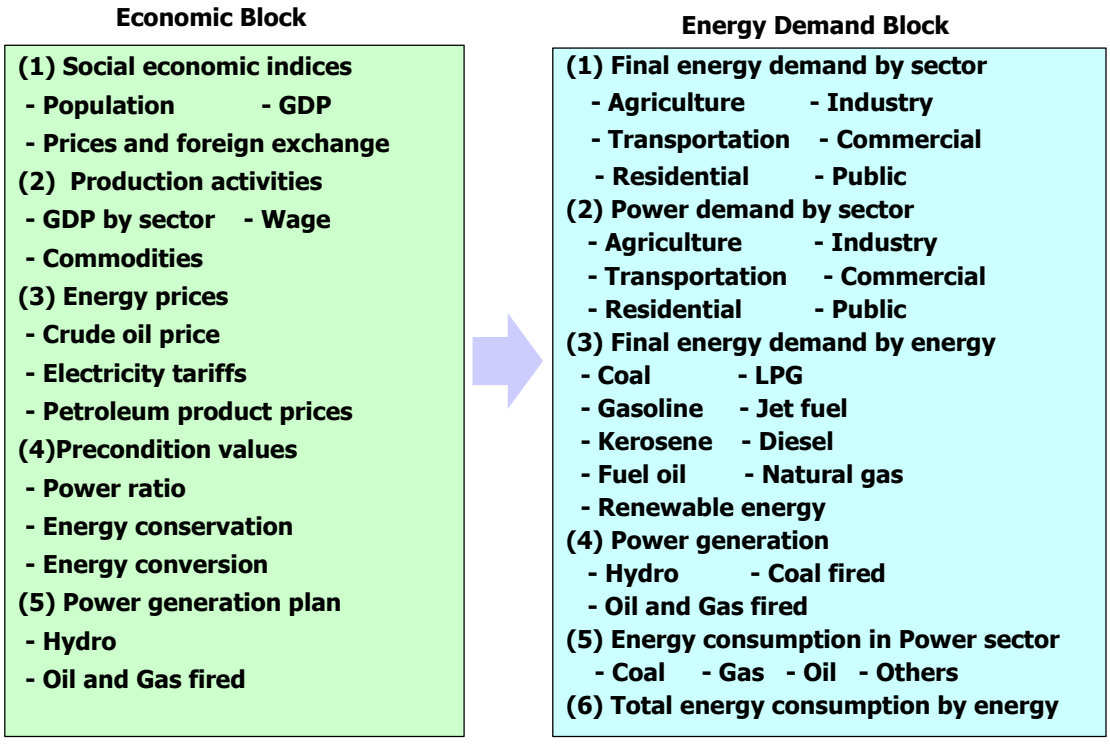



**Figure 1- 4 Method of Demand Forecasts**

### 1.5.3 Analysis on Electricity Consumption (Macro-level)

(1) Objective

The Study formulates an estimated breakdown of cost of electricity supply in each time zone, especially focusing on that in the hours of peak demand, by appropriately allocating the total costs of supply in a year into time-zones. In addition, an analysis is also made to estimate the sectoral composition of the annual load curve of the total power system, which consists of industrial, commercial & offices, residential sectors and so on, in order to identify the

consumers responsible for the incurred costs of supply.

The segmented costs of power supply broken down by time-zones and sectors are referred to as the baseline data for assessing the appropriateness of economic incentives to consumers in the energy efficiency and conservation measures to be proposed in this Study, and are also used as a benchmark to evaluate the overall electricity tariff structure in terms of cost-benefit balance.

(2) Methodology

The tasks in this section mainly consist of two parts, i.e. “analysis of the time-zone segmentation of costs of supply” and “analysis of the sectoral composition of the load curve”. Because these two parts are interrelated, they are carried out in parallel.

In the analysis on the time-zone composition of costs of supply, this Study estimates the fixed costs and variable costs of supply that each 1 kW load in each hour should shoulder. The facilities of power supply are provided in order to meet the peak demand in a year, and they vary in capacity utilization rate, ranging from those constantly utilized to those with fluctuating capacity utilization rate and those only utilized during peak hours. Therefore the fixed costs of constantly utilized facilities need to be allocated evenly to each hour, whereas the fixed costs of facilities with fluctuating utilization or for peak hours only need to be allocated so that only the hours that need to utilize them shoulder the costs. The differentiation of variable costs between light-load hours and heavy-load hours may be taken into account if different types of power plants, i.e. power plants with different variable costs, are put into use between the light-load hours and the heavy-load hours.

In addition, the grouping of the power load in each of the 8,760 hours (24 hours x 365 days) into several time-zones are made based on factors such as seasons, days of the week, time (day/night) and so on, in consultation with the counterparts of Oman. When the designing of the time-of-use tariff system is proposed in the later stage of this Study, this time-zone grouping is referred to in setting the unit price of this tariff

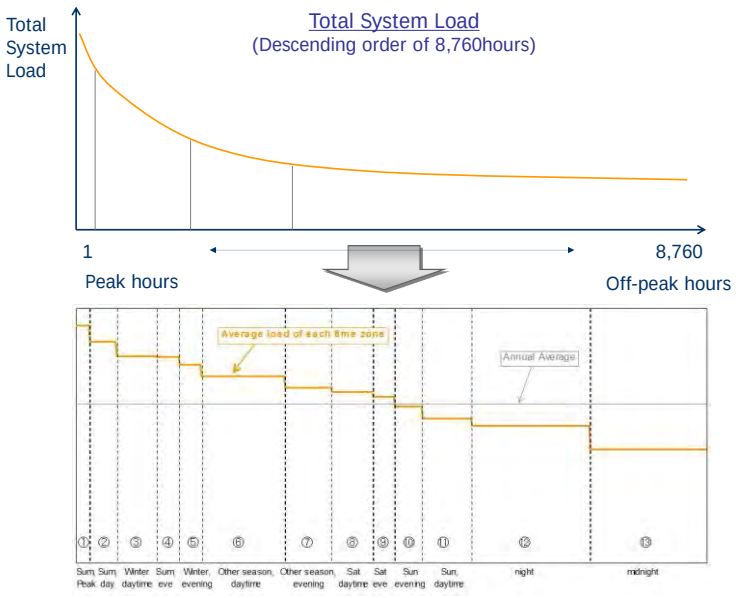



**Figure 1- 5 Time-zone Grouping of Hourly Load in a Year (8,760 Hours) (Image)**

In the analysis on the sectoral composition of the load curve, this Study estimates the sectoral segmentation of the total system load in a year (8,760 hours), referring to the load data of large consumers and the statistics of electricity consumption compiled for each sector. Given that there is a system loss between the volume of electricity that the power system received at higher voltage and the volume of electricity delivered to end-consumers, this Study estimates the electricity necessary for supplying each sector referring to the system loss rate at each voltage level.

Each sector is considered to have a significantly different load pattern by nature, but at this moment it is not certain how far the existing data is available to serve for this analysis. Therefore, this Study first tries a very rough estimation based on the statistics of monthly electricity consumption and some feeder-wise load data, and then undertakes a brush-up using the load data of individual consumers to be obtained in the next sections.

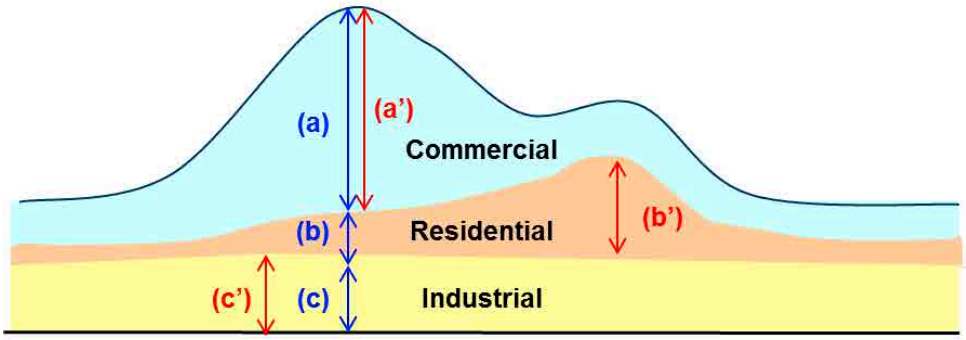



**Figure 1- 6 Analysis on Sectoral Composition of Total Load Curve (Image)**

### 1.5.4 Analysis on Electricity Consumption (Micro-level)

(1) Objective

Concerning micro electricity consumption analysis, the EE&C effect is estimated by assuming the impact of EE&C measures to each sector's energy consumption pattern and composition.

Specifically, it is estimated by estimating the EE&C potential in the future through analysis of the electricity consumption pattern of each sector, which are typical factories, buildings, and residences.

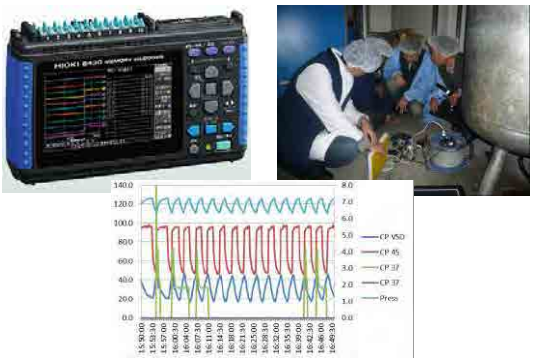
(2) Methodology

The EE&C potential is estimated by considering the facility's features, operational pattern, operational efficiency, power losses, and so on. However, since it is difficult to request consumers unilaterally to submit all data concerning EE&C, the survey is conducted while implementing an energy audit and proposal for EE&C improvements.

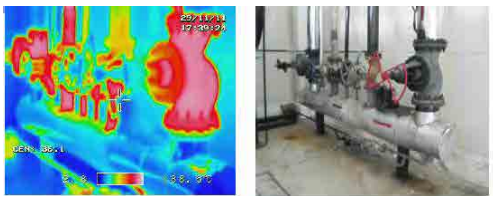
**Energy Audit Implementation at the Site（Factory Case）**

Target: Large energy consumption factory/building

Activity: Grasping facility status by questionnaire, site investigation, measurement of energy consumption, hearing from energy manager, etc.



Electricity Consumption Measurement of Compressor



Heat Loss Measurement by Thermography

**Figure 1- 7 Energy Audit Implementation Image**

### 1.5.5 Potential Survey on Automatic Control System of Electric Appliances

(1) Objective

In the case of a typical automatic control system, the indoor temperature is automatically maintained at a comfortable level by the inverter air conditioner, and the lighting is automatically switched on or off by occupancy sensors fitted to the lighting fixtures. Additionally, the installation of the Home Energy Management System (HEMS) and automatic control system in building in Japan has attracted attention.

In the Study, it verifies the energy saving potential of automatic controls and the feasibility of the installation by checking power usage conditions in residences and buildings in Oman, the operating conditions of appliances and acceptable levels of energy saving activities.

(2) Methodology

In the previous section, Analysis on Electricity Consumption (Micro-level), on-site measurement of power consumption through energy audit is conducted in residences and buildings. Based on the results of the analysis, energy saving potential by automatic controls is analyzed.

### 1.5.6 Energy Consumption Analysis by Site

(1) Objective

Concerning the designation of the Energy Management System (EMS), the identification of large energy consumers and their energy consumption is needed to consider the scope of EMS application. This analysis is located on the basic study on the scope of EMS application. Here, energy consumption means the total amount including heat and electricity consumption.

(2) Methodology

Concerning energy consumption, the most reliable data is electricity energy consumption. First, electricity energy consumption and the sector by the subscriber are confirmed from the distribution company's data. Second, on the premise that the same sector's energy consumption rate of electricity and heat is the same in different countries, the overall energy consumption is assumed in reference to the energy consumption rate of electricity and the heat of other countries in IEA.

The flowchart of the analysis is as follows.

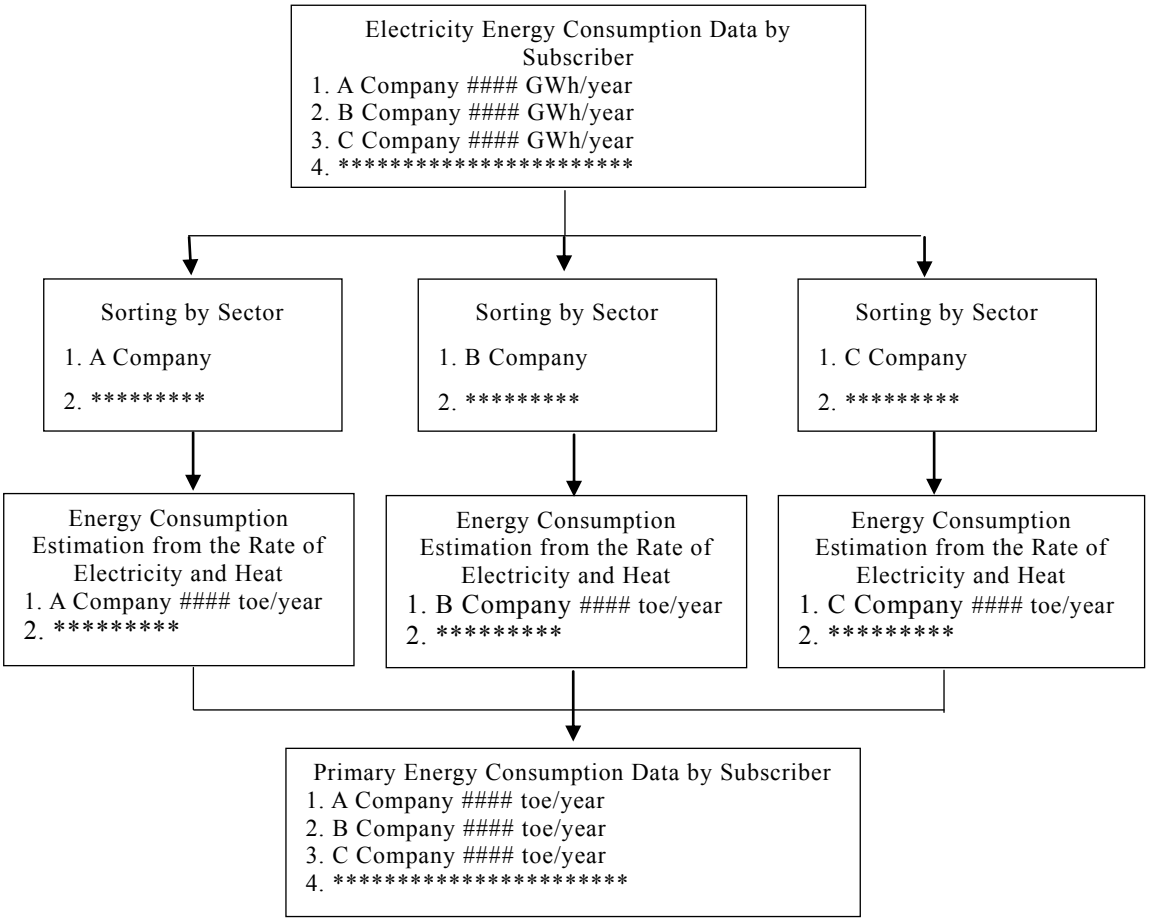



**Figure 1- 8 Analysis Flowchart of Large Energy Consumption buildings**

This analysis is not precisely correct because the electricity consumption data based on the contract is not always the data of each building, and the consumption of the building which has private power generation does not include the amount generated by private power generation.

However, it becomes the basic information to consider the scope of EMS application in Oman by grasping the outline of the large consumers by sector.

The industry and buildings are expected to be the scope of EMS application. Therefore,

these sectors are the scope of the analysis.

### 1.5.7 Analysis of the Electricity Tariff

(1) Objectives

One of the most effective ways of endowing economic incentives to promote energy (electricity conservation is to offer an electricity tariff that serves as a driver for motivating consumers to reduce the energy load during peak hours (peak cut) or to shift the energy load from peak hours to off-peak hours (peak shift). In assessing the appropriateness of economic incentives, not only the demand-side approach, i.e. evaluating whether the peak cut or peak shift will respond to the price driver as expected, the supply-side approach, i.e. evaluating whether the economic incentives are justified as the fair value for reducing the cost of supply with the peak cut or peak shift (so-called "avoidable cost").

In this section, analyses are carried out focusing on the second aspect so that the baseline data to serve for designing the incentive tariff such as the TOU tariff and demand adjustment contract.

(2) Methodology

First, this Study reviews the existing tariff system in Oman. According to the documents provided by the Authority for Electricity Regulation (AER), the electricity tariff system in Oman is designed so that it can recover the total cost of supply including the cost of capital (WACC 7.55 %), but in reality the revenue from electricity sales has not sufficiently covered the costs. Hence, subsidies have been provided by the Government to mitigate the gap. This Study confirms the balance between the total revenue and the total costs referring to the financial data obtained from AER and utility companies.

Based on the analysis of the time-zone segmentation of the costs of supply and the analysis of the sectoral composition of the load curve carried out in previous section, this Study also assesses the appropriateness of the tariff for each sector in terms of the fairly segmented costs of supply. However, it also needs to be noted that, likewise in many other countries, the electricity tariff system in Oman is designed taking also into account various social and political considerations. Therefore, the scope of the Study covers the review of the electricity tariff system and comments on problems if any, but does not cover the recommendation to restructure the total tariff system.

Then, consultation with local counterparts (Government agencies and utilities) is made regarding the introduction of the incentive tariff. In general, there are various types of incentive tariffs such as:

- Incentives in return for the peak cut/peak shift (offering a tariff discount in accordance with the achievement of the peak cut/peak shift that the consumer commits to in advance);
- Incentives in return for installing and using the devices that serve for the peak

cut/peak shift;

- Incentives in return for load leveling (adjusting the composition of the electricity tariff between the capacity charge part and the energy charge part so that the consumers with a high load factor are favored);

Discussion is held with local counterparts to determine which types of incentive tariffs are to be adopted and how, taking into account social background such as the lifestyle of the local people. In addition, this Study also confirms whether there are points that need to be considered in terms of the institutional framework, such as the necessity to amend the laws and regulations in offering an incentive tariff optionally besides the standard tariff in Oman.

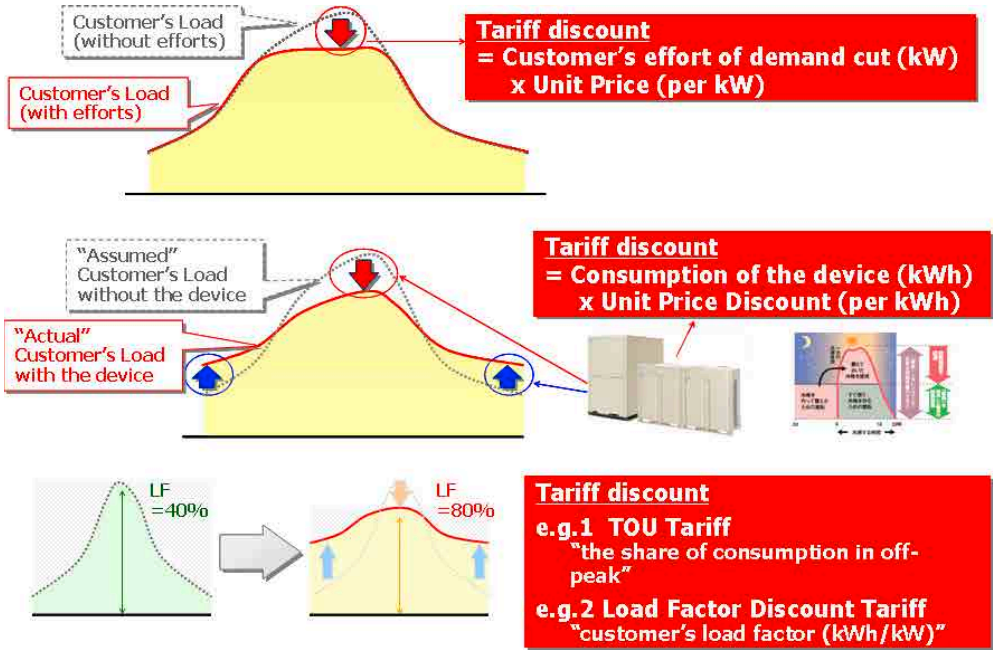



**Figure 1- 9 Various Types of Incentive Tariffs**

### 1.5.8 Awareness Survey on Energy Efficiency and Conservation

(1) Objective

On the Study, an awareness survey on energy efficiency and conservation is conducted in order to collect basic information, awareness level and willingness to act EE&C activities.

(2) Methodology

Targeting at the industrial, commercial, government (central and local) sectors, schools, mosques and residential sectors, a questionnaire survey with interview is conducted. The questionnaire survey is commissioned to local consultants.

### 1.5.9 Market Research on High-efficiency Appliance

(1) Objective

The market survey is conducted in order to review the potential of high-efficient air-conditioners for the residential sector. The survey collects basic information and data to establish the Minimum Energy Standards and Labeling System (MESL) and review effective dissemination programs.

(2) Methodology

An interview survey to suppliers and retailers is conducted by the JICA Study Team.

### 1.5.10 Survey on Possibility of Introduction of Smart Meter

(1) Objective

To widely diffuse the smart meter technology, it is necessary for investors (power utilities) to confirm an economic feasibility of the technology. The survey is conducted to grasp the economic possibility for the smart meter technology.

(2) Methodology

In a selected model site, non-technical loss is calculated. Using the smart meter technology, an impact on reduction of the non-technical loss in the model site is evaluated and the cost/benefit analysis is also conducted.

### 1.5.11 Survey on Applicable EE&C Technology for Street Lighting

(1) Objective

Power demand of street lighting is assumed to increase in the near future. To save the power demand, applicable technologies for power saving are identified in the survey.

(2) Methodology

In a selected model area, applicable technology options are raised and a cost/benefit analysis is conducted for the options to select more economic and realistic measures.

## 1.6 Basic Approach for Proposal of EE&C Measures

### 1.6.1 Understanding and Adjustment of the Concept of Each EE&C Measure

(1) Measures to be Studied

Based on the S/W, the Study proposes the following 8 measures.

① Electricity tariff system aiming at EE&C and peak-cuts

② Energy Management System (EMS)
③ Minimum Energy Standards and Labeling System (MESL)
④ EE&C dissemination activities and educational system
⑤ EE&C building regulation
⑥ Monitoring by power meters
⑦ Automatic control system of electric appliances
⑧ EE&C Center as an executing agency

(2) Introduction of Japanese EE&C Measures through Workshops

Regarding Japanese EE&C measures, the JICA Study Team creates presentations on the executing agencies, players and their roles, the existence of a legal basis, annual workflow, human resources, schematic flow chart, etc. in a workshop, to achieve common understanding. Through discussion in the workshop, direction for EE&C measures for Oman is discussed to obtain consensus of the basic concept.

(3) Concept Paper Proposal for EE&C Measures for Oman

The JICA Study Team creates concept papers for each EE&C measure for Oman. The concept papers are presented at the next workshop after consultation with C/P in advance. The JICA Study Team collects opinions from the participants of the workshop through a questionnaire, and reflects their opinions in the concept.

### 1.6.2 Review EE&C Measure Priorities

The scope of the Study covers the screening of priority measures and a discussion of the scheme design. The JICA Study Team discusses the depth of the scheme design for each measure based on priority.

The following points are the evaluation criteria to decide the priority of each measure.

- Whether a measure matches the national energy policy or strategy
- Whether a measure is effectively aimed at the energy consuming sector or not
- Whether a measure can monitor a sector not sufficiently managed by existing measures
- Whether a measure can obtain economic feasibility compared with its costs, etc.

The priority is determined by a weighted method on the above evaluation criteria, and then the depth of the scheme design discussion is determined by the evaluation results of the priority.

### 1.6.3 Depth of Discussion of Each EE&C Measure according to Priority

EE&C measures are discussed regarding categorizing into mandatory programs and voluntary programs.

(1) Formulation Method for Mandatory Program (EE&C Law)

The scheme design for mandatory programs has a proper order to decide each discussion point. If the proper order is not followed, discussion progress may stall or some discrepancy may arise. To efficiently design schemes in the EE&C Law, the discussions must progress in the following 4-step order.

The items decided by each step are expected to be "a law (EE&C Law)", "order or instruction from legally designated persons", "internal regulations in the executing agency" and "law or internal regulation in the executing agency" respectively.

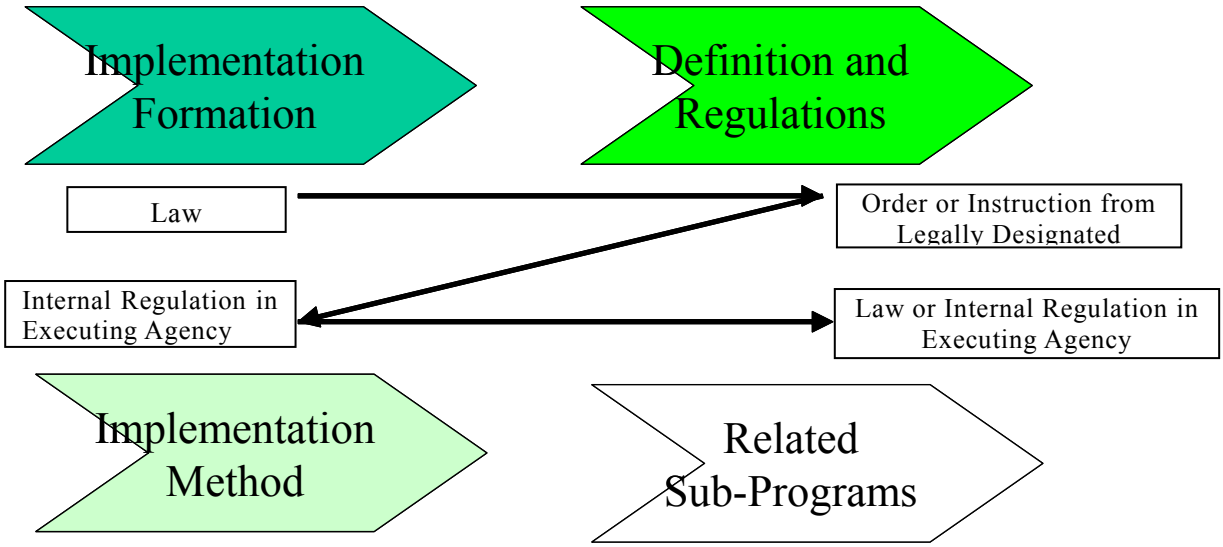



**Figure 1- 10 Steps for Scheme Design and Expected Status of Each Step**

In general, the description of EE&C law is the comprised of the implementation formation and accompanying obligation and rights. The law is effective after the approval of the diet or country council. Since it is difficult to change the contents described in the approved law, the description is limited to minimum requirements such as the implementation formation with its obligation and rights, etc. That is the 1st step.

Furthermore, based on the law, supervisors (legally designated persons), who are stipulated by the law, decide on the concrete definitions and regulations, order or instruct details. That is the 2nd step.

Basically these 2 steps are enough to establish the law. However, by the time the law is to be enforced, the 3rd step (implementation method: internal regulation in an executing agency) and the 4th step (related sub-programs) are expected to be prepared.

(2) Expected Scope of Discussion Depth of Mandatory Programs

The following table explains a map showing the depth of discussion of the scheme design for each measure. A measure, deemed as high priority, is basically examined in the 1st step (Implementation formation with obligation and rights) and the 2nd step (Concrete definition and regulations).

**Table 1- 3 Map of Scope of Discussion Depth (Mandatory Program Case)**

| | **1st Step** (Implementation formation with obligation and rights) | **2nd Step** (Concrete definition and regulations) | **3rd Step** (Implementation method) |
|---|---|---|---|
| Measure A | Scope | Scope | Out of Scope |
| Measure B | Scope | Scope | Out of Scope |
| Measure C | Scope | Scope | Out of Scope |

(3) Expected Scope of Discussion Depth of Voluntary Programs

Voluntary programs are defined as programs which do not have any obligations. This means the number of stakeholders to be discussed is expected to be small. Thus, the scheme design is relatively easier than the case of mandatory programs.

**Table 1- 4 Map of Scope of Discussion Depth (Voluntary Program Case)**

| | Implementation Formation | Contents of the Measure | Budget |
|---|---|---|---|
| Measure D | Scope | Scope | Option |
| Measure E | Scope | Scope | Option |

## 1.7 Basic Approach for Creation of Master Plan

Each EE&C measure is screened and examined per the above method and then these results are comprehensively arranged as a master plan. The master plan is proposed as follows.

### 1.7.1 Roadmap to Show Comprehensive Implementation Schedule

A comprehensive implementation schedule including the establishment of EE&C Law, establishment and enhancement of an executing agency (ex. EE&C Center), is summarized into a roadmap.

The image of the roadmap is shown below.

**Table 1- 5 Image of Roadmap**

| | 1st Period 2013-2015 | 2nd Period 2016-2018 | 3rd Period 2019- |
|---|---|---|---|
| Measure A | Preparation → Pilot Start → Full-scale Implementation | | |
| Measure B | Preparation → Pilot Start → Full-scale Implementation | | |
| . . . . . | Preparation → Partial Start → Full-scale Implementation | | |
| Establishment of Executing Agency and its Operation | Preparation → Establishment → Enhancement of the Organization | | |
| Preparation of EE&C Law and Establishment | Drafting → Proposal → Est. | Enforcement of the Law | |
| **Other Relating Items***1<br>- EE&C Fund<br>- Revision of Electricity Tariff<br>- Establishment of Renewable Energy Measure | △ Est. | △ Est.<br>△ Est. | |

*1 The items shown in the table are samples.

A legal basis (EE&C Law) is a requirement for mandatory programs. However, because the procedures for preparation and approval sometimes takes a long time, there is the practical idea of starting some programs as pilot programs without having an obligation to adhere to all procedures.

In this context, it is expected that the roadmap can be divided into a preparation period (preparation of law and regulations, detailed design of each measure, establishment of executing agency, etc.), a pilot implementation period without any obligation (or partial implementation), and full-scale implementation (or a transition to a mandatory program).

### 1.7.2 Proposal of Executing Agency

(1) Status of Organization

To implement each EE&C measures to be proposed in the Study, new executing agency is considered to be established or existing agencies are expanded to their working scope. Such executing agencies are to be directly stipulated in a law or designated by the right person stipulated in a law.

(2) Staffing Plan of the Organization

Staffing plan for an executing agency considers a scale of executed measures and their

implementation schedule.

### 1.7.3 Economic Analysis

(1) General

Economic analysis is conducted by a comparison of costs and benefits. However, it is substantially difficult to accurately estimate benefits by each EE&C measure. Thus, the benefits are estimated by the targeted value of energy efficiency or the expected value of potential energy saving.

Some measures (EE&C education, dissemination programs, etc.) are completely difficult to estimate in terms of its effects on energy efficiency. Such measures are not considered in the economic analysis.

(2) Estimation of Benefits

"Benefits" can be obtained by a gap between the EE&C promotion case and the BAU case (which does not take special EE&C measures) in fossil fuel consumption (evaluated by the export price) and the investment volume of domestic power system facilities.

(3) Estimation of Costs

In a sense, "costs" are defined as expenses to implement each EE&C measure. However, in the Study, all the expenses spent for the investment of facilities including the private sector are also considered for the nation-wide economic study. These 2 cases are considered into the evaluation of EE&C measures' impact.

(4) Evaluation of the Effectiveness of Each Measure

Each measure is evaluated by the cost/benefit analysis, the economic impact including its impact on stimulation to industry development.

### 1.7.4 Proposal of Action Plan and Recommendation

Action plan shows the necessary activities to implement the master plan consisting of the contents of each EE&C measure, the implementation plan and method, the operation method of the executing agency, etc. The action plan includes the following items.

- Milestones and preparation/implementation activities to realize each measure according to the milestones
- Necessary human resources and equipment/facilities
- Necessary external expertise (consultants) in the preparation and implementation stages

# Chapter 2 Energy Efficiency Policy in Other Countries

## 2.1 Japan

### 2.1.1 Energy Policy and Energy Conservation Law

(1) Overview of the Policy

Energy policy-making in Japan is conducted under the authority of the Ministry of Economy, Trade and Industry (METI). The "Basic Energy Plan" (June 2010) and the "New National Energy Strategy" (May 2006) were both enacted under the "Basic Act on Energy Policy" (June 2002). The Basic Act promotes the following three basic objectives: "Securing of Stable Supply", "Environmental Suitability", and the third one, which is strongly undergirded by the first two is "Utilization of Market Mechanisms". The "Basic Energy Plan", formulated under the "Basic Act on Energy Policy", was introduced as one of the important energy demand policies promoting an economy and society based on energy and natural resource conservation.

The "New National Energy Strategy" was announced in 2006 targeting reduced oil dependence lower than 40 % of present levels by 2030 and had presented specific programs that included an "Energy Efficiency Frontrunner Plan" which aimed for 30 % increased energy efficiency by 2030 as its target. However, reflecting the nuclear power station accident in 2011 in Japan, the energy strategy is now being reviewed by the Government of Japan.

The "Act on the Rational Use of Energy (Energy Conservation Law)" (enacted in 1979.6 and recently revised in 2011.6 respectively) contains stipulations specifying systems and regulations for supporting the aforementioned EE&C activities. The Energy Conservation Law lies at the heart of Japan's EE&C system, and in accordance with the law, EE&C activities in Japan are being promoted.

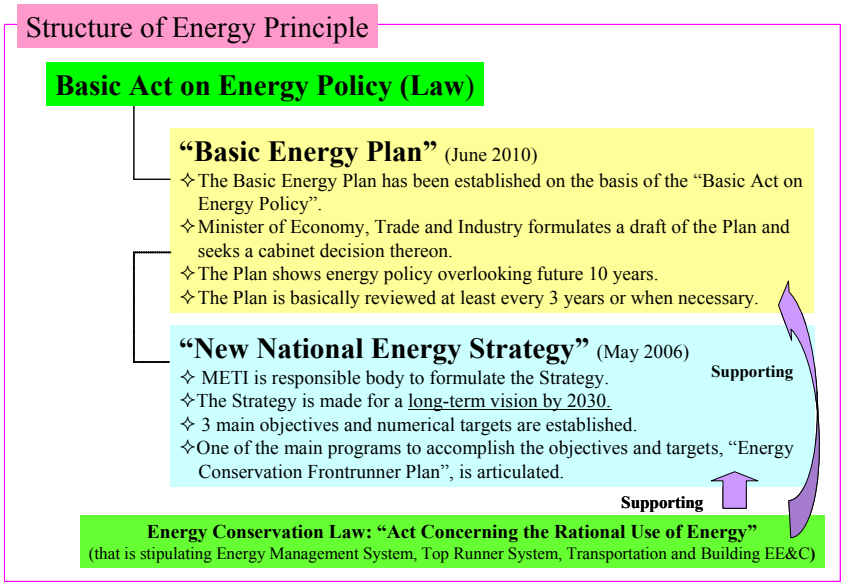



**Figure 2- 1 Structure of Japan's Energy Policy**

(2) Energy Conservation Law

(a) History

The Energy Conservation Law stipulates concrete systems and regulations to be adhered to during the implementation of EC&C activities. The "Heat Management Act" (1951), which precedes this Act, has similar laws that serve as the foundation for current regulations, such as regulations designating the number of business entities to be regulated, the Heat Manager to be appointed in the designated business entities, publication of Evaluation Criteria, and Certified heat managers (predecessors of certified energy managers) etc. After the second oil crisis in 1979, the "Heat Management Act" was converted to the "Act on the Rational Use of Energy" resulting in electricity becoming the target of regulation.

The purpose of the Act is to implement rational energy usage measures required for business entities including factories and buildings, thereby contributing to the sound development of the national economy. This act also consequently gave birth to related laws and regulations, cabinet orders and ministry ordinances. Through the "Act on the Rational Use of Energy", it is the responsibility of the METI to formulate and publicize a "Basic Policy for the rational use of energy" and "Evaluation Criteria" with accompanying measures to be implemented by energy consumers. In response to global energy volatility and increasing environmental awareness, this Act has been amended six times to improve measures concerning EE&C strategy promotion, management and the reporting system. In August 2005, the act was amended to unify energy control of heat and electricity that up until then had been controlled separately. In particular, the rules were amended to define levels of designated business Entities by last year's total energy consumption (fuel, heat and electricity usage amounts were converted into their crude oil equivalent). Further, regarding Energy Managers and Energy Management Officers, a centralized system unifying the management of heat and electricity was introduced in place of the previous system, which had separated the management of heat and electricity. In addition, EE&C measures pertaining to transportation were introduced and EE&C measures pertaining to building and residence construction were strengthened.

The full-scale amendment of the Energy Conservation Law was put into effect on May, 2008 and it introduced new regulations such as the requirement to efficiently promote EE&C activities per management discretion and some measures targeting certain business entities which have many small sites. First, for factories or buildings, which have had their energy consumption regulated on an each site basis only, after the latest amendment, they are required to conduct energy management of the whole entity. Companies, whose total annual energy consumption level of all factories or buildings as a whole exceeds a certain designated level would be classified as a "Designated Company". The designation per unit as a Type 1 Energy Management Factory or Type 2 Energy Management Factory is also conducted the same as before. Furthermore, the new "Specified Chain Business Entities System" was started to introduce the same principle to be applied to franchises such as convenience stores when the total energy consumption level of all the branches as a whole exceeds a certain level to be

designated as a “Specified Chain Business Entity”. The “Specified Business Entity” and “Specified Chain Business Entity” must prepare the Middle and Long Term Plans and Periodical Reports per the whole entity, appoint an energy management supervisor from board members, appoint the “Energy Manager for Energy Management Planning and Promotion” who supports the Energy Management Supervisor, and appoint energy managers for each designated factory or designated building.

(b) Target and Regulatory Range of the Energy Conservation Law

The term “Energy” as defined in the Energy Conservation Law refers to “Fuel”, “Heat” and “Electricity”. The term “Fuel” as used in the Act refers to any oil products such as crude oil, volatile oil, heavy oil (naphtha, kerosene, diesel oil, asphalt made by oil, oil coke, and oil gas), combustible natural gas, coal, coke and other coal products (coal tar, coke-oven gas, blast furnace gas, and converter gas), all of which individually or collectively are used for combustion and /or fuel battery generation. The law’s usage of the term “Heat” refers to heat (Steam, Hot Water, Cold Water, etc.) generated from any of the aforementioned “Fuels” and excludes any heat that is NOT “fuel-based” such as solar heat and geothermal heat etc.

The law’s usage of the term “Electricity” refers to electricity generated from any of the aforementioned “Fuels” and excludes electricity generated from non-fossil energy sources. Non-fossil energy sources refer to photovoltaic generation, wind power generation, waste power generation, all of which have been deemed as “NON-FOSSIL Fuels”.

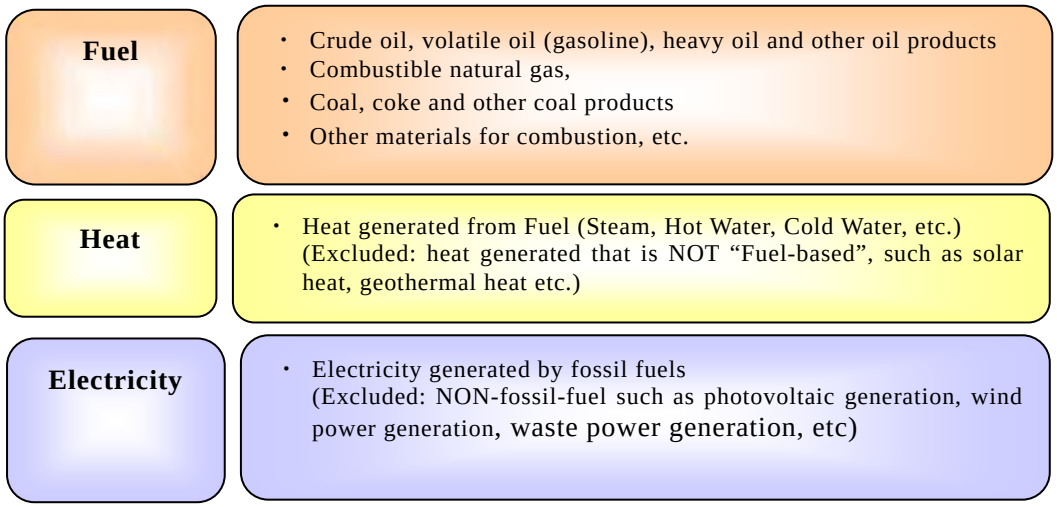



**Figure 2- 2 Targeted Energy under the Energy Conservation Law**

The Energy Conservation Law covers four sectors, namely “Large Consuming Factories and Buildings”, “Transportation”, “Houses and Buildings” and “Machinery and Equipment”. Fields and business entities targeted under the law are as follows. The Energy Management System of Japan is stipulated in the following “Large Energy Consuming Factories and Buildings”.

**Table 2- 1 Fields and Business Entities Targeted under the Energy Conservation Law**

| Fields | Business Entities |
|---|---|
| Large Energy Consuming Factories and Buildings (Designated Organizations) | Business entities in possession of factories (manufacturing, mining, electricity supply, gas supply, heat supply) for business operations<br>Business entities in possession of buildings (including headquarters, branches, factory business offices and buildings other than factories such as hospitals, hotels, and/or schools etc.) used to operate business |
| Transportation | Carriers: Business entities that operates freight or passenger transportation (including freights for personal business usage)<br>Consigners: Business entities in possession of freight carriers to transport their freight (Includes personal business usage) |
| Houses and Buildings | Construction Period: Construction client(s) who intend(s) to construct buildings and/or residences<br>Extension or Reconstruction Period: the owner of the buildings or residences |
| Machinery and Equipment | Manufacturers and importers of machinery and equipment that consume energy |

### 2.1.2 Energy Management System

The full-scale revision of the Energy Conservation Law was made in 2008, and the regulation targets have been changed from the “business unit (factory or building)” to the “designated company (a whole company)”. The targets of the Energy Management System have been enlarged and the scheme has also become more complicated. This section just explains the overview of the Japanese scheme of the Energy Management System to consider the possibility of introducing a similar scheme to Oman. In this context, the previous scheme prior to the 2008 revision is explained for the introduction of the Energy Management System.

(1) Schematic Overview

In Japan, the Energy Management System consists of the following four activities.

- The first activity is regulatory in nature consisting of policy making and establishing laws and regulations.
- The second activity consists of monitoring and instruction which includes overseeing EE&C activities in designated large energy consuming factories and buildings (hereinafter “Designated Organizations”) via report and inspections (or issuing penalties) when deemed necessary.
- The third activity deals with energy conservation and includes data collection/analysis, identification of barriers, resolution etcetera initiated by the Energy Manager in a designated organization.
- The fourth activity consists of examination training for the energy manager qualification, which will be required under a nationally established system.

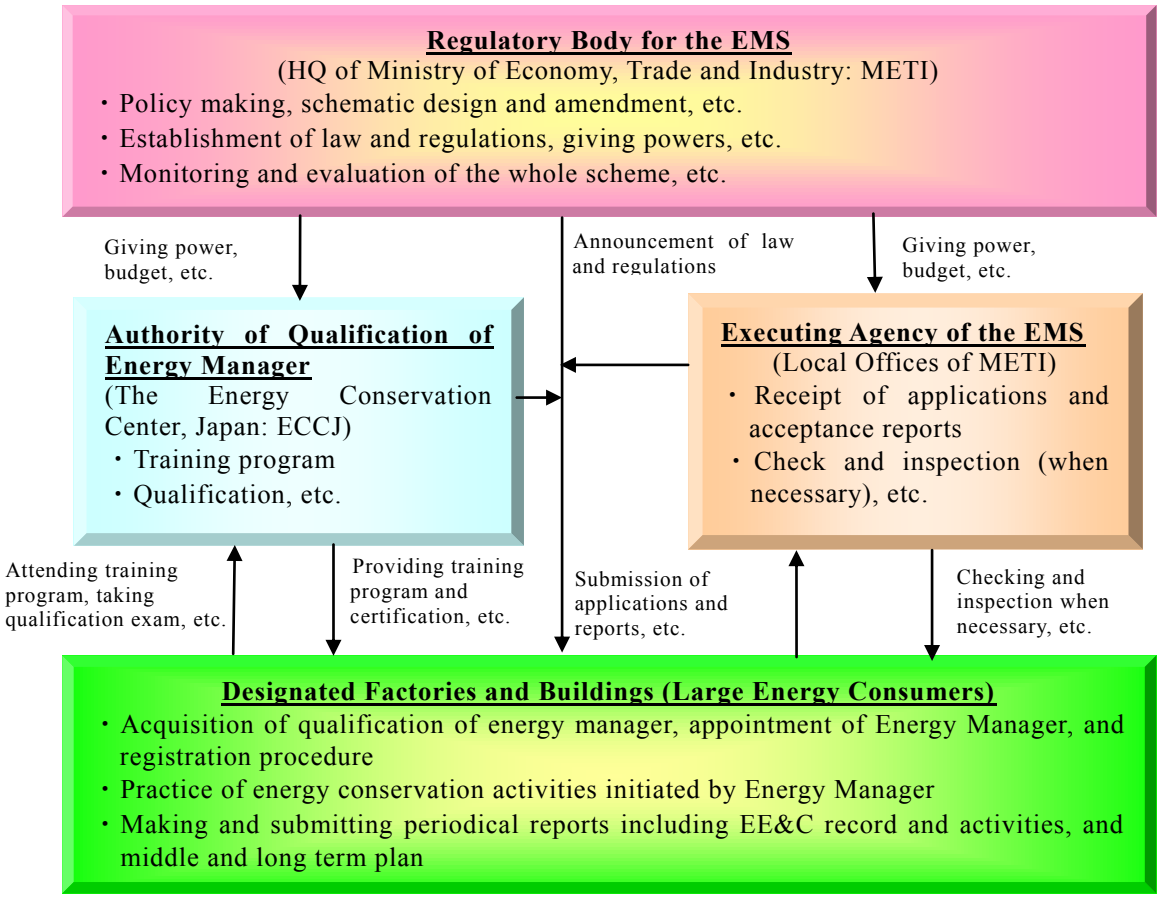



**Figure 2- 3 Overview of Japanese Energy Management System**

(2) Periodical Report

Designated Organizations must submit Periodical Report to the Executing Agency (METI Local Offices) once a year. To respond to these report submissions, the Designated Organization(s) will appoint registered Energy Manager(s) who will initiate onsite EE&C activities. On the other hand, the Executing Agency will determine whether or not certain EE&C activities are to be conducted through checking the contents of the reports and conducting inspections when necessary.

Periodical Report consisting of the EE&C Results Report and the Middle and Long Term Plan Report are to be submitted once a year. EE&C Results Report as shown below includes an energy consumption record, product output, energy intensity (=consumption / product output), compliance checklist with legally established evaluation criteria and so on.

Table 1: Quantity of energy use and quantity of energy sold or by-product

| Type of energy | | | Unit | (Fiscal year) Quantity of use | | Quantity of energy sold or by-product | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Quantity of energy sold | | Quantity not contributing to own production | |
| | | | | Quantity | Calorie GJ | Quantity | Calorie GJ | Quantity | Calorie GJ |
| Fuel and heat | Crude oil (excluding condensate) | | k l | | | | | | |
| | Condensate included in crude oil (NGL) | | k l | | | | | | |
| | Gasoline | | k l | | | | | | |
| | Naphtha | | k l | | | | | | |
| | Kerosene | | k l | | | | | | |
| | Diesel oil | | k l | | | | | | |
| | Fuel oil A | | k l | | | | | | |
| | Fuel oils B/C | | k l | | | | | | |
| | Asphalt | | t | | | | | | |
| | Other fuels | City gas | 1000m³ | | | | | | |
| | | ( ) | | | | | | | |
| | Industrial steam | | GJ | | | | | | |
| | Non-industrial gas | | GJ | | | | | | |
| | Hot water | | GJ | | | | | | |
| | Cool water | | GJ | | | | | | |
| | Sub-total | | GJ | | | | | | |
| Electricity | Ordinary electric power supplier | Daytime purchased power | 1000kWh | | | | | | |
| | | Nighttime purchased power | 1000kWh | | | | | | |
| | Others | Purchased power other than the above | 1000kWh | | | | | | |
| | | Private power generation | 1000kWh | | | | | | |
| | Sub-total | | 1000kWh,/GJ | | | | | | |
| Total GJ | | | | | | | | | |
| Crude oil equivalent kl | | | | | (a) | | (b) | | (c) |
| Comparison vs. previous fiscal year (%) | | | | | | | | | |

**Calculation Sheet of Energy Consumption**

Table 2: Brief summary of facilities related to rational use of energy and major facilities consuming energy and situations of operation including new installation, remodeling or dismantling

| | Name of facilities | Outline of facilities | Operational status | New installation, remodeling or dismantling |
|---|---|---|---|---|
| Facilities related to rational use of energy | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| Major facilities consuming energy other than the above | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Table 3: Production quantity and others

| | (Fiscal year) | Comparison vs. previous fiscal year (%) |
|---|---|---|
| Values closely related to energy consumption such as production quantity, gross floor space or others ( ) | (d) | |

**Utilization List of Energy Consuming Equipment**

Table 4: Unit energy consumption

| | (Fiscal year) | Comparison vs. previous fiscal year (%) |
|---|---|---|
| Unit energy consumption = Quantity of energy used (crude oil equivalent kl) [(a) − ((b)+ (c))] / Values closely related to energy consumption such as production quantity, gross floor space or others (d) | | |

Table 5: Status of change in unit energy consumption for past five years

| | (Fiscal year) | (Fiscal year) | (Fiscal year) | (Fiscal year) | (Fiscal year) | Change in average unit energy consumption for past five years |
|---|---|---|---|---|---|---|
| Unit energy consumption | | | | | | |
| Comparison vs. previous fiscal year (%) | | | | | | |

Table 6: Reasons for (A) a case where unit energy consumption for past five years was not improved by 1% or more or (B) a case where unit energy consumption for past five years was not improved from the previous fiscal year

| |
|---|
| Reasons for (A) above |
| |
| |
| |
| |
| Reasons for (B) above |
| |
| |
| |
| |

**Energy Intensity Calculation Sheet**

Table 7: Status of observing the standards for judgment related to rational use of energy

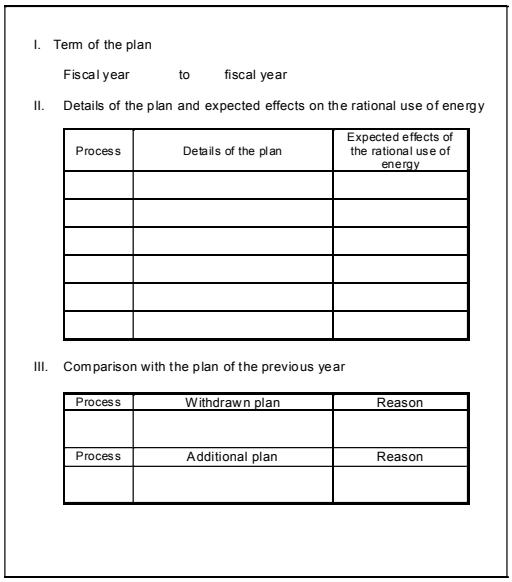
| Target items (facilities) | Status of establishing management standards | Status of observing measurement/record | Status of observing maintenance /inspection | Status of measures taken before new installation |
|---|---|---|---|---|
| Rationalization of fuel combustion (Combustion facility) | Status of establishing management standards for air ratio and others<br>□ Already established<br>□ Being established ( %)<br>□ To be established | Status of implementing measurement/record in management standards<br>□ Regularly done<br>□ Done as needed<br>□ Not done | Status of implementing maintenance/ inspection stated in management standards<br>□ Regularly done<br>□ Done as needed<br>□ Not done | Status of measures taken before installation of combustion facilities<br>□ Done<br>□ Not done<br>□ Not applicable |
| Rationalization of heating, cooling and heat transfer (Heat consumption facility) | Status of establishing management standards for heating equipment and others<br>□ Already established<br>□ Being established ( %)<br>□ To be established | Status of implementing measurement/record in management standards<br>□ Regularly done<br>□ Done as needed<br>□ Not done | Status of implementing maintenance/ inspection stated in management standards<br>□ Regularly done<br>□ Done as needed<br>□ Not done | Status of measures taken before installation for heating equipment and others<br>□ Done<br>□ Not done<br>□ Not applicable |
| | Status of establishing management standards for air adjustment facility and hot water supply facility<br>□ Already established<br>□ Being established ( %)<br>□ To be established | Status of implementing measurement/record in management standards<br>□ Regularly done<br>□ Done as needed<br>□ Not done | Status of implementing maintenance/ inspection stated in management standards<br>□ Regularly done<br>□ Done as needed<br>□ Not done | Status of measures taken before installation of air adjustment facility and others<br>□ Done<br>□ Not done<br>□ Not applicable |
| Waste heat recovery and use (Waste heat recovery facility) | Status of establishing management standards for waste heat recovery facility<br>□ Already established<br>□ Being established ( %)<br>□ To be established | Status of implementing measurement/record in management standards<br>□ Regularly done<br>□ Done as needed<br>□ Not done | Status of implementing maintenance/ inspection stated in management standards<br>□ Regularly done<br>□ Done as needed<br>□ Not done | Status of measures taken before installation of waste heat recovery facility<br>□ Done<br>□ Not done<br>□ Not applicable |
| | | | Status of implementing | Status of measures |

**Check List for Compliance with Evaluation Criteria**

(Source: ECCJ Website)

**Figure 2- 4 EE&C Results Report**

The Middle and Long Term Plan Report contains an energy efficiency investment plan forecasting the next 3-5 years. A sample of the report is shown below.



I. Term of the plan

Fiscal year to fiscal year

II. Details of the plan and expected effects on the rational use of energy

| Process | Details of the plan | Expected effects of the rational use of energy |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

III. Comparison with the plan of the previous year

| Process | Withdrawn plan | Reason |
|---|---|---|
| | | |
| Process | Additional plan | Reason |
| | | |

(Source: ECCJ Website)

**Figure 2- 5 Middle and Long Term Plan Report**

(3) Evaluation Criteria and Management Standards

(a) Evaluation Criteria (Guideline)

The Japanese Energy Management System has set up "Evaluation Criteria (Guideline)" concerning the instruction of what EE&C activities are to be conducted within an organization and can also determine whether or not such activities are actually being carried out. This Criterion is based on the Act on the Rational Use of Energy (Energy Conservation Law) and regulations. The Criteria instructs on fields and methods to be managed, management standards, standard values and target improvement values

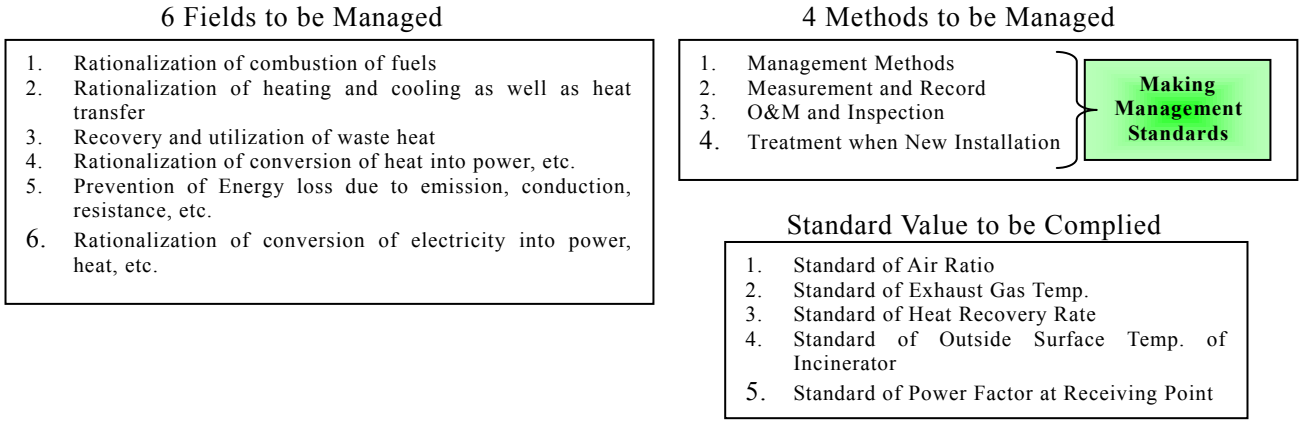



**Figure 2- 6 Composition of Evaluation Criteria (Guideline)**

(b) Management Standards

Management Standards have set up four methods to be managed by each facility as instructed in the Evaluation Criteria. The four methods are management methods, measurement and records, O&M and inspections, and treatments during new installation. In the Japanese Energy Management System, each user in accordance with the Evaluation Criteria sets up Management Standards.

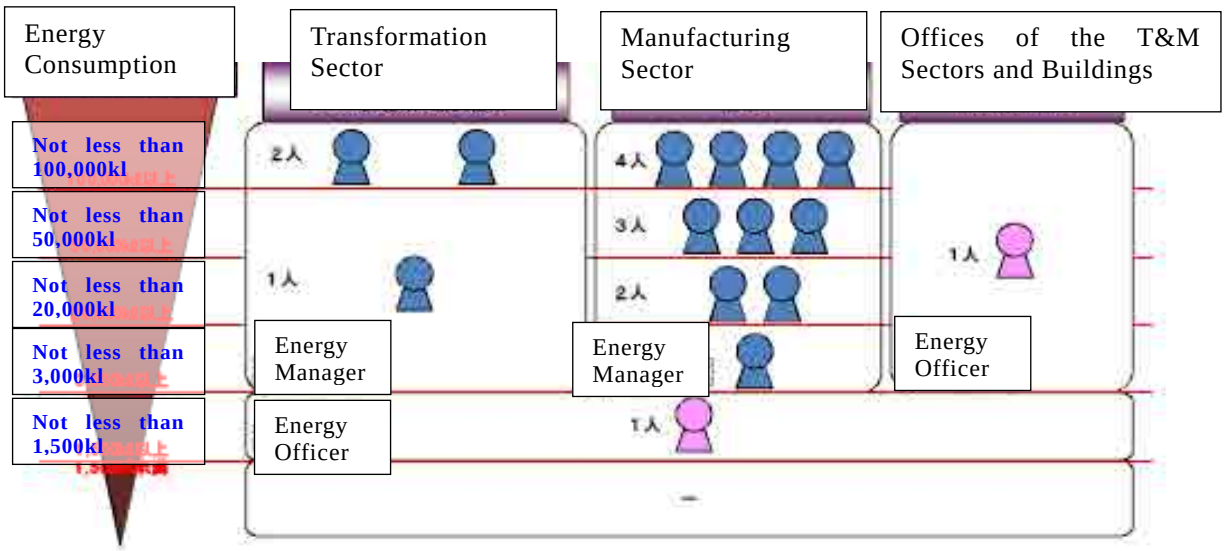
(4) Qualification System

(a) Obligation of Appointing Energy Manager and Energy Officer

Energy Conservation Law of Japan stipulates that Designated Organizations in the transformation sector and manufactures should appoint Energy Manager(s) as a national qualification respectively at each factory that consumes not less than 3,000 kl (crude oil equivalent) / year. The number of Energy Manager(s) to be appointed depends upon the quantity of energy consumption (1 person to 4 persons in one site). Qualifications of an Energy Manager are restricted to those persons experienced in energy management and those who have successfully obtained the national qualification certificate.

On the other hand, with regard to the offices of the transformation sector and manufacturers, and buildings, an Energy Officer, who becomes qualified after a 1-day training program, is appointed at the site. However, the Middle and Long Term Plan Report is authorized by an Energy Manager who can be outsourced.

Besides, consumers using not less than 1,500 kl (crude oil equivalent) / year and less than 3,000 kl may also appoint an Energy Officer regardless types of sector. The detail is shown below.




Energy Manager: Qualification by national examination or training program with certificate examination
Energy Officer: Qualification by receiving 1-day training program

(Source: ECCJ Website)

**Figure 2- 7 Appointment of Energy Manager and Energy Officer**

(b) Methods of Qualification

(i) Energy Manager

The national qualification of Energy Manager is restricted to the following qualified persons.

- One who has passed the Energy Manager examination and possessing more than 1-year experience in the energy management business. The examination is held every August.
- A successful trainee which is one who attends the training program to obtain the certificate examination for Energy Manager (7 days program) and passes the examination. Only persons possessing 3 years or more experience in the energy management business are eligible to apply for this training program. The training program is held every December.

Both the Energy Manager examination and the training program with the certificate examination for the Energy Manager are managed by the Energy Conservation Center, Japan (hereinafter "ECCJ") that is legally designated as the sole examination and training authority by the responsible ministry (METI). Qualified applicants who pass the examination or the training program will receive a certificate from ECCJ resulting in the Minister granting an Energy Manager license.

(ii) Energy Officer

An Energy Officer can be appointed from among those who are qualified by undergoing a 1-day training program. "Training Program for Energy Management" conducted by ECCJ, or has a license of Energy Manager.

(5) Training System

(a) Training Program Classification

In Japan, the ECCJ provides various training programs regarding EE&C (1 day – several days program). These programs are categorized into the following two groups.

(i) Training program with the certification examination for Energy Manager candidates

(ii) General training programs for proper implementation of the Energy Management System (EMS)

The above (i) is a training program including an examination to acquire the national Energy Manager license. So the provider of this program, the ECCJ, by law will be able to issue out valid certifications. The above (ii) are voluntary training programs targeting general engineers or technicians who will assist the Energy Manager in his/her routine tasks

**Table 2- 2 Classification of Training Program regarding EE&C**

| Classification | Contents |
|---|---|
| (i) Training program with certification examination for candidates of Energy Manager | ● Lecture of law and regulations of the EMS<br>● Basic knowledge of heat and electricity<br>● Theory and practice of EE&C activities within a business unit<br>● Measurement and data collection, and analysis<br>● How to make Periodical Report<br>● (Certification examination) |
| (ii) General training programs for proper implementation of the EMS | ● Lecture of law and regulations of the EMS<br>● How to make Management Standards<br>● Theory and practice of EE&C activities within a business unit<br>● Measurement and data collection, and analysis<br>● Theory of heat and electricity in EE&C<br>● Lecture for individual technology (pump, AC, boiler, etc.) |

(b) Training Program with Certification Examination for Energy Manager

The training program with the certificate examination is conducted once a year and lasts seven days. In Japan, there are two types of qualified Energy Managers designated by field, namely the Energy Manager (Heat) and Energy Manager (Electricity). The applicants for Energy Manager can select a suitable subject in light of their expertise. The training program consists of a common subject and an individual subject (the heat course or the electricity course). In order to be eligible to attend the program, one prerequisite is that an applicant has to have more than 3 years experience in energy management activities.

The certificate examination requires sufficient mastery of four subjects including a common subject. Even if an applicant does not pass all four subjects in that year, the applicant will have the opportunity to retake a class the following year.

The following table is a sample of the training program with certification examination.

**Table 2- 3 Training Program with Certification Examination (Japanese Case)**

| | | Subjects | | Contents | Lecture Time |
|---|---|---|---|---|---|
| Common | I | Outline of Energy Management and Law and Regulations | | 1 Outline of energy management<br>2 Energy Conservation Law and Regulations | 7 hours<br>2 hours |
| Heat Field (optional) | II | Basic Theory in Heat and Fluid | | 1 Basic theory in thermodynamics<br>2 Basic theory in fluid mechanics<br>3 Basic theory in heat transfer mechanics | 8 hours<br>5 hours<br>5 hours |
| | III | Fuel and Combustion | | 1 Fuel and combustion management<br>2 Calculation of combustion | 4 hours<br>3 hours |
| | IV | Heat Utilization Facility and its Management | | 1 Measurement and control<br>2 Boiler, steam transmission and stock facility, steam mover, internal combustion engine, gas turbine<br>3 Heat exchanger, heat recovery, chiller, air conditioner<br>4 Incinerator, material of heat facility<br>5 Distillation/boiling/condenser facility, drier facility, carbonization and gasification facility | 5 hours<br>4 hours<br>3 hours<br>3 hours<br>3 hours |
| Electricity Field (optional) | II | Basic Theory in Electricity | | 1 Basic theory in electricity and electronics<br>2 Automatic control and information processing<br>3 Measurement of power | 3 hours<br>3 hours<br>2 hours |
| | III | Facility and Equipment | Distribution in Factory | 1 Planning of distribution in factory<br>2 Operation of distribution in factory<br>3 EE&C in distribution in factory | 2 hours<br>2 hours<br>2 hours |
| | | | Electric Equipment | 1 Outline of electric equipment<br>2 Rotating and stationary machine<br>3 EE&C in electric equipment | 2 hours<br>2 hours<br>2 hours |
| | IV | Application of Electricity | Application of Electric Power | 1 Outline of application of electric power<br>2 Facility of application of electric power<br>3 EE&C in application of electric power | 2 hours<br>3 hours<br>2 hours |
| | | | Electric Heating | 1 Theory of electric heating and its facility<br>2 EE&C in electric heating | 2 hours<br>2 hours |
| | | | Electrochemical | 1 Theory of electrochemical and its facility<br>2 EE&C in electrochemical | 2 hours<br>2 hours |
| | | | Lighting | 1 Theory of lighting and its facility<br>2 EE&C in lighting | 2 hours<br>2 hours |
| | | | Air Conditioning | 1 Theory of air conditioning and its facility<br>2 EE&C in air conditioning | 2 hours<br>2 hours |

(Source: ECCJ Website)

### 2.1.3 Minimum Energy Standards and Labeling System (Top Runner System)

Japan's Top Runner Program is a method of determining equipment energy efficiency standards by setting the goal to exceed the standard already set by the most efficient equipment for a designated period of time. In this context, it is a one of a kind minimum energy standard system. The labeling system is a part of the Top Runner Program that will impose the displaying of the energy performance of certain specified machinery and equipment.

(1) Methodology of Standard Establishment

Japan's energy conservation policies are deliberated by an "Advisory Committee for Natural Resources and Energy," an advisory body to METI. For the Top Runner Standard Values, deliberations are conducted by the "Energy Efficiency Standards Subcommittee", established under the "Advisory Committee for Natural Resources and Energy."

To deliberate standard details, an “Evaluation Standard Subcommittee” is established per product under the “Energy Efficiency Standards Subcommittee.” An advisory committee, consisting of academics, researchers, manufacturers and consumer representatives holds discussions on the following.

- Target scope and classification of appliances
- Measuring method of energy consumption efficiency
- Measurement of whole products in the market
- Decision of the highest efficiency value at the time of setting
- Decision of the target fiscal year when target values are cleared

(2) Target Products and Display Contents

Target products are to indicate “Energy Saving Label” which shows their energy performance under preset conditions. In addition, “Unified Energy Saving Label” shows assumed annual electricity bill and comparative star ranking as well. The “Unified Energy Saving Label” is used for AC, refrigerator, TV sets, electric toilet seat, lighting equipment.

.


**Figure 2- 8 Unified Energy Saving Label**

**Table 2- 4 Target Appliances and Labeling System**

| Target Appliances of Minimum Energy Standards | Target Appliances of Labeling | Annual Electricity Bill Displaying Appliances | Target Appliances of Unified Energy-Saving Label |
|---|---|---|---|
| Air Conditioners | ● | ● | ● |
| TV Sets | ● | ● | ● |
| Electric Refrigerators | ● | ● | ● |
| Electric Freezers | ● | ● | |
| Electric Rice Cookers | ● | ● | |
| Microwave Ovens | ● | ● | |
| Lighting Equipment | ● | ● | ● |
| Electric Toilet Seats | ● | ● | ● |
| DVD Recorders | ● | ● | |
| VCRs | | | |
| Space Heaters | ● | | |
| Gas Cooking Appliances | ● | ●(Fuel Usage) | |
| Gas Water Heaters | ● | ●(Fuel Usage) | |
| Oil Water Heaters | ● | ●(Fuel Usage) | |
| Computers | ● | | |
| Magnetic Disk Units | | | |
| Transformers | | | |
| Copying Machines | | | |
| Vending Machines | | | |
| Passenger Vehicles | | | |
| Freight Vehicles | | | |
| Routes | ● | | |
| Switching Units | ● | | |

(Source: ECCJ Website)

(3) Performance Testing Method

The following table shows the performance testing method of major appliances.

**Table 2- 5 Performance Testing Method**

| | | Measuring Items (Energy Consuming Efficiency) | | Measuring Standard |
|---|---|---|---|---|
| Air Conditioners | | Annual Performance Factor (APF) | Cooling Energy Efficiency<br>Heating Energy Efficiency | Domestic JIS C9612 |
| | | | | Business JIS B8616 |
| Refrigerators | | Annual Electricity Consumption (kWh/Year) | | JIS C9801(1999 & 2006) |
| Freezers | | | | |
| Lighting | Florescent Lamps | Luminous Flux /Electricity Consumption (W) | Total Luminous Flux Value<br>Stabilizer output factor<br>Temperature correction factor<br>the total luminous flux value | JIS C7617-2 |
| | Compact Florescent Lamps (CFL) | | | JIS C7618-2 |
| Electric Toilet Seats | | Annual Electricity Consumption (kWh/Year) | | |
| Television | | | Operation Hours in a day, Stand-by Hours | |
| Personal Computers | | Average Electricity Consumption /Theoretical Operation | Idling Hours, Low Power Consumption Mode | |
| Magnetic Disk | | Electricity Consumption (W) /Memory Capacity (GB) | | |
| Rice Coolers | | Annual Electricity Consumption (kWh/Year) | Cooking, Warn-Keeping, Timer and Stand-by Mode | |
| Microwave Ovens | | | Microwave Function, Oven Function and Stand-by Mode | |
| DVD Recorders | | | Operation Mode, Stand-by Mode | |

(Source: ECCJ Website)

(4) Database System

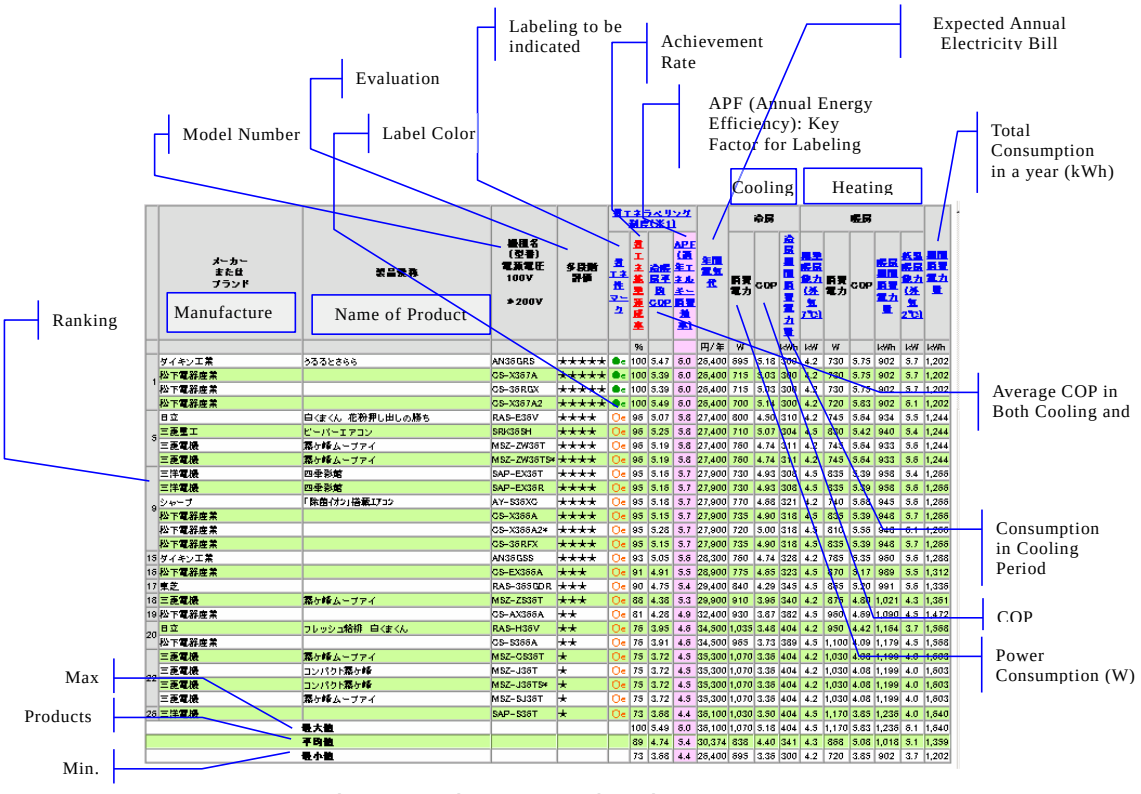
ECCJ prepares the energy conservation efficiency database of target appliances, which retail shops and consumers can easily search through the internet. Also, shops could print out a necessary label sheet for display on the storefront.

The following table shows the database components example of air conditioners.

**Table 2- 6 Database Components Example of Air Conditioners**

| Items | Contents | |
|---|---|---|
| Equipment | Maker or Brand Name<br>Product Nick Name | Model Number (Type Number) |
| Energy Efficiency Performance | Multi-Stage Evaluation<br>Energy Saving Mark<br>Target Year | Achievement Rate of Energy Saving Standard<br>Annual Performance Factor (APF)<br>Yearly Electricity Bill |
| Cooling | Rated Capacity (kW)<br>Power Consumption (W) | Power Consumption during Cooling (kWh) |
| Heating | Rated Capacity (KW) at 7°C<br>Power Consumption (W) | Power Consumption during Heating (kWh)<br>Low Temperature Capacity at 2°C |
| Yearly Electricity Consumption (kWh/Year) | | |

The following figure shows a database display example of air conditioners.




Class name: Cooling Capacity 3.6 kW and Free Dimension

(Source: ECCJ Website)

**Figure 2- 9 Database Components and Actual Description of an Air Conditioner Case**

### 2.1.4 EE&C Building Regulation

(1) Overview

As for the EE&C buildings regulation (residential and non-residential buildings), in the case of new construction, extension of buildings, retrofitting, renovation, etc., it is required for buildings beyond the specified size, under the Energy Conservation Law, to notify the administrative agencies regarding EE&C measures to be implemented. Buildings with a total square floor area of more than or equal to 2,000 $m^2$ have been targeted, and the standards have been lowered to more than or equal to 300 $m^2$ since April, 2010. The buildings with a total floor area of more than or equal to 2,000 $m^2$ are classified as "Type 1 specified buildings", and the rest (the total floor area of which is more than or equal to 300 $m^2$ and less than 2000 $m^2$) as "Type 2 specified buildings". The required activities such as actions to be specified, the contents to be notified, judgment standards, periodical reports etc. (the overview of which is shown in the next table) vary depending on the size and use of the buildings.

In addition, it is stipulated as a requirement to submit a periodical report every 3 years to the administrative agency regarding the situation of maintenance and operations of EE&C measures.

**Table 2- 7 Items regarding Specified Buildings**

| | Type 1 Specified Buildings (Total Floor Area: more than or equal to 2,000 $m^2$) | Type 2 Specified Buildings (Total floor area: more than or equal to 300 $m^2$ and less than 2,000$m^2$) |
|---|---|---|
| Actions to be specified via submission of EE&C measures | New construction, and extension or retrofitting beyond the specified size | New construction, and extension or retrofitting beyond the specified size |
| | Repairing or changing of roofs, walls, or floors beyond the specified size | — |
| | Installing or retrofitting of air-conditioning systems etc. | — |
| Penalty on breach of notification obligation | Penalty equal to or less than JPY 500,000 | |
| Measures which may be taken when the notified EE&C measures are insufficient in light of the judgment standards | Instruction | Admonition |
| | (In case of not-obeying the instruction) Disclosure | — |
| | (In case of not-obeying the instruction without justifiable causes) Order | — |
| | Breach of order → Penalty equal to or less than JPY 1 million | — |
| Target of periodical report | Who notified EE&C measures? | Who notified EE&C measures? (excluding residential buildings) |
| | Situation of maintenance and operation regarding notification items | Situation of maintenance and operation regarding notification items (limited to EE&C measures of air-conditioning systems etc.) |
| Penalty on breach of notification obligation | Penalty of equal to or less than JPY 500,000 | |
| Measures when the notified items are quite insufficient | Admonition | Admonition |

(Source: "Guide for EE&C Standards and Measures of Buildings", IBEC* Website)
*IBEC: Institution of Building Environment and Energy Conservation

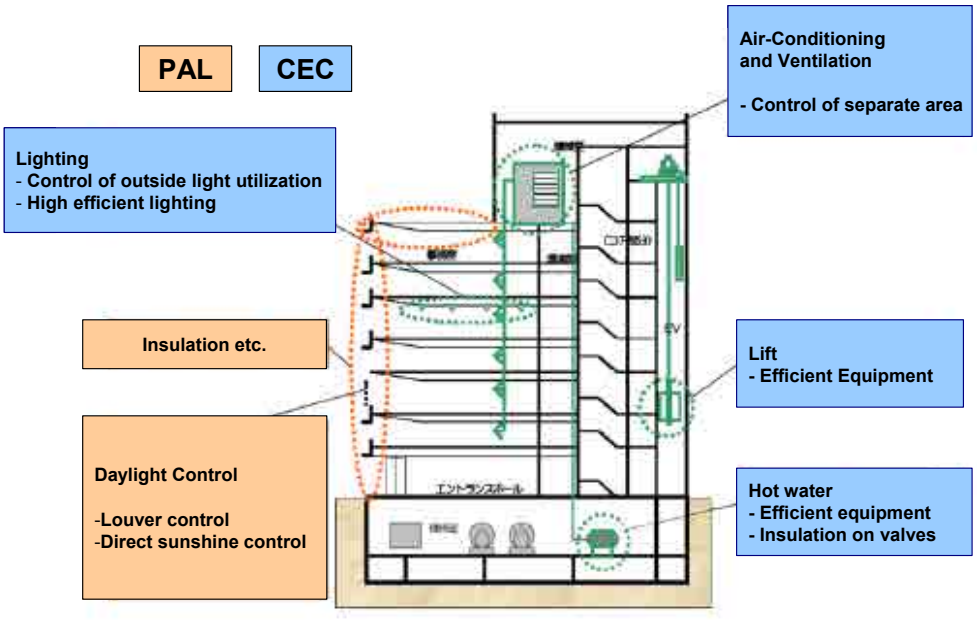
The above requirements for the specified buildings target both residential and non-residential buildings. Besides them, there are target standards stipulated for specified houses (namely, ready-built houses). In addition, although it is not mandatory, an EE&C standard for houses is set as the “obligation to make an effort”.

(2) Scope of Specification and Judgment Standards

The scope of specification and judgment standards differ in their evaluation methods and judgment standard values depending on whether the buildings are residential use or non-residential use (offices, hotels, etc.). Firstly, the case of non-residential buildings is shown in the following.

(a) Non-residential Buildings

The target for EE&C buildings is divided into two items, such as a building envelope and an equipment system (air-conditioning, ventilation, lighting etc.) (Image of the target is shown in the next figure.) There are two ways to evaluate EE&C performance: one is performance standards, the other is prescriptive standards. The prescriptive standards can only be applied to buildings with a total floor area equal to or less than 5,000 $m^2$.




Orange parts: related to the building envelope Green parts: related to equipment system
(Source: ”EE&C Measures in the field of buildings”, Ministry of Land, Infrastructure, Transport and Tourism）

**Figure 2- 10 Image of the Target for EE&C Measures**

(i) Performance Standards

The evaluation indicator of the building envelope EE&C performance is the Perimeter Annual Load (PAL). That of the equipment system is the Coefficient of Energy Consumption (CEC) and it is defined for each equipment system such as air-conditioning (AC), ventilation

(V), lighting (L), hot water supply (HW) and the elevator (EV). Examples of the equation of PAL and CEC are shown below. The judgment standard values of PAL and CEC are published for each building usage category (refer to the next table).

$$PAL = \frac{Annual\_Thermal\_Load\_of\_Perimeter\_Zone*\_(\mathrm{MJ/year})}{Floor\_Area\_of\_Perimeter\_Zone\_(\mathrm{m2})}$$

(*Perimeter Zone: All floor area of top floor and area of 5 m from the external walls of middle floors. Basement is excluded.)

$$CEC/AC = \frac{Annual\_Energy\_Consumption\_of\_Air-conditioning}{Standarized\_Annual\_Air-conditioning\_Load}$$

**Table 2- 8 Performance Indicators (PAL and CEC) and Judgment Standard Values**

| | Hotels etc. | Hospitals etc. | Shops etc. | Offices etc. | Schools etc. | Restaurants etc. | Halls etc. | Factories etc. |
|---|---|---|---|---|---|---|---|---|
| PAL ($MJ/m^2$ year) | 420* | 340* | 380 | 300 | 320 | 550 | 550 | - |
| CEC/AC | 2.5 | 2.5 | 1.7 | 1.5 | 1.5 | 2.2 | 2.2 | - |
| CEC/V | 1.0 | 1.0 | 0.9 | 1.0 | 0.8 | 1.5 | 1.0 | - |
| CEC/L | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| CEC/HW | To be decided from 1.5 to 1.9, depending on the values of (pipe length/ hot water amount) | | | | | | | |
| CEC/EV | 1.0 | - | - | 1.0 | - | - | - | - |

*: Different values in cold areas.
AC: Air Conditioning, V: Ventilation, L: Lighting, HW: Hot Water, EV: Elevator

(Source: "Guide for EE&C Standards and Notification of Buildings", IBEC Website)

How long and how the buildings are used vary. If actual conditions were adopted for the evaluation of EE&C performance, it would be unclear where the changes in PAL and CEC derive from, such as EE&C performance or time of use of buildings. Thus, in calculation of PAL and CEC, the standardized time of use and conditions of use are set according to the use of buildings. They, except CEC/AC which requires a simulation program, can be calculated by hand or spreadsheet software.

(ii) Prescriptive Standards

Prescriptive standards (called the "Point Method") consists of six items (building envelope, air-conditioning system, ventilation system, lighting system, hot water supply system, elevator system) likewise performance standards. The specifications of targeted buildings are checked according to the items which relate to EE&C performance. When they are judged as energy efficient, evaluation points are given according to evaluation standards. When the total points, after adjusting points are given to evaluation points, exceed 100 points, then the corresponding item is judged complying with the EE&C standards.

While the prescriptive standards are easier to evaluate, the quality of evaluation is inferior. Thus, the judgment standards are set rather strict compared to the performance standards.

For example, the items for the building envelope are the following 4 items.

- Evaluation of site planning and floor planning
- Evaluation of thermal insulation performance of external walls and roofs
- Evaluation of thermal insulation performance of windows
- Evaluation of sunlight shielding performance of windows

An example of evaluation items and points regarding thermal insulation performance of external walls is shown in the next table.

**Table 2- 9 Evaluation of Thermal Insulation Performance of External Walls and Roofs**

| Region | Item | Conditions of Measures | Points |
|---|---|---|---|
| General region | External walls | Spray rigid urethane foam insulation materials with the thickness of equal to or more than 20 mm, or other materials corresponding this thermal insulation performance in use | 30 |
| | | Spray rigid urethane foam insulation materials with the thickness of equal to or more than15 and less than 20 mm, or other materials corresponding this thermal insulation performance in use | 15 |
| | | Others except above | 0 |
| | Roofs | Polystyrene foam board with the thickness of equal to or more than 50 mm, or other materials corresponding this thermal insulation in use, or greening system which covers more than or equal to 40 percent of the roof area | 20 |
| | | Polystyrene foam board with the thickness of equal to or more than 25 mm and less than 50 mm, or other materials corresponding this thermal insulation in use | 10 |
| | | Others except above | 0 |
| Cold Region | External Walls | Spray rigid urethane foam insulation materials with the thickness of equal to or more than 40 mm, or other materials corresponding this thermal insulation performance in use | 20 |
| | | Spray rigid urethane foam insulation materials with the thickness of equal to or more than 20 and less than 40 mm, or other materials corresponding this thermal insulation performance in use | 10 |
| | | Others except above | 0 |
| | Roofs | Polystyrene foam board with the thickness of equal to or more than 100 mm, or other materials corresponding this thermal insulation in use, or greening system which covers more than or equal to 40 percent of the roof area | 10 |
| | | Spray rigid urethane foam insulation materials with the thickness of equal to or more than 50 and less than 100 mm, or other materials corresponding this thermal insulation performance in use | 5 |
| | | Others except above | 0 |
| 1”Spray rigid urethane foam” is the spray rigid urethane foam defined at A9526 (spray rigid urethane foam insulation materials for building thermal insulation) of JIS (Japan Industrial Standards).<br>2 ”Polystyrene foam board” is the polystyrene foam board by extrusion method defined at A9511 (spray plastic thermal insulation) of JIS. | | | |

(Source: “Guide for EE&C Standards and Notification of Buildings”, IBEC Website)

(b) Residential Buildings

The targets of EE&C measures are the building envelope and equipment system, same as the non-residential buildings. The equipment systems which are installed in each dwelling, however, are excluded from the target except for the possible cases of the common equipment system of apartments etc.

There are performance standards and prescriptive standards for the building envelope. There are types which are evaluated by the whole house (A and B type in the next table) and

by parts (C type). The outline is shown in the next table. While the A or B type requires a detailed calculation and the cooperation of experts such as designers, the C type only needs the specifications of insulation material, and the fixture and the glass of windows for evaluation.

**Table 2- 10 Matrix of Evaluation of Building Envelope Performance of Residential Buildings**

| Method of Evaluation | Evaluation Target | | Items of Evaluation | |
|---|---|---|---|---|
| Evaluation by the whole house (Performance standards) | Building envelope of Whole House | | <Type A> Annual cooling load per floor area | <B Type> Heat loss factor (Q-value) and summer sunlight factor (η-value) |
| <Type C> Evaluation by parts (Specification standards) | Frame structure | | Heat transmission factor (U-value) | Heat resistance factor of thermal insulation (R-value) |
| | Openings | Thermal insulation performance | Heat transmission factor (U-value) | Prescriptive standards for fittings etc. |
| | | Sunlight shielding performance | Summer sunlight penetration factor (η-value) | Prescriptive standards for fittings etc. |

(Source: "Guide for EE&C Measures of Specified Buildings (Houses)", IBEC Website)

(3) Checking of Performance

EE&C measures of buildings are checked when its documents together with other drawings are submitted to the administrative agencies to apply for building permits. Whether they were installed as described in the documents is checked as one of the certifying activities of construction on site.

### 2.1.5 Energy Conservation Center, Japan

(1) Outline of the Organization

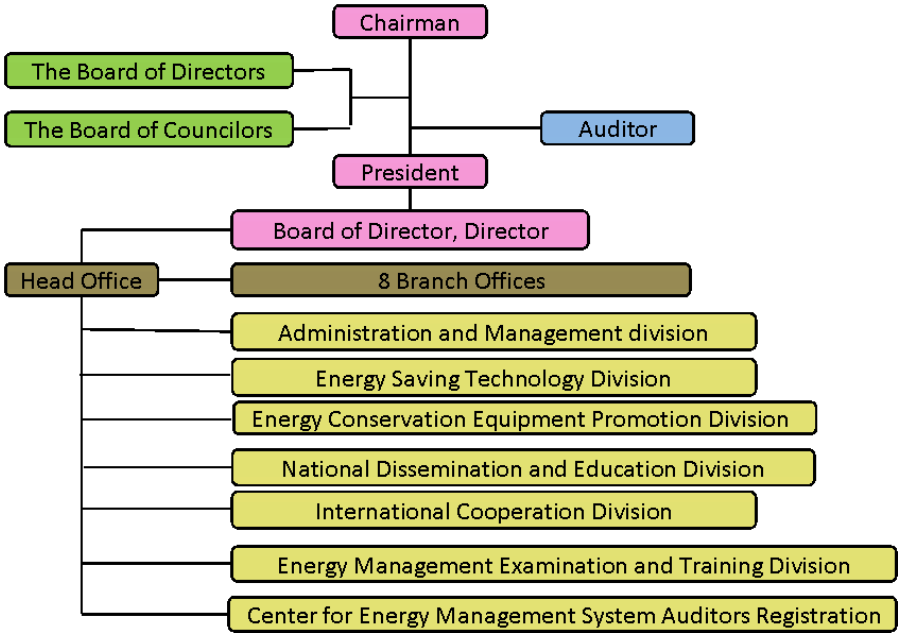
The Energy Conservation Center, Japan (ECCJ) was established in 1978 as an incorporated foundation and its financial income is based on the annual membership fee from supporting members, commissioned business from the Ministry of Economy, Trade and Industry (METI) and the center's own business such as technical training, publishing and so on.

The following column shows the outline of the ECCJ.

| | |
|---|---|
| **Branch offices** | **8 branch offices** |
| **Foundation** | **16 October 1978** |
| **Basic fund** | **475 million yen (5.94 million US$)** |
| **Operation fund** | **1.3 Billion yen (16.3 million US$)** |
| **Number of employees** | **135 (as of 1st July 2011)** |

(Source: ECCJ Website)

The organization consists of the head office and 8 branches under the chairman and the board of directors.




(Source: ECCJ Website)

**Figure 2- 11 Organization Chart of ECCJ**

(3) Supporting Membership System

The ECCJ provides a supporting membership system and its members consist of; (a) Large energy consuming corporations and factories such as steel, petrochemicals, paper, textiles, food etc. (b) the Energy supply industry such as electric power, gas, petroleum etc., (c) The manufacturing industry such as machinery, electricity, electronics, cars etc., (d) Various industries such as construction, engineering, finance, trading, retail, logistics, transportation, medical etc., (e) municipality governments and public organizations. Each business unit of the organization such as the head office, branch office and factory can be members respectively.

The supporting members must pay the membership fee and they are granted the following services;

- Exclusive website service for members which offers the latest energy saving information.
- Latest energy saving countermeasures and technical information
- Documentation support of the various energy management reports
- Free subscription to the monthly magazine “Energy Conservation” and discount on the training course fee and energy conservation promotion goods etc…

Annual membership fees are classified in the following list and based on annual energy consumption volume. 2,658 organization have participated as members as of April 2010.

**Table 2- 11 List of Annual Membership Fee**

| Kind of Organization | Class | Annual Fee Yen | Conditions |
|---|---|---|---|
| Fuel cosuming factories and buisiness body | S | 100,000 | Annual Fuel consumption > 60,000kL |
| | 1 | 80,000 | 30,000 – 60,000kL |
| | 2 | 60,000 | 3,000 – 30,000kL |
| | 3 | 40,000 | < 3,000kL |
| Electricity cosuming factories and buisiness body | S | 100,000 | Peak Demand > 10,000kW |
| | 1 | 80,000 | 5,000 – 10,000kW |
| | 2 | 60,000 | 2,000 – 5,000kW |
| | 3 | 40,000 | < 2,000kW |
| Municiparity government and public organization | 1 | 100,000 | Positively suporting organization |
| Others | | | Positively suporting organization |
| Head office | 1 | 100,000 | |
| Branch office | 2 | 50,000 | |

(Source: ECCJ Website)

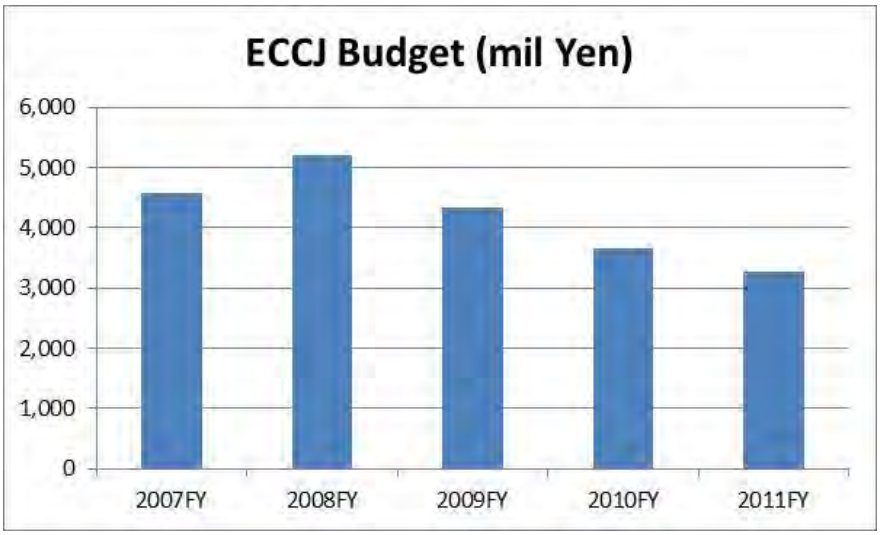
**Table 2- 12 List of Supporting Members (as of April 2010)**

| Business Sector | Numbers |
|---|---|
| Mining, quarrying of stone and gravel | 8 |
| Construction | 104 |
| Manufacturing | 2,014 |
| Electricity, gas heat and water | 321 |
| Information and communication | 14 |
| Transport and postal activities | 9 |
| Whole sale and retail trade | 17 |
| Real estate and goods rental and leasing | 16 |
| Scientific research, professional and technical services | 15 |
| Accommodation, eating and drinking services | 7 |
| Education and learning support | 13 |
| Medical, health care and welfare | 10 |
| Others (financial, general service, public service, etc.) | 110 |

(Source: ECCJ Website)

(4) Budget Scale of Business and its Breakdown

The budget scale of the ECCJ in 2011FY was approximately 3billion Yen and reducing its scale because of the spread of EE&C activities and a review of the subsidy allocation by METI.



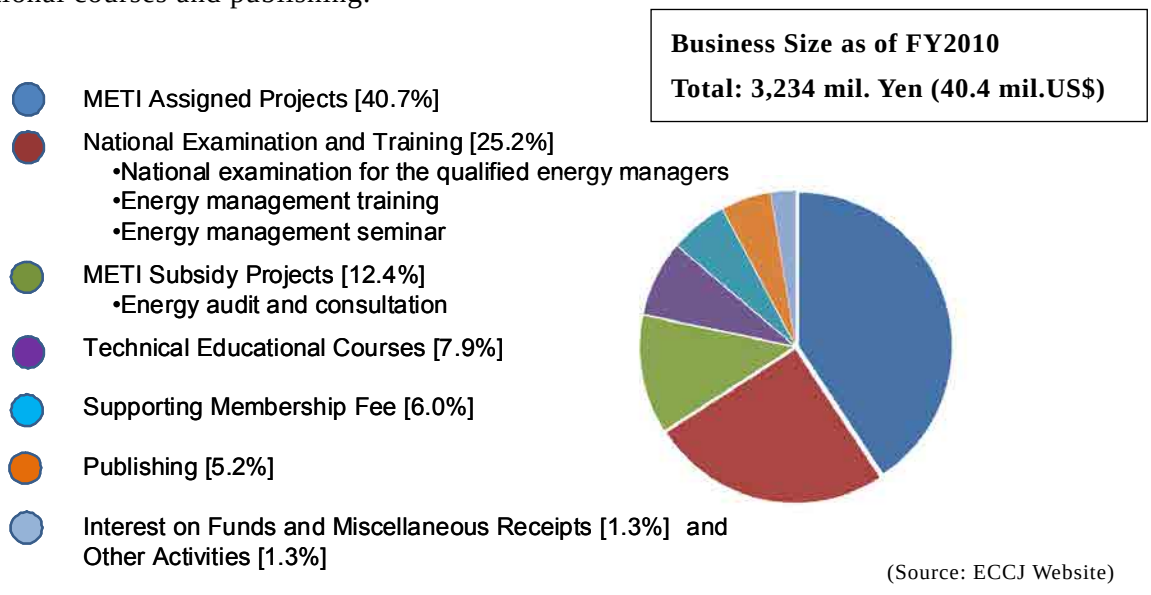

(Source: ECCJ Website)

**Figure 2- 12 Budget Yearly Trend of ECCJ**

A breakdown of the main business budget is shown below.

- METI Assigned Projects for policy execution
- National Examination and Training
- EE&C assessment as a METI Subsidy Project

On the other hand, the ECCJ owned business covers 13 % from the total such as technical educational courses and publishing.




(Source: ECCJ Website)

**Figure 2- 13 Breakdown of Business Budget of ECCJ as of 2010FY**

### 2.1.6 Major Dissemination Programs

(1) Dissemination Programs conducted by ECCJ

(a) Training Programs

There are various general training programs conducted by the ECCJ, such as a training program for the energy manager qualification, general training programs to facilitate energy management know-how in heat and electricity fields and energy conservation activities in the residential sector. The samples of the training programs are shown below.

(i) General Training Programs

The following tables show the general training programs provided by the ECCJ.

**Table 2- 13 Training Program of Heat Course (for General Engineers)**

| | Duration | Theme | Contents |
|---|---|---|---|
| First Term | 2 days | EE&C Technology of Heat and Combustion Management | **EE&C Technology of Heat**<br>● Outline of law and regulation, and energy management<br>● EE&C technology and its application to site<br>● Practical calculation method of heat<br>**Fuel**<br>● Fuel<br>**Combustion Calculation**<br>● Calculation method of combustion<br>**Hands on Practice of Combustion**<br>● Combustion and hands on practice of explosion<br>● Hands on practice of combustion |
| Second Term | 2 days | Steam Management and Steam Trap | **EE&C of Steam**<br>● Necessity of EE&C<br>● Improvement of stream system in Energy Conservation Law<br>● EE&C by utilization of steam<br>● EE&C measures in steam utilization field<br>**Hands on Practice of Steam**<br>● Measure of drain recovery<br>● Practice of engineering software |
| Third Term | 2 days | Energy Assessment of Heat Facility | **Heat Balance Calculation and Assessment**<br>● Introduction of heat balance calculation<br>● Practical assessment method<br>● Cast study of heat balance calculation<br>● Answer of heat balance calculation<br>**Practice of Finding Potential of EE&C**<br>● Introduction of good practice factory<br>● Finding potential of EE&C (group discussion) |
| Fourth Term | 2 days | Good Practice of EE&C of Heat | **Introduction of Good Practice of EE&C in Heat**<br>● Improvement of combustion<br>● Improvement of heat transmission<br>● Improvement of heat radiation<br>● Improvement of heat recovery<br>**Site Visit of EE&C Technology Application**<br>● Site visit<br>● Introduction of EE&C sample in building<br>● Q&A |

(Source: ECCJ Website)

**Table 2- 14 Training Program of Electricity Course (for General Engineers)**

| | Duration | Theme | Contents |
|---|---|---|---|
| First Term | 2 days | EE&C of Building | **EE&C of Building**<br>● Outline of law and regulation, and energy management<br>● Outline of EE&C of building<br>● EE&C of lighting<br>● EE&C of AC<br>● EE&C of transformer<br>● Cogeneration<br>**Measurement of Electricity**<br>● Measurement of voltage and current<br>● Measurement of electric power<br>● Measurement of pressure, flow volume and temperature<br>● Measurement method of each facility<br>**Hands on Practice of Electricity Measurement**<br>● Practice of measurement of pump<br>● Practice of measurement of fan<br>● Practice of measurement of lighting<br>● Practice of measurement of high efficiency transformer<br>● Practice of measurement of AC<br>● Data arrangement and observation |
| Second Term | 2 days | EE&C of Compressor | **EE&C of Compressor**<br>● Type of compressors and their characteristics<br>● Axis power of compressor<br>● Protection of leakage and its effect<br>● Pressure loss of pipe<br>● Measurement tool and how to use<br>● EE&C of compressor equipment<br>● EE&C by control method<br>● EE&C of compressor<br>**Hands on Practice of Compressor**<br>● Hands on practice of compressor<br>● Data arrangement |
| Third Term | 2 days | EE&C of Pump and Fan | **EE&C of Pump and Fan**<br>● Type of pumps<br>● Characteristics of pump<br>● Operation and control of pump<br>● EE&C of pump<br>● Consideration points on installation and maintenance<br>● Type of fans and blowers<br>● Performance of fan<br>● Parallel operation and series operation<br>● EE&C of fan<br>● Diagnosis of faults<br>**Hands on Practice of Pump and Fan**<br>● Measurement of performance of pump<br>● Measurement of performance of fan<br>● Data arrangement |
| Fourth Term | 2 days | Good Practice of EE&C of Electricity | **Introduction of Good Practice of EE&C in Electricity**<br>● Good practice of AC<br>● Good practice of lighting<br>● Good practice of compressor<br>● Goof practice of pump and fan<br>● Good practice of transformer<br>**Site Visit of EE&C Technology Application**<br>● Site visit<br>● Introduction of EE&C sample in building<br>● Q&A |

(Source: ECCJ Website)

Other than heat and electricity training programs, there are various other programs such as a training program on how to find EE&C potential, training for building energy assessment skills, site visits to factories and buildings that engage in good practices and so on. An overview of these programs is shown below.

**Table 2- 15 Other Training Programs**

| Course | Duration | Theme | Contents |
|---|---|---|---|
| How to Find EE&C Potential | 2 days | Practice to Find EE&C Potential in Electricity and Fuel Consuming Factory | 1. Issues and countermeasure in promotion of EE&C<br>2. Methods to find EE&C potential and its application<br>3. Practice |
| Energy Assessment of Building | 2 days | EE&C in Building Facility and Operation | 1. Law and regulations<br>2. EE&C of lighting<br>3. EE&C of AC<br>4. EE&C of pump and fan<br>5. Good practice of building EE&C<br>6. Practice of energy assessment of building |
| How to Make Management Standards | 2 days | Practice of Making Management Standards | 1. Law and regulations<br>2. Practice of making Management Standards<br>・ Resource mapping and grasping current situation<br>・ Selection of targeted facilities<br>・ How to make the Standards<br>・ Drafting a sample standard |
| Site Visits of Good Practice Factory and Building | 2 days | Site Visits and Practice of Energy Assessment | 1. Lecture<br>・ Law and regulations<br>・ Points of EE&C in factory and building<br>2. Practice<br>・ Introduction of overview of facilities<br>・ Introduction of safety code<br>・ Site visit and practice of energy assessment<br>・ Best answer of the energy assessment |

(Source: ECCJ Website)

(ii) Training Courses for the Residential Sector

Regarding EE&C for the residential sector, in order to train experts to disseminate EE&C awareness and activities to their communities or business, the ECCJ provides a certification named “EE&C Expert for Residence”. After passing a certification exam, the trainees will have access to a training opportunity called “Training for Energy Audit Experts for Residences” whose objective is to acquire knowledge for energy audits and EE&C improvements in the residential sector.

**Table 2- 16 Outline of EE&C Expert for Residence**

| Target Group | Exam | Qualification | Lecture | Participants |
|---|---|---|---|---|
| People who can promote EE&C activities in community, home, business, municipality, private organizations | 1 day | Motivated people to promote EE&C for residential sector | 1.Basic information of energy and EE&C in residential sector<br>2.EE&C using appliances<br>3.EE&C house | 1,121 in 2011 |

(Source: ECCJ Website)

(b) Energy Assessment Service

The ECCJ dispatches certified energy assessment experts to small/middle-scale factories or buildings to conduct energy assessment services free of charge. Mainly, there are two types of services. One is an assessment for reduction of power consumption at peak times in the summer, and another is for the reduction of energy consumption including electricity, gas and crude oil. ECCJ has more than 10,000 pieces of data from these energy assessments as of 2012. Good practices are introduced at training courses, written on the guidebooks and published on ECCJ's website. "Energy Assessment Experts for Buildings" is a certified license by ECCJ, and the upper level of it is to be set up as a "Professional of Energy Assessment".

**Table 2- 17 Outline of Training Course for Energy Assessment Experts for Buildings**

| Target | Duration | Objectives | Qualification | Subject of exam | Participants |
|---|---|---|---|---|---|
| People who have experiences for more than 2 years to be engaged in managing, operating, or consulting for building | 2 days | Training of engineers to conduct EE&C activities in office buildings | 1. Possibility of data collection to fill out the assessment repot<br>2. Correspond to one of the following items<br>a. Experiences more than 2 years to operate or maintain AC in buildings.<br>b. Experiences to design or construct buildings, and capable to operate or maintain A C for buildings.<br>c. Finished more than one lecture for engineers by ECCJ. | 1.Basic knowledge(Law / Technology)<br>2.Tips to promote EE&C<br>3.How to fill out assessment report<br>4.ECCT(Target calculating tool), ESUM(intensity calculating tool)<br>5.EE&C measures | 560 as of March 2010 |

(Source: ECCJ Website)

(c) Award Scheme for EE&C

The "Energy Efficiency and Conservation Award" ceremony is held every year, organized by ECCJ, and sponsored by METI. Targeted sectors are business establishments, factories and offices in industrial, office buildings and the transport sectors. The business operators who promote EE&C or activities to develop products for EE&C are evaluated. There are two sections of the awards; "EE&C Activity" and "EE&C Products or EE&C Business Model". The number of expected winners and contents of the application are separated respectively as follows.

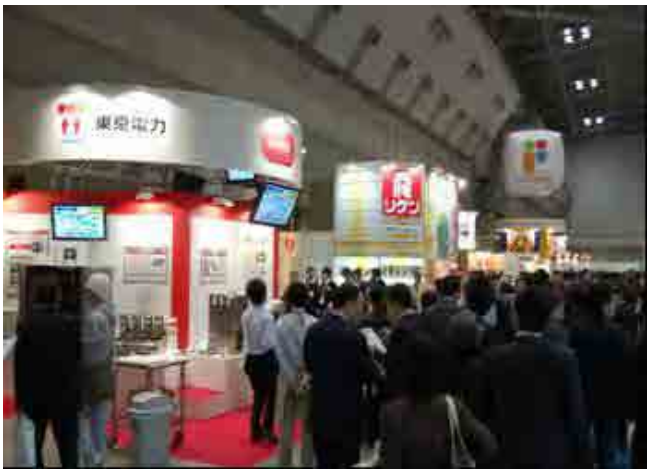
**Table 2- 18 Requirement List of EE&C Award in FY2011**

| Section | Award by Minister of METI | Award by Director General of ANRE | Award by Director General of SMEA | Award by President of ECCJ | Award by Evaluating Committee | Requirement of Application Form |
|---|---|---|---|---|---|---|
| EE&C Activity | 3 or less | 5 or less | 1 | 10 | 1 or less | 1. Organization for energy management<br>2. Outline of EE&C activities<br>3. Objectives to promote EE&C<br>4. Improvement<br>5. Advanced/originality<br>6. Energy efficiency<br>7. Versatility/ repercussion<br>8. Continuous improvement<br>9. Patent, award, publication |
| EE&C Products/Business model | 3 or less | 3 or less | 1 | 7 | 1 | 1. Outline of products/business model<br>2. Technical specifications<br>3. Background and objectives of develop products<br>4. Development process of products/business model<br>5. Advanced/ originality<br>6. Energy efficiency<br>7. Resource conservation/ recycle<br>8. Market potential/ economical<br>9. Environmental/ safety<br>10. Patent, award, publication |

(Source: ECCJ Website)

Every February, which is EE&C awareness month in Japan, an EE&C Award Ceremony is held at the "ENEX". The winners are introduced on the ECCJ's website, monthly magazines and other books. Also, at various training courses, the good practices of the winners are shared.


(Source: ECCJ Website)



(Source: TEPCO)

**Figure 2- 14 Label of Grand Prize for EE&C Award and ENEX**

(d) Database for EE&C

Various pamphlets with EE&C information and calculating tools of the EE&C effects are on the ECCJ website, for free access. Information which is provided on the website is as follows.

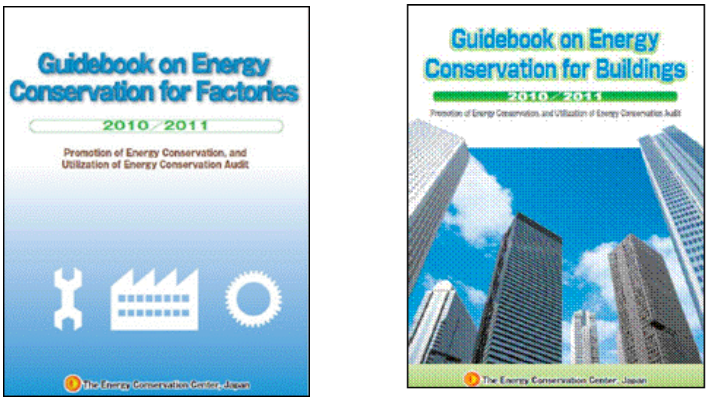
**Table 2- 19 EE&C Database provided by ECCJ**

| Database | Tool | Target sector | Contents |
|---|---|---|---|
| EE&C Products Search Site | Research site of efficiency products | Residential (retailers, consumers) | Search from manufacturer, product name and sales year. Tool for making EE&C labeling |
| | Research site for Industrial equipments | Industrial | Search from manufacturer, product name and industrial classification |
| | Introduction site for "Energy Efficiency Navi" | Residential | Introduction of performance of EE&C equipment named "Energy Efficiency Navi" |
| Retailer Search Site | Research site | Residential (consumers) | Introduction of retailers and address |
| Energy Assessment Database | Application download site | Commercial & industrial | Application form of Energy Assessment |
| | List of Energy Assessment Experts for buildings | Industrial & commercial | Customers can choose the experts. |
| | Target figure setting tool | Commercial & industrial | For buildings |
| | Energy intensity management tool | Industrial & commercial | For buildings |
| | Calculation tool of AC energy consumption (E-tool) | Commercial | Energy consumption of AC for tenants of buildings |
| Best practice Search Site | Introduction of winners of EE&C Award | Industrial & commercial | Introduction of company name and outline of EE&C activities |
| | Result of analysis with Energy Efficiency Navi | Residential, industrial and commercial | Ranking of good practices of EE&C activities at schools, offices and communities |
| Pamphlets Download Site | Pamphlets | Residential, industrial and commercial | Free download of pamphlets of information on EE&C |

(Source: ECCJ Website)

(e) Pamphlets for EE&C

The ECCJ distributes "Guidebook on Energy Conservation for Factories" and "Guidebook on Energy Conservation for Buildings", which is available for download on the ECCJ website.




(Source: ECCJ Website)

**Figure 2- 15 Guidebooks on Energy Conservation for Factories and Buildings**

(2) Dissemination Programs of Power Utilities in Japan

Dissemination programs which TEPCO conducts are shown as follows. It is distinctive that power utilities implement EE&C activities for electricity saving and not for other types of energy.

(a) Educational Programs on EE&C

TEPCO implements EE&C educational programs aimed at various consumer types including students, housewives and teachers. The contents of the programs are shown as follows.

**Table 2- 20 Educational Programs of Power Utilities in Japan**

| Target | Programs | Contents |
|---|---|---|
| Elementary/ junior high school and high school students | Lecture on energy and environment | TEPCO staff is dispatched to school and has interactive lecture as science or social study class. |
| Elementary/ junior high school students | Science Contest | Contest of kids study on summer vacation |
| College students | Environmental Activity Contest | Contest of essay on environmental activities |
| Teachers | Training on environmental and energy education | TEPCO instructs teachers in how to teach energy and environmental education. |
| Women | Cooking lecture | Cooling lecture using IH cooking heater |
| All customers | Study tour to power plant | Introduction of energy saving at power plants |

(Source: TEPCO)


(Source: TEPCO)

**Figure 2- 16 Lecture at Elementary School on EE&C and Environmental Activity Contest for College Students**

(b) Pamphlets/Tips/Advertisement on EE&C

Pamphlets and tips on EE&C for the residential sector are produced by TEPCO. As one of TEPCO's best practices, a character named "Denko-chan" was created just for EE&C activities. "Save electricity!" is Denko-chan's advertising slogan. Along with the tips, the slogan and Denko-chan appear together to attract people. In addition, TEPCO hires famous actresses to play the voice of Denko-chan on TV as an effective means to draw public attention. The result of such dissemination activities is that Denko-chan is now a popular character in Japan and the average awareness level of EE&C has increased. Based on TEPCO's experiences, ideas for pamphlets or TV advertisements can be summarized under the following four points.

- A catchy character should be used to capture the imagination of the young generation.
- Slogan should be easy to remember and appear with a catchy character.
- Mass media campaigns should be frequent and long term.
- Identification of interests of target people is important.

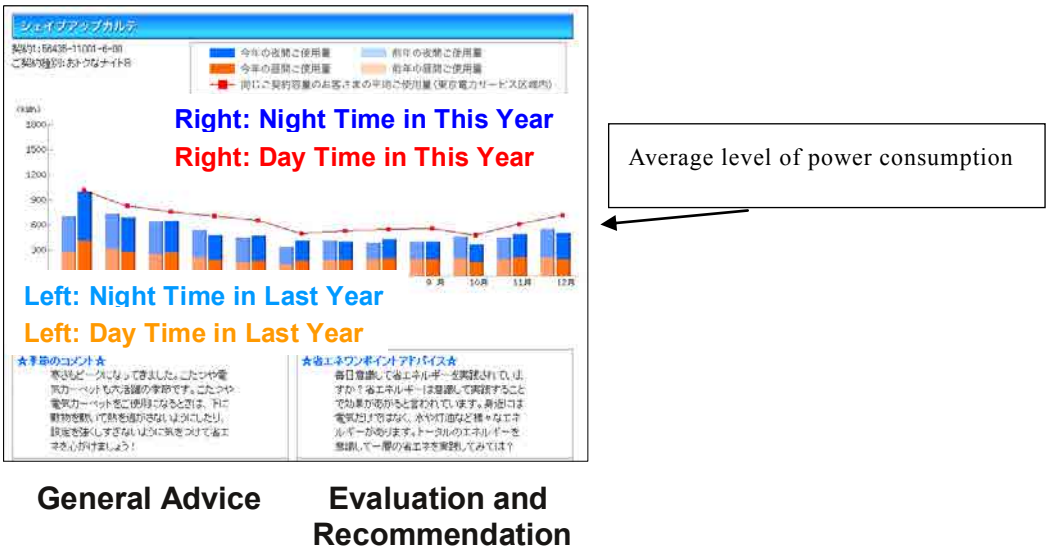
(c) Awareness Survey on EE&C

In order to measure the impact of EE&C dissemination programs, TEPCO conducts a periodical awareness survey. The survey is conducted on the internet to save on labor costs. Denko-chan's tips or EE&C appliances serve as incentives to fill out the questionnaire..

While it is common that the awareness survey is a measure for EE&C supporters to improve dissemination programs, the survey which asks respondents about their awareness level is also an effective dissemination tool.

(d) Information Dissemination of Power Consumption Data for Customers

On TEPCO' s website, there is a tool to monitor the monthly power consumption data of each contract. It is possible for customers to compare the data with the average figure of the same contract. Comparisons with last year's data is also available. This tool aims at setting targets easily for EE&C.




(Source: TEPCO)

**Figure 2- 17 Information Dissemination of Power Consumption Data (Internet Access)**

### 2.1.7 Electricity Tariff

(1) Electricity Tariff in Japan

In Japan, the liberalization of the electricity retail market started from 2000, and currently the retail market can be categorized into two segments; the liberalized market for large and medium-sized customers and the regulated market for small customers. The liberalized market

accounts for about 2/3's of Japan's total electricity sales (about 900 GWh in fiscal year 2010), whereas the regulated market takes up the remaining 1/3.

- Liberalized market: applied to customers with a contract capacity of 50 kW or more (supplying at 6 kV or higher). Customers can choose their electricity supplier.
- Regulated market: applied to customers with a contract capacity of less than 50 kW (supplying at 100 V or 200 V). An electric power utility whose franchise area covers the customer's premises assumes the responsibility to supply electricity.

| | Voltage | Contract capacity | Residential | Commercial etc. | Industrial |
|---|---|---|---|---|---|
| Liberalized Market (about 2/3) | Extra-high (22kV or higher) | 2,000kW or more | | 566,526MWh (total Japan, FY2010) | |
| | High (6.6kV) | 50kW-1,999kW | | | |
| Regulated Market (about 1/3) | Low (100/200V) | Less than 50kW | Light (single-phase): 284,969MWh (ditto) Power (three-phases): 45,173MWh (ditto) | | |
| | Total | | 896,668MWh (ditto) | | |

**Figure 2- 18 Electricity Retail Market – Liberalized Market and Regulated Market**

In the liberalized market, the customers can choose the supplier of electricity not only from the electric power utility that owns the generation, transmission, and distribution functions in the franchise area, but also from other suppliers called Specified-scale Electricity Suppliers (Power Producer and Supplier: PPS) and the contract is made through tendering or direct negotiation. When a PPS supplies electricity to customers, the PPS usually makes use of the wheeling services provided by the regional power utilities used for which wheeling charge is paid to the utilities, because the transmission and distribution functions are apt to be a natural monopoly.

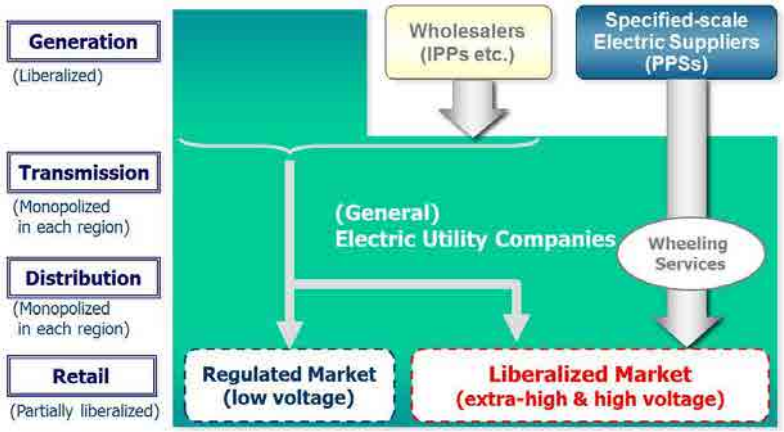



**Figure 2- 19 Structure of Electric Power Sector in Japan and Retail Markets**

In the liberalized market, suppliers, whether they are franchise power utilities or PPS, can set a retail price as agreed upon with customers. Franchise power utilities are obliged to make public a benchmark price in the "Standard Power Supply Contract" that stipulates their

standard tariff, but are also able to make a contract with customers based on an alternative tariff that is not disclosed in public in order to favour customers with a better load factor. Franchise power utilities are also obliged to supply electricity to customers who fail to agree on a contract with any supplier, and in this case power utilities offer another tariff that is higher than the standard tariff as stipulated in the "Last Resort Contract".

In the regulated market, an electric power utility in the franchise area supplies electricity to customers based on the tariff stipulated in the "Power Supply Contract that is approved by the Ministry of Economy, Trade and Industry (METI).

The tariff is regulated based on a methodology called the "Fully Distributed Cost" so that the costs of supply and return on assets are fully recovered. However, when a power utility reduces its tariff, the approval procedures are simplified so that the utility can change the tariff only by notifying METI of it. The calculation of costs of supply to formulate an electricity tariff is made by each power utility, hence the unit price is different among utilities and there's no cross-subsidization to mitigate a difference in the tariff.

In addition to the standard tariff, electric power utilities are also allowed to offer optional tariffs to favour customers who are using thermal storage devices that serve for load levelling.

As aforementioned, the electric power retail tariff has a structure where the liberalized market (large and medium-sized customers) and the regulated market (small customers) coexist, and the competitive division (generation and retail) and the monopolized division also coexist. In order to prove that there's no cross-subsidization in the tariff from the regulated/monopolized part to the liberalized/competitive part, each power utility is obliged to prepare the following two financial reports and to submit to METI every year, besides the financial statements of the entire corporate entity:

- Accounting report to segment between the liberalized market and the regulated market
- Segmented accounting report on power transmission and distribution divisions

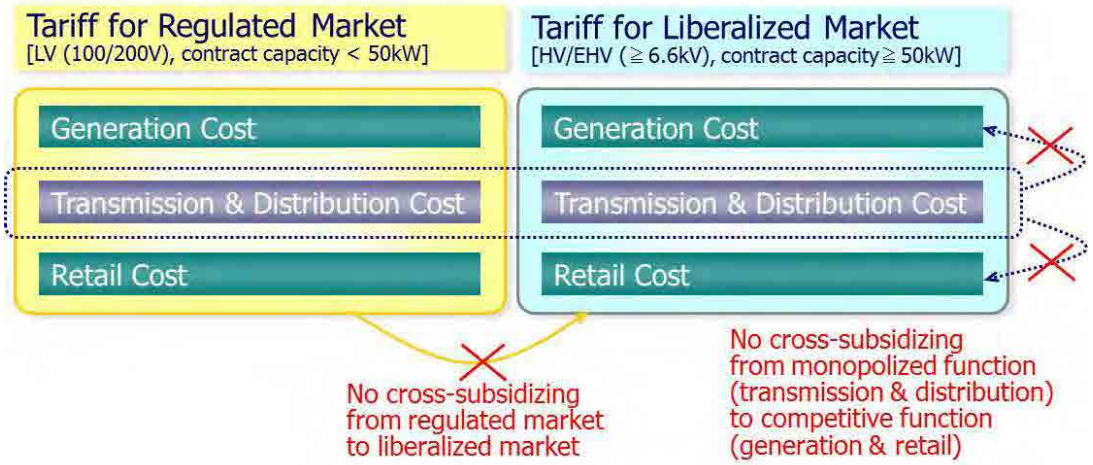



**Figure 2- 20 Segmented Accounting to Prevent Cross-subsidization**

When the results of the segmented accounting indicate a significant imbalance in profitability, the Ministry of Economy, Trade and Industry can issue an order to the power

utility to revise the electricity tariff for improvement. Recently Japan started the discussion regarding the reforms of electric power industry and electricity tariff system, such as the further liberalization of the retail market (as of September 2012).

(2) Electricity Tariff System

(a) Overview of the Tariff System

All the customers that have a contract with an electric power utility, except for some small power demand cases such as street lights, are billed monthly based on the consumption as indicated by a kWh meter that the utility installed. All of the electricity tariffs for customers for whom metered billing is applied consist of two components, i.e. Basic Charge (capacity charge) that is billed in proportion to the contract capacity (kW) and the Energy Charge that is billed in proportion to the consumed energy (kWh). For small contracts without meters, the monthly fixed rate is applied that is set depending on the capacity of the installed device.

(b) Electricity Tariff for the Liberalized Market

As discussed in the preceding section, the electricity tariff offered by the utility companies can be divided into two categories, i.e. tariff for the liberalized market (contract capacity: 50 kW or more, supply voltage: 6 kV or higher) and that for the regulated market (contract capacity: less than 50kW, supply voltage: 100 V or 200 V).

The electricity tariff for the liberalized market can be further broken down into two sub-categories according to usage. One is a tariff for business use, which is applied to shops, offices, public agencies etc., and another is a tariff for industrial use, which is applied to factories and mines. Besides these two, electric power utilities offer a tariff for agricultural use, which is applied to irrigation, a tariff for temporary use (less than one year usage) and so on, but because their share in the total demand is small compared to business use and industrial use, their details are not touched on in this report.

The standard tariff menu is made public for customers in the liberalized market, and this standard tariff menu, both for business use and for industrial use, offers two contract options from which customers can choose. One is the Time-of-Use (TOU) contract that sets a high unit price during the summer peak hours and a low unit price during the off-peak night hours, and another is a flat-rate contract regardless of the time. The TOU tariff was provided and was chosen by a certain number of customers even before the start of market liberalization, hence, the TOU is presented the first option of the “Standard Contract” after the liberalization, whereas the flat-rate tariff also remains as the second option of the “Standard Contract” taking into account some customers who may be charged higher if the TOU is applied. Even in the flat-rate contract, a different unit price is set between the summer (high-demand season from July to September) and other seasons.

Taking into account that the costs of supply vary depending on the voltage of supply (costs that are incurred for supplying electricity at a voltage that is lower than the customer’s voltage of supply should not be charged), a different unit price is provided for each category.

Besides this standard tariff menu, electric power utilities are providing other various optional tariffs, which serve to retain customers with a good load factor from competitors and for motivating customers to improve their load factors.

TEPCO's standard tariff menu for the liberalized market (effective from April 2012) is shown in the following table and figure.

**Table 2- 21 Standard Tariff Menu for Liberalized Market**
**(TEPCO, effective from April 2012, extract)**

| Voltage | | | | | Commercial etc. | | Industrial | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | TOU | Non-TOU | TOU | | Non-TOU | |
| EHV | 154kV | Capacity Charge (JPY/kW) | | | | | 1,480.50 | | 1,480.50 | |
| | | Energy Charge (JPY/kWh) | Summer | Peak(13-16h) | | | 16.12 | | 13.82 | |
| | | | | Daytime | | | 15.54 | | | |
| | | | Other Season (Daytime) | | | | 14.39 | | 12.96 | |
| | | | Night (22h-08h) | | | | 11.24 | | | |
| | 66kV | Capacity Charge (JPY/kW) | | | 1,533.00 | 1,533.00 | 1,533.00 | | 1,533.00 | |
| | | Energy Charge (JPY/kWh) | Summer | Peak(13-16h) | 16.33 | 14.58 | 16.33 | | 14.05 | |
| | | | | Daytime | 15.75 | | 15.75 | | | |
| | | | Other Season (Daytime) | | 14.65 | 13.65 | 14.65 | | 13.17 | |
| | | | Night (22h-08h) | | 11.39 | | 11.39 | | | |
| | 22kV | Capacity Charge (JPY/kW) | | | 1,585.50 | 1,585.50 | 1,585.50 | | 1,585.50 | |
| | | Energy Charge (JPY/kWh) | Summer | Peak(13-16h) | 16.54 | 14.82 | 16.54 | | 14.28 | |
| | | | | Daytime | 15.96 | | 15.96 | | | |
| | | | Other Season (Daytime) | | 14.86 | 13.86 | 14.86 | | 13.38 | |
| | | | Night (22h-08h) | | 11.60 | | 11.60 | | | |
| | | | | | | | ≥500kW | <500kW | ≥500kW | <500kW |
| HV | 6.6kV | Capacity Charge (JPY/kW) | | | 1,638.00 | 1,638.00 | 1,732.50 | 1,233.75 | 1,732.50 | 1,233.75 |
| | | Energy Charge (JPY/kWh) | Summer | Peak(13-16h) | 19.21 | 16.36 | 17.95 | 19.84 | 15.05 | 16.20 |
| | | | | Daytime | 18.53 | | 17.32 | 19.16 | | |
| | | | Other Season (Daytime) | | 17.17 | 15.26 | 15.91 | 17.80 | 14.08 | 15.12 |
| | | | Night (22h-08h) | | 11.81 | | 11.81 | 11.81 | | |

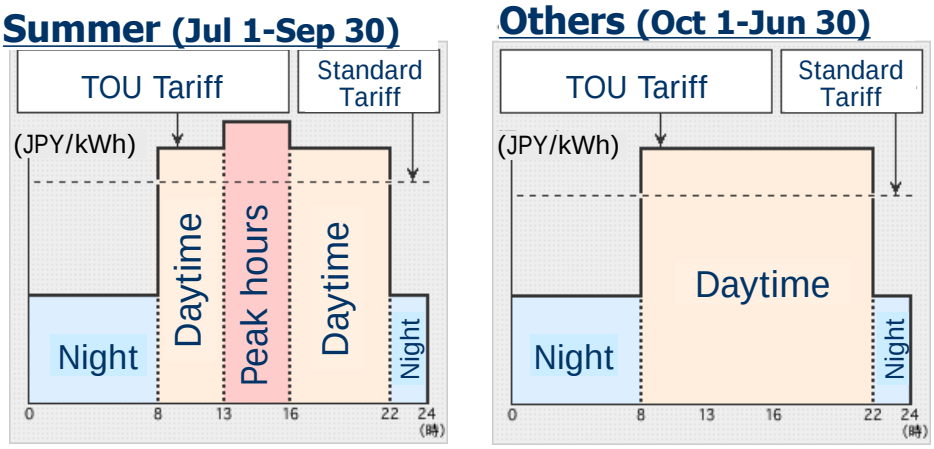



**Figure 2- 21 Image of Time-of-Use (TOU) Tariff (TEPCO's Case)**

(c) Electricity Tariff for the Regulated Market

For small customers to whom electricity is supplied at low voltage, there is no tariff rate discrimination regardless of usage such as residential, commercial, and industrial. There also

exist exceptions that different tariff rates are applied, likewise in the liberalized market, such as tariffs for agricultural usage, which is applied to irrigation, tariffs for temporary lighting use (single-phase 100 V for less than one year), tariffs for temporary power use (three-phases 200 V for less than one year) and so on, but because their share in the total demand is small, their details are not touched on in this report.

Excluding the aforementioned exceptions, the tariff table is in principle the same whether it's for residential, commercial, or industrial use. Instead, different tariff tables, namely "Metered Lighting" and "Low-voltage Power", are applied to the usage of single-phase devices and to the usage of three-phase devices respectively. Therefore, customers who use both the single-phase and three-phase need to enter into two contracts with separate service lines and meters for each of them. Customers are not allowed to use single-phase devices from the three-phase supply, and vice versa.

The number of cases where residential customers use three-phase devices is very few. Hence the application of a "Low-voltage Power" tariff is mostly confined to industrial customers using manufacturing facilities and a part of commercial and office customers using the three-phase air-conditioning system. In the meanwhile, residential use takes up an overwhelming share of "Metered Lighting" tariff customers.

In terms of promoting energy efficiency, the "Metered Lighting" tariff adopts a progressively increasing rate so that the more the customer consumes monthly, the higher the unit price becomes. The two boundaries where the unit price increases, i.e. 120 kWh and 300 kWh, are set assuming the "least necessary monthly consumption to sustain a household" and the "average monthly consumption of a household" respectively. For "Low-voltage Power" customers, different unit prices are set between the summer (high-demand season from July to September) and other seasons, likewise for non-TOU customers in the liberalized market.

Besides the standard tariff for the regulated market that needs approval from METI, optional tariff menus are offered by power utilities that aims at motivating customers to improve their load factor besides the regulated standard menu, and customers can choose a more favoured tariff among them.

TEPCO's standard tariff menu for the regulated market (effective from December 2011) is shown in the following table.

**Table 2- 22 Standard Tariff Menu for Regulated Market**
**(TEPCO, effective from December 2011, extract)**

| | | Metered Lighting B & C (single-phase) | Low-voltage Power (three-phases) |
|---|---|---|---|
| Capacity Charge (per month) | | 273 JPY/kVA | 1,071 JPY/kW |
| Energy Charge (JPY/kWh) | 1st | 18.89 (≤120kWh) | 16.50 (summer)<br>14.99 (other seasons) |
| * Unit price of lighting increases progressively according to monthly use | 2nd | 25.19 (≤300kWh) | |
| | 3rd | 29.10 (over 300kWh) | |

(d) Others

In Japan, more than half of electric power generation is sourced from thermal power using imported fossil fuel, and its price is strongly affected by international fuel prices and the foreign exchange rate. In order to assure the stability of the electric power business, a fuel-cost adjustment system is implemented so that the unit price per consumed energy increases or decreases in accordance with the actual fuel prices. A fuel-cost adjustment rate is formulated based on the weighted-average fuel cost that is calculated by using the prices of imported crude oil, liquefied natural gas (LNG) and coal, which can be found in the monthly trade statistics compiled by the Japanese Government, multiplied by weighing factors that are set by each utility company in consideration of the composition of its fuel consumption.

For customers to whom power is supplied at 6 kV or higher, as well as for low-voltage customers using three-phase power, a capacity charge (JPY/kW) is adjusted depending on their power factor. Here an 85 % power factor is assumed to be the standard, and the customer's capacity charge is discounted (or raised) by 1 % for every 1 % higher (or lower) power factor than 85 %. This adjustment serves to motivate customers to improve their power factor.

(3) Optional Tariff Menu for Load Leveling

As already outlined in the previous section (2), power utilities provide tariff menus to motivate customers to improve their load factor. They are expected not only to serve for peak load control and load factor improvement of the total system, but also to retain customers, especially those with a favourable load factor, from competitors by offering better rate.

In the liberalized market, TOU tariffs for business use and for industrial use are provided as a part of the "Standard Contract", and power utilities also provide various optional tariff menus for load leveling. These optional tariffs fall under a private contract and their specifications are not disclosed, but one example is to offer a tariff with a lower energy charge (variable part) and a higher capacity charge (fixed part) than the "Standard Contract" so that the customers with a high load factor, i.e. those whose contract capacity becomes smaller than that of other customers who consume the same volume of electricity in a year, benefit.

Besides that, in order to encourage customers to reduce or shift their peak load in a more direct way, power utilities also provide a demand adjustment contract targeting large industrial customers. In this contract, power utilities and customers consult in advance to determine how far the customers can shift their operational patterns from peak hours to off-peak hours, and customers can agree on shifting their operations upon the request from power utilities for which a tariff incentive is rewarded by the utilities. There are various types of demand adjustment contracts and their specifications are customized for each contract, but the typical examples of a demand adjustment contract are as follows:

- Emergency adjustment contract: when a tight balance between demand and supply is expected in the peak hours, power utilities request the contracted customers to execute a load reduction as agreed in advance. This request is made a few hours before the

peak hours. A tariff incentive is rewarded to customers who accepted the request. Because the customers need to be always ready for the request throughout the year, an incentive for the status of stand-by is also made even when the request is not made.

- Summer operation adjustment contract, summer weekend operation contract: customers shift their operation from peak hours to off-peak hours, or shift from weekdays to weekends in the summer, based on a prior agreement with power utilities. A tariff incentive is rewarded in accordance with the reduced load during peak hours.

In Japan, the growth of power demand has been slowing down recently and the possibility that a power supply deficit may occur has lowered. Hence, the power utilities' priority in the DSM tariff has shifted from these direct approaches to more indirect approaches to control demand in response to the price signal, such as the TOU and the tariff to favour customers with a high load factor. However, the possibility of a power supply deficit has become a reality again since the outbreak of the accident at Fukushima Daiichi Nuclear Power Station caused by the Great East Japan Earthquake, followed by the successive suspension of nuclear power plants all over the country. In these circumstances, DSM approaches that can expect a peak load reduction have more surely come into the limelight again.

For the regulated market, optional tariff menus for residential customers are provided such as TOU tariffs with differentiated prices in the daytime and nighttime, TOU tariffs with differentiated prices for the summer, other seasons and the nighttime, and the tariff exclusively for nighttime use. The initial purpose of these optional tariffs was to promote the diffusion of thermal storage devices by setting a low rate for nighttime usage, which is typically seen in the "8-hour nighttime" TOU Lighting tariff in the following table. Besides that, following the strong concern about power supply shortage after the Great East Japan Earthquake, another type of "Season and Time of Use" tariff, which focuses more on motivating the reduction of peak load by setting a very high rate for the power usage in summer daytime peak hours.

Power utilities also offer an optional contract for customers using a low-voltage three-phase supply, in which the energy charge (variable part) is set lower while the capacity charge (fixed part) is set higher than the standard contract so that customer can benefit by improving their load factor.

**Table 2- 23 Examples of TOU Tariff for Residential Customers (TEPCO)**

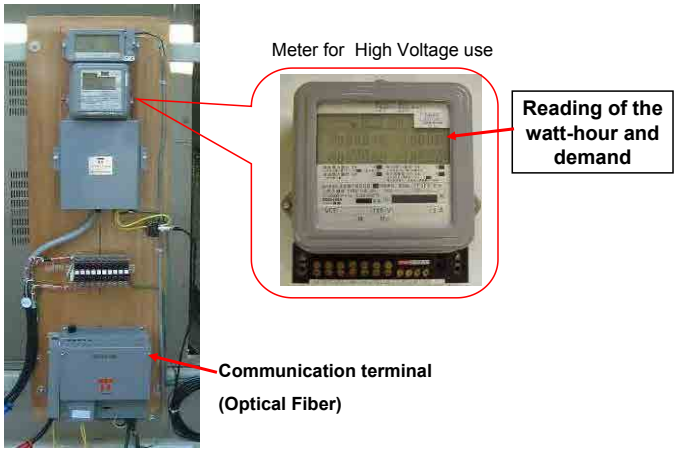
<table>
<tr><th></th><th colspan="3">Season and Time of Use Lighting (Peak-load control)</th><th colspan="3">Time of Use Lighting (8-hour nighttime)</th><th colspan="2">Metered Lighting</th></tr>
<tr><td>Capacity Charge (per month)</td><td colspan="3">1,260.00 JPY ( -6kVA)<br>2,100.00 JPY (-10kVA)<br>* 273JPY/kVA is added when the contract is larger than 10kVA</td><td colspan="3"></td><td colspan="2">273 JPY/kVA</td></tr>
<tr><td rowspan="3">Energy Charge (JPY/kWh)</td><td>Summer peak: 13-16h (Jul-Sep)</td><td>53.16</td><td rowspan="3">Daytime: 7-23h<br>* Progressively increasing with 3 steps</td><td>1st</td><td>23.15</td><td>1st</td><td>18.89 (≤ 120kWh)</td></tr>
<tr><td>Daytime: 7-13h, 16-23h</td><td>28.18</td><td>2nd</td><td>30.87</td><td>2nd</td><td>25.19 (≤ 300kWh)</td></tr>
<tr><td>Night time: 23-7h</td><td>11.82</td><td>3rd</td><td>35.66</td><td>3rd</td><td>29.10 (over 300kWh)</td></tr>
<tr><td></td><td colspan="3"></td><td>Night time: 23-7h</td><td>11.82</td><td colspan="2"></td></tr>
</table>

### 2.1.8 Automatic Meter Reading System

(1) Background of the Introduction of the Automatic Meter Reading System

In 1999, the Electricity Business Act of Japan was revised, and the market for commercial-scale utility customers of more than 2,000 kW was deregulated from March 2000. After that, the market of more than 500 kW was deregulated from April 2004, and more than 50 kW was deregulated from April 2005. Consequently, the utilities must have taken readings of the electricity meters of the deregulated customers every 30 minutes in order to match generation of the PPS (Power Producer and Supplier) and customer demands. (30-minute-equivalence between demand and supply) In Japan, the utilities take readings of almost all customers over 500 kW and customers over 50 kW supplied by PPS remotely.

On the other hand, regarding meter readings in rural regions such as mountainous areas, the cost of manned metering is higher than Automatic Meter Reading (AMR). In that region, AMR is adopted for the purpose of operational efficiency.




(Source: TEPCO)

**Figure 2- 22 Communication Terminal Equipment of AMR (for commercial-scale utility customers)**

**Table 2- 24 Purposes and Function of AMR**

| Customer | Company | Purpose | Function |
|---|---|---|---|
| ― Large scale Customers<br>― High Voltage Customers (Over 50kW) | Power Company | ― Monitoring of Equivalence of Demand and Supply<br>― Operational Efficiency of Meter Reading | Every 30 minutes value<br>Every 5 minutes value<br>Monthly Meter Reading |
| | PPS | ― Monitoring of Equivalence of Demand and Supply | Every 30 minutes value<br>Every 5 minutes value |
| ― Low Voltage Customers | Power Company | ― Operational Efficiency of Meter Reading in the rural region | Monthly Meter Reading |

(2) Outline of Automated Meter Reading System

The following diagram shows the AMR system structure for large-scale customers.

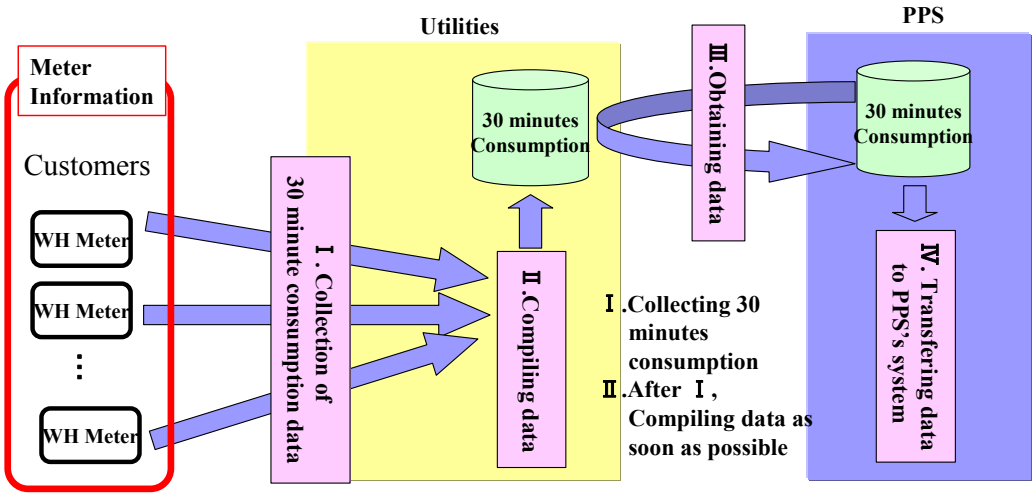
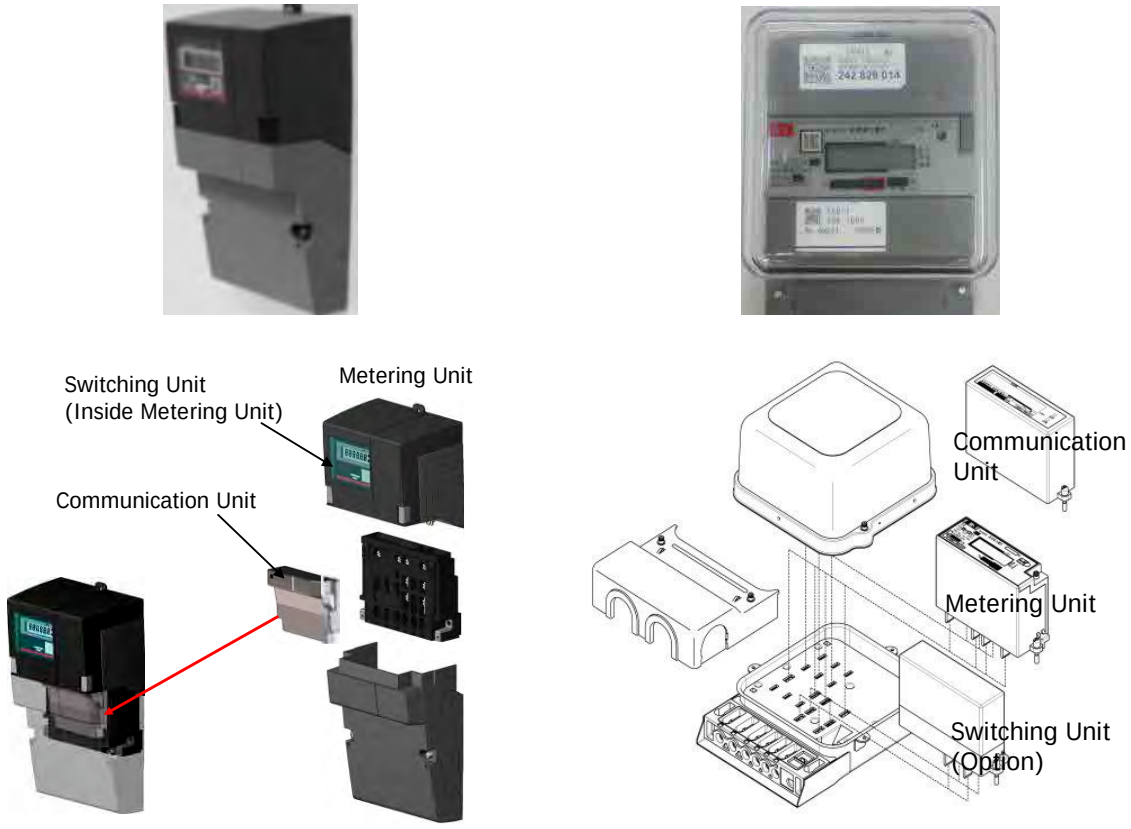



**Figure 2- 23 Structures of AMR system for Large Scale Customers and High-Voltage Customers**

In Japan, the utilities install communication terminal equipment for AMR on customer premises, and collect the monitoring data of electricity meters to their hosts via communication terminal equipment for AMR, and communication media (optical fibers, public mobiles). In the beginning, PPS had installed an AMR system independently as the utilities have done, and collected electricity consumption data every 30 minutes. However, the number of customers increased according to the expanded range of the deregulated market, and the cost of the AMR system of PPS also became larger. And then, the utilities constructed an AMR system the same as PPS, and doubled investments by the utilities and PPS was not efficient from a socio-economic perspective. Consequently, the utilities constructed a system that provides data collected by the utilities every 30 minutes to the PPS via the internet.

(3) Outline of Smart Meters Expected to be Installed in Japan

The AMR as described above is one-way communication system to aim at easy meter reading. As this moment in Japan, smart meter has started field trial tests for a wide introduction. The purposes of smart meter introduction are, in addition to AMR, operational efficiency, and EE&C action by customers with a visual breakdown of electricity consumption, and direct control of demand side appliances for stable electricity supply. The following figures show the aspects of Smart Meters under consideration by utilities in Japan.




(a) Smart Meter of TEPCO etc

(b) Smart Meter of Kansai Electric Power Company etc..

(Source: Study Group on the Smart Meter Scheme)

**Figure 2- 24 Smart Meters under Field Trial Test in Japan**

The "Basic Energy Plan" decided by the cabinet on June 2010, shows that "Considering their cost and benefit, basically, all meters are to be replaced to smart meters by the 2020s." with the goal of smart meter introduction. In addition, the "Immediate Supply-Demand Stabilization Measures" decided at the conference of Energy and the environment, National Policy Unit on July 2011, shows "Meters of 80 % of the demand are to be replaced to smart meters within 5 years" ahead of the "Basic Energy Plan".

In Japan, the METI held "a Study Group on the Smart Meter Scheme" from May 2010, in which utilities, home appliance manufacturers, telecommunication carriers and experts had 10 discussions, and published the report on February 2011.

The essential requirement of smart meters which is expected to be widespread in Japan is shown in the report as follows.

**Table 2- 25 Function of Smart Meter of Japan**

| | |
|---|---|
| Function | Remote Meter Reading, Remote Switching (Switch Connect and Disconnect for Remote Power Supply) |
| Information to be provided | Electricity Consumption, Reverse power flow (sales amount of Solar Power for transactions), Time and Date, Every 30 minutes metering |
| Destination of Information | Customers and Power Companies |
| Timing to inform | Daily (Previous days data is to be transfer by that day) |

(Source: Report of the Study Group on the Smart Meter Scheme)

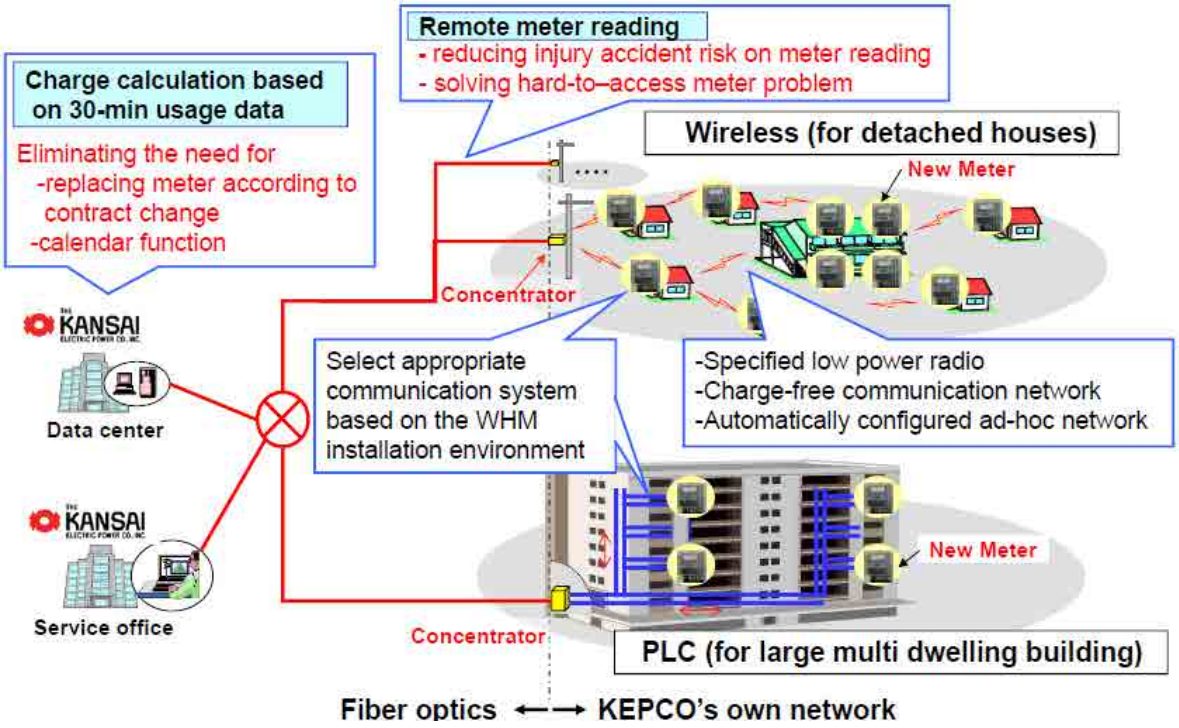
A utility has installed more than 1 million smart meters as shown in the following table. In addition, the Communication system of Smart Meters in Japan is constructed mainly with a radio frequency mesh in consideration of Japan's environment.

**Table 2- 26 Demonstration Projects in Japanese Power Utilities**

| Utilities | Abstract of Operational Test |
|---|---|
| Hokkaido | 125 smart meters have been installed since FY2011. |
| Tohoku | By the end of FY 2012, 700 smart meters will be installed. |
| Tokyo | 700 smart meters have already been installed since FY2010. |
| Chubu | 1,200 smart meters have already been installed since FY2010. |
| Hokuriku | 1,500 smart meters have already been installed since FY2011. |
| Kansai | 500 smart meters have already been installed since FY2011. |
| Chugoku | 1,140,000 smart meters have already been installed since 2008. |
| Shikoku | Operation test with 1,000 smart meters will be conducted from FY2012. |
| Kyusyu | 180,000 smart meters have already been installed since FY2009. |
| Okinawa | Operational test is under planning |

(Source: Report of the Study Group on the Smart Meter Scheme)

The following diagram shows the outline of the communication system which is used for smart meters at Kansai Electric Power Company.




(Source: Kansai Electric Power Company Presentation Material of 2011 APEC Workshop on Addressing Challenges in AMI Deployment and Smart Grids in APEC)

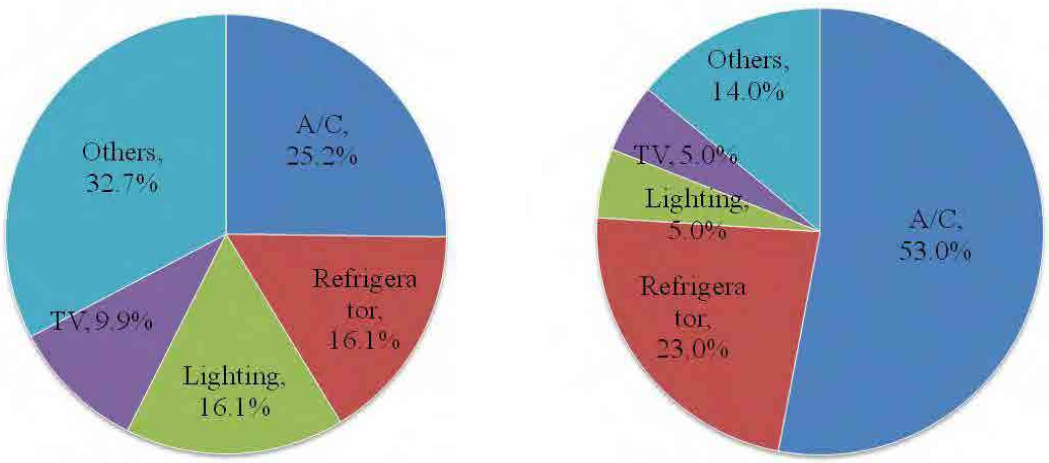
**Figure 2- 25 Communication Network of Smart Meters (Kansai Electric Power Company)**

### 2.1.9 Automatic Control System of Electric Appliances

(1) Automatic Control System in Residence

(a) Residential Electricity Consumption Trends

The charts below show a breakdown of electricity consumption in residences in Japan. Over the course of a year, air-conditioner (AC) units account for the highest proportion with refrigerators and lighting following behind. Additionally, AC units account for more than 50 % of power consumption during summer days, so the main question for the energy saving policy is how to reduce the power consumption of AC units.




(Source: METI Website)

**Figure 2- 26 Aannual Power Consumption in Residence and Power Consumption at the Peak of Summer in Residence**

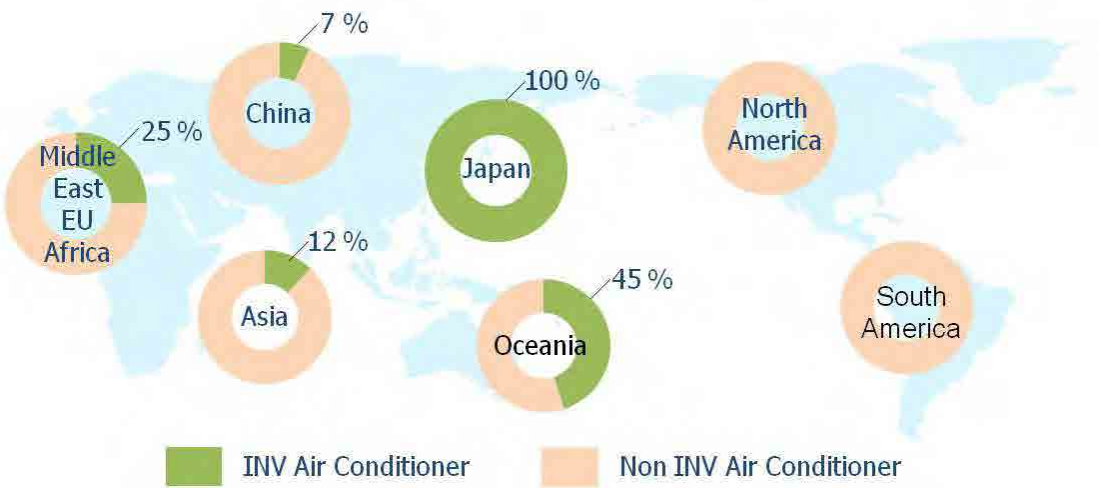
(b) Inverter Air-Conditioner

With an inverter AC, inverter technology is used in the compressor which is the main component of an AC unit, and the number of rotations of the compressor is controlled automatically. By operating at high output when it is hot, the interior of the room is quickly cooled, and when the set temperature is reached it maintains the room temperature while running at low output.

On the other hand, there are also non-inverter ACs, but with such units, the compressor can perform simple on and off controls, so when switched on it runs at high output and when it reaches the set temperature (set at roughly +2°C) the compressor is switched off, so electricity consumption efficiency, as well as the ability to maintain comfort levels are inferior to an inverter AC.

All manufacturers claim a 30 % reduction in power consumption using an inverter air conditioner against a non-inverter air conditioner. The diagram below shows the world wide diffusion of inverter air conditioners. In Japan, the diffusion rate is 100 %, but the diffusion rate in the Middle East, which is where this energy saving policy is being proposed, is 25 %, so an energy saving policy based on the introduction of inverter air conditioners is promising.

Furthermore, as well as the existing automatic operation control and timer functions, recent AC units in Japan have added occupancy sensors so that they are controlled to operate when a room is occupied, and to automatically switch off when no physical presence is detected for a fixed period of time, and a power select function to automatically switch off the AC unit once power consumption reaches a preset value.




(Source: METI Website)

**Figure 2- 27 Worldwide Diffusion Rates for Inverter ACs**

(b) Home Energy Management System (HEMS)

HEMS is a system that supports residential energy management, connected to energy consuming appliances via a network and making it possible to monitor operations and energy usage, and enable remote operations and automatic control.

In the future it is expected that it will be connected to a smart grid to develop optimisation of regional energy usage.

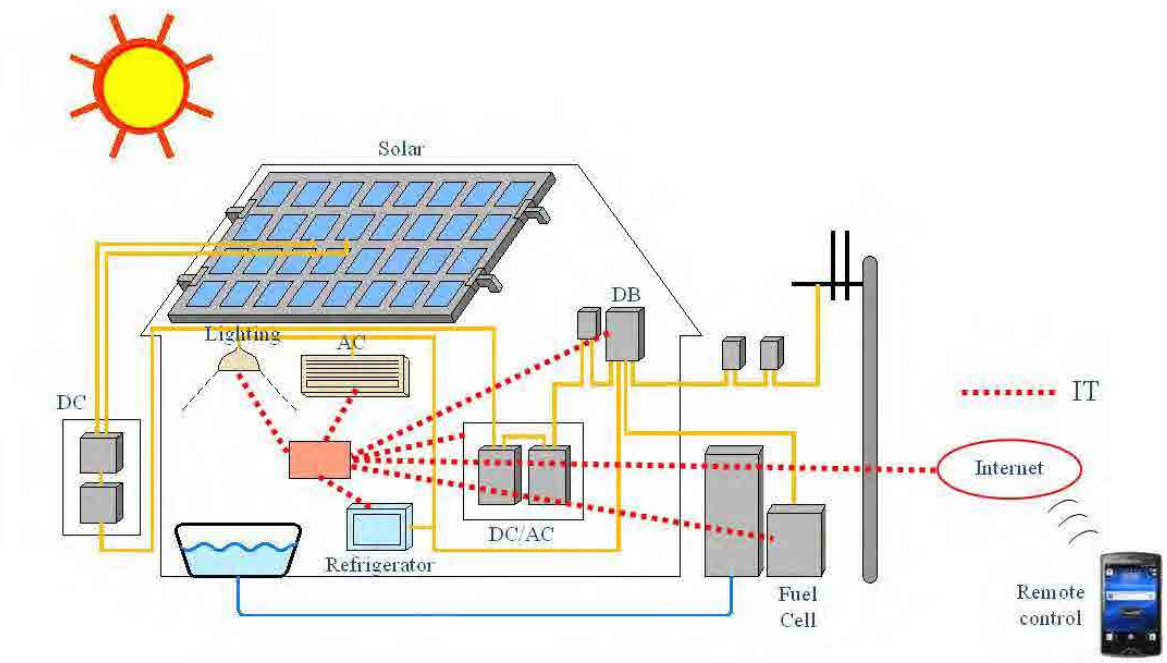



**Figure 2- 28 HEMS Overview**

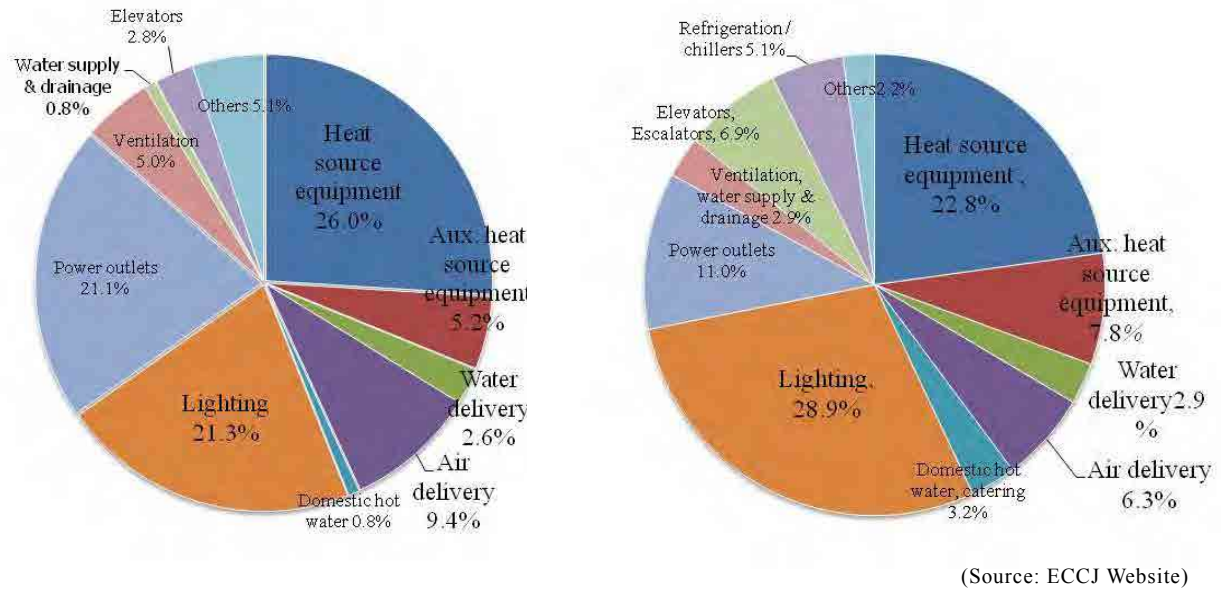
**Table 2- 27 Main Functions of HEMS**

| Menu | Outline of Functions |
|---|---|
| Monitoring | Residential facility operating conditions monitoring<br>Electricity consumption and power billing monitoring |
| Control | Residential facility control<br>Automatic control of AC units and lighting etc. in conjunction with outside conditions<br>Operation using HEMS monitor, mobile, TV etc. |
| Measurements | Residential facility measurements<br>Measure power consumption in residences, automatically turn off A/C units when a preset maximum on power consumption is reached. |
| Optimisation | Optimise energy usage by controlling household appliances, electricity consumption data collection and analysis, making projections of power demand, |
| Learning | Learn the living patterns of inhabitant, automatically control energy to suit their lifestyle. |
| Visualisation | Visualisation of electricity consumption and billing is output on HEMS monitor or television screen to encourage energy saving |

(2) Automatic Control System in Building

(a) Building Energy Consumption Trends

Energy consumption (Primary energy) in Japanese office buildings and commercial facilities is shown below according to usage. Lighting, power outlets and air conditioning, which include the heat source and power for delivery account for much of the energy consumption in office buildings and commercial buildings.




(Source: ECCJ Website)

**Figure 2- 29 Office Building Energy Consumption and Commercial Building Energy Consumption**

**Table 2- 28 Breakdown of Main Energy Consuming Equipment in Office Buildings and Commercial Buildings**

| Breakdown of Energy Usage | | Energy Consuming Equipment |
|---|---|---|
| Item | Details | |
| Heat Source Installation | Heat Source Unit | Refrigerator, water heater and chillers, boilers etc. |
| | Auxiliary Power | Condenser water pump, cooling tower, hot/chilled water primary pump, others |
| Heat Flow | Water Flow | Hot/chilled water secondary pumps |
| | Air Flow | A/C units, Fan coil units, others |
| Domestic Hot Water | Heat Source Unit | Boilers, circulating pumps, electrical water heaters, others |
| Lighting Power Outlets | Lighting | Lighting fixtures |
| | Power Outlets | Office equipment, others |
| Motor Power | Ventilation | Car park fans, others |
| | Water Supply & Drainage | Water pump, others |
| | Elevator | Elevators, escalators |
| Others | Others | Transformer loss, shop motor power, others |

(b) Automatic Control System of Individual Equipment

Regarding the building automatic control system, as well as maintaining comfort, the point is how to use energy eficiently. To this end, various automatic control systems for individual equipment have been introduced. The following is a list of automatic control systems used to support energy saving.

**Table 2- 29 Automatic Control System of Individual Equipment**

| Item | Control Basis | Control Purpose | Reduction Potential |
|---|---|---|---|
| Heat Source Installation | Unit Control | When the heat source is operating at low load, efficiency is usually low, so the number of heat source units is automatically selected based on the load, to operate more efficiently. | 10 % |
| Auxiliary Power | Unit Control | Control of the number of primary pumps in operation based on the capacity of heat source equipment | - |
| | Free Cooing Control | In winter time, when outside air energy can be used effectively, the heat source is not moved and cold water is made from the outside air | - |
| Water Flow | Unit Control | Control of the number of secondary pumps in operation is based on the capacity of heat source equipment | - |
| | Variable Water Volume (VWV) Control | Reductions in power consumption of pumps by adjusting the circulation volume based on the heat load | 30 % |
| Air Flow | Variable Air Volume (VAV) Control | Control of supplied air flow based on temperature sensors etc., to reduce power consumed by ventilators | 10 % |
| | CO2 Control | Reduce the fresh air volume while maintaining a healthy indoor environment, to reduce cooling loads | 20 % |
| | Fresh Air Cooling and Heating | Direct usage of fresh air as a heat source for heating and cooling in the term where there is no need for an air conditioner | - |
| | Warming-up Control | Controlled preparation of an indoor environment until a fixed time and the suspension of fresh air intake during the warming up period to reduce cooling loads | - |
| Lighting | Occupancy sensor Control | Lighting turned on and off automatically using occupancy sensors | 20 % |
| | Initial Lighting Correction Control | Automatic dimming of initial excessive lighting levels to reduce power consumption | 15 % |
| | Daylight Usage Control | Automatic dimming of lights according to levels of daylight to reduce power consumption | 10 % |

## 2.2 European Union (EU)

### 2.2.1 Basic Strategy for Energy Efficiency

(1) Target of EU

EC member countries committed to a 20 % reduction of primary energy consumption by 2020 (compared to the energy consumption forecasts for 2020) in the "Communication from the Commission (2008/11/13)". This commitment is also known as the "20-20-20 Goal" which aims at a 20 % reduction of CO2 emission and 20 % utilization of renewable energy.

(2) Policy for Energy Efficiency

To achieve the above target, EC proposes the following "Next Steps" and "Further Actions".

**Next Steps**

Energy efficiency in buildings

Energy use in residential and commercial buildings is responsible for about 41% of EU's total final energy consumption (2006). The cost-effective energy saving potential by 2020 is expected to reach 30 %. Buildings that have more than 1,000 m2 of total floor area is targeted and improve the efficiency by introduction of "Energy Performance Certificate". The contents of the certificate are described in the "2002/91/EC Directive on Energy Performance of Buildings".

Energy efficiency of products

The existing labeling and standard system has been revised to expand to wider products (ex. tire, waiting power, street and office lighting, etc.) through new "Ecodesign Directive".

Cogeneration

To enhance the utilization of cogeneration that is a highly efficient technique, EU continuously promotes further utilization through "2004/8/EC Directive on Promotion of Cogeneration".

Financing

To support investments to improve energy efficiency, financing schemes exist and the first results are positive: more urban development and renewal projects take energy efficiency into account. On the other hand, Designing effective energy efficiency measures targeted at households and SMEs requires a well coordinated financing framework.

EC is also working with the EIB and EBRD to set up an "EU Sustainable Energy Financing Initiative" to mobilize large-scale funding from capital markets for investments in energy efficiency, renewable energies, the clean use of fossil fuels and combined heat and power from renewable.

**Further Actions**

Evaluation of the European Energy Efficiency Action Plan (EEAP)

In 2009, EC evaluates the EEAP issued in 2006 and prepares a revised Action Plan. The objectives of the revision will have to be more demanding in the longer term e.g. 2030 and 2050, focusing on energy supply, transmission and energy consumption sectors.

International relations

Exchanging views and best practices on energy efficiency with third countries, international partnership in energy efficiency is promoted.

(3) Energy Efficiency Action Plan

EC issued "Energy Efficiency Plan 2011" on March 8, 2011, to achieve a reduction of primary energy consumption of 20 % by 2020. The plan proposed the following measures by sector.

**Table 2- 30 Energy Efficiency Plan 2011**

| Target Sector | Contents |
|---|---|
| Public Sector | • The Commission's work on public procurement for a better environment has supported this by developing procurement criteria that take energy efficiency into account. In addition, public bodies that are subject to the EU public procurement Directives are already required to take into account energy efficiency criteria in their procurement of vehicles or office equipment.<br>• Public bodies should take the lead in bringing their buildings up to high energy performance levels.<br>• Energy performance contracting is relevant for triggering renovation in public buildings and for upgrading the energy efficiency level of public infrastructure such as street lighting. |
| Residential Home and Building Sector | • In residential homes, two thirds of this is for space heating. The Commission will further explore the range of available solutions, including possibilities to promote the use of district heating.<br>• Several Member States have developed legal provisions that define the amount which can be recovered by investors from tenants.<br>• The Commission is launching the 'BUILD UP Skills: Sustainable Building Workforce Initiative' to support Member States in assessing training needs for the construction sector, developing strategies to meet them, and fostering effective training schemes.<br>• Both on national and European level would be an appropriate way to catalyse the development of this Energy Service Company (ESCO) market. |
| Industrial Sector | • Greater use of (high-efficiency) cogeneration, including from municipal waste treatment plants, and district heating and cooling can make an important contribution to energy efficiency.<br>• The Commission will strengthen the basis for national grid regulators to take energy efficiency into account in their decisions and in monitoring the management and operation of gas and electricity grids and markets.<br>• A prerequisite for an energy efficient Europe is creating value for energy savings through market mechanisms. Instruments are therefore needed to put a financial value on energy savings and link the profits of utilities (suppliers or distributors).<br>• For large companies the Commission will propose to make regular energy audits mandatory. It will recommend that Member States should develop incentives for companies to introduce an energy management system (for example as set out in standard EN 16001) as a systematic framework for the rational use of energy. |
| Consumers Sector | • Improvements to the energy performance of devices used by consumers – such as appliances and smart meters – should play a greater role in monitoring or optimizing their energy consumption, allowing for possible cost savings. To this end the Commission will ensure that consumer interests are properly taken into account in technical work on labeling, energy saving information, metering and the use of ICT. |

### 2.2.2 EU Directives in Energy Efficiency

Existing three directives relating to energy efficiency in end-user side are introduced as follows.

(1) 2006/32/EC Directive on Energy End-User Efficiency and Energy Services

This directive was issued in 2006 to promote end-user energy efficiency and energy services. Main contents are described below.

**2006/32/EC Directive on Energy End-User Efficiency and Energy Services**

1. General Targets
   - Member States shall adopt and aim to achieve an overall national indicative energy savings target of 9 % by 2016.
2. Energy End-Use Efficiency in the Public Sector
   - Public Sector has to adopt at least 2 measures.
3. Energy Distributors/Operators and Retail Sales Companies
   - Member States shall ensure a provision of statistical information, a provision of competitively priced energy services, energy audit or funding mechanisms, and a provision of voluntary agreements such as white certificates.
4. Availability of Information
   - Member States shall ensure that information on energy efficiency mechanisms and financial and legal frameworks adopted with the aim of reaching the national indicative energy savings target is transparent and widely disseminated to the relevant market actors.
5. Availability of Qualification, Accreditation and Certification Schemes
   - Member States shall ensure qualification, accreditation and/or certification schemes for providers of energy services, energy audits and energy efficiency improvement measures.
6. Financial Instruments for Energy Savings
   - Member States shall repeal or amendment of national legislation and regulations that unnecessarily impede use of financial instruments for energy savings.
   - Member States shall make model contracts for those financial instruments.
7. Energy Efficient Tariffs and Other Regulations for Net Bound Energy
   - Member States shall ensure removal of incentives in transmission and distribution tariffs to unnecessarily increase energy volume.
8. Funds and Funding Mechanism
   - Member States may establish funds to subsidize the delivery of energy efficiency improvement programs and measures (grants, loans, guarantees, etc.).
9. Energy Audits
   - Member States shall ensure the availability of efficient, high-quality energy audit schemes which are designed to identify potential energy efficiency improvement measures and which are carried out in an independent manner.
10. Metering and Informative Billing of Energy Consumption
   - Member States shall ensure that final customers for electricity, natural gas, district heating and/or cooling and domestic hot water are provided with competitively priced individual meters that accurately reflect the final customer's actual energy consumption and that provide information on actual time of use.

(2) 2010/31/EC Directive on Energy Performance of Buildings

The previous directive issued in 2002, that stipulated an evaluation method of the energy performance of buildings and contained technology and maintenance recommendations, was revised on March 19, 2011.

Main contents are described below.

**2010/31/EC Directive on Energy Performance of Buildings**

1. Adoption of a Methodology
   - Member States shall apply a methodology for calculating energy performance of buildings.
2. Setting of Minimum Energy Performance Requirements
   - Member States shall take the necessary measures to ensure that minimum energy performance requirements for buildings or building units are set with a view to achieving cost-optimal levels.
3. Calculation of Cost-optimal Levels of Minimum Energy Performance Requirements
   - The comparative mythology framework for calculation shall be established.
4. New Buildings (total useful floor area over 1,000m2)
   - Member States shall ensure that, before construction starts, the technical, environmental and economic feasibility of high-efficiency alternative systems are considered and taken into account, (i) decentralized energy supply system based on renewable energy, (ii) cogeneration, (iii) district or block heating or cooling, (iv) heat pumps, before start of construction of new buildings.
5. Existing Buildings
   - Member States shall take the necessary measures to ensure that when buildings undergo major renovation, the energy performance of the building or the renovated part thereof is upgraded in order to meet minimum energy performance requirements.
6. Technical Building Systems
   - Member States shall set system requirements in respect of the overall energy performance, the proper installation, and the appropriate dimensioning, adjustment and control of the technical building systems which are installed in existing buildings.
   - The system requirements shall cover at least, (a) heating systems, (b) hot water systems, (c) air-conditioning systems, (d) large ventilation systems or a combination of such systems.
7. Nearly Zero-Energy Building
   - By 31 December 2020, all new buildings are nearly zero-energy buildings. After 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings.
   - Member States shall draw up national plans for nearly zero-energy buildings.
8. Financial Incentives and Market Barriers
   - In view of the importance of providing appropriate financing and other instruments to catalyse the energy performance of buildings and the transition to nearly zero- energy buildings, Member States shall take appropriate steps to consider the most relevant such instruments in the light of national circumstances.
9. Energy Performance Certificate
   - Member States shall lay down the necessary measures to establish a system of certification the energy performance of buildings.
10. Issue of Energy Performance Certificates
   - Member States shall ensure that an energy performance certificate is issued for: (a) buildings or building units which are constructed, sold or rented out to a new tenant, and (b) buildings where a total useful floor area over 500 m2 is occupied by a public authority and frequently visited by the public.
11. Display of Energy Performance Certificates
   - Member States shall require that the energy performance certificate is displayed in a prominent place clearly visible to the public.
12. Inspection of Heating Systems
   - Member States shall establish a regular inspection of the accessible parts of systems used for heating buildings with boilers of more than 20 kW.
   - Heating systems with boilers of more than 100 kW shall be inspected at least every 2 years.
13. Inspection of Air-Conditioning Systems
   - Member States shall establish a regular inspection of the accessible parts of air-conditioning systems used of more than 12 kW.
14. Reports on the Inspection of Heating and Air-Conditioning Systems
   - An inspection report shall be issued after each inspection of a heating or air-conditioning system.
15. Independent Experts
   - Member States shall ensure that the energy performance certification of buildings and the inspection of heating systems and air-conditioning systems are carried out in an independent manner by qualified and/or accredited experts,
16. Independent Control System
   - Member States shall ensure that independent control systems for energy performance certificates and reports on the inspection of heating and air-conditioning systems are established.

(3) 2010/30/EC Indication by Labeling and Standard Product Information of the Consumption

The previous directive issued in 1992, that stipulated labeling system and standards for energy consumption of home appliances, was revised with expansion of the scope on May 19, 2011.

Main contents are described below.

**2010/30/EC Indication by Labeling and Standard Product Information of the Consumption**

1. Scope

- This Directive establishes a framework for the harmonization of national measures on end-user information, particularly by means of labeling and standard product information.
- This Directive shall not apply to: (a) second-hand products, (b) any means of transport for persons or goods, (c) the rating plate or its equivalent affixed for safety purposes to products.

2. Responsibilities of Member States

- Member States shall ensure that (a) all suppliers and dealers established in their territory fulfill the obligations laid down in the article "Responsibilities of Supplier" and the article "Responsibilities of Dealers", (b) the display of other labels, marks, symbols or inscriptions which do not comply with the requirements of this Directive and of the relevant delegated acts is prohibited, if such display is likely to mislead or confuse end-users, (c) the introduction of the system of labels and fiches (standard table of information) concerning energy consumption or conservation is accompanied by educational and promotional information campaigns, (d) appropriate measures are taken in order to encourage the relevant national or regional authorities responsible for implementing this Directive.
- Where a Member State ascertains that a product does not comply with all the relevant requirements set out in this Directive and its delegated acts for the label and the fiche, the supplier shall be obliged to make the product compliant with those requirements.
- Where there is sufficient evidence that a product may be non- compliant, the Member State concerned shall take the necessary preventive measures and measures aimed at ensuring compliance within a precise time-frame.
- Where non-compliance continues, the Member State concerned shall take a decision restricting or prohibiting the placing on the market and/or putting into service of the product in question or ensuring that it is withdrawn from the market.

3. Information Requirements

- Member States shall ensure that (a) information relating to the consumption of electric energy, other forms of energy and where relevant other essential resources, (b) the information referred to in point (a) is provided in respect of built-in or installed products only where required by the applicable delegated act, (c) any advertisement for a specific model of energy-related products covered by a delegated act under this Directive includes, where energy-related or price information is disclosed, a reference to the energy efficiency class of the product, (d) any technical promotional material concerning energy- related products which describes the specific technical parameters of a product, namely, technical manuals and manufacturers' brochures.

4. Responsibilities of Suppliers

- Member States shall ensure that, (a) suppliers placing on the market or putting into service products covered by a delegated act supply a label and a fiche in accordance with this Directive and the delegated act, (b) suppliers produce technical documentation which is sufficient to enable the accuracy of the information contained in the label and the fiche to be assessed. That technical documentation shall include:
  - a general description of the product;
  - where relevant, the results of design calculations carried out;
  - test reports, where available, including those carried out by relevant notified organisations as defined under other Union legislation;
  - where values are used for similar models, the references allowing identification of those models.
- Member States shall ensure that, (c) suppliers make the technical documentation available for inspection purposes for a period ending five years after the last product concerned was manufactured, (d) in respect of labeling and product information, suppliers provide the necessary labels free of charge to dealers, (e) in addition to the labels, suppliers provide a product fiche, (f) suppliers include a product fiche in all product brochures, (g) suppliers are responsible for the accuracy of the labels and fiches that they supply, (h) suppliers are considered to have given consent to the publication of the information provided on the label or in the fiche.

5. Responsibilities of Dealers

- Member States shall ensure that, (a) dealers display labels properly, in a visible and legible manner, and make the fiche available in the product brochure or other literature that accompanies products when sold to end-users, (b) whenever a product covered by a delegated act is displayed, dealers attach an appropriate label, in the clearly visible position.

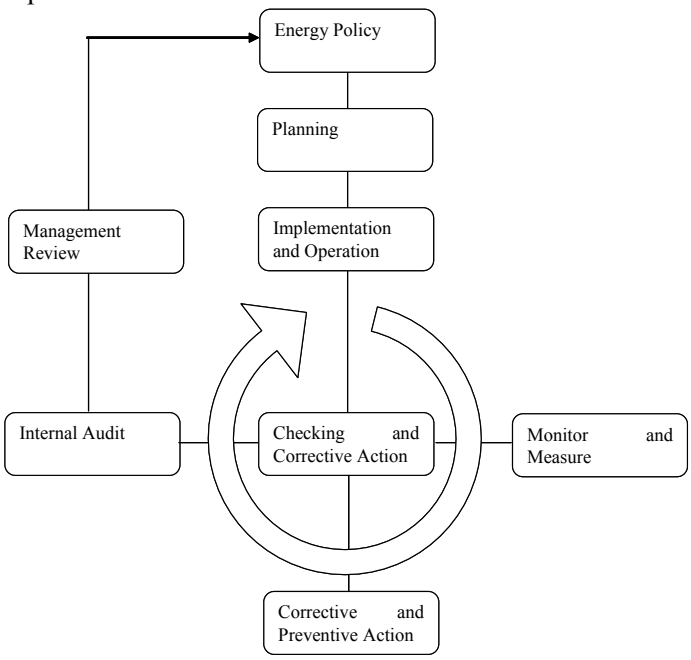
### 2.2.3 Current Situation in Standardization of Energy Efficiency Activities

(1) European Standard

The European Committee for Standardization issued "Guidance and Requirements for Energy Management Systems (EN 16001)" to standardize energy management method in an organization (2009).

This standard is a guide that recommends the assignment of Energy Manager, planning, formation of internal team, check & monitoring, internal audit method, evaluation, etc. The Plan-Do-Check-Action (PDCA) methodology is adopted like ISO14001.

The following figure shows an image of energy efficiency activities within an organization proposed in the European Standard.




(Source: EN 16001)

**Figure 2- 30 Image of Energy Efficiency Activities Proposed in European Standard**

(2) ISO50001

In 2011, the International Organization for Standardization (ISO) issued a new standard, ISO50001 that was an international framework to control energy management in a whole organization.

This standard provides technical and management strategy to organizations and companies having objectives to improve energy efficiency, reduce energy costs and improve environmental performance. This standard also utilizes the PDCA approach for energy management in an organization like the European Standard (EN 16001).

## 2.3 United Kingdom of Great Britain and Northern Ireland (UK)

### 2.3.1 Policy on EE&C

(1) Overview

The UK sets energy efficiency policy as one of its key policies for tackling global warming. Energy efficiency policy lies at the heart of the measures against global warming by 2020, since it is cost effective and can achieve results in the short-term. Sectoral strategies, based on the policy, have been set and implemented in order to realize a low carbon society.

EU's greenhouse gas reduction target in Kyoto Protocol is 8 % on average from 2008 to 2012 according to the 1990 baseline. UK set its (national) 80 %, at minimum, greenhouse gas reduction target by 2050 compared to the emissions of the standard year (carbon dioxide and methane as in 1990 and HFC etc. as in 1995) through the activities in the country and overseas in the Climate Change Act 2008.

(2) Climate Change Act, Energy Review, and White Paper on Energy

Responding to the "Energy Review" conducted by the Performance and Innovation Unit (PIU), which considered the demand-supply planning of UK's energy by 2020 and 2050, the Department of Trade and Industry (DTI), published the "White Paper on Energy" in 2003 and an energy policy "The Energy Challenge" in 2006. In 2007, a new White Paper on Energy, "Meeting the Energy Challenge" was announced responding to the energy policy. In 2008, the Climate Change Act 2008 was established. The abovementioned target and other measures such as the Carbon Reduction Commitment (CRC) Energy Efficiency Scheme were stipulated and a new independent, expert body, Committee on Climate Change, to advise the government was created. Recently, "The Carbon Plan: Delivering our low carbon future" which states the concrete policy and measures to achieve the target were announced in December 2011 in response to the Climate Change Act 2008.

(3) Executing Agency

On 3 October 2008, the Department of Energy and Climate Change (DECC) was established as a center towards global warming, succeeding the role formerly taken by DTI, Food and Rural Affairs (DEFRA) and others. UK's Carbon Budget is still being delivered to the DTI, DEFRA and DECC.

(4) Overview of EE&C Policy and Measures

The overview of measures for each sector is as follows.

- For the building sector, which consumes 37 % of total emissions, the insulation of walls and lofts and double glazing were mentioned. Besides, there are other measures stated such as the deployment of smart meters which enables consumers to see energy consumption on demand, and strengthens the thermal performance of buildings (zero

carbon homes standards) are being planned.

- For the transport sector, which consumes about 25 % of the total emissions, more efficient cars and promotion of biofuels are stated.
- For the industry sector, which consumes about 25 % of the total emissions, it is required to promote further energy efficiency, replace fossil fuels with low carbon alternatives, and promote CCS (Carbon Capture and Storage). In addition, measures which utilize market mechanisms have been already implemented such as EU ETS, Climate Change Agreements, and the CRC Energy Efficiency Scheme etc.
- For the electric power sector, which consumes about 27 % of total emissions, the demand is forecasted to increase, these are recognized as keys for the low carbon future, such as renewable energies, especially wind power, the new construction of nuclear power stations, and gas or coal power generation utilizing CCS technology. In order to realize them, schemes including "Feed in Tariffs with Contracts" have been planned to be implemented.
- In addition to the above, there are measures for the product market which eliminate inefficient lamps, white home appliances, TV and stereos or limit the standby powers of other electric appliances.

### 2.3.2 Major Schemes on EE&C

Key measures for the industrial sector are the EU Emissions Trading System (EU ETS) and Climate Change Levy (CCL). Another inventive, the Climate Change Agreement (CCA) accompanies CCL. Energy intensive users which are not covered by the measures above are targeted by the Carbon Reduction Commitment Energy Efficiency Scheme (CRC). Each measure is briefly described as follows.

There are measures for buildings including houses such as Energy Performance Certificate scheme and Minimum Energy Standards and Labeling System.

(1) EU Emissions Trading System (EU ETS)

The EU ETS (EU Emissions Trading System) is one of the key policies to achieving EU's greenhouse gas emissions target of 8 % below 1990 levels under the Kyoto Protocol. It is a cap and trade scheme of carbon dioxide emissions, having started in 2005.

Firstly, each EU member state must develop a National Allocation Plan (NAP) and must be approved by the European Commission. Then, allowances are allocated to each facility operator. Actual emissions are measured and certified. At the end of the fiscal year, installations are required to surrender allowances to account for their actual allowances. The facility operator must acquire and submit surplus allowances by buying when actual emissions exceed the allocated allowances.

These are the key energy efficiency policies for the industrial sector, which covers power generation and major energy intensive industries (power stations, refineries, iron and steel,

cement, paper, food and drink, glass, ceramics, engineering and the manufacture of vehicles). This measure covers 48 % of carbon dioxide emissions.

(2) Climate Change Levy (CCL) and Climate Change Agreements (CCAs)

The Climate Change Levy is a tax on all energy consumption except the domestic and transport sectors. Renewable energy and energy consumption by designated certified schemes (e.g. cogeneration) are excluded. Tax payment gives an exemption of 0.3 % of the National Insurance of which employers are obliged to pay. Part of the revenue goes to funds for energy efficiency including Carbon Trust.

Climate Change Agreements (CCA) is a scheme targeted at energy intensive industries. Given their energy usage and their exposure to international competition, an 65 % discount from the levy was allowed for those sectors that agreed with the DECC on the targets for improving their energy efficiency or reducing carbon emissions. The regulations cover the ten main energy intensive sectors of industry, (aluminum, cement, ceramics, chemicals food& drink, foundries, glass, non-ferrous metals, paper, and steel) and over thirty smaller sectors, and in agriculture, livestock units for the intensive rearing of pigs and poultry.

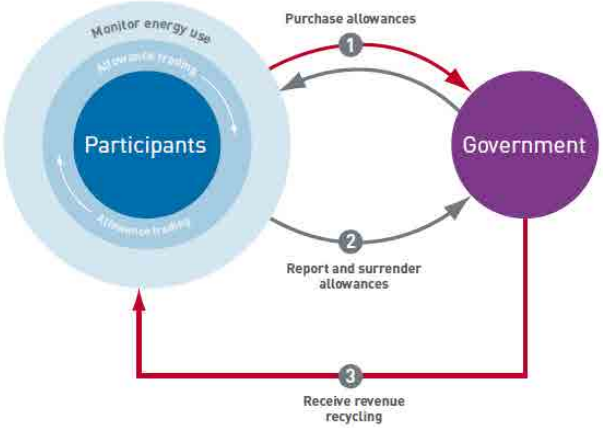
(3) Carbon Reduction Commitment (CRC) Energy Efficiency Scheme

It is a compulsory cap & trade scheme of carbon dioxide emissions allowances to encourage energy efficiency and has been in operation since April, 2010. In order to avoid overlap amongst the measures, energy consumption or carbon dioxide emissions targeted by EU ETS, CCL and CCA are exempt. As a result, its target is mainly the business sector and consists of 12 % of the total emissions.

All companies with half-hourly meters whose electricity consumption during 2008 exceeded 6,000 MWh will have to participate. Participants are defined as a single entity, including subsidiaries and group companies. Participants who do not claim an exemption by CCA etc. are required to monitor and report their energy usage each year, and to surrender $CO_2$ allowances for their emissions.

In more details, the followings are the steps to be taken. (Overall image is shown in the next figure.)

- A cap of the total amount of carbon dioxide allowances of the scheme (summation of all the participants) is calculated.
- Participants purchase allowances at an auction or at the beginning of a fiscal year.
- Participants buy or sell allowances at secondary market levels when necessary
- Participants surrender allowances equal to their carbon dioxide emissions with a report on their actual carbon dioxide emissions at the end of the fiscal year
- A performance league table is complied and published by the scheme administrator.
- Annual sale or auction of allowances is recycled to participants, according to their proportion of carbon dioxide emissions and their performance (CO2 emissions reduction and CO2 intensity reduction).




(Source: "The Carbon Reduction Commitment: User Guide", DECC)

**Figure 2- 31 Process Flow of CRC (Carbon Reduction Commitment)**

This scheme provides incentives for energy efficiency, one as a mandatory incentive for carbon allowance purchases, and at the same time, another as a positive incentive of revenue recycling based on energy efficiency performance.

(4) Energy Performance Certificates: EPCs

Energy consumption or carbon dioxide emissions in the building sector of UK are estimated to be around 20 %.


**Figure 2- 32 Labels for Residential Buildings**

The Energy Performance Certificate (EPC) has been implemented as a measure to tackle this issue, targeting residential buildings/houses with more than 3 bedrooms since 2007 and non-residential buildings with a floor area greater than 50 m2 which contain fixed services that condition the interior environment. (Scotland is excluded.) This scheme, corresponding to the "European Directive 2002/91/EC on the Energy Performance of Buildings", evaluates the energy efficiency of buildings and forces building owners to present the evaluation results to business contacts when undergoing construction, purchase/sales, and leasing. The EPC evaluates energy efficiency in simulated values and classifies the results into 7 ranks of A to G (A: zero emission).

The EPC is accompanied by a scheme of energy efficiency display, Display Energy Certificate (DEP). The DEP evaluates and classifies energy consumption under operation according to benchmarks. Public facilities are compulsory to DEP, as an indicator of energy efficiency.

(5) Standard and Labeling Programme

This scheme, corresponding to the "EU Directive 92/75/EC on Energy Consumption Labeling Scheme", adopts the same labeling as EU countries. The targets cover refrigerators, freezers, fridges and freezers, washing machines, drum-type driers, drum-type washing machines, dish washers, ovens, water heaters, hot water storage tanks, air-conditioners, lamps and TVs. The display contents are efficiency in 7 grades (from the highest A to the lowest G), average cost estimated per usage time and power consumption, level of lousiness, etc.

In order to improve the efficiencies, the EU has prohibited the sale of G grade appliances. Manufacturers also stopped producing D grade of refrigerators and fridge and freezers since 1999.

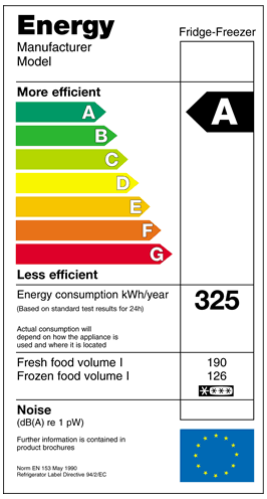



**Figure 2- 33 Labels for Home Appliances**

(6) Energy Saving Trust

Energy Saving Trust, EST, a non-profitable organization established by the government, provides financial and technical supports for projects or companies/institutions which promote energy efficiency, global warming countermeasures and sustainable energy usage. It mainly targets domestic and business sectors and focuses on cooperation with homebuilders, local communities and local authorities. In addition, it financially supports the networking of regional energy efficiency advice centers.

## 2.4 India

### 2.4.1 Policy on EE&C

(1) Overview

The Indian Government has announced that as a part of the nation's climate change efforts, India aims to reduce 20 % - 25 % of CO2 emission intensity to the intensity level it was in 2005, by 2020.

As effective measures to improve the intensity, the fossil energy consumption industries (9 different sectors) have adopted the Indian Energy Management System (At the beginning of this scheme (2001), 15 sectors were selected).

(2) Energy Conservation Act 2001

The Energy Conservation Act was issued in 2001 by the Ministry of Power. The act stipulated the basis of Bureau of Energy Efficiency (BEE) that is an executing agency of EE&C as well as the following three important measures including the energy management system.

- Standard and Labeling Programme
- Indian Industry Programme for Energy Conservation (Energy Management System)
- Energy Conservation Building Code

(3) Bureau of Energy Efficiency (BEE)

(a) Legal Basis

The BEE is an agency established in March 2003 under the Ministry of Power based on the Energy Conservation Act 2001. The mission of the BEE is to assist in developing policies and strategies with a thrust on self-regulation and market principles within the overall framework of the Act.

(b) EE&C Measures of BEE

BEE has two functions that are a regulatory function and a promotion function. Major regulatory functions include:

- Developing minimum energy performance standards and labeling design for equipment and appliances
- Develop specific Energy Conservation Building Codes
- Activates focusing on designated organizations (Energy Management System)
  - Develop specific energy consumption norms
  - Certify Energy Managers and Energy Auditors
  - Define the manner and periodicity of a mandatory energy audit
  - Develop a reporting format on the energy consumption and action taken based on recommendations given by the energy auditors

Major promotion functions include:

- Create awareness and disseminate information on EE&C
- Arrange and organize training of personnel and specialists in the techniques for efficient use of energy
- Strengthen consultancy services in the field of energy conservation
- Promote R&D
- Develop testing and certification procedures and promote testing facilities
- Formulate and facilitate implementation of pilot projects and demonstration projects
- Give financial assistance to institutions for promoting EE&C
- Prepare an educational curriculum on EE&C
- Implement international cooperation, etc.

### 2.4.2 Major Schemes on EE&C

(1) Energy Management System

(a) Implementation Structure

Description of Indian Energy Management System (EMS) is as follows. The feature of the Indian EMS is to monitor the designated organizations by designated agencies appointed by

each state government, and to force them to conduct external energy audit. Designated Organizations have to submit periodical reports based on recommendations by on-site the Energy Manager as well as externally Accredited Energy Auditors.

A framework of the Indian Energy Management System is shown below.

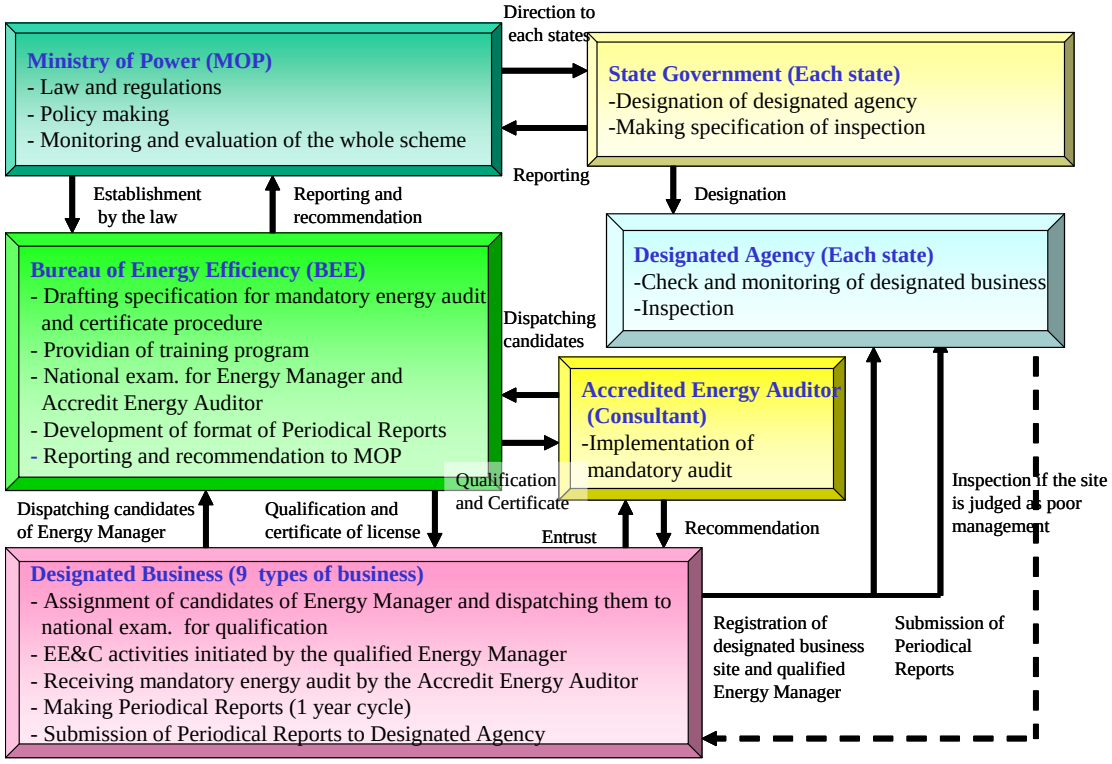



**Figure 2- 34 Framework of Energy Management System in India**

(b) Designated Organizations

The Indian EMS originally targeted 15 sectors in the Energy Conservation Act 2001 and then revised down to nine sectors and define designation unit by the amendment of the Act in March 2007. According to the BEE Website, 563 consumers are designated as of February 2011.

**Table 2- 31 Designation Criteria of Indian EMS**

| Designated Industry | Designation Unit | Threshold (Final Energy Consumption) |
|---|---|---|
| Thermal Power Station | Power Station | 30,000 toe/year |
| Fertilizer | Factory | 30,000 toe/year |
| Cement | Factory | 30,000 toe/year |
| Iron & Steel | Factory | 30,000 toe/year |
| Chlor-Alkali | Factory | 12,000 toe/year |
| Aluminum | Factory | 7,500 toe/year |
| Railways | Traction sub-section, diesel loco shed and workshop | 30,000 toe/year |
| Textile | Factory | 3,000 toe/year |
| Pulp & Paper | Factory | 30,000 toe/year |

(Source: BEE Website)

(2) Energy Conservation Building Code (ECBC)

The Energy Conservation Building Code (ECBC) has been launched since 2007 by the Ministry of Power. The ECBC, targeting large buildings with a connected load of 500 kW or 600 kVA, provides the minimum standards in design and construction for buildings and their facilities. The BEE has made efforts to promote the ECBC through preparing ECBC guidelines. ECBC regulated fields are as follows.

- Building envelop
- Heating, Ventilation and Air-conditioning (HVAC)
- Water heating and pumping
- Lighting
- Electric power facilities (transformer, motor, etc.)

(3) Standard and Labeling Programme

Based on the Energy Conservation Act 2001, the Standard and Labeling Programme has been introduced. As shown in the following table, four appliances have been mandatorily introduced and 10 appliances have been voluntarily introduced, as of 2012.

A penalty is imposed on manufacturers and sellers who do not abide by the compulsory minimum energy standards and display standards.

**Table 2- 32 Target Appliances of Standard and Labeling Programme**

| Mandatory Appliances | Voluntary Appliances |
|---|---|
| • Frost Free Refrigerator<br>• Florcent Lamp<br>• Air Conditioner<br>• Distribution Transformer | • Direct Cool Refrigerator<br>• General Purpose Industrial Motors<br>• Monoset Pumps<br>• Openwell Pump Sets<br>• Submersible Pump Sets<br>• Ceiling Fans<br>• Domestic Gas Stoves<br>• Stationary Storage Type Water Heaters<br>• Color Televisions<br>• Washing Machine |

(Source: BEE Website)

As for air-conditioners, the residential appliances under the capacity of 9,000 kcal/hour are targeted. For a reference, a rating list of 1.5 tons cooling capacity is shown below. The label shows the ranking via the number of stars, Energy Efficiency Ratio (EER: = Output (W) / Input (W)) as an indicator of the efficiency, brand name, production year, etc.

The rating lists of other air-conditioners are also confirmed on BEE's Website.

**Table 2- 33 Label and Rating Table of 1.5 ton Capacity Air Conditioner**


| Star Rating | Minimum Energy Efficiency Ratio (EER) | Maximum Cooling Capacity | Input Power | Units Consumption /Day | Power Unit Charge | Electricity Cost /Month | Cost Saving Pwer Year |
|---|---|---|---|---|---|---|---|
| | | Watt | Watt | kWh | Rs. | Rs. | Rs. |
| No Star | 2.20 | 5,200 | 2,364 | 9.45 | 2.5 | 709 | 0 |
| 1 | 2.30 | 5,200 | 2,261 | 9.04 | 2.5 | 678 | 309 |
| 2 | 2.50 | 5,200 | 2,080 | 8.32 | 2.5 | 624 | 851 |
| 3 | 2.70 | 5,200 | 1,926 | 7.70 | 2.5 | 578 | 1,313 |
| 4 | 2.90 | 5,200 | 1,793 | 7.17 | 2.5 | 538 | 1,712 |
| 5 | 3.10 | 5,200 | 1,677 | 6.71 | 2.5 | 503 | 2,059 |

* Electricity consumption: Under the condition of 8 hours daily operation

(4) Energy Conservation Award

The scheme has been introduced since 1993 to encourage consumer's EE&C activities. Ministry of Power has designated the "National Energy Conservation Day" take place on December 14 and holds an award ceremony on that day. The best practices are selected from industries, office buildings, hotels, zonal railways, State Designated Agencies and municipalities.

## 2.5 Thailand

### 2.5.1 Policy on EE&C

(1) Overview

The energy policy in Thailand was issued under the Energy Minister's name in January 2009. According to the policy, the following goals are targeted.

- The EE&C target will be raised 20 % via additional efficiency achievements in the industrial and transportation sectors
- Reducing unit energy consumption in industrial sector by 20 % from 2006
- Implementation of 11 strategies at the local government level and save 100,000 million Baht per year
- Promotion of EE&C at the city government level

(2) Energy Conservation and Promotion Act

Energy Conservation and Promotion Act E.E 2535 was established in 1992. It regulates the

following measures.

**Table 2- 34 Overview of the Energy Conservation and Promotion Act**

| No. | Title | Features |
|---|---|---|
| 1 | Energy Management System for Designated Factories and Assignment of Energy Managers | - Designation of factories by criteria of energy consumption (Power contract: 1,000 kW, Transformer: 1,175kVA or Energy consumption of 20 mil MJ/year)<br>- Assignment of Energy Managers<br>- Submission of periodical reports and middle-term plan document<br>- Qualification of the Energy Manager (Upper class job course graduation and 3 years experience, or bachelor degree of engineering or science, trainee of specific training Course) |
| 2 | Energy Management System for Designated Buildings and Assignment of Energy Managers | Same as the above |
| 3 | Promotion of Energy Saving Machines and Equipment | - Designation of energy conserving machines and equipment for receiving support |
| 4 | Energy Conservation Fund (ENCON Fund) | - Establishment of a fund to support and subsidize energy conservation |

(Source: JETRO Bangkok Website)

(3) Department of Alternative Energy Development and Efficiency (DEDE)

The Department of Alternative Energy Development and Efficiency (DEDE) is the main organization that promotes EE&C in Thailand. The DEDE conducts nationwide programs for the promotion of EE&C and renewable energy. It also provides various training regarding EE&C and has its own Practical Energy Training Center (PETC) which provides examinations and training programs for Energy Managers.

### 2.5.2 Major Schemes on EE&C

(1) Energy Management System

(a) Overview

The Energy Management System was introduced in 1992 when the Energy Conservation and Promotion Act was implemented. DEDE has an authority for EE&C policies and measures.

The energy management system covers factories and buildings over certain sizes and such factories and buildings are required to designate energy managers and submit periodical reports to the DEDE. They are required to submit periodical reports including energy consumption data every 6 months and lists of energy conserving equipment. They also need to submit a mid-term plan including a target to be accomplished and implemented plan every 3 years.

(b) Conditions for Designation

The latest (since 2000) conditions for designations are those with a contract capacity of electricity exceeding 1,000 kW, with the total capacity of transformers exceeding 1,175 kVA,

or with annual electricity consumption exceeding 20 million MJ/year.

(c) Energy Manager

Designated factories and buildings are required to assign Energy Managers. Such Energy Managers need to meet one of the three conditions below.

- Having more than 3 years of working experience after completing the graduation requirements of the Senior management course
- Bachelors degree in Mechanical Engineering
- Completed the EE&C training course or a course of equivalent level

Duties of the Energy Managers are defined in the Act

- Conducting periodical maintenance and inspections for all energy conserving equipment
- Setting policies for EE&C and promotion of energy efficiency
- Examination of periodical reports submitted to DEDE by owners of designated factories or buildings
- Document control of periodical records for checking and examination by DEDE staff
- Supporting owners of designated factories or buildings for setting EE&C plans and targets
- Guarantee of analysis results for implementation of EE&C plans and targets
- Supporting owners of designated factories or buildings regarding actions needing correction upon request by the director of the DEDE.

(d) Penalties

Violations of each regulation caused the levy of a fine of from 50,000 Baht to 200,000 Baht.

(2) Technical Support Services

Technical support services provided by DEDE are as follows

- Energy audit service for factories
- Energy audit service for buildings

(3) Energy Conservation Promotion Fund (ENCON Fund)

Thai government conducts the promotion of EE&C through the Energy Conservation Promotion Fund (ENCON Fund) as stipulated in Energy Conservation Law. The fund is being budgeted based on 5 year periods for implementation of each program. The fund covers programs of free energy audit service for designated factories and buildings.

(4) EGAT Labeling System

The Electricity Generating Authority of Thailand (EGAT) conducts Energy Label No.5 Project for peak cut.

The labeling system by EGAT is voluntary base. The EGAT bears the expense of label attaching and appliance testing. The test results are accredited by the Electrical and Electronics Institute (EEI). The highest efficiency appliances are certified as "Label 5". The target appliances are refrigerators, air conditioners, lighting and blasts, etc.


**Figure 2- 35 EGAT Labeling**

## 2.6 Australia

### 2.6.1 Policy on EE&C

(1) Overview

The main policies on EE&C in Australia are decided by the Ministerial Council on Energy (MCE). The Council announced the "National Framework for Energy Efficiency (NFEE)" on December 2004 that aimed at promotion of energy efficiency in the consumption sector. The Framework raised the following nine priority sectors and expected annual energy saving of 50 PJ/year by 2015.

- Residential buildings
- Commercial buildings
- Commercial/industrial energy efficiency
- Government energy efficiency
- Appliance & equipment energy efficiency
- Trade and professional training & accreditation
- Commercial/industrial sector capacity building
- General consumer awareness
- Finance sector awareness

Further, the Council set up the second stage of the NFEE in December 2007 covering the following fields.

- Expending and enhancing the Minimum Energy Performance Standards (MEPS) program
- Heating, ventilation and air conditioning (HVAC) high efficiency systems strategy
- Phase-out of inefficient incandescent lighting
- Government leadership though green leases
- Development of measures for a national hot water strategy, for later consideration.

(2) Energy Efficiency Opportunities Act 2006

In 2006, in order to target large energy consumers, the Energy Efficiency Opportunity Program (that is Australian EMS) was introduced based on the "Energy Efficiency Opportunities Act 2006". The EMS orders a reporting duty to corporations which consume 0.5 PJ/year. There are more than 220 corporations (incorporating about 1,200 subsidiaries) registered and covers 45 % of all the energy used in Australia.

(3) Department of Resources, Energy and Tourism (DRET)

A member of MCE, Department of Resources, Energy and Tourism (DRET) is responsible for policy-making on energy industry and resources as well as implementation of the Australian EMS.

### 2.6.2 Major Schemes on EE&C

(1) Energy Efficiency Opportunity Program (Australian EMS)

The Energy Efficiency Opportunity Program was introduced in 2006. The framework of the program is shown below.

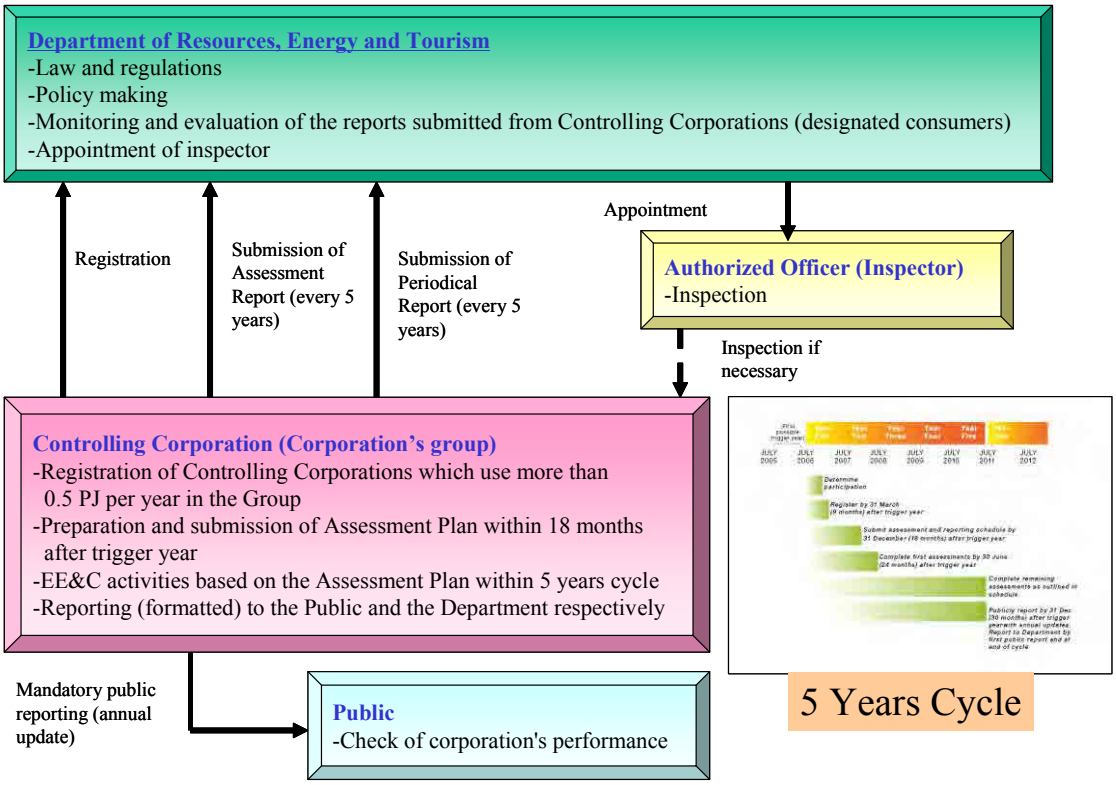



**Figure 2- 36 Framework of Energy Management System in Australia**

The features of the program are to target corporation units and to evaluate plans, implementation and results in a 5 year cycle. A designated corporation submits an EE&C plan at the beginning of the cycle and a result reports at the end of the cycle. Public reporting has to be updated on a yearly basis.

(2) National Framework for Energy Efficiency (NFEE)

NFEE promotes energy efficiency in various sectors including industry and buildings. The main schemes targeting industry and buildings are summarized below.

- **Commercial/Industrial Energy Efficiency**

  This introduced the Energy Efficiency Opportunity Program. It provides a training program for energy auditors as well.

- **Commercial & Industrial Sector Capacity Building**

  This implements demonstration projects to provide best practices in main industries, and new and renovated buildings. It establishes a network of the best practices on a national level.

- **Government Energy Efficiency**

  In order to demonstrate government leadership, a measurement and reporting system has been introduced for the Government sector. The Government sector has to positively install energy efficient equipment.

(2) Minimum Energy Performance Standards and Energy Rating Labels

Australia together with New Zealand has introduced the mandatory Minimum Energy Performance Standards (MEPS) and mandatory Energy Rating Labels (ERL) since 1999.

The MEPS has been enforced by state government legislation based on the Australia Government regulations. Penalties are imposed if a party does not comply with the requirements. The state governments, which have a responsibility for the resource management of energy, established legislation for the standards and labeling system. The following figure shows the targeted appliances, years of enforcement and historical revisions.

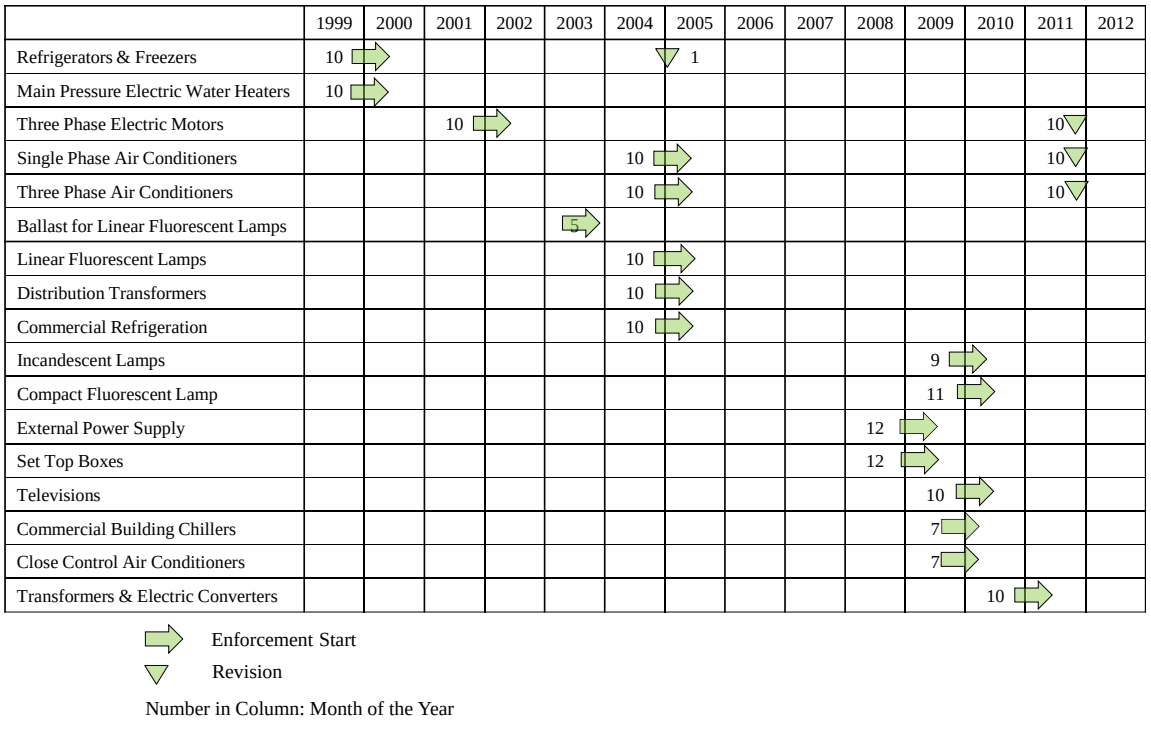



**Figure 2- 37 Introduction and Revision Year of Austrian Minimum Energy Standards and Labeling System**

On the other hand, Energy Rating Labels (ERL) is a mandatory scheme for a range of appliances, these currently include: refrigerators, freezers, clothes washers, clothes dryers, dishwashers, air conditioners and televisions. When offered for sale, these appliances must display a label that shows the star rating and other useful information about energy consumption. The label gives the appliances a star rating of between one and ten stars. The greater the number of stars, the higher its efficiency is. It enables consumers to compare the energy efficiency of domestic appliances on a fair and equitable basis. It also provides incentives for manufacturers to improve the energy performance of appliances.

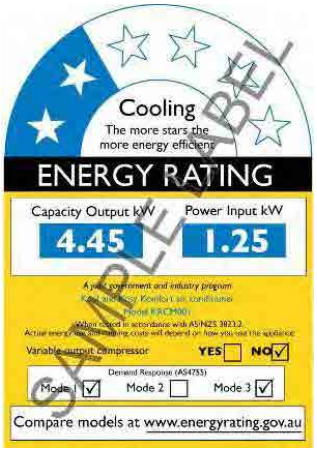



**Figure 2- 38 Energy Rating Label**

## 2.7 Saudi Arabia

### 2.7.1 Policy on EE&C

(1) Overview

JICA conducted "the Master Plan Study for Energy Conservation in the Power Sector in Saudi Arabia (2007-2009)" together with the Ministry of Water and Electricity (MOWE) of Saudi Arabia. The study proposed 13 measures such as the Energy Management System for Large Energy Consumers and Training Program, Energy Consumption Efficiency Label Regulation, Energy Audit Scheme, EE&C Campaign, etc.

Besides, it was proposed that the Saudi Energy Efficiency Center (SEEC) would be established as a new implementation agency for some measures.

(2) Implementing Agency for EE&C

(a) Saudi Energy Efficiency Center (SEEC)

The Government of Saudi Arabia approved the establishment of SEEC as a permanent implementation agency for EE&C promotion through the Council of Ministers Decision No. 363 in March 2010.

SEEC is operated by 16 representatives from the government concerning energy and industry, energy-related companies, etc. These operators consist of regulating agencies and large consumers in fossil fuel and electricity. It is said that SEEC can cover the fields of both fuel and electricity.

SEEC raised the vision to, "To play a leading role for KSA to achieve the world average energy intensity by 2020 capitalizing on the support of the stakeholders and the integration of their energy efficiency efforts" and defines their mission as follows.

**SEEC's Mission**

- Support the preservation of national energy resources to enhance the national development and economy through the rationalization of energy consumption and improving energy efficiency in order to achieve the lowest possible levels of energy intensity.
- SEEC's main activities include:
  - Development of policies, rules and regulations governing energy efficiency and supporting their implementation.
  - Support the integration of the stakeholders' efforts to improve energy efficiency and coordination amongst them.
  - Promote energy efficiency awareness at both public and institutional levels.
  - Participate, as needed, in the implementation of energy efficiency pilot projects.

(b) Activities of SEEC

According to the above mission, SEEC's activities are conducted in the following 4 phases.

**Table 2- 35 Activities of SEEC**

| Leadership Role in Raising EE Awareness, Education and Training | Active Role in the Implementation of Pilot Projects | Outstanding Ability in the Development of Policies, Regulations and Specifications and Follow-up the Application | Effective Coordination and Integration among Stakeholders |
|---|---|---|---|
| Support Institutional EE Awareness | Application of Best Practices in Project Implementation | Support Research and Studies | Build EE Database for those Involved and Facilitate Access to it |
| Raise Public Energy Saving Awareness | Identify Pilot Projects that Require SEEC Participation | Build Specified Expertise in Policies, Regulations and Specifications Development | Develop a Practical Program for Communication and Coordination between the Concerned Parties |

(Source: SEEC)

## 2.7.2 Major EE&C Schemes

(1) Energy Consumption Efficiency Label Regulation

(a) Overview

The minimum energy performance standard and labeling program in Saudi Arabia took effect on April 27, 2010 per the "Energy Consumption Efficiency Label Regulation". This program is compulsory for air conditioners, refrigerators, freezers and washing machines. The Saudi Arabian Standards Organization (SASO) under the umbrella of MOCI (Ministry of Commerce and Industry) establishes testing standards and also accredits testing institutions.

In Saudi Arabia, Intertek is an accredited testing institution. The testing results by manufacturers under the supervision of Interek are also accepted.

The manufacturers or suppliers of target appliances are required to display these performances on the labels designed by SASO, after submitting the testing results and obtaining certification. In Saudi Arabia, the labels are attached to all target appliances under the responsibility of manufacturers and suppliers. As for imported appliances, the custom office verifies label attachment.

(b) Air Conditioners

The following are examples of air conditioners in the Saudi Arabian labeling system. Products whose cooling capacity is below 70,000 Btu/h (Single-phase or three-phase) are targeted. Efficiency is expressed through the Energy Efficiency Rate (EER) and the unit is the ratio of cooling capacity and the required electricity (Btu/W).

Depending on the EER, the performance is displayed from six-stars to one-star. (More stars equals higher efficiency.) The cooling capacity and required electricity are also displayed.

| Performance | Number of Star |
|---|---|
| EER>10 | 6 |
| 10≥EER>9.5 | 5 |
| 9.5≥EER>9 | 4 |
| 9≥EER>8.5 | 3 |
| 8.5≥EER>7.5 | 2 |
| EER≤7.5 | 1 |


**Figure 2- 39 Saudi Arabian Labeling (Air Conditioner)**

Several Middle Eastern countries have already adopted the standard and labeling system. As reference, the following are the performance display labels of air conditioners. The minimum standard should be cleared for the sales in the market.

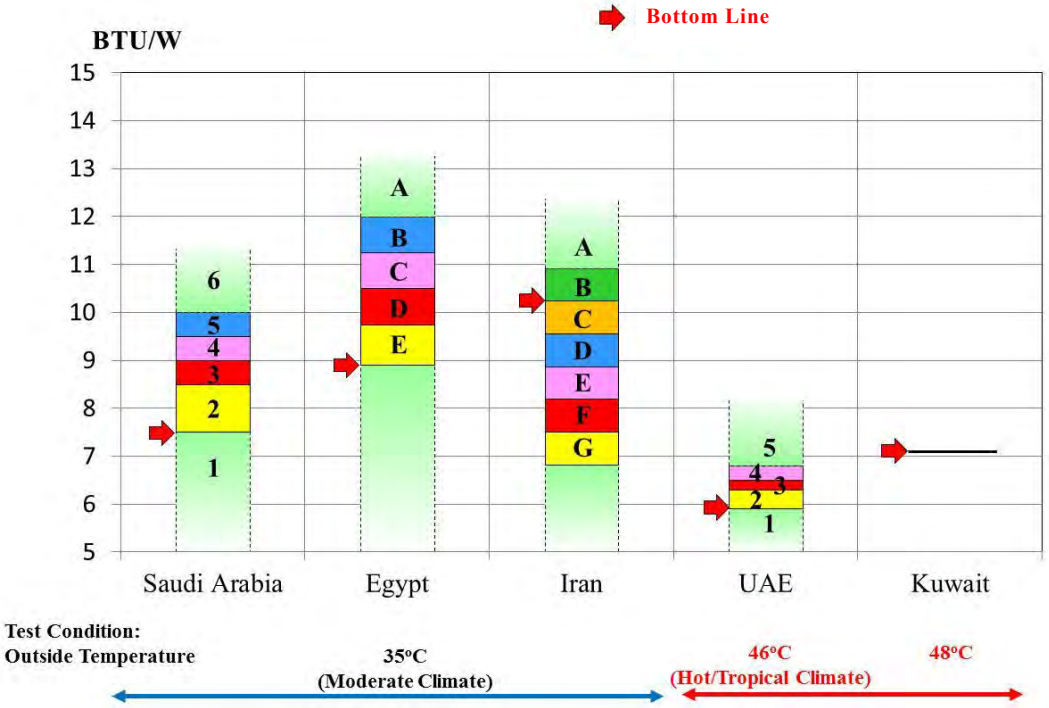



**Figure 2- 40 Performance Display Labels of Middle East Countries**

(2) EE&C Building Regulation

EE&C building regulations is considered important in the course of promoting EE&C so that codes for EE&C are included in the newly developed Saudi Building Code (refer to 601 in the following table). It had been developed under the Saudi Building Code National Committee (SBCNC) and the committees under the SBCNC and is based on the codes of the U.S.A. As for the codes for EE&C, International Energy Conservation Code (IECC) of the U.S.A was modified and applied to Saudi Arabia.

**Table 2- 36 Saudi Building Code Requirements**

| | |
|---|---|
| 201 | Architectural |
| 301 | Structural - Loading and Forces |
| 302 | Structural - Testing and Inspection |
| 303 | Structural – Soil and Foundations |
| 304 | Structural – Concrete Structures |
| 305 | Structural – Masonry Structures |
| 306 | Structural – Steel Structures |
| 401 | Electrical |
| 501 | Mechanical |
| **601** | **Energy Conservation** |
| 701 | Sanitary |
| 801 | Fire Protection |
| 901 | Existing Buildings |

(Source: ”Saudi Building Code 601”)

Although the Saudi building codes were developed, it turns out to be difficult to implement, since even only the codes for EE&C, 601, comes to about 200 pages (in English). Currently, July, 2012, it is now under redevelopment for simplification.

(3) Dissemination Programs

Dissemination programs which are conducted by SEEC are shown below.

- Training programs for engineers
- Energy seminar for technical college students
- Exhibitions for the introduction of SEEC and the Saudi Labeling and Standards System in the shopping mall
- EE&C campaign for women and kids in the amusement parks and summer holiday activities
- EE&C events targeting primary school students (6-12 ages)
- Introduction of energy saving ACs in government buildings and large companies, etc.

(Source: SEEC)

**Figure 2- 41 Exhibition and EE&C Campaign for Kids**

(4) Demand Side Management

Demand side management programs which are conducted by Saudi Electricity Company (SEC) are shown below.

(a) Optional Tariff System for Encouraging Peak Shifts

The SEC has introduced a TOU tariff and seasonal tariff system for the industrial and commercial sector. The TOU tariff system set a low price in the off peak time (17:00-12:00). On the other hand, the seasonal tariff provides low prices in the off peak season (October-April).

These tariff systems are optionally selected by customers.

**Table 2- 37 Optional Tariff System for Encouraging Peak Shifts**

| TOU Tariff (For plants with digital meter) | | Seasonal Tariff (For plants with electromechanical meters) | | Consumption period |
|---|---|---|---|---|
| Tariff (Halala/Kwh) | Consumption time | Tariff (Halala/Kwh) | Consump-tion time | |
| (Small companies) 12<br>(Big companies) 14 | All the time | (Small companies) 12<br>(Big companies) 14 | All the time | 1st of October – End of April |
| 10 | Out of peak period<br>Saturday to Thursday : 8:00 – 00:00<br>Friday : 9:00 – 21:00 | 15 | All the time | First of May – End of September |
| 26 | Peak period<br>Saturday to Thursday : 17:00 – 12:00 | | | |
| 15 | Other times | | | |

(Source: SEC)

The following table shows the participating customers for the TOU tariff system from the industrial and commercial sector. According to SEC, the total 780 MW peak shift was achieved by 2011 per the TOU tariff. The thermal storage system which can contribute to peak

shifts of power consumption of large scale chillers has been introduced in some large companies, encouraged by the TOU tariff.

**Table 2- 38 Participation to TOU Tariff**

| Item | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|
| Number of Industrial Customers | 34 | 145 | 296 | 721 | 913 | 6,890 |
| Number of Commercial Customers | 11 | 37 | 72 | 191 | 218 | 20 |
| Total Number of Customers | 45 | 182 | 368 | 912 | 1,131 | 6,910 |
| Displaced Loads (MW) | 22 | 91 | 196 | 412 | 548 | 780 |

(Source: SEC)

(b) Remote Control of AC

SEC has introduced a remote control system for ACs in government buildings and large companies. The system reduces power consumption of chillers of contracted customers when the power supply balance becomes severe. According to the severe level, the power consumption of chillers is reduced by 20 %, 40 % and 100 % (totally stop).

## 2.8 Summary

### 2.8.1 Policy on EE&C in Other Countries

Policy on EE&C of each country is summarized as follows.

**Table 2- 39 Policy on EE&C of Each Country (Summary)**

| Country | Policy on EE&C |
|---|---|
| Japan | A "New National Energy Strategy" was announced in 2006 targeting reduced oil dependence lower than 40 % of present levels by 2030 and had presented specific programs that included an "Energy Efficiency Frontrunner Plan" which aimed for 30 % increased energy efficiency by 2030 as its target. However, reflecting the nuclear accident in 2011 in Japan, the energy strategy is now being reviewed by the Government of Japan. |
| UK | UK sets energy efficiency policy as one of its key policies for tackling global warming. Energy efficiency policy lies at the heart of the measures being taken against global warming by 2020, since it is cost effective and can achieve results in the short-term. UK set its (national) 80 %, at minimum, greenhouse gas reduction target by 2050 compared to the emission of the standard year (carbon dioxide and methane as 1990 and HFC etc. as 1995) through the activities in the country and overseas in Climate Change Act 2008. |
| India | The Indian Government has announced that as a part of the nation's climate change efforts, India aims to reduce 20 % - 25 % of CO2 emission intensity to the intensity of 2005, by 2020. As an effective measures to improve the intensity, the fossil energy consuming industries (9 different sectors) have adopted the Indian Energy Management System (At the beginning of this scheme (2001), 15 sectors were selected). |
| Thailand | The energy policy in Thailand was issued under the Energy Minister's name in January 2009. 20 % reduction of unit energy consumption in industrial sector by 20 % from 2006 has been targeted. |
| Australia | Main policies on EE&C in Australia are decided by the Ministerial Council on Energy (MCE). The Council announced the "National Framework for Energy Efficiency (NFEE)" on December 2004 that aimed at promotion of energy efficiency in the consumption sector. The Framework raised the following nine priority sectors with an expected annual energy saving of 50 PJ/year by 2015. |
| Saudi Arabia | To play a leading role in enabling Saudi Arabia to achieve the world average energy intensity by 2020 capitalizing on the support of the stakeholders and the integration of their energy efficiency efforts. SEEC was newly established in 2010. |

### 2.8.2 Law on EE&C

The following table is a summary of Laws on EE&C for each country. In the report, a "Law on EE&C" defines a complexity of obligatory regulations for the purpose of enforcing comprehensive EE&C promotion and implementation.

**Table 2- 40 Law on EE&C of Each Country (Summary)**

| Country | Law on EE&C | Stipulated Contents |
|---|---|---|
| Japan | Act on the Rational Use of Energy (Established in 1979, the latest revision, June 2011) | • Energy Management System for Designated Organizations<br>• EE&C for transportation (carriers and consigners)<br>• EE&C for houses and buildings (owners and administrators)<br>• EE&C for machinery and equipment (Labeling and Standard System) |
| UK | Climate Change Act, 2008 (Established in 2008) | • Emissions Trading Scheme/System (EU ETS)<br>• Carbon Reduction Commitment Energy Efficiency Scheme (CRC), etc. |
| | European Union Energy Label (EU Directive 92/75/EC) (Established in 1992 and the latest revision, 2010) | • Energy Consumption Labeling Scheme |
| India | Energy Conservation Act 2001 (Established in 2001 and the latest revision, March 2007) | • Energy Management System<br>• Energy Conservation Building Code<br>• Labeling and Standard System |
| Thailand | Energy Conservation and Promotion Act (Established in 1992 and the latest revision, 2000) | • Energy Management System<br>• Designation of EE&C equipment and promotion<br>• Energy Conservation Fund (ENCON Fund) |
| Australia | Energy Efficiency Opportunities Act 2006 (Established in 2006) | • Energy Efficiency Opportunity Program |
| | Minimum Energy Performance Requirements (AS/NZS 4474 Part 2) (Established in 1999 and the latest revision, October 2011) | • Minimum Energy Performance Standards |
| Saudi Arabia | Energy Consumption Efficiency Label Regulation (Established in October 2010) | • Energy Consumption Efficiency Label Regulation |

# Chapter 3 General Information of Oman

## 3.1 General Information

### 3.1.1 Basic Information of the Country

(1) Geography of the Country

The gross area of Oman is 309,500 km² which is approximately three quarters of that of Japan. Oman is situated in lat. 16°40' N to 26°20' N and long. 51°40' E to 59°40' E in the southeastern end of the Arabic Peninsula Oman borders UAE, Saudi Arabia and Yemen. The coastal line measures 3,165 km. Oman is surrounded by the Arabic Gulf, the Strait of Hormuz, the Gulf of Oman and the Arabian Sea.

While there is no river, 0.3 % of the whole land around the oasis is used for agriculture.

The coastal length of the Oman Gulf from the northern point of the Musandam Peninsula facing the Strait of Hormuz, to Sur is 500-600 km. The Musandam Peninsula is independently located surrounded by the UAE area. The Hajar mountain area, existing along the Oman Gulf, has 1,000 m – 2,000 m height mountains. The highest peak exceeds a 3,000 m height.

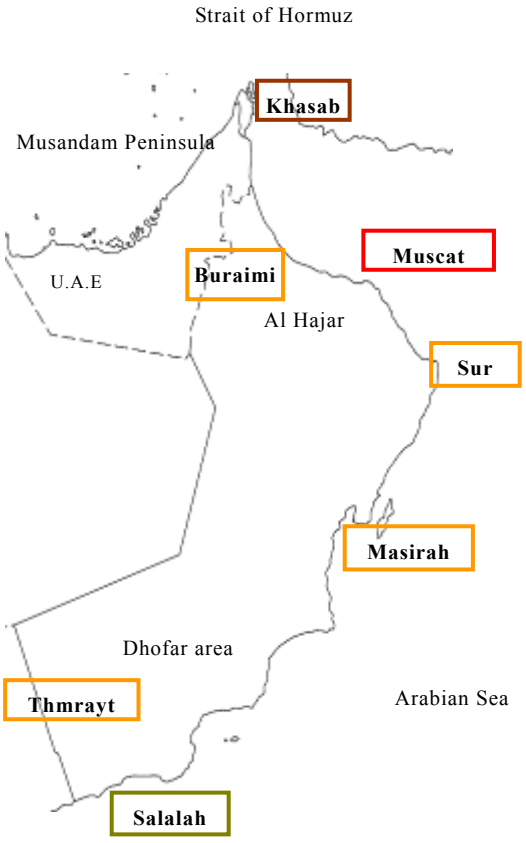



**Figure 3- 1 Map of Oman**

(2) Races and Religion

The population in Oman is made up of various races. Arabs account for the largest portion, and the others are East Africans, Indians, Pakistanis and Iranians. The official language of Oman is Arabic, and English is frequently used. In some areas, Swahili, Balochi and Urdu are commonly spoken.

Regarding religion, 75 % of the whole population is Islamic Ibadi Muslim, 25 % is Sunni Muslim. Few people are Hindus and Christians. Islam is a national religion in Oman. Although restrictions are placed on women's activities and clothing, it is more liberal than Saudi Arabia. Many women hold jobs and account for 20 % of the whole labor population.

(3) Population

78 % of the whole population lives in urban areas. 1 million people live in the capital city of Muscat, and 210,000 people live in the second capital, Salalah. The young generation of 20 years

or under makes up 55 % of the whole population. As of 2010, 12 % of government expenditures were put into educational infrastructure development. The basic educational system consists of primary and secondary education: primary education starts at the age of 6 and lasts for 10 years followed by 2 years of secondary education. The educational curriculum stresses the importance of science, mathematics and computers due to a demanding future labor market. English education starts from the age of 6.

### 3.1.2 Natural Environment

Desert area covers 82 % of the whole land in Oman, and the climatic division of almost all the land is a desert climate. 15 % of the mountain area and 3 % of the plain area comprises the rest of the land. The coastal area has a hot and humid climate, the inland area has a hot and dry climate due to the desert region, and the mountain area has a yearly-warm climate.

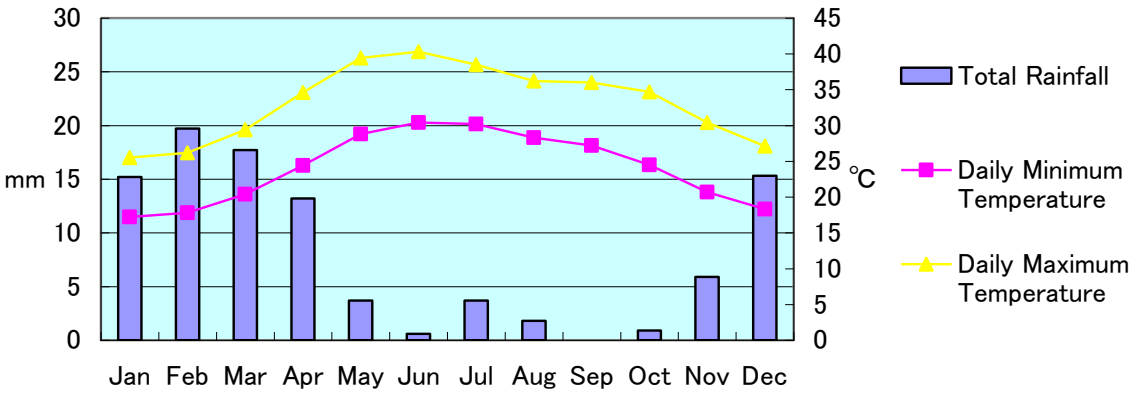
The climate of the coastal area including Muscat has a summer season that continues from April to October, and during the months from May to August temperatures can be as high as 40 ˚C to 50 ˚C and as low as over 30 ˚C. Humidity reaches 80 % on average from June to September. During December to February, the temperature changes from 10 ˚C to 20 ˚C, which is the most comfortable season.

Compared with the Muscat or Batina coast, the temperature of the climate of the inland area in the summer is higher and in the winter is a bit of lower. The humidity is lower and precipitation is less. On the other hand, the climate of Hagar mountain which is 1,000 to 2,000 m in height is rainy frequently both in the summer and winter. At around 3,000 m above sea level, it sometimes reaches below freezing.

In the South Dhofar area covering the second capital of Salalah, the climate is divided to the monsoon climate. From June, the rainy season begins and lasts until September, and the humidity is high. The temperature from June to September is around 30 ˚C, which is cooler than other areas. In the dry season, humidity decreases. The temperature increases a little bit before and after the rainy season, and in the winter season it decreases.

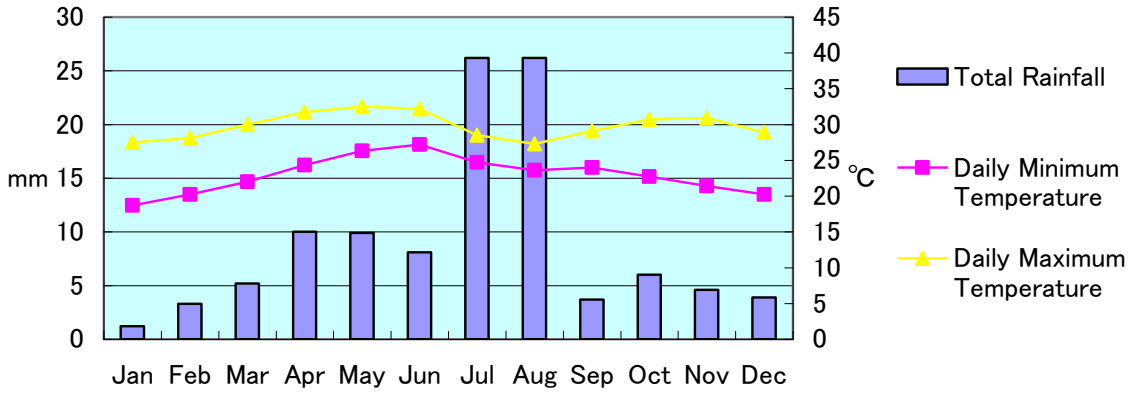
Approximately 80 % of the annual precipitation evaporates, 5 % flows into the ocean, and 15 % is accumulated as groundwater.

In 2007, a huge cyclone attacked Muscat directly, resulting in power and water supply infrastructure damage. It took several days to restore in some areas. It was the first time that cyclonic damage was experienced in Oman.




(Source: MET Malaysia)

**Figure 3- 2 Average Monthly Precipitation and Temperature in Muscat**




(Source: MET Malaysia)

**Figure 3- 3 Average Monthly Precipitation and Temperature in Salalah**

### 3.1.3 Economic Activity

(1) Economic Activity and Life Pattern

The main industry in Oman is oil production. According to the Ministry of Information, as of 2010, the average amount of daily production is estimated to be 864,600 bbls and the average amount of annual production is 76.64 million bbls. Oil production value accounts for 76 % of the gross export value. In Oman, a few metal resources such as chromium steel, silver and gold are mined.

Due to no rivers, it is not applicable for agriculture, while 9 % of the population is engaged in agriculture. The main agricultural product is dates. Potatoes share the largest amount of production in the field of grains and root crops.

(2) Economic Activities in a Year

Islamic national holidays are the norm. The holidays in 2012 are as follows.

**Table 3- 1 National Holidays in 2012**

| Islamic Calendar/ Christian Era | In 2012 | Holiday |
|---|---|---|
| Christian era, 1st January | 1st January | New Year's Day |
| Islamic calendar , 12th Rabi II | Around 4th February | Prophet's birthday |
| Islamic calendar , 27th Rajab | Around 17th June | Prophet's ascension |
| Islamic calendar , 1st -4th Shawaal | Around 19th August | Eid Al-Fitr |
| Islamic calendar , 9th -13th Dhul-Hijah | Around 24th October | Eid Al-Adha |
| Christian era, Two days in the end of November | Around 18th November | National Day |
| Christian era, 19th November | 19th November | Sultan Qaboos' Birthday |
| Islamic calendar , 1st Muharram | 7th December | Muslim New Year |

(Source: Japan Cooperation Center for the Middle East)

(3) Economic Activity in a week

Due to the national religion of Islam, a week starts from Saturday, and a weekly holiday is every Friday. The working hour of governmental agencies, banks, private establishments and shops is as follows. During Ramadan, working hours are shortened by two hours.

**Table 3- 2 Working Hours**

| Category | Day | Working Hour |
|---|---|---|
| Governmental agencies | Saturday-Wednesday | 7:30-14:30 |
| | Ramadan | 9:00–14:00 |
| Banks | Sunday-Wednesday | 8:00-14:00 |
| | Thursday | 8:00-12:00 |
| Private establishments | Saturday-Wednesday | (7:00 or 8:00) – (16:00 or 17:00)<br>Or (8:00-13:00, 15:00-18:00) |
| | Thursday | 8:00-13:00 |
| Shops | Saturday-Thursday | 8:30-13:30, 16:00-21:00 |
| | Friday | 16:00-21:00 |

(Source: Japan Cooperation Center for the Middle East)

Regarding private establishments, most large establishments take two days off every Thursdays and Fridays. As for shops, several supermarkets and convenience stores are open until 1 Am.

According to Oxford Business Group, because Omani makes a habit of prioritizing spending time with their family, many people who come to the urban area to find work go back to their homes every weekend and on national holidays.

In general, primary and secondary schools have weekdays from Saturday to Wednesday.

(4) Life Pattern in a Day

Omani considers Islamic customs to be a very important part of their daily life. Most of public/private organizations adhere to a lifestyle per the customs and traditions of the religion of Islam for their business operations.

Muslims have the custom of holding religious services 5 times a day; before sunrise, at noon, afternoon, just after sunset and before sleeping. During the services, many shops are closed.

## 3.2 Social Economic Development

### 3.2.1 Population Trends

(1) Population Statistics

According to the Statistical Year Book 2010 (published by the Ministry of National Economy: MONE）, the Omani population as of 2010 is with Omani nationals totaling 2.07 million and number of foreigners totaling 0.7 million. The total population of Oman was 2.77 million in 2010.

The population period growth rate increased by 10.5 % from 2005 to 2010, the growth rate of Omani original people was 12.3 %. And the annual average growth rate of the total population during the term was 2.0 % per year and Omani original people was 2.4 %. Although the number of foreign people in Oman fluctuates per Omani's economic situation, Omani population growth rate at around 2 % per year is comparatively high as well as other semi developed countries.

Omani's national census was conducted in December 2003 and December 2010. The total population including foreigners in Oman during the term increased from 2.34 million in 2003 to 2.77 million in 2010. Most of the foreigners are workers who came from Gulf Coast Countries (GCC), so it can be found that the labor market in Oman is supported by the workers in GCC. It is observed that the population of foreigners suddenly dropped in 2010. It is assumed that the economic recession by the "Lehman Shock" affected decrease of foreign workers.

**Table 3- 3 Population Trends in Oman**

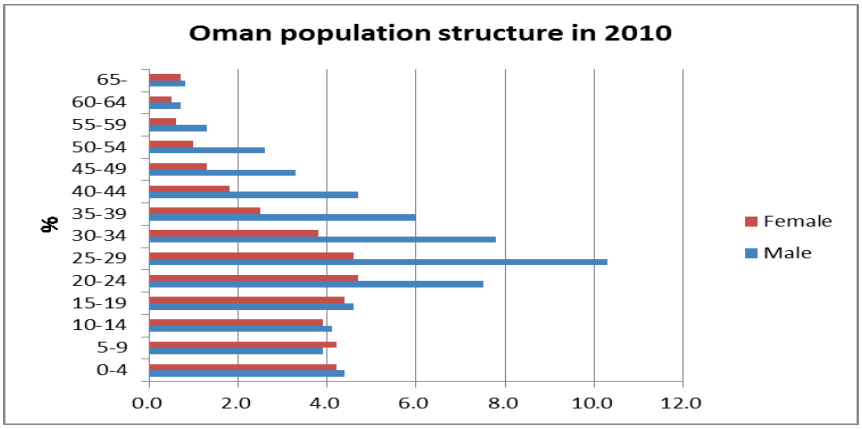
| Year | Total | Foreigners | Omani | Growth Rate of the total | Contribution of Foreigners |
|---|---|---|---|---|---|
| | 1,000persons | 1,000persons | 1,000persons | % | % |
| 1990 | 1,625 | 304 | 1,321 | | 18.7 |
| 1991 | 1,757 | 388 | 1,369 | 8.1 | 22.1 |
| 1992 | 1,882 | 465 | 1,417 | 7.1 | 24.7 |
| 1993 | 2,000 | 535 | 1,465 | 6.3 | 26.8 |
| 1994 | 2,050 | 538 | 1,512 | 2.5 | 26.2 |
| 1995 | 2,131 | 574 | 1,557 | 4.0 | 26.9 |
| 1996 | 2,214 | 612 | 1,602 | 3.9 | 27.6 |
| 1997 | 2,255 | 613 | 1,642 | 1.9 | 27.2 |
| 1998 | 2,287 | 602 | 1,685 | 1.4 | 26.3 |
| 1999 | 2,325 | 596 | 1,729 | 1.7 | 25.6 |
| 2000 | 2,402 | 624 | 1,778 | 3.3 | 26.0 |
| 2001 | 2,478 | 652 | 1,826 | 3.2 | 26.3 |
| 2002 | 2,538 | 668 | 1,870 | 2.4 | 26.3 |
| 2003 | 2,341 | 559 | 1,782 | -7.8 | 23.9 |
| 2004 | 2,416 | 613 | 1,803 | 3.2 | 25.4 |
| 2005 | 2,509 | 666 | 1,843 | 3.8 | 26.5 |
| 2006 | 2,577 | 693 | 1,884 | 2.7 | 26.9 |
| 2007 | 2,743 | 820 | 1,923 | 6.4 | 29.9 |
| 2008 | 2,867 | 900 | 1,967 | 4.5 | 31.4 |
| 2009 | 3,174 | 1,156 | 2,018 | 10.7 | 36.4 |
| 2010 | 2,773 | 703 | 2,070 | -12.6 | 25.4 |

(Source: Ministry of National Economy, Oman)

(2) Labor Population

According to Oman's statistical year book, Omani households are shifting to a nuclear family model along with other semi developed countries. It means that the number of households is at a higher growth rate than the population size in Oman, and the family members per household are decreasing year by year. While most of the foreign workers are located in the category from 20 years old to 39 years old, and its generation shares 47 % of the Omani total population. (Refer to the following figure) It can be said that the phenomenon to of a comparatively high share occupied by the middle age class in three a million population country is contributed significantly by foreign workers. Regarding worker recruitment activities in Oman, the government has adopted an "Omanisation policy" which is an ethnic preferential policy to employ Omani people. In order to carry out the policy, the government prepares education and occupational training systems to improve worker quality. Private companies in Oman employed 80 % of Omani people in 2010. However, the increase of foreign workers will increase at Omani private companies in the future.

When looking at the nationality of workers, there is a trend that people from India, Pakistan, Bangladesh and the Philippines are working in the construction sector. On the other hand, people from the GCC, EU and USA are working as technocrats.




（Source: Ministry of National Economy, Oman）

**Figure 3- 4 Contribution of Male and Female in Oman**

(3) Future Population

According to the "Oman Economic Insight April 2011" by the Qatar National Bank (QNB), the future Omani population will increase at an annual 2 % rate, and the contribution of foreign workers will increase from 2012 to 2015 in Oman. However, the foreign worker's contribution will decrease due to Omani economic stability and the increase of Omani workers in the further future.

As the Omani population was 2.8 million (Omani: 2.0 million) in 2010, when considering the above trends, it can be estimated that the population will reach 3.0 million (Omani: 2.2 million) in 2015, 3.3 million (Omani :2.5 million) in 2020, 3.6 million (Omani:2.8 million) in 2025 and 3.9 million (Omani: 3.1 million) in 2030.

**Table 3- 4 Future Population in Oman**

| | | Unit | 2010 | 2011 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|
| Population | Growth | % | -12.63 | -0.47 | 2.5 | 2.0 | 1.5 | 1.5 |
| | Population | 1000 | 2,773 | 2,760 | 3,037 | 3,353 | 3,612 | 3,891 |
| | Omani | 1000 | 2,069 | 2,110 | 2,247 | 2,515 | 2,781 | 3,074 |
| | Foreigner | 1000 | 704 | 650 | 790 | 838 | 831 | 817 |
| Contribution | Omani | % | 74.6 | 76.4 | 74.0 | 75.0 | 77.0 | 79.0 |
| | Foreigner | % | 25.4 | 23.6 | 26.0 | 25.0 | 23.0 | 21.0 |

(Source: Provided by the Study Team as reference from "Oman Economic Insight" of QNB)

(4) Population by Governorate

The Omani regions are separated by 10 governorates as follows; Muscat, Musandam, Al Buraimi, Al Dakhiliyah, Al Batinah North, Al Batinah South, Al Sharqiyah South, Al Sharqiyah North, Al Dhahira, and Al Wosta Governorate. The main governorates are Muscat (population : 950,000 in 2009), Al Batinh (820,000 in 2009), Ash Shardiyan (400,000 in 2009) and Dhofar including Salalah (310,000 in 2009). As noted, Adh Dhahiran governorate in the following table includes Al Burami governorate. It can be surmised that generally population growth meets economic growth, as long as the population growths of Muscat, Al Wusta and

Dhofar shown in the following table continue, the three governorates are comparatively higher than other governorates, so the three governorates may have higher economic growth than others.

**Table 3- 5 Population Trends by Governorates (Unit :1,000 persons)**

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 09/05 |
|---|---|---|---|---|---|---|---|
| Muscat | 696 | 719 | 785 | 837 | 949 | | 8.1% |
| Al Batinah | 688 | 704 | 736 | 760 | 818 | | 4.4 % |
| Musandam | 31 | 31 | 34 | 35 | 40 | | 6.6 % |
| Adh Dhahiran | 224 | 230 | 246 | 258 | 289 | | 6.6 % |
| Adh Dakhliyah | 281 | 287 | 299 | 308 | 332 | | 4.3 % |
| Ash Sharqiyah | 331 | 338 | 355 | 367 | 402 | | 5.0 % |
| Al Wusta | 25 | 26 | 27 | 28 | 33 | | 7.2 % |
| Dhofar | 235 | 241 | 260 | 273 | 308 | | 7.0 % |
| Total | 2,509 | 2,577 | 2,743 | 2,867 | 3,174 | 2,773 | 6.1 % |

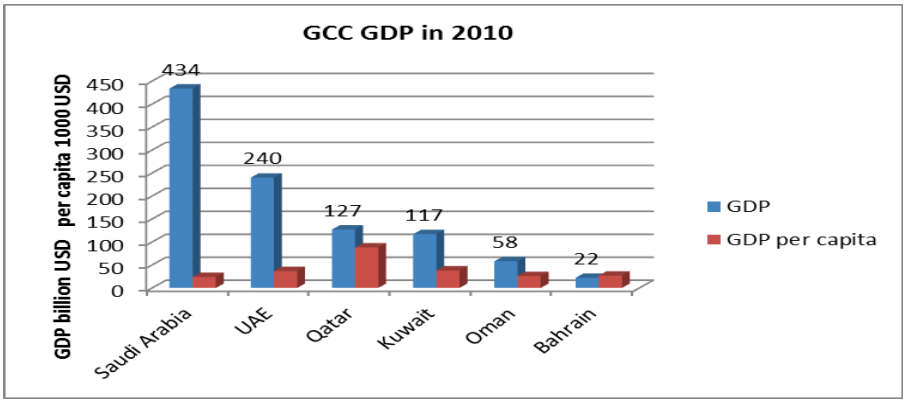
(Source: Statistical Year book 2010, 2007)

### 3.2.2 Economy and Development plan

(1) Current Economy

The world economy in 2011 shows a gradual recovery following the Lehman shock that happened in 2008. The IMF estimates the world economic growth rate at 4.4 % in 2011, it is lower than the growth rate at 5.0 % in 2010. When looking at the breakdown of the growth rate in 2011, the developed countries are 2.4 % (3 % in the previous year) and the growth rate in the emerging countries is 6.5 %. (7 % in the previous year)

Omani GDP was 58 billion US$ in 2010 (average annual growth from 2005-2010 is 6.4 %). The Omani economic size shown by the GDP is located in the fifth position in 6 countries of the Gulf Coast Countries (Saudi Arabia, Qatar, UAE, Kuwait, Oman and Bahrain).




Note: GDPs are shown by is PPP as US$, the unit is billion US$

Note: GDP per capita are calculated by the above GDP, unit is 1000 US$ per person

(Source: IMF and QNB Capital estimates 2011)

**Figure 3- 5 GDP Comparison in GCC Countries**

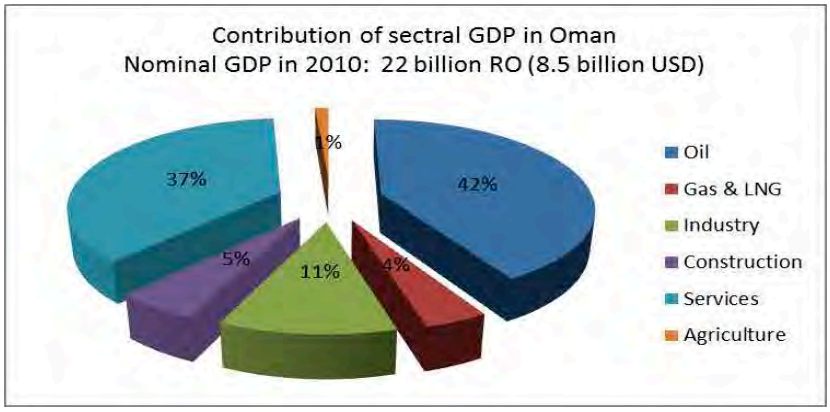
(2) GDP Contribution by Sector

The oil and gas sector contributions including the related industries in Omani GDP occupied 46 % in 2010. The sector became an important industry in Oman. As Oman does not participate in an OPEC regime, Oman does not have an obligation to follow the OPEC decision. Although OPEC had an oil production cut strategy in 2009, the Omani oil production amount in 2010 increased by 1.9 % from the previous year.

In addition, the GDP growth rate of the non-oil and gas sector increased by 6.1% per the recovery of the sector in 2010. The commercial sector has a big contribution following the oil and gas sector, the GDP contribution is 37 % to the total GDP. As the GDP of the sector was 38% in the year of 2005, it is found that the contribution of the sector was 1 % down in 2010. This is caused by high growth in other sectors. It is not a phenomenon that the commercial sector remained on a plateau.

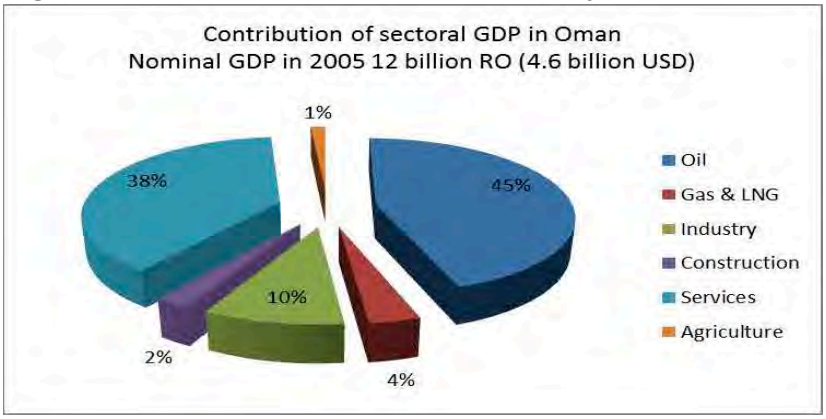
The contribution of the industrial GDP increased to 11 % of the total GDP in 2010 due to the operational start of the petrochemical and metal industries in Sohar. When considering that the contribution of the sector was 10 % in 2010, the growth of the sector is mostly dependent on the support and effort of the government.

The agriculture and fishery sector was a 1 % contribution to the total GDP in 2005, and it was the same level in 2010.




(Source: Illustrated from Annual report 2010 of Central Bank of Oman)

**Figure 3- 6 Contribution of Nominal GDP by Sector in 2010**




(Source: Illustrated from Annual report 2010 of Central Bank of Oman)

**Figure 3- 7 Contribution of Nominal GDP by Sector in 2005**

(3) GDP Contribution by Subsector

By looking at the nominal contribution trends by subsector, the economic activities of the subsectors can be analyzed.

**Table 3- 6 Nominal GDP and Contribution in Oman**

| | | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 10/05 |
|---|---|---|---|---|---|---|---|---|
| **Exchange rate** | RO/USD | 0.3845 | 0.3845 | 0.3845 | 0.3845 | 0.3845 | 0.3845 | |
| **GDP at current price** | **million RO** | **11,883** | **14,151** | **16,111** | **23,288** | **18,020** | **22,243** | **13.4** |
| Crude oil | million RO | 5,434 | 6,157 | 6,538 | 10,915 | 6,610 | 9,420 | 11.6 |
| Natural gas | million RO | 442 | 582 | 601 | 859 | 706 | 912 | 15.6 |
| Agri & fishing | million RO | 183 | 191 | 209 | 245 | 259 | 271 | 8.2 |
| **Industry total** | million RO | 1,694 | 2,290 | 2,760 | 3,838 | 3,325 | 3,721 | 17.0 |
| Mining & Quarrying | million RO | 28 | 27 | 43 | 70 | 82 | 85 | 24.9 |
| Manufacturing | million RO | 1,007 | 1,527 | 1,749 | 2,463 | 1,853 | 2,202 | 16.9 |
| Electricity & water | million RO | 202 | 169 | 176 | 189 | 210 | 230 | 2.6 |
| Building & Construction | million RO | 457 | 566 | 792 | 1,117 | 1,179 | 1,204 | 21.4 |
| **Service total** | **million RO** | **4,130** | **4,932** | **6,003** | **7,431** | **7,120** | **7,919** | **13.9** |
| Wholesale & Rerail trade | million RO | 859 | 1,088 | 1,489 | 2,060 | 1,731 | 1,943 | 17.7 |
| Hotel & Restaurants | million RO | 89 | 115 | 143 | 176 | 175 | 181 | 15.3 |
| Transport & Communication | million RO | 636 | 803 | 909 | 1,177 | 1,082 | 1,206 | 13.7 |
| Banking & Real Estate | million RO | 1,010 | 1,141 | 1,390 | 1,664 | 1,790 | 1,916 | 13.7 |
| Public & Defence | million RO | 910 | 1,062 | 1,192 | 1,282 | 1,334 | 1,500 | 10.5 |
| Other Services | million RO | 626 | 723 | 880 | 1,072 | 1,008 | 1,173 | 13.4 |
| **GDP at current price** | **S%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **0.0** |
| Crude oil | S% | 45.7 | 43.5 | 40.6 | 46.9 | 36.7 | 42.4 | −1.5 |
| Natural gas | S% | 3.7 | 4.1 | 3.7 | 3.7 | 3.9 | 4.1 | 2.0 |
| Agri & fishing | S% | 1.5 | 1.4 | 1.3 | 1.1 | 1.4 | 1.2 | −4.6 |
| **Industry total** | **S%** | **14.3** | **16.2** | **17.1** | **16.5** | **18.5** | **16.7** | **3.3** |
| Mining & Quarrying | S% | 0.2 | 0.2 | 0.3 | 0.3 | 0.5 | 0.4 | 10.2 |
| Manufacturing | S% | 8.5 | 10.8 | 10.9 | 10.6 | 10.3 | 9.9 | 3.2 |
| Electricity & water | S% | 1.7 | 1.2 | 1.1 | 0.8 | 1.2 | 1.0 | −9.5 |
| Building & Construction | S% | 3.8 | 4.0 | 4.9 | 4.8 | 6.5 | 5.4 | 7.1 |
| Service total | S% | 34.8 | 34.9 | 37.3 | 31.9 | 39.5 | 35.6 | 0.5 |
| Wholesale & Rerail trade | S% | 7.2 | 7.7 | 9.2 | 8.8 | 9.6 | 8.7 | 3.9 |
| Hotel & Restaurants | S% | 0.7 | 0.8 | 0.9 | 0.8 | 1.0 | 0.8 | 1.7 |
| Transport & Communication | S% | 5.4 | 5.7 | 5.6 | 5.1 | 6.0 | 5.4 | 0.3 |
| Banking & Real Estate | S% | 8.5 | 8.1 | 8.6 | 7.1 | 9.9 | 8.6 | 0.3 |
| Public & Defence | S% | 7.7 | 7.5 | 7.4 | 5.5 | 7.4 | 6.7 | −2.5 |
| Other Services | S% | 5.3 | 5.1 | 5.5 | 4.6 | 5.6 | 5.3 | 0.0 |
| **GDP at current price** | G% | | 19.1 | 13.8 | 44.5 | −22.6 | 23.4 | |
| Crude oil | G% | | 13.3 | 6.2 | 67.0 | −39.4 | 42.5 | |
| Natural gas | G% | | 31.6 | 3.3 | 43.0 | −17.8 | 29.1 | |
| Agri & fishing | G% | | 4.4 | 9.6 | 16.7 | 6.1 | 4.6 | |
| **Industry total** | G% | | 35.2 | 20.5 | 39.1 | −13.4 | 11.9 | |
| Mining & Quarrying | G% | | −3.6 | 59.3 | 62.8 | 17.1 | 3.7 | |
| Manufacturing | G% | | 51.6 | 14.5 | 40.8 | −24.8 | 18.8 | |
| Electricity & water | G% | | −16.3 | 4.1 | 7.4 | 11.1 | 9.5 | |
| Building & Construction | G% | | 23.9 | 39.9 | 41.0 | 5.6 | 2.1 | |
| **Service total** | G% | | 19.4 | 21.7 | 23.8 | −4.2 | 11.2 | |
| Wholesale & Rerail trade | G% | | 26.7 | 36.9 | 38.3 | −16.0 | 12.2 | |
| Hotel & Restaurants | G% | | 29.2 | 24.3 | 23.1 | −0.6 | 3.4 | |
| Transport & Communication | G% | | 26.3 | 13.2 | 29.5 | −8.1 | 11.5 | |
| Banking & Real Estate | G% | | 13.0 | 21.8 | 19.7 | 7.6 | 7.0 | |
| Public & Defence | G% | | 16.7 | 12.2 | 7.6 | 4.1 | 12.4 | |
| Other Services | G% | | 15.5 | 21.7 | 21.8 | −6.0 | 16.4 | |
| | | | | | | | | |

(Note) RO means: Oman Rival, G% : Growth rate percentage, S% : Contribution percentage

（Source : Prepared by the JICA Study Team from Annual Report 2010 of Central Bank Oman）

From 2005 to 2010, the construction sector made its contribution increase, it was 3.8 % in 2005, and became 5.4 % in 2010. This shows that the construction business such as infrastructures, buildings, houses and so on increase in concert with economic growth in Oman.

The next high growth is the wholesale subsector. Its contribution was 7.2 % in 2005, and it is increased to 8.7 % in 2010. Furthermore, the contribution of the manufacturing subsector increased from 8.5 % in 2005 to 9.9 % in 2010.

Per the above reasons, it can be found that the non-oil and gas industrialization policy of Oman brings about high growth in construction, manufacturing and the wholesale subsectors. The 7th Five-year Development Plan (2006-2010) of the government realized considerable achievements. Furthermore, the mining subsector advanced considerably in the past, even though the scale is small. Mining products like copper, nickel, chrome, iron, gold and silver are to be expected.

(4) Real GDP by Subsector (at 2000 constant price)

The sectoral average growth rates of the real GDP (at a 2000 constant price) from 2005 to 2010 in Oman are 6.4 % of the total GDP, 10.4 % for the mining and manufacturing sector excluding the oil and gas sector and 7.7 % for the commercial and service sector. In this period, it is at a considerable higher growth in the mining and manufacturing sector.

**Table 3- 7 Real GDP and Growth Rate at 2000 Price**

| | | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 10/05 |
|---|---|---|---|---|---|---|---|---|
| **Exchange rate** | RO/USD | 0.3845 | 0.3845 | 0.3845 | 0.3845 | 0.3845 | 0.3845 | |
| **GDP at 2000 price** | **million RO** | **8,696** | **9,177** | **9,794** | **11,052** | **11,176** | **11,853** | **6.4** |
| Crude oil | million RO | 2,895 | 2,714 | 2,553 | 2,761 | 2,958 | 3,147 | 1.7 |
| Natural gas | million RO | 299 | 341 | 351 | 362 | 360 | 383 | 5.1 |
| Agri & fishing | million RO | 98 | 154 | 161 | 173 | 179 | 188 | 13.9 |
| **Industry total** | **million RO** | **1,529** | **1,586** | **1,904** | **2,236** | **2,367** | **2,509** | **10.4** |
| Mining & Quarrying | million RO | 23 | 21 | 29 | 39 | 48 | 51 | 17.2 |
| Manufacturing | million RO | 788 | 868 | 980 | 1,078 | 1,035 | 1,107 | 7.0 |
| Electricity & water | million RO | 278 | 174 | 188 | 198 | 207 | 219 | -4.6 |
| Building & Construction | million RO | 440 | 523 | 708 | 921 | 1,076 | 1,130 | 20.8 |
| **Service total** | **million RO** | **3,875** | **4,382** | **4,825** | **5,520** | **5,312** | **5,625** | **7.7** |
| Wholesale & Rerail trade | million RO | 776 | 920 | 1,126 | 1,364 | 1,091 | 1,156 | 8.3 |
| Hotel & Restaurants | million RO | 79 | 86 | 92 | 106 | 111 | 118 | 8.3 |
| Transport & Communication | million RO | 637 | 768 | 798 | 1,006 | 1,013 | 1,074 | 11.0 |
| Banking & Real Estate | million RO | 916 | 995 | 1,104 | 1,243 | 1,296 | 1,374 | 8.4 |
| Public & Defence | million RO | 840 | 955 | 960 | 984 | 1,017 | 1,078 | 5.1 |
| Other Services | million RO | 627 | 658 | 745 | 817 | 784 | 826 | 5.7 |
| GDP at 2000 price | S% | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 0.0 |
| Crude oil | S% | 33.3 | 29.6 | 26.1 | 25.0 | 26.5 | 26.6 | -4.4 |
| Natural gas | S% | 3.4 | 3.7 | 3.6 | 3.3 | 3.2 | 3.2 | -1.2 |
| Agri & fishing | S% | 1.1 | 1.7 | 1.6 | 1.6 | 1.6 | 1.6 | 7.1 |
| Industry total | S% | 17.6 | 17.3 | 19.4 | 20.2 | 21.2 | 21.2 | 3.8 |
| Mining & Quarrying | S% | 0.3 | 0.2 | 0.3 | 0.4 | 0.4 | 0.4 | 10.2 |
| Manufacturing | S% | 9.1 | 9.5 | 10.0 | 9.8 | 9.3 | 9.3 | 0.6 |
| Electricity & water | S% | 3.2 | 1.9 | 1.9 | 1.8 | 1.9 | 1.9 | -10.4 |
| Building & Construction | S% | 5.1 | 5.7 | 7.2 | 8.3 | 9.6 | 9.5 | 13.5 |
| Service total | S% | 44.6 | 47.7 | 49.3 | 49.9 | 47.5 | 47.5 | 1.3 |
| Wholesale & Rerail trade | S% | 8.9 | 10.0 | 11.5 | 12.3 | 9.8 | 9.8 | 1.8 |
| Hotel & Restaurants | S% | 0.9 | 0.9 | 0.9 | 1.0 | 1.0 | 1.0 | 1.8 |
| Transport & Communication | S% | 7.3 | 8.4 | 8.1 | 9.1 | 9.1 | 9.1 | 4.3 |
| Banking & Real Estate | S% | 10.5 | 10.8 | 11.3 | 11.2 | 11.6 | 11.6 | 1.9 |
| Public & Defence | S% | 9.7 | 10.4 | 9.8 | 8.9 | 9.1 | 9.1 | -1.2 |
| Other Services | S% | 7.2 | 7.2 | 7.6 | 7.4 | 7.0 | 7.0 | -0.7 |
| **GDP at 2000 price** | G% | | 5.5 | 6.7 | 12.8 | 1.1 | 6.1 | |
| Crude oil | G% | | -6.3 | -5.9 | 8.1 | 7.1 | 6.4 | |
| Natural gas | G% | | 14.0 | 2.9 | 3.1 | -0.6 | 6.4 | |
| Agri & fishing | G% | | 57.1 | 4.5 | 7.5 | 3.5 | 5.0 | |
| **Industry total** | G% | | 3.7 | 20.1 | 17.4 | 5.9 | 6.0 | |
| Mining & Quarrying | G% | | -8.7 | 38.1 | 34.5 | 23.1 | 6.0 | |
| Manufacturing | G% | | 10.2 | 12.9 | 10.0 | -4.0 | 7.0 | |
| Electricity & water | G% | | -37.4 | 8.0 | 5.3 | 4.5 | 6.0 | |
| Building & Construction | G% | | 18.9 | 35.4 | 30.1 | 16.8 | 5.0 | |
| **Service total** | G% | | 13.1 | 10.1 | 14.4 | -3.8 | 5.9 | |
| Wholesale & Rerail trade | G% | | 18.6 | 22.4 | 21.1 | -20.0 | 6.0 | |
| Hotel & Restaurants | G% | | 8.9 | 7.0 | 15.2 | 4.7 | 6.0 | |
| Transport & Communication | G% | | 20.6 | 3.9 | 26.1 | 0.7 | 6.0 | |
| Banking & Real Estate | G% | | 8.6 | 11.0 | 12.6 | 4.3 | 6.0 | |
| Public & Defence | G% | | 13.7 | 0.5 | 2.5 | 3.4 | 6.0 | |
| Other Services | G% | | 4.9 | 13.2 | 9.7 | -4.0 | 5.3 | |

(Source: Prepared by the JICA Study Team from Annual Report 2010 of Central Bank Oman )

When looking at the growth rates of the subsectors, the agriculture, mining, construction, transportation and communication subsectors are at higher growth rates (double digit) from 2005 to 2010. However, the agriculture and transportation subsectors do not increase when looking at the contribution of the nominal GDP. As for the reason of the phenomenon, it can be considered that the prices of the agriculture, transportation and communication subsector

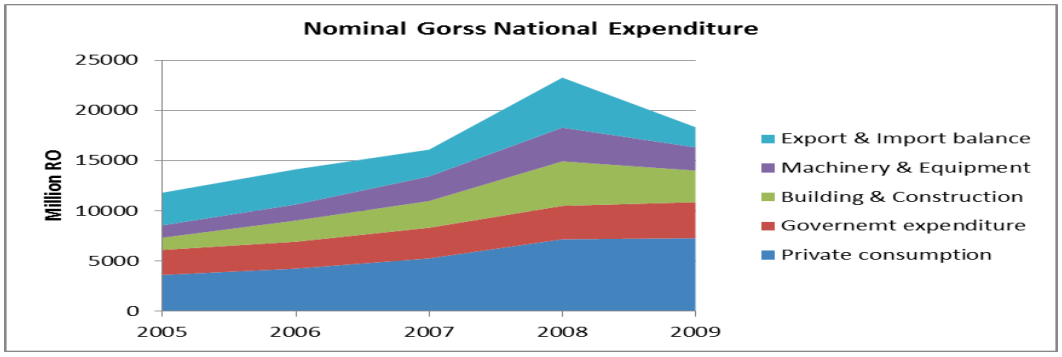
decreased in the period. (The phenomenon was not reflected in real GDP.)

The manufacturing (growth rate is 7.0 % per year) and wholesale (growth rate is 8.3 % per year) as a big contribution subsector in the following table have been pointed out. The growth rates of the subsectors are higher than the total GDP growth rate at 6.4 %.

(5) Gross Domestic Expenditure

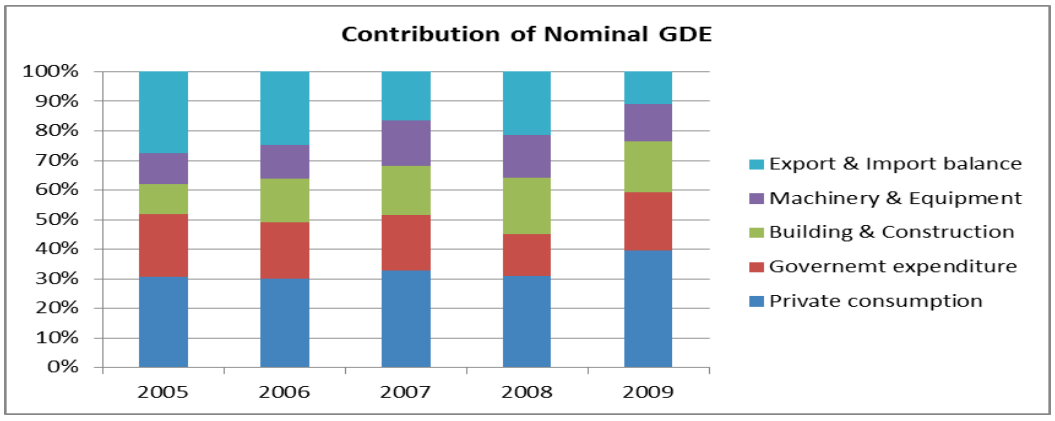
According to Central Bank of Oman, the Gross Domestic Expenditure (GDE) in 2009 was lower than the previous year due to a world economic recession, and regarding the contribution of GDE, it changed from 2005 to 2008. The average contributions from 2005 to 2008 are Private consumption at 30 %, Government expenditures at 20 %, Building & Construction at 20 %, Machinery & Equipment at 10% and Exports & Imports at 20 %. (It sometimes happens that the foreign trade balance has a big contribution like plus 20% in oil exporting countries.)

The total of the "Building & Construction (Fixed capital formation)" and "Machinery & Equipment" is named by "Investment". The investment occupied 30 % of the GDE in the current Oman. The contribution of the maximum investment in developing countries and semi developed countries sometimes reaches 40 % of GDE. Oman has room to increase a higher contribution of the investment, and it is expected to in the future. In the next 10 years, it can be predicted that the Omani GDP growth rate will increase from 6 % to 7 % per year.




(Source: Annual Report 2011, Central Bank of Oman)

**Figure 3- 8 Nominal GDE Trends**




(Source: Annual Report 2011, Central Bank of Oman)

**Figure 3- 9 Nominal GDE Contribution Trends**

### 3.2.3 The 8th Five Year Development Plan

(1) Outline of the Long Term Plan

The Omani economy has been developing significantly since the first long term national development strategy (1970 – 1995). However, as their oil resource dependent economy depending has limitations, the government would like to change the economic structures in order to sustain development. Many problems such as inefficient energy consumption in the country and the quality of Omani workers has surfaced in past years.

Therefore, the government set the direction of the economic policy in The Second Long Term Development Strategy ("The 25-year Oman Economic Vision 1996-2020" or "Oman Vision 2020") enacted in 1996. The contents of the policy aim to change the current economy to a sustainable economy and develop human resources by using income from the oil and gas business. As for the details, the policy aims to improve economic efficiency and environmental protection, to create the best mix between human and natural resources and to upgrade the lifestyles of the people. In the Oman Vision 2020, there are also targets to optimize the balance of the economy, to promote sustainable economic growth, to educate and train human resources and to create employment opportunities. The main targets of the Oman Vision 2020 are as follows;

- ✧ Stability of private income, keeping economic growth at 3 % per year and suppressing governmental expenditures
- ✧ Promoting attendance to institutes of higher learning, reformation of the education system, human development via technical training
- ✧ Reduction of the infant mortality rate by improving medical facilities and systems
- ✧ Enhancing employment chances for Omani workers
- ✧ Promoting the non-oil sector
- ✧ Strength of the private sector by promoting investment
- ✧ Promoting private investment to gas and related businesses
- ✧ Enhancing investment from private saving and foreign and domestic investors
- ✧ Privatization of power stations, sewage treatment systems in Muscat, airport and communication systems.

In order to implement the above targets, the 6th Five Year Development Plan (2001 – 2005), the 7th Five Year Development Plan (2006 – 2010) and the 8th Five Year Development Plan (2011 – 2015) have been established. The 8th Five Year Development Plan will be implemented by 2012. The targets of the Oman Vision 2020 have been achieved in the past several five- year- plans. However, some parts in the manufacturing and agriculture sectors cannot be achieved yet. The government aims to catch up to the unachieved targets in the 8th Five Year Development Plan.

(2) The Contents of the 8th Five Year Plan

The government revenues and expenditures in the 8th Five Year Plan from 2011 to 2015

are in the following table. Most of the governmental revenues comes from oil and gas sector.

**Table 3- 8 Government Revenues and Expenditures in the 8th Five Year Plan**

Unit: Billion RO

| | Items | 2011 | 2012 | 2013 | 1014 | 2015 |
|---|---|---|---|---|---|---|
| Revenues | Oil | 4.9 | 4.6 | 4.8 | 4.9 | 5.3 |
| | Gas | 0.9 | 0.9 | 1.0 | 1.0 | 1.0 |
| | Others | 1.4 | 1.6 | 1.6 | 1.7 | 1.8 |
| | Total | 7.2 | 7.3 | 7.4 | 7.6 | 8.1 |
| Expenditures | Defense | 1.7 | 1.7 | 1.7 | 1.7 | 1.8 |
| | Welfare | 2.8 | 3.0 | 3.2 | 3.4 | 3.6 |
| | Oil& Gas | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | Investment | 2.5 | 2.6 | 2.5 | 2.5 | 2.5 |
| | total | 7.3 | 7.6 | 7.7 | 7.9 | 8.2 |

(Source: Oman Budget 2011 and the 8th Five Year Plan 2011-15 by Oman Economic Research January 17, 2011)

In the 8th Five Year Plan, the export oriented and high added value projects are implemented with high priority for converting from an oil dependent economy to a non-oil economy, it aims to promote the industry and service sectors with a focus on the manufacturing, agriculture and tourism subsectors.

It has been predicted that the industry sector with an 11 % contribution to the GDP will be advanced more and the power and energy consumption may be increased per sector. As industrial parks will be established somewhere, the manufacturing subsector will be advanced nationwide. Especially, the Salalah Tax Free Zone (SFZ) will be marked as a special economic zone.

In the tax free trade zones, raw materials are imported abroad and manufactured and processed in the zones. In addition, most of the products are exported directly from the zones. At present, the introduction of power intensive industries like iron, aluminum and caustic soda are planned. Usually power intensive industries have in-house power generation systems. In case, it is expected that the public power supply companies have to enhance their capacity for preparing back up power systems for the industries.

In The 8th five Year Plan, the important policies and projects such as infrastructure, industry, water and energy, education and welfare are as follows;

**Table 3- 9 Policies and Projects in the 8th Five Year Plan**

| Fields | Contents |
|---|---|
| Economic policy | • The targeted average GDP growth rate is a minimum 3 % (MONE proposes 5 %)<br>• Strengthen to increase exports, investment and productivity<br>• Total investment reaches 30 billion RO during the five years, government investment in the total is 12 billion RO. |
| Infrastructure policy (Housing, road Airport, Harbor) | • The investment of the government is 8.1 billion RO for infrastructure in the total investment with 12 billion RO.<br>• Implement house investment and house loan system (Targets are different by region)<br>• Implement house construction for relocation in a company with construction of Al Batinah coastal road<br>• Construct an additional double track of the Ibri-Jibrin road, Nizwa-Thumrait road and Bid-Sur road<br>• Construct the third intersection of Al Mualih-Bait Al Barkah<br>• Construct Al Burj road, Al Batinah express way<br>• Construct road network in the Muscat governorate<br>• Construct Wadi Hyat (Al Hamra)-Wadi Bani Auwf road<br>• Traffic efficiency improvement of Sinaw-Mahout-Ad Duqum road<br>• Start the third construction for Al Batinah coastal road<br>• Airport constructions of Muscat, Salalah , Sohar, Adam, Ras Al Hadd and Ad Duqum<br>• Harbor construction of Al Halaniyat ,Ad Duqumt, Salalah, Hasik, Al Shuaymiya and Masirah port<br>• Construct fishery harbors of Barka, Al Musanah, Muhout, Sadah and Al Shuiymiah<br>• Dam constructions of Al Khoudh、Izki, Al Mudhaibi , Ibra, Ibri and Nizwa |
| Industry support policy | • Make non-oil industries grow by 10 % per year<br>• Investment with 56 million RO for tourism<br>• Make an increase of production for date palm trees |
| Water& Energy Policy | • Investment with 80 million RO for water, electricity and energies<br>• Increases of reserves of crude oil and natural gas<br>• Development of oil and petroleum industry with a comparatively big scale in GCC.<br>• Enhancement of water distribution system, especially hospitals.<br>• Construction of water supply systems from Wadi Dheqeh to Muscat and Quriyat<br>• Enhancement of water supply network nationwide.<br>• Establishment of emergency water reserve system for Muscat governorate |
| Education& welfare policy | • Construction of schools<br>• Establishment of scholarship<br>• Expansion of hospitals (Sumail, Muidhabi,Muscat l and Salalah）<br>• Construction of new hospitals (As Suwaiq, Mahout, Sinaw, Dhalkut and Al Muziunah）<br>• Construction health center （Wilayats） |

(Source: Oman Budget 2011 and 8th Five Year Plan 2011-15 by Oman Economic Research January 17, 2011)

### 3.2.4 GDP Outlook in Long Term

For evaluating EE&C policies, the baseline of power and energy demand is required. The GDP outlook used for making the baseline impacts the demand greatly. The following table

shows the future GDP outlook per the JICA Study Team, after the following Omani economy and industry policies and current circumstances are referred.

- ✧ The growth of the population looks at the trend from 2 % in the near future to 1.5 % in the further future, and the ratio of foreigners in the population decreased gradually.
- ✧ The GDP growth rate targeted in the Oman Vision 2020 is implemented at more than 3 % per year.
- ✧ The prediction of the GDP growth rate at 5 % proposed by MONE has to be referred due to having high expectation of the reality.
- ✧ Put the emphasis on non-oil industry growth
- ✧ No increase in crude oil exports exceeding the current level and the crude oil price does not increase at a high speed from the current price at the 2012 constant price.
- ✧ The LNG export is forecasted at the current level in near future. Furthermore, the LNG price increased at a slow pace in the international market.
- ✧ The growth rate of the future large scale energy intensive industries are promoted as much as the GDP growth rate.
- ✧ The inflation rate is processed in the stability in the company with the stabilization of energy prices worldwide.

Given the above considerations, the future Omani GDP growth rates are assumed to be 5.0 % from 2012 to 2015, (4.6 % from 2010 to 2015), 5.0 % from 2015 to 2020 and 4.0 % from 2020 to 2035 per the JICA Study Team.

**Table 3- 10 Growth Rates of Nominal GDP and Real GDP**

| | | Unit | 15/10 | 20/15 | 35/20 | 20/10 | 35/10 |
|---|---|---|---|---|---|---|---|
| Nominal | GDP | % | 12.6 | 7.3 | 6.3 | 9.9 | 7.7 |
| GDP | Petro GDP | % | 10.4 | 4.0 | 2.0 | 7.2 | 4.0 |
| | Non Petro GDP | % | 9.7 | 9.2 | 8.0 | 9.5 | 8.6 |
| Real | GDP at 2000 price | % | 4.6 | 5.0 | 4.0 | 4.8 | 4.3 |
| GDP | Petro GDP at 2000 price | % | 2.7 | 2.0 | 0.0 | 2.4 | 0.9 |
| | Non Petro at 2000 price | % | 5.4 | 6.0 | 4.9 | 5.7 | 5.2 |

(Source: JICA Study Team)

**Table 3- 11 Nominal and Real GDP from 2010 to 2035 (in RO)**

| | | Unit | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2020 | 2025 | 2030 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nominal | GDP | Million RO | 22,243 | 26,950 | 32,430 | 34,869 | 37,491 | 40,310 | 57,361 | 77,810 | 105,550 | 143,178 |
| GDP | Growth rate | % | 23.4 | 21.2 | 20.3 | 7.5 | 7.5 | 7.5 | 7.3 | 6.3 | 6.3 | 6.3 |
| | Petro GDP | Million RO | 10,332 | 13,000 | 15,037 | 15,645 | 16,277 | 16,934 | 20,643 | 22,791 | 25,163 | 27,782 |
| | Growth rate | % | 41.2 | 25.8 | 15.7 | 4.0 | 4.0 | 4.0 | 4.0 | 2.0 | 2.0 | 2.0 |
| | Non Petro GDP | Million RO | 11,911 | 13,950 | 14,050 | 15,527 | 17,152 | 18,938 | 29,434 | 43,792 | 64,405 | 93,899 |
| | Growth rate | % | 11.3 | 17.1 | 0.7 | 10.5 | 10.5 | 10.4 | 9.1 | 8.2 | 7.9 | 7.8 |
| Real | GDP at 2000 price | Million RO | 11,853 | 12,209 | 12,819 | 13,460 | 14,133 | 14,840 | 18,940 | 23,044 | 28,036 | 34,110 |
| GDP | Growth rate | % | 6.1 | 3.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 4.0 | 4.0 | 4.0 |
| | Petro GDP at 2000 price | Million RO | 3,530 | 3,732 | 3,806 | 3,882 | 3,960 | 4,039 | 4,460 | 4,460 | 4,460 | 4,460 |
| | Growth rate | % | 6.4 | 5.7 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 0.0 | 0.0 | 0.0 |
| | Non Petro at 2000 price | Million RO | 8,322 | 8,477 | 9,013 | 9,578 | 10,174 | 10,801 | 14,481 | 18,584 | 23,577 | 29,651 |
| | Growth rate | % | 5.9 | 1.9 | 7.0 | 7.0 | 7.0 | 7.0 | 6.0 | 6.0 | 5.0 | 5.0 |

(Source: JICA Study Team)

## 3.3 Energy Policy

### 3.3.1 Organizations Related to Oil and Gas

Under the Ministry of Oil and Gas of Oman, there are five energy administrated organizations including Petroleum Development Oman (PDO), Oman Oil Company (OOC), Oman Refineries and Petrochemical Company (ORC), Oman Gas Company (OGC） and Oman LNG (OLNG).The organizations work for oil and gas exploration, oil refinery and sales.

Ministry of Oil and Gas

- Petroleum Development Oman (PDO）
- Oman Oil Company (OOC）
- Oman Refineries and Petrochemical Company (ORC）
- Oman Gas Company (OGC）
- LNG (Oman LNG (OLNG))

The outlines of the organizations are as follows;

- PDO (established in 1942) is in charge of exploration, development and production of crude oil and natural gas. PDO holds the most desirable concession rights in the country. Although PDO is now a state-owned company, the shareholders are the government (60 %), Sell (34 %), Total (4 %) and Partex (2 %).
- OOC (established in 1992) is in charge of the energy business in domestic and international markets. OOC has invested in oil exploration in Kazakhstan and the oil refinery business in India as an international business.
- ORC (established in 1982) is in charge of the oil refinery in the country, and supplies gasoline, jet fuel, diesel oil and heavy fuel oil in the domestic market. The ORC merged with the Sohar Petroleum Company in 2007. The current oil processing capacity of ORC is 0.1 million bbl per day. Currently ORC is doing business in petrochemical products.
- OGC (established in 1999) is in charge of the gas pipeline business in the country. The shareholders are the government (80 %) and OOC (20 %).
- OLNG (established in 1992) is in charge of LNG projects in the country. The shareholders are the same contribution to PDO that are the government (60 %), Shell (34 %), Total (4 %) and Partex (2 %).

### 3.3.2 Visions on Energy Sector

The total exports in 2009 was 10 billion RO and 70 % of the total depended on the exports of oil and natural gas. The GDP in 2010 was 22.2 billion RO, and 46 % of the GDP depends on energy production. Therefore, it is important policy for the government to maintain the

stability of oil incomes.

Even now, the government is aimed actively at the introduction of foreign investment to promote oil development. Shell, Total, Occidental and so on are already connected to the energy business in Oman. Especially Occidental is expected concerning the development of the new natural gas reserves estimated around 100 Tcf.

In addition, Oman has been promoting the use of natural gas for domestic economic diversification so far. Per the activities, Oman has been able to secure oil exports as much as oil products saved from domestic consumption. LNG exports have been promoted as a new source of foreign income in recent years. LNG exports have become important export products along with crude oil exports.

Fuel consumption for the power sector in the year 2010 was 6.5 million toe (tons oil equivalent), and as the details of the fuels, natural gas was 5.4 million toe and diesel oil for diesel engines used in the rural area was 1.1 million toe. The natural gas consumption for the power sector in recent years has been increasing rapidly. PAEW is considering the utilization of renewable energies and the dissemination of energy saving for increasing energy efficiency.

On the other hand, Oman is promoting the diversification of the economy for the purpose of breaking away from dependence on the oil and gas businesses. Non-oil exports grew by up to 20 % of the whole year in 2009. That is one of the results that Oman has been focusing on in the petrochemical business development shown in the following table since 2005 and the export of such products has increased.

**Table 3- 12 Petrochemical Business in Oman**

| Company Names | Products | Shareholders | Site & Start |
|---|---|---|---|
| Oman India Fertilizer Company | Ammonia 3.5kton/day<br>Urea 5kton/day | Oman Oil Company 50 %<br>Indian companies 50 % | Site : Sur<br>Start : 2005 |
| Oman Aromatics | Benzene 210kton/year<br>Para-xylene 810kton/year | Oman Oil Co. 60 %<br>Oman Refinery 20 %<br>LLG Corp. 20 % | Site : Sohar<br>Start : 2006 |
| Oman Polypropylene LLC | Polypropylene340kton/year | Oman Oil 60%<br>Gulf Investment Cor. 20 %<br>LG International. Corp. 20 % | Site : Sohar<br>Start : 2006 |
| Oman Methanol Company L.L.C | Methanol 3 k ton/day | MAN Ferrostaal AG<br>Oman Methanol Holding Company | Site : Sohar<br>Start : 2007 |
| Liwa Petrochemical Co | EDC 300kton/year<br>Chlor-alkali 240kton/year | LG International 33.3 %<br>Oman Oil Co 33.3 %<br>Iran NPC 33.3% | Site : Sohar<br>Start : 2008 |
| Oman Petrochemical Industries Company | Ethylene（from Ethane）<br>Polyethylene450kton/year | Dow 50 %<br>Oman Gov 25 %<br>PDO 25 % | Site : Sohar & Fahoud<br>Start : 2009 |
| Sohar International Urea and Chemical Industries | Ammonia 2kton/day<br>Urea 3.5kton/day | Sheikh Suhail Salem Bahwan | Site : Sohar<br>Start2009 |

(Source: JICA Study team)

### 3.3.3 Visions on Renewable Energy

(1) Possibility of Renewable Energy

AER asked Salar Circle Overseas Corporation in Denmark and Cowi company in Oman to survey the possibility of introduction of renewable energy, and the results were announced in May 2008. The outline is in the following table.

**Table 3- 13 Renewable Energy Possibility in Oman**

| Energies | Possibility |
|---|---|
| Solar energy | ➢ Collected Solar Power（CSP) is suitable for Oman.<br>➢ Logically CSP with the size of 280km2can generate power 14TWh consumed in 2009<br>➢ PV is suitable in northern region and rural area. When considering transmission, it can introduce up to 420 MW as of 2009. |
| Wind | ➢ Wind power is suitable for Quiroon Hariti, Thumrait, Masirah, Joba and Sur.<br>➢ Exist possibility of wind power in Salalah. When generation capacity in Salalah is 580MW, the wind power can introduce up to 120MW. |
| Biogas | ➢ There are agricultural wastes and waste water in the northern region. However those are already used as fertilizer. The utilization as bio fuel is limited. |
| Others | ➢ Possibilities of geothermal and waves are very low. |

（Note） COWI is a consultant company in Denmark, mainly study on environment, energy and engineering

(Source: Study on Renewable Energy Resources, Oman by AER)

(2) Renewable Energy Policies

The government has established the “Ministerial Committee” in the MONE and “Technical Committee” in the PAEW in order to support the introduction of renewable energy. At the same time, PAEW has begun to make the necessary policies and institutions. For performing solar thermal and wind power projects, PAEW is making a policy consisting of three phases: strategy, project implementation and capacity building. The contents are shown in the following table.

**Table 3- 14 Renewable Energy Strategy of PAEW**

| Strategy | Project Implementation | Capacity Building | | |
|---|---|---|---|---|
| | | R&D | Industrial | Human resources |
| Developing Policy for R.E development | Pilot Projects (RAECO) | R.E Desalination | Row material extractions | University Programs |
| Regulatory review | 100 – 200 MW Solar Plant (Grid Connected) | Hybrid Solutions | Manufacturing | Engineering and O & M Skills |
| | Wind Monitoring Program then Wind farm | Solar Cooling | Added value services | Research & Development |
| | | Focused research on specific technologies | | Utilities experience |
| | R.E Database | | | |

(Source：Renewable Energy in Oman by PAEW, department of Renewable Energy & Technology)

In the above renewable energy projects, the outlines of the "Pilot projects 2009-2012" and "Large scale solar heat projects 2011-2014" are described in the following table.

**Table 3- 15 Renewable Energy Introduction Plans of PAEW**

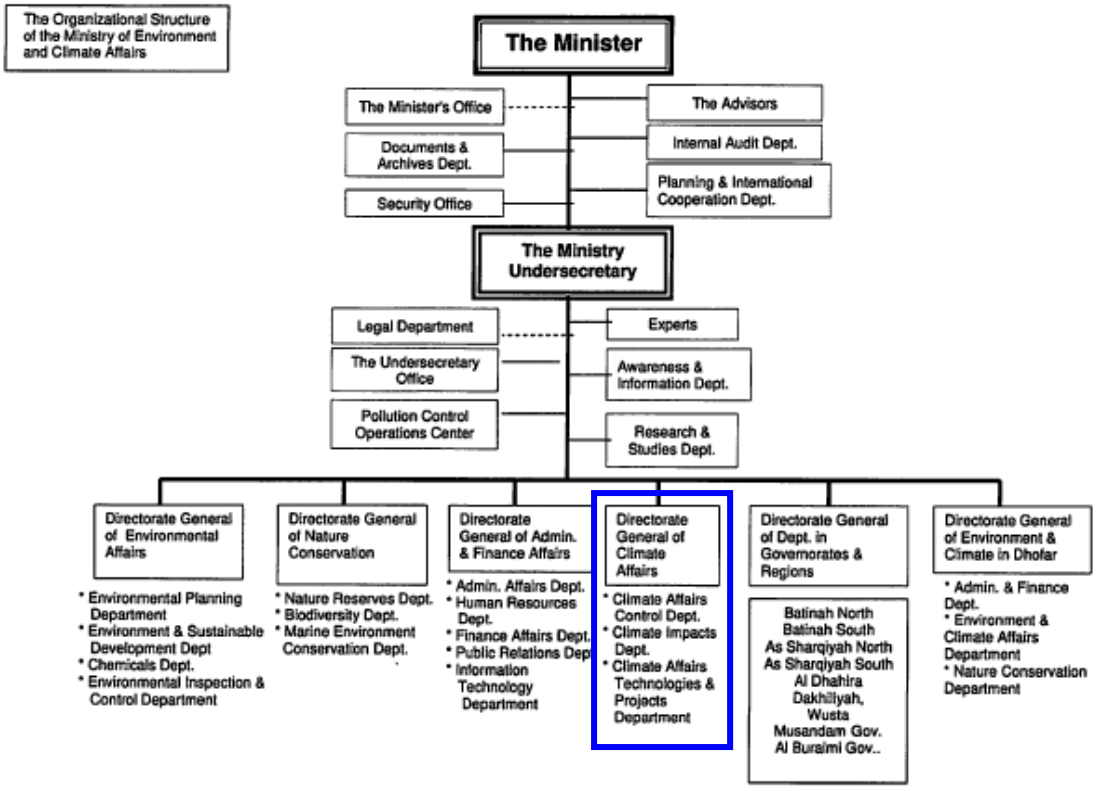
| First Step: Pilot Projects | Second Step: Large Scale Solar Heat Project |
|---|---|
| Term: 2009－2012 | Term:2011-2014 |
| Size: 6 projects（total :8 MW） | Size :Feasibility study totalling 200 MW |
| Implementation: RAECO, as substitution of Diesel engines | Sites: Suitable sites & Capacity scale |
| Hybrid: PV & Wind | Institutes: Market structures and regulatory schemes |
| PAEW plan：when not connecting renewable energy to grid, renewable energy is used for power of desalination plants | Players: Open requirement by BOO formation |

・ (Source: Renewable Energy in Oman by PAEW, Department of Renewable Energy & Technologies)

In addition, OPWP has plans to introduce wind and solar power by 2014 and AER has plans to introduce four solar and wind hybrid systems and two wind powers. It is believed to help reduce consumption of fossil fuels, especially in rural areas.

### 3.3.4 Policy on Greenhouse Gas Emission Reduction

Directorate General of Climate Affairs, Ministry of Environment and Climate Affairs (MECA) is a management body whose objective is to reduce of Greenhouse Gas (GHG) emissions in Oman. Although a comprehensive policy for climate change has not been established yet, Oman concluded United Nations Framework Convention on Climate Change (UNFCCC) as a Non-Annex I Party on February 8 in 1995, and ratified the Kyoto Protocol on January 19 2005. The Directorate General of Climate Affairs of MECA is in charge of the Designated National Authority (DNA) of CDM projects of UNFCCC. The following is MECA's organization chart.




(Source: MECA)

**Figure 3- 10 Organization Chart of MECA**

As of September 2012, the validation of CDM projects and Programme of Activities (PoA) (shown in the following table) was finished. One of the PoAs is an EE&C program ("Advanced Energy Solutions for Buildings"), which is a combined heat and power system or tri-generation system (that is a cogeneration system with an additional function which can utilize emitted CO2 effectively for greenhouse cultivation and other measures) introduced in the existing buildings for the reduction of fossil fuels and GHG emissions. It is possible to apply the same methodology for approval of projects comprised of PoA.

**Table 3- 16 List of CDM Project in Oman**

| Project | Outline | Estimated Reduction Volume (tons of $CO_2$ equivalent) |
|---|---|---|
| Waste Management Project at Al-Amerat | Organic sewage sludge generated through waste water treatment which has been dumped in the Al-Amerat landfill will be composted. | 31,762 |
| Associated Gas Recovery and Utilization at Block 9 | Associated gas at the Safar oil field in A'Dhahirah Region of Northern Oman will be recovered. | 804,662 |

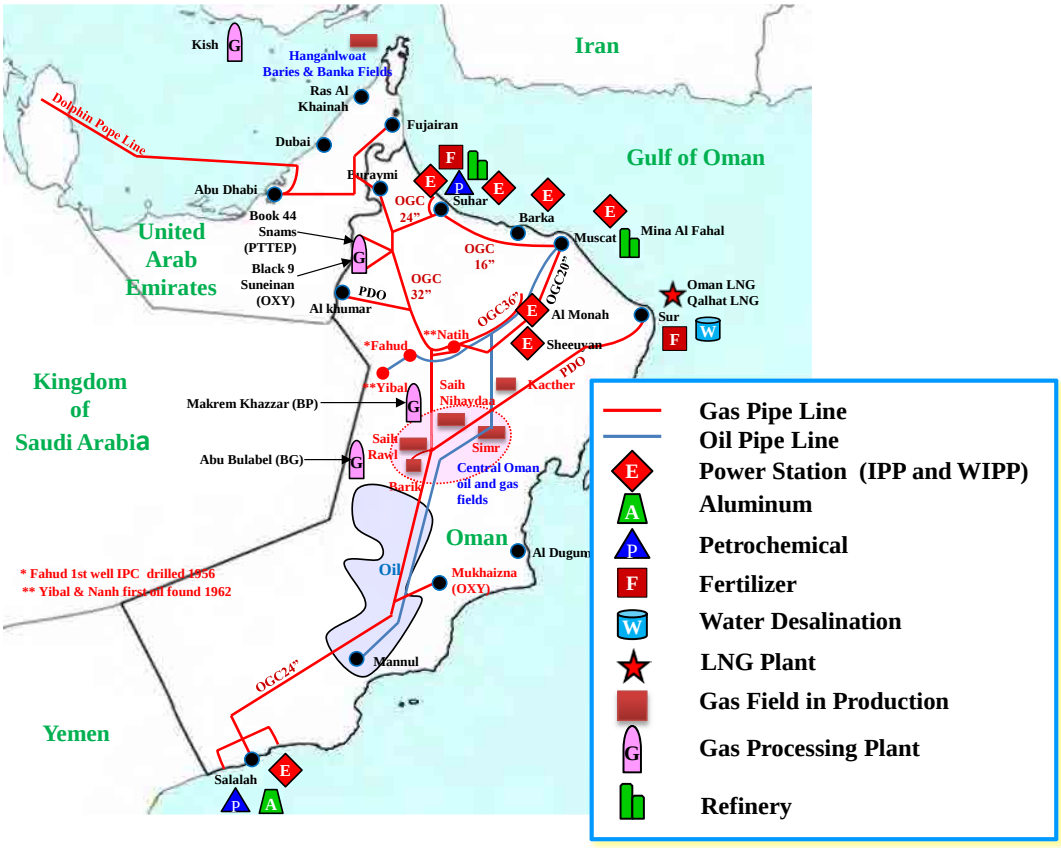
(Source: UNFCCC Website)

## 3.4 Energy Data

### 3.4.1 Energy Trend of Oman

(1) History of Oil and Gas Development in Oman

Petroleum Development Oman (PDO) together with the Iraq Petroleum Company (IPC) drilled its first well in Fahud in 1956. Furthermore, oil was found in Yabal and Natih, which led to the investment in pipelines to transport oil 275km to the coast of Mina Fahal with the first export of crude oil in 1967. In 1975, new oil fields and the oil infrastructure of Saih Nihayda and Saih Rawl has being developed. In January of 1974 the Government of Oman acquired a 25 % percent interest in PDO increasing its shares six months later to 60 % percent (Shell 34 %, Compagnie Francaise des Petroles (CFE), Partex 2 %). In the early 1990s, the government decided to develop a gas export project as a means of earning and diversifying exports marking a departure away from oil. In 1996, the PDO signed an agreement with the government to develop the central Oman field at Saih Nihayda, Barik and Saih Rawl and to construct a gas processing plant at Saih Rawl and a new 352 km pipeline to Qalhat. The first LNG cargo was shipped to Korea in April 2000.

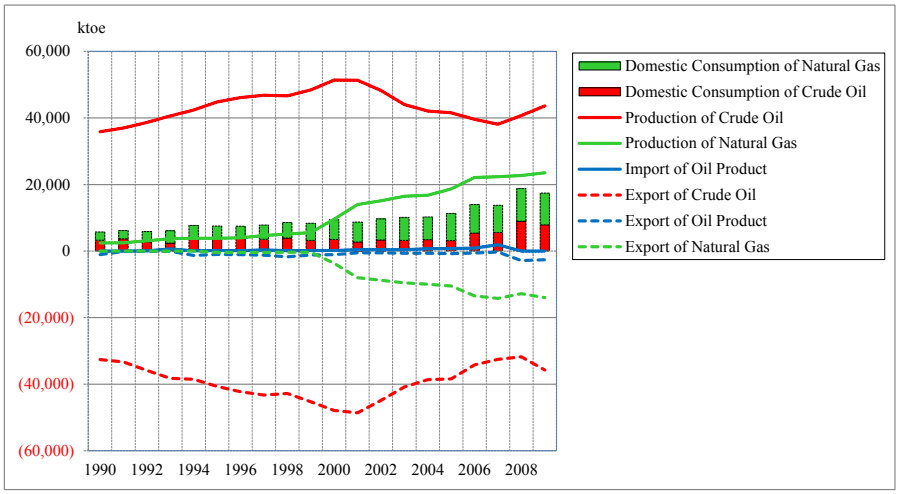



(Source: Natural Gas Markets in the Middle East and North Africa)

**Figure 3- 11 Oil and Gas System of Oman**

(2) Production, Imports, Exports and the Domestic Consumption of Primary Energy

The following figure shows the production, imports, exports and the domestic consumption trends of primary energy in Oman.



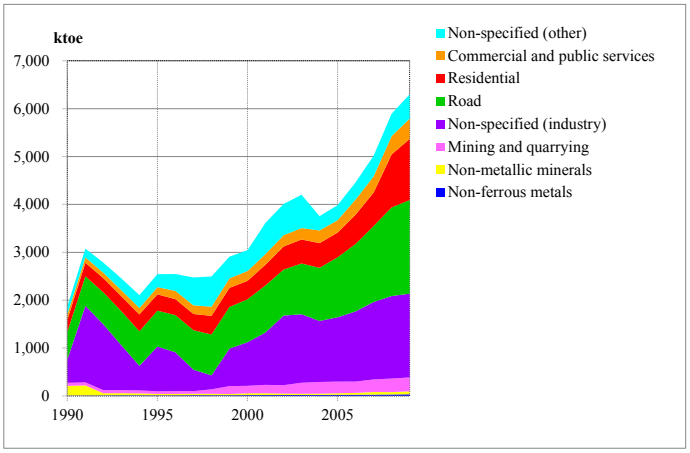

(Source: IEA Energy Balance 2011)

**Figure 3- 12 Production, Import, Export and Domestic Consumption Trend of Primary Energy in Oman**

From 2001, the production of crude oil underwent a decrease. On the other hand, the production of natural gas has drastically increased. Crude oil production in 2009 was 812,000 bbl/day, a 7.3 % increase compared to 2008. Out of which 81.9 % was exported to mainly Asia and 18.2 % was refined in the refineries of Muscat and Sohar. Crude oil contains about 12.3 % of condensate. Currently coal, hydro power and renewable energy are not being utilized on a commercial basis. Domestic consumption of natural gas has recently increased.

(3) Energy Consumption Trend

The following figure shows the final energy consumption trend per sector. The highest consuming sector is transportation, followed by the industrial and residential sectors. Among these sectors, the transportation sector and residential sector grew rapidly at an annual rate of about 12 % and 28 % respectively after 2006. In addition, the consumption of the industrial sector increased over the past five years via the start-up of metal processing and petrochemical plants to diversify into forms of energy other than oil and energy and job creation in the long-term plan.



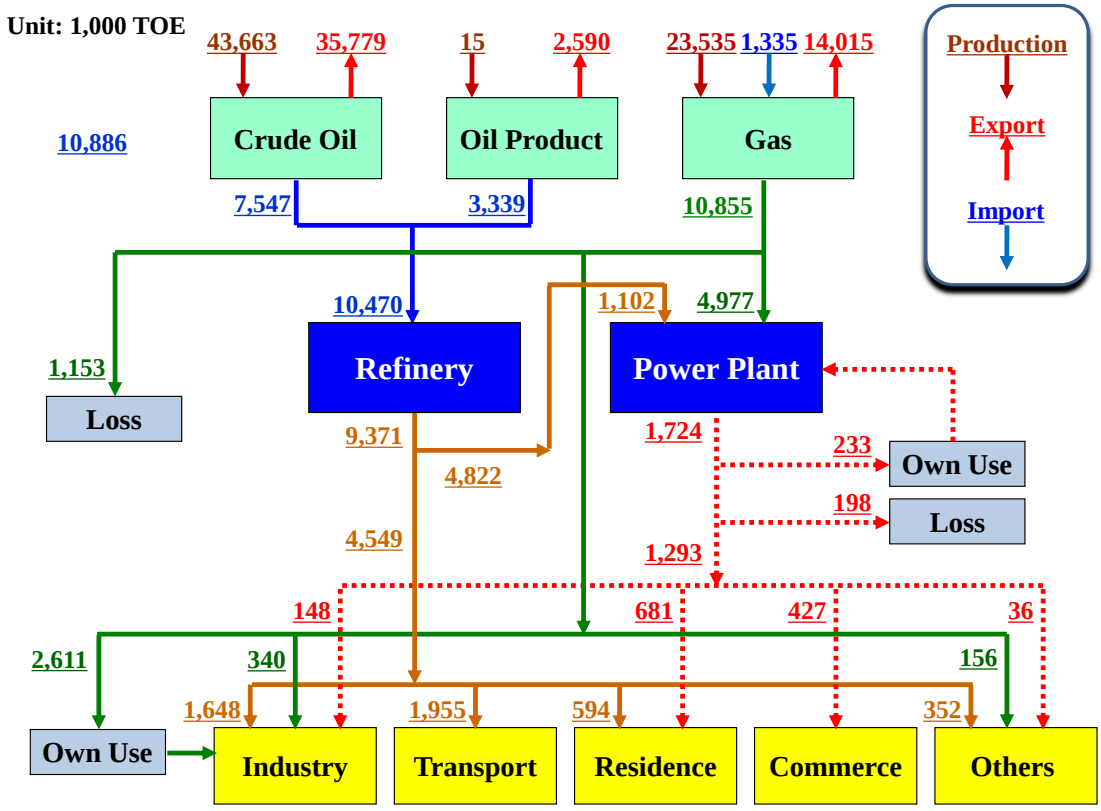

(Source: IEA Energy Balance 2011)

**Figure 3- 13 Final Energy Consumption Trend by Sectors in Oman**

(4) Energy Production and the Consumption Structure of Oman

Oman produces and exports oil and gas. The surplus of oil and gas are consumed in refineries, power stations, industries, transportation, and the residential and commercial sectors. Although the supply of oil and gas hit a peak in recent years, energy and electricity consumption has rapidly increased to the point that the promotion of energy and electricity conservation is now the country's most essential theme.

The following figure shows the energy production and consumption structure of Oman in 2009.




(Source: IEA Energy Balance 2011)

**Figure 3- 14 Energy Production and Consumption Structure of Oman in 2009**

### 3.4.2 Energy Data Comparison within Middle East Countries

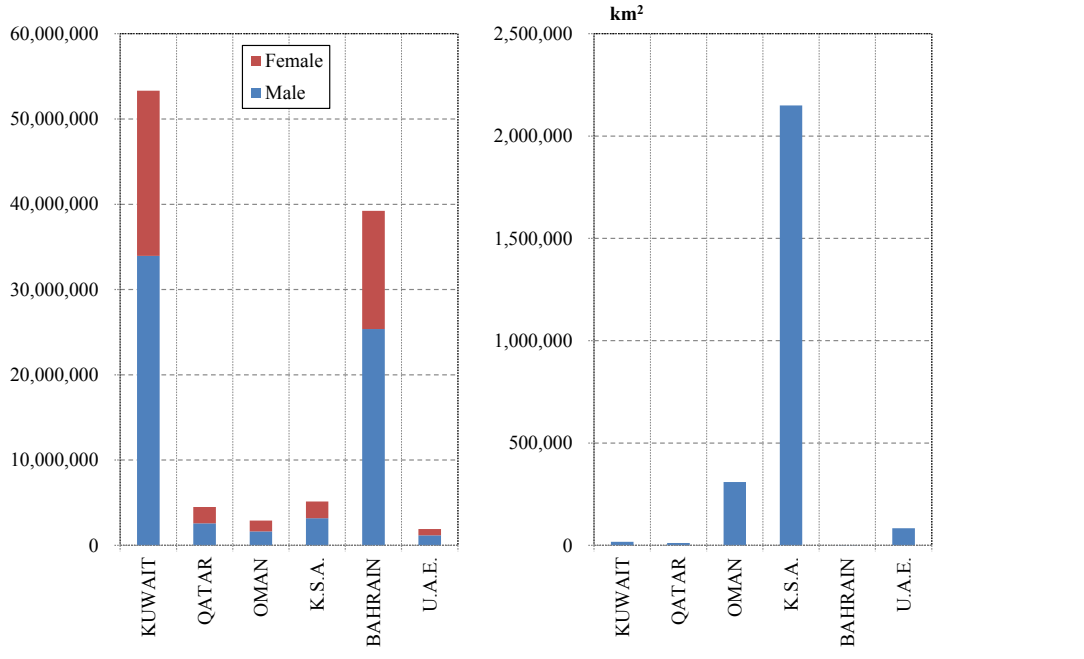
The Gulf Cooperation Council (GCC) was established in May 1981. The current participating nations are Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and UAE (6 countries).

Energy macro data comparison including Oman is described below. It can help understanding the position of Oman in the GCC countries.


**Figure 3- 15 GCC Countries**

(1) Population and Land Area

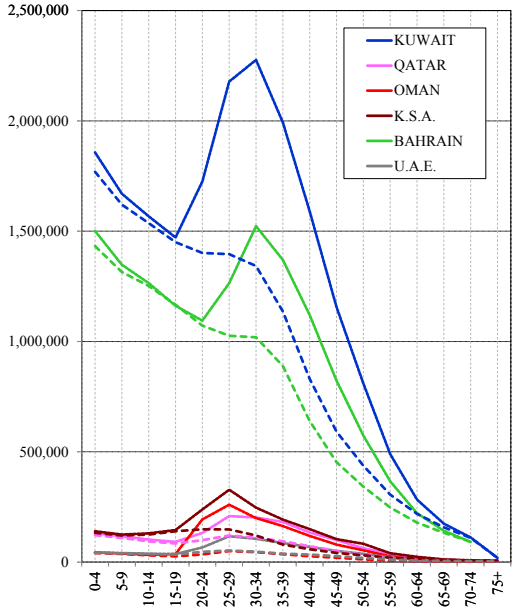
The population of Kuwait and Bahrain are in the 50 and 40 millions, other countries including Oman are below 10 million. The land area of Oman is 309 thousand km$^2$ next to Saudi Arabia. The population of males above the age of 20 is prominent in all six countries.




(Source: GCC Statistics 2011)

**Figure 3- 16 Population and Land Area of Six GCC Countries**

The following figure shows that the male population exceeds the female population significantly in 20's and 30's generation. Hence, it has been estimated that many foreign workers in their 20's and 30's have come into Oman.

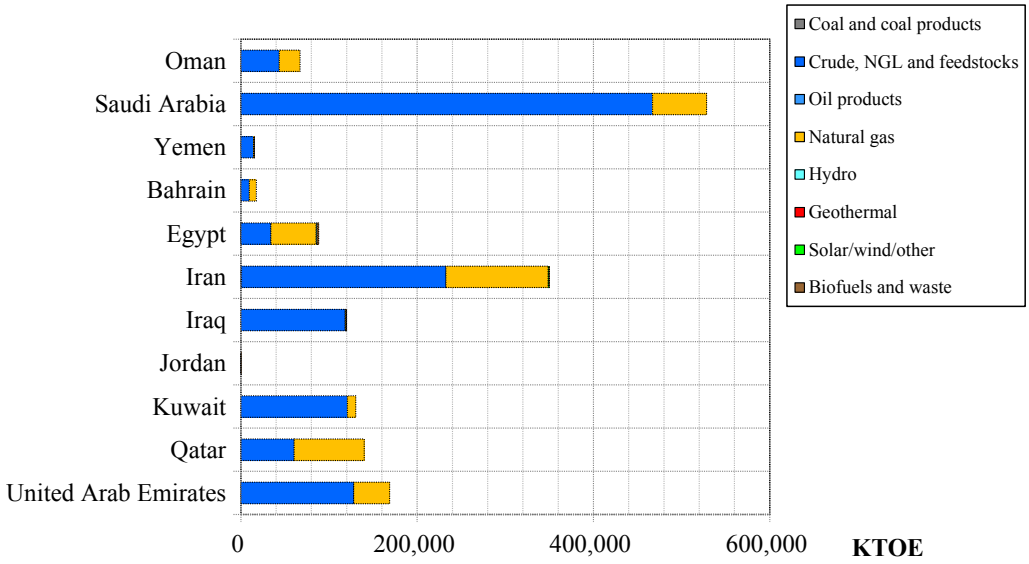



(Source: GCC Statistics 2011)

**Figure 3- 17 Population Structure by Ages of Six GCC Countries (Dotted Line: Female)**

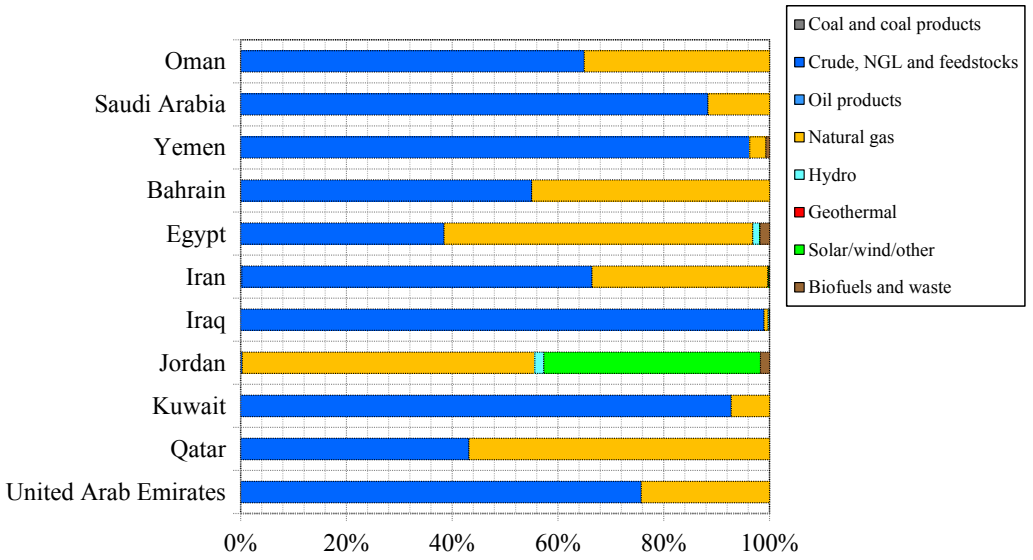
(2) Energy Production of Middle East Countries

The following two figures show the energy production and composition of Middle East countries. Saudi Arabia now produces the highest amount followed by Iran.




(Source: IEA Energy Balance 2011)

**Figure 3- 18 Comparison of Energy Production in Middle East Countries (2009)**




(Source: IEA Energy Balance 2011)

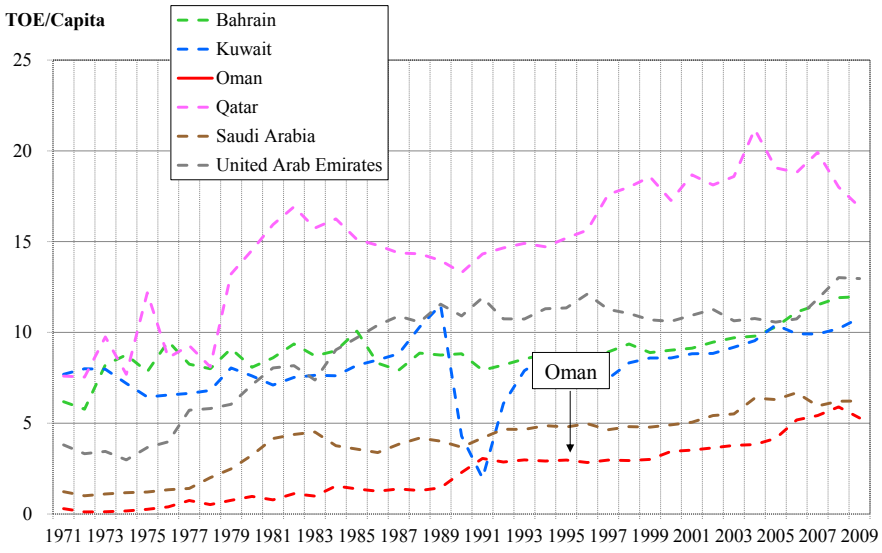
**Figure 3- 19 Share of Energy Production in Middle East Countries (2009)**

Other types of energy are produced in the following countries.

- Hydro: Egypt and Jordan
- Solar, Wind and Others: Egypt, Iran and Jordan
- Biomass and Waste: Yemen, Egypt, Iran, Iraq and Jordan

(3) Comparison of Energy Consumption

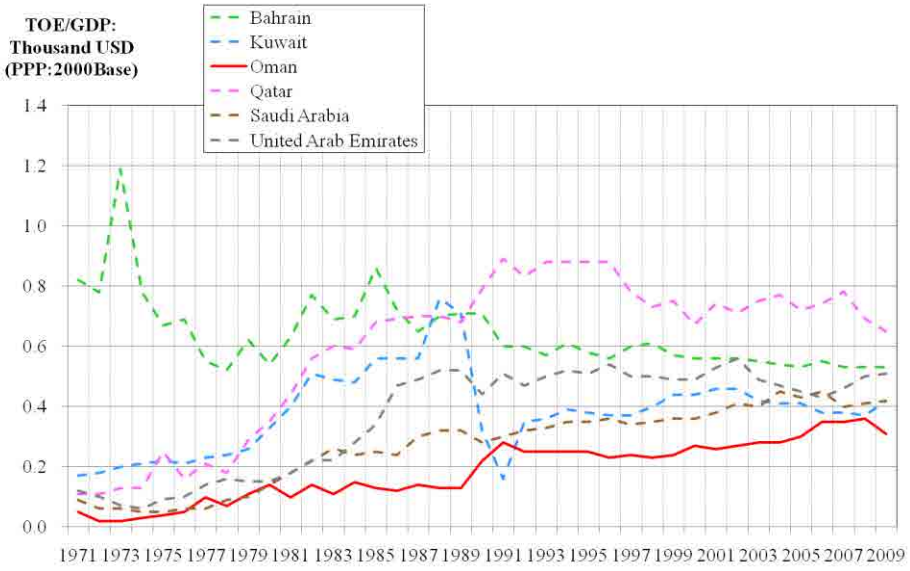
The following figure shows the energy consumption per capita. The value of Oman indicated the smallest. It is estimated that the land of Oman is large compared with the population and energy consuming equipment is not so prevailed in rural area.




(Source: IEA Energy Balance 2011)

**Figure 3- 20 Energy Consumption per Capita in GCC Countries**

Energy intensity by GDP with the Purchasing Power Parity (PPP) of 2000 is shown below. Oman indicated the lowest values among the GCC 6 countries. However, GDP in the Middle-east countries highly depends on market price of oil and natural gas. So it is not said that Oman is high efficiency among these countries from the following figure.

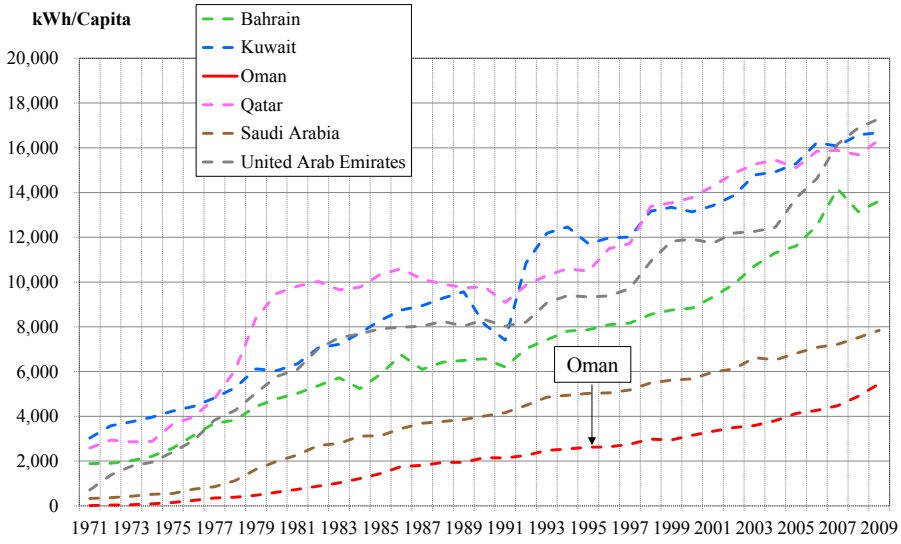



(Source: IEA Energy Balance 2011)

**Figure 3- 21 Energy Consumption per GDP in GCC Countries**

(4) Comparison of Electricity Consumption

The following figure shows the electricity consumption per capita. The indicator of Oman is the smallest. The same reason mentioned above is guessed. However, the growth rate of Oman since 2000 has been prominent compared with other countries.




(Source: IEA Energy Balance 2011)

**Figure 3- 22 Electricity Consumption per Capita of GCC Countries**

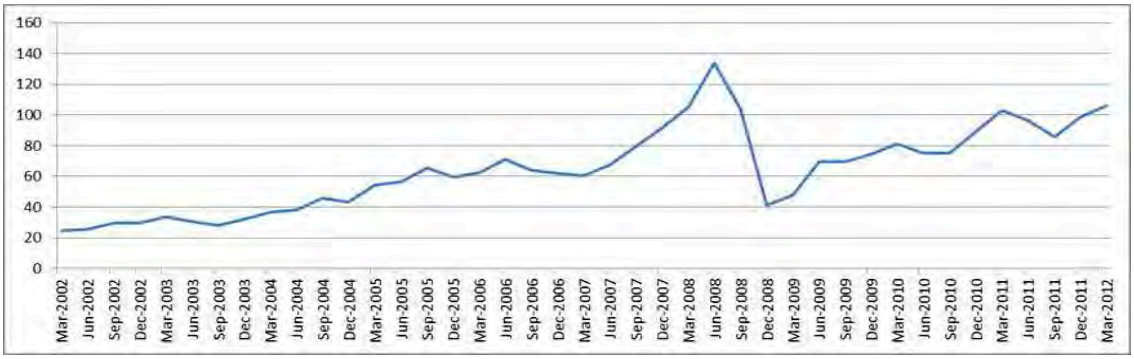
## 3.5 Fuel Prices

### 3.5.1 Crude Oil Price

(1) Crude Oil Trends

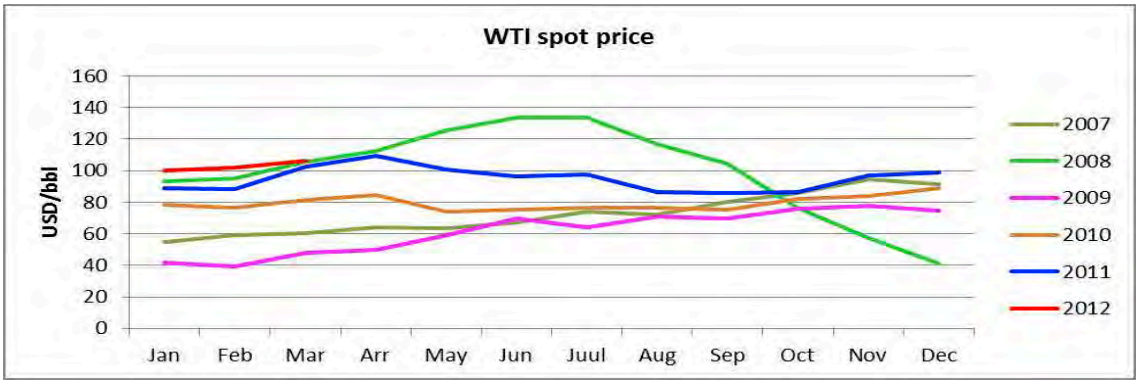
The crude oil price (West Texas Intermediate (WTI) spot price) increased rapidly from 2007 to 2008. However, crude oil prices declined by a sudden turn since Lehman's monetary shock in the second half of 2008. However, the WTI started to increase again after November 2011. According to the Institute of Energy Economics, Japan (IEEJ), the following factors are pointed out as the reasons behind the crude oil price increase in 2008.

- ✓ High economic growth of emerging countries like China, India, Brazil and Russia
- ✓ Stagnation of crude oil production capacity in OPEC & other counties
- ✓ Devaluation of US Dollar
- ✓ Increase in crude oil supply costs
- ✓ Rising resource nationalism
- ✓ Shortage of oil refinery capacity in the USA and a gasoline demand increase in Asia
- ✓ Nuclear problems in Iran, political instability in Nigeria and terrorism in oil producing countries




(Source: USA Department of Energy Website)

**Figure 3- 23 Long Trends of WTI Spot Price**




(Source: USA Department of Energy Website)

**Figure 3- 24 Monthly Trends of WTI Spot Prices from 2007 to 2012**

(2) Price Trends of Fossil Fuels

The following table shows Oman's crude oil price and other fossil fuel prices (crude oil and natural gas) in the world main energy trading markets.

**Table 3- 17 Price Trends of Oman's Crude Oil and Other Market Prices**

| | Oman crude oil price | Dubai crude oil price | WTI spot price | Natural gas NBP index | Natural gas Hub index | LNG Japan import cif |
|---|---|---|---|---|---|---|
| | $/bbl | $/bbl | $/bbl | $/MMBtu | $/MMBtu | $/MMBtu |
| 2000 | 23.0 | 26.2 | 30.4 | 2.7 | 4.2 | 4.7 |
| 2001 | 24.3 | 22.8 | 25.9 | 3.2 | 4.1 | 4.6 |
| 2002 | 27.8 | 23.7 | 26.2 | 2.4 | 3.3 | 4.3 |
| 2003 | 34.4 | 26.8 | 31.1 | 3.3 | 5.6 | 4.8 |
| 2004 | 34.4 | 33.6 | 41.5 | 4.5 | 5.9 | 5.2 |
| 2005 | 50.3 | 49.4 | 56.6 | 7.4 | 8.8 | 6.1 |
| 2006 | 61.7 | 61.5 | 66.0 | 7.9 | 6.8 | 7.1 |
| 2007 | 65.2 | 68.2 | 72.2 | 6.0 | 7.0 | 7.7 |
| 2008 | 101.1 | 94.3 | 100.1 | 10.8 | 8.9 | 12.6 |
| 2009 | 56.7 | 61.4 | 61.9 | 4.9 | 3.9 | 9.1 |
| 2010 | 76.6 | 78.1 | 79.5 | 6.6 | 4.4 | 10.9 |
| 2011 Sep | 88.0 | 90.0 | 90.0 | 10.0 | 8.0 | 17.0 |

Note: The red colored values are estimation by the JICA Study Team

(Source: Estimated by the JICA Study Team from British Petroleum Statistics)

### 3.5.2 Measurements against Crude Oil Price Hikes

It has been considered that future crude oil prices will be increased due to increased oil demand in emerging countries, crude oil production peak outs in conventional oil producing countries and international political conflicts. As for measurements in oil consuming countries, it is required to implement economic activities with anti-oil price increase policies and change oil product consumption activities. The following activities are prepared for the short and long term measurements not to increase oil prices.

**Table 3- 18 Short Term Measurements for Suppressing Oil Price Increases**

| Measurements | Countries |
|---|---|
| a. Increase crude oil supply | |
| ✓ Increase crude oil production | Saudi Arabia, Kuwait |
| ✓ Development off shore oil wells | USA |
| ✓ Construction of oil pipelines | Kazakhstan |
| ✓ Supply shale gas and shale oil | USA, Poland, Australia etc. |
| b. Oil demand suppression | |
| ✓ Lift the subsidiary of oil utilization and adjust petroleum products prices | China, Malaysia |
| ✓ Dissemination of hybrid cars | Japan |
| ✓ Dissemination of bio ethanol use | USA, Brazil |
| ✓ Energy conservation policies | Many countires |
| c. Control of hedge fund investment | |
| ✓ Restrain the hedge funds to oil market | USA |
| ✓ Restrain of pension money to the oil markets | EU, USA |

(Source: "Future Oil and Energy Prospects 2010" by IEEJ)

**Table 3- 19 Long Term Measures for Suppressing Oil Price Increases**

| Measures | Remarks |
|---|---|
| a. Power sector<br>✓ Introduction of high efficiency combined cycle<br>✓ Expansion of renewable energy utilization | <br>Development of high efficiency (50-60 %) combined cycle |
| b. Transportation sector<br>✓ Expansion of electricity, hydro and hybrid car use<br>✓ Utilization of fuel cell battery cars<br>✓ Expansion of natural gas vehicle use | <br>Efficiency improvement:50 %up<br>CO2 free<br>CO2 reduction |
| c. New energy<br>✓ Tar sand<br>✓ Orinoco tar<br>✓ Shale gas<br>✓ Methane hydrate | <br>Canada（Reserves:200 billion bbl）<br>Venezuela (Reserves240 billion bbl）<br>China, USA, Australia<br>World 17,000 Tcf |
| d. Petroleum products by Liquefaction technology<br>✓ GTL（Natural gas to Dimethyl-ether, Diesel）<br>✓ Coal liquefaction (Coal to Diesel)<br>✓ Bio technology（Bio to Methanol and Diesel） | <br>Development small gas wells<br>Diesel production of low quality coal<br>Fuel for vehicles |
| e. Energy efficiency and conservation<br>✓ Improvement of existing engine fuel efficiency<br>✓ Energy conservation of factories and Buildings<br>✓ Energy efficiency of home appliances | <br>Small size vehicles：30 km/liter<br>Energy management system<br>Standards and labeling system |

(Source: "Future Oil and Energy Prospects 2010" by IEEJ)

### 3.5.3 Future Prospects for Crude Oil Prices

Future crude oil prices are expressed by so many energy institutes including the IEA. A future prospect for crude oil prices, which was jointly announced with Institute of Energy Economics, Japan (IEEJ), FACTS Global Energy Group, and Strategic & International Studies Center, are introduced in this section.

**Supply and Demand Balance of Crude Oil in the World**

- ✓ The future 20 year's world economy (2010 to 2030) will be carried out at the rate of 3.5 % per year. The powerful countries are mainly located in the Asian region.
- ✓ The crude oil consumption in 2010 was 85 million bbl/day in the world, and consumption has continued to increase by 1 million bbl/ day in a year. Especially Asian countries like China and India increased their oil consumption. Meanwhile, the USA, Japan and the EU rather have decreased their oil consumption. .
- ✓ The IEA predicts that crude oil demand will increase by 1 % per year. While, the two experts think that crude oil demand in the world will increase by 0.6 % per year. When crude oil demand increases by 0.6 %/year by 2030, world crude oil demand in 2030 reaches 95 million /day.
- ✓ As global warming measurements, the reduction of oil consumption in the world is pointed out, and natural gas, renewable energy, nuclear energy and so on are considered as future substitution energies.
- ✓ In the future, additional oil production is expected in Iraq. Iraq's current production (in 2010) is 0.25 million / day, and it is said that future oil production will reach 4 million bbl/day. (Otherwise, the Iraq government announced that future production will increase to 10 million bbl /day.)
- ✓ On the other hand, it is predicted that OPEC has oil production allowance with 6 million bbl/day. There is the possibility that the production allowance including Iraq and OPEC will reach 10 million bbl /day. It means that the allowance can supply crude oil for additional demand in the world in the future.
- ✓ It is said that the oil refinery plants in the world has continued to exceed capacity of global oil demand in in the past. However, oil refinery plant constructions are going to be planned in the developing countries. Therefore, scrap with 7 million bbl/day of oil refinery capacity is required to the current oil refinery capacity with 85 million bbl/day. The scrap will be mainly implemented in the EU, USA and Japan.

**Middle & Long Term Crude Oil Price Prediction**

- ✓ The current crude oil price (around 100 US$/bbl) will continue until 2013 and it is forecasted that the crude oil price will become the range from 120 US$/bbl to 180 US$/bbl in 2020.

- ✓ While there are two forecasts of the crude oil price in 2020, 100±$20US$/bbl and rather lower than the said value.

Considering the above forecasts, the JICA Study Team tries to study crude oil prediction using the cost competitiveness method between crude oil and substitution energies.

- It is said that the production costs of tar sand, Oronoco tar, coal liquefaction and methane-hydrate and so on are located in the range during 50 US$/bbl to 60 US$/bbl at the current US$ price. It can be considered that the crude oil price in the year of 2012 is around 80 US$/bbl when comparing the crude oil price to the substitution energy costs.
- Per the method, the crude oil price will reach 97 US$/ bbl in 2020 and 124 US$/bbl in 2030, when USA inflation will be processed with 2.5% per year. And as the hedge funds money comes to world oil markets, the crude oil price has to be predicted with the range of ±20 US$/bbl. As the results of the cost competitiveness method, the crude oil price will be 80 US$/bbl～120 US$/bbl in 2020 and 105 US$/bbl～145 US$/bbl in 2030.
- As the Omani oil price will be trended in line with the world oil prices, therefore the Omani oil price at the 2012 constant price of the US$ will become 95 US$/bbl in 2020 and 120 US$/bbl in 2030.

### 3.5.4 Future Prospects for Natural Gas Prices

Future prospects for natural gas prices made by Oxford of Institute for Energy Studies were announced in a seminar room of IEEJ in October 2011. The contents are introduced herewith.

**Supply and Demand Balance of World Natural Gas**

- ✓ The natural gas supply has increased rapidly in recent years. The countries of Papua New Guinea (PNG), Australia and Qatar supply additional natural gas to world markets. Furthermore, natural gas with an additional 13 million tons will be supplied from PNG and Australia by 2014. (According to the Oxford of Institute for Energy Studies, the above both countries will finally supply additional natural gas with 30 million tons in the future)
- ✓ Furthermore, the USA does not need to introduce new LNG import ports due to the fact that shale gas is produced domestically (LNG import plans has been considered since 2005.) The capacity of the LNG plants before 2008 was the total 10 Tcf /year, however it has decreased to 1 Tcf /year in 2011.
- ✓ Under the circumstances, Qatar has been worried about how to find LNG customers. However, the tremendous earthquake that struck Japan in March 2011 turned out to be a game changer. The nuclear power plants in Japan have now ceased operations due to the earthquake and political reasons, and Japanese power companies have been importing additional LNG from mainly Qatar. As a result, global LNG imports have been temporarily mitigated.
- ✓ However, LNG production in Qatar was 70 million tons per year up to 2010, it is said that the production will have increased to 80 million tons by 2012. It can be considered that the LNG balance will continue to exceed supply even though Japan is in dire need of LNG imports.
- ✓ Via the reduction of LNG import plans in most of the USA, most of the LNG from the Middle-east countries will be exported to Asian counties, and the volume will reach from 30 million tons to 40 million tons in 2012.

✓ The future natural gas balance in the Mediterranean and North Africa (MENA) are shown in the following table from the Oxford of Institute for Energy Studies.

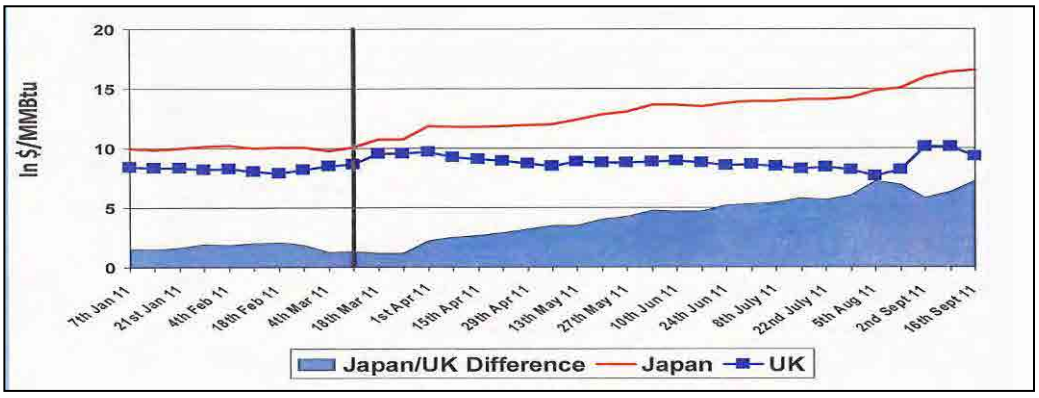
**Future Natural Gas Balance in MENA countries**

| | | |
|---|---|---|
| ✓ | Egypt | The pipeline export of the country reaches the maximum. |
| ✓ | Libya | It is processed slowly on natural gas export. |
| ✓ | Israel | It delimitates natural gas import by 2015, there is possibility to export natural gas after that. |
| ✓ | Iran | It will become net import of natural gas by 2015. |
| ✓ | Iraq | It will export natural gas to the neighboring countries by 2020. |
| ✓ | Saudi Arabia | It will become natural gas import country by 2020. |
| ✓ | Oman | There is possibility to reduce natural gas (LNG) export. |
| ✓ | Qatar | It will continue to be a big natural gas exporter in future. |

(Source: National Gas Market, Oxford institute for Energy Studies)

The LNG price before March 2011 was 8 US$-12 US$/MMBtu to Japan. Meanwhile, the natural gas price in the EU at the same time was 3 US$-5 US$/MMBtu. After March 2011, the LNG price was hiked to 18 US$/MMBtu on Sep 18th 2011 due to increasing Japanese demand.

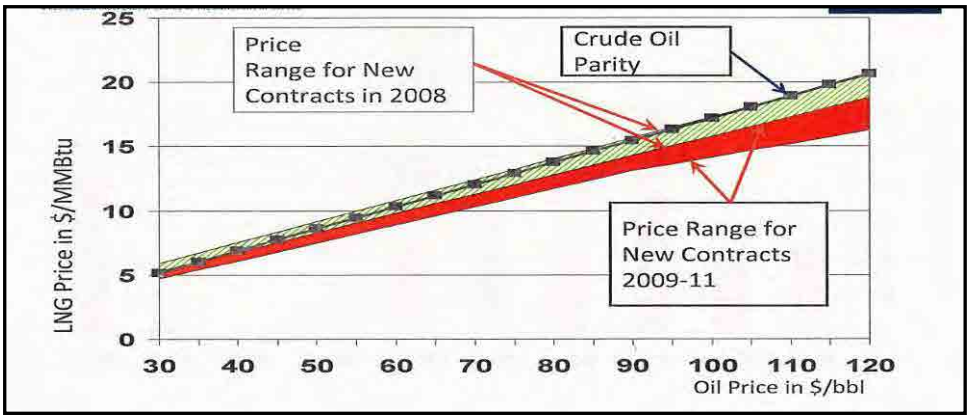
According to the future prediction of the LNG price of the Oxford of Institute for Energy Studies, the difference will become wider than the current one between the spot price and long term contract price. This means that the spot price will decrease to lower than the long term contract price.




(Source: National Gas Market, Oxford institute for Energy Studies)

**Figure 3- 25 Natural Gas Price Trends of Japan (LNG Long Term Contract Price) and UK NBP Index**

The LNG long term contract price has been linked to the crude oil price such as in the following figure. The price in 2008 was decided in the green belt in the following figure. However, the price was decided in the red belt from 2009 to 2011.

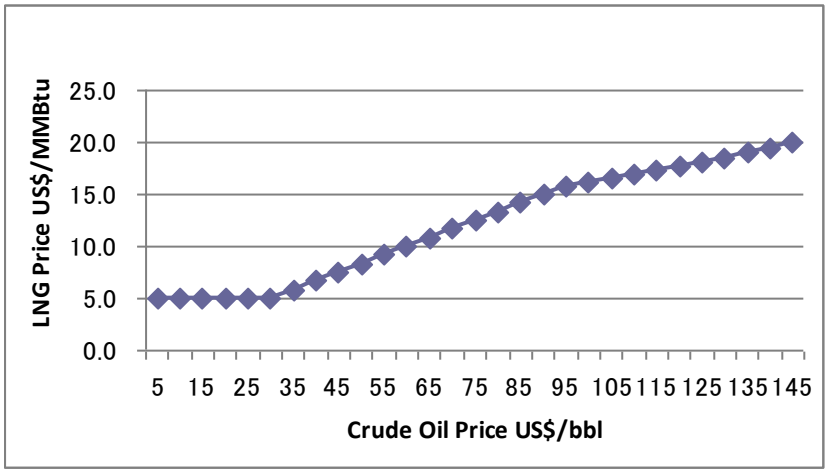



(Source: National Gas Market, Oxford institute for Energy Studies)

**Figure 3- 26 Linkage between LNG Long Term Contract Price and Crude Oil Price from 2008 to 2011**

Qatar LNG out of 70 million tons in 2010 was exported to 50 million tons by a long contract and another 20 million tons by the spot market. Although the LNG spot price is exported at the supply and demand market price at the time, up until now, the spot price has always been lower than the long-term contract price in past years.

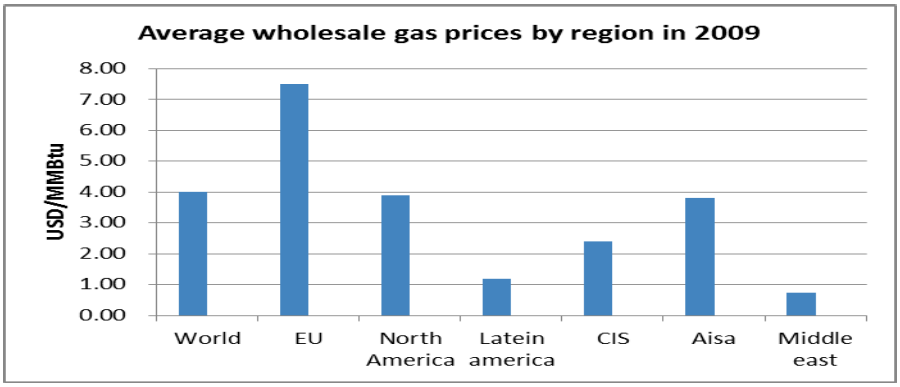
It is said that the LNG long term contract price is decided per the following “S shape curve”. When the crude oil price is increasing, the LNG price also increases moderately, adversely if the crude oil price declines, the LNG price does not decrease to below the minimum LNG price. Therefore the future LNG price can be roughly estimated from the crude oil price by using the S shape curve.




(Source: JICA Study Team)

**Figure 3- 27 Formulation between LNG Long Term Contract Price and Crude Oil Price**

Apart from the international natural gas price, wholesale gas prices in gas producing countries are increased in companies with gas production cost hikes. The wholesale gas prices of the world's main gas producing countries in 2009 are shown in the following figure. The natural gas price in the Mid East countries with 0.75 US$/MMBtu is strongly affected by Saudi Arabia's gas price.




(Source: Fulwood 2011 "Trends in Wholesale Gas Price for National Mechanisms")

**Figure 3- 28 Domestic Gas Prices (Wholesale Gas Prices) in the World (2009)**

The price that gas is to be sold to the power sector in Oman (as of February 2012) is 1.5 US$/MMBtu. However, it is predicted that the future cost of gas in Oman will be increased due to the fact that IOC dependency of gas production will increase. Therefore, it can be estimated that the domestic gas prices in Oman will increase in the future.

**Table 3- 20 MIS's Gas Consumption Estimated by OPWP**

| Items | Unit | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| Power Generation | TWh | 17.9 | 19.5 | 21.3 | 22.5 | 24.0 |
| Desalination Water | million $m^3$ | 207 | 209 | 216 | 222 | 236 |
| Gas Consumption | million $m^3$ /day | 16.8 | 17.5 | 17.2 | 18.0 | 19.1 |

(Source: OPWP Seven Years Statements)

### 3.5.5 Prediction of Crude Oil and LNG Prices in Oman

Per the above consideration and an analysis of the previous sections, the crude oil and LNG prices in Oman are predicted in the following table. This prediction is used for evaluation of impact of EE&C measures proposed in the Study.

**Table 3- 21 Prediction of Crude Oil and LNG Prices in Oman (per Common Use Unit)**

| Price | Unit | 2010 | 2011 | 2012 | 2020 | 2030 |
|---|---|---|---|---|---|---|
| WTI Spot Price | US$/bbl | 79.5 | 90.0 | 100 | 120 | 145 |
| Oman's Crude Oil Export Price | US$/bbl | 76.6 | 88.0 | 95 | 115 | 140 |
| Oman's Domestic Crude Oil Price | US$/bbl | N.A. | N.A. | N.A. | N.A. | N.A. |
| Oman's LNG Export Price | US$/MMBtu | 10.9 | 15.0 | 15.0 | 18.0 | 20.0 |
| NBP Index | US$/MMBtu | 6.6 | 9.0 | 11.1 | 12.6 | 14.0 |
| Oman's Domestic Natural Gas Price | US$/MMBtu | N.A. | N.A. | N.A. | N.A. | N.A. |

(Note) WTI is one of the international crude oil spot price.
Omani Crude Oil Export Price is 5 US$/bbl lower than WTI.
Omani LNG Export Price is set by long term contract price linked to crude oil price.
NBP Index is UK domestic average gas price index.

(Source: JICA Study Team)

**Table 3- 22 Prediction of crude oil and LNG prices in Oman (per toe)**

| Price | Unit | 2010 | 2011 | 2012 | 2020 | 2030 |
|---|---|---|---|---|---|---|
| WTI Spot Price | US$/toe | 549 | 622 | 691 | 829 | 1,002 |
| Oman's Crude Oil Export Price | US$/toe | 529 | 608 | 657 | 795 | 968 |
| Oman's Domestic Crude Oil Price | US$/toe | N.A. | N.A. | N.A. | N.A. | N.A. |
| Oman's LNG Export Price | US$/toe | 436 | 600 | 600 | 720 | 800 |
| NBP Index | US$/toe | 264 | 360 | 444 | 504 | 560 |
| Oman's Domestic Natural Gas Price | US$/toe | N.A. | N.A. | N.A. | N.A. | N.A. |

(Note) WTI Spot Price＝(US$/bbl) / (0.159 kl/bbl x 0.91 ton/kl)
Oman's Crude Oil Export Price = (US$/bbl) / (0.159 kl/bbl x 0.91 ton/kl)
Oman's LNG Export Price = (US$/MMBtu) / (25 koe/MMBtu) x 1,000 (koe /toe)
NBP Iindex= (US$/MMBtu) / (25 koe/MMBtu) x 1,000 (koe/toe)

(Source: JICA Study Team)

## 3.6 Other Information

### 3.6.1 Number of Household

According to the population census in 2010, the number of household accounts for about 400 thousands. Out of which, Omani households are 260 thousands. The average number of the households are 7.8 persons in a whole country.

**Table 3- 23 Oman Population Distribution and Growth Rate by Region**

| | Number of Household | | | Persons per Household | | | |
|---|---|---|---|---|---|---|---|
| | 2003 | 2010 | Growth Rate (%) | 2003 | 2010 | Growth Rate (%) | Persons |
| Muscat | 100,232 | 120,992 | 2.7 | 53,630 | 62,299 | 2.2 | 7.0 |
| Al Batinah | 89,425 | 105,899 | 2.4 | 66,882 | 76,539 | 1.9 | 8.3 |
| Musandam | 4,541 | 4,709 | 0.5 | 3,079 | 3,126 | 0.2 | 7.1 |
| Adh Dhahirah | 29,614 | 19,979 | -5.5 | 17,312 | 14,386 | -2.6 | 8.5 |
| Ad Dakhliyah | 36,581 | 44,121 | 2.7 | 29,393 | 34,619 | 2.4 | 7.9 |
| Ash Sharqiyah | 47,001 | 54,749 | 2.2 | 36,928 | 42,500 | 2.0 | 7.1 |
| Al Wusta | 2,978 | 3,960 | 4.2 | 2,284 | 2,695 | 2.4 | 7.3 |
| Dhofar | 27,207 | 33,000 | 2.8 | 16,056 | 17,926 | 1.6 | 9.6 |
| Al Buraymi | | 11,865 | | | 5,939 | | 7.7 |
| Total | 337,579 | 399,274 | 2.4 | 225,564 | 260,029 | 2.1 | 7.8 |

(Source: Censuses of 2003 and 2010)

### 3.6.2 Number of Residential Houses

The following table shows the total and occupied number of housing units according to the result of a 2010 census. The occupancy rate is about 70 %, in other words 30% of the housing units are vacant.

**Table 3- 24 Number of Total and Occupied Housing Units and Occupancy Rate**

| | Housing Units | | | Occupied Housing Units | | | Occupancy | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2003 | 2010 | Growth Rate (%) | 2003 | 2010 | Growth Rate (%) | 2003 | 2010 | Growth Rate (%) |
| Muscat | 118,473 | 153,381 | 3.8 | 100,653 | 119,921 | 2.5 | 85.0 | 78.2 | -1.2 |
| Al Batinah | 111,414 | 140,638 | 3.4 | 89,325 | 105,006 | 2.3 | 80.2 | 74.7 | -1.0 |
| Musandam | 8,226 | 10,764 | 3.9 | 4,589 | 4,774 | 0.6 | 55.8 | 44.4 | -3.2 |
| Adh Dhahirah | 38,603 | 29,697 | -3.7 | 29,865 | 19,931 | -5.6 | 77.4 | 67.1 | -2.0 |
| Ad Dakhliyah | 48,219 | 63,225 | 3.9 | 36,718 | 44,051 | 2.6 | 76.1 | 69.7 | -1.3 |
| Ash Sharqiyah | 63,833 | 82,490 | 3.7 | 46,870 | 54,357 | 2.1 | 73.4 | 65.9 | -1.5 |
| Al Wusta | 4,233 | 6,387 | 6.1 | 3,125 | 4,033 | 3.7 | 73.8 | 63.1 | -2.2 |
| Dhofar | 37,995 | 46,774 | 3.0 | 27,801 | 32,502 | 2.3 | 73.2 | 69.5 | -0.7 |
| Al Buraymi | | 17,702 | | | 11,846 | | | 66.9 | |
| Total | 430,996 | 551,058 | 3.6 | 338,946 | 396,421 | 2.3 | 78.6 | 71.9 | -1.3 |

(Source: Censuses of 2003 and 2010)

### 3.6.3 Number of Buildings

The number of constructed buildings during 2007 to 2009 and the "cumulative number" are shown in the next table. The period of the "cumulative number" is not described and it is expressed as "till the end of 2009".

**Table 3- 25 New Construction Number and Cumulative Number (Unit: 1,000)**

| | | 2007 | 2008 | 2009 | Cumulative (up to 2009) |
|---|---|---|---|---|---|
| Building | Commercial | 2.1 | 1.3 | 1.2 | 6.4 |
| | Commercial & Residential | 3.2 | 2.9 | 1.5 | 11.4 |
| | Industrial | 1.9 | 1.8 | 0.7 | 6.1 |
| | Government | 1.1 | 1.5 | 1.7 | 5.4 |
| Building Total | | 8.3 | 7.5 | 5.1 | 29.3 |
| Others | Residential | 80.5 | 94.7 | 54.8 | 352.1 |
| | Agriculture | 5.4 | 7.2 | 9.2 | 25.9 |
| Total | | 94.3 | 109.4 | 69.2 | 407.4 |

(Source: Oman Statistical Yearbook 2010)

### 3.6.4 Number of Mosques

The following table shows the number of mosques by region in 2007 according to the statistics of Ministry of Awqaf and Religious Affairs. The large-scale mosques in total is 1,098. The total number of mosques is 13,945.

**Table 3- 26 Number of Mosques per Region**

| | Large-Scale Mosque | | Mosques | | Total | |
|---|---|---|---|---|---|---|
| | Number | % | Number | % | Number | % |
| Muscat | 178 | 16.2 | 1,082 | 8.4 | 1,260 | 9.0 |
| Al Batinah-N | 224 | 20.4 | 1,187 | 9.2 | 1,411 | 10.1 |
| Al Batinah-S | 162 | 14.8 | 2,052 | 16.0 | 2,214 | 15.9 |
| Musandam | 31 | 2.8 | 197 | 1.5 | 228 | 1.6 |
| Adh Dhahirah | 69 | 6.3 | 2,788 | 21.7 | 2,857 | 20.5 |
| Ad Dakhliyah | 76 | 6.9 | 1,687 | 13.1 | 1,763 | 12.6 |
| Ash Sharqiyah-N | 33 | 3.0 | 1,732 | 13.5 | 1,765 | 12.7 |
| Ash Sharqiyah-S | 102 | 9.3 | 1,179 | 9.2 | 1,281 | 9.2 |
| Al Wusta | 25 | 2.3 | 173 | 1.3 | 198 | 1.4 |
| Dhofar | 135 | 12.3 | 427 | 3.3 | 562 | 4.0 |
| Al Buraymi | 63 | 5.7 | 343 | 2.7 | 406 | 2.9 |
| Total | 1,098 | 100.0 | 12,847 | 100.0 | 13,945 | 100.0 |

Note: Definition of large-scale mosque is not described

(Source: Ministry of Awqaf and Religious Affairs)

### 3.6.5 Number of Hospitals

As of 2009, there are 60 national hospitals and 50 hospitals under the jurisdiction of the Ministry of Health.

**Table 3- 27 Number of Hospitals**

| | National Hospitals | Under Ministry of Health | Total |
|---|---|---|---|
| Hospital Numbers | 60 | 50 | 110 |
| Bed numbers | 5,619 | 4,653 | 10,272 |
| Health Center, Pharmacy, Clinic | 1,034 | 151 | 1,185 |
| Doctor Numbers | 5,563 | 3,909 | 9,472 |
| Nurse Numbers | 12,102 | 9,753 | 21,855 |
| Dentist Numbers | 623 | 231 | 854 |
| Pharmacist Numbers | 1,087 | 240 | 1,327 |

(Source: Ministry of National Economy "Facts & Figures" 2010)

### 3.6.6 Number of Schools

According to "Oman's Industrial Structure" of a judicial foundation of the Middle East Cooperative Center of Japan, the Government of Oman is reinforcing the educational system to lay emphasis on human resource development. Although a compulsory education system has not been introduced in Oman, almost all school age children go to schools. The total number of general education public schools in 2009 was 1,418. The total number of students is 620,353 and the number of teachers is 50,796.

The total number of students enrolled in advanced education in 2009 was 23,644. As for other governmental advanced education institutes, there exist six colleges of education, one college of Sharia and law, five colleges of industry and technology, institute for banking and financial study, medical/health schools and a job training center. The length of the higher education study period depends on the type of schooling. In general, it takes approximately 3 years to earn a diploma's degree from college, approximately 4 years to earn a bachelor's degree from university and approximately 2-3 years to earn a master's degree from graduate school.

**Table 3- 28 School Number, Student Number and Teacher Number in 2009**

| | Public | Private | Total |
|---|---|---|---|
| School Number | 1,043 | 375 | 1,418 |
| Student Number | 523,036 | 97,317 | 620,353 |
| Class Number | 19,482 | 4,295 | 23,777 |
| Teacher Number | 44,687 | 6,109 | 50,796 |

(Source: Ministry of National Economy "Facts & Figures" 2010)

# Chapter 4 Outline of Electricity Sector and Environment Programs in Oman

## 4.1 History of Electric Power Industry

### 4.1.1 History of Electric Power Industry

The electric power industry has been developing since the MHEW (Ministry of Housing, Electricity and Water) was established in 1978. Along with an increase in the exports of crude oil, the country has evolved per a five-year plan and a long-term economic policy. From those days, the demand of water and power has increased all over the country. The MEHW had produced and supplied water and electricity and operated and managed the facilities. In 2003, 97 % of the residential area of Oman, except for the mountain areas, had been electrified.

According to the country's development, the demand for electricity has been increasing, and the government has been encouraging the private sector to invest in the electricity sector. Furthermore, in 1999, the government decided to sell those assets owned by MHEW, and eventually establish independent organizations to implement the electricity industry. In addition, on February 2003, the government announced they would sell the main power plants as part of asset reorganization efforts by the government, and on July 2003, established TRANSCO (Transmission and Dispatch Company). After that, per Royal Decree 78/2004 (the Law for the Regulation of the Electricity & Related Water Sector), the EHC (Electricity Holding Company SAOC) was established in May 2005. The EHC has owned a Transmission Company, Power Generation Companies, and Distribution Companies. On the other hand, in the government, per Royal Decree 92/2007, the MHEW was divided into MOW (Ministry of Housing) and PAEW.

### 4.1.2 Legal System of Electric Power Industry

The following articles of the electricity sector law (the Law for the Regulation and Privatization of the Electricity and Related Water Sector, 2004) are important to understanding the electricity sector.

The law regulates the following activities as regulated activities, and those activities are prohibited minus an AER license.

(a) Generation, Transmission, Distribution, Export, Import or Supply of Electricity;
(b) Generation of electricity related to Desalination of Water;
(c) Generation of electricity co-located with Desalination of Water in the same site;
(d) Operation of the central Dispatch system;
(e) The development and/or operation of International Interconnections; and
(f) The functions assigned to the Oman Power and Water Procurement Company provided for in this Law.

**Article (4)**
It shall not be permissible for any Person to undertake any of the regulated activities stipulated in the preceding Article without obtaining a License or Exemption from the Authority, and the undertaking of the licensed activity shall be by the licensee in accordance with the terms, periods and rules contained in this law and pursuant to the contents of the License or Exemption.

**Article (7)**
Save for the Rural Areas Electricity Company or a special provision to the same effect in this law, it is not permissible for any licensee to undertake more than one regulated activity or to acquire any direct or indirect economic interest in any other Licensee.

**Article (10)**
The Public Authority for Electricity and Water before issuing the regulations mentioned in the preceding article shall:

(1) Take the opinion of the Authority, which is bound to coordinate with Licensed Suppliers, and Licensed Distribution System Operators, and the Rural Areas Electricity Company, and the Oman Power and Water Procurement Company;
(2) Submit such proposed regulations to the Council of Ministers for approval. The amendment or modification of tariffs shall be in the same way.

**Article (11)**
Permitted Tariff regulations may include the following:

(a) The provision for the payment of Permitted Tariffs by commercial, industrial, and residential and other categories of Customers or specific groups of Customers in the manner provided for in the regulations;
(b) A provision for the non-application of Permitted Tariffs to specific categories of Customers;
(c) To distinguish between different categories of Customers on the basis of the level of consumption or the time or geographic location;
(d) The determination of different structures, levels and times relating to the Permitted Tariffs to be applied as between different categories or groups of Customers or at different times or according to other bases specified by the regulations including the negotiation of Permitted Tariffs in each case with specific categories of Customers;
(e) All that is related to the cost of providing Connection;
(f) Exemption of specific categories or groups of Customers from the total or partial payment of Permitted Tariffs;
(g) Other provisions in respect of Supply and Connection Permitted Tariffs as the Public Authority for Electricity and Water deem to be appropriate.

**Article (25)**
The Authority shall have the following functions:

(1) Implementation of the general policy for the electricity and Related Water sector and the policy of the State in relation to regulated activities pursuant to the provisions of this Law;
(2) Preparation of programmes and plans necessary for the development of the general policy of the electricity and Related Water sector in the Sultanate of Oman;
(3) Issuance, modification and revocation of Licenses and approval of Exemptions and follow up its compliance and to oblige Licensees and Exemption Holders to discharge their duties prescribed in this Law;
(4) Determine the form of Licenses in respect of each regulated activity, which is subject to the provisions of this Law;
(5) Taking of measures for the implementation of obligations arising from international agreements in the field of electricity and Related Water to which the Sultanate of Oman is a party, and the resolutions issued by international and regional organizations to which the Sultanate has acceded, or will accede to, all being in coordination with the Competent Authorities in this respect and in a manner not in conflict with the provisions of this Law;
(6) Determination of the terms, rules, specifications and obligations, which Licensees and Exemption Holders shall comply with;
(7) Monitoring of the implementation of the terms and rules of Licenses or Exemptions by Licensees and Exemption Holders;
(8) Examination of complaints submitted by Customers and Licensees and taking prescribed procedures in respect thereof pursuant to the provisions of this Law;
(9) Preparation of programmes necessary for the creation of awareness about the importance of the electricity and Related Water sector and the effect resulting from the development of the sector on development plans and welfare of the citizens;
(10) Coordination with the relevant ministries, Government units and the Public Authority for Electricity and Water with respect to all that is required for the development of the sector, and provision of consultation to the Public Authority for Electricity and Water upon its request with respect to those matters which are within its competencies pertaining to the electricity and Related Water sector
(11) Issuance of regulations specifying the manner of expending the RAEC Connection and Electrification Funding, monitoring the extent of compliance with such regulations by the Rural Areas Electricity Company, and the Authority shall submit a report in this respect, a copy of which shall be sent to the Ministry of National Economy,

The Ministry of Finance and the Public Authority for Electricity and Water;

(12) Setting out rules to regulate the keeping and maintenance of records by Licensees in the manner specified by the Authority;

(13) Setting out standard technical criteria to be complied with in relation to Connection to a transmission or distribution System of a Licensee, and in relation to the use and operation of such Systems, and the criteria relating to the maintenance and development of the Licensee's System;
(14) Settlement of disputes arising between License Holders or Exemption Holders or between Customers, or any other Persons in accordance with the provisions of a License or Exemption pursuant to the provisions of this Law;
(15) Issuance of regulations and decisions authorized by this Law.

**Article (38)**

The Authority may, after coordination with the Public Authority for Electricity and Water, issue regulations for achieving the following purposes:
(a) Secure the provision of regular supplies of electricity and desalinated water produced in the electricity and Related Water sector.
(b) Protection of the Public from the risks of injury that may result from works and installations related to the electricity and Related Water sector.
(c) Encourage the efficient use of electricity by observing relevant rules and standards which are approved by the Public Authority for Electricity and Water.

**Article (66)**

Ownership by the Government of the shares in the following companies shall be through its ownership of the shares of the Electricity Holding Company:
(a) The Oman Power and Water Procurement Company SAOC.
(b) The Oman Electricity Transmission Company SAOC.
(c) The Wadi Al Jizzi Power Company SAOC;
(d) The Al Ghubrah Power and Desalination Company SAOC;
(e) The Mazoon Electricity Company SAOC;
(f) The Majan Electricity Company SAOC;
(g) The Muscat Electricity Distribution Company SAOC; and
(h) The Rural Areas Electricity Company SAOC.
(i) The Companies that shall be established pursuant to the provisions of Clauses (e & h) of the preceding Article.

**Article (135)**

The Public Authority for Electricity and Water shall have the following duties and functions:
(a) To cooperate with the Ministry of National Economy in the implementation of the Transfer Scheme in order to distribute and Transfer the Relevant Assets and Liabilities pursuant to the provisions of this Law;
(b) To identify its forecasts in respect of demand for Desalinated water on a short, medium and long term basis and to provide the Oman Power and Water Procurement Company and the Rural Areas Electricity Company with such forecasts, and with any information about the demand for New Capacity for Desalinated water required by either company to enable them to fulfill their duties in respect of the procurement of New Capacity for Desalinated water;
(c) To coordinate with the Ministry of National Economy in respect of its forecasts in relation to the required amount of new Production Capacity for Desalinated water;
(d) To pay the Bulk Supply Tariff to the Oman Power and Water Procurement Company and/or the Rural Areas Electricity Company, as appropriate, in consideration of the new Desalinated water Production Capacity procured on behalf of the Public Authority for Electricity and Water and in consideration of the sale of Desalinated water Output by the Oman Power and Water Procurement Company and the Rural Areas Electricity Company to the Public Authority for Electricity and water.
(e) To cooperate with the Oman Power and Water Procurement Company and the Rural Areas Electricity Company to decide whether there is a duty to procure New Capacity for Desalinated water, whether by the Oman Power and Water Procurement Company pursuant to Article (79) of this Law, or independently by the Public Authority for Electricity and Water, or there is a duty to procure New Capacity for Desalinated water in rural areas pursuant to Article (84) of this Law by the Rural Areas Electricity Company whether connected with electricity Production Capacity, or independently by the Public Authority for Electricity and Water;
(f) To comply with the duties prescribed to it pursuant to the provisions of this Law;
(g) To furnish the Licensed Transmission System Operators with the following:
(i) Sufficient information to enable each of them to operate his System in order to discharge his duties pursuant to Article (82) of this Law;
(ii) Sufficient information in respect of the Public Authority for Electricity and Water requirement for Desalinated water from Production Facilities that are Connected to the System of any Licensed Transmission System Operator being the subject matter of a contract with the Oman Power and Water Procurement Company;
(h) To provide the Authority with such information required by it to enable it to perform its functions and duties pursuant to this Law;
(i) To become and remain as a party to and comply with the Grid Code;
(j) To conduct researches and development in relation to the electricity Supply sector and to submit its recommendations (if any) in this respect to the Council of Ministers;
(k) To submit recommendations to the Council of Ministers in respect of International Interconnections and to cooperate with the Authority and Successor Entities pursuant to the provisions of this Law.

### 4.1.3 Implementation Structure and Organization Overview of Electric Power Industry

(1) Implementation System

Concerning the electricity sector of Oman, PAEW and AER are in charge of the laws, policies, regulations, licenses, etc. PAEW has formulated a policy on electric power industry. The AER regulates the utilities and licenses them to start regulated activities.

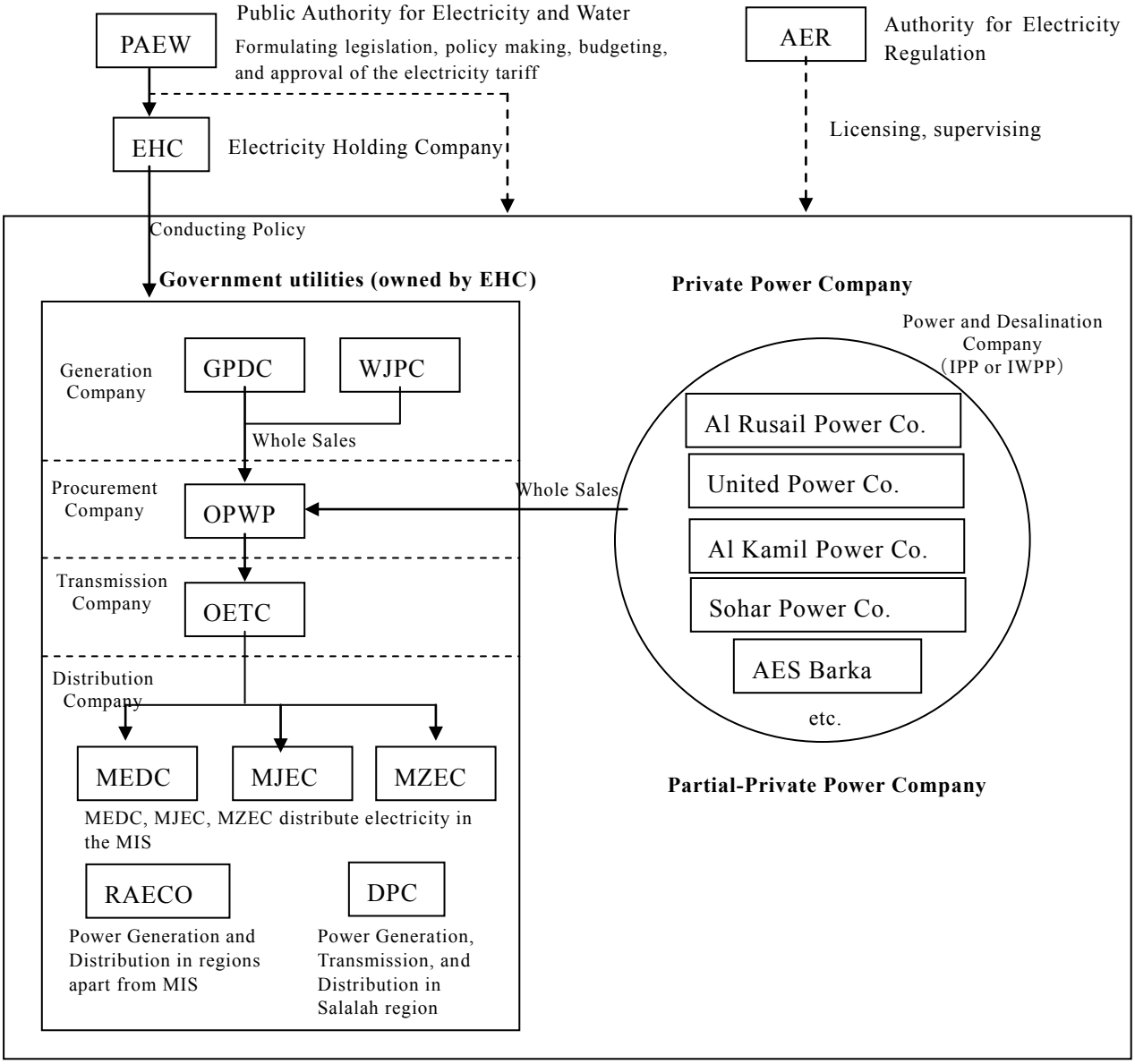
There are two types of private power companies, one is a type of government utility funded by the ministry of finance through EHC and the other is a type of utility funded by private capital.

Government utilities are classified into four types; generation, power procurement, transmission, and distribution. It is typical to have an OPWP (Oman Power & Water Procurement Company), which procures power (purchasing and sales), forecasts electricity demand and creates a power plan. Actually, the OPWP has a planning function in Oman. In addition, there are two government generation companies, which are GPDC (Ghubrah Power and Desalination Company) and WJPC (Wadi Al Jizzi Power Company). Both companies generate electricity in the MIS..

Concerning the transmission company, the OETC (Oman Electricity Transmission Company) is only one company for electricity transmission. The OETC conducts operations, planning, and maintenance of the power system. The government distribution companies are divided by region, and there are 3 companies which are receiving electricity from OETC, and there is RAECO (Rural Area Electricity Company) which is in charge of power generation, and distribution and supply in rural areas only (outside the MIS). MEDC, MJEC, MZEC distribute and supply in the MIS..

On the other hand, the private utilities consist of power and desalination companies and DPC (Dhofar Power Company). The DPC conducts power generation, transmission, and distribution for the Salalah region.

The following diagrams show the structures of the electricity sector, distribution company areas, and Oman's power system diagram.




(Source: JICA, The Report on the Detail Planning of the Project for Energy Conservation Master Plan in the Power Sector in the Sultanate of Oman, 2010)

**Figure 4- 1 Structure of Electricity Sector in Oman**

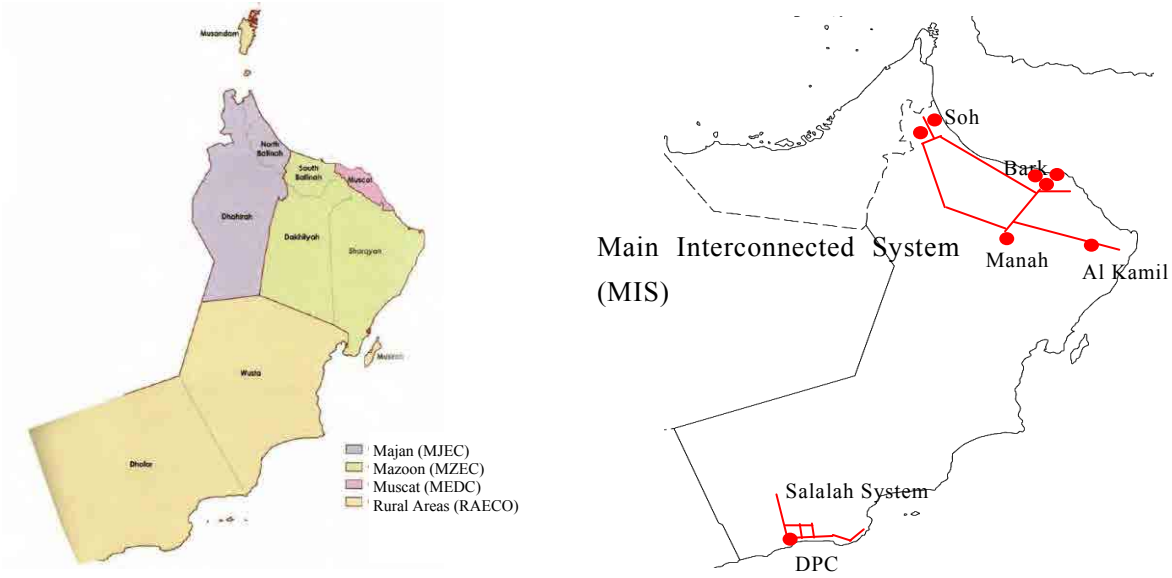



**Figure 4- 2 Distribution Company Areas of Oman and Oman's Power System Diagram**

(2) Overview of Government Agencies and Each Electric Utility

(a) PAEW (Public Authority for Electricity and Water)

There are 6 sections under PAEW Chairmanship, and most of the sections are in charge of the water section following the privatization of the electricity sector.

In the case that a utility generates water using a desalination plant with electricity generation, its water supply business is also conducted by the same utility, but in the case that a utility generates water without electricity generation, some of water supply business will be directly conducted by PAEW.

The scope of work of the electricity sector of PAEW is Law formulation, Decision-making, Budgeting, and the Approval process of the electricity tariff. The policies of PAEW are as follows.

- Electricity for Everyone
- Best Utilization of Gas
- Fuel Diversity
- Market Liberalization
- Demand Management

EHC formulates the budget, and then submits it to PAEW, which conducts procedures in the government. The electricity tariff must be approved by the cabinet,

(b) AER (Authority for Electricity Regulation)

The AER was established in 2004, when the privatization and separation of the electricity sector was implemented.

The main scope of work of the AER is licensing and supervision of the electricity sector, and the procedures for a subsidy in the government and punitive measures.

Concerning the subsidy, the AER calculates the subsidy from the cost and the income of the utilities and submits it to MOF to be approved.

(c) EHC (Electricity Holding Company)

EHC started business operations from May 2005. (The year when EHC was registered as a stock company is on October 2002). The members of the board of directors consist of people who are not associated with PAEW, but the chairman doubles as EHC and PAEW.

The policy decided by PAEW is to be conducted by EHC.

(d) OPWP (Oman Power & Water Procurement Company)

OPWP was established in 2003. OPWP is a planning unit of the electricity sector of Oman, but it isn't in charge of filed services.

The OPWP is in charge of the demand forecast of electricity and water in Oman. To balance the demand and supply, the OPWP created the power plan, and studied new power generation and the desalination project. However, OPWP is not in charge of business in rural areas (RAECO's services region). This means that the OPWP conducts a demand forecast and power planning within the Muscat and Salalah region.

Based on the license by AER, OPWP has annually published the 7 year statement (the demand forecast and the power plan) and the Bulk Supply Tariff.

(e) OETC (Oman Electricity Transmission Company)

OETC was licensed for the Transmission and System Operations on May 2005.

The OETC has owned, maintained, and managed the power system facilities of MIS (Main Interconnected Transmission System), which is the main system of 220kV and 132kV in Oman. In addition, they are in charge of system operations. Their services area is 130,000 $km^2$ (Covered area by MIS).

Based on the demand forecast and power plan drawn up by OPWP, OETC has annually formulated the 5 year Capability Statement which is the electricity transmission facility plan.

(f) Distribution Company (3 companies)

The government distribution companies connected to the MIS system including Muscat are the following 3 companies. They are divided regionally into MEDC, MJEC, and MZEC.

MEDC (Muscat Electricity Distribution Company)

MJEC (Majan Electricity Company)

MZEC (Mazoon Electricity Company)

Each distribution company owns, maintains, and manages the distribution facilities of 33 kV, 11 kV, and 415 V, and collects electricity tariffs. Based on the demand forecast and power plan created by OPWP, they will formulate a 3-year Capability Statement annually.

The following table shows an outline of each company

**Table 4- 1 Overview of Government Distribution Company**

| | MEDC | MJEC | MZEC |
|---|---|---|---|
| Established year | Dec. 2002 | Dec. 2002 | Feb. 2003 |
| Licensed year | May 2005 | May 2005 | May 2005 |
| Supply Area | Muscat ($3,900km^2$) | Northwestern Oman ($50,250km^2$) | Eastern Oman ($64,630km^2$) |

(Sources: JICA, Report on the Detail Planning of the Project for Energy Conservation Master Plan in the Power Sector in the Sultanate of Oman, 2010, MEDC Website, MJDC Annual Report 2010, MZEC Annual Report 2009)

(g) DPC (Dhofar Power Company)

The DPC has been a semiofficial company with 35% of its stock being publicly-held. The DPC became a subsidiary of EHC in 2011. The DPC has a branch office in Muscat.

The DPC has supplied electricity through the Salalah system in the southern area of Oman. The DPC owns one electrical power plant, and also 132 kV transmission lines, and 33 kV, 11kV and 415V distribution facilities.

DPC also has billed, and collected electricity tariffs, and it is only one vertical integrated utility in Oman. The maximum demand of the DPC in 2009 was 297 MW. Based on the demand forecast and the power plan, the DPC formulates a 5-year statement annually.

(h) RAECO (Rural Area Electricity Company)

RAECO was established in 2004, when the electricity sector was converted to joint stock corporations per the 2004 laws.

RAECO has an independent service area where MIS is not able to reach including the Musandam area. Besides, the RAECO has been licensed to conduct power generation, distribution, and also water production as needed. RAECO owns water desalination plants in Masira island and Musandam. There are approx. 55 areas supplied by RAECO.

## 4.2 Power Demand Supply Status of Power Sector

### 4.2.1 Power System

The power system in Oman consists of some of the independent power network systems that are categorized into the following.

- The main power system in the north region: Main Interconnected System (MIS)
- The main power system in the south region: Salalah Power System
- Small scaled rural systems that are operated by the Rural Areas Electricity Company
- The power system owned and operated by PDO (Petroleum Development Oman) that carries out oil and the gas evacuation and production business (the system is connected to the north and south main power system.)

MIS is the main power network system in the north region with using its voltage levels as 400 kV, 220 kV and 132 kV that supplies the power to the capital Muscat and its surrounding areas. Oman Electricity Transmission Company (OETC) owns and operates the power system facilities of MIT. The three distribution companies owned by the Government, Muscat Electricity Distribution Company SAOC (MEDC), Majan Electricity Company SAOC (Government Ownership), and Mazoon Electricity Company SAOC (Government Ownership) are supplied their power consumption by MIS. The medium voltage levels of the distribution system are used as 33 kV and 11 kV. The 220 kV transmission lines between the Al Foah substation in the UAE (Abu Dhabi Transco) and Mahadah substation in the MIT system was completed in 2007 as an international interconnection line, and started the operation in October 2011. As the interregional connection line to other systems, a 132 kV transmission line with a single circuit has been constructed between Niswa substation in MIS of OETC and Nahda substation in PDO. The next table shows the outline of the system facilities of OETC in 2010. The following figure shows the power system of OETC in 2011.

**Table 4- 2 Outline of System Facilities of OETC**

| Items | | Unit |
|---|---|---|
| Energy (measured at generation terminals) | 16,357,501 | MWh |
| Loss ratio | 2.7 | % |
| Peak power demand | 3613 | MW |
| Number of substations | 43 | |
| Capacity of transformers | 16,019 | MVA |
| Circuit length of 220 kV transmission lines | 835 | km |
| Circuit length of 13 2kV transmission lines | 2,970 | km |
| Length of 220 kV underground cables | 12 | km |
| Length of 132 kV underground cables | 64 | km |

(Source: OETC Annual Report 2010)

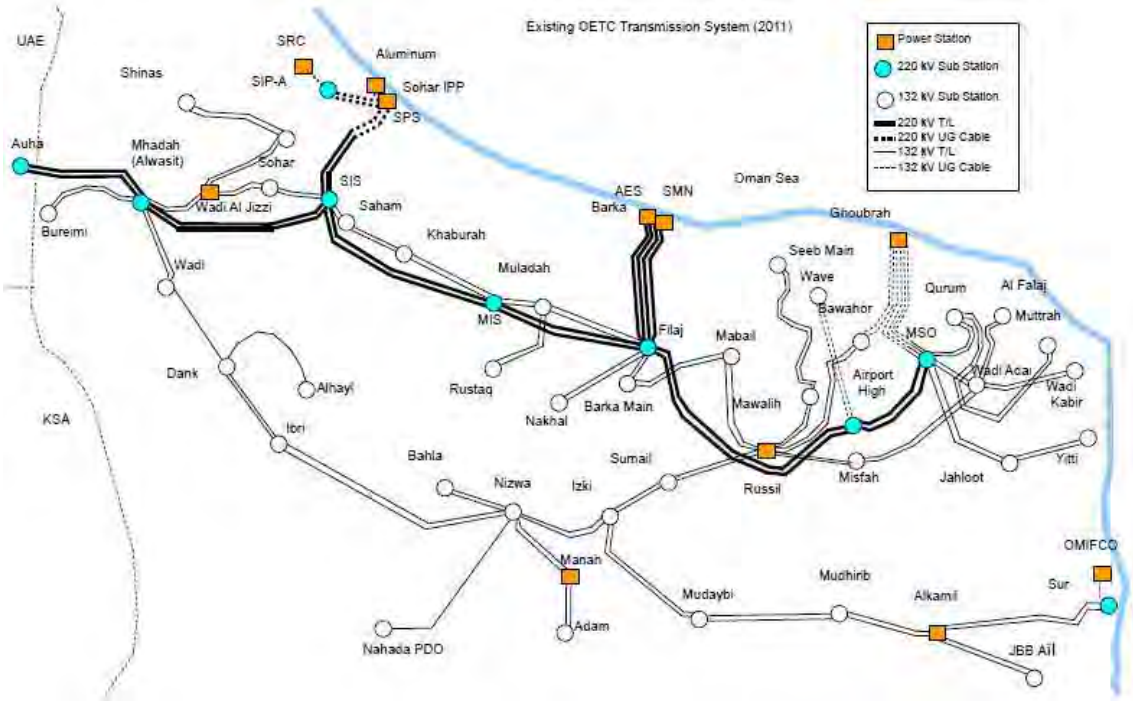



**Figure 4- 3 Power System of OETC in 2011**

The Salalah system located in the southern part of Oman is operated by Dhofar Power Company(DPC) and its subsidiary company, Dhofar Generating Company SAOC (DGC) as the integrated system of power generation, transmission and distribution. The power generation business in Salalah system is done by DPC as well as Rural Areas Electricity Co. (RAEC), and the newly emerging Salalah IWPP. The Slalah IWPP started its operations in 2011 with 61 MW and in January 2012, 173 MW.

Although the Salalah system was an isolated power system as before, the interconnection to the system of Petroleum Development Oman (PDO) was constructed in 2011 and was to be operated in 2012. The effects of the interconnection on the enhancement of power supply reliability is to be expected, however, the operation methodology of power trading has not yet been decided.

### 4.2.2 Power Generation Facilities

Power energy generated by IPPs and IWPPs in Oman is once purchased by OPWP as a single buyer and sold to distribution companies and other large power consumers.
OPWP makes firm contracts with main power stations. Their power generation capacities are called “Contracted Capacity”. When the total amount of the contracted capacity is insufficient for the power supply, the OPWP purchases power trade energy through interconnections to the other system based on the “reserve-sharing agreement” and surplus power from the in-house power generators in factories called “non-firm resources”.

The table shown below shows the power generation units in MIS in 2011. OPWP makes contact with IWPPs for power generation and desalination and IPP only for power generation. All the units use natural gas, however, the diesel can be used as secondary fuels. Braka1, Barka2 and Sohar1 are combined cycle power stations. The other power stations are open cycle power stations.

**Table 4- 3 Power Stations and Their Units in MIS System in 2011**

| Name of Units | Type of Units* | Maximum Available Capacities (MW) |
|---|---|---|
| **Ghubrah (IWPP)** | | |
| Ghubrah_GT1 | OCGT | 16.0 |
| Ghubrah_GT2 | OCGT | 16.0 |
| Ghubrah_GT3 | OCGT | 16.0 |
| Ghubrah_GT4 | OCGT | 16.0 |
| Ghubrah_GT5 | OCGT | 16.0 |
| Ghubrah_GT6 | OCGT | 16.0 |
| Ghubrah_GT7 | OCGT | 16.0 |
| Ghubrah_GT8 | OCGT | 16.0 |
| Ghubrah_GT9 | OCGT | 16.0 |
| Ghubrah_GT10 | OCGT | 26.3 |
| Ghubrah_GT11 | OCGT | 26.3 |
| Ghubrah_GT12 | OCGT | 91.0 |
| Ghubrah_GT13 | OCGT | 91.0 |
| Ghubrah_ST4 | Auxilary Boiler | 37.0 |
| Ghubrah_ST5 | Auxilary Boiler | 30.0 |
| Ghubrah_ST6 | Auxilary Boiler | 30.0 |
| Total | | 475 |
| Desal. Plant Load | | (25) |
| **Rusail (IPP)** | | |
| Rusail_GT1 | OCGT | 81.5 |
| Rusail_GT2 | OCGT | 81.5 |
| Rusail_GT3 | OCGT | 81.5 |
| Rusail_GT4 | OCGT | 83.9 |
| Rusail_GT5 | OCGT | 83.9 |
| Rusail_GT6 | OCGT | 83.9 |
| Rusail_GT7 | OCGT | 95.9 |
| Rusail_GT8 | OCGT | 94.6 |
| Total | | 687 |

| Name of Units | Type of Units* | Maximum Available Capacities (MW)) |
|---|---|---|
| **WadiJizzi (IPP)** | | |
| WadiJizzi_GT3 | OCGT | 19.2 |
| WadiJizzi_GT4 | OCGT | 29.8 |
| WadiJizzi_GT5 | OCGT | 29.8 |
| WadiJizzi_GT6 | OCGT | 30.0 |
| WadiJizzi_GT7 | OCGT | 30.0 |
| WadiJizzi_GT8 | OCGT | 29.1 |
| WadiJizzi_GT9 | OCGT | 30.5 |
| WadiJizzi_GT10 | OCGT | 30.5 |
| WadiJizzi_GT11 | OCGT | 30.5 |
| WadiJizzi_GT12 | OCGT | 32.5 |
| WadiJizzi_GT13 | OCGT | 32.5 |
| Total | | 325 |
| **Manah (IPP)** | | |
| Manah_GT1A | OCGT | 28.8 |
| Manah_GT1B | OCGT | 28.8 |
| Manah_GT1C | OCGT | 28.8 |
| Manah_GT2A | OCGT | 93.5 |
| Manah_GT2B | OCGT | 93.5 |
| Total | | 273 |
| **AlKamil (IPP)** | | |
| AlKamil_GT1A | OCGT | 99.0 |
| AlKamil_GT2A | OCGT | 99.0 |
| AlKamil_GT3A | OCGT | 99.0 |
| Total | | 297 |

| Name of Units | Type of Units* | Maximum Available Capacities (MW) |
|---|---|---|
| **Barka1 (IWPP)** | | |
| Barka1_GT1 | CCGT | 129.0 |
| Barka1_GT2 | | 129.0 |
| Barka1_ST | | 192.0 |
| Total | | 450 |
| Desal. Plant Load | | (30) |
| **Sohar1 (IWPP)** | | |
| Sohar1_GT1 | CCGT | 136.6 |
| Sohar1_GT2 | | 136.6 |
| Sohar1_GT3 | | 136.6 |
| Sohar1_ST | | 180.0 |
| Total | | 589.8 |
| Desal. Plant Load | | (40) |
| **Barka2 (IWPP)** | | |
| Barka2_GT1 | CCGT | 136.6 |
| Barka2_GT2 | | 136.6 |
| Barka2_GT3 | | 136.6 |
| Barka2_ST1 | | 150.1 |
| Barka2_ST2 | | 150.1 |
| Total | | 710 |
| Desal. Plant Load | | (21) |

* OCGT: Open Cycle, CCGT: Combined Cycle

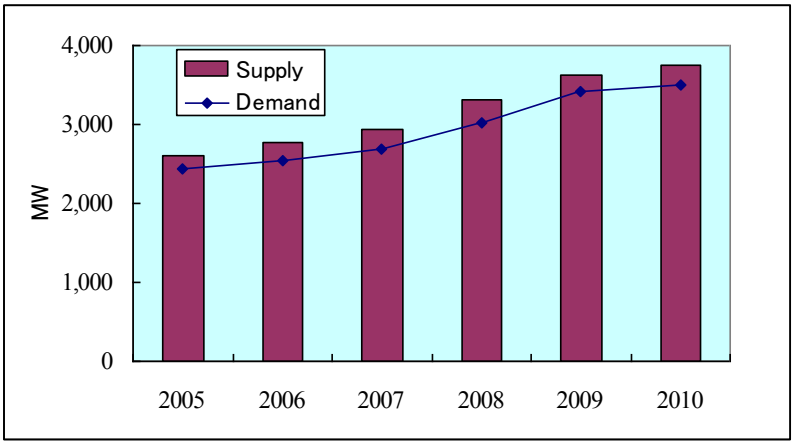
(Source: Data obtained from OPWP)

In Salalah, the OPWP enters into fixed-price contracts with the Dhofar Power Company SAOG and Salalah IWPP that started its operations in 2011. There are other power stations

that have short term contracts with OPWP for peak power generation.

### 4.2.3 Supply and Demand Balance of Electric Power

The next figure shows a comparison of the maximum demand and supply capacity of MIS. The capacity margin has been secured at around 6 % to 9 % since 2005. However, the maximum demand increase in 2008 and 2009 was high (more than about 10 %), and the development plan of power generation for 2010 seemed to be delayed. Thus, the situation has been severe as a temporary diesel power station (116 MW) had to be additionally constructed to secure the balance.

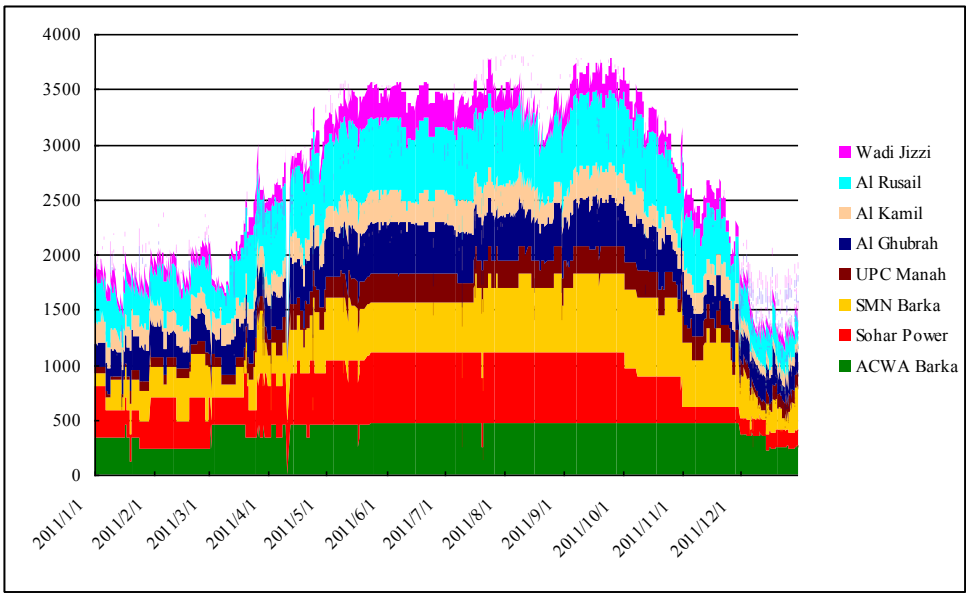



(Source: OPWP Annual Report)

**Figure 4- 4 Supply and Demand Balance of MIS (Transmission Point)**

### 4.2.4 Operation of Power Stations

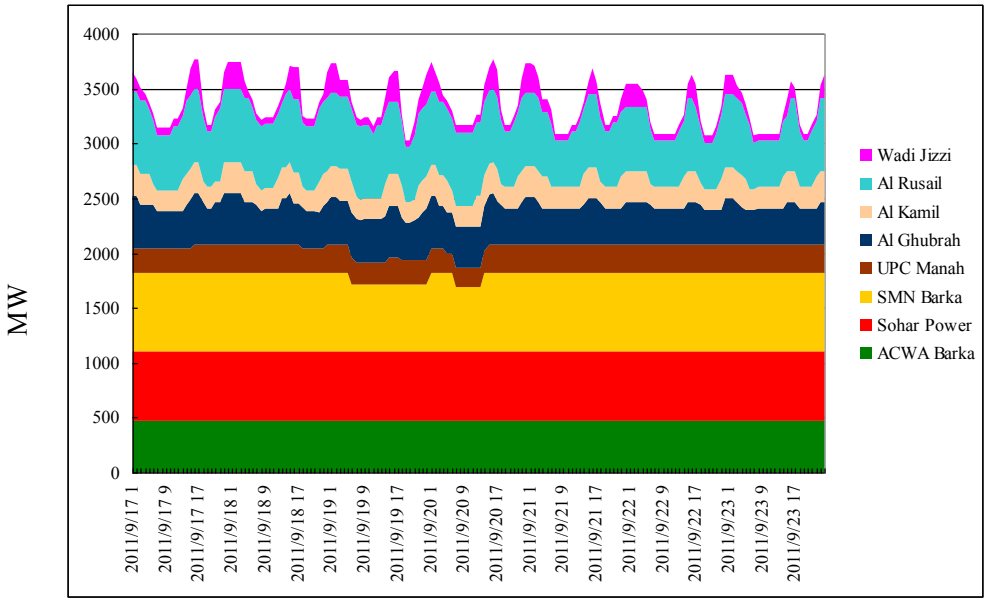
The power generation pattern in the MIS system in 2011 is shown below. As can be seen from the figure, all the power stations are operated both in the peak demand period of time and off peak.




(Source: Data obtained from OETC)

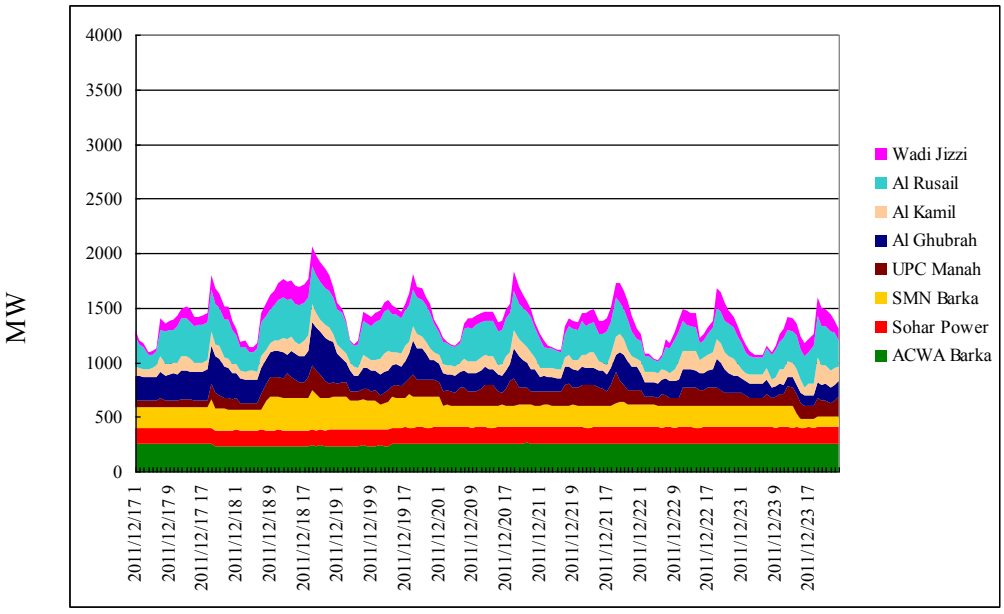
**Figure 4- 5 Power Generation Pattern in MIS System in 2011**

The weekly operation patterns of power generation during the peak demand period of time and the off-peak demand are shown below. Although the daily power output of Barka I, Barka II and Sohar power stations do not vary dramatically that are combined cycle power stations, the amount of daily power outputs of other power stations is changing largely according to the increase and decrease in power demand. BarkaI, BarkaII, and Sohar that have the units of combined cycle power stations consisting of some of the gas turbines (GT) and one or two steam turbines (ST) are operated as the base power generation units.




(Source: Data obtained from OETC)

**Figure 4- 6 Power Generation Pattern in MIS System**
**(From Sep 17 (Sat) to Sep 23 (Fri) in 2011))**



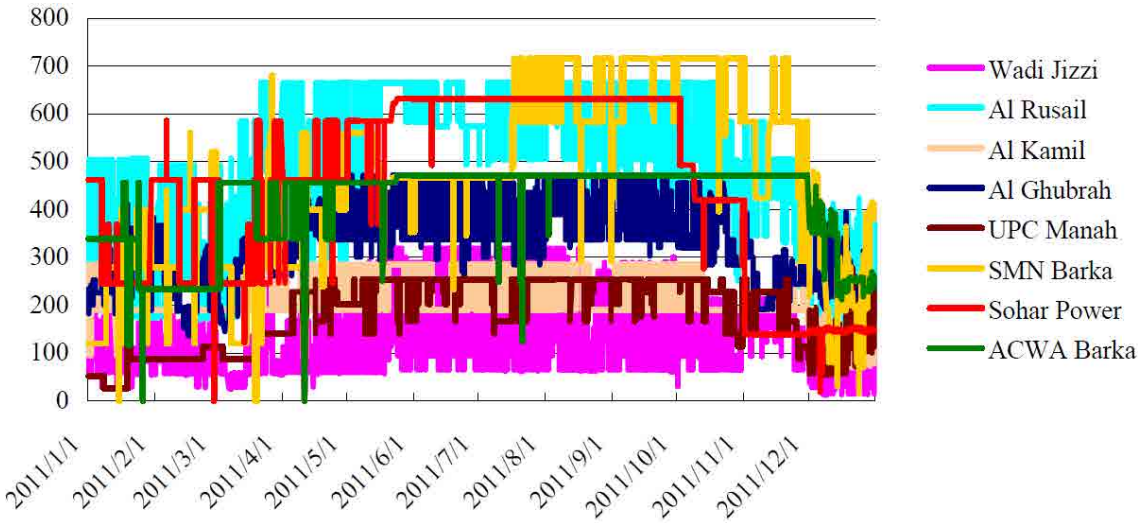

(Source: Data obtained from OETC)

**Figure 4- 7 Power Generation Pattern in MIS System**
**(From Dec 17 (Sat) to Dec 23 (Fri) in 2011))**

For example, given that the total amount of the generation capacity of the three of the combined cycle power stations are capable of supplying power for the off peak power demand, it is expected that more economical operations can be realized by operating such high efficient units at a high operating level and stopping Ghubra, Rusail, Wadi Jizzi and Al Kamil that have

open cycle gas turbine generators. However, some units of each power station have to be stopped for the annual inspections for maintenance of its machinery during the off-peak period of time and all the units of each power station cannot be stopped due to the constraints of power transmission such as avoiding the voltage drops around the power stations or keeping the amount of power flow within its allowable ranges under the transmission capacity. Thus, the operation pattern is not an exact economic operation from the viewpoints of generation costs.

The figure below illustrates the generation operation records in 2011. The changes in power outputs of Barka I and Sohar that are combined cycle power stations are small as mentioned before and not so much for several months. On the other hand, the changes in power outputs of Ghubra, Rusail, Wadi, Jizzi and Kamil are very large and they are operated as peak power generations.




(Source: Data obtained from OETC)

**Figure 4- 8 Annual Power Operation Record of Each Power Station in 2011**

### 4.2.5 Power Generation Plan

The power generation plan in the MIS system by OPWP is listed in the table shown below. Among the contracted capacities, the contract with Ghubra will be terminated in 2017. Al Lamil and Barka I will be terminated in 2016 and 2017 respectively, however, their contracts are expected to be renewed. Sohara and BakraIII will start their new units in 2012 to 2013. The Sur power station is now being constructed from 2013 to 2014 successively

**Table 4- 4 Power Generation Plan in MIS System**

| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|
| **Current Contracted Capacity** | | | | | | | |
| Ghubrah | 475 | 325 | 235 | 235 | 235 | 235 | - |
| Rusail | 687 | 687 | 687 | 687 | 687 | 687 | 687 |
| Wadi Al Jizzi | 325 | 245 | 245 | 157 | 157 | 157 | 157 |
| Manah | 273 | 273 | 273 | 273 | 273 | 273 | 273 |
| Al Kamil | 297 | 282 | 282 | 282 | 282 | - | - |
| Barka I | 450 | 435 | 435 | 435 | 435 | 435 | - |
| Sohar I | 600 | 590 | 590 | 590 | 590 | 590 | 590 |
| Barka II | 710 | 679 | 679 | 678 | 678 | 678 | 678 |
| Sohar II | 495 | 745 | 742 | 740 | 739 | 738 | 738 |
| Barka III | 495 | 745 | 742 | 740 | 739 | 738 | 738 |
| Sur | - | 433 | 2000 | 1992 | 1988 | 1985 | 1983 |
| **Sub Total** | **4807** | **5439** | **6910** | **6809** | **6803** | **6516** | **5844** |
| **Prospective Contracted Capacity** | | | | | | | |
| *Prospective Contract Extensions* | | | | | | | |
| Wadi Al Jizzi | - | 80 | 80 | 168 | 168 | 168 | 168 |
| Al Kamil | - | 15 | 15 | 15 | 15 | 297 | 297 |
| Barka I | - | 15 | 15 | 15 | 15 | 15 | 450 |
| Sohara I | - | 10 | 10 | 10 | 10 | 10 | 10 |
| **Sub Total** | **-** | **120** | **120** | **208** | **208** | **490** | **925** |
| Temporary Diesel | 300 | - | - | - | - | - | - |
| Solar Project(s) | - | - | - | - | 200 | 200 | 200 |
| **Total Contracted Capacity** | **5107** | **5559** | **7030** | **7017** | **7211** | **7206** | **6969** |
| **Contingency reserves** | | | | | | | |
| *Agreements for temporary reduction of Desalination Water Production* | | | | | | | |
| Barka II | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| *Reserve Sharing Agreements* | | | | | | | |
| PDO Interconnection | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| Abu Dhabi Interconnection | 200 | 200 | 200 | 400 | 400 | 400 | 400 |
| *Surplus Generation Agreements* | | | | | | | |
| Sohar Aluminum Co. | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| Oman Refineries & Petrochemicals Co. | 15 | - | - | - | - | - | - |
| Oman Mining Co. | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Oman Cement Co. | 0-5 | 0-5 | 0-5 | 0-5 | 0-5 | 0-5 | 0-5 |
| Oman India Fertilizer Co. | 0-5 | 0-5 | 0-5 | 0-5 | 0-5 | 0-5 | 0-5 |
| Ministry of Defence | 0-5 | 0-5 | 0-5 | 0-5 | 0-5 | 0-5 | 0-5 |
| **Sub Total** | **635** | **620** | **620** | **820** | **820** | **820** | **820** |
| **Total** | **5742** | **6179** | **7650** | **7837** | **8031** | **8026** | **7789** |

(Source: OPWP's 7-Year Statement (2012-2018))

The power generation plan in the MIS system by the Salalah system is listed in the table shown below. The Raysut New power station is operated by DPC. It has a Concession Agreement with OPWP and eight of its open cycle gas turbine units, the total amount of them is 256 MW, will start operations and continue up to 2023. At the same location, Ratsult A&B diesel power station (Twelve diesel units operated and their total capacity is 55 MW). However, they are scheduled to be abolished in 2012.

**Table 4- 5 Power Generation Plan in Salalah System**

| Total Power Generation Resources - Salalah System | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** |
| **Contracted Capacity** | | | | | | | |
| Raysut New Power Station | 256 | 256 | 256 | 256 | 256 | 256 | 256 |
| Salalah IWPP | 445 | 445 | 445 | 445 | 445 | 445 | 445 |
| **Prospective Contracted Capacity** | | | | | | | |
| New Salalah I(W)PP2 | - | - | - | - | 200-400 | 200-400 | 200-400 |
| **Sub Total** | **701** | **701** | **701** | **701** | **901-1101** | **901-1101** | **901-1101** |
| **Reserve Sharing Agreement** | | | | | | | |
| PDO Interconnection | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| **Total** | **801** | **801** | **801** | **801** | **1001-1201** | **1001-1201** | **1001-1201** |

（Source: 7-Year Statement (2012-2018), OPWP）

The planned capacities of power generation in each system are shown below. The power generation will be operated as gas and combined cycle power stations and diesel power generation has not been planned in the MIS system from 2012 and in the Salalah system from 2013. The renewable energy planned in the MIS system is the solar power station.

**Table 4- 6 Planned Capacities of Power Generation in Each System**

**MIS**

| Year | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** |
|---|---|---|---|---|---|---|---|
| Diesel TPP | 300 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gas TPP | 2,407 | 2,242 | 2,152 | 2,152 | 2,152 | 2,152 | 1,917 |
| Gas Combined Cycle TPP | 2,775 | 3,677 | 5,238 | 5,225 | 5,219 | 5,214 | 5,212 |
| Renewable Energy | - | - | - | - | 200 | 200 | 200 |
| Interconnection | 260 | 260 | 260 | 460 | 460 | 460 | 460 |
| Total | 5,742 | 6,179 | 7,650 | 7,837 | 8,031 | 8,026 | 7,789 |

*(Source: OPWP's 7-Year Statement(2012-2018) & information from OPWP)*

**Salalah**

| Year | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** |
|---|---|---|---|---|---|---|---|
| Diesel TPP | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gas TPP | 256 | 256 | 256 | 256 | 256 | 256 | 256 |
| Gas Combined Cycle TPP | 445 | 445 | 445 | 445 | 845 | 845 | 845 |
| Renewable Energy | - | - | - | - | - | - | - |
| Interconnection | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Total | 801 | 801 | 801 | 801 | 1,201 | 1,201 | 1,201 |

*(Source: OPWP's 7-Year Statement(2012-2018))*

**REACO**

| Year | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** |
|---|---|---|---|---|---|---|---|
| Diesel TPP | 247 | 244 | | | | | |
| Gas TPP | - | - | | | | | |
| Gas Combined Cycle TPP | - | - | | | | | |
| Renewable Energy | - | - | | | | | |
| Interconnection | - | - | | | | | |
| Total | 247 | 244 | | | | | |

*(Source: RAECO 3 Years Capability Statement 2011-2013)*

Power system plan of PETC in 2015 is shown below.

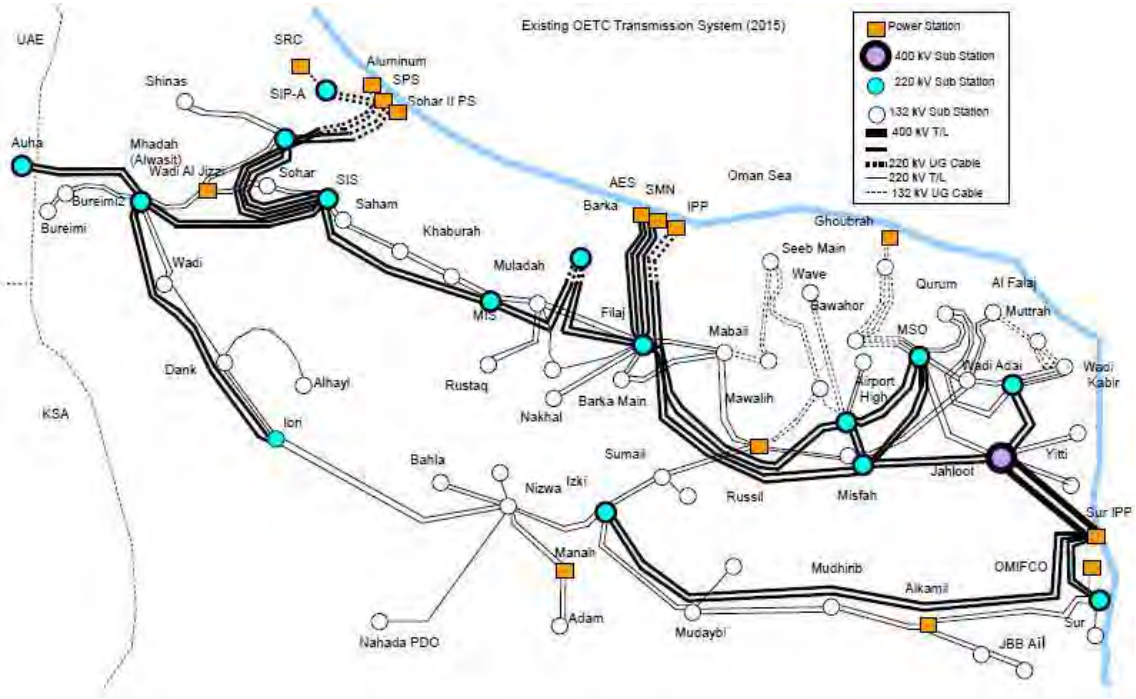



**Figure 4- 9 Power System Plan of OETC (2015)**

### 4.2.6 Overview of Distribution System

(1) Distribution System

(a) Overview

Most of the distribution lines of Oman are overhead lines, and most of the underground cables are constructed in the urban region. The distribution companies are in charge of the operations, maintenance, management of facilities which are from primary substations (33 kV/11 kV) to the demand sides, and the primary substations are supplied electricity by the transmission company (OETC except for DPC). The electricity transformed 33 kV to 11 kV at primary substations are transferred to distribution substations, which transform 11 kV to the 3-phase 4-wire 415/240 V, and then the electricity is distributed to demand sites. In case it is not appropriate to apply an 11 kV network because of a low demand region, electricity is directly transformed from 33 kV to a low voltage with 33/0.433kV transformers.

The 11 kV feeders emanating from the 33/11 kV primary substations are the overhead lines feeding the distribution transformers. These 11 kV feeders are normally operated as radial feeders, with open points selected for the ease of operational access to minimize customer minutes lost. The interconnection between the feeders forms the same primary substation or from different substations through RMU (Ring Main Unit), ABS (Air Break Switch) and Open Jumpers are the normal practice.

The distribution facilities of Oman need to meet OES (Oman Electrical Standards).

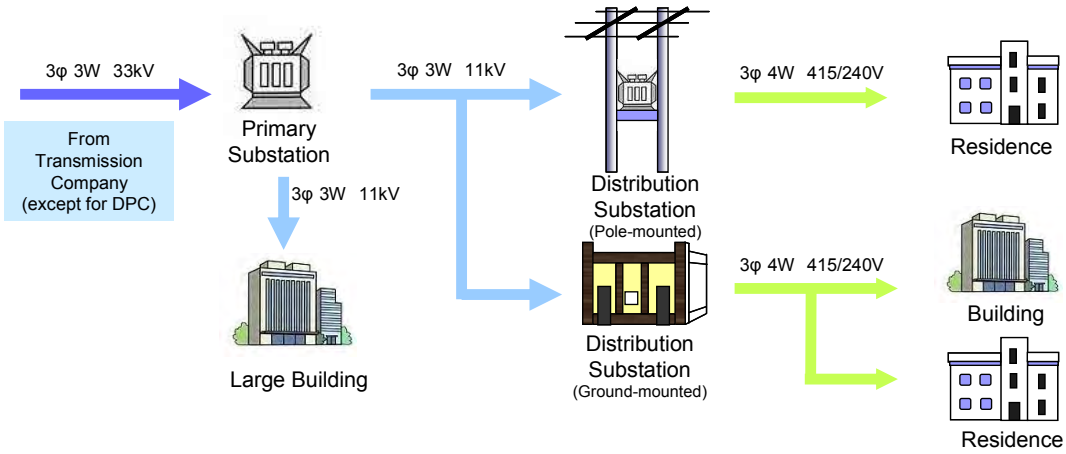



**Figure 4- 10 Overview of Distribution System of Oman**

(b) Primary Substation

Primary Substations are of two types, namely the indoor type and outdoor type. The outdoor primary substations are installed in the region where demand is normally less than 12MVA. The indoor primary substations are 2 x 10 MVA, 2 x 16MVA, and 2 x 20 MVA with 33 kV outdoor/indoor circuit breakers and 14 panels 11 kV indoor switchgear. The majority of primary substations are of the standard two transformer type with two separate 33 kV and 11 kV busbars. The normal practice is to supply each primary substation with two 33 kV feeders; each feeder is feeding one transformer and serves as an alternative supply for the whole substation in case the other feeder fails. In some cases where demand is much less than the capacity of two transformers, primary substations with only one 33/11 kV transformer are installed. Primary substations are monitored and controlled remotely with SCADA (Supervisory Control And Data Acquisition), and unmanned.

The transformers installed at the primary substations are of two types, a 33/11 kV transformer and a 33/0.433 transformer which are used in the rural region. The ratings in use are 1, 3, 6, 10 and 20 MVA. The 1, 3, 5 and 6 transformers are equipped with Off Load Tap Changers, whereas 10 and 20 MVA transformers are equipped with On Load Tap Changers.

The smallest rating of the 33/0.433 kV transformer in use is kVA and the highest is 1,000 kVA.


**(a) Aspect of Primary Substation**

**(b) Capacitor Bank**

**(c) 33/11 kV Transformer**

**(d) 11 kV Switchgear**

**Figure 4- 11 Primary Substation (2 x 20 MVA) (DPC)**

(c) Distribution Substation

Distribution Substations are of two types, ground-mounted and pole-mounted. For ground-mounted distribution substations, normally one transformer of rated capacity 500 kVA or higher are used, whereas those transformers with ratings less than 500 kVA are installed on H-Pole structures. Both types of substations are fed from the 11 kV feeders either directly with jumpers (Pole-Mounted) or through 11 kV cables (Ground-Mounted). Expulsion fuses are used to protect both types of substations on the high voltage side and HRC fuses on the low voltage side. Some distribution companies are going to implement smaller ratings, namely 25 kV and 50 kV to minimize transformer losses.

**(a) Ground-Mounted (5 x 1MVA)** **(b) Pole-Mounted (315 kVA)**

**Figure 4- 12 Distribution Substations (DPC)**

(d) 11 kV Overhead Lines

ACSR (Aluminum Cable Steel Reinforced) with conductor sizes of 100 $mm^2$ and 150 $mm^2$ on wooden poles are used for the 11 kV Overhead Lines.

**Figure 4- 13 11 kV Overhead Lines (MEDC)**

(e) 11 kV Underground Cables

11 kV underground cables are mainly used to connect overhead lines with primary substations, connect some distribution substations with overhead lines, road crossing situations and in urban areas and towns where overhead lines cannot be installed. The standard sizes commonly in use are 50 $mm^2$, 70 $mm^2$, 120 $mm^2$, 185 $mm^2$ and 240 $mm^2$ copper XLPE (Cross-Linked Polyethylene Insulation) three-core cables.

(f) Low Voltage System

Low voltage systems are single 3 phase 4-wire systems, and of two types, overhead lines on 9 meter wooden poles and underground cables. Concerning overhead lines, the new main lines are constructed using insulated conductors of 120 $mm^2$, 185 $mm^2$ and 200 $mm^2$ according to the load although 95 $mm^2$ are still in use. Underground cables used the connection between the distribution substations and the overhead lines, and between the overhead lines and the customers. The conductor sizes of the underground cables are 1 x 630 $mm^2$, 4-core 120 $mm^2$, 4-core 150 $mm^2$, 4-core 185 $mm^2$ and 4-core 240 $mm^2$.

**Figure 4- 14 Overhead Low Voltage Lines (DPC)**

### 4.2.7 Current Status of Existing Electricity Meters

(1) Current Status of Existing Electricity Meters

The electricity meters are of three types, a single phase electromagnetic meter, a 3-phase 4-wire electromagnetic meter, and a 3-phase 4-wire electromagnetic meter with current transformers, which are standardized Oman Electrical Standards (OES)-22. Most of the meters in use are 3-phase 4-wire electromagnetic meters. The accuracy of the electricity meters is Class 2. Originally, electricity meters were installed indoors. However, in light of having to have customers present during the meter reading and the increased possibility of tampering, installation locations are being moved from indoors to outdoors. In addition, electricity meters are being installed in the electrical rooms of the buildings for rent.

In Oman, there is no periodical inspection system of electricity meters following installation. Only when customers raise doubts or feelings of inaccuracy in the meter reading do the distribution companies inspect the meters. In this manner, there are many meters that have not been inspected for a long time, and distribution companies are unable to grasp the accuracy of the meters. Electromagnetic meters used for a long time tend to indicate less than their true values, consequently, their errors may affect distribution losses.

Recently, in order to reduce non-technical losses and to increase operational efficiency, some distribution companies are planning or are implementing a pilot project to introduce electricity meters which have an automatic monitoring function.

(a) Residential Electricity Meter and Distribution Board

(b) Electricity Meters in Building for Rent

**Figure 4- 15 Example of Installation of Electricity Meters**

**Table 4- 7 Specification of the Electricity Meter of Oman**

| | | Current | Voltage | Frequency | Accuracy | Maximum Ambient Temperature |
|---|---|---|---|---|---|---|
| Single Phase | | 20-100 A | 240 V | 50Hz | Class 2 | 50 Deg. C |
| Three Phase | 100A | 20-100 A | 3 phase 4 wire 415V | 50Hz | Class 2 | 50 Deg. C |
| | 50A | 20-50 A | 3 phase 4 wire 415V | 50Hz | Class 2 | 50 Deg. C |
| Three Phase with current transformers | | 200 A, 300 A, 400 A | 3 phase 4 wire 415V | 50Hz | Class 2 | 50 Deg. C |

(Source: Oman Electrical Standards)

(2) Status of Introduction of Smart Meters (including simple digital meters)

(a) Status of Introduction of Smart Meters

The status of introduction of smart meters for each company is as follows.

- **MEDC**

MEDC has already installed digital meters at 2,000 customer locations, that are ranked higher than their consumption, and their demand occupies 50% of the total demand of MEDC. Some digital meters have communication modems to enable remote metering, and also have a function that records consumption for 12 months to support the TOU tariff.

In addition, MEDC has also installed prepaid meters at 50 low voltage customers. Also, these prepaid meters have in-house displays, and the customers are able to check yesterday's consumption. The customers tend to prefer the prepaid type to the postpaid type. The prepaid meter will be fully installed from now on.

- **MZEC**

MZEC had installed digital meters with a communication function on the pilot project, however, after finishing the project, the communication equipment was removed, and only the digital meters remained. Currently, the digital meters are installed at 80% of the industrial customer sites. The rate of the digital meters installation for residences and commercial enterprises is approx. 7 %.

- **MJEC**

MJEC has been replacing old conventional meters to new digital meters for customers whose contract capacity exceeds 60 kW. This digital meter has a function that enables

customers to check their own electricity consumption.

- **RAECO**

RAECO has conducted a pilot project of the smart meters in Masirah Island. PLC (Power Line Communication) is used for communications between the concentrator and the meters are PLC, but it is needed in order to manually read the concentrated meter data at the concentrator because GPRS (General Packet Radio Service) is not available there.

- **DPC**

DPC hasn't installed smart meters yet.

(a) Digital Meter with Communications for High Voltage Customers

(b) Digital Meter with Communications at the secondary side of DSS

**Figure 4- 16 Examples of Installation of Digital Meters with Communication (MEDC)**

(a) Prepaid Meter in Electrical Room

(b) In-house Display

**Figure 4- 17 Examples of Installation of Prepaid Meters (MEDC)**

(b) Smart Meter Installation Issues

Distribution companies (MEDC, MZEC, MJEC) and RAECO have already installed smart meters (including digital meters) for the purpose of reduced distribution losses and fair billing. However, a recent study has been conducted by each company from an independent perspective and the sharing of knowledge obtained from the pilot project is insufficient. Smart meter specifications should be standardized from the knowledge obtained from the pilot study.

AER has already published the specifications of the body of the meter, but the specifications of the system are still insufficient (e.g. related devices, servers). The equipped functions also need to be clarified. Oman Electricity standards of not only the meter body, but other related devices, servers and functions should be defined until the full scale spread

period.

### 4.2.8 Electricity Consumption

(1) Historical Trend of Electricity Sales by Company

The historical trend of electricity sales by company (2007-2010) is shown below. MEDC alone accounts for about 40 %, and the sum of three distribution companies in the MIS area (MEDC, MJEC and MZEC) comprises more than 80 % of electricity consumption in the whole country respectively.

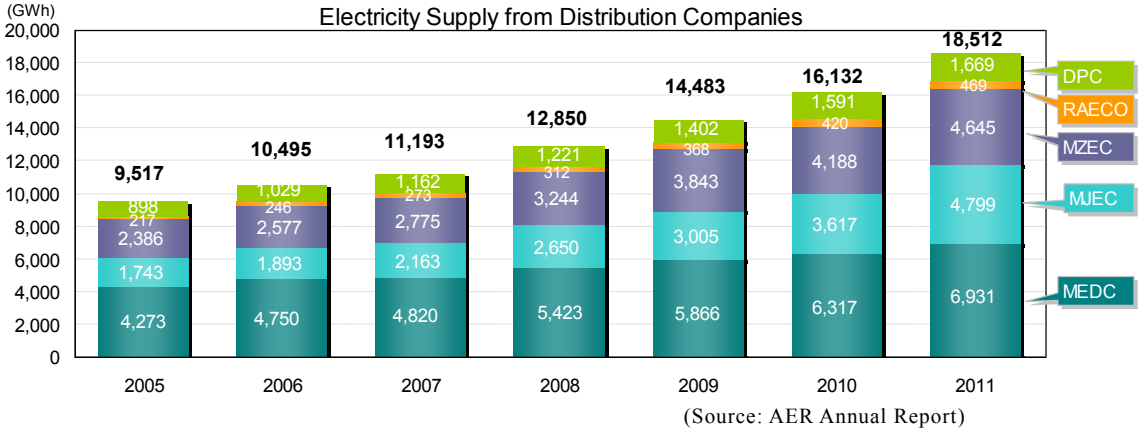



**Figure 4- 18 Historical Trend of Electricity Sales by Company (2007-2011)**

(2) Electricity Sales by Customer Category

Electricity sales per customer category are shown below. Electricity sales in the residential sector occupy more than 50 %, followed by the commercial and government sectors. The historical trend over the past several years has witnessed an approximate 10% p.a. power demand growth

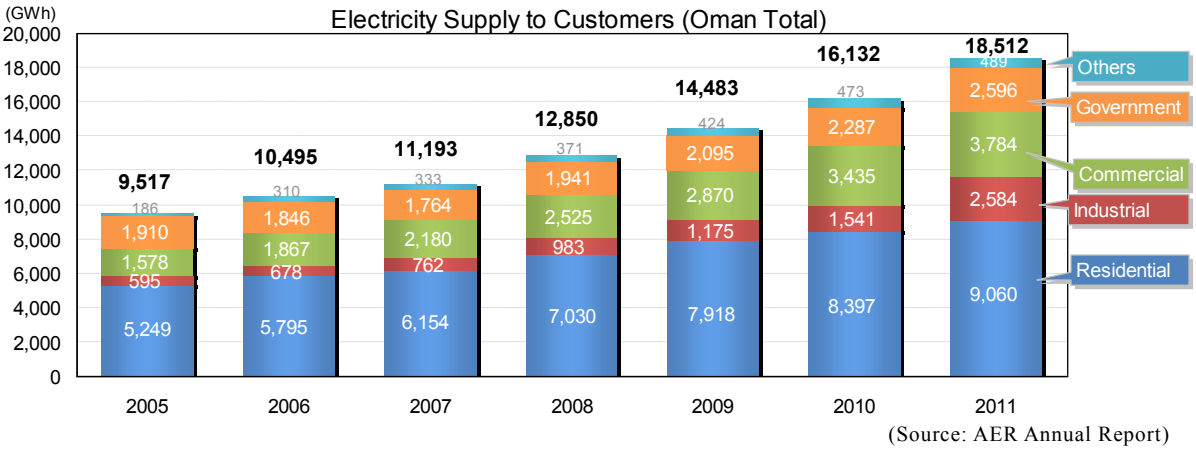



**Figure 4- 19 Electricity Sales by Customer Category**

(3) Number of Customers and Electricity Consumption per Customer

The following figure shows the customer sales by company and category. The data shows that:

- Electricity consumption per customer in the industrial sector is high, especially in cities such as Majan and DPC.
- Electricity consumption per customer in the residential and government sector in Muscat is large.

**Table 4- 8 Number of Customers and Electricity Consumption per Customer (2010)**

| | | | Number of Customer (as of end of FY) | Electricity Sales (MWh) | Annual Electricity Consumption by Customer |
|---|---|---|---|---|---|
| | | | 2010 | 2010 | 2010 |
| Main System (MIS) | Muscat | Residential | 158,271 | 3,144,671 | 19.87 |
| | | Industrial | 184 | 409,122 | 2,223.49 |
| | | Commercial | 41,369 | 1,711,242 | 41.37 |
| | | Agriculture& Fisheries | 135 | 3,134 | 23.21 |
| | | Hotels & Tourism | 0 | 0 | - |
| | | Government | 6,460 | 1,010,469 | 156.42 |
| | | Ministry of Defence | 94 | 38,228 | 406.68 |
| | | Area Total | 206,513 | 6,316,866 | 30.59 |
| | Majan | Residential | 108,005 | 1,728,788 | 16.01 |
| | | Industrial | 155 | 732,676 | 4,726.94 |
| | | Commercial | 24,034 | 706,569 | 29.40 |
| | | Agriculture& Fisheries | 2005 | 69,267 | 34.55 |
| | | Hotels & Tourism | 276 | 9,975 | 36.14 |
| | | Government | 6,811 | 352,050 | 51.69 |
| | | Ministry of Defence | 19 | 17,200 | 905.26 |
| | | Area Total | 141,305 | 3,616,524 | 25.59 |
| | Mazoon | Residential | 196,620 | 2,712,824 | 13.80 |
| | | Industrial | 72 | 64,390 | 894.31 |
| | | Commercial | 38,870 | 670,514 | 17.25 |
| | | Agriculture& Fisheries | 2064 | 114,423 | 55.44 |
| | | Hotels & Tourism | 23 | 8,346 | 362.87 |
| | | Government | 11,565 | 563,420 | 48.72 |
| | | Ministry of Defence | 38 | 54,276 | 1,428.32 |
| | | Area Total | 249,252 | 4,188,194 | 16.80 |
| | MIS Total | Residential | 462,896 | 7,586,283 | 16.39 |
| | | Industrial | 411 | 1,206,188 | 2,934.76 |
| | | Commercial | 104,273 | 3,088,326 | 29.62 |
| | | Agriculture& Fisheries | 4204 | 186,824 | 44.44 |
| | | Hotels & Tourism | 299 | 18,321 | 61.27 |
| | | Government | 24,836 | 1,925,939 | 77.55 |
| | | Ministry of Defence | 151 | 109,704 | 726.52 |
| | | Area Total | 597,070 | 14,121,584 | 23.65 |
| Rural Systems | RAECO | Residential | 15,552 | 209,883 | 13.50 |
| | | Industrial | 17 | 6,080 | 357.65 |
| | | Commercial | 3,594 | 61,588 | 17.14 |
| | | Agriculture& Fisheries | 180 | 12,861 | 71.45 |
| | | Hotels & Tourism | 22 | 12,159 | 552.68 |
| | | Government | 2,257 | 105,429 | 46.71 |
| | | Ministry of Defence | 40 | 12,103 | 302.58 |
| | | Area Total | 21,662 | 420,103 | 19.39 |
| Salalah System | DPC | Residential | 44,652 | 600,543 | 13.45 |
| | | Industrial | 53 | 328,365 | 6,195.57 |
| | | Commercial | 10,447 | 289,849 | 27.74 |
| | | Agriculture& Fisheries | 83 | 9,896 | 119.23 |
| | | Hotels & Tourism | 82 | 2,833 | 34.55 |
| | | Government | 3,526 | 255,600 | 72.49 |
| | | Ministry of Defence | 93 | 103,727 | 1,115.34 |
| | | Area Total | 58,936 | 1,590,813 | 26.99 |
| Total Oman | | Residential | 523,100 | 8,396,709 | 16.05 |
| | | Industrial | 481 | 1,540,633 | 3,202.98 |
| | | Commercial | 118,314 | 3,435,005 | 29.03 |
| | | Agriculture& Fisheries | 4467 | 209,581 | 46.92 |
| | | Hotels & Tourism | 403 | 33,313 | 82.66 |
| | | Government | 30,619 | 2,286,967 | 74.69 |
| | | Ministry of Defence | 284 | 225,534 | 794.13 |
| | | Total | 677,668 | 16,132,499 | 23.81 |

(Source: AER)

### 4.2.9 Street Lighting

(1) Street Lighting Power Demand in Oman

Electrical power demand in different sectors in Oman shows that street lighting accounts for 0.6 %.

Given that street lighting constantly consumes electricity throughout the night, common energy saving solutions can be adopted for the whole country. The following table shows the breakdown of power demand and the power consumption of street lighting.

**Table 4- 9 Breakdown of Power Demand by Sector**

| Sector | Annual Electricity Consumption in 2010 [GWh] | Share [%] |
|---|---|---|
| Agriculture & Fishery | 210 | 1.1 |
| Industry | 1,540 | 8.1 |
| Commercial & Services | 3,470 | 18.2 |
| Government & Publics | 2,390 | 12.5 |
| Street Lighting | 120 | 0.6 |
| Residential | 8,400 | 44.0 |
| T/D Loss | 2,940 | 15.4 |
| Total | 19,070 | 100.0 |

(Source: AER and Power Companies in Oman)

**Table 4- 10 Power Consumption of Street Lighting in the Whole Country**

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2010/2005 |
|---|---|---|---|---|---|---|---|
| MEDC | 33.4 | 32.7 | 31.3 | 32.2 | 35.5 | 43.6 | 5.5 % |
| MZEC | 12.2 | 15.5 | 16.1 | 21.2 | 20.7 | 23.8 | 14.3 % |
| MJEC | 12.0 | 17.0 | 20.0 | 26.3 | 31.3 | 39.8 | 27.1 % |
| DPC | 0.5 | 1.5 | 1.0 | 1.3 | 3.9 | 4.6 | 55.9 % |
| RAECO | 3.5 | 5.7 | 6.7 | 7.5 | 8.1 | 8.2 | 18.6 % |
| Total | 61.6 | 72.4 | 75.1 | 88.5 | 99.5 | 120.0 | 14.3 % |

(Source: Power Companies in Oman)

(2) Street Lighting Installation Standards in Oman

Oman has standards for street lighting installation. However, Muscat Municipality, Sohar Municipality, and Dhofar Municipality have their own standards which define planning, design, construction, inspection and maintenance. As for the other municipalities, the Ministry of Regional Municipalities and Water Resources (MRMWR) have their own standards. Each organisation's jurisdiction and power companies are shown in the following table.

**Table 4- 11 Jurisdiction and Power Companies in Oman**

| Organisation | Jurisdiction | Power Company |
|---|---|---|
| Muscat Municipality | Muscat | MEDC |
| Sohar Municipality | Sohar | MJEC |
| Dhofar Municipality | Dhohar | DPC |
| MRMWR | Other Municipalities | MZEC, RAECO |

(3) Comparison of Standards

A comparison among international standards, Japanese standards and Oman standards is made in this section. As a result, the following points were clarified.

- MRMWR prescribed average brightness levels are two times the levels prescribed in Japan.
- As it is important to secure a degree of uniformity in street lighting, there is no variation in the spacing of the light installations. So the lighting lamp output is necessarily large and as a result power consumed by lighting is also large.
- Regarding installation locations, the lighting is basically installed continuously on principle roads in Oman. It is assumed that this standard was set up in consideration of serious traffic accidents in Oman.

**Table 4- 12 Comparison of Standards of Street Lighting**

| Country | | International | | Japan | | Oman | | | |
|---|---|---|---|---|---|---|---|---|---|
| Jurisdiction | Organization | Commission internationale de l'éclairage (CIE) | | Ministry of Land, Infrastructure, Transport and Tourism | | MRMWR | | Muscat Municipality | |
| | Area | Global | | All the country | | Other municipalities than Muscat, Sohar and Dhofar | | Muscat Municipality | |
| Standards | Name | Recommendations for the lighting of roads for motor and pedestrian traffic | | Installation standard of street lighting | | Installation standard of street lighting | | Installation standard of street lighting | |
| | Established by | CIE | | Ministry of Land, infrastructure, transport and tourism | | MRMWR | | CIE | |
| | Established year | 1977<br>Rev 1995<br>Rev 2010 | | 1967<br>Rev 1981<br>Rev 2007 | | 1980<br>Rev 2010 | | 1975<br>Rev 2000 | |
| | Contents | -Purpose<br>-Eyesight condition by driver<br>-Standard for traffic<br>-Requirement for traffic<br>-Street lighting for congestion point<br>-Lighting for pedestrian | | -Summary and definition of words<br>-Purpose<br>-Installation criteria and standard<br>-Lighting fixture detail<br>-Detail design<br>-Construction<br>-Inspection<br>-Maintenance | | -Lighting in all the roads<br>-Without any darkness | | -Purpose<br>-Eyesight condition by driver<br>-Standard for traffic<br>-Requirement for traffic<br>-Street lighting for congestion point<br>-Lighting for pedestrian | |
| Brightness level | General road Average brightness (cd/m2) | M1<br>M2<br>M3<br>M4<br>M5 | 2.0<br>1.5<br>1.0<br>0.75<br>0.5 | High way<br>Local road | 0.7-1.0<br><br>0.5-1.0 | Inter-change<br>Main road<br>Internal road<br>Service road | 2.0<br><br>2.0<br><br>2.0<br><br>1.0-1.5 | All | 4.0 |
| | Conflict area Average luminance (lux) | C0<br>C1<br>C2<br>C3<br>C4<br>C5 | 50<br>30<br>20<br>15<br>10<br>7.5 | Cross roads<br>Pedestrian Footpath | 10-20<br><br>10-20<br>5 | N/A | N/A | All | 60-70 |
| Uniformity ratio | L min/L ave | 0.4 | | 0.4<br>Footpath: 0.2 | | 0.4 | | 0.6 | |

- ✓ For high way, traffic volume and complexity of road shape
  High- M1, Normal-M2, Law-M3
- ✓ For high way, installation condition of signal, priority rule, sign, guidance, etc.
  Difficult to understand: M1, Easy to understand:M2
- ✓ For local road, installation condition of signal, priority rule, sign, guidance, etc.
  Difficult to understand: M2, Easy to understand:M3
- ✓ For local road to rural area and residence, installation condition of signal, priority rule, sign, guidance, etc.
  Difficult to understand: M4, Easy to understand:M5
- ✓ Cross road
  C(N)=M(N)
- ✓ Junction, cross roads, ramp, etc.
  C(N)=M(N)
- ✓ Rotary without signal,
  Complication and large: C1, middle complication: C2, simple: C3

**Table 4- 13 Comparison of Installation Standards of Street Lighting**

| Country | International | Japan | Oman | |
|---|---|---|---|---|
| Jurisdiction | Commission internationale de l'éclairage (CIE) | Ministry of Land, Infrastructure, Transport and Tourism | MRMWR | Muscat Municipality |
| | Global | All the country | Other municipalities than Muscat, Sohar and Dhofar | Muscat Municipality |
| Installation standards | Not described | <For highways, as continuous lighting><br>-Areas where building lighting near urban roads affects traffic<br><br><For highways, as local lighting><br>-Interchanges<br>-Toll gate areas<br>-Rest areas<br>-Areas with rapidly changing road widths, types<br>-Bridges<br><br><Local roads, as continuous lighting><br>-Areas where there are concerns about pedestrians crossing roads, and with heavy traffic and large numbers of pedestrians. (over 25,000 vehicles/day)<br>-Areas where there is a risk of vehicles leaving the lane and with large volumes of traffic<br>-Other than the above, areas where special conditions require continuous lighting<br><br><Local roads, as local lighting><br>-Particularly dangerous locations for night traffic<br>-Cross roads or pedestrian crossings<br>-Footpaths etc.<br>-Locations with rapid changes in road width and type<br>-Bridges<br>-Road sections connected to public facilities<br>-Rest facilities | All of road | All of road |

**Table 4- 14 Comparison of Dimming Standards of Street Lighting**

| Country | International | Japan | Oman | |
|---|---|---|---|---|
| Jurisdiction | Commission internationale de l'éclairage (CIE) | Ministry of Land, Infrastructure, Transport and Tourism | MRMWR | Muscat Municipality |
| | Global | All the country | Other municipalities than Muscat, Sohar and Dhofar | Muscat Municipality |
| Installation standards | In order to save energy, when the street lighting class changes to meet the changes in traffic volume, the appropriate higher or lower level road surface luminance, uniformity ratio and glare control should be sufficient. | <For continuous lighting><br>**1. Dimming method**<br>Reducing luminance, reduction in the number of light units is acceptable, it is necessary to avoid impacts to traffic safety given that the uniformity of the brightness will decrease<br>**2. Brightness level**<br>Brightness level could be reduced by half of the average road surface brightness, however minimum the brightness level should be 0.5 cd/m2<br>**3. Dimming periods**<br>Generally from evening till late at night, the conditions improve with the passage of time and the dimming is suitable for this time period.<br><br><For local lighting><br>**1. Dimming target**<br>Footpaths etc., interchanges and car park lighting<br>Except for crossroads and pedestrian crossings where there could be an impact on traffic safety<br>**2. Dimming method**<br>Reducing luminance, reduction of the number of light units is acceptable, it is necessary to avoid impact to traffic safety given that the brightness uniformity will decrease<br>**3. Dimming periods**<br>Generally from evening till late at night conditions improve with the passage of time and dimming is suitable for this time period. | Not described (In the future, the standards will be introduced) | Not described |

**Table 4- 15 Comparison of Lighting Fixture of Street Lighting**

| Country | | Japan | | Oman | | | |
|---|---|---|---|---|---|---|---|
| Jurisdiction | Organization | Ministry of Land, Infrastructure, Transport and Tourism | | MRMWR | | Muscat Municipality | |
| | Area | All the country | | Other municipalities than Muscat, Sohar and Dhofar | | Muscat Municipality | |
| Road type | | High way | Local road | Main road | Internal road | Main road | Internal road |
| Lighting fixture | Lamp type | -High pressure sodium vapor lamp<br>-Ceramic metal halide lamp | | -High pressure sodium vapor lamp | | -High pressure sodium vapor lamp | |
| | Lamp watt | 220-360W | 150-220W | 600W | 400W | 400-600W | 250-70W |
| | Lamp life | 24,000 h | 12,000-24,000 h | 24,000 h | 24,000 h | 24,000 h | 24,000 h |
| | Pole length | 12-14m | 6-10m | 16m | 10m | 10-25m | 4-8m |
| | Installation distance | 40m | 20-40m | 80m | 70m | 40-125m | 25-40m |
| Lighting control | Method | -Program schedule timer<br>-Photoelectric sensor control | | -Schedule timer | | -Program schedule timer | |
| | Installation of dimming | There are some introduction examples | | There is not introduction example, there is plan of installation | | There is not introduction example, there is plan of installation | |

Main Road in Central Muscat

Main Road in the Suburbs of Muscat

Main Road between Muscat and Nizwa

Main Road between Muscat and Nizwa

**Figure 4- 20 Oman Street Lighting**

(4) Introduction of Japanese Standards and Technology in Street Lighting (Reference)

(a) Japanese Standards for Street Lighting Installation

Regarding the Japanese standards for street lighting installations, the Japan Road Association publishes "Guidelines on Street Lighting Installation Standards" which provides clear explanations of the purpose, installation criteria and installation locations for street lighting. These guidelines are based on the standards issued by the Ministry of Land, Infrastructure, Transport and Tourism. The planning, design, construction, inspection and maintenance are implemented based on these standards and guidelines.

These standards and guidelines prescribe brightness levels of 0.7-1.0 cd/$m^2$ for highways and 0.5-1.0 cd/$m^2$ for general roads, which are low to mid-level in comparison with the regulations set forth in the global standards of the Commission international de l'eclairage (CIE).

With regards to installation locations, detailed provisions are provided for locations where continuous lighting or local lighting is required. However, based on the latest standards, continuous lighting was not installed on the recently constructed New Tomei highway or other local highways, and only local lighting was installed to secure the minimum brightness required for traffic safety, resulting in low costs and energy savings.

(b) EE&C Technology for Street Lighting in Japan

Energy saving dimmable light fixtures has been introduced in certain parts of Japan to cut levels of brightness at night. However, the Ministry of Land, Infrastructure, Transport and Tourism recently issued "Guidelines on the introduction of LED and tunnel lighting", and many LED street light fixtures have been developed and introduced. LED street light fixtures not only offer about 45 % energy savings in comparison to the high pressure sodium (HPS) light fixtures and the ceramic metal halide (CMH) light fixtures commonly used at present, but there is also the advantage of lower maintenance costs as they last 2.5 times longer. LED fixtures also have excellent dimming capabilities, so dimmable LED street light fixtures can be used to reduce the brightness to the required minimum at night to achieve further energy savings.

| Group | A | B | C | D |
|---|---|---|---|---|
| Fixture |  |  |  |  |
| Lamp type | Mercury lamp | High pressure sodium vapor lamp | Ceramic metal halide lamp | LED |
| Efficiency | 55 lm/W | 114 lm/W | 114 lm/W | 70-80 lm/W |
| Power consumption | 470 W | 285 W | 285W | 158W |
| Lamp life | 12,000 h | 24,000 h | 24,000 h | 60,000 h |
| Reduce illuminance | Possible | Possible | Possible | Possible |

(Source: Iwasaki Electric Website)

**Figure 4- 21 EE&C Technology Adopted in Japan**

(5) Applicable Technology for Oman

Based on interviews with MRMWR and Muscat Municipality, it was found that studies of the applicability of the following two technologies had been implemented.

- Adoption of dimmable energy saving light fixtures at night.
- Adoption of LED street light fixtures.

In particularly, a pilot scheme is underway for the introduction of LED street light fixtures in the Muscat Municipality. 10 LED units have been installed and are currently under evaluation.

Regarding practical energy saving measures, the Muscat Municipality is using a programmable timer which is recorded during the sunrise and sunset and efforts are being made to reduce waste lighting as much as possible.

## 4.3 Electricity Tariff

### 4.3.1 Overview of the Electricity Tariff System in Oman

In the electric power sector in Oman, each of the functions such as generation, transmission and distribution are operated separately by different entities, and tariffs to recover the costs are set for each of the functions. In setting these tariffs, approval of Authority for Electricity Regulation (AER), which is the regulatory body for electric power industry in Oman, is required.

- Bulk Supply Tariff
  Power generation wholesale tariff, for which Oman Power and Water Procurement Company (OPWP) charges to licensed suppliers (distribution companies). Power generation costs shall be recovered by end-consumers in the end as a part of retail tariffs.
- Transmission Use of System Charges
  Power transmission tariff, for which Oman Electricity Transmission Company (OETC) charges to licensed suppliers (distribution companies) and OPWP (in the case of power exports). Power transmission costs shall also be recovered by end-consumers in the end as a part of the retail tariff (except for the case of power exports).
- Permitted Tariff
  Retail tariff, for which licensed suppliers (distribution companies) such as MEDC, MZEC, MJEC, RAECO, DPC charge to their customers (end-consumers). In addition to power generation and transmission costs, their own costs of supply shall be recovered.

Prices where the OPWP procures generated electricity from power generation companies, factories with captive generators and power imports are set through the Power Purchase

Agreement (PPA). The PPA is a private contract and the prices are not directly regulated by AER, but because OPWP needs AER's approval in setting the Bulk Supply Tariff to recover the costs of power procurement, the OPWP needs to procure electricity for a reasonable price.

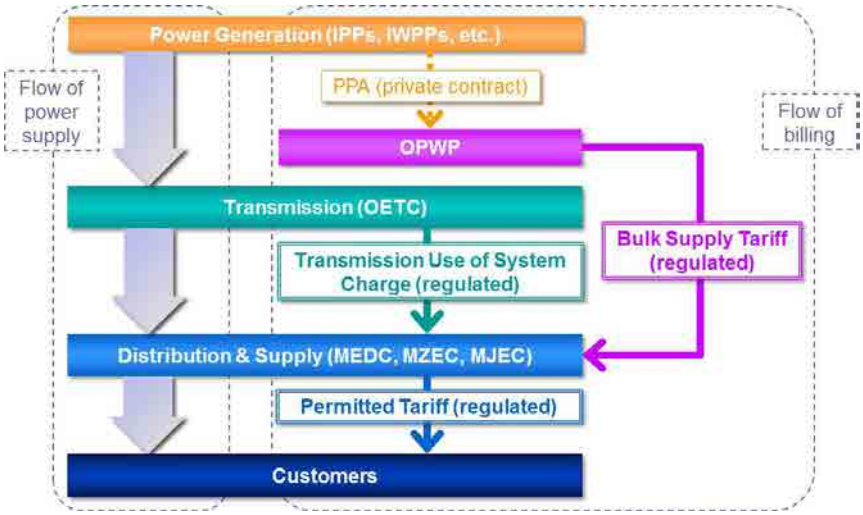



**Figure 4- 22 Flow of Power Supply and Flow of Billing (MIS Area)**

### 4.3.2 Power Generation Wholesale Tariff (Bulk Supply Tariff)

(1) Overview of Wholesale Electricity Tariff (Bulk Supply Tariff)

The Bulk Supply Tariff (BST), for which OPWP wholesales the generated electricity to licensed suppliers (distribution companies), is revised every year and is applied upon AER's approval.

BST consists solely of the energy charge per supplied electricity (MWh), i.e. a two-component tariff consisting of capacity charge (per MW) and energy charge is not adopted. Hence, the fixed part of power procurement costs also needs to be recovered by the energy charge.

Taking into account that the system load fluctuates by far among seasons and time-zones, the BST segments a year into six seasons by four time-zones in the MIS area and into six seasons by six time-zones in the Salalah area as follows, and different prices are set for each of them. Seasonal characteristics in parentheses are supplemented by the JICA Study Team.

- Seasonal segmentation in MIS area
  - January–March (winter: low-load season)
  - April (spring: intermediate season)
  - May–July (early summer: highest-load season)
  - August–September (late summer: high-load season)
  - October (autumn: intermediate season)
  - November–December (winter: low-load season)
- Time-zone segmentation in MIS area
  - Night-Peak: All days of the week, 00:00–02:00 and 22:00–24:00

- Off-Peak: All days of the week, 02:00–13:00 and 17:00–22:00
- Weekday Day-Peak: from Saturday to Thursday, 13:00–17:00
- Friday Day-Peak: Friday, 13:00–17:00

■ Seasonal segmentation in the Salalah area

- January–March (winter: low-load season)
- April (spring: intermediate season)
- May–June (early summer: highest-load season)
- July–August (late summer: intermediate season)
- September–October (autumn: high-load season)
- November–December (winter: low-load season)

■ Time-zone segmentation in Salalah area

- On-Peak Weekday: from Saturday to Thursday, 0:00–04:00 and 15:00–17:00
- On-Peak Friday: Friday, 0:00–04:00 and 15:00–17:00
- Off-Peak Morning: All days of week, 04:00–11:00
- Mid-Peak Weekday: from Saturday to Thursday, 11:00–15:00
- Mid-Peak Friday: Friday, 11:00–15:00
- Off-Peak Night: All days of week, 17:00–24:00

The following tables show the tariff rates of the BST in 2012 for the MIS area and Salalah area respectively. For the MIS area, the tariff rates in 2011 are indicated in parentheses. In the Salalah area, 2012 is the first year to implement BST.

**Table 4- 16 Bulk Supply Tariff in MIS Area (2012)** (RO/MWh)

| Month | Day | 0:00-02:00 (Night-Peak) | 02:00-13:00 (Off-Peak) | 13:00-17:00 (Day-Peak) | 17:00-22:00 (Off-Peak) | 22:00-24:00 (Night-Peak) |
|---|---|---|---|---|---|---|
| January-March | All days | 8 (7) | 8 (7) | 8 (7) | 8 (7) | 8 (7) |
| April | All days | 10 (8) | 10 (8) | 10 (8) | 10 (8) | 10 (8) |
| May-July | Sat-Thu | 14 (20) | 11 (8) | 55 (50) | 11 (8) | 14 (20) |
| | Friday | | | 17 (20) | | |
| August-September | Sat-Thu | 11 (15) | 10 (8) | 15 (35) | 10 (8) | 11 (15) |
| | Friday | | | 11 (15) | | |
| October | All days | 10 (8) | 10 (8) | 10 (8) | 10 (8) | 10 (8) |
| November-December | All days | 8 (7) | 8 (7) | 8 (7) | 8 (7) | 8 (7) |

Note: Numbers in ( ) indicate Bulk Supply Tariff in 2011

**Table 4- 17 Bulk Supply Tariff in Salalah Area (2012)** (RO/MWh)

| Month | Day | 0:00-04:00 (On-Peak) | 04:00-11:00 (Off-P Morning) | 11:00-15:00 (Mid-Peak) | 15:00-17:00 (On-Peak) | 17:00-24:00 (Off-P Night) |
|---|---|---|---|---|---|---|
| January-March | All days | 8 | 8 | 8 | 8 | 8 |
| April | All days | 11 | 10 | 11 | 10 | 11 |
| May-June | Sat-Thu | 55 | 11 | 15 | 55 | 14 |
| | Friday | 17 | | 14 | 17 | |
| July-August | All days | 10 | 10 | 10 | 10 | 10 |
| September-October | Sat-Thu | 14 | 10 | 11 | 11 | 11 |
| | Friday | 14 | | 11 | 11 | |
| November-December | All days | 8 | 8 | 8 | 8 | 8 |

(2) Formulation of BST (Logic of Time-zonal Pricing)

In formulating BST, the OPWP first forecasts the annual system load to calculate the costs of power procurement from IPPs, IWPPs and fuel costs and determines the total costs that need to be recovered in a year.

Then, based on the forecast of the annual duration curve (that rearranges hourly loads in a year in descending order), the short-run marginal costs are estimated, for capacity costs and energy costs respectively. The costs for the base-load generation, which runs constantly throughout the year, are allocated evenly for the whole year, whereas the costs for peak-load generation (including power purchases from captive generators etc.) are allocated exclusively to the hours when it operates.

The costs of supply that are allocated hourly are then aggregated into each time-zone, and the unit price of the BST can be formulated by dividing the aggregated costs by the total electricity supply for each time-zone. Because the peak hours in the summer assume exclusively the costs of power generation that only operates in these hours, the tariff rate in peak hours becomes higher than other time-zones. The sharper the peak in the duration curve becomes, the bigger the price gap between peak hours and off-peak hours.

Reflecting the load pattern of MIS that sees its peak load in early summer (especially in June), the highest rate is set on “Day-Peak” (13:00-17:00) from May to July.

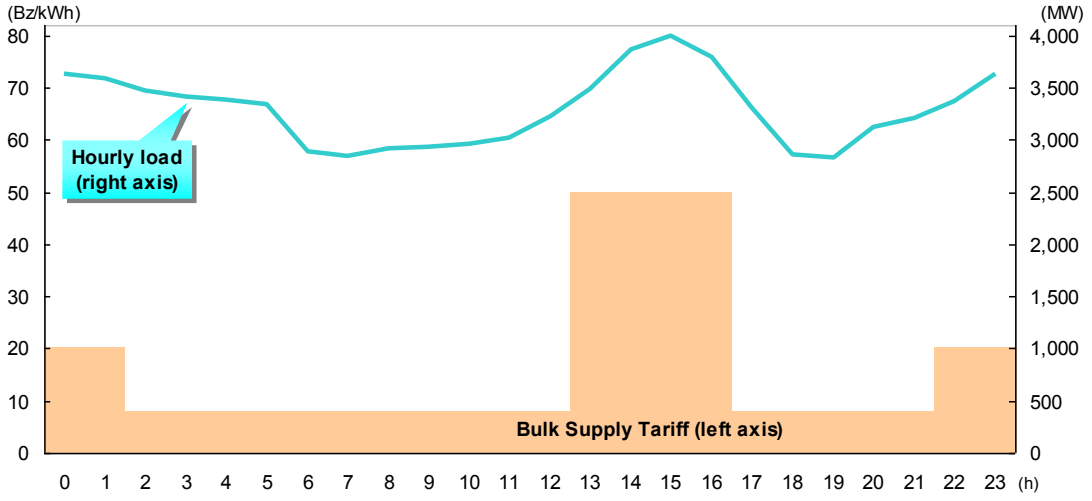



**Figure 4- 23 Load Curve and BST of MIS, 18th June 2011 (Peak Load of the Year)**

The following figure depicts the trend of the Bulk Supply Tariff of MIS in June from 2007 to 2012. It needs to be noted that the definition of seasons and time-zones is different between 2007-2008 and the years afterwards, which affects the cost allocation thus the rates cannot be simply compared, and the BST rate in peak hours is also affected not only by the sharpness of the peak load in the duration curve but also by the difference in the costs of power plants (including the purchase from captive power generation) to be used for each year’s peak load. Aside from that, a gradually increasing trend of BST rates in the “Day-Peak” may indicate the possibility that the peak load in the summer is getting sharper recently.

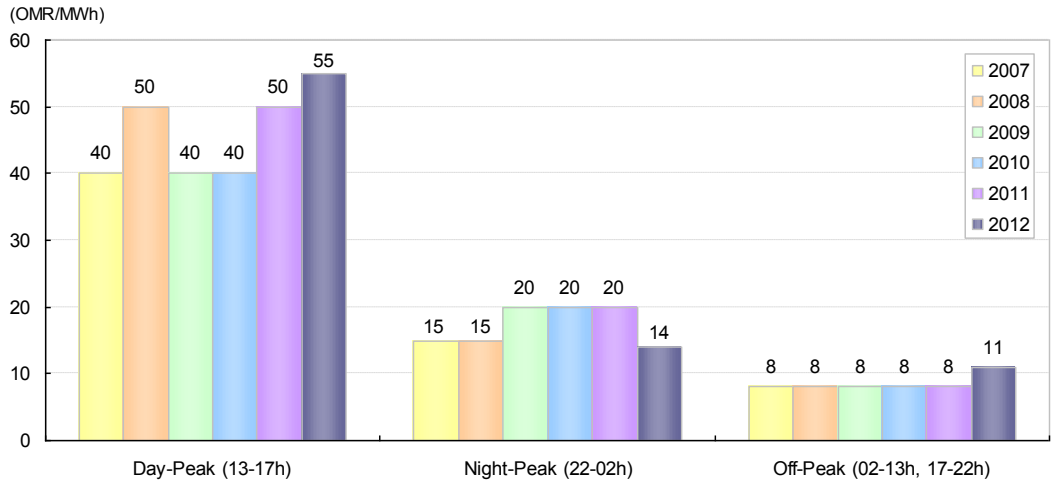



**Figure 4- 24 BST Rates in June from 2007 to 2011 (MIS)**

### 4.3.3 Transmission Charge

Transmission Use of System Charge, which OETC charges to licensed suppliers (distribution companies) and OPWP (in the case of power export) is billed in proportion to each user's maximum transmission capacity (MW), and is not billed for the transmitted energy (MWh).

Methodologies to formulate a transmission charge are stipulated in OETC's "Connection and Use of System Charge Methodology Statement (Condition 25 Statement)". At the end of the fiscal year, the OETC first estimates the "Maximum Allowed Revenue" of the next year based on the demand forecast. The OETC then subtracts the "Connection Charges" that are billed individually to suppliers (and power generating companies) that exclusively use the specific facilities, and the remainder is charged to DisCos in proportion to their (provisional) maximum load from the transmission system. In allocating the billing, each DisCo's individual maximum load, not the DisCo's share in the total system's maximum load, is used as a cost driver.

After determining the annual billing to each DisCo, the OETC charges this amount to DisCos evenly every month. Based on the gap between the year's actual performance and the initial forecast regarding the DisCos' maximum load and transmission costs, the annual billing is adjusted and the settlement is made along with the billing of the transmission charge in December.

The following table shows the recent trend of the Transmission Use of System Charge. The numbers from 2006 to 2011 are the finalized values after settlement whereas the numbers in 2012 are provisional for billing. The unit price saw a sharp increase from 2009 to 2010 and a gradual decrease afterwards. This trend is supposed to mainly depend on whether a huge increase of facilities and/or large-scale repair works took place these years, because the overwhelming majority of transmission costs derive from facility-related costs such as depreciation and repair expenses.

**Table 4- 18 Trend of Transmission Use of System Charge**

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| Total Billing (1,000 RO) | 23,645 | 24,155 | 28,450 | 38,417 | 41,332 | 43,413 | 45,705 |
| Maximum Transmission Capacity (MW) | 2,444 | 2,582 | 2,977 | 3,342 | 3,392 | 3,770 | 4,060 |
| **Unit Price (RO/MW)** | **9,674** | **9,355** | **9,556** | **11,496** | **12,187** | **11,515** | **11,258** |

Note: Numbers from 2006 to 2011are finalized values after settlement and those in 2012 are provisional for billing.

(Source: OETC)

### 4.3.4 Retail Tariff

The Permitted Tariff, which is the electricity retail tariff that licensed suppliers such as MEDC, MZEC, MJEC, RAECO and DPC charge to their customers (end-consumers), only consists of the energy charge (per kWh), i.e. A two-component tariff consisting of a capacity charge (per kW) and the energy charge is not adopted. An electricity retail tariff is set for each of the following sectors.

- Industrial
- Commercial
- Ministry of Defence
- Residential
- Government
- Agriculture & Fisheries
- Tourism

The current tariff is shown in the following table. The tariff rate is universal all over the country in principle regardless of the suppliers. The minor difference is the definition of the period of "summer" for industrial customers, during which the unit price is set at twice (24 Bz/kWh) of that in other seasons (12 Bz/kWh). Likewise with Japan's "Metered Lighting" tariff, a progressively increasing rate is adopted for customers that fall under "Residential", "Government", "Agriculture & Fisheries", and "Tourism".

**Table 4- 19 Current Rates of Electricity Retail Tariff (Permitted Tariff)** (Bz/kWh)

| Category | Tariff Structure | | | | |
|---|---|---|---|---|---|
| Industrial | All Region except Dhofar<br>September to April: 12 Bz/kWh<br>May to August: 24 Bz/kWh | | | Dhofar<br>August to March: 12 Bz/kWh<br>April to July: 24 Bz/kWh | |
| Commercial | 20 Bz/kWh | | | | |
| Ministry of Defense | 20 Bz/kWh | | | | |
| Residential | 0-3000 kWh | 3001-5000 kWh | 5001-7000 kWh | 7001-10000 kWh | 10001 kWh & above |
| | 10 Bz/kWh | 15 Bz/kWh | 20 Bz/kWh | 25 Bz/kWh | 30 Bz/kWh |
| Government | 0-3000 kWh | 3001-5000 kWh | 5001-7000 kWh | 7001-10000 kWh | 10001 kWh & above |
| | 10 Bz/kWh | 15 Bz/kWh | 20 Bz/kWh | 25 Bz/kWh | 30 Bz/kWh |
| Agriculture & Fisheries | 0-7000 kWh | | | Above 7001 kWh | |
| | 10 Bz/kWh | | | 20 Bz/kWh | |
| Tourism | 0-3000 kWh | 3001-5000 kWh | | 5001-7000 kWh | 7001 kWh & above |
| | 10 Bz/kWh | 15 Bz/kWh | | 20 Bz/kWh | 20 Bz/kWh |

(Source: AER Website)

No literature has been available that clearly describes when the current tariff was implemented. Probably the electricity tariff hasn't changed for a long time, judging from the fact that the AER's study report, which was prepared by the consulting firm KEMA in 2007, puts the identical tariff table along with a description that this tariff "has been in place for many years", and that the local stakeholders told the Study Team that this electricity tariff "has probably not changed for more than 10 years".

Whereas the wholesale tariff (BST) sets different rates among seasons and time-zones in accordance with the load fluctuation in a year, the retail price has no structure to reflect this. In other words, despite the wholesale tariff that is designed to motivate peak load control by setting high prices during the day-peak hours in the summer, the retail tariff, which is not designed to reflect this, prevents the price incentive to control peak load from functioning effectively.

The structure of the current retail tariff has some price incentives to control demand modestly, such as pricing twice for industrial use during summer and progressively increasing rates for residential and government use etc. However, their effectiveness to control peak demand in the summer daytime may be weak because the differentiated pricing is not made for each of the time-zones.

As for the residential use, when the monthly consumption exceeds 3,000 kWh, the unit price above this becomes 1.5 times (15 Bz/kWh) of that below 3,000 kWh (10 Bz/kWh). However, considering the fact that the average monthly consumption of residential customers on MIS is 1,366 kWh (as of 2010: Total electricity sales 7,586,283 MWh / Number of customer accounts 462,896 / 12 x 1,000 = 1,366 kWh/account), these progressively increasing rates may only be applied to a very limited number of high-class households and some medium-class households in the summer when the average monthly consumption becomes higher than that.

Unlike the wholesale tariff and the transmission tariff that are revised annually so that the power generation business (OPWP) and transmission business (OETC) are allowed to recover their costs, the retail tariff has not been changed for a long time. Hence, this retail tariff is not sufficient to cover the total costs of supply including the costs of power generation and transmission, and the DisCos sustain their business by receiving subsidies to make up for the loss. This topic will be discussed in more detail in Chapter 5.

## 4.4 Current EE&C Activities of Oman

### 4.4.1 Dissemination Programs for EE&C

(1) EE&C Awareness Campaign

In cooperation between PAEW and EHC, the "Switch to Save Campaign" started in 2009. The budget is on EHC. The target of the campaign is the reduction of electricity and water consumption of residences and commercial buildings during peak hours.

In March 2010, the advanced campaign called "Save Energy Oman" started. The campaign

was also sponsored by EHC, and the objective is the reduction of electricity consumption during the summer peak period. An Arabian Oryx named “Noor” was made up by EHC as a special character for EE&C appealing or EE&C tips, which is produced both in Arabic and in English.

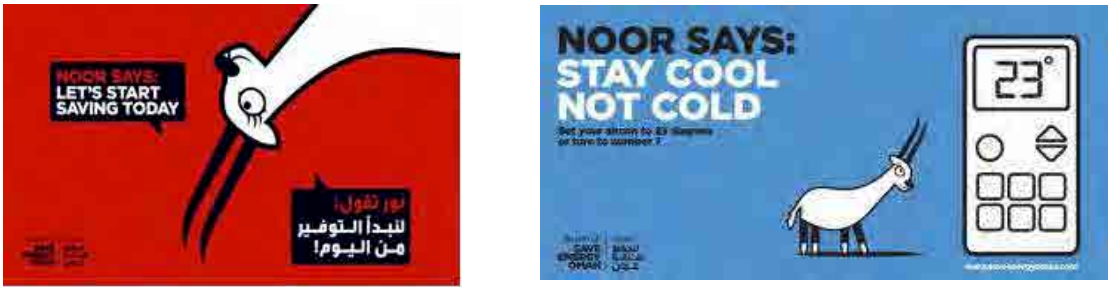



**Figure 4- 25 Posters using Noor**

On the website for kids, many posters on EE&C which were made by kids are published. The website is arranged to attract kids as an important target.

Save Energy Oman emphasis on designating temperature settings at 23 ℃ for AC in summer. (In Japan, the temperatures are set at 26-28 ℃ in general.)

As one of the EE&C measures, the AER publishes the number of customers and the electricity consumption in residential, commercial, industrial and governmental sectors on the official website.

(2) EE&C Dissemination Programs of Distribution Companies

The role of distribution companies which relates to the demand side is important in order to promote Demand Side Management, DSM. The current activities of distribution companies are shown as follows.

Each activity basically depends on the distribution company respectively. However, in the case of a nation-wide campaign, it is usual that all distribution companies cooperate with each other.

**Table 4- 20 Current Dissemination Programs of Distribution Companies**

| Company | Section in Charge | Main Activities |
|---|---|---|
| MEDC | New section called "Energy Efficiency Section" | ・ Production and distribution of guidebooks and posters for EE&C<br>・ Information dissemination of AC and lighting (outside/inside) for EE&C<br>・ Promotion of residential insulation materials<br>・ Save Energy Campaign (Awarding scheme)<br>・ Promotion of Earth Hour |
| MJEC | Custer Service Section | ・ Educational programs for students<br>・ Educational programs for women (Women Association is an effective supporter.)<br>・ Event with football club team<br>・ Media campaign on TV, newspaper and magazines<br>・ CFL giveaways (40,000per year, maximum 4 per house)<br>・ Electricity consumption monitoring using SMS<br>・ EE&C lessons by Imams at Mosque<br>・ Awarding at best houses reducing electricity consumption<br>・ Promotion of Earth Hour |
| MZEC | Customer Service Section | ・ Educational programs for school, women and sports clubs<br>・ Educational programs for communities<br>・ Identification of good customers as role models<br>・ Production of leaflets on EE&C<br>・ Media campaign on TV, radio and magazines<br>・ Intensification of dissemination programs during Ramadan<br>・ Lighting is a target appliance.<br>・ EE&C character, "Mesbah"<br>・ Effect assessment of dissemination programs<br>・ 100 RO for power saving<br>・ Incentives for power contract |
| RAECO | None | ・ Switch to Save<br>・ Partial installation of digital meters<br>・ CFL giveaways |

### 4.4.2 Dissemination Programs of Distribution Companies

As for the dissemination programs of distribution companies, MJEC's programs are as follows. The distribution companies in Oman are governmental companies whose management is based on subsidies to supply electricity. Therefore, the reduction of electricity consumption results in their cost reduction. That is the reason distribution companies conduct dissemination programs for EE&C.

(1) Outline of MJEC's Strategy for the Dissemination Programs

Outline of MJEC's strategy for the dissemination programs is shown as follows.

- Annual budget in 2012: 70,000 RO
- Section in charge: Awareness Team, in the Customer Office which is involved in customer contracts. The service area is divided into three areas, and each area has one awareness team. The members consist of voluntary various experts from several sections.
- Target group: women, men and the next generation (students and kids) in communities

- Supporters: Women Association, Ministry of Education, MJEC football club, Ministry of Religious Affairs
- Three kinds of activities; Awareness, Project and Survey
  ① Awareness: seminars, leaflets, tips and CFL giveaways.
  ② Project: community leaders are choosing houses, asking to conduct EE&C activities and awarding good results for reducing electricity consumption. Awards are ACs, TVs or washing machines.
  ③ Survey: The project participants mentioned in 2) make a final report to analyze the change of awareness for EE&C.
- CFL giveaways: In 2012, 40,000 CFLs are supposed to be distributed free-of-charge. As a manufacturer, in 2011, ALSAM from Germany cooperated with MJEC, and in 2012, PHILIPS in 2012. MJEC directly purchases bulk CFLs at a lower price than the market price and widely distributes CFL to consumers. MJEC realized that a direct giveaway is a very effective way to train and motivate people to instill EE&C habits.
- Seminar with MJEC football club teams: Football is very attractive sport for various generations. The MJEC gathers people on holidays to promote their activities at the EE&C seminar with the football club team.
- Awareness survey: a survey on customer satisfaction is conducted on the phone every year, which includes a questionnaire about the interest in the EE&C seminar. Another survey was conducted in 2009. The objective was to survey the effects of the dissemination programs and the result of the survey reflected the dissemination programs started in October 2011. In 2012, an awareness survey is conducted.
- A dissemination program at the Mosque: To request EE&C at the Mosque, Imams give speeches on the importance of EE&C.
- Promotion for the “Earth Hour”: the Oman government endeavors to disseminate the Earth Hour throughout the whole country. MJEC has programs to provide presentations on the Earth Hour, to distribute candles and to hand out leaflets which provides info on when the Earth Hour starts and how to act for the Earth Hour.

(2) MJEC Educational Programs

The educational programs for EE&C are implemented in elementary schools and colleges/universities. The seminars at elementary schools are funded by the Ministry of Education. 80 schools are targeted in 2012 for MJEC, which is one fifth of the number of schools in the MJEC supply area. Regarding the seminars at colleges/universities, the participants are from various departments. Besides the seminars, a symposium such as the “World Technology Forum”, joint studies among three universities including Sohar University and a training course for MJEC engineers.

For kids, educational seminars are held with seminars for women so that kids can come to the venue with their mother or relatives. The Women Association provides venues and calls for communities for the seminars. The contents of those seminars are as follows.

- Seminars for Kids
  - Poster making contest with an energy efficiency lifestyle theme and a non-efficiency lifestyle
  - Before making posters, a lecture on EE&C is conducted.
  - The teacher is a MJEC officer, and classes are taught in Arabic.
  - Participants: around 60
  - Age of participants: from preschool children (6 or less) to 10 years old. There are many brothers and sisters.
  - Prize: 15 works are chosen and awarded. All participants are given a box of snacks.

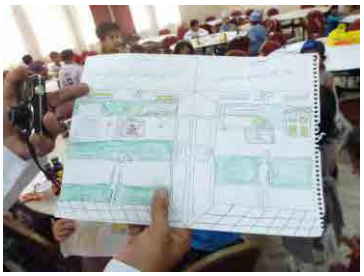


**Figure 4- 26 Poster Making Contest**

- Seminars for Women
  - Presentation: how to reduce home appliance energy consumption (1 hour)
  - Participants: 25
  - After the presentation, a quiz is conducted. As a result of the quiz, some are awarded due to the best score.
  - Teachers are MJEC officers, and the classes are taught in Arabic.
  - All participants are given leaflets, a set of daily necessities and CFL.

**Figure 4- 27 EE&C Seminars for Women**

## 4.5 Current EE&C Activities of MECA

### 4.5.1 Reduction Measures for Greenhouse Gas Emission

In Oman, although the laws related to the reduction measures of GHG emissions have not been enacted yet, MECA prescribes that owners of the new, large factories should submit the amount of GHG emissions including CO2 and the plan to reduce GHG emissions to the

Directorate-General of Climate Affairs of MECA in the Environment Impact Assessment (EIA) report when it is set up as a project. In addition, MECA urges the owners to submit periodical reports quarterly in order to grasp GHG emissions. Different from the EIA report which is mandatory for submission, the periodical reports are not mandatory. MECA conducts the monitoring of the project sites based on the periodical reports. If necessary, MECA will conduct an energy audit and give the owners advice on energy efficiency or environmental issues.

The calculation methods of each emission gas and emission factor depend on the factor of the Intergovernmental Panel on Climate Change, IPCC. The reporting scheme started from 2010, and the number of factories targeted is very few. The collected information is under the control of MECA' s database.

The reporting scheme is similar to the proposed Energy Management System (EMS) in the Study. There is a slight difference in the targeted data. In the proposed EMS, energy consumption is targeted, and GHG emissions are incorporated into the reporting scheme of MECA. These schemes are similar to the two points that the amount of energy consumption and GHG emission should be submitted periodically and that the reduction measures for energy consumption and GHG emission should be reported. That is because the reporting scheme is expected to work in cooperation with the proposed EMS.

### 4.5.2 Environment Education Program

MECA implements awareness programs on environmental issues throughout Oman. The Department of Awareness & Information in MECA takes responsibility for the educational programs. There are 5-6 MECA members in the department of Awareness & Information and the annual budget is 10,000 RO. In 2012, the following activities are conducted by MECA based on the decision of the Awareness Committee comprised of representative members of all departments.

- Media campaign (magazines, newspaper, TV CM, TV program, Radio CM)
- Giveaways (picture books, drawing books, pamphlets)
- Seminars for women and children
- Environmental Day (January 8th)
- Awareness survey on environmental issues
- Conference on environmental education in GCC countries
- Establishment of an Energy Management Course in universities (Sultan Qaboos University)
- Cooperation project with private entities (Environmental seminar in school)

The supporting agencies of MECA are the Ministry of Education, Ministry of Higher Education and the Ministry of Information. Regarding international organizations, UNICEF supports the educational programs. Environment Society of Oman, which is an Omani NGO

established in 2004, cooperates in events such as “Earth Hour.”

## 4.6 Current Educational Program of University in Oman

As educational programs in universities, a program of Sultan Qaboos University (SQU) is introduced as described below. In the SQU, a new course called the “Energy Conservation and Management Course” started from the spring semester in 2012 in the Department of Mechanical & Industrial Engineering, College of Engineering. Upon successful completion of this course, the student is expected to have gained the following six skills.

- Ability to apply the basic engineering principles in the analysis of energy systems
- Ability to identify energy saving opportunities for a given energy system or process
- Ability to conduct an energy audit of energy systems in the industrial as well as building applications
- Ability to quantify the importance and realization of the energy management and its impact on system energy consumption as well as on the environment
- Ability to evaluate the engineering design for energy-efficient performance
- Ability to conduct an economic analysis of alternative investments and life cycle costing

The contents of this course focus on mainly the industrial sector more than the building sector. The following table shows the contents of classes.

**Table 4- 21 Contents of Energy Conservation and Management Course**

| | Contents |
|---|---|
| 1 | Introduction on fuel and energy use, forms of energy, trends in energy demand and impact on environment. Sustainability and renewable energy sources. |
| 2 | Review of thermofluids science, first and second laws of themodynamics, power cycles and efficiency measures |
| 3 | Energy analysis techniques for energy systems processes |
| 4 | Energy conservation principles and energy management systems |
| 5 | Waste energy recovery and cogeneration in steam and gas turbines and other energy systems |
| 6 | HVAC systems and equipment, lighting, air leakage, insulation and sustainable building energy management |
| 7 | Energy rate structures, economic analysis of alternative technology investments, life cycle costing |
| 8 | Energy audit, energy audit tools, instrumentation and testing procedures |
| 9 | Energy conservation in electrical systems; motors and variable speed drive and power factor |
| 10 | Total energy management system functions and controls |
| 11 | Thermal energy storage |
| 12 | Case studies |