The Kingdom of Thailand

Office of Transport and Traffic Policy and Planning (OTP)

State Railway of Thailand (SRT)

The Study on
Development of Smart City Concept
for The Bang Sue Area
in
The Kingdom of Thailand

FINAL REPORT

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Japan International Cooperation Agency (JICA)

Pacific Consultants Co., Ltd. (PCKK)
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List of Acronyms

AMC	Asset Management Company
ASCN	ASEAN Smart City Network
ASEAN	Association of South-East Asian Nations
BCP	Business Continuity Plan
BMA	Bangkok Metropolitan Administration
BMR	Bangkok Metropolitan Region
BOI	Board of Investment
BOT	Build-Own-Transfer
BRT	Bus Rapid Transit
CCTV	Closed Circuit Television
CGS	Cogeneration system
DEPA	Digital Economy Promotion Agency
EEC	Eastern Economic Corridor
EGAT	Electricity Generating Authority of Thailand
EIA	Environmental Impact Assessment
EIU	Economist Intelligence Unit
ERC	Energy Regulatory Commission
ETDA	Electronics Transactions Development Agency
EV	Electric Vehicle
EXAT	Expressway Authority of Thailand
FDI	Foreign Direct Investment
HEMS	Home Energy Management System
ICR	Inception Report
ICT	Information and Communication
IoT	Internet of Things
IRR	Internal Rate of Return
ITR	Interim Report
J-CODE	Japan Conference on Overseas Development of Eco-Cities
JICA	Japan International Cooperation Agency
JOIN	Japan Overseas Infrastructure Investment Corporation for Transport and Urban Development
JV	Joint Venture
KPI	Key Performance Indicator
MaaS	Mobility as a Service
MDES	Ministry of Digital Economy and Society
MEA	Metropolitan Electricity Authority
MEMS	Mansion Energy Management System
MICE	Meeting, Incentive tour, Convention, Conference, Exhibition
MLIT	Ministry of Land Infrastructure Transport and Tourism
MOE	Ministry of Energy
MOI	Ministry of Interior
MONRE	Ministry of Natural Resources and Environment
MOT	Ministry of Transport
MOTS	Ministry of Tourism and Sports
MOU	Memorandum of Understanding
MRTA	Mass Rapid Transit Authority of Thailand
MWA	Metropolitan Waterworks Authority
NACTO	National Association of City Transportation Officials

NBTC	National Broadcasting and Telecommunications Commission
NDI	National Digital Identity
NESDC	National Economic and Social Development Council
OECD	Organization for Economic Cooperation and Development
OSSC	One Stop Service Center
OTP	Office of Transport and Traffic Policy Planning
PMO	Project Management Office
PPP	Public-Private Partnership
PRT	Personal Rapid Transit
PV	Photovoltaics
R&D	Research and Development
SEMC	Smart Energy Management Center
SEPO	State Enterprise Policy Office
SPV	Special Purpose Vehicle
SRT	State Railway of Thailand
SSC	Smart City Company
SWOT	Strength-Weakness-Opportunity-Threat
TCC	Thai Charoen Corporation
TFF	Thailand Future Fund
TOD	Transit Oriented Development
UR	Urban Renaissance Agency

Summary

1 Background and Objectives

1.1 Background of study

(1) Context for Bang Sue Smart City development

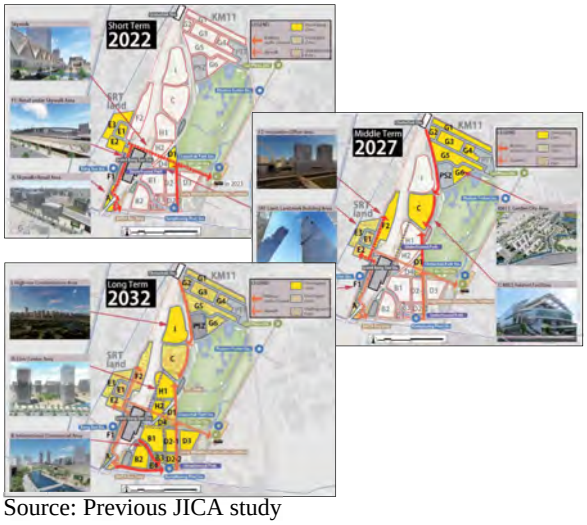
The Bang Sue area – the target area of this study – will accommodate 6 intersecting lines, including a high-speed rail and airport link line with the Bang Sue Grand Station and its adjacent stations as a traffic hub. The plan is to develop the area as a new urban core for Bangkok incorporating urban business functions by applying a Transit Oriented Development (TOD) approach. The area is thus envisaged to become a Gateway for Bangkok through which a variety of people and businesses come and gather.

The Bang Sue area is also conceived as a pilot city to promote Smart City development under the ASEAN Smart City Network (ASCN) framework. Thailand has vigorously promoted Smart City development policies by leveraging the "Thailand 4.0" national development strategy to accelerate economic development through enhancing added value and creating new industries. The government formed a "Smart City Steering Committee" chaired by the Deputy Minister of Transport that established the seven Smart City components of Smart Economy, Smart Mobility, Smart Energy, Smart Environment, Smart Governance, Smart Living and Smart People. A working group was set up for each seven smart component and relevant ministries assigned as secretariat to elaborate detailed criteria for becoming a Smart City.

In this context, the study supports realization of a Smart City in the Bang Sue area in an integrated manner covering more than 300 ha of land – most of which owned by the State Railway of Thailand (SRT).

(2) Previous studies on Bang Sue area development

The development plan for the area as an urban hub for integrated business functions was proposed in the 2007 JICA study "Data Collection Survey on Urban Redevelopment in Bang Sue Area" ("the previous study"). Specifically, a spatial plan, land use plan and phased development scheme were devised along with a development vision proposal and draft concept paper. Most importantly, integrated development was conceived as a basic policy permeating the entire plan.



Source: Previous JICA study

Figure 1. Stepwise Development Plan

1.2 Objectives of study

The objective of this study is to propose a Smart City Concept together with development plan, implementation structure, business plan and roadmap to realize the Smart City based on the basic roadmap for integrated development suggested in the FY2017 JICA study.

This study builds upon general policy such as integrated development and plans such as spatial and land use plans set forth in the FY2017 JICA study.

2 Smart City Development Concept

2.1 Capturing the Bang Sue area development context

To devise the Bang Sue area Smart City concept, development project attributes and potentials were recaptured from several aspects outlined below.

(1) ASEAN regional context

- **Area-based approach:** The project designates a specific Smart City development site in the Bang Sue Area.
- **Multi-sectoral approach:** The Smart City development project targets solving various urban issues by urban and spatial planning.

(2) Bangkok urban context

- **Transit Oriented Development approach:** Various roads and railways intersect while the existing bus terminal connects suburban and regional areas. Huge potential exists to become a highly convenient transit hub.
- **New urban core development:** The area is far from the traditional urban core and business center, representing a great possibility to become a new Central Business District in Bangkok.
- **New urban form:** Away from the busy and densely built traditional urban area, Bang Sue could present a new urban form for Bangkok.

(3) Bang Sue district context

- **Existence of prominent Thailand companies:** Located in the area are PTT offices, the Energy Complex office space, SCG offices, as well a plan to establish the State Railway of Thailand (SRT) head office. Collecting these prominent Thailand companies forms a new potential business district.
- **Large green area:** Chatuchak Park is known as one of the largest city parks and a place for rest.
- **Unique infrastructures:** Gas pipelines as well as transport related infrastructures such as a train station, bus terminal, and highways constitute a unique infrastructure setting.
- **Traditional urban lifestyle:** Chatuchak Weekend Market and residential areas are representative of traditional Bangkok urban lifestyle.

(4) People and user context

- **Diversity of people:** A wide range of people with various ages, incomes, purposes, residences and nationalities are expected to come to the area.

2.2 Implications of other Smart City / urban development

Implications for Bang Sue Smart City were drawn from case studies of other Smart City or urban development projects in Japan and other Asian cities.

- **Integrated development (Kashiwa-no-ha, Umekita, Japan):** Coordination of development under the overall plan and overarching concept contribute to creating a harmonized urban atmosphere and branding of the area.
- **Urban management utilizing city information (Kashiwa-no-ha, Chinese cities):** Using various kinds of urban data compiled on urban data platform achieves efficient urban management.
- **Walkable urban environment (Umekita, Seoul, Korea):** Developing a walkable urban environment around traffic hubs such as stations create a vibrant urban atmosphere.

2.3 Mission for Bang Sue area development

Following the attributes and potentials for Bang Sue area development, the Smart City development mission is outlined as follows.

- To create a new urban core which would be a hub for business, living and recreation.
- To fulfil potential as the "Largest station in South East Asia" through TOD approach.
- To propose a new urban lifestyle by merging traditional and modern global trends.
- To serve as a show case model for ASEAN cities by embodying a problem-solving approach.

2.4 Bang Sue Development Vision

"Global Gateway Bang Sue" is the proposed development vision. According to the vision, the area is seen as becoming a city where new business, industry, education, lifestyle and culture come together, merge and takeoff.

Figure 2. Development Vision: "Global Gateway Bang Sue"

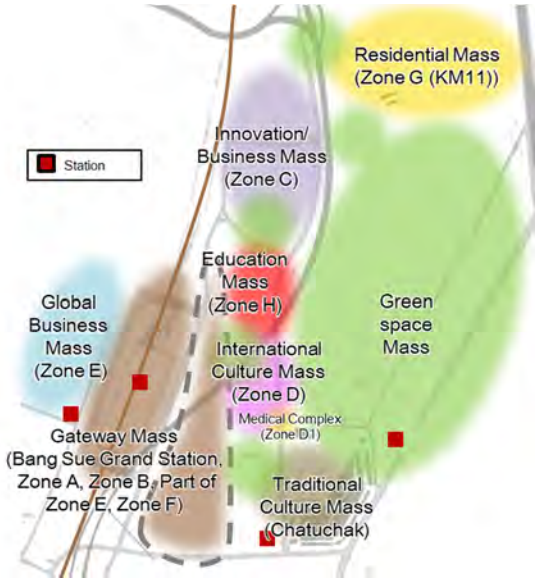


Figure 3. Spatial Planning Concept for Bang Sue

Seven gateway components function to support this development vision: "Business", "Urban Lifestyle", "Education", "International Culture", "Traditional Culture", "Rest and Recreation" and "Innovation".

The zoning of the area is redefined to embody this vision, as indicated in Figure 3. Zones are reorganized as larger mass units. Distinct functions are assigned to each mass so that activities inside the zone are promoted and enhanced, while effectively interlinking with each other to catalyze a "chemical reaction" which further vitalizes activity and injects new elements to the area.

2.5 Bang Sue Smart City Concept – **"Platform for Innovation"**

The "Platform for Innovation" Smart City function weaves together each of the seven gateway functions that catalyze connection and interaction to support the continuously evolving city. Connection and interaction among people, businesses, social needs, technologies and culture are activated on this "Platform for Innovation". Bang Sue becomes a place where people get inspired. Innovative ideas are generated and thus

implemented and demonstrated in the area to enhance living comfort or to solve urban issues.

Figure 4. Bang Sue Smart City Concept

3 Proposed Smart City Components

This study focusses on three Smart City Components identified following consultation with the Thailand Government and stakeholders: Smart Mobility, Smart Energy, and Smart Environment. These project concepts are described in the following sections.

3.1 Smart Mobility

(1) Overview

'Smart Mobility' is a comprehensive concept in the Bang Sue area: sustainable mobility balanced socially, environmentally and economically to provide solutions for urban transport challenges using remarkably advanced technologies.

(2) Key Concepts of Smart Mobility

Key concepts are determined towards the following city:

- A city where people can walk around comfortably and safely; a Walkable City.
- A city where people can move comfortably, easily, and friendly to the environment.
- A city where people can enjoy abundant space with proper management of multimodal transportation systems.

Key concepts of smart mobility are formulated as follows in order to realize the urban vision:

- The Sky deck network will be developed to connect Bang Sue Grand station, development zones and transport bases.
- Public transport services using small, environmentally friendly Personal Rapid Transit (PRT) electric vehicles would be established on the Sky Deck using IoT. Automated driving systems could be introduced in the future.
- Visitors from outside the area will park their private cars in parking lots positioned at the outer edge of the development area and be able to move inside the Bang Sue area by foot or PRT.
- Road congestion in the zones will be alleviated by suppressing automobile inflow and promoting public transportation use.

Figure 5. Smart Mobility Conceptual Image

(3) Smart Mobility Development Plan

- **Sky Deck Network**: The plan proposes an elevated sky deck network connecting Bang Sue Grand station, main facilities and fringe parking lots. Sky deck transport modes could be limited to pedestrians, bicycles and small transport. As part of the 'Walkable City', sky deck will segregate automobiles and pedestrians vertically to realize smooth inter and intra zone trips. Considering Thailand's climate, a rain or sun proof roof structure should be installed in harmony with city block building development.

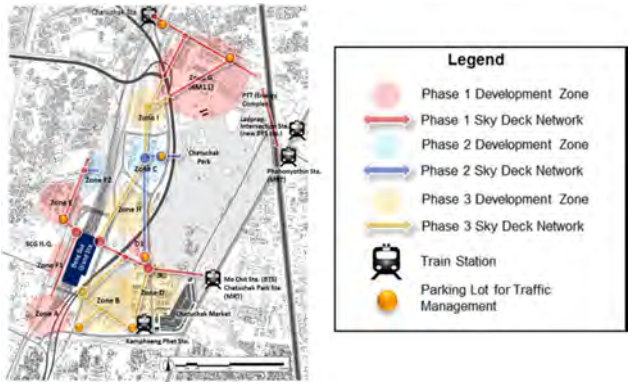


Figure 6. Sky Deck Network Conceptual Design

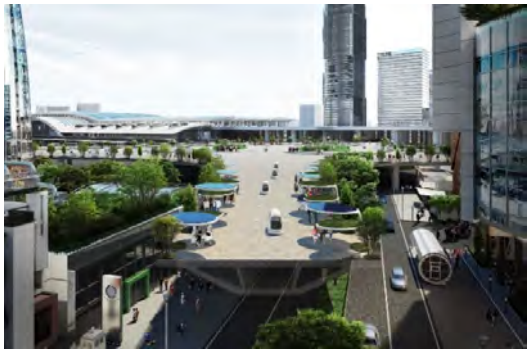


Figure 7. Sky Deck Network and PRT Image

- **Smart Public Transport**: An eco-friendly compact electric vehicle Personal Rapid Transit (PRT) system is proposed for the sky deck network. PRT can be introduced according to step-wise development phases, and achieve high transport capacity by high frequency operation. Introduction cost is lower than other urban traffic systems. Provided traffic service can respond flexibly to various traffic demands depending on development situation or time period.
- **Limiting Vehicle Inflow to Development Zones and Developing Fringe Parking Lots**: Automobile inflow to development zones is limited to alleviate traffic congestion and create attractive urban spaces. Moreover, fringe parking lots will be positioned at outer edges of the development area to receive automobile traffic and switch to other transport modes.

Figure 8. Traffic Control Section and Fringe Parking

Figure 9. Fringe Parking Conceptual Image

- **Street Design**: By restricting automobile inflow, space for road traffic in the Bang Sue area could be reallocated and redesigned from traffic oriented roads into urban public places to connect people to people, society and the green environment.
- **Other Smart Mobility Related Measures**: In addition to the previous concepts, the study highlights importance of developing transport information management systems, bicycle and personal mobility lanes, and car and ride sharing.

(4) Smart Mobility Policy Impact Evaluation

To verify impacts of smart mobility policies quantitatively, traffic simulation was used to analyze the following three scenarios .

- Case 1: Without smart mobility measures in 2032
- Case 2: Sky Deck and PRT system installed in 2032
- Case 3: Sky Deck Network and PRT system, vehicle flow restrictions into development zones and fringe parking installed in 2032

As a result, average traffic speeds in Case 2 and 3 were higher than in Case 1. Introducing smart mobility policies could improve traffic conditions in addition to ensuring attractive urban spaces and a Walkable City. Although the study's target area is limited to the Bang Sue area, it is important to consider transport activity covering surrounding areas in the future.

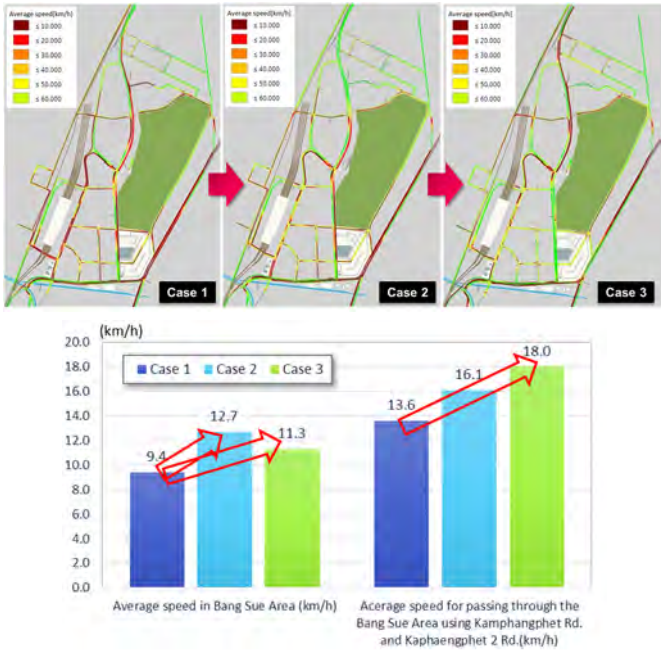


Figure 10. Average Traffic Speed Comparison

3.2 Smart Energy

(1) Overview

The “Smart Energy” project for Bang Sue has been considered and suggested toward reducing CO_2 emissions as much as possible, facilitate local energy production for local consumption and to supply the area with highly reliable, sustainable energy as a comprehensive concept.

In addition, it is proposed that the PTT-owned gas pipeline installed close to SRT’s existing train line be used as an energy source and a distributed energy supply system should be established.

(2) Basic Concept and Development Policy

- **Smart Energy Concept/Development Policy**: The energy supply system suitable for the Smart City in Bang Sue is considered based on the following concepts and development policies.

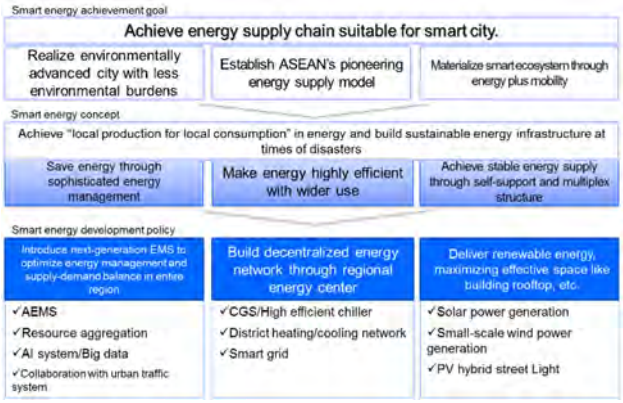


Figure 11. Smart Energy Concept

- **Basic Smart Energy Network Concept**: In Bang Sue the regional cooling network, composed mainly of high-efficiency cold source equipment, is combined with a microgrid system consisting mainly of Customer Grid Supply (CGS) and solar power generation in order to achieve sophisticated management with ICT technology and build a highly efficient, reliable smart energy network with less environmental burdens. In this smart energy network each energy center is installed in respective zones to serve as an energy supply hub for each zone and achieve energy-saving operational control and sophisticated management through unified management in the smart energy management center (SEMC) .

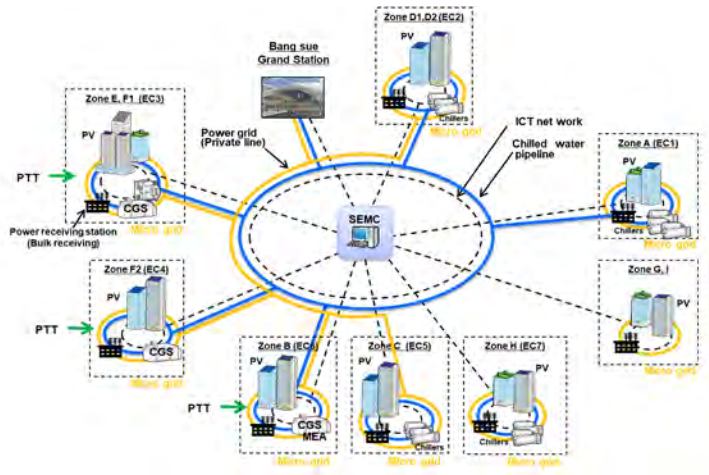


Figure 12. Smart Energy Network Concept

- **Area Energy Management System (AEMS)**: The SEMC introduces AEMS to consolidate management of distributed energy systems like energy centers installed in respective zones and optimize intraregional energy supply and demand systems by an AI system.

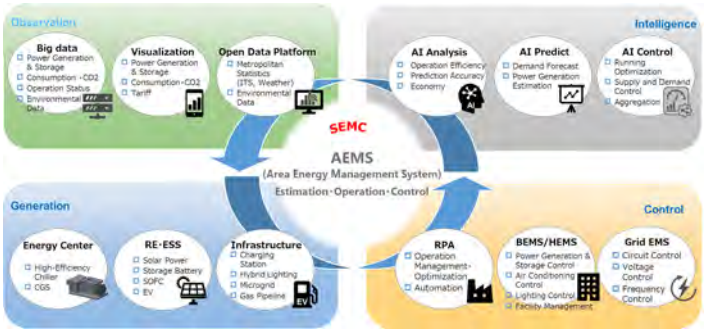


Figure 13. AEMS Concept

- **Ecosystem Establishment**: The smart energy system collaborates with the smart mobility system to supply power including intraregional renewable energy for PRT’s power sources to establish an intraregional public transportation system with less environmental load. Furthermore, the storage cell mounted on PRTs is highlighted for adoption as a multipurpose energy supply and demand

coordination resource, achieving an ecosystem under the smart energy plus smart mobility system.

Figure 14. Collaboration between Smart Energy System and Smart Mobility System

- **Energy supply model:** The Bang Sue energy supply system builds a platform combined with energy supply and value-added energy service to construct a pioneering business model in ASEAN.

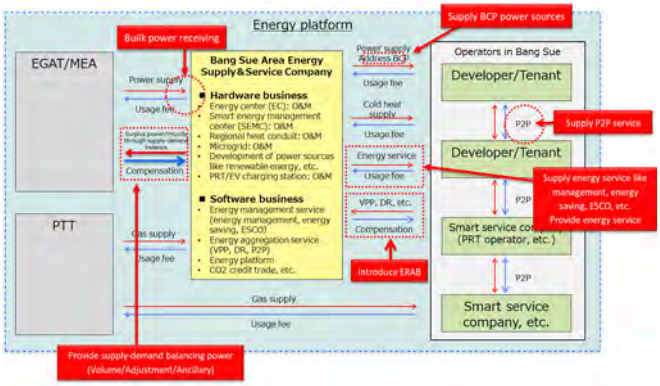


Figure 15. Energy supply model

(3) Smart Energy Development Plan

- **Regional cooling network:** Each energy center installed in Zones A, B, C, D1, D2, E, F2 and H adopts the following two systems respectfully: a regional cooling system to build a network for cooling water pipes between zones (Zones A, B, D1, D2, E, and F2) and a city block cooling system exclusive for each zone (Zones C, D1 and H).
- **Microgrid:** To achieve energy management under each EMS, a microgrid system shall be built via a self-supporting line within each zone where power is supplied collectively and a solar power generation system is installed on roofs of all facilities.
- **Business continuity planning (BCP) measures:** To contribute to the urban energy security system, an energy center, introducing CGS in Zones B, E and F2, supplies emergency power sources to key facilities like Bang Sue Grand Station, the medical complex (Zone D1) and the Meeting, Incentives, Conferences and Exhibition (MICE) center (Zone C).

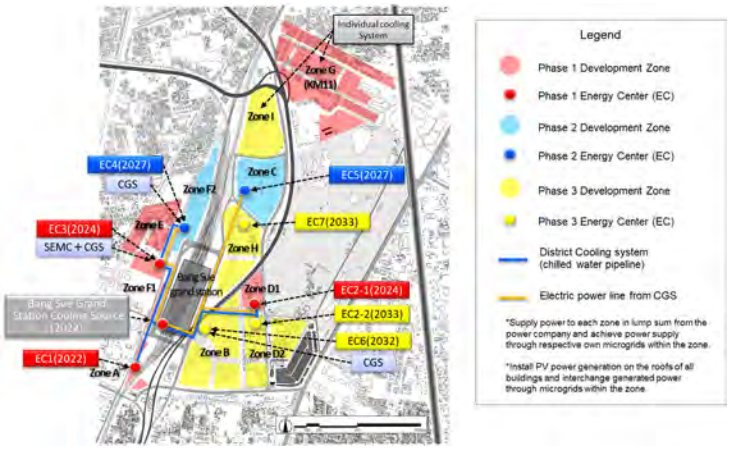


Figure 16. Development Layout

(4) Smart Energy Network Advantage

- **CO_2 Emission Reduction Impact:** The Bang Sue area smart energy network is expected to reduce CO2 emission by approximately 28% compared with a traditional individual ventilation system.
- **Life Cycle Cost**: The Bang Sue smart energy network slashes life cycle costs by approximately 21% compared with a traditional individual ventilation system.

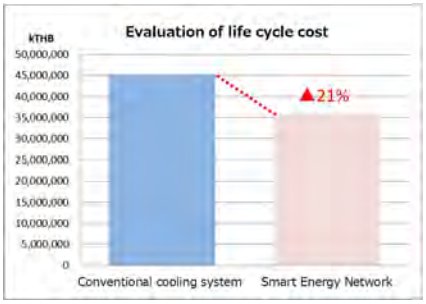


Figure 17. Life Cycle Cost Comparison

3.3 Smart Environment

(1) Overview

Smart Environment is a compulsory. Smart Component to be included in Smart City projects in Thailand. Several Smart Environment contents are proposed, taking into account Bang Sue Area attributes.

(2) Basic Policy and Concept for Development

Some of the key contents and approaches proposed for Smart Environment areshown as below.

Figure 18. Proposed contents for Smart Environment

- **Green Network:** A Green Network will be developed around Chatuchak Park to form a comfortable and walkable nature environment that will be defined in the development plan. The City Development Guideline will specify management.
- **Environment monitoring system:** The following approaches will be suggested to embody an environmentally conscious city: (1) information collection and disclosure on the environment such as an air pollution index; and (2) introduction of an environmental management system such as a complaint management system.
- **Waste and water management**: Waste management will be implemented in coordination with BMA. Promotion of recycling and reuse will reduce solid waste disposal. As well, waste separation systems utilizing ICT will improve waste treatment efficiency.

  For water supply and sewage services, water recycling will be promoted and quality management enhanced in coordination with MWA.
- **Environmentally friendly transportation:** Environmentally friendly transportation will be promoted such as electric powered vehicle public transport and a bicycle sharing system, as well as introduction of pedestrian priority zones and sky decks, together with Transit Oriented Development (TOD).

  Landscaping and control of noise and vibration: The City Development Guideline will manage landscaping. Noise and vibration will be controlled by introducing noise-control technologies which have delivered performance results in the Japanese road facilities such as noise barriers, sound-absorbing concrete finishing and sound-absorbing road joints.
- **City Development Guideline and Area Management Body:** The production of a City Development Guideline is proposed as a key tool to facilitate integrated development. The guideline will stipulate environmental regulations and landscaping and disaster prevention rules to be followed by zone developers and individual operators. An Area Management Body will be set up to enforce the Guideline and coordinate with relevant stakeholders.

3.4 Open Data Platform and Smart City Center

(1) Open Data Platform Concept

An Open Data Platform using 5G networks and IoT technology is proposed to support innovation-incubating businesses and services. All kinds of data will be collected and integrated on the data platform for multiple purposes such as urban management, research and planning for business promotion as well as providing information.

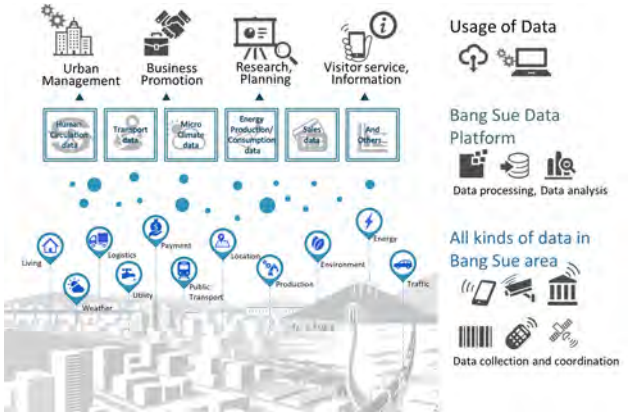


Figure 19. Open Data Platform Concept

Open Data Platform could contribute to creating various new services and businesses for private companies, especially start-ups. These systems and social infrastructures will create an innovation-incubating environment to open up business opportunities and enhance area value. The following activities are proposed to realize the Open Data Platform.

- **Establishing a Smart City Center**
- **Collecting and disclosing Open Data:** Developing a service to collect open data (e.g. 3D modeling data, traffic data, energy data) and disclosing data collected for launching creative and innovative businesses.
- **Installing fiber optics:** Installing fiber optics to maintain 5G quality (i.e. eMBB, eMTC and URLLC) in the Bang Sue area.
- **Installing Surveillance Cameras:** Installing CCTV and application software for traffic congestion surveillance and marketing analysis in commercial areas.

(2) Establishing a Smart City Center

A Smart City Center is proposed in Zone E. The Smart City Center is a facility complex to manage smart services and deploy a Data Center. It will also include other Smart Services such as a long-life learning center, a cultural exchange space and an administrative customer service. Cooperation with related organizations like Bangkok Metropolitan Admin. (BMA) and Digital Economy Promotion Agency (DEPA) is essential to establish the Smart City Center.

Figure 20. Proposed Smart City Center location and Image

Table 1. Proposed Facility Plan and Functions

Facility Plan	Functions	Cooperate with:
Monitoring Room	Space (control rooms) to display CCTV and collected data on large monitors	BMA, RTP
Data Center	Server room to store software and data needed to implement the smart service business	CAT/ DEPA
Exhibition Room	Exhibition room to introduce Smart City service	CAT/ DEPA
Work/ Conference Space	Work/Conference space to address staff and visitors	CAT/ DEPA
Energy Plant	Facilities to install cogeneration and cooling systems	MEA EGAT
Community Space	Space for lifelong learning center or administrative consultation service	BMA
PRT Parking Lot	PRT parking lot, inspection, and recharging space	BMA

4.1 Preconditions for development structure

The overall structure to implement Bang Sue Area development was devised underlining the integrated development concept and private participation for Smart City development. The overall structure also reflects the following three key factors identified in discussion with Thailand counterparts and upon considering current Thailand administrative conditions:

- **High level decision making and coordination:** To implement the large scale long term development project, an organization needs to be set up in government to oversee, manage and coordinate with relevant stakeholders.
- **Setting up SRT Asset Management Company:** SRT is in the process establishing the Asset Management Company (AMC). The AMC is tasked with managing SRT assets, and so considered suitable to manage Bang Sue area development.
- **Filling technical and financial gaps:** SRT and the AMC do not have experience in Smart City development and as well face limited funding sources. Filling these gaps needs to be arranged.

4.2 Overall development structure

Given these preconditions, the overall development structure proposed is shown in Figure 21. Roles of each organization are described as follows.

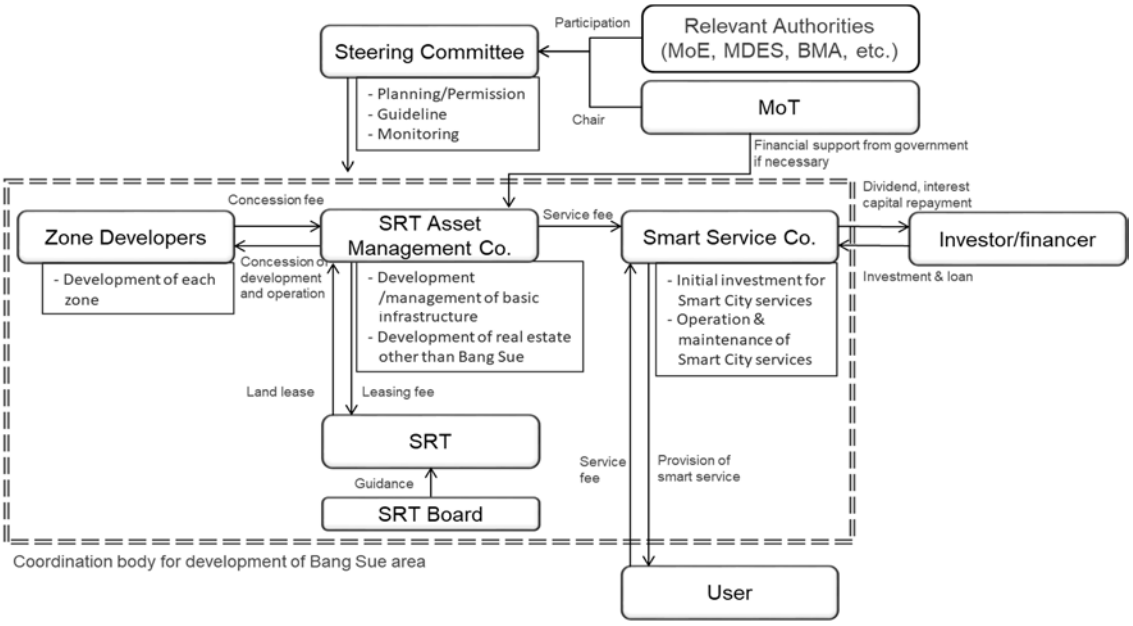


Figure 21. Proposed overall structure for Bang Sue area development

(1) Steering Committee

The Steering Committee will be chaired by the Permanent Secretary of the Ministry of Transport (MoT), with Co-secretariat role by MoT Office of Transport and Traffic Policy and Planning (OTP) and SRT. The committee takes charge of quick decision making for policies, development plans, and town management policies.

The committee secures agreement on basic policy among stakeholders, promotes projects, and monitors Bang Sue development progress. The committee will also have authority to authorize the Master Plan and Development Guideline.

Working groups may be set up for respective smart services under the Steering Committee, considering various coordination and deregulation of smart services and commercialization measures, and so forth.

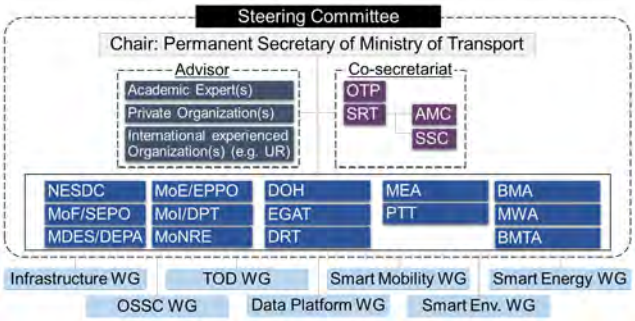


Figure 22. Steering Committee Organization

(2) Asset Management Company (AMC)

The AMC serves as the entity responsible for Bang Sue Development and coordinates stakeholders engaged in Bang Sue development. The AMC will lease land from SRT and develop land or sub-leasing of areas to developers. The company will manage leasing contracts, service agreements and so forth between the AMC and zone developers and between the AMC and the Smart Service Company (SSC).

Figure 23. SRT AMC Organization

The AMC will also coordinate with BMA, MWA, MEA and so forth to develop basic road, drainage, water, sewerage and waste management infrastructure in the Bang Sue area.

The AMC will also pay a "Service Fee" to the SSC from concession fees paid by developers, covering costs of non-profitable smart services provided by the SSC. AMC shall continuously consider providing innovative smart services together with SSC.

It will be noted that in the case of delay or failure to set up the AMC, SRT will take on all responsibilities specified for the AMC.

(3) Smart Service Company

The Smart Service Company (SSC) will develop, operate, manage and maintain infrastructure for smart city services, offering smart services to zone developers and users or visitors to the Bang Sue area, and introduce new technologies. SSC shall continuously consider providing innovative smart services together with AMC.

The SSC could be established in the form of a Special Purpose Vehicle (SPV), in which the government would decide the shareholders. Establishment of the SSC as an SPV will be approved by the cabinet. An alternative is for the SSC to be set up with investments from SRT and other entities (e.g. state-owned enterprises) as a Joint Venture (JV) company. In the future public institutions and/or private companies from overseas could join the SSC.

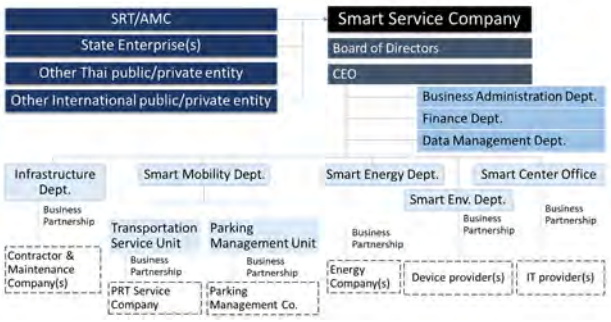


Figure 24. Smart Service Company Organization

(4) Zone developer

Bidding sessions select Zone Developers for Zones A to I respectively. Developers conclude a contract with the AMC to develop and operate zones stipulated in the contract. In the process they also earn revenues and pay concession fees in line with their contract with the AMC.

5.1 Investment sharing and cost estimate

(1) Investment sharing structure

Investment funds for this development project will be covered by combining government budgets, state-owned enterprise investment, private developer investment and smart service company investment. The financing structure to develop facilities and introduce Smart services is classified into four layers depending on project features and responsibilities of the entities.

Layer 1 – Basic Infrastructure will be developed by government budget or funds provided by SRT as the landowner.

Layer 2 – Smart City Infrastructure will be partially covered by private companies.

Layer3 – Smart Service businesses will be covered mainly by SSC and other private companies.

Layer 4 – In-zone development will in principle be implemented by respective zone developers as private investment projects.

Figure 25. Investment Layer System

(2) Investment cost estimate

The estimated total investment cost is calculated based on the proposed Smart City Components and general unit costs. Table 2 summarizes the investment cost estimate.

Table 2. Investment cost estimate by Layer and Phase

Category			Approximate cost (Million THB)			
			Total	Phase 1	Phase 2	Phase 3
Layer 1	Basic Infrastructure	Major Road	134	24	19	91
		Zone Boundary Road	277	111	21	145
		Others (Water, etc.)	4,817	2,884	832	1,101
	Disaster Prevention		32	13	6	13
	Green Network		37	13	6	18
Layer 2	Sky Deck (Outside the Zones)		2,318	1,534	457	327
	Smart Environment		19	18	1	0
	Smart City Platform		745	377	171	198
Layer 3	Smart Mobility		3,376	1,398	1,062	916
	Smart Energy		11,140	3,905	2,795	4,440
TOTAL (Layer 1~3)			***22,895***	***10,277***	***5,370***	***7,249***
Layer 4	Buildings	Office	42,089	20,222	5,691	16,177
		Commercial facility	34,767	9,226	10,706	14,835
		Residence	172,568	65,532	39,439	67,597
		Hotel	17,343	5,852	4,282	7,208
		Cultural facility	8,723	4,758	3,965	0
		Public office	4,758	4,758	0	0
	Inter-zone Infrastructure		1,147	643	93	411
	Sky Deck (Inside the Zones)		3,932	1,606	620	1,705
TOTAL (Layer 4)			***285,327***	***112,597***	***64,796***	***107,933***
TOTAL			***308,222***	***122,874***	***70,165***	***115,183***

5.2 Proposed business model

(1) Proposed Smart City business model (Base case)

Considering the Bang Sue area, since the land of the Bang Sue area (approx. 370 ha as a whole) belongs to SRT, all the development activities including infrastructure development shall be primarily managed by SRT. SRT/AMC, however, would not have enough capacity from both financial and technical aspects, thus the establishment of Smart Service Company with sufficient capacity to raise funds and to manage Smart City development is proposed in this study

Figure 26. Money flow Conceptual Image

Under the proposed Base Case business structure, the SSC will cover initial investments for smart infrastructure and services (Layer 1 to 3). Once the AMC secures revenue (land lease fees) from zone developers, the AMC will share revenue as a service fee to the SSC to cover initial investment. Smart energy and mobility services could be feasible without the service fee from the AMC.

(3) Business Components

Smart City business to be undertaken by the SSC comprise the following components:

- **Smart Mobility:** Operate PRT system and provide and manage fringe parking service.
- **Smart Energy:** Provide energy services including cogeneration, district cooling and area energy management.
- **Smart Environment:** Manage green and open spaces.
- **Smart City Center:** Operate and manage Smart City Center.
- **Smart Infrastructure:** Operate and manage smart infrastructures such as the Sky Deck Network.

Smart Mobility and Smart Energy services business components generate direct revenue from users, while service fees paid by SRT and the AMC sustain Smart Environment, Smart City Center, and Smart Infrastructure services.

5.3 Financial feasibility analysis

Infrastructure development in Bang Sue shall basically be undertaken by SRT since the land of the Bang Sue area belongs to SRT. However, there would be some options for the demarcation of infrastructure development. More involvement from public sector would be encouraged, as the area is too huge to be covered by one entity for infrastructure development, and that the Bang Sue Smart City development should be recognized as a national project since the project is one of the Flagship projects of Smart City to be developed as a new gateway for ASEAN.

Financial feasibility analysis for overall business of the SSC is conducted for the following four cases as shown in Table 3:

- **Case 1:** SRT will secure initial investment cost before getting revenue from zone developers;
- **Case 2:** Public agencies and public companies will cover infrastructure investment cost (incl. sky deck);
- **Case 3** (Base case): All basic infrastructure and Sky Deck (Outside the Zones) are implemented by SSC;
- **Case 4:** SSC and the public agencies will coordinate to share infrastructure investment.

The service fee was instituted based on the percentage at which Case 3 – the Base Case – would

be financially viable. Analysis results indicate that the proposed business model could be financially viable as private businesses at the specified service fee level, while this could also contribute to reducing SRT's deficit.

It must be noted, however, that financial analysis results are highly volatile and depend strongly on demand. A detailed follow up study will be necessary, therefore, once a concrete business plan is established. In addition, a risk mitigation scheme and flexible arrangements would be essential to ensure viability and business sustainability.

Table 3. Result of financial feasibility analysis

Category			Case1	Case2	Case3 (Base Case)	Case4
Demarcation						
Layer 1	Basic Infrastructure	Major Road	AMC/SRT	Public	SSC(w/ SF)	Public
		Zone Boundary Road	AMC/SRT	Public	SSC(w/ SF)	SSC(w/ SF)
		Other (Water, telecom, etc.)	AMC/SRT	Public	SSC(w/ SF)	Public
	Disaster Prevention		AMC/SRT	Public	SSC(w/ SF)	Public
	Green Network		AMC/SRT	Public	SSC(w/ SF)	Public
Layer 2	Sky Deck (Outside the Zones)		AMC/SRT	Public	SSC(w/ SF)	SSC(w/ SF)
	Smart Environment		SSC(w/ SF)	SSC(w/ SF)	SSC(w/ SF)	SSC(w/ SF)
	Smart City Platform		SSC(w/ SF)	SSC(w/ SF)	SSC(w/ SF)	SSC(w/ SF)
Layer 3	Smart Mobility		SSC(w/o SF)	SSC(w/o SF)	SSC(w/o SF)	SSC(w/o SF)
	Smart Energy		SSC(w/o SF)	SSC(w/o SF)	SSC(w/o SF)	SSC(w/o SF)
Layer 4	Inter-zone Development		Private	Private	Private	Private
Criteria						
Coordination in infrastructure development			★★★	★	★★★★	★★
Financial burden on SRT (especially for initial cost)			★	★★★★	★★	★★★
Financial burden on Public			★★★	★	★★★	★★
Execution capability of the agency			★	★★★★	★★	★★★
Risk distribution(too much risk on one agency)			★	★★	★	★★★
Public sector involvement			★	★★★★	★	★★★
Private sector involvement and future prospect			★	★	★★★	★★★
Smart Service Co.	**Project IRR (2020-61)**		**39.4% (36.2%)**	**39.4% (36.2%)**	**8.7% (14.9 %)**	**20.8 % (26.1 %)**
	Average of ROE (2034-61)		**22.6 % (25.8%)**	**22.6 % (25.8%)**	**5.8% (15.1%)**	**14.7% (21.9%)**
AMC (SRT)	**Accumulated NCF (2034) (Million THB)**		**17,719 (17,267)**	**28,514 (28,062)**	**27,753 (27,240)**	**28,254 (27,802)**
	Accumulated NCF (2061) (Million THB)		**112,185 (111,733)**	**131,316 (130,863)**	**130,554 (139,942)**	**131,056 (130,604)**

SSC (w/ SF): SSC investment with Service Fee, SSC investment without Service Fee

* Service fee from AMC (SRT) to the SCC set as 33% (2022-2033) and 14% (2034-2061) of SRT's revenue from developers (Land Lease Fee) respectively.

** Figures in () include Smart Mobility Services. Since financial feasibility of smart mobility service is highly volatile according to demand (depending on demand fluctuation), revenue of the smart mobility service is excluded to evaluate the feasibility of SRT and the SSC. If the SSC can earn enough revenue from the smart mobility service, the service fee from the AMC to SRT could be considered to change.

6 Way Forward

6.1 Actions to be taken

(1) Challenges

As outlined previously, the Bang Sue Smart City development project presents the opportunity to unlock undoubted potential that could bring vast benefit to the society of Thailand by showcasing new urban development while accelerating the economic transformation set forth in the "Thailand 4.0" policy.

It must be noted, however, that a myriad challenges need to be tackled, given the scale and timeframe of development. Prompt actions need to be taken, especially as first phase development needs to synchronize with the Bang Sue Grand Station and Red Line Mass Transit System construction projects.

Among various issues, the study team has identified three key areas in which actions need to be taken imminently:

Challenge 1: High level decision making and coordination
- Implement necessary deregulation measures
- Approve and authorize plans and actions

Challenge 2: Fill financial and technical capability gaps
- Finance for initial investment
- Technical capability to lead Smart City project

Challenge 3: Integrated Development Mechanisms
- Phased infrastructure development
- Coordinating interface among stakeholders
- Incorporating private sector skills and expertise

(2) Proposed measures and key points to consider

Proposed measures and key points to consider regarding these identified challenges are as follows.

Measures for Challenge 1
Establishing Steering Committee
- Establish clear roles and responsibility among related organizations
- Allow flexible arrangement, set up Working Groups for specific issues

Measures for Challenge 2
Establishing the AMC and SSC
- Ensure transparent governance structure and independence
- Address demand risk mitigation and arrange incentive schemes
- Recruitment and capacity building

Measures for Challenge 3
Formulation of Integrated Infrastructure Development Plan, Smart City Development Plan, and City Development Guideline
- Establish guidelines and incentive scheme to coordinate development
- Ensure coordination of plans at various levels – Integrated Infrastructure Design, Master Plan, District Plan, Zone Plan, Smart Service F/S

6.2 Action Plan

The Action Plan for Bang Sue Smart City development is devised with the focus on the year leading up to 2021, which is to be a key milestone year when Grand station and the Red line are both planned to start operation. The recommended timeline by year is summarized as follows.

- **By early 2020:** The Smart City concept approved and authorized by the MoT and SRT; Steering Committee set up by initiative of the MoT; and the AMC and SSC preparatory offices set up by initiative of SRT.
- **By end of 2020:** Development plan and activities authorized by the Steering Committee, managed and coordinated by the MoT; Integrated Infrastructure Development Plan, Smart City Development Plan, and City Development Guidelines devised by the AMC (or its preparatory office); and Feasibility Study for Smart Services conducted by the SSC (or its preparatory office).

- **By end of 2021:** Fully functionality of proposed Steering Committee, AMC and SSC promoting vehicles together with institutional framework comprising plans and guideline.

As mentioned, the swift establishment of the overall development structure, including the establishment of the Steering Committee, AMC, and preparation for the establishment of SSC, is highly recommended. It is also expected that further concrete Smart City development plan be developed following this study and that Smart City development be realized under quick decision making by the Steering Committee.

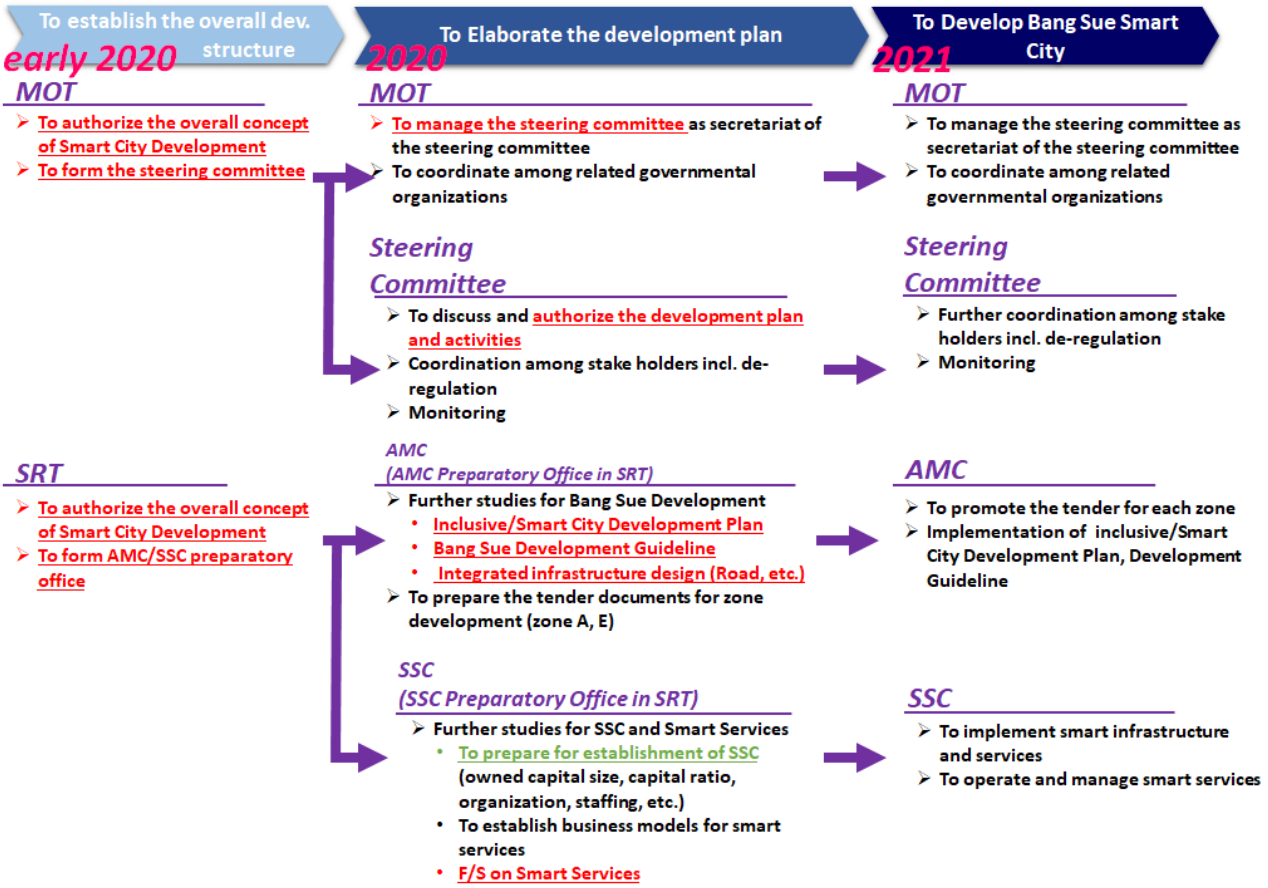


Figure 27. Action Plan to 2021

6.3 Conclusion: Towards realizing Bang Sue Smart City

Smart City development in the Bang Sue Area is expected to be shared among all related organizations in Thailand and subsequently taken forward under the initiative of implementation agencies such as the MoT Office of Transport and Traffic Policy and Planning (OTP) and the State Railway of Thailand (SRT). It is also expected that proposals set forth in this study be implemented at an early stage, while at the same time, flexibly accommodating rapidly evolving technology. Commitment from the Thailand Government and associated organizations will be a key factor in developing the Bang Sue Area as a cutting-edge Smart City which will be a model not only for Thailand, but also for the ASEAN region.

ภูมิหลังและวัตถุประสงค์ในการศึกษา

1.1 ภูมิหลังในการศึกษา

(1) บริบทในการพัฒนาบางซื่อสมาร์ทซิตี้

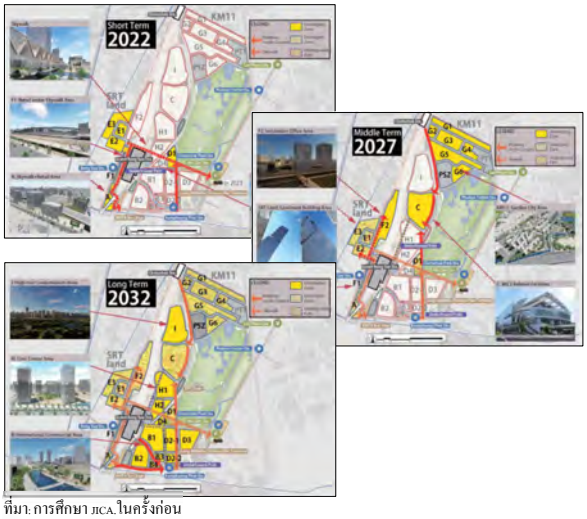
พื้นที่บริเวณบางซื่อซึ่งเป็นพื้นที่เป้าหมายในการศึกษาครั้งนี้ ในอนาคตจะเป็นพื้นที่เชื่อมต่อเส้นทางรถไฟ 6 สาย ซึ่งรวมถึงรถไฟความเร็วสูง รถไฟแอร์พอร์ตลิงค์ เป็นศูนย์กลางการคมนาคมในบริเวณสถานีกลางบางซื่อและสถานีใกล้เคียง พื้นที่นี้ได้รับการวางแผนพัฒนาให้เป็นศูนย์กลางเมืองใหม่ของกรุงเทพ ผนวกธุรกิจหลากหลายประเภทเข้าไว้ด้วยกัน ผ่านแนวคิดการพัฒนาพื้นที่รอบสถานีขนส่งมวลชน (Transit Oriented Development: TOD) คาดหวังว่าพื้นที่ดังกล่าวจะเป็นประตูสู่กรุงเทพซึ่งผู้คนหลากจะเข้ามาพบปะและทำกิจกรรมร่วมกัน

พื้นที่บริเวณบางซื่อถือเป็นหนึ่งในพื้นที่นำร่องในการส่งเสริมการพัฒนาเมืองอัจฉริยะภายใต้กรอบ ASEAN Smart City Network (ASCN) ประเทศไทยภายใต้นโยบาย “ไทยแลนด์ 4.0” ซึ่งมุ่งเน้นในการขับเคลื่อนอุตสาหกรรมด้วยเทคโนโลยีทันสมัยเพื่อสร้างมูลค่าเพิ่ม จึงมีการส่งเสริมการพัฒนาเมืองอัจฉริยะอย่างเต็มที่ ได้มีการจัดตั้งคณะกรรมการขับเคลื่อนเมืองอัจฉริยะ (Smart City Steering Committee) ขึ้นเพื่อประสานงานกับหน่วยงานภาครัฐและภาคส่วนที่เกี่ยวข้อง อีกทั้งยังมีคณะทำงานซึ่งประกอบด้วยแต่ละหน่วยงานผู้รับผิดชอบทำหน้าที่ส่งเสริมและประเมินโครงการตามองค์ประกอบของเมืองอัจฉริยะทั้ง 7 ด้าน คือ ด้านการคมนาคมขนส่ง ด้านพลังงาน ด้านสิ่งแวดล้อม ด้านเศรษฐกิจ ด้านธรรมา ภิบาล ด้านความเป็นอยู่ ด้านประชาชน

ภายใต้บริบทดังกล่าว การศึกษาในครั้งนี้มุ่งเน้นในการสนับสนุนให้เกิดการพัฒนาเมืองอัจฉริยะในพื้นที่บริเวณบางซื่อ ซึ่งมีพื้นที่มากกว่า 300 เฮคเตอร์ และพื้นที่ส่วนใหญ่เป็นกรรมสิทธิ์ของการรถไฟแห่งประเทศไทย

(2) การศึกษาครั้งก่อนเกี่ยวกับการพัฒนาพื้นที่บางซื่อ

ในการสำรวจครั้งก่อนเรื่อง “การรวบรวมและยืนยันข้อมูลเกี่ยวกับการพัฒนาพื้นบริเวณบางซื่อของไทย”โดย JICA ในปี 2560 ได้มีการพิจารณาและเสนอแผนการจัดการพื้นที่ แผนการใช้ที่ดิน และแผนการพัฒนาตามลำดับขั้น โดยมุ่งเน้นสร้างพื้นที่บริเวณบางซื่อให้เป็นศูนย์กลางใหม่ของกรุงเทพ พร้อมด้วยความสามารถในการรองรับธุรกิจระหว่างประเทศ โดยใช้แผนและนโยบายการพัฒนาแบบบูรณาการเป็นแนวคิดพื้นฐาน



ที่มา: การศึกษา JICA ในครั้งก่อน

ภาพที่ 1 แผนการพัฒนาตามลำดับขั้น

1.2 วัตถุประสงค์การศึกษา

วัตถุประสงค์ในการศึกษาครั้งนี้ คือ การพิจารณาและนำเสนอแนวความคิดเรื่องเมืองอัจฉริยะ พร้อมทั้งแผนการพัฒนา โครงสร้างการดำเนินงาน แผนธุรกิจ แผนการดำเนินงาน เพื่อขับเคลื่อนให้เกิดเมืองอัจฉริยะขึ้น โดยตั้งอยู่บนพื้นฐานของ roadmap พื้นฐานในการประสานการพัฒนาให้เป็นไปในทิศทางเดียวกัน ซึ่งได้มีการเสนอแนะไว้ในการศึกษาครั้งก่อนของ JICA เมื่อปี 2560

การศึกษาในครั้งนี้จะดำเนินการตามแผนงานด้านต่างๆ เช่น หลักการพื้นฐาน แผนการจัดการพื้นที่ แผนการใช้ที่ดิน แผนการพัฒนาตามลำดับขั้น ซึ่งได้ระบุไว้ในการศึกษาครั้งก่อนเมื่อปี 2560

2.1 ความหมายและบริบทในการพัฒนาพื้นที่บริเวณบางซื่อ

ในการพัฒนาแนวความคิดเมืองอัจฉริยะสำหรับพื้นที่บริเวณบางซื่อได้มีการรวบรวมลักษณะเฉพาะและศักยภาพของโครงการพัฒนาดังกล่าวจากหลายมุมมอง ดังนี้

(1) ระดับภูมิภาคอาเซียน

- **แนวคิดแบบเน้นพื้นที่ (Area-based approach):** พื้นที่บริเวณบางซื่อได้รับการกำหนดให้เป็นพื้นที่เป้าหมายในการพัฒนาเมืองอัจฉริยะตาม ASCN
- **แนวคิดเน้นการบูรณาการระหว่างภาคส่วน (Multi-sectoral approach)** : การพัฒนาบางซื่อสมาร์ทซิตี้มุ่งหวังให้ช่วยแก้ปัญหาของเมืองซึ่งเป็นประเด็นปัญหาร่วมที่เกิดขึ้นในเมืองต่างๆของอาเซียน ผสานระหว่างผังเมืองและแผนการจัดการพื้นที่

(2) ระดับกรุงเทพ

- **แนวคิดTOD**: เนื่องจากพื้นที่ดังกล่าวมีถนนและทางรถไฟฟ้าที่สำคัญพาดผ่าน อีกทั้งยังมีสถานีขนส่งขนาดใหญ่อยู่ภายในบริเวณ เป็นจุดเชื่อมต่อการคมนาคมขนส่งหลากหลายประเภท จึงมีศักยภาพสูงในการพัฒนาตามแนวคิด TOD
- **การพัฒนาเป็นศูนย์กลางเมืองแห่งใหม่:** พื้นที่บริเวณบางซื่อมีศักยภาพในการพัฒนาไปเป็นศูนย์กลางใหม่ของเมืองช่วยเติมเต็มพื้นที่เขตเมืองเดิมของกรุงเทพ
- **รูปแบบใหม่ของเมือง:** บางซื่อจะแตกต่างจากเมืองเก่าที่ประสบปัญหาด้านเศรษฐกิจอันเกิดจากความหนาแน่นของประชากร บางซื่อมีศักยภาพในการเป็นเมืองในรูปแบบใหม่สำหรับกรุงเทพ

(3) ระดับพื้นที่บริเวณบางซื่อ

- **ศูนย์รวมของบริษัทขนาดใหญ่ของไทย:** พื้นที่บริเวณบางซื่อนอกจากจะมีสำนักงานใหญ่ของบริษัท ปตท. จำกัด และบริษัท ปูนซิเมนต์ไทย จำกัดแล้ว การรถไฟแห่งประเทศไทยยังมีแผนจะดำเนินการย้ายสำนักงานใหญ่มายังบริเวณดังกล่าวอีกด้วย ดังนั้นเมื่อการพัฒนาดำเนินไปบางซื่อก็จะสามารถกลายเป็นศูนย์กลางใหม่ของเมืองได้
- **พื้นที่สีเขียวขนาดใหญ่**: สวนสาธารณะจตุจักรเป็นที่รู้จักในฐานะสวนสาธารณะที่ใหญ่ที่สุดแห่งหนึ่งในกรุงเทพและเป็นสถานที่พักผ่อนที่ประชาชนชื่นชอบ
- **โครงสร้างพื้นฐานที่เป็นเอกลักษณ์**: พื้นที่บริเวณบางซื่อมีโครงสร้างพื้นฐานที่เป็นเอกลักษณ์ มีทั้งเส้นท่อก๊าซพาดผ่าน ทางรถไฟ สถานีขนส่ง รวมทั้งยังมีทางด่วนตัดผ่าน
- **แหล่งวัฒนธรรมดั้งเดิมของเมือง**: ตลาดนัดจตุจักรในช่วงสุดสัปดาห์เป็นสถานที่ท่องเที่ยวเชิงวัฒนธรรมที่เป็นที่นิยมของทั้งประชาชนในท้องที่และนักท่องเที่ยวชาวต่างชาติ

(4) ระดับประชาชนผู้อยู่อาศัยและผู้ใช้งาน

- **ความหลากหลายของผู้คน**: คาดว่าจะมีผู้ใช้บริการหลากหลายกลุ่มอายุ ระดับรายได้ จากสถานที่ต่างๆ รวมทั้งบุคคลหลากหลายเชื้อชาติเดินทางมายังพื้นที่บริเวณดังกล่าวด้วยวัตถุประสงค์ที่ต่างกันออกไป

2.2 บทเรียนจากการพัฒนาเมืองอัจฉริยะอื่น

คณะผู้ศึกษาได้ศึกษาตัวอย่างจากการพัฒนาเมืองอัจฉริยะและเมืองอื่นๆ ในญี่ปุ่นและเมืองต่างๆ ในภูมิภาคอาเซียน

- **การพัฒนาแบบบูรณาการ (Kashiwa-no-ha, Umekita)**: การประสานงานในการพัฒนาภายใต้แผนและแนวคิดโดยรวมควรก่อให้เกิดบรรยากาศและแบรนดิ้งของเมืองที่สอดคล้องเป็นแบบแผนเดียวกัน
- **การจัดการเมืองโดยใช้ข้อมูล (Kashiwa-no-ha, Chinese cities):** สามารถผลักดันให้เกิดการจัดการเมืองให้มีประสิทธิภาพได้ด้วยการใช้ข้อมูลที่หลากหลายซึ่งรวบรวมจากแพลตฟอร์มข้อมูลของเมือง

❖ **บรรยากาศของเมืองที่สามารถเดินภายในเมืองได้ (Umekita, Seoul):** สามารถสร้างให้เกิดบรรยากาศที่มีชีวิตชีวาภายในเมืองได้จากการจัดให้มีบริเวณทางเดินรอบจุดสำคัญ เช่น บริเวณสถานี เป็นต้น

2.3 พันธกิจในการพัฒนาพื้นที่บริเวณบางซื่อ

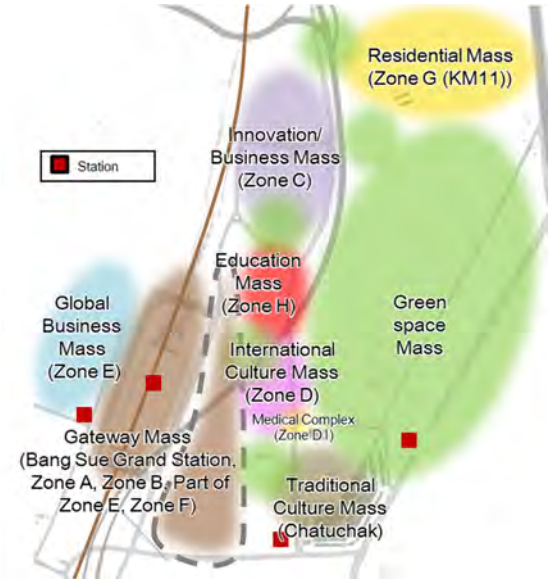
จากลักษณะเฉพาะและศักยภาพในการพัฒนาพื้นที่บริเวณบางซื่อดังกล่าวข้างต้น จึงได้กำหนดพันธกิจที่จำเป็นในการพัฒนาพื้นที่บริเวณบางซื่อ ดังนี้

- ✱ เพื่อสร้างศูนย์กลางเมืองในรูปแบบใหม่ ตอบโจทย์ทั้งทางด้านธุรกิจ การดำรงชีวิต และการพักผ่อนหย่อนใจ
- ✱ เพื่อดึงศักยภาพเพื่อการเป็นสถานีที่ใหญ่ที่สุดในเอเชียตะวันออกเฉียงใต้โดยการดำเนินการตามแนวคิด TOD
- ✱ เพื่อนำเสนอรูปแบบการใช้ชีวิตในเมืองแบบใหม่ที่เป็นการนำกระแสวัฒนธรรมต่างประเทศที่ทันสมัยมาผสมผสานกับวัฒนธรรมและวิถีชีวิตดั้งเดิม
- ✱ เพื่อเป็นกรณีตัวอย่างสำหรับเมืองต่างๆในอาเซียน โดยใช้วิธีการแก้ไขประเด็นปัญหาต่างๆ

2.4 วิสัยทัศน์ในการพัฒนาพื้นที่บริเวณบางซื่อ

วิสัยทัศน์ในการพัฒนาที่นำเสนอ คือ “Global Gateway Bang Sue” ภายใต้วิสัยทัศน์ดังกล่าว คาดหวังว่าบางซื่อจะกลายเป็นเมืองที่มีการพัฒนาโดยผสมผสานภาคธุรกิจอุตสาหกรรมใหม่ วิถีชีวิต และวัฒนธรรมเข้าไว้ด้วยกัน

ภาพที่ 2 วิสัยทัศน์การพัฒนา : “Global Gateway Bang Sue”



ภาพที่ 3 แนวคิดการจัดการพื้นที่ภายใน

วิสัยทัศน์ในการพัฒนาเป็นหน้าที่ในการเป็นจุดเชื่อมต่อ (gateway)ทั้ง 7 ด้าน ประกอบด้วยด้านธุรกิจ วิถีชีวิตเมือง การศึกษา วัฒนธรรมสากล วัฒนธรรมดั้งเดิม การพักผ่อนและสันทนาการ และนวัตกรรม

ภาพที่ 3 เป็นการจัดวางแผนโซนใหม่ตามวิสัยทัศน์ในการพัฒนา โดยแต่ละโซนมีจัดพื้นที่ในรูปแบบ mass ซึ่งในแต่ละ mass มีบทบาทหน้าที่ของตนเอง ทั้งนี้ คาดว่าหากมีการสนับสนุนให้แต่ละ mass ดำเนินการตามบทบาทหน้าที่ของตนเอง ในอีกทางหนึ่งก็เชื่อมโยงให้เกิดเป็นปฏิสัมพันธ์ระหว่าง

กัน เกิดความมีชีวิตชีวาในพื้นที่บริเวณโดยรวมและเป็นแรงดึงดูดผู้คนให้เข้ามาภายในบริเวณ

2.5 แนวคิดบางซื่อสมาร์ทซิตี้ – “Platform for Innovation”

สำหรับแนวคิดเมืองอัจฉริยะสำหรับพื้นที่บริเวณบางซื่อจะใช้แนวคิด “Platform for Innovation” ภายใต้แนวคิดนี้ บทบาทหน้าที่ของสมาร์ทซิตี้ในบริเวณพื้นที่บางซื่อ กล่าวคือ หน้าที่ในการเป็นจุดเชื่อมต่อในแต่ละด้านทั้ง 7 ด้านจะต้องสอดประสานกัน ทำให้พื้นที่ดังกล่าวมีการเติบโตอย่างยั่งยืน เทคโนโลยีและบริการอัจฉริยะที่จะถูกนำไปใช้ในพื้นที่จะช่วยสนับสนุนการเชื่อมโยง การมีปฏิสัมพันธ์ของผู้คน ภาคธุรกิจ ความต้องการ เทคโนโลยี การแลกเปลี่ยนวัฒนธรรม ทำให้เกิดแนวคิดและนวัตกรรมใหม่ เป็นพื้นฐาน (แพลตฟอร์ม) ในการเติบโตของพื้นที่ ตามแนวความคิดนี้ คาดว่าบางซื่อจะเป็นพื้นที่ที่สร้างแรงบันดาลใจให้กับผู้ที่มาเยือน อีกทั้งเป็นพื้นที่ที่มีการใช้เทคโนโลยีและนวัตกรรมใหม่ในการแก้ไขประเด็นปัญหาของสังคม

ภาพที่ 4 แนวคิดบางซื่อสมาร์ทซิตี้

ในการศึกษาครั้งนี้จะเน้น 3 องค์ประกอบของเมืองอัจฉริยะ คือ Smart Mobility Smart Energy และ Smart Environment ซึ่งเป็น 3 องค์ประกอบสำคัญที่ทางคณะผู้ศึกษาได้ด้รับการยืนยันหลังจากการหารือกับภาครัฐของไทยและหน่วยงานที่เกี่ยวข้อง การออกแบบโครงสร้างการดำเนินงานใน 3 ด้านที่สำคัญมีดังต่อไปนี้

3.1 Smart Mobility

(1) ภาพรวม

แนวความคิด Smart mobility ภายในพื้นที่บริเวณบางซื่อเป็นแนวความคิดแบบบูรณาการ มีการประยุกต์ใช้เทคโนโลยีสมัยใหม่ มีการพิจารณาทั้งในด้านสังคม สิ่งแวดล้อม และเศรษฐกิจ จึงขอเสนอแนวความคิด Smart mobility ที่จะเป็นทางแก้ไขต่อประเด็นปัญหาภายในบริเวณบางซื่ออย่างยั่งยืน

(2) แนวคิดพื้นฐานของ Smart Mobility

คาดหวังให้รูปแบบของเมืองออกมาในลักษณะ ดังต่อไปนี้:

- เป็นเมืองที่ผู้คนสามารถเดินในบริเวณพื้นที่ได้อย่างสบายและปลอดภัย (Walkable City)
- เมืองที่ผู้คนสามารถเคลื่อนที่ไปยังจุดต่างๆได้อย่างสบาย ง่าย และเป็นมิตรต่อสิ่งแวดล้อม
- เมืองที่ผู้คนสามารถใช้ประโยชน์จากพื้นที่ที่กว้างขวางโดยมีการจัดการระบบการจราจรภายในพื้นที่อย่างเหมาะสม

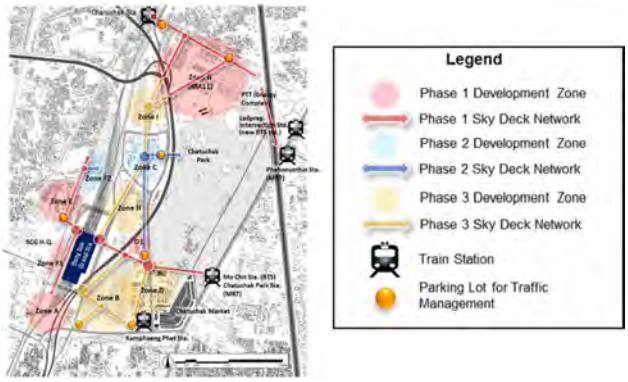
เพื่อผลักดันภาพของเมืองในอนาคตให้เกิดขึ้นจริง คณะผู้ศึกษาขอเสนอแนวคิดพื้นฐานเกี่ยวกับ smart mobility ดังนี้

- สร้างเครือข่ายทางเดินลอยฟ้า (Sky deck) เชื่อมระหว่างสถานีกลางบางซื่อ โซนที่มีการพัฒนา และสถานีขนส่ง
- คาดว่าจะมีการนำรถ EV ที่เรียกว่า PRT (Personal Rapid ransit) มาใช้ วิ่งบนทางเดินลอยฟ้า มีการใช้เทคโนโลยี IoT มาใช้ ทั้งนี้ สามารถนำระบบเคลื่อนที่อัตโนมัติเข้ามาใช้ได้ในอนาคต และ
- สถานที่จอดรถจะอยู่ในบริเวณรอบนอกของพื้นที่ที่ทำการพัฒนา ผู้มาเยือนจากภายนอกจะต้องจอดรถยนต์ไว้ภายนอก แล้วเดินหรือใช้บริการPRT เพื่อเคลื่อนย้ายภายในบริเวณ
- สำหรับถนนในแต่ละโซน เพื่อควบคุมปริมาณการเข้าออกของรถยนต์ภายในบริเวณ จะสนับสนุนการใช้ระบบขนส่งสาธารณะ เพื่อลดความแออัดของการจราจร

ภาพที่ 4 ภาพแนวคิด Smart Mobility

(3) แผนการพัฒนา Smart Mobility

- **เครือข่ายทางเดินลอยฟ้า:** เสนอให้มีการสร้างทางเดินลอยฟ้ายกระดับ เชื่อมต่อระหว่างแต่ละโซนกับสถานีกลางบางซื่อ ให้ทางเดินลอยฟ้าเป็นพื้นที่ที่มีแค่ผู้เดินเท้าและรถ PRT เท่านั้นที่จะสามารถเคลื่อนที่บนทางเดินดังกล่าวได้ อีกทั้งการแบ่งแยกทางของรถบ้านและผู้เดินเท้าด้วยความสูงที่ต่างระดับกัน ทำให้การสัญจรทั้งภายในโซนและระหว่างโซนเป็นไปอย่างราบรื่นสมกับเป็นเมืองที่สามารถเดินภายในบริเวณได้ (Walkable City) เพื่อให้เหมาะสมกับสภาพอากาศของไทย จึงควรพิจารณาจัดสร้างหลังคาบังแดด สอดประสานกับการพัฒนาพื้นที่อาคาร



ภาพที่ 5 แนวคิดการออกแบบเครือข่ายทางเดินลอยฟ้า

ภาพที่ 6 แนวคิดเครือข่ายทางเดินลอยฟ้า และ PRT

- **ระบบขนส่งสาธารณะอัจฉริยะ:** เสนอให้นำรถ PRT ซึ่งเป็นรถ EV ขนาดเล็กที่เป็นมิตรกับสิ่งแวดล้อมมาใช้วิ่งบนทางเดินลอยฟ้า ในการนำเทคโนโลยีรถ PRT มาใช้นั้น สามารถแบ่งการประยุกต์ใช้เป็นระยะๆได้ โดยสามารถรองรับผู้โดยสารได้เป็นจำนวนมากในกรณีที่มีความถี่ในการเดินรถสูง ค่าใช้จ่ายในการนำมาใช้ต่ำกว่าระบบคมนาคมขนส่งอื่นๆ สามารถให้บริการด้านคมนาคมขนส่งที่ตอบสนองความต้องการ ซึ่งแตกต่างกันไปในแต่ละระดับการพัฒนาของพื้นที่และในแต่ละช่วงเวลาได้อย่างยืดหยุ่น
- **การจำกัดปริมาณจราจรที่จะเข้าสู่บริเวณพื้นที่ที่ทำการพัฒนาและการสร้างที่จอดรถรอบนอก:** เสนอให้มีการจำกัดปริมาณการจราจรที่จะเข้าสู่บริเวณพื้นที่ที่ทำการพัฒนา เพื่อบรรเทาความหนาแน่นของการจราจรและเกิดเป็นพื้นที่เมืองที่น่าดึงดูดใจ ทั้งนี้ ควรสร้างที่จอดรถรอบนอกบริเวณที่ทำการพัฒนาเช่นบริเวณใกล้ถนนสายสำคัญ เพื่อเป็นที่รองรับรถยนต์จากผู้มาเยือนจากภายนอกและเปลี่ยนมาใช้ระบบขนส่งอื่นแทน

ภาพที่ 7 บริเวณที่มีการควบคุมการจราจรและสถานที่จอดรถรอบนอก

ภาพที่ 8 แนวคิดการออกแบบสถานที่จอดรถรอบนอก

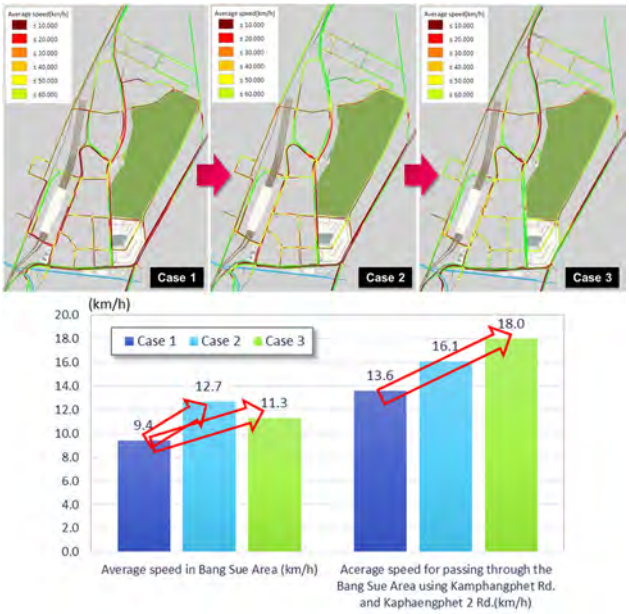
- **การวางผังถนน**: เพื่อให้สอดคล้องกับมาตรการจำกัดปริมาณจราจรเข้าสู่ภายในบริเวณ เสนอให้มีการจัดสรรออกแบบพื้นที่ที่เป็นถนนใหม่ เปลี่ยนจากถนนที่เน้นให้ความสำคัญกับการเดินรถของรถยนต์ส่วนบุคคล มาเป็นพื้นที่สาธารณะของเมืองที่เชื่อมโยงระหว่างผู้คน สังคม และธรรมชาติ
- **มาตรการอื่นๆที่เกี่ยวข้องกับ Smart Mobility**: นอกเหนือจากแนวความคิดในการดำเนินงานข้างต้น การส่งเสริมให้มีระบบจัดการข้อมูลจราจร ช่องทางเดินรถสำหรับรถยนต์และช่องทางสำหรับผู้เดินเท้า การทำ car sharing และระบบ ride sharing ก็เป็นประเด็นที่สำคัญ

(4) **การประเมินผลกระทบของนโยบาย** Smart Mobility

การจำลองสภาพจราจรจะทำการทดสอบโดยแบ่งออกเป็น 3 กรณี เพื่อทดสอบประสิทธิภาพของนโยบาย

- **กรณีที่ 1:** สภาพการจราจรในปี 2575 ที่ไม่มีการใช้มาตรการ smart mobility
- **กรณีที่ 2:** สภาพการจราจรใน ปี 2575 ในกรณีที่มีการนำระบบทางเดินลอยฟ้าและรถ PRT ไปใช้
- **กรณีที่ 3:** สภาพการจราจรใน ปี 2575 ในกรณีที่มีการนำระบบเครือข่ายทางเดินลอยฟ้าและรถ PRT ไปใช้ มีการจำกัดปริมาณรถยนต์ที่เข้าสู่บริเวณพื้นที่ภายในและจัดให้มีที่จอดรถรอบนอก

จากผลการวิเคราะห์พบว่า ความเร็วเฉลี่ยในการเคลื่อนตัวของการจราจรบนถนนในพื้นที่บริเวณบางซื่อในกรณีที่ 2 จะเร็วกว่ากรณีที่ 1 ในการนำมาตรการ smart mobility ไปใช้เป็นการสร้างพื้นที่ภายในบริเวณให้เป็นเมืองที่ผู้คนสามารถเดินเท้าได้ (Walkable City) ส่งผลให้การจราจรบนถนนภายในบริเวณได้รับการปรับปรุงให้ดีขึ้น ถึงแม้ว่าขอบเขตการศึกษาในครั้งนี้จะจำกัดเฉพาะภายในพื้นที่บริเวณบางซื่อ แต่การพิจารณาถึงสภาพการจราจรในบริเวณรอบข้างในอนาคตก็เป็นสิ่งสำคัญเช่นเดียวกัน



ภาพที่ 9 การเปรียบเทียบความเร็วเฉลี่ยในการจราจรแต่ละกรณี

3.2 Smart Energy

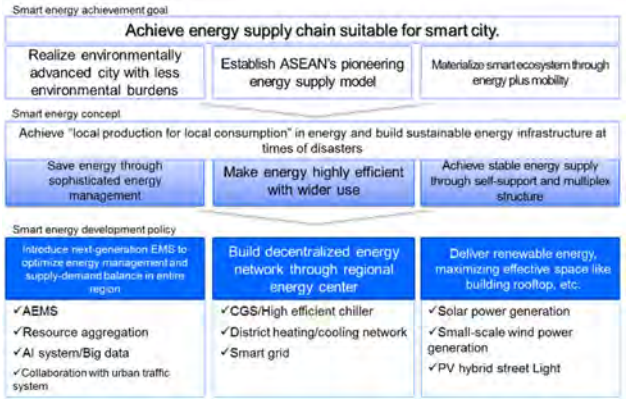
(1) ภาพรวม

"Smart Energy" สำหรับพื้นที่บริเวณบางซื่อเป็นแนวความคิดแบบบูรณาการ ซึ่งมีวัตถุประสงค์มุ่งเน้นให้เกิดการลดการปล่อยก๊าซคาร์บอนไดออกไซด์ สนับสนุนให้ผลิตไฟฟ้าเองและนำไปใช้ภายในบริเวณ อีกทั้งเป็นพื้นที่มีแหล่งไฟฟ้าที่มีความเสถียรและน่าเชื่อถือ สามารถส่งไฟฟ้าได้แม้ในยามเกิดภัยพิบัติ

นอกจากนี้ ในบริเวณใกล้เคียงทางรถไฟเดิมของการรถไฟมีเส้นท่อก๊าซของปตท.อยู่ จึงเสนอนำมาใช้เป็นแหล่งพลังงานอีกแหล่งหนึ่ง โดยสร้างระบบจ่ายกระแสไฟฟ้าแบบ distributed energy system

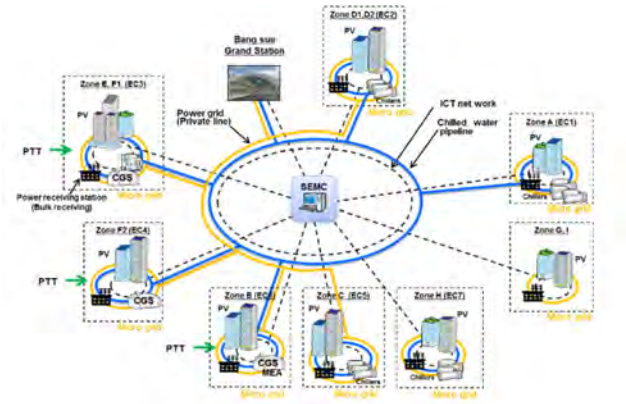
(2) แนวคิดและหลักการพื้นฐานในการพัฒนา

❖ **แนวคิดและหลักการพัฒนาด้าน Smart Energy**: ระบบพลังงานที่เหมาะสมกับเมืองอัจริยะที่มุ่งหวังจะให้เกิดขึ้นในบริเวณพื้นที่บางซื่อนั้นจะพิจารณาตามแนวคิดและหลักการพัฒนา ดังต่อไปนี้



ภาพที่ 10 แนวความคิด Smart Energy

❖ **แนวคิดพื้นฐานเกี่ยวกับเครือข่าย Smart Energy**: ระบบ regional cooling network ซึ่งประกอบด้วยอุปกรณ์แหล่งกำเนิดความเย็นประสิทธิภาพสูงในพื้นที่บริเวณบางซื่อจะรวมกับระบบ microgrid ซึ่งประกอบด้วย CGS และระบบผลิตพลังงานแสงอาทิตย์ เพื่อจัดการกับระบบพลังงานที่มีความซับซ้อนจะมีการใช้เทคโนโลยี ICT มาใช้เพื่อให้เกิดเป็นเครือข่าย Smart energy ที่มีประสิทธิภาพสูง เป็นแหล่งพลังงานที่ไว้วางใจได้ และสร้างภาระต่อสิ่งแวดล้อมน้อยลง สำหรับเครือข่าย smart energy นี้จะมีการจัดตั้งศูนย์พลังงานในแต่ละโซน ซึ่งจะเป็นแหล่งพลังงานไฟฟ้าภายในแต่ละโซน ในขณะเดียวกันการรวมการบริหารศูนย์พลังงานไว้ที่ศูนย์จัดการพลังงาน (SEMC) จะช่วยลดการใช้พลังงานในการควบคุมการปฏิบัติงานของระบบและทำให้การควบคุมระบบที่ซับซ้อนได้ดียิ่งขึ้น



ภาพที่ 11 แนวความคิดเรื่องเครือข่าย Smart Energy

❖ **ระบบควบคุมพลังงานในรายพื้นที่ (Area Energy Management System: AEMS):** SEMC จะนำระบบ AEMS มาใช้ เป็นตัวประสานระบบพลังงานที่แยกออกไป

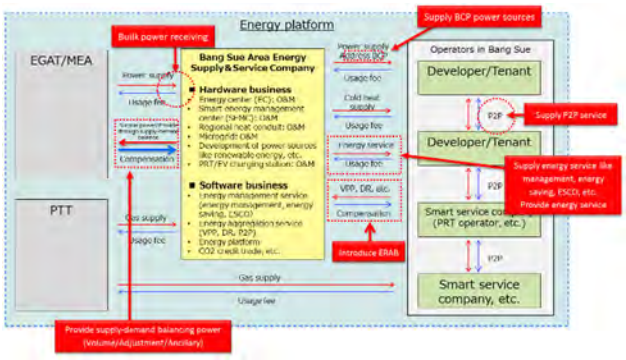
ในแต่ละศูนย์พลังงานที่กระจายอยู่ในแต่ละโซน นำระบบ AI มาใช้เพื่อให้เกิดการจัดการอุปสงค์และอุปทานของพลังงานไฟฟ้าภายในบริเวณอย่างเหมาะสม

ภาพที่ 12 แนวความคิดเกี่ยวกับ AEMS

- **การสร้างระบบนิเวศเชื่อมโยงระหว่าง smart energy และ smart energy**: ระบบ smart energy จะประสานกับระบบ smart mobility และทำหน้าที่ส่งกระแสไฟฟ้า (รวมถึงกระแสไฟฟ้าที่มาจากพลังงานทดแทนด้วย) ให้แก่รถ PRT สร้างให้เกิดเป็นระบบนิเวศของระบบการขนส่งสาธารณะภายในบริเวณที่ทำให้เกิดภาระต่อสิ่งแวดล้อมน้อยลง ในขณะเดียวกัน จะมีการติดตั้งแบตเตอรี่เก็บพลังงานที่รถ PRT โดยแบตเตอรี่ดังกล่าวจะเป็นตัวปรับอุปสงค์อุปทานต่อพลังงาน โดยมุ่งหวังว่าจะมีการนำไปใช้ประโยชน์ต่อได้หลากหลายวัตถุประสงค์ ด้วยระบบเช่นนี้จะก่อให้เกิดเป็นระบบนิเวศระหว่างระบบระบบ smart energy และระบบ smart mobility

ภาพที่ 13 การประสานระหว่างระบบ Smart Energy และระบบ Smart Mobility

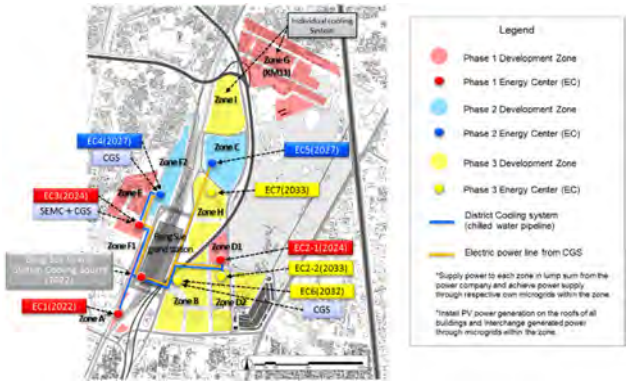
- **รูปแบบในการจัดหาพลังงาน:** ระบบการจัดหาพลังงานในพื้นที่บริเวณบางซื่อจะเป็นการสร้างแพลตฟอร์มซึ่งประสานการจัดหาแหล่งพลังงานและบริการด้านพลังงานที่มีมูลค่าเพิ่มสูงเข้าไว้ด้วยกันสร้างเป็นโมเดลทางธุรกิจที่มีความล้ำสมัยในอาเซียน



ภาพที่ 14 โมเดลการจัดหาพลังงานรูปแบบใหม่

(3) แผนการพัฒนา Smart Energy

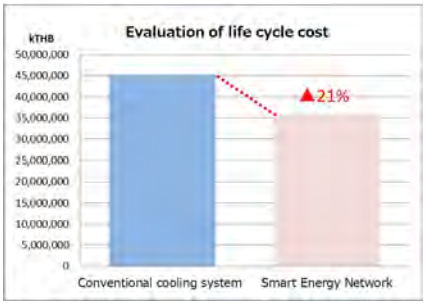
- **Regional cooling network**: จะมีการจัดตั้งศูนย์พลังงานในโซน A B C E D1 D2 F2 และ H โดยจะใช้ 2 ระบบ คือ ระบบ regional cooling network ซึ่งเป็นโครงข่ายท่อน้ำเย็นเชื่อมโยงระหว่างโซน (สำหรับโซน A, B, E, D1, D2 และ F2) และระบบทำความเย็นที่ทำงานเสร็จสิ้นภายในโซนนั้นๆ เลย (โซน C, D1 และ H)
- **Microgrid:** ระบบ Microgrid จะถูกสร้างขึ้นตามสายของตนเองในแต่ละโซน ซึ่งจะมีการจ่ายพลังงานไฟฟ้ารวม ในส่วนของพลังงานไฟฟ้าแสงอาทิตย์จะถูกติดตั้งบนหลังคาของทุกอาคารสิ่งอำนวยความสะดวก เพื่อให้เกิดการบริหารพลังงานภายใต้แต่ละ EMS
- **มาตรการสำหรับกรณีฉุกเฉิน**: จะมีการส่งกระแสไฟฟ้าสำหรับกรณีฉุกเฉินจากศูนย์พลังงานที่มีการนำระบบ **CGS** มาใช้ (โซน B E และF2) ไปยังสถานที่สำคัญ คือ สถานีกลางบางซื่อ ศูนย์การแพทย์ (โซน D1) โซน MICE (โซน C) ซึ่งจะช่วยส่งเสริมความมั่นคงด้านพลังงานให้กับบริเวณพื้นที่ดังกล่าว



ภาพที่ 15 แผนร่างการพัฒนา

(4) ข้อดีของเครือข่าย Smart Energy

- **ผลดีในการลดการปล่อยก๊าซคาร์บอนไดออกไซด์**: เครือข่าย smart energy ในบริเวณพื้นที่บางซื่อ เมื่อเทียบกับกรณีการใช้ระบบปรับอากาศแยกส่วนแบบดั้งเดิมคาดว่าจะช่วยลดการปล่อยก๊าซคาร์บอนไดออกไซด์ได้ประมาณร้อยละ 28
- **ต้นทุนรวมตลอดวงจรชีวิต (Life Cycle Cost):** เครือข่าย smart energy ในบริเวณพื้นที่บางซื่อช่วยลดต้นทุนรวมตลอดวงจรชีวิตได้ราวร้อยละ 21 เมื่อเทียบกับกรณีใช้ระบบปรับอากาศแยกส่วนแบบดั้งเดิม



ภาพที่ 16 การเปรียบเทียบต้นทุนตลอดวงจรชีวิต

3.3 Smart Environment

(1) ภาพรวม

Smart Environment เป็นองค์ประกอบที่เป็นข้อบังคับที่จะต้องประกอบอยู่ในโครงการเมืองอัจฉริยะของประเทศไทย มีการเสนอประเด็นเกี่ยวกับ Smart Environment หลายประการ โดยคำนึงถึงลักษณะของพื้นที่บริเวณบางซื่อ

(2) หลักการพื้นฐานของ **Smart Environment**

ได้มีการนำเสนอประเด็นสำคัญและวิธีการปฏิบัติสำหรับ Smart Environment ดังต่อไปนี้

ภาพที่ 17 เทคโนโลยีและบริการด้าน Smart Environment ที่นำเสนอ

- **เครือข่ายสีเขียว:** ควรมีการพัฒนาเครือข่ายสีเขียวบริเวณรอบสวนจตุจักร เพื่อให้เกิดสภาพแวดล้อมตามธรรมชาติที่ร่มรื่น สามารถเดินเท้าสัญจรได้ (green network) ประเด็นนี้ควรมีการอธิบายไว้ในแผนการพัฒนา อีกทั้งควรมีการระบุหน่วยงานผู้บริหารงานในคู่มือแนวทางการพัฒนาเมืองบริหาร
- **ระบบติดตามสภาพแวดล้อม:** แนะนำให้มีการนำมาตรการดังต่อไปนี้ไปดำเนินการเพื่อให้เกิดเป็นเมืองที่มีการตระหนักถึงความสำคัญของสิ่งแวดล้อม (1) การเก็บและเปิดเผยข้อมูลเกี่ยวกับสิ่งแวดล้อม เช่น ดัชนีมลพิษทางอากาศ และ (2)การนำระบบจัดการสิ่งแวดล้อม เช่น ระบบจัดการคำร้องทุกข์เกี่ยวกับสิ่งแวดล้อมมาใช้ เป็นต้น
- **การจัดการน้ำและสิ่งปฏิกูล:** การจัดการขยะและสิ่งปฏิกูลควรดำเนินงานร่วมกับกรุงเทพมหานคร ลดการทิ้งขยะที่เป็นของแข็งด้วยการส่งเสริมให้เกิดการรีไซเคิลและการนำกลับไปใช้ซ้ำ รวมทั้งการใช้ระบบแยกขยะที่มีการนำเทคโนโลยีเข้ามาประยุกต์ใช้จะทำให้ประสิทธิภาพในการจัดการขยะดียิ่งขึ้นอีกด้วย สำหรับการจัดการน้ำและสิ่งปฏิกูล ควรมีการส่งเสริมให้มีการรีไซเคิลน้ำ และดูแลคุณภาพของน้ำโดยร่วมมือกับการประปานครหลวง
- **การขนส่งสาธารณะที่เป็นมิตรต่อสิ่งแวดล้อม:** สนับสนุนโครงสร้างระบบบริการขนส่งสาธารณะที่เป็นมิตรต่อสิ่งแวดล้อม เช่น การให้บริการด้านการขนส่งคมนาคมด้วยรถ EV การส่งเสริมการแชร์จักรยาน รวมไปถึงการจัดโซนที่ให้ความสำคัญกับผู้เดินเท้าเป็นอันดับแรก และทางเดินลอยฟ้า ตามแนวคิด TOD
- **การจัดการภูมิทัศน์ที่เหมาะสมและมาตรการเกี่ยวกับเสียงรบกวนและแรงสั่นสะเทือน:** ควรมีการควบคุมการจัดการภูมิทัศน์ตามคู่มือแนวทางการพัฒนาเมือง เสียงรบกวนและแรงสั่นสะเทือนควรได้รับการผ่านควบคุมผ่านการใช้เทคโนโลยีต่างๆ เช่น การใช้วัตถุป้องกันเสียง การเทคอนกรีตเพื่อดูดซับเสียง รอยต่อบนถนนที่ดูดซับเสียง ซึ่งเป็นเทคโนโลยีที่นำไปใช้แล้วเห็นผลประจักษ์ในกรณีของถนนในญี่ปุ่น เป็นต้น
- การจัดทำแนวทางการพัฒนาเมืองและการจัดตั้งหน่วยงานบริหารพื้นที่: แนะนำให้จัดทำแนวทางการพัฒนาเมืองเพื่อเป็นเครื่องมือสำคัญในการพัฒนาพื้นที่บริเวณบางซื่อให้เป็นแบบแผนเดียวกันโดยแนวทางดังกล่าวจะช่วยกระตุ้นให้ผู้พัฒนาพื้นที่ในแต่ละโซนปฏิบัติตามกฎเกณฑ์ในด้านสิ่งแวดล้อม กฎเกณฑ์เกี่ยวกับภูมิทัศน์ของเมือง และกฎการป้องกันภัยพิบัติ โดยมีการจัดตั้งหน่วยงานในการบริหารพื้นที่เพื่อเป็นผู้บังคับใช้แนวทางดังกล่าว และประสานงานระหว่างผู้เกี่ยวข้อง

3.4 แพลตฟอร์มข้อมูลเปิด (Open Data Platform) และศูนย์เมืองอัจฉริยะ (Smart City Center)

(1) แนวคิดแพลตฟอร์มข้อมูลเปิด (Open Data Platform)

แพลตฟอร์มข้อมูลเปิดเป็นการรวบรวม ผสมผสานข้อมูลต่างๆ เพื่อใช้ในวัตถุประสงค์ต่างๆ เช่น การบริหารเมือง การสำรวจและวางแผนเพื่อส่งเสริมธุรกิจ มุ่งหวังให้แพลตฟอร์มดังกล่าวมีบทบาทในการช่วยเหลือการจัดตั้งธุรกิจและบริการใหม่ที่มีการนำเครือข่าย 5G และเทคโนโลยี IoT มาใช้

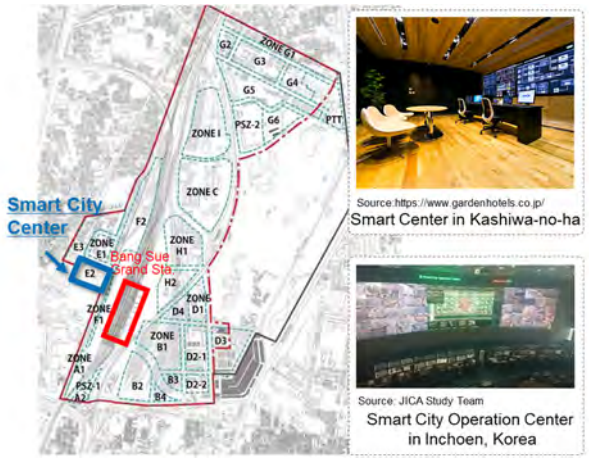
ภาพที่ 18 แนวคิดเรื่องแพลตฟอร์มข้อมูลเปิด

แพลตฟอร์มข้อมูลเปิดช่วยสนับสนุนการสร้างบริการจัดตั้งธุรกิจใหม่ของบริษัทเอกชน เช่น บริษัท start-up ที่ต้องใช้ข้อมูลมากมาย การสร้างสภาพแวดล้อมเช่นนี้จะทำให้พื้นที่บริเวณบางซื่อกลายเป็นศูนย์รวมของภาคเอกชนที่แสวงหาโอกาสทางธุรกิจ ซึ่งคาดว่าจะทำให้สินทรัพย์ภายในพื้นที่บริเวณดังกล่าวมีมูลค่าสูงขึ้นตามไปด้วย ในการผลักดันให้เกิดสภาพแวดล้อมดังกล่าวจำเป็นต้องดำเนินการดังต่อไปนี้

- **การจัดตั้งศูนย์เมืองอัจฉริยะ**
- **การเก็บรวบรวมและเปิดเผยข้อมูลเปิด:** ให้บริการเก็บรวบรวมและเปิดเผยข้อมูลสิ่งก่อสร้างและลักษณะพื้นที่แบบ 3D ข้อมูลเกี่ยวกับสภาพการจราจรและพลังงานไฟฟ้า
- **การติดตั้งไฟเบอร์ออพติก**: ติดตั้งไฟเบอร์ออพติกเพื่อรักษาคุณภาพสัญญาณ 5G (เช่น eMBB, eMTC และ URLLC เป็นต้น) ในพื้นที่บริเวณบางซื่อ
- **การติดตั้งกล้องวงจรปิด:** นำกล้องวงจรปิดที่ใช้สำหรับมาตรการแก้ไขปัญหาการจราจรติดขัดและช่วยด้านกลยุทธ์ด้านการตลาดของสถานที่เชิงพาณิชย์ รวมทั้งแอพพลิเคชั่นสำหรับใช้งานมาใช้

(2) การจัดตั้งศูนย์เมืองอัจฉริยะ

เสนอให้มีการจัดตั้งศูนย์เมืองอัจฉริยะในบริเวณโซน D ศูนย์เมืองอัจฉริยะจะเป็นอาคารขนาดใหญ่ ประกอบด้วยออฟฟิศสำหรับบริหารกิจการเกี่ยวกับบริการอัจฉริยะ (smart service) ศูนย์ข้อมูลขนาดเล็ก อีกทั้งยังมีสิ่งอำนวยความสะดวกที่ช่วยพัฒนาสภาพแวดล้อมความเป็นอยู่ของประชาชนในบริเวณนั้น เช่น ศูนย์การเรียนรู้ตลอดชีพ ศูนย์ชุมชน เคาน์เตอร์ติดต่อหน่วยงานของรัฐ เป็นต้น เพื่อจัดตั้งศูนย์เมืองอัจฉริยะความร่วมมือจากร่วมกับหน่วยงานที่เกี่ยวข้อง เช่น กรุงเทพมหานคร และสำนักงานส่งเสริมเศรษฐกิจดิจิทัลเป็นสิ่งที่ขาดไม่ได้



ภาพที่ 19 บริเวณและภาพจำลองศูนย์เมืองอัจฉริยะ

ตารางที่ 1 แผนเกี่ยวกับสิ่งอำนวยความสะดวกต่างๆในศูนย์เมืองอัจฉริยะ

Facility Plan	Functions	Cooperation with:
Monitoring Room	Space (control rooms) to display CCTV and collected data on large monitors	BMA, RTP
Data Center	Server room to store software and data needed to implement the smart service business	CAT/DEPA
Exhibition Room	Exhibition room to introduce smart city service	CAT/DEPA
Work/ Conference Space	Work/Conference space to address staff and visitors	CAT/DEPA
Energy Plant	Facilities to install cogeneration and cooling systems	MEA EGAT
Community Space	Space for lifelong learning center or administrative consultation service	BMA
PRT Parking Lot	PRT parking lot, inspection, and recharging space	BMA

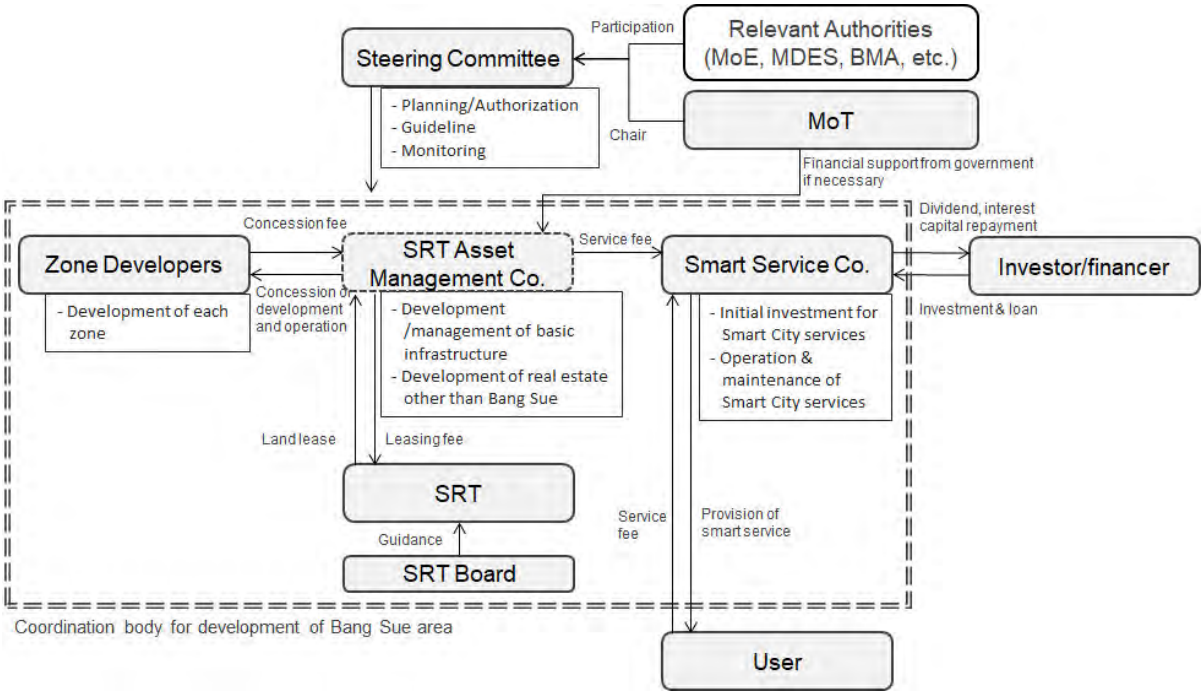
4.1 เงื่อนไขในการพิจารณาโครงสร้างการดำเนินงาน

ในการพิจารณาโครงสร้างการดำเนินงานในการพัฒนาพื้นที่บริเวณบางซื่อโดยรวมได้นำเสนอแนวทางโดยคำนึงถึงการพัฒนาอย่างเป็นแบบแผนเดียวกันและการเข้ามามีส่วนร่วมของภาคเอกชนเป็นพื้นฐาน อีกทั้งยังได้หารือกับทางรัฐบาลไทยและได้นำเจตจำนงและสภาพการปัจจุบันของทางการไทยมาพิจารณาร่วมด้วย ทั้งนี้จะให้ความสำคัญกับ 3 ประเด็น ดังนี้

- **การตัดสินใจระดับสูงในด้านนโยบายและการประสานงาน:** ในการดำเนินงานโครงการพัฒนาขนาดใหญ่และเป็นการพัฒนาระยะยาวเช่นกรณีพื้นที่บริเวณบางซื่อนั้น จำเป็นต้องมีการจัดตั้งหน่วยงานในฐานะหน่วยงานระดับสูงของรัฐบาล ซึ่งจะมาทำหน้าที่ประสานงานระหว่างภาครัฐกับหน่วยงานที่เกี่ยวข้อง และบริหารโครงการ
- **การจัดตั้งบริษัทบริหารสินทรัพย์ของการรถไฟแห่งประเทศไทย (Asset Management Company: AMC):** การจัดตั้ง AMC ขณะนี้อยู่ในขั้นตอนอนุมัติขั้นสุดท้าย เนื่องจาก AMC จะได้รับมอบหมายให้ ควบคุมดูแลทรัพย์สินของทางการรถไฟแห่งประเทศไทย จึงควรทำหน้าที่เป็นหน่วยงานหลักในการพัฒนาพื้นที่บริเวณบางซื่อ
- **การเสริมศักยภาพทางด้านเทคนิคและการเงินให้กับการรถไฟและ AMC:** ทั้งการรถไฟและAMCที่กำลังจะจัดตั้งขึ้นใหม่ต่างไม่มีประสบการณ์ในการพัฒนาเมืองอัจฉริยะ อีกทั้งยังมีข้อจำกัดอย่างมากในด้านงบประมาณ จำเป็นต้องมีการเสริมศักยภาพในส่วนที่ยังขาด

4.2 แนวคิดเกี่ยวกับโครงสร้างการดำเนินงานโดยรวม

จากเงื่อนไขข้างต้น จึงขอเสนอโครงสร้างการดำเนินงานโดยรวม บทบาทหน้าที่และโครงสร้างของแต่ละหน่วยงานดังต่อไปนี้



ภาพที่ 20 โครงสร้างการดำเนินงานโดยรวมในการพัฒนาพื้นที่บริเวณบางซื่อ

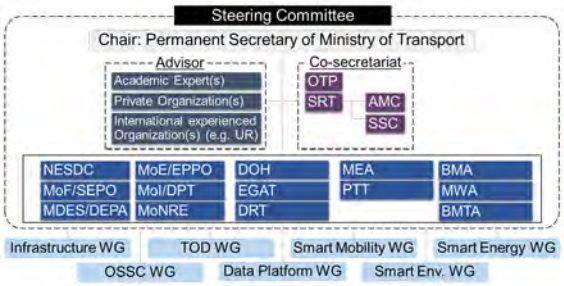
(1) คณะกรรมการขับเคลื่อน

สำหรับคณะกรรมการขับเคลื่อน เสนอให้ปลัดกระทรวงคมนาคมเป็นประธานคณะกรรมการ โดยมีกระทรวงคมนาคม (สำนักงานนโยบายและแผนการขนส่งและจราจร) และการรถไฟแห่งประเทศไทยเป็นฝ่ายเลขานุการ โดยคณะกรรมการจะเป็นผู้ตัดสินใจเกี่ยวกับนโยบาย แผนการพัฒนา และนโยบายการบริหารเมืองโดยเร่งด่วน

โดยนโยบายพื้นฐานคณะกรรมการฯนอกจากจะสนับสนุนโครงการด้วยการประชุมหาความเห็นชอบจากผู้มีส่วนเกี่ยวข้องแล้ว ยังมีหน้าที่ในการควบคุมความคืบหน้าของการพัฒนาอีกด้วย

นอกจากนี้คณะกรรมการยังมีอำนาจในการอนุมัติ master plan และแนวทางการพัฒนาอีกด้วย

สำหรับการประสานงานเกี่ยวกับ smart service การพิจารณาการผ่อนปรนกฎหมาย การดำเนินธุรกิจ smart service เป็นบริการเชิงพาณิชย์ ควรมีการจัดตั้งคณะทำงานภายใต้คณะกรรมขับเคลื่อน



ภาพที่ 21 ผังองค์กรของคณะกรรมการขับเคลื่อน

(2) บริษัทบริหารทรัพย์สิน (Asset Management Company: AMC)

AMC จะเป็นหน่วยงานผู้รับผิดชอบการพัฒนาพื้นที่บริเวณบางซื่อโดยรวม และประสานงานกับหน่วยงานที่เกี่ยวข้อง AMC จะเช่าซื้อที่ดินจากการรถไฟแห่งประเทศไทยทำการพัฒนาที่ดิน หรือนำที่ดินไปให้เอกชนผู้พัฒนาที่ดินเช่าซื้อต่อ AMC จะเป็นผู้ดูแลสัญญาเช่าซื้อกับเอกชนผู้พัฒนาที่ดินและสัญญาให้บริการกับทางบริษัท Smart service (SSC)

ในการพัฒนาโครงสร้างพื้นฐาน เช่น ถนน การระบายน้ำ น้ำประปา การจัดการขยะและสิ่งปฏิกูล ในพื้นที่บริเวณบางซื่อ AMC จะประสานงานกับหน่วยงานที่เกี่ยวข้อง เช่น กรุงเทพมหานคร การประปานครหลวง การไฟฟ้านครหลวง เป็นต้น

นอกจากนี้ AMC ยังจะต้องนำค่าสัมปทานจากบริษัทผู้พัฒนาพื้นที่ไปจ่ายเป็นค่าบริการให้กับ SSC เป็นเงินทุนให้กับ SSC ที่เป็นผู้ให้บริการ smart service ซึ่งทำกำไรได้ยาก AMC จะพิจารณาการให้บริการ smart services ร่วมกับ SSC

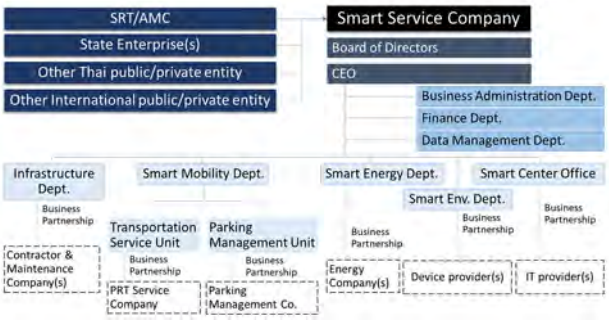
หากการจัดตั้ง AMC ล่าช้าหรือจัดตั้งไม่ได้ การรถไฟแห่งประเทศไทยจะต้องเป็นผู้รับผิดชอบแทนในส่วนของ AMC

ภาพที่ 22 ผังองค์กรของ AMC

(3) บริษัท Smart Service (SSC)

SSC จะเป็นหน่วยงานที่ดำเนินการทั้งก่อสร้าง ดำเนินงาน บริหารงาน ซ่อมบำรุงโครงสร้างพื้นฐานที่เป็นพื้นฐานของบริการภายในเมืองอัจฉริยะ โดยเฉพาะอย่างยิ่ง เป็นผู้ให้บริการ smart service แก่บริษัทผู้พัฒนาพื้นที่ ประชาชนภายในพื้นที่ และผู้มาเยือนผ่านเทคโนโลยีสมัยใหม่ SSC จะพิจารณาให้บริการ smart services ร่วมกับ AMC

อาจจัดตั้ง SSC ในรูปแบบ Special Purpose Vehicle (SPV) ซึ่งรัฐบาลไทยเป็นผู้กำหนดผู้ถือหุ้นและต้องได้รับการอนุมัติจากคณะรัฐมนตรี (ซึ่งโดยส่วนใหญ่ผู้ถือหุ้นจะเป็นรัฐวิสาหกิจ) หรือรูปแบบกิจการร่วมค้า (joint venture) ระหว่างการรถไฟแห่งประเทศไทยกับหน่วยงานอื่นเช่น รัฐวิสาหกิจอื่น ซึ่งภายใต้รูปแบบนั้น นอกจากคาดว่าหน่วยงานทั้งภาครัฐและภาคเอกชนจากต่างประเทศจะสามารถเข้าร่วมได้ในอนาคต



ภาพที่ 23 ผังองค์กรของ Smart Service Company

(4) **บริษัทผู้พัฒนาพื้นที่**

บริษัทผู้พัฒนาพื้นที่แต่ละโซนจะได้รับการคัดเลือกโดยการประมูล โดยแยกเป็นแต่ละโซนโดยเริ่มจากโซน A จนถึง I และเริ่มทำการพัฒนาตามสัญญา ได้รับผลตอบแทนจากการพัฒนา และจ่ายค่าสัมปทานตามสัญญาให้กับ AMC

5.1การร่วมลงทุนและการประเมินมูลค่าโครงการ

(1) การร่วมลงทุน

เงินลงทุนในโครงการพัฒนาพื้นที่บริเวณบางซื่อจะมาจากงบประมาณของภาครัฐ รัฐวิสาหกิจ เงินลงทุนจากเอกชนผู้พัฒนาพื้นที่ และเงินทุนของบริษัท Smart service การจัดหาเงินทุนเพื่อนำมาใช้ในการพัฒนาโครงสร้างพื้นฐานและสิ่งอำนวยความสะดวกของเมืองอัจฉริยะจะแบ่งออกเป็น 4 ระดับ ตามลักษณะของโครงสร้างพื้นฐานและสิ่งอำนวยความสะดวกนั้นๆ และลักษณะของหน่วยงานผู้ดำเนินการ

ระดับที่ 1 โครงสร้างพื้นฐานทั่วไปจะได้รับการพัฒนาโดยใช้เงินลงทุนจากงบประมาณภาครัฐหรือเงินทุนจากการรถไฟแห่งประเทศไทยซึ่งเป็นเจ้าของพื้นที่ ระดับที่ 2 โครงสร้างพื้นฐานสำหรับการเป็นเมืองอัจฉริยะ ส่วนหนึ่งจะเป็นการลงทุนจากภาคเอกชน ระดับที่ 3 กิจการ smart service SSC และภาคเอกชนอื่นจะเป็นผู้ลงทุน ระดับที่ 4 การพัฒนาในแต่ละโซน โดยหลักการจะเป็นการลงทุนโดยภาคเอกชน

ภาพที่ 24 การลงทุนในแต่ละระดับ

(2) การประเมินค่าใช้จ่ายในการลงทุน

ทางคณะผู้ศึกษาได้คำนวณต้นทุนทั้งหมดเบื้องต้นบนฐานขององค์ประกอบเมืองอัจฉริยะที่ได้นำเสนอไปและต้นทุนต่อหน่วยเบื้องต้น การประเมินต้นทุนในการลงทุนดังสรุปได้ในตารางที่ 2

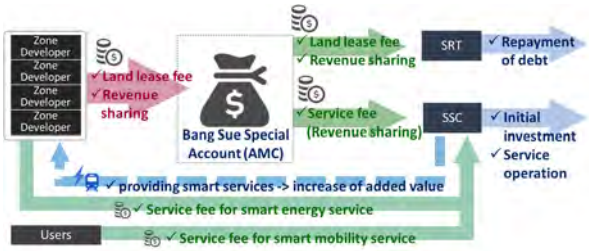
ตารางที่ 2 ต้นทุนในการลงทุนประเมินตามระดับและระยะของการดำเนินงาน

Category			Approximate cost (Million THB)			
			Total	Phase 1	Phase 2	Phase 3
Layer 1	Basic Infrastructure	Major Road	134	24	19	91
		Zone Boundary Road	277	111	21	145
		Other (Water, etc.)	4,817	2,884	832	1,101
	Disaster Prevention		32	13	6	13
	Green Network		37	13	6	18
Layer 2	Sky Deck (Outside the Zones)		2,318	1,534	457	327
	Smart Environment		19	18	1	0
	Smart City Platform		745	377	171	198
Layer 3	Smart Mobility		3,376	1,398	1,062	916
	Smart Energy		11,140	3,905	2,795	4,440
TOTAL (Layer 1~3)			***22,895***	***10,277***	***5,370***	***7,249***
	Buildings	Office	42,089	20,222	5,691	16,177
		Commercial facility	34,767	9,226	10,706	14,835
		Residence	172,568	65,532	39,439	67,597
		Hotel	17,343	5,852	4,282	7,208
		Cultural facility	8,723	4,758	3,965	0
		Public office	4,758	4,758	0	0
	Inter-zone Infrastructure		1,147	643	93	411
	Sky Deck (Inside the Zones)		3,932	1,606	620	1,705
TOTAL (Layer 4)			***285,327***	***112,597***	***64,796***	***107,933***
TOTAL			***308,222***	***122,874***	***70,165***	***115,183***

5.2 แนวความคิดเกี่ยวกับโมเดลธุรกิจ

(1) โมเดลทางธุรกิจของเมืองอัจฉริยะที่นำเสนอ (กรณีพื้นฐาน)

ในการพิจารณาเกี่ยวกับบริเวณพื้นที่บางซื่อ เนื่องจากที่ดินของบริเวณพื้นที่บางซื่อ (ทั้งหมดราว 370 เฮคเตอร์) เป็นของการรถไฟแห่งประเทศไทย ดังนั้นกิจกรรมการพัฒนาต่างๆ รวมถึงการพัฒนาโครงสร้างพื้นฐานจึงควรบริหารงานโดยการรถไฟแห่งประเทศไทย การรถไฟแห่งประเทศไทยหรือAMC อาจไม่มีขีดความสามารถพอทั้งในด้านงบประมาณและความรู้ด้านเทคนิค ดังนั้นจึงคาดหวังว่าการจัดตั้ง Smart Service Company จะส่งผลให้มีความสามารถเพียงพอในการระดมทุน และบริหารการพัฒนาเมืองอัจฉริยะตามที่ได้เสนอในการศึกษาครั้งนี้



ภาพที่ 25 ภาพแนวคิดเกี่ยวกับกระแสเงินตามโมเดลธุรกิจที่นำเสนอ

ในกรณีพื้นฐาน โครงสร้างพื้นฐานในระดับ 1-3 SSC เป็นผู้รับผิดชอบ หลังจาก AMC ได้รับค่าสัมปทานจากบริษัทผู้พัฒนาพื้นที่เป็นที่เรียบร้อยแล้ว ก็จะแบ่งรายได้ส่วนหนึ่งไปให้กับทาง SSC เป็นค่าบริการ smart service เป็นผลตอบแทนจากที่ SSC ได้ลงทุนขั้นต้นไป ในส่วนของบริการด้าน Smart energy และ mobility services คาดว่าจะสามารถคุ้มทุนได้โดยอาศัยค่าบริการจากผู้ใช้งานเพียงอย่างเดียว

(2) องค์ประกอบทางด้านธุรกิจ

กิจการเมืองอัจฉริยะของ SSC จะประกอบด้วยธุรกิจดังต่อไปนี้:

- **Smart Mobility**: ดำเนินการระบบรถโดยสาร PRT และให้บริการที่จอดรถรอบนอกพื้นที่
- **Smart Energy**: ให้บริการและบริหารงานเกี่ยวกับพลังงานผ่านระบบ cogeneration ระบบ regional cooling ภายในพื้นที่
- **Smart Environment:** บริหารพื้นที่สีเขียว และพื้นที่เปิดสาธารณะ
- **ศูนย์เมืองอัจฉริยะ**: ดำเนินการและบริหารงานศูนย์เมืองอัจฉริยะ
- **Smart Infrastructure:** ดำเนินการและบริหารงานโครงสร้างพื้นฐานอัจฉริยะ เช่น เครือข่ายทางเดินลอยฟ้า เป็นต้น

ในส่วนบริการด้าน Smart Mobility และ Smart Energy เป็นธุรกิจที่สร้างรายได้ได้โดยตรงได้จากผู้ใช้บริการ ในขณะที่ธุรกิจอื่นเช่น smart Environment ศูนย์เมืองอัจฉริยะจะสามารถดำเนินการได้โดยอาศัยรายได้จากค่าบริการจากการรถไฟ และ AMC

5.3 การวิเคราะห์ความคุ้มทุน

ที่ดินของบริเวณพื้นที่บางซื่อโดยพื้นฐาน (ทั้งหมดราว 370 เฮคเตอร์) เป็นของการรถไฟแห่งประเทศไทย แต่อย่างไรก็ตาม อาจมีบางกรณีที่มีการแบ่งเขตการพัฒนาโครงสร้างพื้นฐานได้ เนื่องจากพื้นที่กว้างเกินกว่าจะได้รับการพัฒนาจากหน่วยงานเพียงหน่วยงานเดียว และการพัฒนาบางซื่อสมาร์ทซิตี้ควรได้รับความสำคัญในฐานะโครงการระดับชาติ เนื่องจากโครงการบางซื่อสมาร์ทซิตี้เป็นหนึ่งในโครงการเรือธงของการพัฒนาเมืองอัจฉริยะและเป็นประตูเชื่อมโยงอาเซียนแห่งใหม่ ซึ่งได้รับคาดหวังว่าภาครัฐควรเข้ามามีส่วนร่วมมากขึ้น

การวิเคราะห์ความคุ้มทุนครอบคลุมทุกธุรกิจของ SSC โดยจะแบ่งออกเป็น 4 กรณี ตามแผนการลงทุน ดังปรากฏในตารางที่ 3

กรณีที่ 1 เป็นกรณีที่การรถไฟแห่งประเทศไทยจะลงทุนในเงินลงทุนเบื้องต้นให้ก่อนได้รับรายได้จากผู้พัฒนาในแต่ละโซน กรณีที่ 2 เป็นกรณีที่หน่วยงานภาครัฐและรัฐวิสาหกิจจะลงทุนในโครงสร้างพื้นฐาน (รวมทางเดินลอยฟ้า) กรณีที่ 3 (กรณีพื้นฐาน) ซึ่ง SSC จะเป็นผู้ดำเนินการโครงสร้างพื้นฐานทั้งหมดและทางเดินลอยฟ้า (นอกโซนพัฒนา) และกรณีที่ 4 ซึ่ง SSC และหน่วยงานภาครัฐจะช่วยรับผิดชอบการลงทุนในโครงสร้างพื้นฐานบางส่วน

สำหรับระดับของค่าบริการ smart service ได้ตั้งเงื่อนไขไว้ให้สามารถคุ้มทุนได้สำหรับทางเลือกที่ 3 ซึ่งเป็นกรณีพื้นฐาน จากผลการวิเคราะห์ความคุ้มทุน ตามโมเดลธุรกิจที่นำเสนอไป เมื่อถึงจุดที่เกิดความคุ้มทุน ก็จะสามารถช่วยลดการขาดดุลของการรถไฟได้

อย่างไรก็ตาม สิ่งที่ควรระวังคือความคุ้มทุนนั้นขึ้นกับอุปสงค์ต่อบริการเป็นอย่างมาก ดังนั้นหากมีวางแผนแผนธุรกิจของ SSC เสร็จสิ้นเรียบร้อยแล้ว เห็นควรให้มีการพิจารณาในรายละเอียดอีกครั้ง นอกจากนี้ แผนการในการลดความเสี่ยงและการจัดการที่มีความยืดหยุ่นเป็นสิ่งสำคัญในการรักษาให้เกิดความคุ้มทุนและสามารถดำเนินธุรกิจต่อไปได้อย่างยั่งยืน

ตารางที่ 3 ผลการวิเคราะห์ความคุ้มทุน

Category			Case1	Case2	Case3 (Base Case)	Case4
Demarcation						
Layer 1	Basic Infrastructure	Major Road	AMC/SRT	Public	SSC(w/ SF)	Public
		Zone Boundary Road	AMC/SRT	Public	SSC(w/ SF)	SSC(w/ SF)
		Other (Water, telecom, etc.)	AMC/SRT	Public	SSC(w/ SF)	Public
	Disaster Prevention		AMC/SRT	Public	SSC(w/ SF)	Public
	Green Network		AMC/SRT	Public	SSC(w/ SF)	Public
Layer 2	Sky Deck (Outside the Zones)		AMC/SRT	Public	SSC(w/ SF)	SSC(w/ SF)
	Smart Environment		SSC(w/ SF)	SSC(w/ SF)	SSC(w/ SF)	SSC(w/ SF)
	Smart City Platform		SSC(w/ SF)	SSC(w/ SF)	SSC(w/ SF)	SSC(w/ SF)
Layer 3	Smart Mobility		SSC(w/o SF)	SSC(w/o SF)	SSC(w/o SF)	SSC(w/o SF)
	Smart Energy		SSC(w/o SF)	SSC(w/o SF)	SSC(w/o SF)	SSC(w/o SF)
Layer 4	Inter-zone Development		Private	Private	Private	Private
Criteria						
Coordination in infrastructure development			★★★	★	★★★★	★★
Financial burden on SRT (especially for initial cost)			★	★★★★	★★	★★★
Financial burden on Public			★★★	★	★★★	★★
Execution capability of the agency			★	★★★★	★★	★★★
Risk distribution(too much risk on one agency)			★	★★	★	★★★
Public sector involvement			★	★★★★	★	★★★
Private sector involvement and future prospect			★	★	★★★	★★★
Smart Service Co.	**Project IRR (2020-61)**		39.4% (36.2%)	39.4% (36.2%)	8.7% (14.9 %)	20.8 % (26.1 %)
	Average of ROE (2034-61)		22.6 % (25.8%)	22.6 % (25.8%)	5.8% (15.1%)	14.7% (21.9%)
AMC (SRT)	**Accumulated NCF (2034) (Million THB)**		17,719 (17,267)	28,514 (28,062)	27,753 (27,240)	28,254 (27,802)
	Accumulated NCF (2061) (Million THB)		112,185 (111,733)	131,316 (130,863)	130,554 (139,942)	131,056 (130,604)

SSC(w/ SF): การลงทุนของ SSC แบบมีค่าบริการ SSC(w/o SF): การลงทุนของ SSC แบบไม่มีค่าบริการ

* กำหนดค่าบริการที่ทางการรถไฟแห่งประเทศไทยจ่ายให้กับ SSC ไว้ที่ร้อยละ 33 (2565-2576) และร้อยละ 14 (2577-2604) ของรายได้ของการรถไฟที่ได้รับเป็นค่าเช่าซื้อที่ดินจากบริษัทผู้พัฒนาที่ดินตามลำดับ

** ตัวเลขในวงเล็บรวมบริการด้าน Smart Mobility เนื่องจากความคุ้มทุนของบริการด้าน smart mobility service ค่อนข้างผันผวนตามความต้องการ (ขึ้นกับความผันผวนของความต้องการใช้บริการ) รายได้ในส่วนของ smart mobility จึงถูกแยกออกจากการประเมินความคุ้มทุนของการรถไฟและ SSC ถ้า SSC สามารถทำรายได้ได้อย่างเพียงพอจากบริการ smart mobility อาจพิจารณาเปลี่ยนแปลงค่าบริการที่ AMC จ่ายให้กับการรถไฟได้

6 บทส่งท้าย

6.1 แผนปฏิบัติการในการขับเคลื่อนโครงการ

(1) ประเด็นปัญหาในการดำเนินโครงการ

ดังกล่าวข้างต้นการพัฒนาบางซื่อสมาร์ทซิตี้เป็นการนำศักยภาพที่มีออกมาใช้อย่างเต็มที่ สนับสนุนนโยบายไทยแลนด์ 4.0 อีกทั้งยังถือเป็นตัวอย่างในการพัฒนาเมืองในรูปแบบใหม่ ซึ่งจะสร้างประโยชน์ให้กับสังคมไทยเป็นอย่างมาก

อย่างไรก็ตาม มีประเด็นปัญหามากมายที่ต้องแก้ไขและจำเป็นต้องเร่งดำเนินการอย่างรวดเร็ว เนื่องจากโครงการดังกล่าวมีขนาดใหญ่อีกทั้งระยะเวลาดำเนินงานยาวนานจึง โดยเฉพาะอย่างยิ่งการพัฒนาในระยะแยกที่จะต้องสอดคล้องกับการก่อสร้างสถานีกลางบางซื่อและและรถไฟสายสีแดงใกล้จะเปิดดำเนินการ ให้สอดคล้องกับการพัฒนาเครือข่ายคมนาคมดังกล่าว

ในบรรดาประเด็นปัญหามากมาย ทางคณะผู้ศึกษาขอเสนอประเด็นปัญหา ซึ่งเป็นประเด็นสำคัญและจำเป็นต้องได้รับการแก้ไขอย่างเร่งด่วน 3 ด้าน ดังนี้

Challenge 1:
High level decision making and coordination

- Implement necessary deregulation measures
- Approval and authorization of plans and actions

Challenge 2:
Fulfil financial gaps and technical capabilities

- Finance for initial investment
- Technical capability to lead Smart City project

Challenge 3:
Mechanism for integrated development

- Phased infrastructure development
- Interface coordination among stakeholders
- Incorporation of private sector skills and expertise

(2) มาตรการที่นำเสนอและประเด็นสำคัญที่ควรพิจารณา

จากประเด็นปัญหาที่ได้กล่าวไว้เบื้องต้น ทางคณะผู้ศึกษาจึงขอเสนอมาตรการและประเด็นสำคัญที่ควรพิจารณาดังนี้

Measures for Challenge 1

Establishment of Steering Committee

- Establish clear roles and responsibility among related organizations
- Allow flexible arrangement, setting up of a Working Group for specific issues

Measures for Challenge 2

Establishment of AMC, and SSC

- Ensure transparent governance structure and independence
- Address demand risk mitigation and arrange incentive schemes
- Recruitment and capacity building

Measures for Challenge 3

Formulation of Integrated Infrastructure Development Plan, Smart City Development Plan, and City Development Guidelines

- Establish guidelines and incentive scheme to coordinate development
- Ensure coordination of plans at various levels – integrated infrastructure design, Master Plan, District Plan, District Plan, Zone plan, Smart Service F/S

6.2 แผนปฏิบัติการ

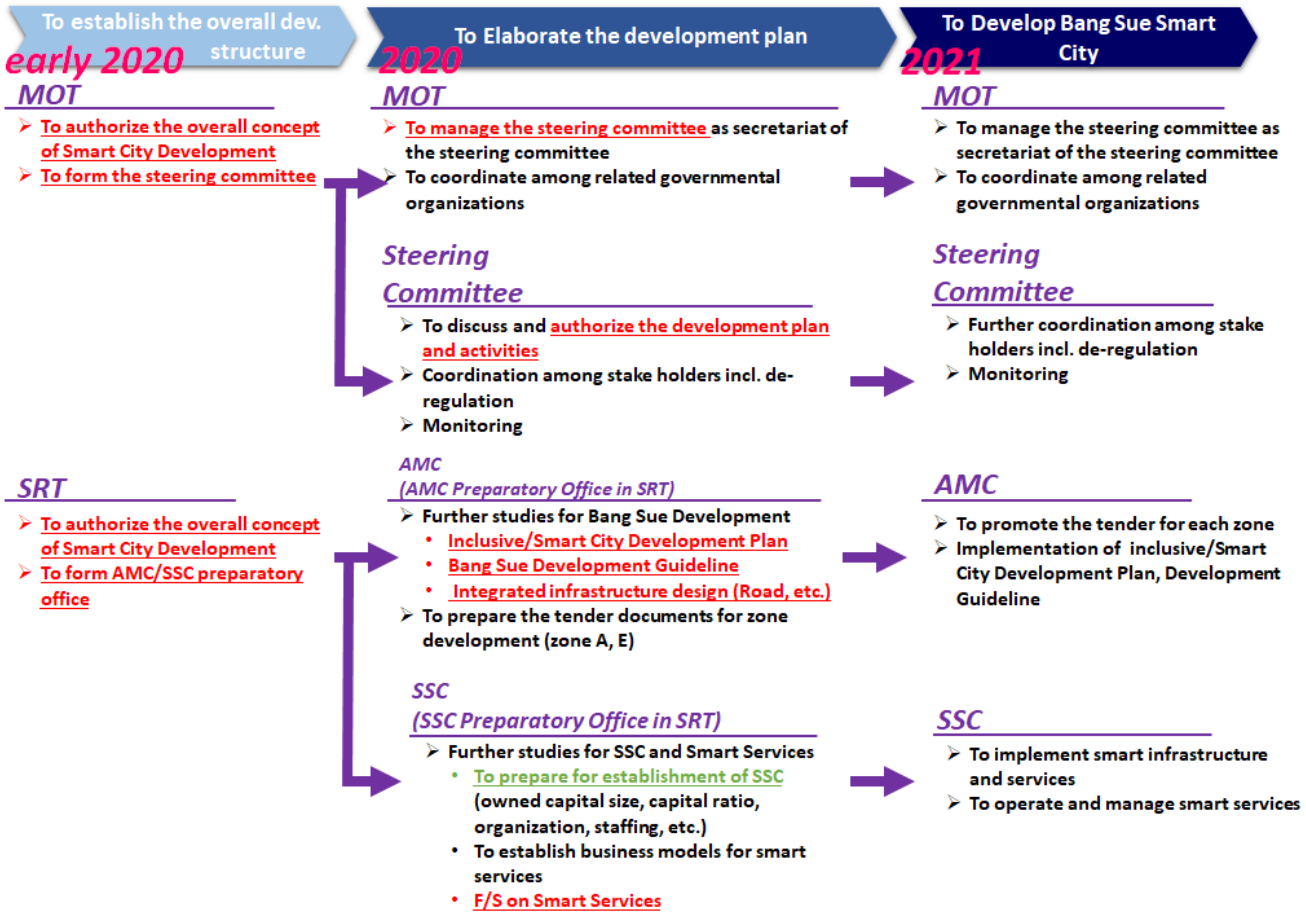
ทางคณะผู้ศึกษาได้รวบรวมประเด็นที่ควรเร่งดำเนินการและสรุปแผนปฏิบัติการเพื่อผลักดันให้บางซื่อสมาร์ทซิตี้เกิดขึ้นในปี 2564 ซึ่งเป็นปีที่สถานีกลางบางซื่อและรถไฟสายสีแดงเริ่มเปิดให้บริการ โดยมีกิจกรรมที่ควรดำเนินการในแต่ละปีดังต่อไปนี้

- **ต้นปี 2563**: แนวคิดเมืองอัจฉริยะได้รับการอนุมัติจากกระทรวงคมนาคมและการรถไฟแห่งประเทศไทย มีการจัดตั้งคณะกรรมการขับเคลื่อนโดยการริเริ่มของกระทรวงคมนาคม มีการจัดตั้งหน่วยงานเตรียมความพร้อมในการจัดตั้ง AMC และ SSC ภายใต้การรถไฟแห่งประเทศไทย (ซึ่งหน่วยงานดังกล่าวจะเป็นหน่วยงานดำเนินโครงการแทนในระหว่างที่รอจัดตั้ง AMC และ SSC)
- **ภายในปี 2563**: แผนงานและกิจกรรมในการพัฒนาที่เป็นรูปธรรมได้รับการอนุมัติจากคณะกรรมการขับเคลื่อน AMC (หรือหน่วยงานจัดตั้ง AMC) จัดทำแผนการพัฒนาโครงสร้างพื้นฐานโดยรวม แผนพัฒนาเมืองอัจฉริยะ และแนวทาง

การเมือง SSC (หรือหน่วยงานจัดตั้ง SSC) ศึกษาเบื้องต้นเกี่ยวกับการดำเนิน smart service

- ภายในปี 2564: หน่วยงานสนับสนุนการพัฒนาเมืองอัจฉริยะที่ทางคณะผู้ศึกษาเสนอไป คือ คณะกรรมการขับเคลื่อน AMC และ SSC พร้อมดำเนินงาน อีกทั้งโครงสร้างเชิงสถาบันที่จัดตั้งขึ้นตามแผนและแนวทางพัฒนาก็ควรมีการจัดตั้งแล้วเสร็จด้วยเช่นกัน

ดังได้กล่าวไว้เบื้องต้น การเร่งจัดตั้งหน่วยงานในการพัฒนาเป็นสิ่งที่ได้รับการคาดหวัง ซึ่งรวมการจัดตั้งคณะกรรมการขับเคลื่อน AMC และการเตรียมการจัดตั้ง SSC นอกจากนี้ยังคาดหวังให้มีการจัดทำแผนการพัฒนาเมืองอัจฉริยะให้เป็นรูปธรรมยิ่งขึ้นต่อจากการศึกษาในครั้งนี้ และสร้างให้เกิดการพัฒนาเมืองอัจฉริยะได้ภายใต้การตัดสินใจด้านนโยบายที่รวดเร็วของคณะกรรมการขับเคลื่อน



ภาพที่ 26 แผนปฏิบัติการถึงปี 2564

6.3 บทสรุป: การขับเคลื่อนบางซื่อสมาร์ทซิตี้

จากนี้ไปหน่วยงานผู้ปฏิบัติงานฝั่งไทยโดยมีสำนักงานนโยบายและแผนการขนส่งและจราจรและการรถไฟแห่งประเทศไทยเป็นแกนหลักจะมีการประชุมหารือ ประสานงานระหว่างผู้เกี่ยวข้อง โดยมีผลการศึกษาในครั้งนี้เป็นพื้นฐาน อีกทั้งคาดหวังว่าจะมีการแบ่งปันแนวความคิดเกี่ยวกับการพัฒนาเมืองอัจฉริยะในพื้นที่บริเวณบางซื่อแก่หน่วยงานที่เกี่ยวข้องทางฝั่งไทย นอกจากนี้ เนื่องจากการพัฒนาพื้นที่บริเวณบางซื่อเป็นโครงการระยะยาวต่อเนื่องจากนี้กว่า 10 ปี คาดหวังว่าเนื้อหาที่ได้นำเสนอในรายงานฉบับนี้จะได้รับการนำไปปฏิบัติในเร็ววัน และอาจมีการปรับเปลี่ยนตามช่วงระยะเวลาที่ผ่านไป ซึ่งการพัฒนาในโครงการนี้ไม่เพียงเป็นตัวอย่างการพัฒนาเมืองอัจฉริยะที่ล้ำสมัยสำหรับประเทศไทย หากแต่เป็นตัวอย่างสำหรับภูมิภาคอาเซียนโดยรวม

Main Part

1. Introduction

1.1 Background and Objectives

Bang Sue area, the target area of this study, will incorporate 6 intersecting lines in and around Bang Sue Grand Station while functioning as a terminal for long and middle distance buses. Accordingly, the district is envisaged to become *Bangkok's new central station and public transport hub*, and an alternative to Hua Lamphong Station. Moreover, the district is planned to incorporate urban business functions as the new *Gateway of Bangkok*, while embodying the contemporary urban development concept of a *Smart City*.

The development plan for the area as an urban hub for integrated business functions was proposed in a previous study, "Data Collection Survey on Urban Redevelopment in Bang Sue Area" (hereafter referred to as the *previous study*). In the previous study, a development vision and a draft concept paper were proposed, while the idea for Bang Sue area's development into a *Smart City* was partially presented as well. Furthermore, the *Smart City development* of Bang Sue area has been conceived as "Phahonyothin Transportation Hub" in the ASEAN Smart City Network (ASCN), thereby identified as one of Thailand's priority projects for its Smart City development. Nevertheless, the proposal remains conceptual, and its specific contents are yet to be examined to the full extent.

On the other hand, the development of Bang Sue area will be mainly led by private companies on land owned by SRT. In principle, the Thai Government's expected role in the Bang Sue area development project will be to support the formulation of development plans and establishment of systems and structures that will contribute to inducing private investment, rather than actively promoting infrastructure development through public investment or external debt.

Considering the above-mentioned situation, this study shall support the realization of Bang Sue Smart City development through proposing a specific vision of a *Smart City* in Bang Sue area to the Thai Government and stakeholders. The project framework (including project implementation structure and financing, as well as the roadmap for realization, etc.) shall also be elaborated and a consensus developed among the stakeholders concerned with the area development.

This study is aimed at supporting the realization of a Smart City for 100 ha of Bang Sue area, or covering the whole 360 ha Bang Sue area if necessary, as the new *symbol of Bangkok/Thailand* by proposing a Smart City development plan. This Smart City development plan will include the infrastructure development and spatial planning, the real estate development plan, as well as the project implementation plan which will outline the steps for its realization.

In formulating the plan, local conditions will be fully considered while coordination with the counterpart will be ensured through close discussion. The potential of incorporating advanced Japanese smart technologies shall also be considered.

1.2 Project Area

Source: Material provided by JICA, compiled by the Study Team

Figure 1.1 Bang Sue area

1.3 Outline of the Study

1) To review JICA's previous study of the Bang Sue M/P and understand the current organizational structure and planning on the Thai side for Bang Sue Smart City development (ex. related committees, PMO, etc.).

2) To analyze the relevant legal systems for smart city development and propose the items which shall be enacted, such as deregulation in the area.

3) To analyze and propose smart city technologies (efficient energy management, reusable energy, transportation, water usage, mitigation of disaster risks, etc.). For transportation in particular, proposed transport system shall be quantitatively analysed.

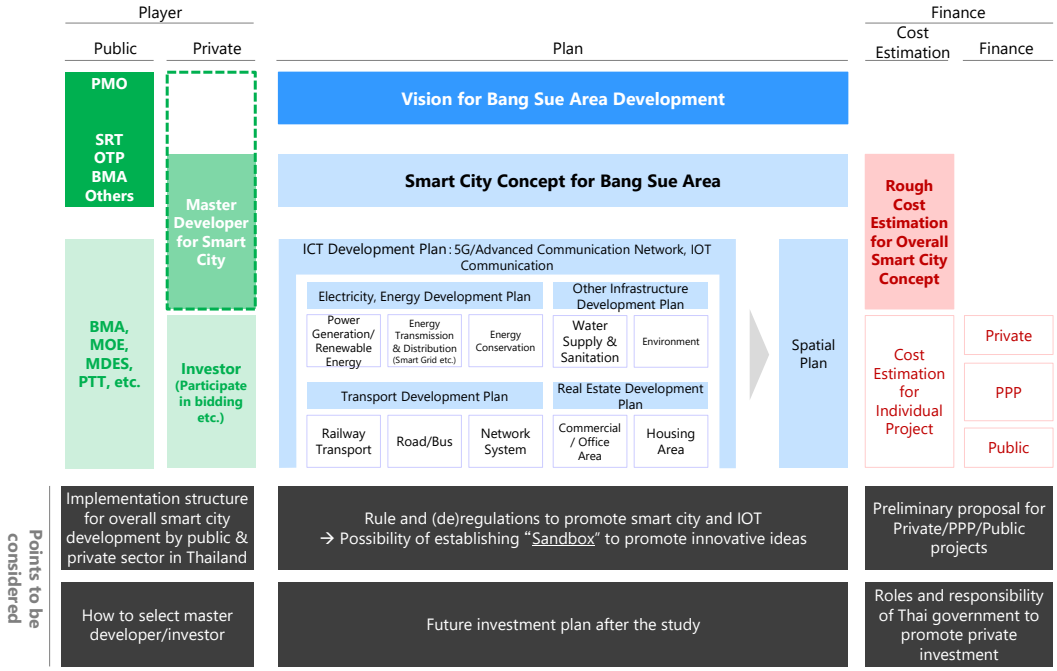
4) To analyze energy demand and a suitable energy control system including utilities in the area.

5) To design the concept and propose a roadmap to realize Bang Sue Smart City.

6) To propose an organizational structure with related Thai agencies and an investment/financing scheme.

7) To implement an Invitation Program to Japan.

8) To hold seminars in Bangkok and Tokyo.

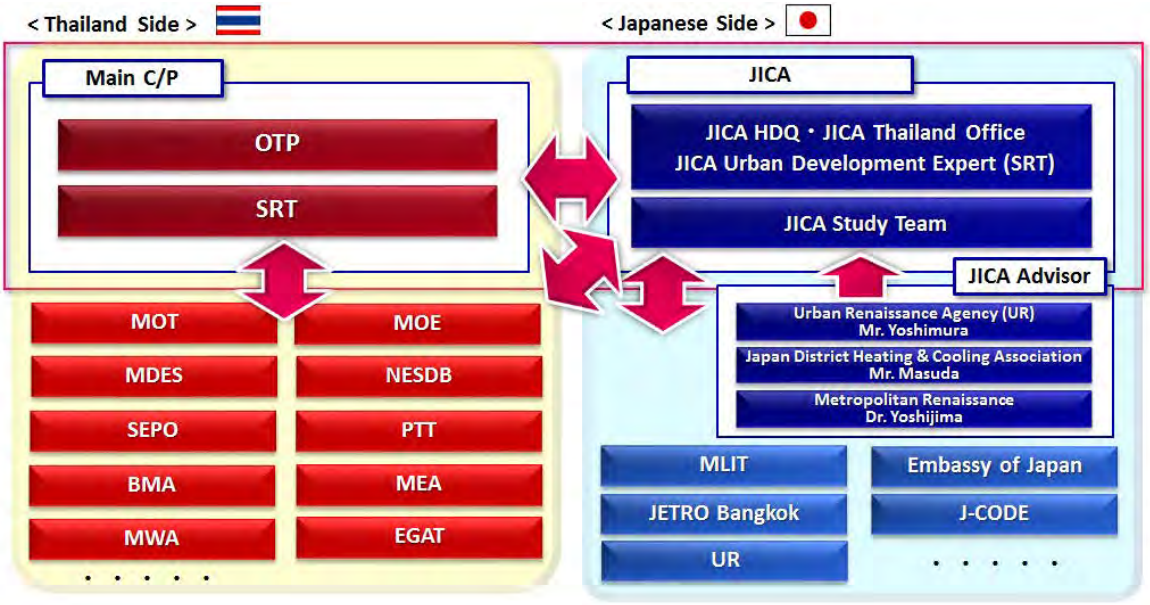


Source: JICA Study Team

Figure 1.2 Outline of the Study

1.4 Study Implementation Structure

The Study implementation structure is as shown below:

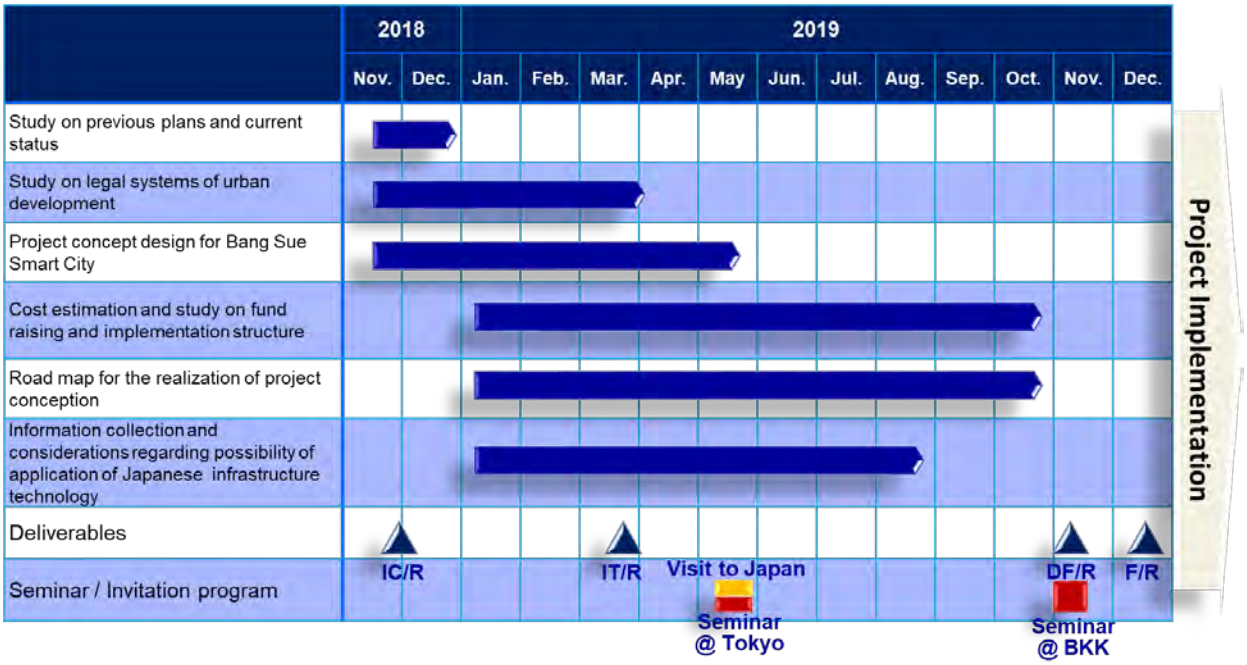


Source: JICA Study Team

Figure 1.3 Implementation Structure

1.5 Study Schedule

The study schedule is as shown below.



Source: JICA Study Team

Figure 1.4 Study Schedule

Study Team activities in Thailand from Oct. 2018 to October 2019

■ First Mission : 5th Nov. 2018 – 23rd Nov. 2018

Date	Meeting	Discussion Points
7th Nov. 2018	ICR Meeting	(Explanation of ICR to relevant ministries, and discussion on the way forward.) • This Study on Bang Sue Smart City shall be in line with previous JICA Study. The Study shall contribute to proposing more concrete smart city concept and technology. • The Master Plan proposed by previous JICA Study has got the Board approval of SRT, and now passed to NESDC to be approved. • Issue on transportation and mobility shall be an important factor for Bang Sue as a new gateway for Bangkok. • Developing the area and the infrastructure system in an integrated manner shall be emphasized. Jatujak Park and Energy Complex also shall be considered. • Bang Sue Smart City Project shall be presented in ASCN in June 2019.
14th Nov. 2018	Discussion with OTP	(Discussion on the existing infrastructure and mid to long term plan in Bang Sue Area, Institutional framework for transportation policies, urban planning and other relevant issues, and Smart City implementation structure for Thailand, and relevance to Bang Sue.) • Part of Zone G (KM11) is planned to be developed in Phase 1 (~2022). • The existing Bus Terminal in Zone C is planned to be moved to the area in front of BTS Mo Chit station, but its schedule is not so clear. • The proposed Personal Rapid Transit (PRT) system would be good idea. Autonomous driving system is interesting, but need to check safety and legal issues. • Smart City Criteria for 7 Smart Components is now under discussion in Thai Gov, and JICA Study team was requested to hold workshops for each Smart Criteria. • JICA Study Team is to support OTP in studying Smart City criteria and provide support to each working group.

Date	Meeting	Discussion Points
16th Nov. 2018	Meeting with Minister and Deputy Minister of MOT	(Explanation of ICR to Minister, and discussion on the way forward.) • Smart component of: mobility, energy, and environment should be focal area for Bang Sue. Smart technology and service for these area shall be studied further and proposed through the JICA Study. • Smart City Criteria for 7 Smart Component would be publicized in Jan. 2019. • The JICA Study Team shall provide support for energy infrastructure and Zone A development, with coordination with SRT.
20th Nov. 2018	Discussion with SRT	(Discussions on Smart Energy and Zone A development) • SRT would coordinate with the Study Team on proposed energy system of Gas Cogeneration. • About Smart Energy, Co-generation plant would be difficult to be implemented due to space availability, legal and regulation issues, financing, development structure, etc. We need to form a working team to discuss inviting MEA, EGAT, PTT, SRT, and JICA Study Team. • SRT and JICA Study Team would closely coordinate on Zone A development, especially regarding the infrastructure and energy system interoperation.

■ Second Mission : 10th Dec. 2018 – 21st Dec. 2018

Date	Meeting	Discussion Points
12th Dec 2018	Discussion with DEPA	(Institutional framework and support schemes regarding Smart City initiatives in Thailand) • Bang Sue is categorized as Smart City in "Green Field" hence all Smart Criteria (7) would need to be considered. • KPIs for each Smart Component would be developed and used for criteria of BOI incentives. • DEPA is mainly focusing on Smart City Project in cities and have developed some funding support program for Smart City activities. • Demonstration project of 5G could be approved with proper application, not limited to Huawei.
14th Dec 2018	Discussion with SEPO	(Outline of Thailand Future Fund (TFF), Governance structure for state owned enterprises in Thailand, SEPO's stance on Bang Sue Smart City Development project) • Thai Gov. now prefer PPP to TFF. • About the PPP tender for Zone A, revenue sharing scheme with SRT shall be well considered. • About SRT's participation for Bang Sue Development, conflict of interest and securing innovativeness of an entity shall be considered.
18th Dec 2018	Site visit to Grand Station and discussion with SRT	(Current situation and future plans for the infrastructure and utility facilities in the Area) • There is a chiller plant for A/C of the Bang Sue Grand Station. • There is a plan to newly construct on/off ramp along KamphaengPhet Rd. (need to check with EXAT)
19th Dec 2018	Discussion with OTP	(Schedule for Japan visit program and candidate sites to visit) • We need to consult with H.E. Minister Arkorm to coordinate. • Besides site visit of Smart City Project in Japan, we also want to know how to realize the projects (financing, business scheme, structure, government role. etc.).
20th Dec 2018	Discussion with DEPA	(5G and IoT implementation, Digital Park) • There is one 5G test bed in Siracha and working group has been formed. Legal maters are covered by ETDA (Electronics Transactions Development Agency) and coordination with private companies are by NTBC. • Digital Park project is now under PPP tender process and would be the first Complete Smart City in Thailand (covering 7 Smart City Criteria). • BMA has implemented CCTVs to monitor traffic conditions, which is open to public (BMAtraffic.com)
21st Dec 2018	Discussion with BMA	(Initiative by Bangkok Metropolitan Administration for realizing compact city, new Bangkok Comprehensive Plan, Bang Sue Development) • New Bangkok Comprehensive Plan will be publicized in early 2019 and some new incentives and schemes will be introduced.

Date	Meeting	Discussion Points
		• Since around 100 years ago (the era of Rama I), Bang Sue area have been planed to be “Intermodal Transport City”. • Land use of Bang Sue area is categorized in red (Commrecial:C4) and Blue (public use), no detail land use plan have been developed under BMA.
Dec. 13 - 21, 2018	Theme-based workshop	Smart Mobility: MOT, OTP, MOE, BMA, SRT, PTT, BMTA, etc. • Feasible mobility technology and ideal technology for Bang Sue area, including automated driving, connected car, MaaS concept, etc. Smart Economy: MOF, NESDC, DEPA, BOI, OTP, SRT, etc. • Feasible technology or system for Bang Sue, including e-commerce or e-payment Smart Governance: OPDC, DEPA, CAT, OTP, SRT • Administrative procedure, public service, etc., leveraging data platform Smart People: MOTS, MDES, DEPA, CAT, MDE, OTP, SRT • Universal design, lifelong learning, etc. Smart Living: MOI, MOPH, DEPA, EGAT, OTP, SRT • Healthcare service, service for tourists, etc. through IoT or smartphone application Smart Energy: MEA, EGAT, PTT, PEA, OERC, EPPO, OTP, SRT • Significance of diversified energy and area-based energy management through cogeneration and their application to Bang Sue area Smart Environment: PTT, DPT, BOI, ONEP, OTP, SRT • Adoption of waste treatment, water and sewerage, air pollution measures and greenery development in Bang Sue area

* PTT: PTT Public Company Limited, BMTA: Bangkok Mass Transit Authority, BMA: Bangkok Metropolitan Administration, MOE: Ministry of Economy, MOTS: Ministry of Tourism and Sports, NESDC: National Economic and Social Development Council,
MOT: Ministry of Transport, OTP: Office of Transport and Traffic Policy and Planning, SRT: State Railway of Thailand, MOF: Ministry of Finance, DEPA: Digital Economy Promotion Agency, CAT: CAT Telecom Public Company Limited, MOI: Ministry of the Interior, MOPH: Ministry of Public Health, EGAT: Electricity Generating Authority of Thailand, MEA: Metropolitan Electricity Authority, PEA: Provincial Electricity Authority, OERC: Office of the Energy Regulatory Commission, EPPO: Energy Policy and Planning Office, Ministry of Energy BOI: Board of Investment of Thailand, JICA: Japan International Cooperation Agency
ONEP: Office of the Natural Resources and Environmental Policy and Planning, Ministry of Natural Resources and Environment

■ Third mission: 12th Feb. 2019 – 22nd Feb. 2019

Date	Meeting	Discussion Points
13th Feb. 2019	Meeting with SRT	(Energy, Mobility and business scheme) • Meetings have been held with PTT, EGAT, MEA and others to discuss smart energy business. However, specific system has not been decided. • It is highly likely to require approval from the cabinet on the development of sky observation deck. Coordination with OTP is needed on proposed sky deck network. • SRT expected to set up a business company for each zone in the execution process of development projects. The establishment of the business company is not preferable as integrated development, which is to be explained in the study team’s presentation of the IT/R meeting.
14th Feb. 2019	ITR meeting	(Energy, Mobility and business scheme) • As it is recognized that immediate consultations are important in the implementation of smart city, it is desirable to prioritize the implementation structure and scheme over other discussion issues in the briefing to the minister. • As proposal for mobility-related issues especially in Bang Sue is significant, it is desirable to realize development in line with TOD concept. • As Smart Energy proposals (cogeneration, local cooling system) are related to development for Zone A, consideration is needed with SRT or other private business operators.
15th Feb. 2019	Discussion with SRT Board	(Energy, Mobility and development management system)

Date	Meeting	Discussion Points
		• As investments are needed on the development of smart city infrastructure, including energy, it is important to consider financial scheme. • As PTT is expected to independently develop pedestrian deck between Mo Chit Station and Phahonyothin Station and other facilities, it is effective to consider Mobility with PTT. • AMC is thought difficult to manage all project. First, it is important to set up Steering Committee so that the stakeholders concerned can discuss and coordinate.
15th Feb. 2019	Briefing to the Minister of Transport	(Business execution system and way to proceed with future surveys) • Although a national-level committee has been set up at this point in time, it is also desirable to establish ministerial-level committees as a cross-ministerial coordinating function. • Regarding the implementation plan, detail consideration on Zone A or sky deck is needed in line with the concept. • It is necessary to consider investment costs and the implementation structure with specific investment entities in mind. • Bang Sue Smart City concept could be presented at ASEAN Smart City Network (ASCN) scheduled in the first and second weeks of June.
21st Feb. 2019	Meeting with OTP	(TOD survey in Thailand and invitation program to Japan) • OTP is separately conducting TOD surveys in Thailand. It is desirable to collaborate with JICA Bang Sue project as needed. • Three officials are to be invited to Japan after Songkran Festival (mid-April).

■ Fourth mission: 18th April 2019 – 29th April 2019

Date	Meeting	Discussion Points
19th April 2019	Meeting with OTP	(Invitation to Japan and Smart City Seminar scheduled in Tokyo) • Visit to Ecoful Town in Toyota City, Aichi Prefecture is preferable, considering study tour for mobility in the invitation to Japan. • Mr. Chayatan Phromsorn, OTP Deputy Director General, will make a presentation on Thai's efforts to develop smart city in Thai Smart City Seminar scheduled in Tokyo.
23rd April 2019	Meeting with SRT board members	(Gas cogeneration and project steering entity) • It is desirable to discuss with PTT for the proposed gas cogeneration in the energy field, since PTT has experience and knowledge. • It is important to collaborate with Bang Sue Grand Station on energy and mobility. • It is necessary to work out the entire plan and establish a structure to steer the project to realize integrated area development.
25th April 2019	Meeting with SRT Red Line construction team	(Infrastructure development plan and Grand Station structure in Bang Sue area) • Confirm development plans and their entities in Zones A and E, and their neighboring areas. • Confirm route planning for pedestrians in the exit for Bang Sue Grand Station or its surrounding area.

■ Invitation program to Japan: 15th May 2019 – 19th May 2019

- Invitation members Mr. Chayatan Phromsorn, OTP Deputy Director General
  Ms. Puttamon Ratajeen, OTP Policy & Analyst (Expert Level)
  Mr. Ekapon Akarapanitkorn, OTP Civil Engineer (Professional Level)

Date	Meeting	Discussion Points
15th May 2019	Visit to MLIT (Ministry of Land, Infrastructure, Transport and Tourism)	• Meeting with Mr. Tokunaga, Assistant Vice-Minister for Engineering Affairs, Minister's Secretariat, MLIT • MLIT's introduction on smart city projects in Japan

Date	Meeting	Discussion Points
15th May 2019	Visit to Yokohama Minato Mirai	• Yokohama Minato Mirai development project introduced by Urban Renaissance Agency (UR) • Onsite study tour to Minato Mirai
16th May 2019	Visit to Kashiwa-no-ha Smart City	• Study tour to Kashiwa-no-ha Smart City • Introduction on concept and projects in Kashiwa-no-ha Smart City
16th May 2019	Thai Smart City Seminar held in Roppongi Academy Hills <No. of attendees: 135>	• Thai smart city projects presented by Mr. Chayatan Phromsorn, OTP Deputy Director General • Bang Sue area development plan and its current status explained by Mr. Fujita, JICA expert. • Bang Sue Smart City development briefed by JICA study team leader Kannami
17th May 2019	Visit to Ecoful Town in Toyota City, Aichi Prefecture	• Introduction on smart city projects in Toyota City
18th May 2019	Visit to Osaka Umekita area	• Umekita area development project introduced by Urban Renaissance Agency (UR) • Onsite study tour to Umekita area
18th May 2019	Visit to Hanshin Building, Osaka Hug Museum and NEXT21	• Tour on cogeneration system in Hanshin Building • Presentation and tour on energy-saving technology • Presentation and tour on energy-saving technology for residence

■ Fifth mission: 28th May 2019 – 8th June 2019

Date	Meeting	Discussion Points
30th May 2019	Meeting with OTP	(Traffic policy and project implementation structure in Bang Sue area) • OTP considers that both structural and non-structural measures are needed to flexibly respond to traffic demand in the Bang Sue area. • It would be desirable to propose project setup or operation, related to the establishment of council, based on the case of Umekita area development or Kashiwa-no-ha Smart City development.
5th June 2019	Meeting SRT deputy Governor Mr. Voravuth	(Role of AMC, infrastructure development entity and way forward) • It is recognized to be difficult that Asset Management Company (AMC) plays a vital role in Bang Sue smart city development just after the setup of AMC. It is also difficult to cover the initial investment related to area infrastructure development due to difficulty in financing. • It is necessary to have rough project cost estimate regarding sky deck and other infrastructure development and discuss with stakeholders concerned. • The infrastructure plan, considered in this study, and its drawings are expected to be reflected to Zone E plan or the entire master plan which is to be formulated after the study.
5th June 2019	Meeting with SRT Board	(Setup of Steering Body, prioritization of projects implementation scheme) • The establishment of Steering Body or similar structure is urgently needed to monitor Bang Sue development status. Participation from Japanese institutions including JICA/UR with advice based on Japan's experiences would be appreciated in setting up the structure. • Although there are many challenging issues on Bang Sue development, SRT Board considers the opening of Bang Sue Grand Station in 2021 to be an important milestone. There is a need to clarify prioritized issues to be solved by 2021 together with their directions. • It is necessary to keep in mind that government budget for public infrastructure projects is limited.

■ Sixth Mission : 18th Sep. 2019 – 20th Sep. 2019

Date	Meeting	Discussion Points
18th Sep 2019	Meeting with SRT deputy Governor Mr. Voravuth	(SRT's role, implementation structure and opinion on Smart Service Co.) • SRT is discussing with state owned company such as PTT, on the idea of setting up a company to provide Smart City-related services, however, nothing concrete is decided. • The establishment of AMC is expected to be authorized with approval from the Cabinet, but specific date is not clear. • SRT is generally in line with the Study Team's proposal on setting up a Smart City-related company, however budgetary limitation is an issue that needs to be addressed.
19th Sep 2019	Meeting with OTP	(Role of AMC, implementation structure and way forward) • Asset Management Company (AMC) is expected to play a central role in managing Bang Sue smart city development. • For successful implementation, recruitment of the leader of AMC would be important. • The development of infrastructure shall, in principle, be initiated by SRT, as the landowner. Cost sharing may also possible among public entities upon individual consultation and negotiation.
20th Sep 2019	Meeting with PTT	(Implementation structure, business schemes) • PTT, along with other state owned enterprises, shall cooperate closely with SRT to realize Smart City development in Bang Sue. • To come up with a viable business scheme would be one of the most important issue to take the project forward. Incentive schemes and public support would also be important. • PTT would be willing to seek business opportunity with various companies, including that of Japan. It would be meaningful if a Government-to-Government cooperative framework could be established.

■ Seventh Mission : 4th Nov. 2019 – 8th Nov. 2019

Date	Meeting	Discussion Points
6th Nov 2019	Draft Final Report Presentation	(Way forward for implementation) • The recommendation for Thailand side towards realization of Bang Sue area development project are: to set up Steering Committee for decision making and coordination, to have AMC to be responsible for the project; establish Smart Service Company (SSC) to provide Smart City infrastructure and service; and to establish overall plan. • The report would be a reference for related organizations in Thailand towards implementing the Smart City project.
7th Nov 2019	Thai Smart City Seminar in Bangkok <No. of attendees: 80>	• Plan of Bang Sue area development and Smart City concept, presented by SRT Deputy Governor Mr. Voravuth • Smart City development projects in Thailand, presented by OTP Mr. Ekapon • Bang Sue Smart City development briefed by JICA study team leader Kannami
7th Nov 2019	Briefing to the Minister of Transport	(Introduction of Bang Sue project and discuss way forward) • Bang Sue development is a project with huge potential and there is a big expectation in Thailand. • The adverse impact from development, such as environmental issues and traffic congestion is a concern for the project. • Continued cooperation of Japan would be beneficial for realization of Bang Sue Smart City.

2. Understandings of the External and Internal context of Bang Sue Smart City Development

2.1 Review of the Histories of Urban Development in Bangkok

2.1.1 Review up to Thailand 3.0 Era

It would be insightful to look back over the history of Urban Development in Bangkok when envisioning the future of Bangkok. Thailand 4.0 defines the progress of socio-economic development of Thailand with 4 stages of "Thailand 1.0" to "Thailand 4.0".

Thailand 1.0 is the period of modernization before 1960. In this period, Thai society is based on rural society with agriculture-based economy, which is before starting industrialization. Thailand 2.0 is the period of take-off of modernization and industrialization of Thailand, which corresponds to the period between 1960 and 1987 (the year of Plaza Agreement). Thailand starts modernization and industrialization with promoting light industry and resource-based industry with lower labor cost. Then, Thailand 3.0 is the period of take-off of economic development. After the Plaza Agreement in 1987, FDI to Thailand sees drastic increase. Many factories of heavy industry, particularly export-oriented manufacturing factories were established at Bangkok Metropolitan Area (BMR) and Eastern Seaboard Area. Thailand enjoys being a middle-developed country with continuous economic growth, however, Thailand, at the same time, starts to suffer negative aspects of economic development like economic disparity, congestion and pollution. Therefore, Thailand policy gradually shifted its emphasis on "people-centered development" and sufficient economy".

Following this definition of 4 stages, urban issues and urban development in Bangkok could be summarized as the table below.

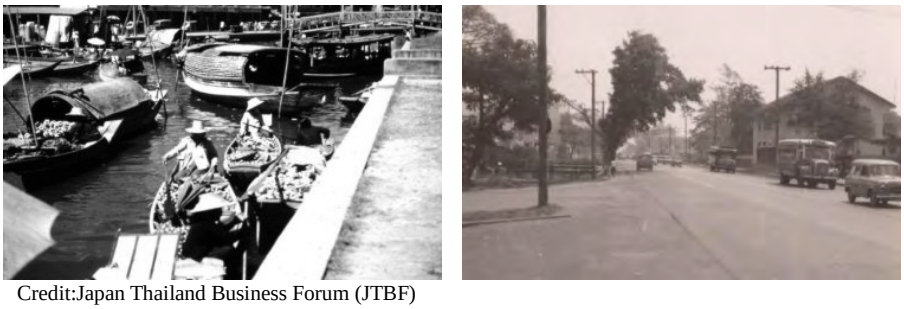
	1.0 - 1960	2.0 1960 - 1987	3.0 1987- 2018	4.0 2018-
Key Direction	Modernization of Thai Society	Start Industrialization and Modernization	Take-off and Enter Middle-developed Country Sufficient Economy Peoples-centered Development	Value-based Economy Sustainable Development Smart and Eco
Populations	• Slow population growth	• Faster population growth • Migration	• Over-concentration of Population into BMR	• Deceleration of population growth • Depopulation in rural area
Leading Economy	• Agriculture • Cottage industry	• Light industry • Import-substitution industry	• Heavy Industry • Assembling manufacturing with FDI • Tourism	• High value added manufacturing • R&D, Management, financing business,
Urban Issues in Bangkok	• Defense and security • Disaster prevention • Satisfaction of basic human needs • Safety and security • Urban expansion for population increase	• Infrastructure development in large cities • Urban poor • Urban expansion • Traffic congestion	• Mitigation of traffic jam • Flood protection • Urban environment • Decentralization (to release over-concentration and reduce economic disparity) • Global competition	• Mitigation of traffic jam • Flood prot4ection • Barrier free for all peoples under aged society • Greenhouse effect gas • Respond to innovations (AI, ICT/ IOT etc.)
Urban Development in Bangkok/BMR	• Transfer Capital to Bangkok (1782) • Expansion of Rattanakosin • Sampeng and Klong Kasem Development • Ram IV(Thanon Trong) and New Road (Charoen Krung Road) • Suwan Dusit Project • Tram development (in1894)	• Town and Country Planning Act (1975) • Slum Clearance • NHA housing	• Expressways • Urban Railways (BTS in 1993, MRTA Blue in 2004, MRTA Purple in 2016) • Land Readjustment Act (2004) • Large shopping complex developments • Mubaan development in suburban area	• Smart city (mobility management , energy, saving with renewable energy, smart peoples and living, smart governance, smart environment, smart economy) • Eco-city/ low carbon city • Sustainable city

Figure 2.1 Urban Development by Stage

Urban Development 1.0 (Thailand 1.0 era; ~Mid-20th century) was the era in which original landscape of Bangkok took its shape. In 1557, French Fort was constructed along Chao Phraya

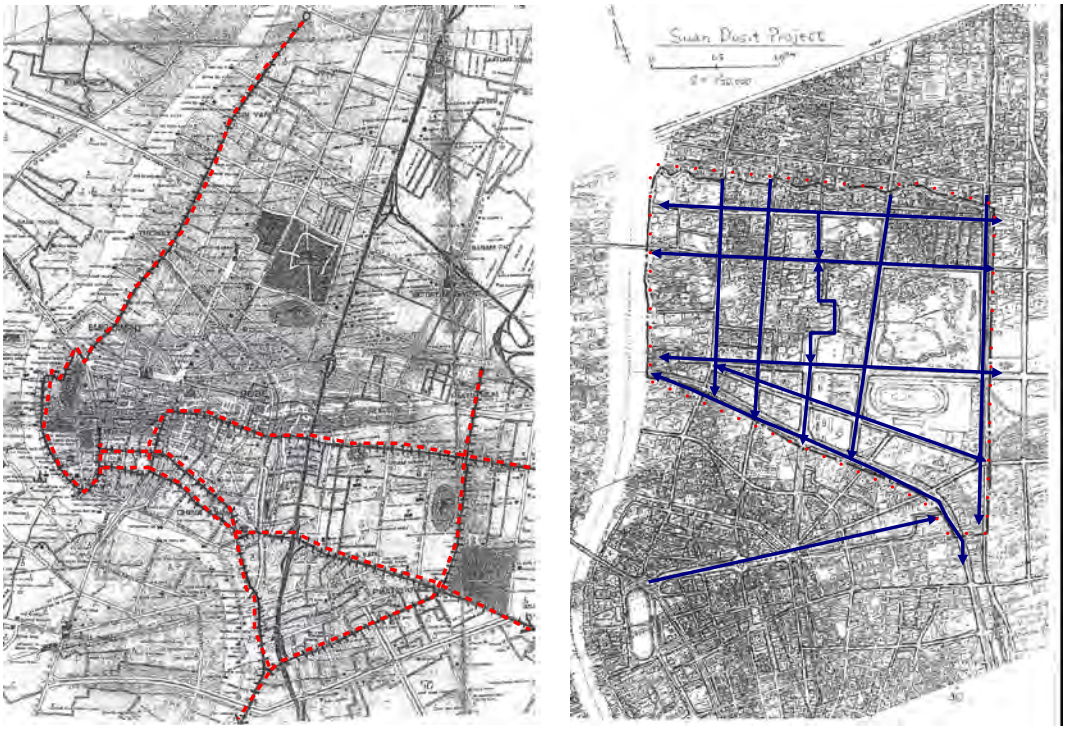
River that was the Origin of Bangkok. In 1782, King Rama I moved capital to Bangkok and constructed the Palace at the place of French Fort. In 19th century, urban area of Bangkok was expanded with many Channels and “Soi”, of which land scape is called “Venice of Orient”. In this era, Bangkok was an international city with many races and various businesses, which generated unique and different landscape in downtown (Chinese shophouses) and suburban area (Thai local houses). In late 19th century, there were two modernization and urban development projects; 2 tram lines (1894), Suwan Dusit Project (1899~1902, 570 ha, 400 to 600m basic land block).

Thailand Urban Development 2.0 (Thailand 2.0 era; 1960s~1980s) was the era of industrialization. Population growth speeded up and population migration started from rural to urban areas for finding better jobs, especially to Bangkok. The migrants generated many urban poor who lived at slum areas and worked in the informal sector. Accordingly, Thailand Urban Development 2.0 can be considered as the era in which population migration to Bangkok increased and poverty alleviation was an issue. Accordingly, major urban issue was providing reasonable housing for the urban workers as well as uplifting living environment at slums.



Credit:Japan Thailand Business Forum (JTBF)

Figure 2.2 Old landscape of Bangkok – Krung Kasem Canal (left) and Ploenchit Road (right)



Source: Project on the Development of the Method of Urban Development in Thailand (left), JST (right)

Figure 2.3 Tram lines (left) and Suwan Dusit Project (right)

Credit: Japan Thailand Business Forum (JTBF)

Figure 2.4 Tram lines

The period of Thailand 3.0 was the period of take-off of Thai economy with lots of FDI. Although Thailand enjoyed continuous economic growth, however, gradually faced negative aspects of economic development like regional economic disparity, congestion and pollution in Bangkok. In particular, traffic congestion, which was started at the era of Thailand Urban Development 3.0, heavily influenced peoples' life and economic activities. Accordingly, Thailand Urban Development 3.0 (Thailand 3.0 era; 1980s~2018) was considered as the era in which Bangkok was confronted with some actual urban issues associated with big cities, such as environment deterioration, chronic traffic congestion and flooding etc.

In this period, many transport infrastructures like expressways, road and bridges, and urban railways (BTS in 1993, MRTA Blue in 2004, MRTA Purple in 2016) were constructed by reclaiming channels or on the existing roads. Depending upon economic growth and rise of income level, many investments went to real estate businesses, old buildings were replaced by high-rise building developments and large shopping complex developments in downtown and rice field was reclaimed with residential area developments in suburban area. These developments drastically changed landscape of Bangkok.

2.1.2 Urban Development under Thailand 4.0 Era and Bang Sue Development

The Thai society under the "Thailand 4.0" faces the depopulation and aged society. Enhancement of productivity and added value is essential for sustainable economic development for Thailand in future. Thailand needs to shift its core economic activities to high-value added service from labor-oriented processing industry. For this, Bangkok would be well situated to become a place to foster "new high-value added service".

Furthermore, new innovative technologies are actively promoted through the "Thailand 4.0" policy. In particular, AI technologies, ICT/IOT technologies as well as robotics technologies is expected to become a "Game Changer" for economy and society, which could qualitatively and quantitatively influence the requirement for urban facility, infrastructure, and land use.

On the other hand, Bangkok would be expected to play a more active role in meeting to new social demands such as: care to aged peoples and handicapped, safety and security against disaster and eco-friendly, in particular low carbon emission, which is a national commitment at Paris Agreement of COP24[1].

[1] Thailand committed 7% of CO2 reduction in 2030 in Paris Agreement.

Considering the history of urban development at Bangkok, development of Ratanakhosin area was implemented at the time of drastic change of country (generation of new dynasty). The "canal" was center piece of the new urban development, considering the geopolitical aspects regarding safety and security, efficiency of transport and economy. The water-front area of the canal generated a functional business space for global trading businesses. Bangkok was a global city with various peoples from 17th century.

Suwan Dusit Development Project was implemented by the Royal Thai Government at the beginning of 20th century, which led to a drastic change of structure of society and political system in Thailand. Thailand experienced the change to the constitutional monarchy from absolute monarchy. The Suwan Dusit Development Project was a symbol of new political structure. The project led to expansion of urban area, and newly generated the modern landscape (Thai-European style) to the Bangkok which remains along Ratchadamnoen Avenue.

The project is regarded highly as a project symbolizing the "3rd Industrial Evolution" that led to further development of Bangkok, especially formation of basic road network pattern as well as urban railway network of Bangkok.

Reflecting on these past developments, Bang Sue development could also be regarded as a modern version of Rathanakhosin or Suwan Dusit development. Now is the time of "Thailand 4.0" or "4th Industrial Evolution", which is expected to bring drastic change with new innovative technologies. Similarly to Ratanakhoin and Swan Siam developments, Bang Sue are development is expected to be the flagship project to realize Smart City as a new urban style for "Thailand 4.0" or "4th Industrial Evolution". Bang Sue is well situated for this, because the area is presented with a large space to create new urban area in Bangkok. Accordingly, Bang Sue area is expected to be a unique site which incorporates innovative solutions for urban issues such as mobility management, energy saving (management) and eco-friendly environment with cutting-edged technologies, to embody "4th Industrial Evolution". In this regard, Bang Sue Smart City shall be positioned as the prototype of urban development in 21st century, which could serve as a model for other urban areas in Thailand or in ASEAN countries with the following roles/functions:

- Realization of efficient mobility
- Realization of Eco-friendly and low carbon society
- Enhancement of safety and security
- Provision of universal services for all people
- Development of competitive business environment for globalization
- Development of a Regulatory Sand Box to introduce cutting-edged technologies for future Thailand

2.2 Smart City Projects in Asian Countries

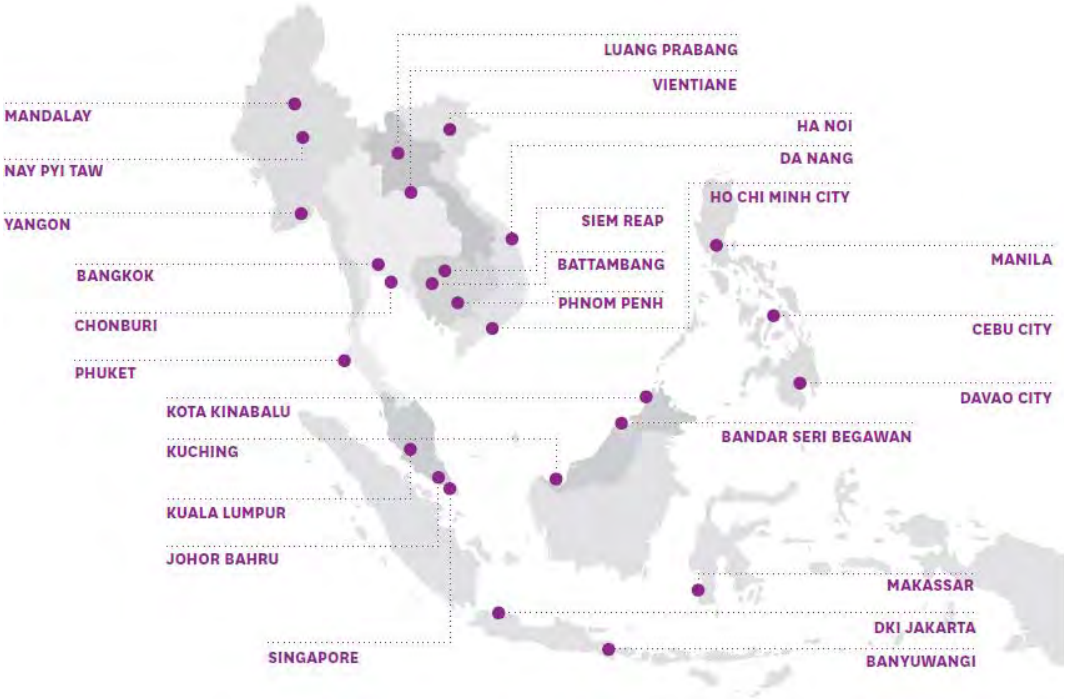
2.2.1 ASEAN Smart City Network (ASCN)

ASCN is a framework for cooperation and collaboration between cities for the Smart City Project. Led by Singapore and promoted by the countries of ASEAN, its first annual meeting was held in July 2017. The project is to be officially launched at the ASEAN summit on November 2018. Since Thailand chairs the ASEAN Summit in 2019, Thailand Government also hosts the ASCN in 2019.

26 ASEAN cities have been selected as pilot-cities, and its scheme is to form action plans for the Smart City development from 2018 to 2025. Three sites from Thailand: Bang Sue, Chonburi (AMATA), and Phuket, have been identified as ASCN.

Listed below are the 26 cities that have been selected:

- Cambodia (3 cities) : Battambang, Phnom Penh, Siem Reap
- Indonesia (3 cities) : Makassar, Banyuwangi, Jakarta
- Malaysia (4 cities) : Johor Bahru, Kuala Lumpur, Kota Kinabalu, Kuching
- Myanmar (3 cities) : Nay Pyi Taw, Mandalay, Yangon
- Philippines (3 cities) : Cebu, Davao City, Manila
- Singapore (1 city) : Singapore
- Thailand (3 cities): Bangkok, Chonburi, Phuket
- Lao PDR (2 cities) : Luang Prabang, Vientiane
- Vietnam (3 cities) : Da Nang, Hanoi, Ho Chi Minh
- Brunei (1 city) : Bandar Seri



Source:Ministry of Foreign Affairs of Singapore, "*ASEAN Smart City Network*"

Figure 2.5 26 ASEAN Smart Cities

2.2.2 Smart City Projects in Asian Countries

(1) Singapore

Singapore is one of the region's leading cities for smart city initiative. Singapore places emphasis on developing digital technologies which contribute to realizing digital society and digital economy. The two notable projects that are currently promoted are introduction of e-payment system, and of National Digital Identity (NDI).

A seamless, secure, and integrated e-payment system is being developed which enables cashless payment and an integrated payment platform for business processes. This is aimed to reduce business costs associated with cash and checks, increase convenience for daily payments for consumers, and potentially promote new business and services with the collaborative platform.

National Digital Identity system is targeted to be operational by 2020 with progressive trials for digital signatures to facilitate paperless transactions. It will be a nationally-available means for an individual to prove his legal identity in the digital realm. It will be issued to all residents and can be used for seamless and secure transactions with both the public and private sector.

(2) Indonesia

Another country that constitutes the smart city initiative is Indonesia. Through digital transformation and accessibility enhancement, the country contemplates on bringing innovative transformations to the cities of DKI Jakarta, Makassar, and Banyuwangi.

The capital of Indonesia, Jakarta, expands on its vision of becoming "a city leading forward towards happy citizens". Their focus lies in the creation of new jobs through the implementation of a platform which connects research institutes and potential entrepreneurs. The city also plans on introducing a new transit payment system, OK OTrip, where they wish to integrate transit payments to one cashless system.

Similarly, Makassar visualizes a "Liveable World Class City for All" by promoting the socio-economic growth it is currently going through. They insist on ensuring an improved healthcare system for all, where they plan on building seamless services with highly accessible data. Moreover, Makassar plans to install an integrated online tax collection system in order to increase the city's revenues.

Banyuwangi is rather fixated on mitigating physical boundaries—improving accessibility at all levels. One of their primary targets is to encourage and strengthen their citizens with the acquisition of IT skills, and thus inducing industrial growth. Another priority for Banyuwangi is to create inclusive economic growth: they are planning on developing their local tourism industry through improving the citizens' access to public amenities and information services.

(3) Thailand

Thailand is also part of the smart city initiative, with the cities of Bangkok, Chonburi and Phuket assigned as their pilot-cities. The three cities, each having their unique vision, aim to empower the region by adopting cutting edge technology to work on their focus areas.

Bangkok, the capital of Thailand, aims to become a Visitor-Friendly International Community

by creating a new central district. They are focusing on forming a transport hub in the Bang Sue area anticipating that it will alleviate the stress in the existing terminal, as well as cut down the commuting time. Furthermore, they are contemplating on a Smart City Plan for Pahonyothin, by establishing a New Central District full of attractions, involving various transport systems.

Chonburi aspires to become a self-reliant, energy-efficient city which operates on renewable energy sources and sustainable environment management. The city puts their focus on a Smart Grid Project which requires a systematic energy management and an energy storage structure. They also intend to work on the Waste to Energy Plant in order to resolve the issues of waste generated in Chonburi.

Phuket, which relies heavily on tourism industry for its regional economy, envisions to realize sustainable tourist development. One of Phuket's priorities is to construct a City Data Platform using real-time data in order to closely observe on their residents and tourists, and improve the city's efficiency, utilities, and businesses. Another major concern is to realize a safe city for all by using Big Data. Phuket plans on expanding their CCTV coverage along with collaborations with Cloud companies.

In addition to Smart City development initiative under ASCN, there are many other plans for Smart City development. It is important to understand the relative position of Thailand and Bang Sue in the context of the competition among cities for Smart City development. First, in terms of Smart City policy at the state-level, Thailand is promoting Smart City development under "Thailand 4.0" initiative, and has several schemes to financially or institutionally support private companies or local governments. This would be regarded as one of the advantages for Thailand. Second, from city-level, the unique aspect for Bangkok's Smart City development initiative is that a specific area is designated as project site (area based approach). In other cities such as Singapore or Kuala Lumpur, project site is not necessarily identified, but identifies specific technologies or services to be promoted (technology based approach). In Bang Sue, various technologies could be introduced and developed by linking unique attributes of the city and advanced technologies.

(4) Other ASEAN countries

The visions and projects for each of the ASEAN Smart City Network are as summarized below:

Table 2.1 Visions and priority projects of ASCN cities

Country	City	Vision	Priority Issue 1	Priority Issue 2
Cambodia	Battambang	To achieve a socially responsible, environmentally friendly and economically successful city whilst retaining Battambang's unique character.	**Urban Street and Public Space Management** In order to improve liveability, Battambang plans to upgrade public street and space design, organise street vendors, and better the infrastructure for informal settlers. This will be done through development of market, low-cost housing and skills upgrading.	**Solid and Liquid Waste Management** Battambang aspires to become a green and healthy city. To this end, Battambang will move away from river-based natural waste management to sewage and wastewater management systems. Works on drainage systems are being carried out by the Battambang provincial authority and Chinese partners supported by the Asian Development Bank. However, the city needs to develop additional drain and sewage infrastructure.
	Phnom Penh	To improve the urban environment, to enhance citizen's quality of life.	**11 Sidewalks Rejuvenation Project** Phnom Penh aims to increase pedestrianisation through the rejuvenation, restoration and repurposing of the sidewalks for 11 boulevards. The project is expected to deliver traffic de-congestion and public space benefits by managing unlicensed street vendors and illegal parking.	**Improving Efficiency of Phnom Penh Public Transit** Improve urban public transport mobility and active mobility (pedestrian paths)
	Siem Reap	Siem Reap as a beautiful, unique and ideal tourist destination, characterised by the harmony of Khmer history, arts and nature.	**Smart Tourist Management System** Siem Reap's vision is to be a liveable, smart, clean, safe and sustainable city for both local residents and tourists alike, through the use of security enhancement systems such as CCTVs and traffic sensors.	**Solid Waste and Wastewater Management** This project seeks to develop infrastructure for solid waste and wastewater management, to ensure a high-quality environment. This can be done by capitalising on technology and data management systems, which would allow for feedback loops to improve planning and implementation.
Indonesia	Makassar	The city's vision is "To Create Makassar as Liveable World Class City for All"	**Improved Health Care** Provide citizens with improved and well integrated health care services. Makassar seeks to ensure that all citizens have easy and direct access to health care services. The city plans to develop a healthcare ecosystem that connects various healthcare entities and enables easy exchange of data. Access to health care services will also be made seamless such that people can access these at any place, any time.	**Integration of Online Tax Services** Makassar plans to increase the city's revenues through improved tax collection via an integrated e-tax system. Through personal mobile applications and one-time submission platforms, citizens and businesses will be encouraged to file taxes. Taxes including building and land tax, parking tax, local revenue tax, advertisement tax, will be brought under an integrated tax filing and payment platform.
	Banyuwangi	To develop an integrative system of government, accelerate development through the optimization of information technology, build a reliable generation through education, promote partnerships for basic infrastructure, and create inclusive economic growth through tourism based development.	**Spearing Industrial Growth through Education** Banyuwangi is on its journey to break physical boundaries with technology. The physical constraints of its villagers in trading goods will be addressed through upskilling the youth and the residents with digital entrepreneurial skills. Banyuwangi seeks to collaborate with private entities to impart knowledge on e-commerce and online trading through inclusion of customised IT modules in the skills curriculum. All the 24 subdistricts will be covered under the digital-based learning programme for students.	**Creating Inclusive Economic Growth Through Tourism-Based Development** Harnessing the community-wide benefits of eco-tourism, Banyuwangi is working towards developing its local tourism industry, with collaboration and support of strategic partners. To ensure overall development, Banyuwangi plans to improve citizen's access to public amenities, and information services.
	Jakarta	Jakarta – a city leading forward towards happy citizens	**Job Creation Through Linking Research Institutes and Potential Entrepreneurs** This project aims to create new jobs by providing platforms for innovations arising from research institutions to evolve into business ideas. It would require an information sharing system to encourage synergies between research institutions and potential entrepreneurs.	**OK OTrip Integrated Transit Cashless System** To integrate all Jakarta transit payment systems into one cashless system to improve urban mobility, enhance modal share and reduce travel time, while keeping travel affordable.
Malaysia	Johor Bahru	To develop Johor Bahru smart city into a strong and sustainable metropolis of international standing.	**Iskandar Malaysia Urban Observatory (IMUO) Tool for Decision Making, Stocktaking and Measurement** To ease decision-making in planning and to improve government transparencies in tracking development, policies and targets, Johor Bahru aims to improve its planning approval process via informed decision-making. Johor Bahru plans to develop a Central Data Centre, the Iskandar Malaysia Urban Observatory (IMUO) to collate, update, analyse, manage and disseminate data.	**Integrated Urban Water Management Blueprint which Include Sourcing of New Water Solutions and Enhancement** In 2018, Johor Bahru's water reserves could only meet 8% of the water demand, and is expected to decline to 5% in 2019. Through an Integrated Urban Water Management blueprint, Johor Bahru is determined to improve water sustainability practices to increase water reserves by 20% all year round and to source for new water sources through innovation and technology. Johor Bahru

Country	City	Vision	Priority Issue 1	Priority Issue 2
			IMUO will also function as a Knowledge Hub to improve regional urban knowledge, and as a Monitoring and Assessment Centre to monitor development progress. IMUO could also provide technical services that aid programme monitoring and capacity building for policy implementation at the city and regional level.	plans to upgrade existing water plants with advanced technology and smart water management systems.
	Kuala Lumpur	Kuala Lumpur envisions to be A World Class Sustainable city by 2020.	**Kuala Lumpur Urban Observatory** In line with the Master Plan, the KL Urban Observatory is a Central Data Repository to collate, update and disseminate social, economic and physical data for planning purposes. This is a collaborative effort by the local authorities, residential associations and government agencies. Coordination is needed for more effective planning to improve the liveability of Kuala Lumpur.	**Kuala Lumpur Pedestrian and Bicycle Lane** In line with the Kuala Lumpur Pedestrian and Bicycle Master Plan 2019-2028, Kuala Lumpur aims to be a world-class liveable city through promoting a healthier lifestyle among city folks and allowing for a convenient and safe commute for pedestrian and cyclists. The project has started in the city centre area where Kuala Lumpur has built an 11km dedicated bicycle lane.
	Kota Kinabalu	Transforming Kota Kinabalu into a Clean, Green and Liveable City.	**Integrated Public Transport System** This project aims to create a seamless and quality public transport travel experience to attain sustainable transport plans by 2030. This project includes an Integrated Bus Rapid Transit (BRT), Light Rail Transit (LRT), and Bus Lanes Project.	**Integrated Solid Waste Management** This project aims to develop efficient and effective governance and transform the city into a clean, green and liveable city with sustainable waste management. It will encompass comprehensive action plans for effective waste collection and waste processing in order to reduce the generation of waste and toxic emissions from the landfill.
	Kuching	Kuching envisions to improve the quality of life and achieve smart city status through digital transformation.	**Smart Mobility – Integrated Smart Traffic Light System** This project aims to ease the traffic congestion in Kuching city through smart management of the traffic flow using digital technology. Out of the 140 signalised junctions, only 32 have been digitally connected and managed as the pilot projects only cover 4 major routes. The government plans to expand the project to cover all major urban roads and signalised junctions in Kuching City so as to coordinate the traffic flow with better synchronised traffic lights and provide 'real time' traffic information.	**Integrated Flood Management and Response System** This project aims to better alert the response team or the Disaster Committee, to flooding events to ensure safety of the people and property. An efficient monitoring and response system will reduce the occurrence of flash floods and waterlogging in flood prone areas.
Myanmar	Nay Pyi Taw	To be a green, liveable, and environmentally sustainable city that also serves as the center of knowledge/global market hub. By promoting core infrastructures and high quality of life, Nay Pyi Taw aims to become the role model in Myanmar.	**Affordable Housing and Low Cost Housing Project** The project involves the construction of medium-rise low-cost affordable housing for retired government employees. The old townships of Pyinmana, Lewe, Tatkone and their semi-urban areas will be need to be developed with infrastructure amenities to support new affordable housing projects.	**International Comprehensive University** Proposed as an Education Hub, the first International University in Myanmar includes an Engineering School, Business School, Medical School, and Art and Design School. Collaborating with Korea, Nay Pyi Taw's Comprehensive University is to be constructed on a 250 acre-wide land near the Diplomatic Zone, where the Smart City Initiative Project is partially implemented. While the Hotel Zone has been completed, funding assistance is required for the rest of the development.
	Mandalay	Mandalay aspires to be a city with safe and smooth mobility.	**Traffic Congestion Management** In light of the increasing vehicle ownerships that results from population growth and the ease of import laws, the number of motorcycles and private car ownership peaked at 2016, resulting in traffic challenges. Reliable and up-to-date traffic data, and strategic management of road conditions by road infrastructures such as traffic lights, guard grails and road signs could address the traffic congestions in Mandalay, thereby improving road safety.	**Solid Waste and Waste Water Treatment** Good solid waste and waste water management, to ensure quality water supply.
	Yangon	An Attractive International Port and Logistics Hub – A city of Blue, Green and Gold.	**Conservation of Yangon City Downtown Area** Yangon, a city with unique heritage features and identity, aspires to transform into a well-developed and sustainable economic hub where its people can live and work peacefully. Conservation of its heritage and buildings could boost Yangon's attractiveness as a tourist destination. Towards transforming its heritage areas, Yangon has planned a Downtown Area Conservation project. Under this plan, the streetscape, infrastructure and amenities at Pandosan Street will be improved, and the heritage buildings lying vacant will be repurposed for sustainable and compatible uses such as Food & Beverage outlets, bookstores, and offices. Traffic conditions in this area will also be eased. To facilitate efficient planning in this area, Yangon will need to define its zoning regulations.	**Low Cost Rental Housing and Transit Oriented Development** Western Yangon has nearly 30,000 workers employed in its industries. Due to inadequate housing options in the industrial zone, these workers commute long distances to get to work every day. In order to improve the city's public rental housing system and the socio-economic status of its workers, the Yangon City Development Committee has planned to develop the Hlaing Tharyar Township as a sustainable development, anchored around principles of Transit-Oriented-Development. This township will house low-cost rental housing, with Smart City elements (traffic management, environmental protection, and security) such that workers can reside in the Industrial Zone safely. A highway bus terminal will be built between Yangon and Ayeyarawaddy division, for smooth transit.

Country	City	Vision	Priority Issue 1	Priority Issue 2
Philippines	Cebu	By upgrading Bus Rapid Transit (BRT) Systems and CCTV cameras, Cebu City aims to support urban growth with improved urban mobility and security.	**Automated Citywide Traffic Control Systems** Through the Automated Citywide Traffic Control Systems project, Cebu City aims to enhance traffic regulation and enforcement, and improve information collection and sharing. The operation of the intelligent traffic control system entails the installation of necessary sensors, equipment and infrastructure.	**Bus Rapid Transit (BRT) System** As Cebu faces traffic congestion challenges, it has plans to establish, operate, maintain and substation a BRT to provide efficient intra-city mass transportation. Improvements to the current transportation system will help to reduce commuting time. Under this project, Cebu aspires to start operations of Phase 1 of BRT by 2021, and to further extend BRT Phase 1 by 15km in the Phase 2 in 2025.
	Davao City	Davao City envisions to create a community that harnesses digital connectivity and technological advancement in providing high-quality living and a safe and secured environment for the Dabawenyos.	**Converged Command and Control** Using intelligent surveillance and upgraded communication capabilities, Davao City will develop technological solutions that enable efficient inter-agency collaboration for improved public safety and planning. The Public Safety and Security Command Center (PSSCC) is specifically tasked to orchestrate all undertakings related to safety and security, and to lead multi-agency mechanisms for incidents beyond the purview of a single agency. A converge command & control solution will enable the PSSCC to link with agencies and gather near-time critical information. By 2021 Davao City plans to upgrade the capability of the PSSCC by increasing the coverage area of the CCTVs to cover all intersections and key facilities.	**Intelligent Transport and Traffic Systems with Security** Davao City aims to use technology to address the growing transportation challenges. The city seeks to enhance traffic management capabilities by leveraging on latest technology and innovations. Under this project Davao City will install sensors, equipment and infrastructure that support the operation of an intelligent traffic control system and public safety initiatives. The solutions developed for improved traffic and transport management will also be integrated with other security management systems.
	Manila	Governance at the Palm of your Hands.	**Command Centre Upgrade (Transport/ Disaster Prevention/ Security)** Rehabilitation and Reorientation of our Command Centre to a cloud-based system, to be more responsive to concerns of Manila residents and visitors. This would include connecting Traffic/Peace and Order/Disaster Monitoring into a Command / Administration and Supervision/Response-able Centre.	**E-Education** Development of joint-instruction Tutorial Applications, based on Department of Education's (DepEd) curriculum that can run on mobile phones which will allow students to practice study or review lessons with teacher supervision. These will be partly implemented with construction of Internet-ready classrooms, acquisition of computer and presentation equipment and distribution of tablets to all public elementary and high school teachers. It is part of an ongoing project of DICT and City of Manila in the installation of Free Wifi areas.
Singapore	Singapore	To transform Singapore through technology.	**E-Payments** Providing seamless, secure, and integrated e-payment platforms, options for cashless payments, and integrating e-payments into business processes from end to end. It will result in: - Reduced business costs associated with handling cash and cheques - Increased daily transactional convenience to consumers - Potentially new and innovative services riding on e-payments platforms We want to explore cross-border collaboration and linkages for e-payments systems.	**National Digital Identity (NDI)** The National Digital Identity (NDI) will be a nationally-available means for an individual to prove his legal identity in the digital realm. It will be issued to all residents and can be used for seamless and secure transactions with both the public and private sector. It is planned to be operational in 2020, with progressive trials for digital signatures to facilitate paperless transactions. We want to explore cross-border collaboration and recognition of digital signatures.
Thailand	Bangkok	To be a Visitor-Friendly International Community with a New Central District filled with various attractions and infrastructures.	**Transport Hub Development at Bang Sue Area** Serving as the main stop for the High-Speed Rail, the Bang Sue Central Railway will function as the hub of the new Commuter Rail System that provides new lines serving the areas near the city centre. The Transport Hub Development aims to overcome the existing infrastructural pressure on the existing terminal while simultaneously reducing commuting time.	**Smart City Plan** The Smart City Plan of Pahonyothin aims to be the ideal place for visitors with its strong international community, and the New Central District full of attractions. Coined as the Gateway to City of Angels, Pahonyothin is to consist of arious transport systems such as pedestrianization, cycling, bus and metro.
	Chonburi	To be a self-reliant, energy-efficient city with renewable energy sources and sustainable environmental management	**Smart Grid Project** This project aims to move Chonburi forward to be a self-reliant, energy-efficient city with renewable energy sources and sustainable environmental management. It entails the management of electrical networks, generation systems, transmission systems and power distribution systems, with a systematic energy management and energy storage structure.	**Waste to Energy Plant** This project aims to address the waste treatment and management issues arising from the generated waste at Chonburi, and to source for renewable energy integration and regional smart micro-grids, which is aligned with the relevant National Plans on built infrastructure developments in Thailand.
	Phuket	With tourism accounting for 97% of its Gross Domestic Product, Phuket's smart city vision	**City Data Platform** Using real-time big data from sources such as free-WiFi and CCTVs, Phuket plans to build a City Data Platform that allows for better understanding of residents and tourists in Phuket. The City Data Platform functions to build big	**Phuket Eagle Eyes – Safe City based on Big Data Harvesting and Analytics** **CCTV Safe City** With the vision of making Phuket a safe city for all, Phuket aims to maximise the coverage area of CCTVs by inviting private firms and corporations to share

Country	City	Vision	Priority Issue 1	Priority Issue 2
		is to achieve sustainability in its tourism development	data that can aid the city administration in more efficient and accurate planning of infrastructure, public utilities, common amenities etc. The data will also provide valuable insights to businesses and start-ups in their analysis.	their CCTV generated data with the government. While video analytics and CCTVs have been implemented and integrated since 2017, Phuket plans to expand the coverage of CCTVs. Phuket city government seeks to collaborate with Cloud companies to take this project forward
Lao PDR	Luang Prabang	A city of tourism centre and regional connection, Luang Prabang envisions to be a clean, green, liveable environment and smart city with the world heritage in the core by 2025.	**Heritage Wetland Restoration for City Green Spaces and Habitats** Located in the northern Laos, Luang Prabang has 183 ancient wetlands and small ponds previously used by surrounding households for food production and local drainage. So far, 22 wetlands were rehabilitated, while the associated drainage systems and tourism infrastructures were constructed. Unrestored wetlands, however, are biologically degraded and polluted with increasing urban development pressure, detracting the inherent heritage values of the city. Restoring these wetlands and small ponds to their original values can lead to—improved green spaces, enhanced eco-tourism / ecological diversity, new tourism enterprises around the wetlands, wastewater treatment storm water retention to prevent floods, and restoration of heritage values of the city.	**Construction of Concrete Alleyways and Footpaths** Famous for its numerous Buddhist temples and monasteries, Luang Prabang aims to complete the upgrading of 44 paths within 5 years in order to encourage pedestrianisation and to reduce dependency on polluting vehicles. Registered as an UNESCO World Heritage Site in 1995, Luang Prang's tourism industry has been fundamental for the city's economic growth. As part of this project, Luang Prabang seeks to upgrade existing footpaths, improve amenities in order to improve visitor experience.
	Vientiane	Vientiane envisions environmentally friendly urban development with—peace, clean, green, light, charm and prosperity. By organizing e-governance and applying high-technology solutions, the city aims to improve the quality of their people's lives for their future.	**Establishment of Drainage System** Incorporating drainage management systems into the city Master Plans and socio-economic development plans, Vientiane Capital aims to effectively improve the operation and maintenance of the drainage system. Each year, the city is flooded for at least 5 months. The existing master plan doesn't capture information on the drain infrastructure, resulting in data gap among government agencies. An upgraded drainage system can increase Vientiane Capital's urban resilience with fewer flooding incidents. Support in the form of funding for the operation and maintenance of drainage systems, and strong enforcement of development control is required.	**Sustainable Transport Plan** Increasing population, poor road quality, and inadequate public transport systems have resulted in traffic congestion on Vientiane Capital's streets. Vientiane Capital needs to synchronise its Sustainable Transport Plan with its Master Plan to ensure better landuse and transport integration. The city seeks to collaborate with key stakeholders such as private transport corporations and local transport department to identify underlying transport issues and develop a strategic roadmap specifying the short-term and long-term action plans.
Vietnam	Da Nang	Da Nang envisions itself to be a smart, liveable, and sustainable city by 2030. With a citizen-centric strategy, Da Nang aims to deliver high quality of life and sustainable environment for citizens while ensuring economic growth and competitiveness.	**Intelligent Traffic Control System** To reduce traffic congestion and improve logistical efficiency, Da Nang plans to upgrade the existing traffic control system to effectively collect, manage and analyse comprehensive traffic information. This requires the installation of a CCTV network and associated software to detect traffic flow and violations. The desired outcomes include sharing real-time data and information on transport to be used by both the public and private sectors, reducing travelling time, enhancing public transport management, and improving control and supervision of traffic conditions.	**Smart Water Management** In the context of rapid urbanization, climate change, and environmental degradation, efficient water resource utility is crucial to enhance quality of life while ensuring sustainability in Da Nang city. Da Nang aims to improve water supply, drainage, and wastewater treatment for higher water quality and reliability and lower operational costs.
	Hanoi	A green, culturally-rich, civil and modern city with sustainable development to create a better life for the people by 2030. As the national political centre, Hanoi places its economic, trade, investment, culture and social priorities at heart.	**Intelligent Operation Centre (IOC)** With the current public transport systems not well integrated with city's geography, the inter-modal hub and spoke system has yet to evolve. The establishment of an Intelligent Operations Centre will enable Hanoi to manage information and resources across all sectors. This would aid leaders in decision-making and responding to emergencies. Hanoi's urgent need is to have a centralized management system for monitoring and controlling signals and sensors, and for capturing visual information to effectively coordinate transport management.	**Development of Intelligent Transportation** With a clear strategic focus to provide access to better-managed public transport, Hanoi aims to reduce congestion and improve logistical efficiency. Using technology platforms to generate and collect traffic data, Hanoi will improve transport services and communication with the people.
	Ho Chi Minh	Ho Chi Minh City's vision by 2025 is to attain rapid and sustainable economic development through optimal resource utilization and citizen-centric governance.	**Integrated Operations Centre (IOC)** This project will be the 'brain' of the Smart City by integrating daily information and resources across all sectors in Ho Chi Minh City. Data and information will be collected and integrated from CCTV, sensors, and operation centres in all government sectors.	**Integrated and Unified Emergency Response Centre** Ho Chi Minh City plans to develop an integrated and unified emergency response centre for security and public order issues, fire-fighting and prevention, as well as medical services by 2020. The response centre will include upgraded features such as automatic location and number identification, Computer Aided Design / Geographic Information Systems for resource management and

Country	City	Vision	Priority Issue 1	Priority Issue 2
				operation, integrated video surveillance systems and IP Call Centre management software.
Brunei	Bandar Seri Begawan	To Develop Kampong Ayer as the Jewel of Bruneian Heritage and facilitate its growth as part of Bandar Seri Begawan's smart city development plan.	**Revitalization of Kampong Ayer (Water Village)** Located to the South of Bandar Seri Begawan, the village of Kampong Ayer has been identified as an integral part of Bandar Seri Begawan's sustainable and smart city development plan. Kampong Ayer will be redeveloped into a liveable city with a sustainable environment and a diverse economy with a distinct Bruneian identity.	**Clean River Management Project** To overcome the challenges related to waste generation, waste collection and disposal, Bandar Seri Begawan is determined to put in place an institutional framework that promotes sustainable waste management practices. Specifically, the city seeks to restore the quality of the Brunei River. Brunei's move towards being a smart and sustainable city involves strengthening regulatory and enforcement measures related to effluent discharges into the River and management of waste through latest technological interventions.

2.2.3 Smart City development in Asian countries

Taking a look at smart city development in Asian countries other than the ASEAN countries, China and South Korea have promoted smart city development as a national policy. Several urban redevelopment project has been implemented in Japan at a railway depot like the Bang Sue area, though the projects have not necessarily been implemented as “smart city” project.

This section covers Umekita urban development project in Osaka and Kashiwa-no-ha Smart City in Chiba Prefecture as redevelopment cases for the former railway site, and also reviews smart city development in China and South Korea thereby summarizing suggestions to the Bang Sue Area.

Table 2.2 Case study and perspective

Case	Perspective of case study and suggestion to Bang Sue
Japan: Umekita Area Development	Area development and implementation structure
Japan: Kashiwa-no-ha Smart City	Smart City concept and function
South Korea	Digital infrastructure development and Skywalk for Seoul Station
China	Urban management with data platform

(1) Japanese case: Umekita Area development

1) Overview

Osaka Station North District (Umekita area) is located around the former Umeda Freight Terminal, north of JR Osaka Station. The area has been designated as Urgent Urban Redevelopment Area – an area applicable for urban redevelopment area - in 2012, and is currently being redeveloped. Out of the total area of approximately 32.3 ha, about 8.6 ha had been developed as first phase development zone (Umekita Phase I) and Grand Front Osaka was opened in April 2013 as its centerpiece. Umekita Phase II zone (approx. 23.7 ha) is currently being developed.

2) Area development by steps (Phase I development)

The steps regarding area development was compiled as reference for the Bang Sue area development. Generally, the process of area development could be distinguished into several phase: formulation the entire design concept; establishment of the basic plan; selection of developers; basic infrastructure development; and area development. Responsible promotion organizations have been set up in accordance with respective phases.

The following table shows the series of events by period.

Table 2.3 Umekita Area development by phase

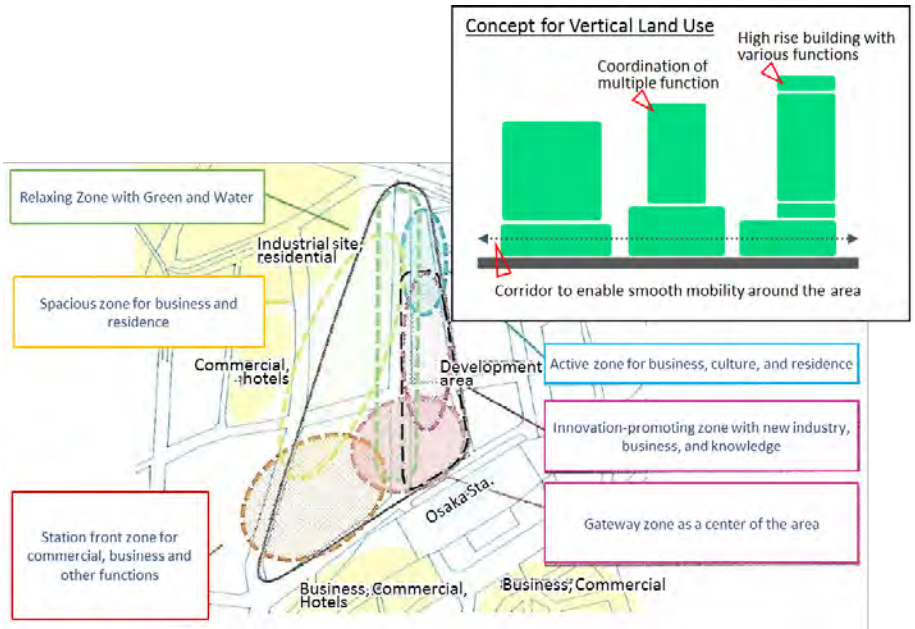
Period	Events
Mar. 2002	Gathering for Urban Redevelopment in Osaka North District.
Aug. 2002	Establishment of a committee to formulate entire development plan for Osaka North District.
Sep. 2002 - Mar. 2003	Implementation of international competitions for concept design.
Oct. 2003	Osaka City released “Grand Plan for Osaka Station’s North District.” *Starts development of 7-ha area that is unrelated to freight transfer, as first phase development.
Mar. 2004	Establishment of Area Development Promotion Committee for Osaka Station North

Period	Events
	District
Jul. 2004	Osaka City Office released "Basic Plan for Area Development in Osaka Station North District."
Nov. 2004	Establishment of Umekita Area Development Promotion Agency.
Dec. 2004	Definement of Development Plan for Phase I development area.
May 2005	Explanation to developers regarding B block tender.
Jun. 2005	Commencement of basic infrastructure development (Permission for land readjustment project)
Feb. 2006	Commencement of application process for A/B/C block developers.
May 2006	Selection of B block developer.
Nov. 2006	Selection of A/C block developers.
Dec. 2006	Establishment of Committee for Phase I development Zone.
Nov. 2009	Establishment of Umeda Area management committee.
Mar. 2010	Commencement of building construction in Phase I development zone.
Feb. 2011	Area name decided as "Umekita".
May 2012	Establishment of Grand Front Osaka TMO.
Apr. 2013	Commercial opening of Grand Front Osaka

The established organizations for respective development phase and its roles are as follows.

1st Step: "Grand Concept Design" Formulated by Osaka City

- Years 2002 to 2003: Held "international concept competitions" to decide the development concept which would be the base for Area development plan.
  - Committee was set up with coordination with the local government, business community. International competition was held in which academic experts, renowned architects were included for the reviewing committee.
  - 966 proposals were submitted.
  - The total amount of prize: 20 million yen.
- Oct. 2003: Osaka City Office formulated "Grand Concept for Osaka Station's North District." based on proposals in the international competitions.

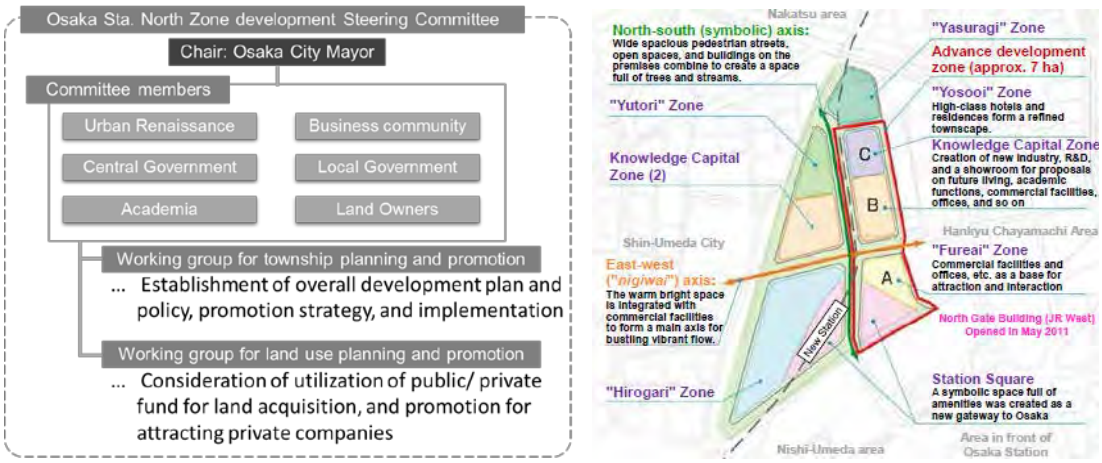


Source: Materials provided by UR

Figure 2.6 Image of Grand Concept for Osaka Station's North District

2nd Step: Establishment of Area Development Promotion Committee for Osaka Station North District and Formulation of Basic Plan

- March 2004: Set up the promotion committee chaired by Osaka City Mayor.
  - Role: Consider and discuss, based on Grand Concept, the development plan, business plan, and town management, to build a consensus for the basic policy and to execute the projects, etc.
- Jul. 2004: Formulation of "Basic Plan for Area Development in Osaka Station North District."



Source: Materials provided by UR

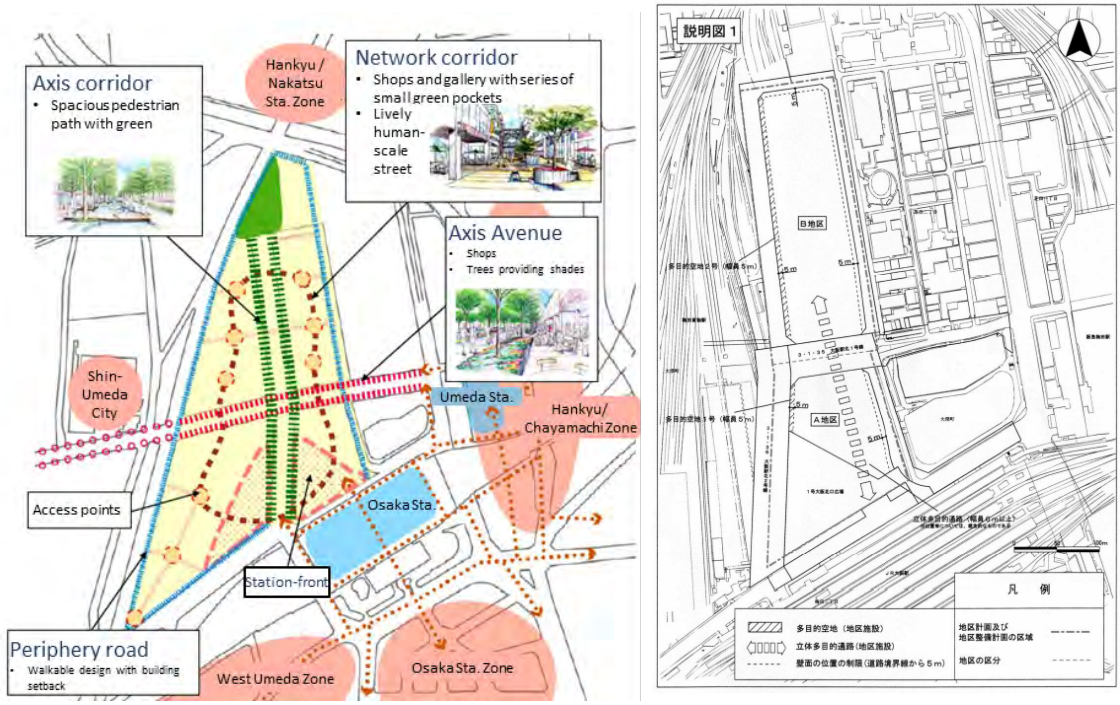
Figure 2.7 Organization Structure for Urban Development Promotion Committee (Left) and Basic Plan (Right)

3rd Step; Establishment of Grand Front Osaka TMO and Implementation of Town Management

- May 2012: Establishment of Grand Front Osaka TMO.(Town Management Organization)
  - Role: The role for TMO is to manage the town in a sustainable and integrated manner through public-private cooperation in order to: vitalize the area; improve the environment; develop business projects for strengthening community. This would contribute to enhancing added values in the development area. TMO is established through the participation of area developers.

3) Construction of Sky Deck

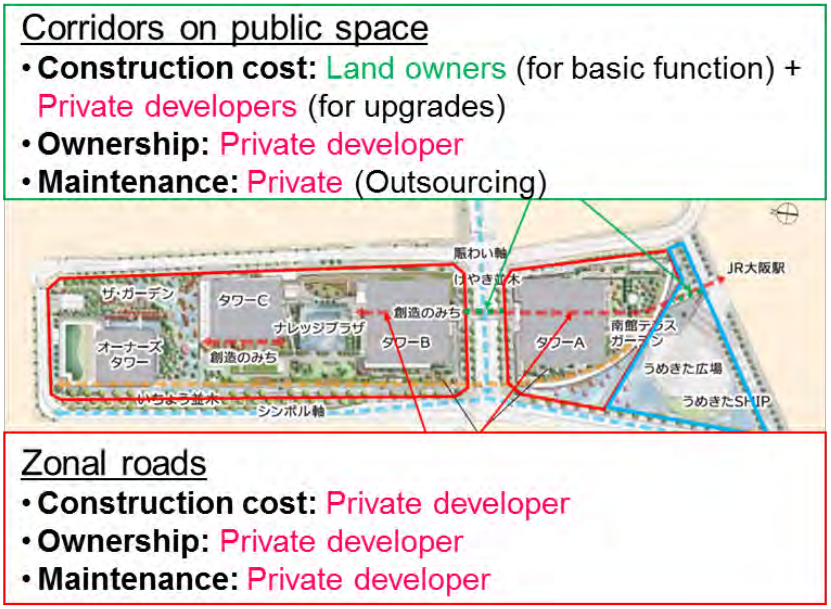
- Development of a network of pedestrian corridor was stipulated in the Basic Plan for Area Development in Osaka Station North District. Based on the Plan, it was specified in the district plan that "the Sky Deck shall connect Osaka Station and B-1 zone via Zone A to form a comfortable and safe pedestrian corridor network, while at the same time considering cityscape".
- TOR for the developers for the area stipulated that the developer shall conform to the Basic Plan and the district plan. Also the tender documents clarified the responsibility and cost to be borne by the entity in charge of land adjustment (in this case UR), and thus the development and management of pedestrian corridor was stipulated as item to be proposed by the tenderer.



Source: Materials provided by UR

Figure 2.8 Pedestrian network image (left), and facility plan in district plan (right)

- As for the construction cost, the private developers were in charge of the section on the private land, whereas the land owners covered the cost for ensuring minimum required function for passage for the section on the public land. It is worth noting that the capital borne by UR (as an implementing body) for Sky Deck on the public land was raised upon the sale of the land owners' land from the land adjustment project. Also, the upgrade portion for the corridors on public space was borne by the private developers.



Source:Materials provided by UR

Figure 2.9 Cost allocation for Sky Deck construction

4) Implications for Bang Sue Development

Establishment of committee with stakeholders' participation and formulation of Basic Plan under the committee

At the time of formulating a basic plan for Umekita development project, the governor of the local government was appointed as chair of the committee, with participation from national government organizations, private economic federations, academic experts and land owners as members. In addition, Urban Development Promotion Agency was set up as an implementation organization to realize the development plan, whereby planning or coordinating to realize integrated development as a national projects.

For Bang Sue Area development, no committee have been set up for stakeholders to coordinate. The responsibility for the project is almost solely left to SRT, and thus formulation of common understanding, discussions or coordination has not been sufficient. It is desirable to set up a committee for Bang Sue development project, in which basic plan would be formulated and executed with coordination among stakeholders.

Specifically, it is proposed that a development committee, equivalent to Umekita Development Promotion Committee, should be set up under Thailand's Transport Ministry OTP as the council head. The committee is expected to authorize the basic policy or plan for the entire development. In addition, SRT Board (or a consultative body that centers around SRT Board) could take up the role of development promotion organization, similar to Umekita Area Development Promotion Committee. Through these institutional set up, realization of integrated development whereby planning of suitable infrastructure and facility and efficient and effective coordination of zone development would be expected.

Implementation of development based on Overall Development Plan

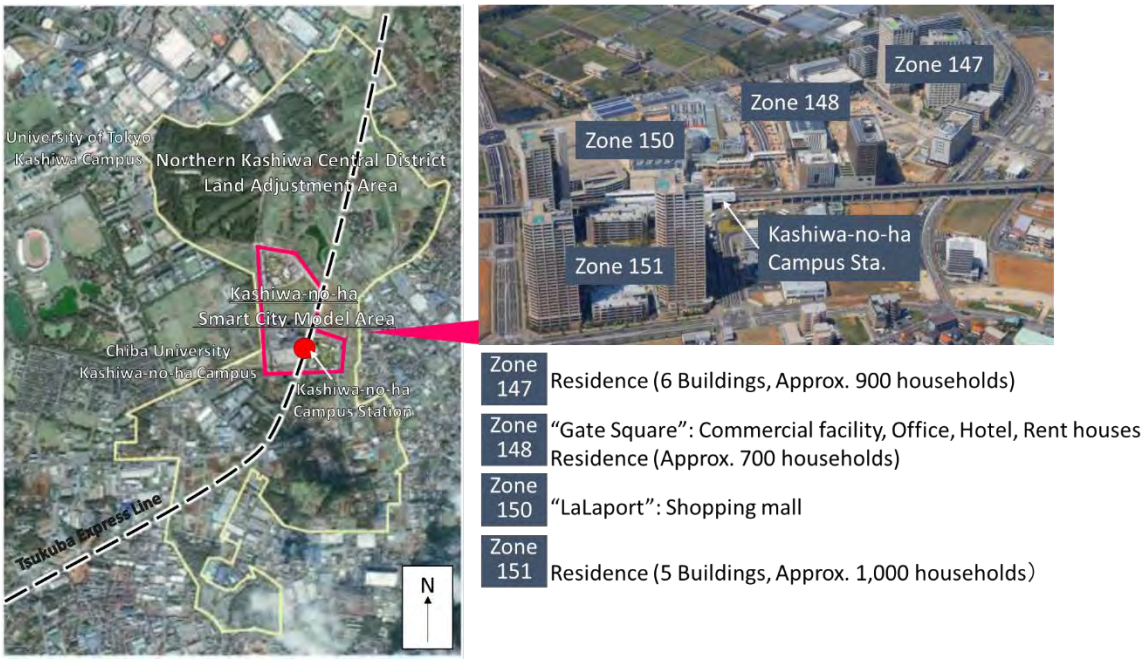
In the Umekita development project, respective stakeholders were gathered to formulate the overall development plan, and development process was kept in line with the overall plan.

Although the overall development plan for Bang Sue Area were considered through OTP or JICA studies, the plans were not necessarily being referred. Currently, the plans are revised separately at each zones, while development projects have been implemented independently. It is important to set up a committee in order to coordinate the overall development plan for Bang Sue area, and also to ensure that the developers would follow the established development plan.

(2) Japanese Case: Kashiwa-no-ha Smart City

1) Overview

Kashiwa-no-ha Smart City, located in the suburbs of the Tokyo metropolitan area, is an area around Kashiwa-no-ha Campus Station on Tsukuba Express Line that opened its operation in 2005. Since the operation of the line, land reallocation projects and development by private operators have resulted in construction of condominium apartments, large-scale commercial facilities or hotels.



Source: Compiled by JICA Study Team, based on press release documents published by Mitsui Fudosan Co., Ltd.

Figure 2.10 Kashiwa-no-ha Smart City

Table 2.4 Development Scale for Kashiwa-no-ha Smart City

Developer	Mitsui Fudosan Group (Mitsui Fudosan Co., Ltd./Mitsui Fudosan Residential Co., Ltd.)
Area	Approx. 14.2 ha
No. of houses	Approx. 2,700
Project Size	Approx. 125 billion yen (Expected as of March, 2018)
Planned Land Use	Residence (Approx. 2,700 houses), hotel (166 rooms), commercial facilities (Approx. 7 million visitors annually), office (No. of employees: approx. 1,000)

Source: Compiled by Study Team, based on press release documents published by Mitsui Fudosan Co., Ltd.

This smart city aims to solve urban problems in collaboration with public, private and academic sectors, especially in the field of: energy, traffic, and aging society. For this, three pillars are set out: "Environmental symbiosis city", "Healthy longevity city", and "New industry creation city".

2) Service and facility by theme in Kashiwa-no-ha Smart City

The major services or facilities are described below, based on the three themes of "Environmental symbiosis city," "Healthy longevity city" and "New industry creation city."

"Environmental symbiosis city": Establishment of energy management system and green, comfortable pedestrian space

"Gate Square" located at zone 148 introduces Area Energy Management System (AEMS), based in "Kashiwa-no-ha Smart Center" under ICT system, in order to operate, manage and control energy for the entire town. It adopts lithium ion battery system (approx. 3,800 kWh of storage capacity), solar power generation (approx. 720 kW of total power output) and gas generator for emergency use (approx. 2,000 kW of power output). These systems are used to interchange electricity through smart grid and achieve power peak cut and energy saving. Furthermore, even if power supply is suspended by electric power companies, about 60% of day-to-day power volume can be supplied to the town for three consecutive days, achieving a business continuity plan (BCP) and a life continuity plan (LCP).

In addition to AEMS, the town block adopts home energy management system (HEMS) to monitor and visualize energy consumption status with tablet terminal or other equipment in the house, commercial facility and individual office facility, encouraging residents or tenants to consume energy in an optimal manner.

Kashiwa-no-ha Smart Center

Rooftop solar power generation

Latium iron battery system

HEM system (Image)

Source: Based on press release documents distributed by Mitsui Fudosan Co., Ltd.

Figure 2.11 Energy System in Kashiwa-no-ha Smart City

Meanwhile, a 1.5-m wide personal mobility lane, installed along the pathway to boost mobility in Zone 148, allows Segway or other next-generation vehicles to run on, though they are not permitted to drive on the Japanese public road. The area aims to build the sustainable mobility system, while demonstrating cutting-edge technologies.

As for road space, moreover, sidewalks with planting or comfortable greenery space or roads for cyclists are developed in an effort to create vibrant town landscape.

Personal Mobility Lane

Road Space

Source: Based on press release documents distributed by Mitsui Fudosan Co., Ltd.

Figure 2.12 Road Space in Kashiwa-no-ha Smart City

<u>"Healthy longevity city": Service supporting healthy lifestyle</u>

"Machi-no-Sukoyaka-Station (Health Station for Town)", installed on one floor of a commercial facility, includes medical facilities under the theme of disease prevention, based on the healthcare concept of "from treatment to prevention". Several businesses that supply exercise, diet or other heath advice are stationed in the facility.

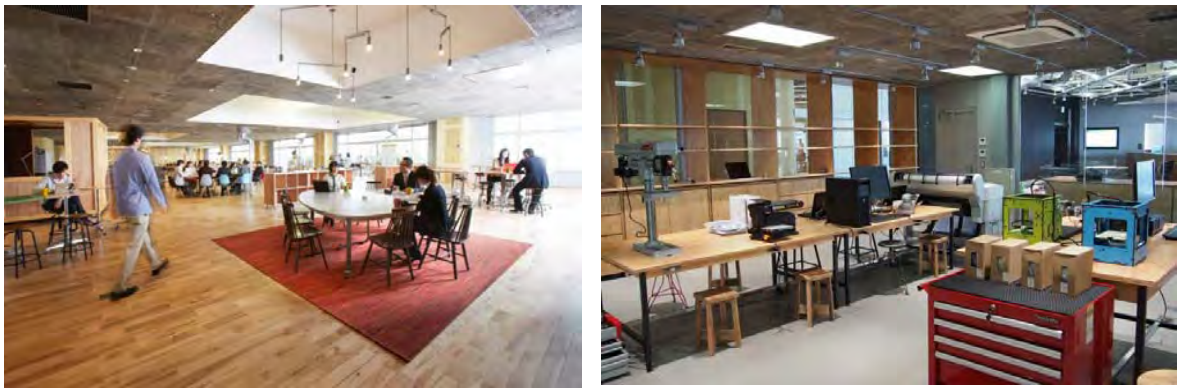
Furthermore, "A-Shi-Ta (meaning tomorrow in Japanese)" Community Health Promotion Laboratory is installed as a hub to provide regional residents with various health checkup measurement services, professional advice and event/lecture programs so that residents can keep young and healthy, using state-of-the art knowledge, services or products on beauty, diet/nutrition, oral function, walk, and nursing-care prevention.

Source:Based on press release documents distributed by Mitsui Fudosan Co., Ltd.

Figure 2.13 "A-Shi-Ta" Community Health Promotion Laboratory and Available Equipment

"New industry creation city": Innovation office and conference center

Innovation center "KOIL," located in "Gate Square" of Zone 148, is designed under the concept of creating new industries by sharing knowledge, technologies and ideas. "KOIL" provides large-scale co-working space, a manufacturing atelier with 3D printers and other equipment, and cafes or studios for personal exchanges. And also, a conference center in "KOIL" accommodates about 400 visitors together with six small and large meeting rooms in order to hold a wide variety of exhibitions or meetings.



Co-working Space　　KOIL Factory (Manufacturing Atelier)

Source: Based on press release documents distributed by Mitsui Fudosan Co., Ltd.

Figure 2.14 Innovation Office in Kashiwa-no-ha Smart City

3) Implications to Bang Sue

Problem-solving Approach

As described previously, Kashiwa-no-ha Smart City proposes an ideal smart city to tackle challenging issues, based on social problems in Japan like energy consumption or dwindling

birthrate and an aging population. As Bang Sue development is also a large-scale project positioned as a national project and expected as a model for other cities under ASCN's pilot project, it is desirable to promote development in the direction of solving social problems in Thailand or Bangkok.

Mobility Policy (Next-generation Vehicle Lane, Road Space)

Ensuring connectivity and mobility for visitors to Bang Sue Station so that they can easily access area facilities or neighboring stations is indispensable. As in the case of Kashiwa-no-ha Smart City, the personal mobility lane is built to introduce and demonstrate next-generation vehicles, this facility is effective for Bang Sue, too. As traffic demand density is high and travel distance is likely to be long in Bang Sue, the space for small public transport system can be considered.

It is also desirable to secure comfortable road space for regional mobility and safety.

Energy Measures (Energy Efficiency through AEMS, BCP at Emergency)

The area management system, based in a smart center as a hub, can be applied to the Bang Sue area. Considering stepwise development in Bang Sue, the smart grid system needs to be expanded in accordance with the phased development.

Meanwhile, as Bang Sue Grand Station is located in the business district with many users, it is important to establish sustainable energy system in preparation for emergency, as shown in Kashiwa-no-ha Smart City.

Promotion of Healthcare

As Thailand is also expected to age in the future, healthcare services are needed as described in Kashiwa-no-ha Smart City. As the Ministry of Health plans to build a medical complex facility (Medical Complex) in the Bang Sue Area, the facility could serve as a hub for healthcare measures.

(3) South Korea

1) Overview

South Korea government has been promoting large-scale smart city projects as a national policy, in cities such as Seoul, Incheon and Busan.

Local autonomies have an initiative in smart city development under the support of the national government, and have installed many CCTVs across the cities to comprehensively oversee traffic conditions, disasters and crimes. Information are typically provided through the digital signage.

The collected information is compiled on the platform, whereby the control center installed in each city monitors the information, contributing to town safety, traffic management, etc. in collaboration with the police and the fire department.

Furthermore, in Seoul, a sky deck connecting to Seoul Station has been developed. The deck was originally used for a highway but it has been refurbished as a pedestrian deck, and provides a comfortable network for pedestrians leading to the station.

2) Implications for Bang Sue Development

Establishment of Data Platform

The data platform was established covering the local autonomies in South Korea, and a wide

variety of information is organized and made available on the platform.

Such data platform that compile various data (CCTV image information, traffic information, building information, infrastructure status, energy information, etc.), and provide processed information in a usable, accessible, and secure form is proposed in Bang Sue Area as well. This would contribute to efficient urban management and creation of new business opportunity.

Sky Deck Network

The sky deck in Seoul Station offers comfortable pedestrian space, on which pedestrians can access to the surrounding facilities from the station on foot.

It is also proposed in the Bang Sue area that a sky deck should be built, and network formed centering on the Grand Station so as to offer comfortable pedestrian space and create connections and interactions among zones.

(4) China

1) Overview

China has continuously advanced its efforts on smart city development since the latter half of the 2000's. The 13th five-year program (from 2016 to 2020), stipulated in 2016, envisages to improve infrastructure and public services with the development of new digital technologies through smart city initiative. It is reported that around 500 Chinese cities are included in smart city projects in 2018.

The Chinese government has coordinated with IT firms in the smart city development project – notably four IT giants, called PATH: Pingan, Alibaba, Tencent and Huawei.)

For example, Alibaba has established its AI platform called ET City Brain, which "can immediately correct defects in the urban operation with the use of all kinds of real-time urban data and optimize the entire public urban resources." The platform has been introduced to Hangzhou City and others, and is scheduled to be experimentally launched in Kuala Lumpur, Malaysia, as the first non-Chinese city.

2) Implication for Bang Sue Development

Utilization of big data and development of data platform for urban management could be referred to a certain degree in the Bang Sue Area. Meanwhile, in order to analyse traffic information and use it for traffic congestion measures, data need to be gained and analysed not only from the Bang Sue area, but also from wider areas. For example, AI-based management could be first implemented and demonstrated in the field of energy management.

2.2.4 Examples of urban development projects in the neighbouring countries in ASEAN under PPP scheme

(1) Urban development projects under PPP projects in ASEAN

Japan Overseas Infrastructure Investment Corporation for Transport & Urban Development

Large-scale urban development projects under PPP scheme in ASEAN were observed since 1990s. One of the typical cases of such project is "SENAYAN SQUARE PROJECT" in Jakarta, Indonesia. It is a 40-year BOT project (1989 to 2036) between the Government of Indonesia and a private company to develop 19 ha national land.

Such large-scale urban development has been accelerated since 2000s, and more players has been involved. In case of Japan, construction companies were main player such large-urban development players before but other players, real estate, trading, transport operators and hotel operators were being involved such projects. Government of Japan has been also promoting the private sector's activity in ASEAN countries to make use of Japanese superiority in urban development in Transit Oriented Development (TOD), Smart City (in particular, energy saving, recycle, urban development in harmony with nature, safety & security and recycling). Typical promotion policies of the government are (i) promotion of overseas activities by independent administrative agencies (parastatals) and (ii) preparation of financial schemes (equity investment, loan, Yen loan and trade insurance) for overseas infrastructure development including urban development. The government has established an infrastructure development fund, "Japan Overseas Infrastructure Investment Corporation for Transport & Urban Development (JOIN)" in corporation with private sector to enhance the equity investment in September 2014.

Since the establishment, JOIN has supported urban development projects indicated in Table 2.5. The following sections explain projects which provide lessons to Bang Sue development.

Table 2.5 Financial supports by JOIN for urban development in ASEAN

Month and year	Country and city	Name of the projects	Investment/debt guarantee amount	Development area
July 2016	Yangon, Myanmar	Urban Development Project - Landmark Project	Investment: USD20 mill	4 ha
October 2016	Jakarta, Indonesia	Mixed-use Urban Development Project in Bumi Serpong Damai City	Investment: JPY3.4 bill	6 ha
May 2017	Jakarta, Indonesia	Jakarta Garden City Project	Investment: JPY5.0 bill	8.5 ha
July 2017	Jakarta, Indonesia	Southeast Capital Project	Investment: JPY3.0 bill	12 ha
July 2017	Yangon, Myanmar	Redevelopment of the Defense Services Museum site	Investment: USD49.4 mill Guarantee: USD41.8 mill	1.6ha
December 2017	Jakarta, Indonesia	Mega Kuningan Project	Investment: JPY6.5 bill	1.1 ha
August 2018	Ho Chi Minh City, Vietnam	Waterpoint Project	Investment: JPY1.9 bill	165ha
December 2018	Chonburi Province, Thailand	Amata Nakorn Project	Investment: JPY0.6 bill	2.1ha

Source: JOIN website (http://www.join-future.co.jp/english/our-mission/investments.html)

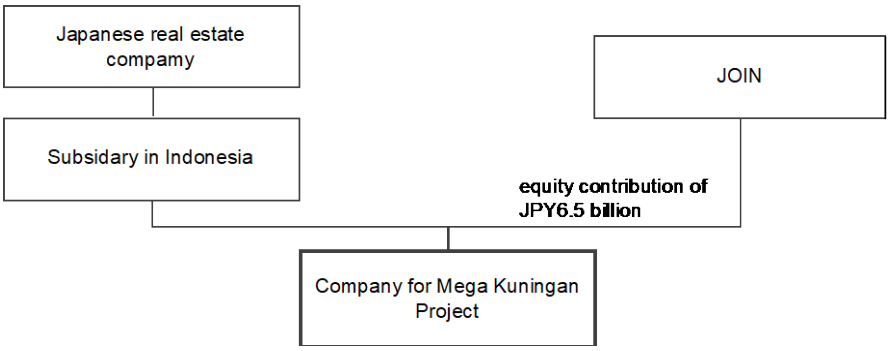
Mega Kuningan Project

Mega Kuningan Project in Jakarta is the largest investment contribution project. The project is to develop a mixed-use complex urban area comprised of housings (sale and rent) and commercial facilities with total floor area is approximately 110,000m2 in Mega Kuningan, one of the major redevelopment areas in Jakarta Central Business District (refer to Figure 2.15). The total investment cost id not published but it is estimated around JPY 20 billion.

Source: Press release from the development company

Figure 2.15 Location of Mega Kuningan Project

JOIN supported the project by JPY 6.5 billion of equity contribution to the project development company which is established under Indonesian subsidiary company of a Japanese real estate company. The Japanese real estate company intends that all process of the development and operation (land acquisition, plan, design, construction and operation & management) will be conducted by Japanese or Japanese-affiliated companies.



Source: Press release from JOIN (http://www.join-future.co.jp/english/news/pdf/20171222_01_01.pdf)

Figure 2.16 Implementation structure of the Mega Kuningan Project

Waterpoint Project (Phase 1)

Waterpoint Project is a residential development project (355 ha of total area) located in Ben Luc, the gateway to the Mekong Delta from Ho Chi Minh City (refer to Figure 2.17). The project has initiated by a leading Vietnamese real estate development company (Nam Long Investment), and the company prepared the project from 2000s.

The phase 1 project is a housing complex comprised of townhouses, villas, land plots, and public facilities on about 165 ha, which consists of around 3,000 houses, 20ha of park area, 17 ha of a university and 2.5 ha of the community area (refer to Figure 2.18). In order to carry out the Phase 1 project, Nam Long Investment has established a project company for the Waterpoint Project with other Vietnamese companies, and a Japanese private railway operator joined the member in June 2018. Total investment cost for the Phase 1 project amounts to VND 6,900 billion (USD300 million), and the Japanese private railway operator invested 35% of the total investment cost. JOIN decided to support the project and provided equity contribution of JPY1.9 billion to a SPC

established with the Japanese private railway operator as show in Figure 2.19. All investment cost for the Phase 1 project is prepared by the Joint Venture partners.

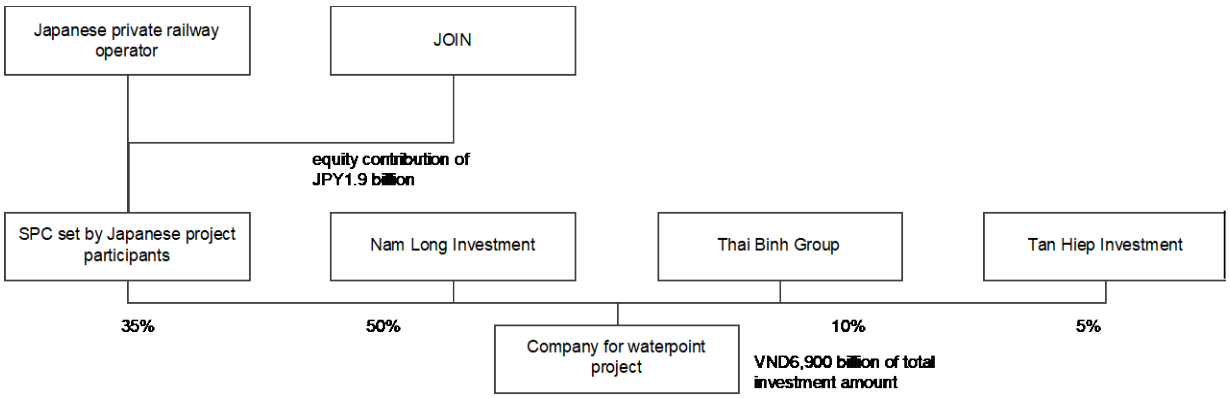
The Japanese private railway operator is going to operate high-speed bus between the project site and Ho Chi Minh City as well large-scale housing complex development.

Source: Press release from JOIN (http://www.join-future.co.jp/english/news/pdf/20180824_01_01.pdf)

Figure 2.17 Location of Waterpoint Project

Source: Press release from JOIN (http://www.join-future.co.jp/english/news/pdf/20180824_01_01.pdf)

Figure 2.18 Development image of the Waterpoint Project



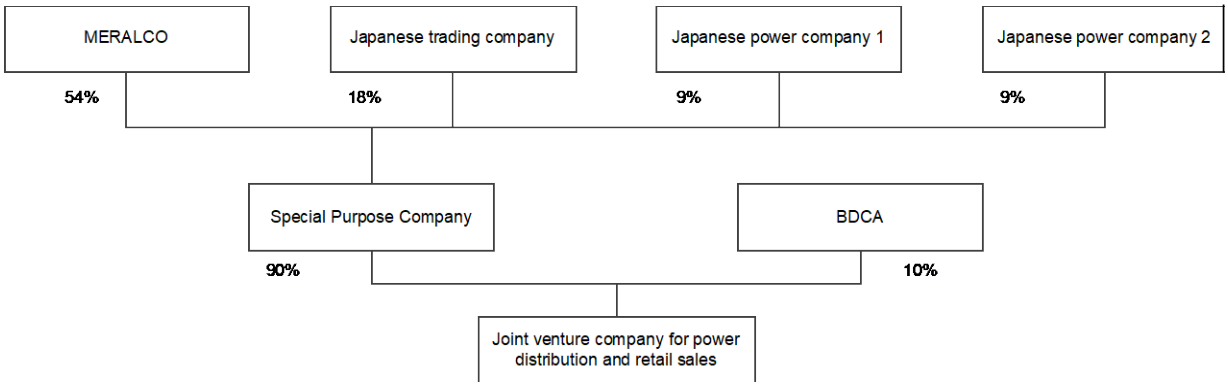
Source: Press release from JOIN (http://www.join-future.co.jp/english/news/pdf/20180824_01_01.pdf)

Figure 2.19 Implementation structure of the Waterpoint Project

New Clark City

New Clark City is a new city development project in Municipality of Capas, Province of Tarlac, Central Luzon. Total area is 9,450 ha, and it is one of the former Clark Air Force Base site utilization projects. The project of initiated by the Bases Conversion and Development Authority (BDCA), and the Philippine Congress approved House Resolution 116 in support of New Clark City in March 2015.

Phase 1A area (200ha) of the New Clark City is the National Government Administrative Center (200 ha) which will primarily host facilities for the Philippine government such as offices of various government agencies, government housing units, and other support services facilities. It also includes New Clark City Sports Complex (40ha) for 2019 Southeast Asian Games. Apart from the Phase 1A area, 288ha of land is being developed by Filinvest (local real estate development company). The area is used for the industrial area (around 120ha) and residential area.



Source: Press release from a power company

Figure 2.20 Implementation structure of a joint venture company for power distribution and retail sales for New Clark City Project

JOIN exchanged a MoU with the BDCA on development of New Clark City in March 2015, and has been supporting to connect relation between the BDCA and Japanese private sector. In April 2019, a Japanese consortium released an announcement that the consortium and Manila Electric Company (MERALCO) won the bidding to power distribution and retail sales. The companies will build a smart grid for New Clark City containing 45 km of power lines and about 30,000

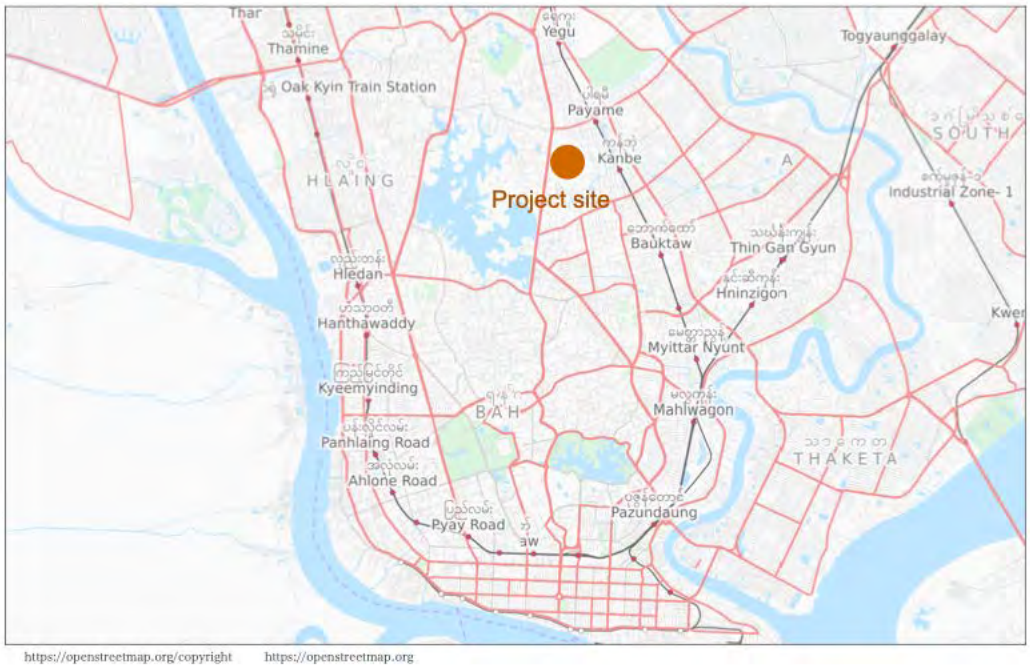
electricity meters that can transmit data. The city's power needs are projected at 250 MW. The consortium will form a Joint Venture Company shown in Figure 2.20.

Regarding water supply, the BDCA called open bid, and select a consortium which offers lowest unit price for water supply. The BDCA intends to form a joint venture like power distribution.

Japan Conference on Overseas Development of Eco-Cities

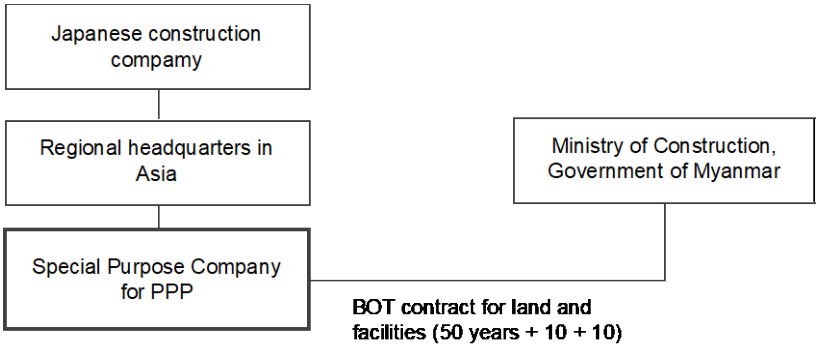
Another remarkable action of the Japanese PPP based urban development support for ASEAN city development is establishment of organizations like associations and conferences. This action is more private-driven one than establishment of the JOIN. "Japan Conference on Overseas Development of Eco-Cities (J-CODE) established in 2011 is one of such associations, and 57 companies relevant to design, construction and operation of real estates joined the organization.

J-CODE's objectives is "To create eco-friendly and self-sustainable urban city in Asian countries using the technology and experience accumulated in Japan, and its major activities are (i) planning of overseas eco-friendly urban projects, (ii) information collection and sharing of overseas eco-friendly urban projects, and (iii) proposing institutions and policies for promoting overseas eco-friendly urban projects. After the J-CODE's dialogues with Ministry of Construction in Myanmar, a Japanese company had BOT contract with the MOC for development of mixed-use complex (offices, hotels and commercial facilities; total floor area development (total floor area of 170,000 m2) in Yankin Township (total area of 2.7 ha, refer to Figure 2.21). The project is a new development model of public land for Myanmar, and it is 50-year (and twice of 10 year-extension) BOT project. Total investment cost is estimated around USD 400 million, and the land and facility are going to be transferred to the Government of Myanmar in the end of the contract (refer to Figure 2.22).



Source: Prepared by the study team based on the news release of the Japanese construction company

Figure 2.21 Location of Yankin Development Project



Source: Prepared by the study team based on the news release of the Japanese construction company

Figure 2.22 Implementation structure of the Yankin Development Project

Cooperation among public & private sectors of foreign countries and Japanese private sector: Tokyu Binh Duong Garden City

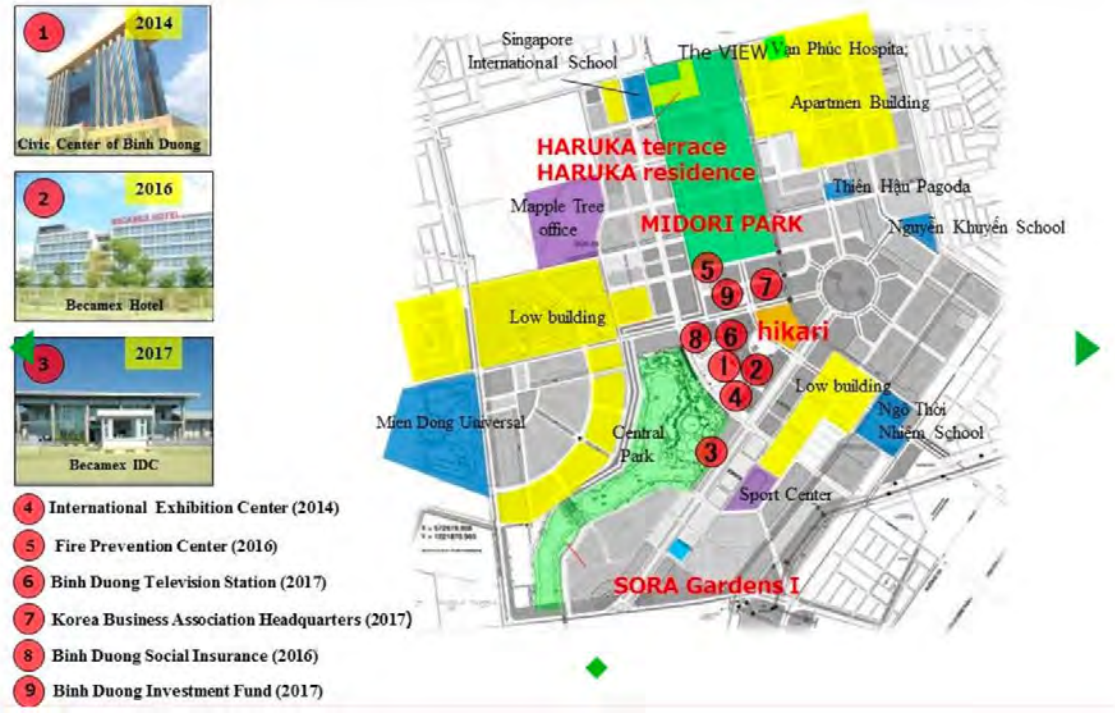
Tokyu Binh Duong Garden City (110 ha) is a part of Binh Duong New City (total area of 1,000 ha). Binh Duong New City is located around 30 km from Ho Chi Minh City, and it intends to accommodate 125,000 of residents and 400,000 working people in 2020 (refer to Figure 2.23). Development of the new city is initiated by the Investment and Industrial Development Joint Stock Corporation (BECAMEX IDC), which is a construction and urban development company owned by Binh Duong Provincial Committee. The Provincial Committee has relocated the central administrative office from old downtown to the new city area.

Source: BECAMEX Tokyu website

Figure 2.23 Location of Tokyu Binh Duong Garden City

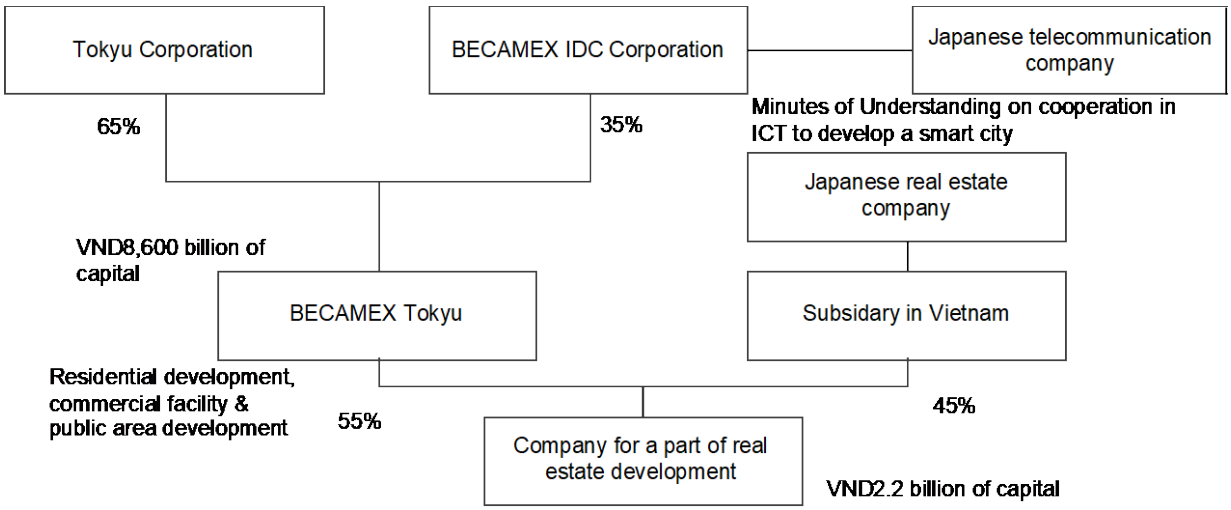
In order to develop the Garden City, Tokyu Corporation, a Japanese private railway operator formed a joint venture company, “BECAMEX Tokyu Co., Ltd” with the BECAMEX IDC in March 2012. Its total investment amount is VND 8,600 billion and Tokyu Corporation’s share accounts for 65% of the total. The BECAMEX Tokyu is developing around 7,500 houses, commercial facilities and offices at the Tokyu Binh Duong Garden City (refer to Figure 2.24). It also established a subsidiary, “BECAMEX Tokyu Bus Co., Ltd” in February 2014, and operates

7 bus lines as of June 2019 to connect the old down town and the new city.



Source: BECAMEX Tokyu website

Figure 2.24 Development image of the Tokyu Binh Duong Garden City



Source: Prepared by the Study Team based on the news release of BECAMEX Tokyu and other Japanese companies

Figure 2.25 Implementation structure of the Tokyu Binh Duong Garden City

In order to further residential development, a Japanese real estate company join the Tokyu Binh Duong Garden City development, and establish a joint venture company with BECAMEX Tokyu. In Addition, a Japanese telecommunication company made a Minutes of Understanding on cooperation in ICT sector to develop a smart city at Binh Duong New City (including Tokyu Binh Duong Garden City). Joint ventures with several Japanese companies are being implemented with BECAMEX IDC as the core in order to promote new urban development.

Lessons from urban development projects under PPP in ASEAN

Examples of urban development projects under PPP outside of Thailand shows the following characters.

- Availability of strong project initiator: local investment companies have a strong initiative in Waterpoint project, New Clark City and Tokyu Binh Duong Garden City, while Japanese companies have an initiative and freehand for decision making in Mega Kuningan Project and Yankin Project.
- Strong support from central or local government: local investment companies mentioned above are fully supported by the central government (New Clark City) and local governments (Waterpoint project and Tokyu Binh Duong Garden City); In case Japanese companies have initiatives, JOIN and J-CODE supports those projects.
- Simple finance procurement method: In most cases, development funds are not the projects themselves, but rather the ones gathered with the trust and self-funding of development companies. In two Vietnamese cases, almost of all investment cost for the Phase 1 project is prepared by the joint venture members. In case of Mega Kuningan Project, JOIN contributed a large financial support to the Japanese company.

(2) Examples of PPP projects in Thailand

Similar to other countries in Asia, the participation of private sectors in large-scale developments in Thailand has been growing.

In Thailand, Public Private Partnership (PPPs) has been employed as a main method to bring private sector to engage in development of infrastructures for a long time since the first PPP law in 1991. To supervise the PPP project to be consistent with country development plan and provide more clear directions, “Private Investments in State Undertaking Act” have been enforced in 2013 and this act covers various aspects of PPP projects comprehensively ranging from the definition of PPPs, the structure and the role of committee on PPPs, strategic plan on PPPs projects, to the whole process and procedures of PPP projects from applying, implementing to monitoring. Under the PPP scheme, the Private Investments in State Undertaking Committee will be the main committee who approve the project in principle and the State Enterprise Policy Office (SEPO) will act as the secretariat of the committee and the focal point to promote and facilitate PPP project in Thailand.

Under the Strategic Plan on Private Investments in State Undertakings 2017-2021, there are four subsectors which require private investment which are development of urban rail transit line, toll roads in metropolitan areas, public logistics port and high-speed rail line and other 19 subsectors which government encourage participation and investment from private sectors such as telecommunication networks, digital economy infrastructure, power infrastructure, real estate development for low to middle income population, and etc.

However, PPPs in Thailand still mainly concentrate in development infrastructures up until now as indicated in Table 2.6. Zone A development project of Bang Sue Area is on bidding based on the PPP law in 2013.

On 10th March 2019, “Joint State and Private Investment Act” came into force. It will replace the “Private Investments in State Undertaking Act,” and be a new PPP law. The new PPP law intends to expedite the joint investment process between the public and private sectors, empowered by the cabinet to tackle obstacles and any delays. For example, A Joint Investment Project with a value of THB 5 billion or more shall proceed according to criteria, procedures and conditions prescribed in the PPP Act. Joint Investment Projects with a value less than THB 5

billion shall proceed according to criteria and procedures determined and notified by the Public-Private Partnership Policy Committee. In the previous PPP law, THB 1 billion or more Joint Investment Project followed the PPP law.

According to Bangkok Post on 31st March, SRT Governor mentioned that “The Joint State and Private Investment Act, which came into force on March 10, opens the door for the SRT to lease its land to private developers instead of relying on Public-Private Partnership (PPP) deals”. It means that the new PPP law allow the SRT to call for an open bid for land leases without having to undergo an evaluation process with the PPP committee, the State Enterprise Policy Office and the cabinet. The scheme only needs to be approved by the SRT's board and the Transport Ministry[2].

[2] https://www.bangkokpost.com/business/1653948/srt-ramps-up-efforts-to-lease-its-land

Table 2.6 Examples of PPP projects in Thailand

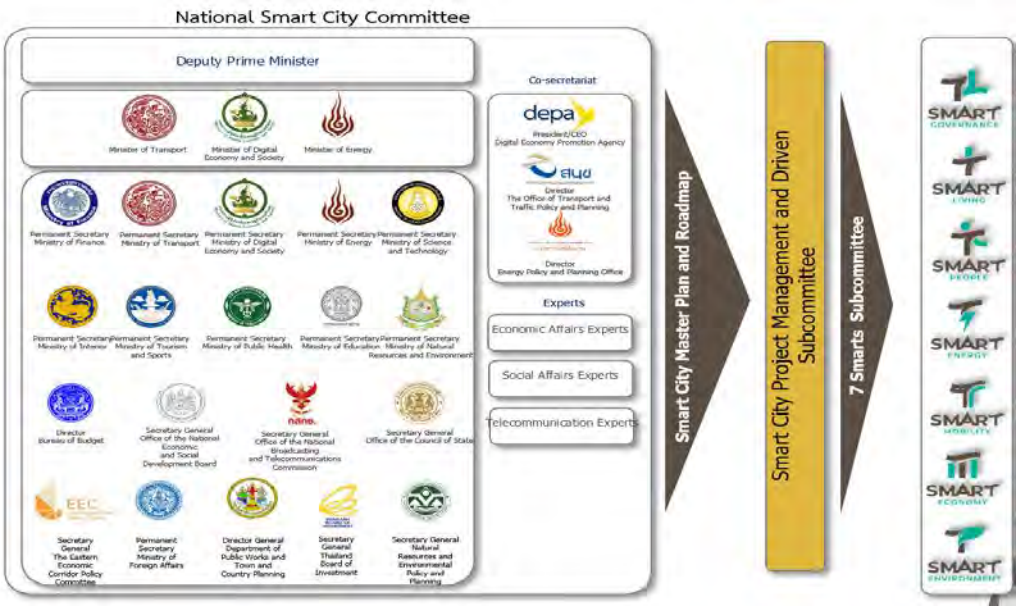
No.	Project Name	Project Owners	Investment Amount Mil Baht	Duration	Content of Project
1	Monorail Yellow Line (Ladprao-Samrong)	Public: Mass Rapid Transit Authority of Thailand (MRT) Private: Eastern Bangkok Monorail Co., Ltd	43,104	33 years 3 months (3years3 months for construction and 30-year operating period)	- 30 kilometer extension and connecting line of existing monorail with 23 station, 1 maintenance center and 1 parking lots. - Private companies signed the contracts on Jun 20, 2017.
2	Monorail Pink Line (Kaerai-Minburi)	Public: Mass Rapid Transit Authority of Thailand (MRT) Private: Northern Bangkok Monorail Co., Ltd	45,764	33 years 3 months (3 years 3 months and 30-year operating period)	- 34.5 kilometer extension and connecting line of existing monorail with 30 station, 1 maintenance center and 1 parking lots. - Private companies signed the contracts on Jun 20, 2017.
3	Highway system Phrase 2 (Srirat Expressway)	Public: Expressway Authority of Thailand (EXAT) Private: Bangkok Expressway Public Company Limited (BECL)	n/a	30 years (Mar 1, 1990 – Feb 28, 2020) Operation start date: Mar 2, 1993	Construction and operating of highway (Build–operate–transfer Model)
4	Transfering the right to produce and sell water service project	Public: Provincial Waterworks Authority Private: Pathum Thani Water Co., Ltd.	n/a	25 years (Oct 15, 1998-Oct 14, 2023)	Water supply system (Build–operate–transfer Model)
5	Warehouse in Suwannabhumi Airport	Public: Airport of Thailand Private: WFSPG Cargo Co., Ltd.	n/a	20 years (Sep 28, 2009 - Sep 27, 2026)	- Providing warehouse service. - Ownership of the warehouse will be transferred to the governmental agency after the construction finished.
6	Udonrattaya Highway (Bangbon–Pakkret)	Public: Expressway Authority of Thailand Private: Northern Expressway Co., Ltd.	n/a	30 years (Sep 27, 1996 - Sep 26, 2026)	Construction and operating of Highway (Bangbo-Pakkret)
7	Energy pipe for aviation	Public: Airport of Thailand Private: Thai Aviation Refuelling Co., Ltd.	n/a	30 years (2006-2036)	Installing and operating of 2 energy pipelines in airport area
8	Train system (Chaleamratchamongkon Line)	Public: Mass Rapid Transit Authority of Thailand (MRT) Private: Bangkok Metro PCL	n/a	25 years (Jul 2, 2004–Jul 1, 2029)	- Designing, building and operating train system. - Ownership will be transferred to MRT after the contracts finished.
9	Operating of shipyard at Lamchabang Port	Public: Port Authority of Thailand Private: Unithai Shipyard and Engineering Co., Ltd.	n/a	30 years (Dec 18, 1990–Dec 17, 2020)	- Building and operating of shipyard. - Ownership on factory and office will be transferred to Port Authority of Thailand while the ownership of the machines such as cranes and forklifts will still be the asset of Unithai.
10	BTS System	Public: Bangkok Metropolitan Administration (BMA) Private: Bangkok Mass Transit System Public Company Limited	n/a	30 years (Dec 5, 1999 - Dec 4, 2029)	- Designing, building and operating train system. - Ownership will be transferred to BMA after the contracts finished.

Source: State Enterprise Policy Office

2.3 Smart City Projects in Thailand

2.3.1 Smart City Framework

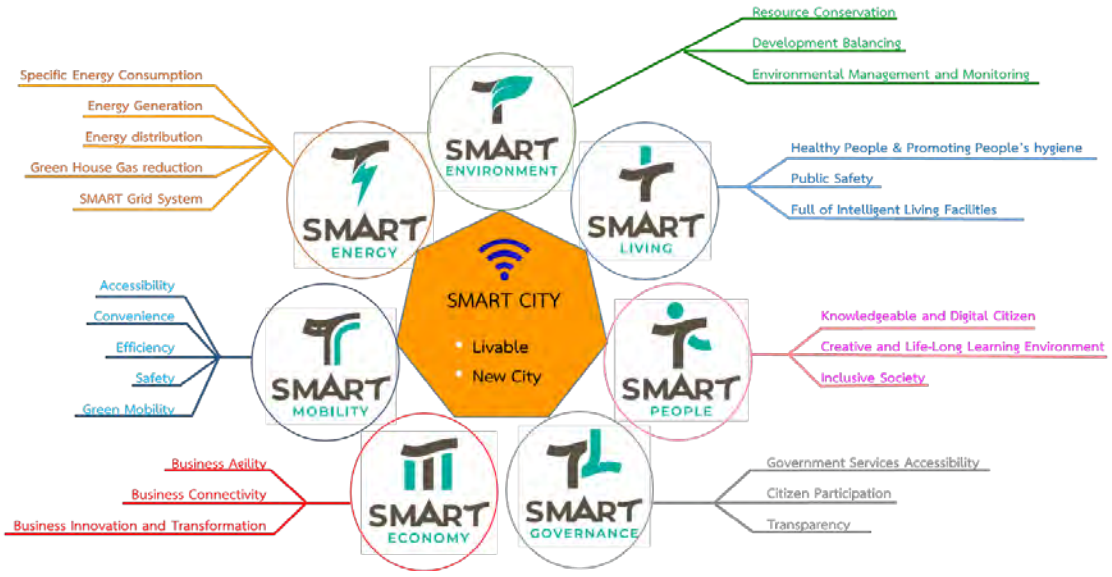
The Thai government has formed a "Smart City Steering Committee", chaired by the Deputy Minister of Transport, and set seven criteria for becoming a Smart City, namely Smart Economy, Smart Mobility, Smart Energy, Smart Environment, Smart Governance, Smart Living and Smart People (shown in the figure below). A Working Group (WG) has been set up for each of the seven smart items and the relevant ministries have been assigned as the secretariat tasked with elaborating the details of the criteria for becoming a Smart City. The Office of Transport and Traffic Policy and Planning (OTP) is appointed as the secretariat for all seven smart items.



Source: OTP, presentation material at "Thailand Smart City Seminar"

Figure 2.26 Smart City Development Framework

In the Smart City framework which is under consideration in Thailand, Smart City projects and businesses that are approved by the Steering Committee and the Board of Investment (BOI) are entitled to special rights and privileges such as tax exemption. In a typical case, it is assumed that the landowner or area owner will submit a Smart City proposal to the Steering Committee, where it will be evaluated based on the pre-set criteria and KPIs. If the proposal is approved by the Steering Committee, the Smart City proposal will be presented to BOI for tax exemption privileges.



Source: OTP, presentation material at "Thailand Smart City Seminar"

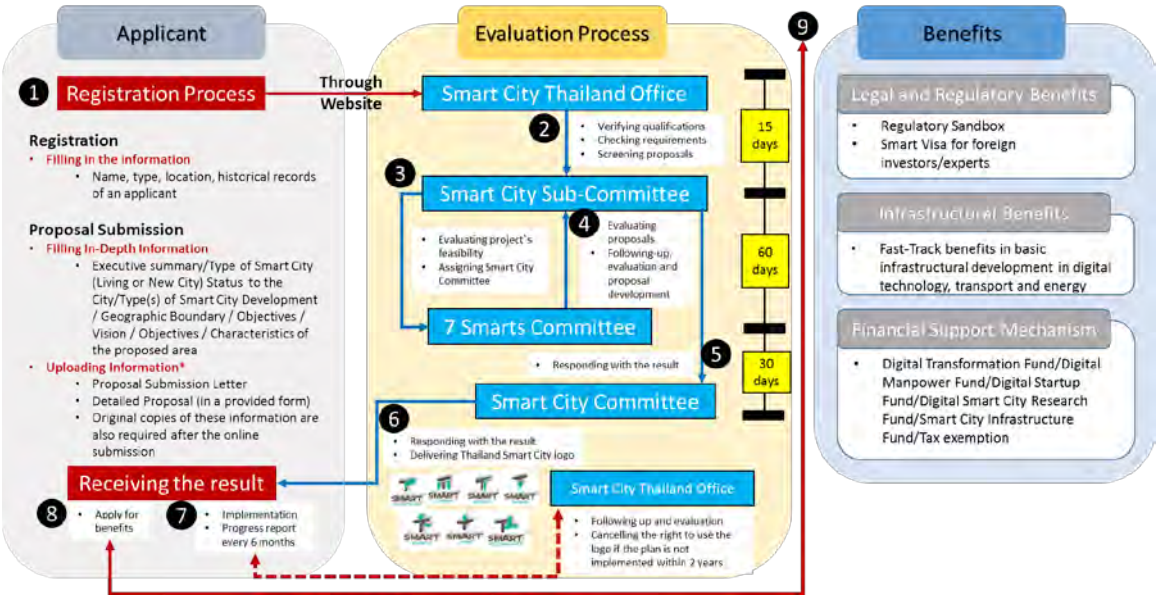
Figure 2.27 Seven smart fields

The Smart City application must meet the criteria for at least two Smart items including the "Smart Environment" criteria, which is a compulsory Smart Item that all Smart City projects must satisfy. The evaluation of the proposal is carried out based on the KPIs set for each criterion, and it will be judged on both aggregate and disaggregate scores. An eligible proposal must score more than 70 points in each selected criterion while also scoring more than 80 points in total average.

Bang Sue Smart City is one of the first target cities to become a Smart City under this framework. This study is currently communicating closely with the committee and each working group to follow the guidelines and help elaborate the criteria for being a Smart City.

It is generally understood that Smart City projects in Thailand are typically carried out primarily by the City Development Company established in each city, while also collaborating with the private sectors, local municipalities, and universities. The project plans are led by the local municipalities, and the necessary funds are gathered from the government, public support schemes, private investments, and other funds.

The necessary applications are submitted to the Smart City Sub-committee and Smart City Committee, which would be responsible for screening the proposals. The procedure regarding the application is as shown below.



Source: Compiled by the Study Team based on "Smart City Thailand Annual Report2018"

Figure 2.28 Smart City application flow

2.3.2 Definition and specifications for Thailand Smart City

Smart City in Thailand is defined as below:

> "Smart City" means a city that takes advantage of modern technology and innovation to increase the efficiency of the city service and management, reduce the cost and resource usage of the target city and citizens. It focuses on good design and participation of business and public sectors in urban development, under the concept of a modern and liveable city development, for people in the city to have a good quality of life and sustainable happiness.

Source: https://smartcitythailand.or.th/

The definition of seven smart in Thailand is as follows:

Table 2.7 Definition of Seven Smart components

Component	Definition
Smart Environment	Smart Environment means a city that considers impact on the environment and climate change by using technology to help manage systematically, such as water management, weather care, waste management, and disaster surveillance as well as increasing public participation in natural resource conservation.
Smart Economy	Smart Economy means a city that uses digital technology to create additional value in the economy and effectively manage resources such as intelligent agriculture city, intelligent tourist city, etc.
Smart Energy	Smart Energy means a city that can manage energy efficiently. Create balance between production and energy use in the area to create energy sustainability and reduce dependence on energy from the main power network system
Smart Governance	Smart Governance means a city that develops a government service system, to facilitate stakeholders who have access to government information by focusing on transparency and participation, and is continuously updated through the application of innovative services.
Smart Living	Smart Living means the city that has developed facilities, taking into account the Universal Design, providing people with good health and quality of life, safe and have a happy life.
Smart Mobility	Smart Mobility means a city that focuses on developing traffic systems and intelligent transportation to drive the country, by increasing the efficiency and connectivity of various transportation systems, also increasing convenience and safety in travel and transportation, including being environmental friendly.
Smart People	Smart People means a city that aims to develop knowledge, skills and the environment. It is also conducive to lifelong learning, reduce social and economic disparity, and openness for creativity, innovation and public participation.

Source: https://smartcitythailand.or.th/

For each of the Smart City components, a criteria is set. Initially, a specific KPI was set as criteria, but in the current arrangement, there is no specific KPI. The applicant is required to propose along the criteria, and the Committee would make the evaluation based on the proposal.

The criteria for Smart Mobility, Smart Energy, and Smart Environment is shown below.

Table 2.8 Smart Mobility Criteria

framework	goal	Criteria for consideration
1.The accessibility to transportation network/public transport (Accessibility)	1.1. Promoting the use of transportation systems	There is a plan to develop public transportation systems that cover the area
	1.2.Facilitng to provide the transportation services	There are plans to develop the facilities For all people (Universal Design)
2. Convenience in	2.1. Providing	There is a plan to develop information providing

framework	goal	Criteria for consideration
using utilities and facilities, including public transportation network (Convenience)	information to passengers	services about public transportation such as a channel to inform the location of public vehicles, waiting time informing system, etc.
	2.2.Parking management	There is a plan to promote the use of advanced parking management system such as Parking registration via online system, notification of parking status/parking guidance through the system
	2.3.Promoting cashless society	There are plans to promote the e-payment of transportation fees. e.g. e-ticket, Electronic Toll Collector (ETC), online ticket purchase, etc.
3.Efficiency in managing, transportation and traffic (Efficiency)	3.1.Traffic Management	There is a plan to develop automatic/ real time traffic management such as real time traffic light management, Bus Priority, traffic management center, etc.
	3.2.Providing information to passengers of information to travelers	There are plans to develop travel/traffic information services (for personal car)such as Intelligent signs, travel information channel (Website / App. / SMS), etc.
	3.3.Freight Management	There is a plan to manage freight cars such as GPS installation, bus control center
4.Safety in transportation	4.1.Safety in providing public transportation services	Having safety equipment in public transport vehicle as required by standard such as having a CCTV camera in the public transportation system, having security tools within public transportation systems (glass hammer, firefighting equipment, emergency door, emergency exits).
	4.2.Safety in the transport network	There are plans to develop safe network/transportation infrastructure, such as the installation of CCTV camera, and measuring vehicle speed equipment.
	4.3.Safety in the transport network	There is an electrical illuminating system throughout all route.
	4.4.Safety Management System	There is a plan to develop a safety management system and plan for emergency situations.
5.Promoting the usage of vehicles that help reducing pollution transmission (Green Mobility)	5.1. Promoting the travel without using engines	There are plans to develop (roads, pedestrians, bike lane) within the area.
	5.2.Vehicle sharing	Having plans/measures to promote the usage of vehicle sharing such as Carpool, Vehicle (Car / Bike / Motorcycle) Sharing, etc.
	5.3 Usage of energy-saving low emission vehicles	Having plans/measures to promoting the usage of economical and low emissions vehicles such as Electric vehicles (EV), hybrid, providing charging stations
6.Other innovative proposals for the Mobility	4.1 To support the innovation that can support the development of smart cities in the terms of Smart Mobility, concretely	Presenting innovations that can support the development of smart cities in terms of Smart Mobility

Source: Compiled by the Study Team based on Smart City Thailand website (https://smartcitythailand.or.th/)

Table 2.9 Smart Energy Criteria

framework	goal	Criteria for consideration
1. Specific Energy Consumption (Mandatory)	1.1. All buildings in Smart City must have must meet the specific energy consumption (SEC) according to the average reference criteria for each types of buildings or enterprises.	All buildings and enterprises within the smart city have to meet the energy consumption average reference criteria for each types of buildings and enterprises.
2. Energy generation	2.1 To focus on renewable energy production and to reduce the impact on the environment and society caused by the use of fossil fuel energy.	Renewable energy production (mandatory)
	2.2 To promote local power production by public, private and individual service providers and connect these source of power to Smart Micro grid network system effectively	Onsite power generation
	2.3 To increase the efficiency of local power production system. reduce the amount of wasting energy as well as to reserve energy for the smart city from the level of the business building to the household level in order to reduce the cost and increase energy self-sufficiency	Energy storage
3. Energy distribution	3.1 To optimize both heating and cooling energy distribution to various areas of smart city	District cooling or district heating system
	3.2 To promote the usage of environmental-friendly vehicles such as electric vehicles, CBG and fuel cell vehicles, etc.	Promoting the usage of environmental friendly vehicles (Eco-vehicle)
4. Greenhouse gas reduction	4.1 To allow the smart city to have greenhouse gas reduction goal that conforming to the country's goals and allow the energy usage of the smart city to be consistent with effective energy usage policy which is under Ministry of Energy's current energy conservation plan.	Greenhouse gas reduction target throughout the project period. Greenhouse gas reduction target within the first years of the project
5. SMART Grid system	5.1 To manage local energy production and usage as regarding the lowest cost by designing an energy management system (EMS) which is a part of the Smart Grid System as well as working with utilities systems in other categories such as Smart Mobility, Smart Living and Smart Environment.	Area energy management system (AEMS)
	5.2 To have basic equipment for Smart Grid System as well as the channel to communicate with the energy providers in order to manage the energy for the electricity users.	SMART Meters
	5.3 To generate electricity regarding of the balance between power production and energy usage within Micro-grid by using Main-grid in order to strengthen the energy security for the smart city.	Micro-grid system
	5.4 To manage local energy usage such as the electricity usage of building and household	Smart Home / Smart Building system
6. Other innovative proposal for Smart Energy (SMART Energy Innovation)	To support the innovation that can support development of smart City, and implementation of smart Energy concretely.	Presenting the innovations that can support the development of smart city in Smart Energy field.

Source: Compiled by the Study Team based on Smart City Thailand website (https://smartcitythailand.or.th/)

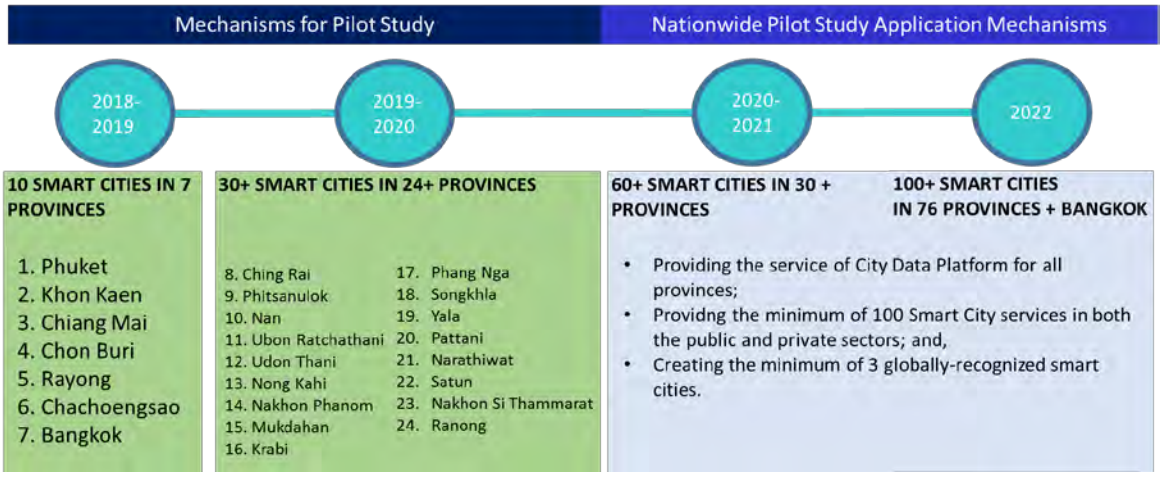
Table 2.10 Smart Environment Criteria

framework	goal	Criteria for consideration
1. Conserve the environment as the resources base that can be used for living and occupations in the way that do not affect the quality of life	1.1 Comprehensive waste management for the community according to academic principles	Increasing amount of waste that is utilized before handling
		No remaining waste
		Solid waste that has been properly managed according to regulations
	1.2 sufficient water for consumption	Access to clean water
		Clean water service area cover more than % of community area
		Basic standard for clean water used for consumption
	1.3 Urban/ community/ development projects manage wastewater efficiently	Basic wastewater treatment system
		Community level waste water treatment system
		The area that provide wastewater treatment services should cover more than 50% of community.
	1.4 Air quality does not affect people in the community.	Handling the complaints related to air quality
		Environmental-friendly public transport management
2. Maintaining the balance of nature which is suitable for living and occupation of people in the community	2.1 City/ community/ development project have sufficient green spaces meeting with the standards.	The proportion of public green areas in the city / community / development project is not less than 10 square meters / person.
	2.2 Appropriate land use	For land use, environment and ecology should be taking into account.
	2.3 Safe city	There are plans or systems to monitor the risks from weather changes.
	2.4 Beautiful and tidy city	Environmental landscape management
3. Management efficiency and monitoring of the environment	3.1 Urban Development Innovation	Having the technology and innovations improving environmental and pollution management
	3.2 Effective measure to cope with environmental problems	Methods, mechanisms to promote the management of urban environment through residences' participatory processes Efficiency in dealing with environmental problem complaints
	3.3 People have environmental friendly consumption and way of life	Production, service and consumption are environmentally friendly.
4. Other innovative proposals in environmental aspect (SMART Environment Innovation)	4.1 To support the innovation that can support development of smart City, and implementation of smart environment concretely.	Having the innovative proposal that can support the development of smart city in Smart Environment field.

Source: Compiled by the Study Team based on Smart City Thailand website (https://smartcitythailand.or.th/)

2.3.3 Smart City Projects in Thailand

In 2018 and 2019, a pilot study for Smart City was carried out in 10 cities in 7 provinces. From 2019 to 2020, 30 smart city projects are targetted to be implemented, while from 2020 to 2023, 100 smart city projects are targetted to be implemented.



Source: Compiled by the Study Team based on "Smart City Thailand Annual Report2018"

Figure 2.29 Smart City Development Plan in Thailand

According to the IDC, Phuket and Khon Kaen cities in Thailand are listed among the 19 out of 148 most outstanding smart city projects in Asia Pacific (excluding Japan) initiated by DEPA in 2018. Both the winning projects illustrated the best practices of urban innovation with ultimate focus on the use of technologies (cloud, platforms, analytics, IoT, mobile solutions) and data, unique partnerships, funding models and/or community involvement.

Source: IDC Web sites, https://www.idc.com/getdoc.jsp?containerId=prAP44102018

Figure 2.30 List of the most outstanding smart city projects in Asia Pacific

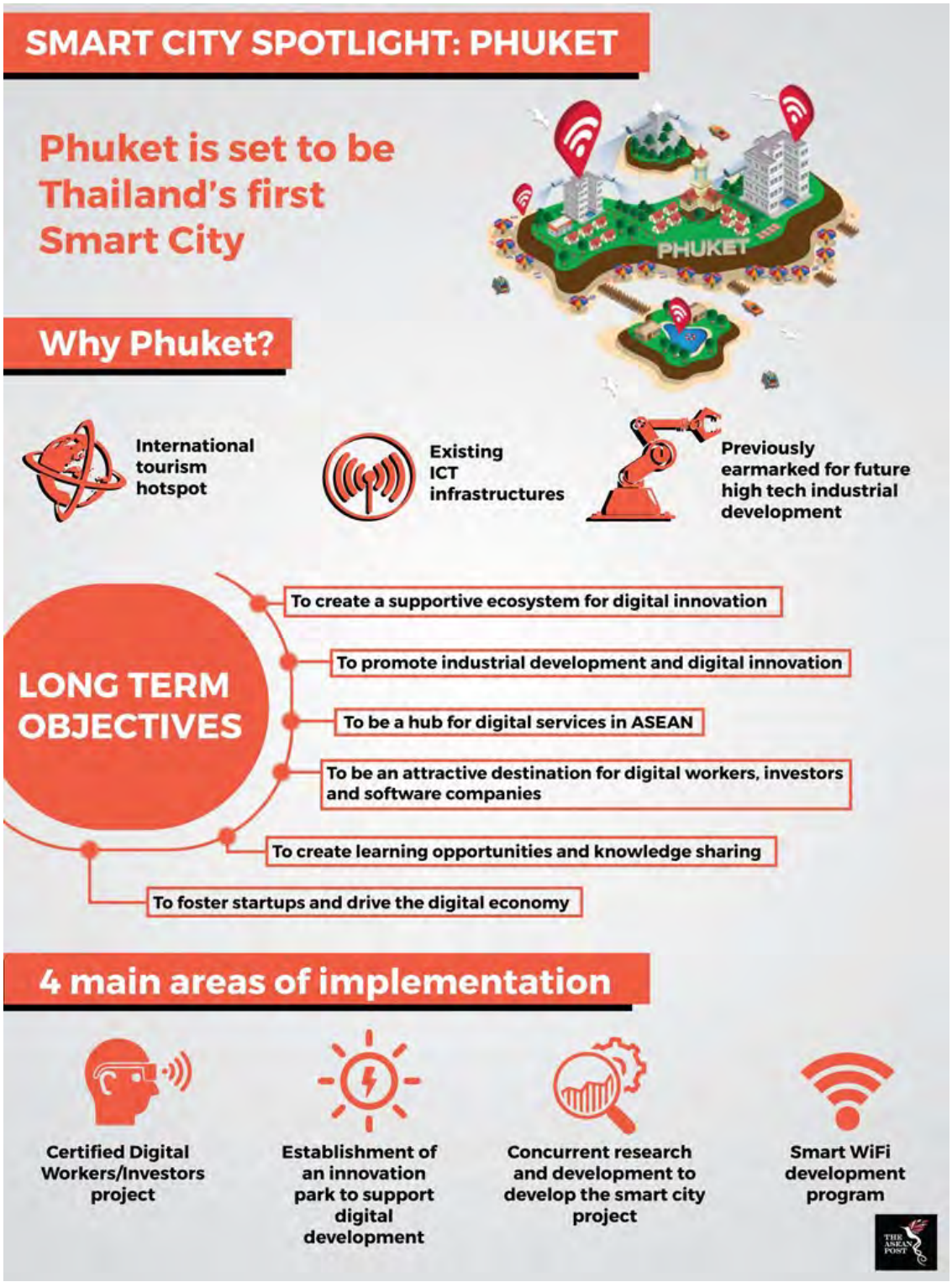
(1) Phuket

Phuket has been touted as Thailand's first ever smart city. It has also been included as one of 26 cities within the ASCN which envisions a collaborative platform for selected cities to work

towards sustainable and smart development.

DEPA has proceeded with the Smart City Project which comprises the following:

1. City Data Platform: An information integration project in Phuket Province:
   - Data on behaviour of Phuket tourists.
   - Data on immovable property.
   - Data on environment.
2. Smart Safety: Marine safety based on a proposal for sandbox development for control of safety of marine tourism in 3 Andaman provinces (Phuket, Pang Nga, Krabi) by applying digital technology.
3. City Investment: Method and conditions of joint investment with the private sector for smart city development by proposing 3 formats, namely BOT, BLT, PPP.
4. Smart Safety, Smart Environment, Smart Governance: Increased CCTV installation points based on a survey of Phuket Provincial Police and local authorities, so as to safeguard the lives and property of citizens and tourists, including control when a disaster occurs. A smart data integration center is also set up which increases city management efficiency by applying digital technology mainly to promote a complete Phuket Smart City.



Source: The Asian post, https://theaseanpost.com/article/smart-city-spotlight-phuket

Figure 2.31 Outline of the Phuket's Smart City

(2) Khon Kaen

1) DEPA-initiated project

The purpose of this project is the development of an ecological system for the digital economy within the area in order to lay the guidelines on development of Khon Kaen Smart City. The details are as follows.

1. Summarize the urgent issues of Khon Kaen Province jointly by government agencies and private entities in the following areas:
    - Preparation of standards for linking of data recognized both domestically and abroad and division of data storage so that it is systematic and can be actually utilized at provincial level and national level (City Data Center or SCOPC).
    - Preparation of standards on storage of medical data and public health data within Khon Kaen first, so that it can be developed as an important model for linking of personal data.
    - Khon Kaen Smart Living Development Plan in respect of safety by using smart CCTV technology so as to create confidence and convenience for a MICE City.
    - Stimulate tourism and seminars by promoting tourist spots by applying digital technology.
    - Enhancing mobility so that it spreads all over the country, thus increasing efficiency in order that it can be exported using the skills of Thai people.

2. Prepare a digital business promotion plan for smart city operators, such as cooperation in setting up business, promotion of development and upgrading of business by support measures and assistance from the DEPA as well as enhancing awareness to create understanding when accessing capital sources and promoting DEPA measures, by emphasis on developing:

    (1) Smart Living (public health and smart medical services)*.

    (2) Smart Mobility (smart device for small taxi buses).

    (3) Smart People (supporting E-sports industry and development of digital skills in labour force).

    (4) Smart Government (management system for government meeting documents).

    (5) Smart Environment (smart garbage collection system), etc.

Additionally, the DEPA is preparing a city data platform development plan for use as the basic structure of the city when gathering, analysing, and disclosing data, comprising:

- Data on population, economy, and society from the Provincial Statistical Office.
- Smart data integration and CCTV data processing system.

*Note: The Khon Kaen Smart Health project

The Khon Kaen Smart Health project is an initiative by DEPA with local healthcare service providers and universities that consists of 3 components:

1. A smart ambulance that utilizes teleconferencing, IoT, and robotics technology to increase emergency dispatch efficiency and allow healthcare professionals to perform initial diagnosis and emergency treatment before patients arrive at the hospital,
2. A preventive healthcare service that leverages smart wristbands and smart home solutions to monitor and collect citizens' health data and provide health guidance accordingly, and

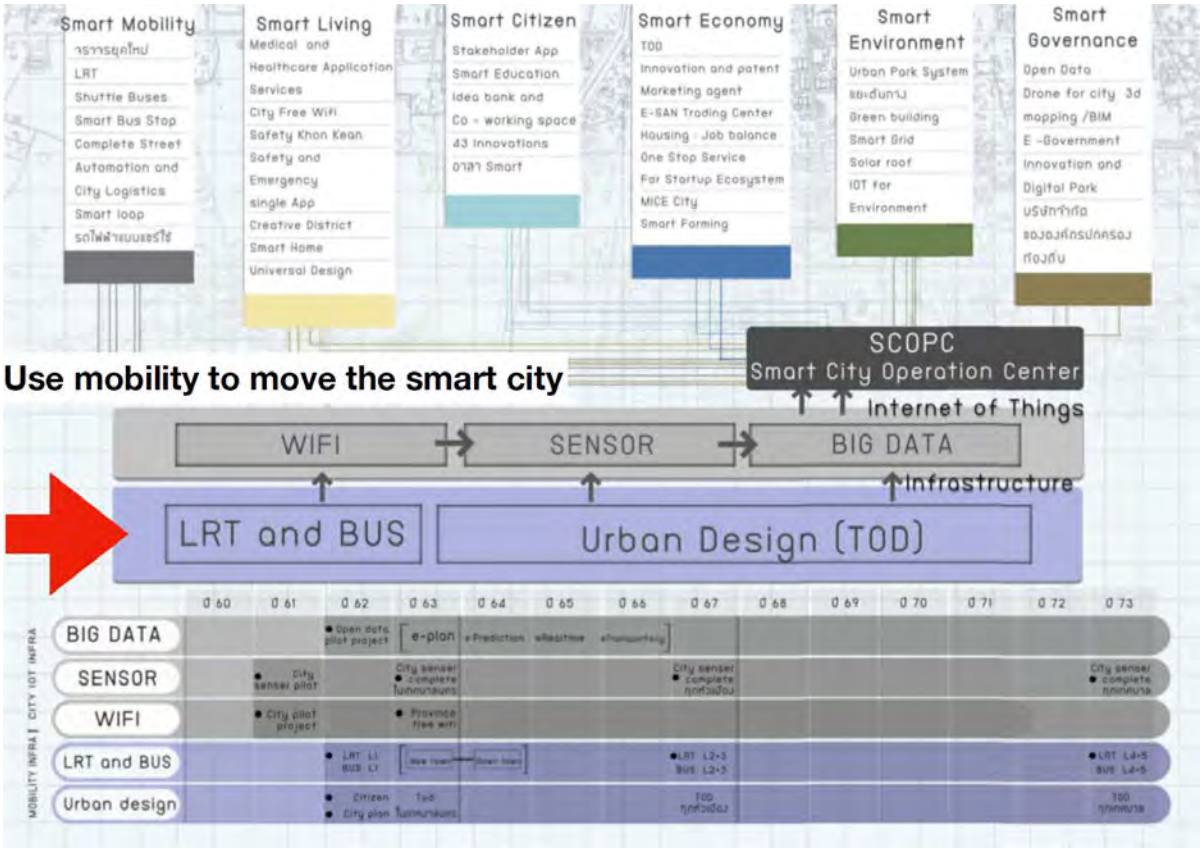
3. Still in development, the use of blockchain and big data analytics to develop a medical data sharing platform that can be accessed by both public and private healthcare service providers.

Source:https://www.himssasiapac.org/content-library/exclusive-articles/khon-kaen-smart-health-project-will-be-completed-2019

2) Khon Kaen public-private partnership-initiated project

Khon Kaen Municipality and Khon Kaen Pattana Mueang Co., Ltd. (KKTT) have prepared a business model for the development of Khon Kaen Smart City in the vicinity of Mueang Khon Kaen, Khon Kaen Province, according to the concept of Mobility Drives City, by focusing on using all 5 communication networks. The model was originally studied in 2008 and introduced a mobility –centered model which was also intended to account for issues in various area. However, the model had some issues due to insufficiency of city budget allocation for infrastructure (water, electricity, public health services, security, and waste treatment, building construction).

Mobility Drives City acts as a mechanism linking the lives of residents and people coming into the city, while creating new economic activities. Presently, Khon Kaen Smart City Project is listed in the 'Khon Kaen Smart City 2029' Strategic and Development Plan.



Source:Thailandcop24,https://thailandcop24.com/wp-content/uploads/2018/11/Khon-Kaen-Smart-City-COP24-Rev-2.pdf

Figure 2.32 A Smart City as strategic plan of Khon Kaen

(3) Chiang Mai

1) Chiang Mai University-initiated project

Chiang Mai University has prepared a business model for developing the CMU Smart City-Clean Energy Project. The policy underlying the projects is green energy management. Some projects have already been implemented and others are underway (e.g. clean energy from sunshine and biomass, project for reduction of use of private motor cars in the city, zero garbage project, and waste-to-energy public bus project). The projects which are being implemented include an absolute smart control network project which focuses on establishing a comprehensive control network system and city measurement system, be it an energy system, security system, travelling system, or public participation promotion system.

Also, projects such as the public transport network, smart business project, TREEs project, preparation for construction of new TREEs-Platinum certified buildings, and so on are increasing. CMU Smart City - Clean Energy Project is included in the Chiang Mai Development Project No. 12 (2017-2021).

Presently, Chiang Mai University has duly implemented the following projects according to the business model: electric bus and tram project, smart meter installation project to measure use of energy of all buildings within Chiang Mai University perimeter, and 500 kWh Energy Storage Installation Project.

2) DEPA-initiated project

The DEPA is preparing a City Data Platform Development Plan that will be the basic structure of the city in gathering, analyzing, and disclosing data. The plan comprises:

- Data on population, economy, and society from the Provincial Statistical Office.
- Agricultural production data such as rice, longan, and sweet corn, and data on management, production, transportation, marketing and circumstances of said agricultural produce.
- Linking of agricultural tourism and logistics, and linking of production places, chefs, and consumers.
- Data on elderly, and patients suffering from specific diseases (diabetes, kidney diseases, etc.)

Additionally, the DEPA is promoting the development and upgrading of businesses by applying digital technology, comprising:

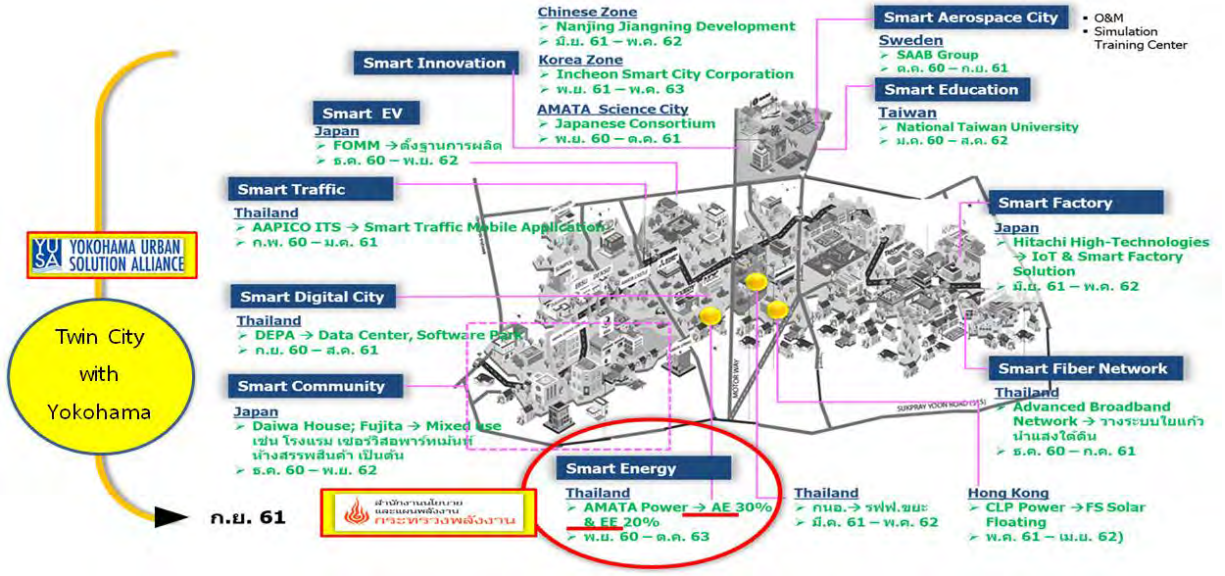
- Development of a smart agriculture model and selection of IoT equipment for agriculture so that it can be a model project, and analysis of investment worthiness of smart agriculture, with modern organic rice-growing as the starting project.
- Smart data integration system and CCTV data processing system.
- Prepare a digital business promotion plan for smart city operators, such as cooperation on setting up of business, promotion for development and upgrading of business by support measures and assistance from DEPA.

(4) AMATA Smart City

AMATA Smart City is one of the three cities that is nominated in ASCN framework. The project area includes 4,000 ha land in the existing industrial site and 1,000 ha land in the northern part of the owned land which would be newly developed as Smart City.

AMATA Smart City development is being planned under cooperative framework with Yokohama City in Japan. In January 2018, AMATA Corporation contracted Yokohama Urban Solution Alliance (YUSA) as a consultant. The term of the contract is to 1) provide technical recommendation for AMATA to promote Smart City development at AMATA's industrial area, and to 2) conduct technical study and make proposal on project formation to accelerate Smart City development in AMATA.

For Smart City development, AMATA has signed MOU with several other companies and cities in the world to realize Smart City development as is shown below.



Source: Material provided by OTP

Figure 2.33 AMATA Smart City

(5) EEC Area

The EEC area is designated as Smart City as a whole. The Smart City development is expected to create synergy effect with the development of Laem Chabang Port, U-Tapao Airport and the High Speed Rail.

Especially notable project in EEC area is the Digital Park Thailand project in Siracha, which is promoted by DEPA. The project focuses on research and development on "Smart Mobility", "Smart Economy", and "Smart People". More specifically, the below facilities are to be developed and promoted to advance research and development of cutting edge technologies.

- Research facility for smart logistics
- Test Bed Area for 5G network
- Research facility for IoT
- Accumulation zone for start-ups and incubation

Source: Digital Park Thailand, http://digitalparkthailand.org/witp-2/

Figure 2.34 Overview of Digital Park Thailand development project

(6) Discussion

Smart City development has been planned and initiated in several cities under DEPA, such as Phuket, Khon Kaen, and EEC area. Moreover, according to 2018 annual report Smart City project is planned to be initiated at Ubonrachathani and Ubonthani region as well.

Table 2.11 Pilot Smart City projects in Thailand in 2019-2020

Areas	Smart Economy	Smart Mobility	Smart Energy	Smart Environment	Smart Living	Smart People	Smart Government
Chiang Mai	√ (Tourism)						√ (IOC*)
Khon Kaen					√ (Health)		√ (IOC*)
Ubonrat-chathani	√ (Tourism)						
Udonthani	√ (Trade)	√ (Border)			√ (Safety)	√ (Community)	
Phukhet		√ (Bus)		√ (Waste, Disaster)			√ (IOC*, Regulatory sandbox)
EEC	√ (Tourism, Startups)	√ (Port, Bus)	√ (Factory)	√ (Factory)	√ (Safety, Health)	√ (University)	√ (IOC*, Regulatory sandbox)

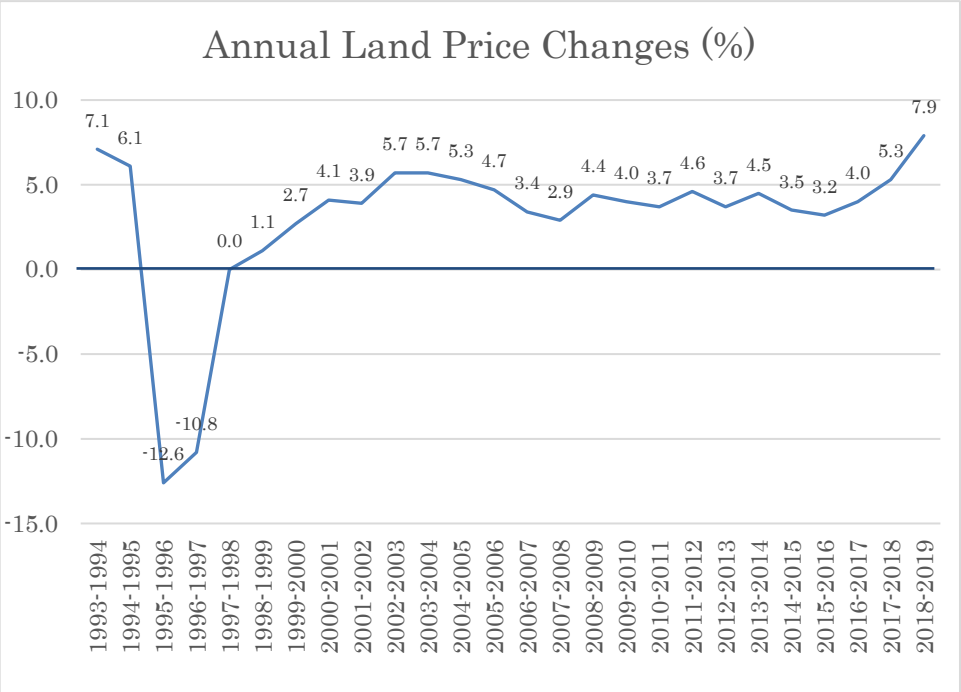
*IOC: Intelligent Operation Center
Source: Smart City Thailand Annual Report 2018

In shaping the Smart City project in Bang Sue, it is also important to consider the unique regional attributes that would not compete with other cities' initiatives.

2.4 Large-scale Development Projects in Bangkok

2.4.1 Property Development and Land Price Trend in Bangkok

The property market in Bangkok has been expanded, supported by a solid increase in land prices. Land prices have recorded continuous stable growth in the period except for the Asian Financial Crisis in the latter half of the 1990's. Figure 2.35 shows a land price trend from 1993 to 2019 in Bangkok. When taking a look at a five-year average, the change rates for land prices have risen annually at an average of a 4% range in the periods from 2004 to 2009, from 2009 to 2014 and from 2014 to 2019.

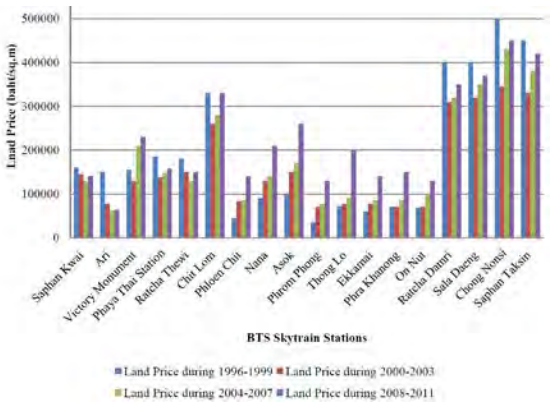


Source: Agency for Real Estate Affairs

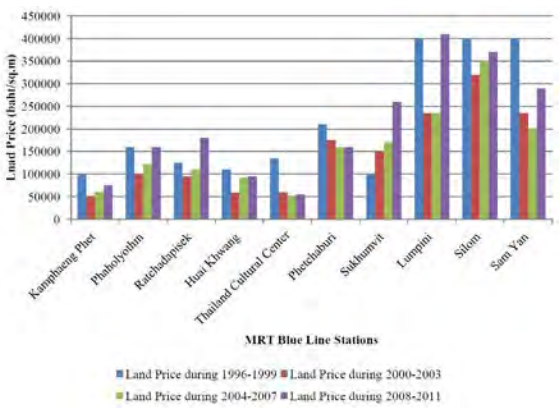
Figure 2.35 Land Price Trend in Bangkok from 1993 to 2019

Land price growth in Bangkok is led by that in the Central Business District (CBD). According to Thai real-estate research firm AREA (Agency for Real Estate Affairs), growing land prices by the mid-2000's are attributable mainly to housing demand expansion coupled by income growth in the middle class and large-scale development in the CBD. In recent years, as BRT and other public transportations have been developed, the land price especially with high transportation convenience has risen remarkably. AREA reported that the land price has been increased by 11% in the area near the metro stations in 2018.

The following table, as related data, shows an appraised value trend of land by BTS and MRT stations, compiled by researchers from Kyoto University. The table finds a high growth rate trend for land prices in the 2000's onward and higher land prices in Bangkok CBD. As of 2011, especially, the appraised land value around Pahonyothin Station in the Bang Sue area is approximately half of that near Silom Station.



Appraised land value trend at BTS station



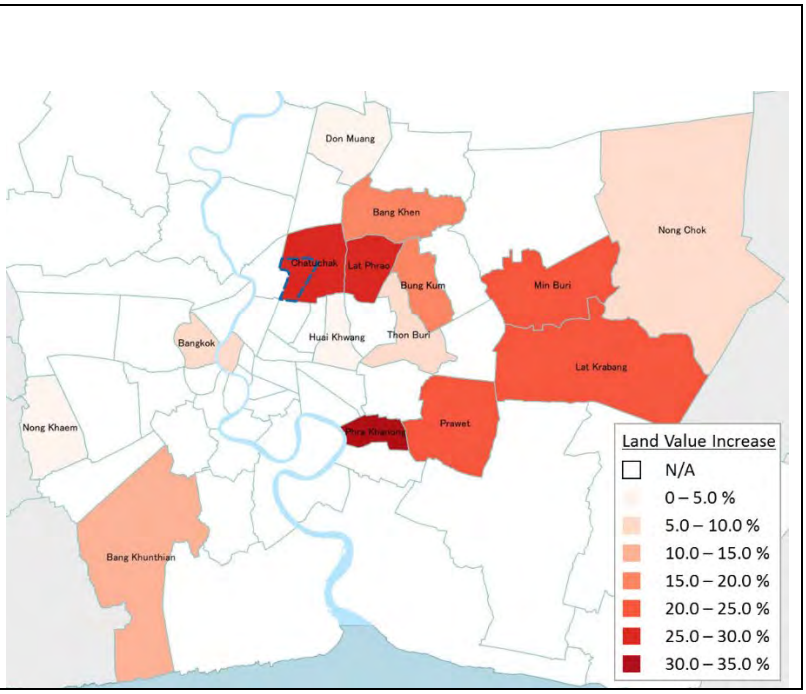
Appraised land value trend by MRT station

*The above land prices are different from market ones due to appraised values of land.
Source: Malaitham, Sathita, "A Study of Urban Rail Transit Development Effects in Bangkok Metropolitan Region" (2013), released by Kyoto University

Figure 2.36 Appraised Land Value Trend at BTS and MRT Stations

As Red Line and other metro or public transportation networks have been expanded or improved, land prices along the line or stations are expected to rise due to higher convenience. As the appraised values of land have been revised in some areas of Bangkok in 2019, land prices have grown by about 30% on average in the Chatuchak area of Bang Sue. After the opening of Bang Sue Grand Station, when it connects with Red Line and high speed railways with higher transportation convenience and Bang Sue is developed as a new CBD, land prices are likely to rise further. Figure 2.37 shows growth rates of revised appraised values of land from 2016.

No.	Areas	Average change (%)
1	Phra Khanong	33.54
2	Chatuchak	29.75
3	Bang Kapi	27.73
4	Lat Phrao	25.63
5	Lat Krabang	22.63
6	Prawet	21.93
7	Min Buri	21.43
8	Bang Khen	19.85
9	Bung Kum	19.21
10	Bang Khunthian	10.83
11	Thon Buri	7.35
12	Bankok Noi	6.87
13	Nong Chok	6.19
14	Bangkok	5.01
15	Nong Khaem	4.76
16	Don Muang	4.52
17	Huai Khwang	1.04



Source: Produced by the Study Team, based on documents released by Thailand Treasury Department.

Figure 2.37 Growth Rate of Appraised Value of Land by Area from 2016 to 2019 (Area with Appraised Value of Land Revised in 2019)

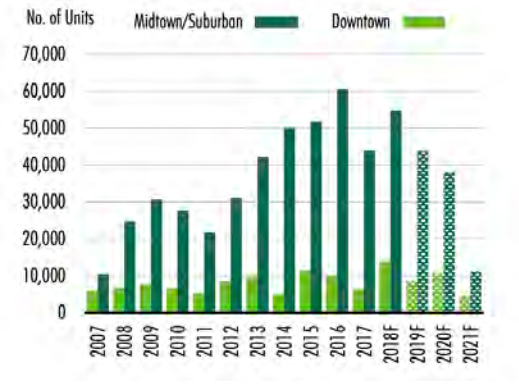
In the Bang Sue area, as described earlier, land prices are expected to soar due to the development of the public transportation system. However, in the area with a 5-minute walk range from a

station in Bangkok especially, property values are said to be high and condominiums far away from a station provide residents with their own transportation services (such as Tuktuk) to the station. Therefore, in order to raise property values more, it is indispensable to "improve accessibility to the station."

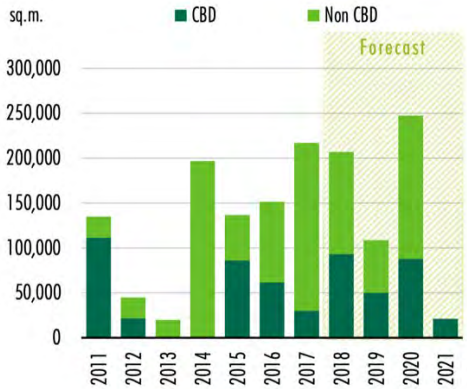
As the project area in Bang Sue is vast, the existence of Grand Station itself does not necessarily ensure accessibility. It is indispensable to secure smooth accessibility to the station and boost mobility for the entire area to enhance property values.

2.4.2 Development Projects in Bangkok

Real estate development in Bangkok has been accelerated since around 2010. As show in Figure 2.38, unit number of newly completed condominiums in Bangkok has increased since 2013 (left), and floor space of new office supply has increased since 2014 (right). However, new development of condominium units seems to be stipulated after marking its peak in 2016.



Newly completed Bangkok condominiums
Source: Bangkok Overall Property Market, Q3 2018, CBRE



New office supply by area
Source: 2018 Asia Pacific Real Estate Market Outlook Bangkok, CBRE

Figure 2.38 Evolution of new condominium/office supply in Bangkok

Table 2.12 New office supply at Bangkok from 2017 to 2024

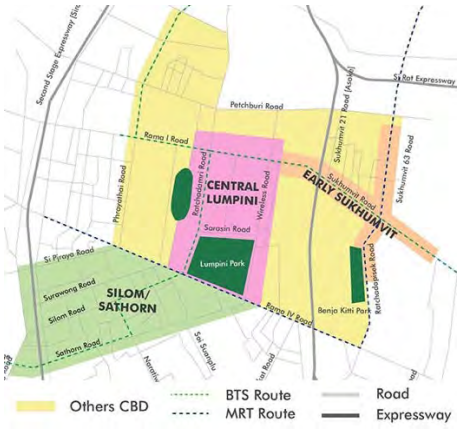
Year	location	No of buildings	Total of net rentable area (sqm)
2017	CBD	1	30,000
	Non-CBD	8	199,000
	Total	9	229,000
2018	CBD	3	88,500
	Non-CBD	5	83,400
	Total	8	171,900
2019	CBD	1	45,000
	Non-CBD	2	40,000
	Total	3	85,000
2020-24	CBD	11	891,439
	Non-CBD	5	252,110
	Total	16	1,143,549

Source: Compiled by JICA Study Team from "Thailand Industry Focus Property, Funds, REITs, and IFFs" by DBS Group Research, April 2018

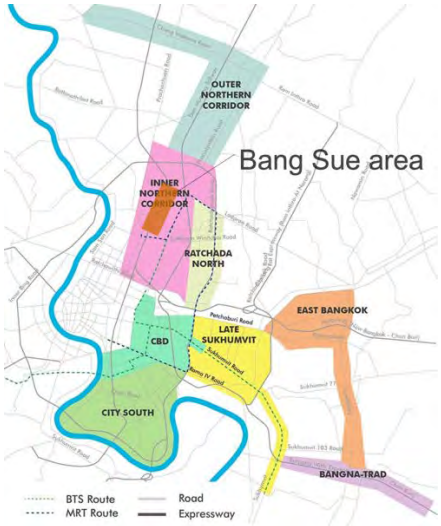
Table 2.12 indicates new office supply (number of buildings and total net rentable area) at Bangkok from 2017 and 2024. Around 200,000 square meters' office space was provided in both of 2017 and 2018. The figure will decrease to less than 100,000 square meters in 2019 but new

office supply will amount to 1.1 million square meters during the period from 2020 to 2024. In addition, 73% of the new office supply will be at CBD area and only one project, One Bangkok which will be developed at the center of the CBD will provide 500,000 square meters of office space during the period from 2021 and 2024. Therefore, "Thai banks are being conservative about new project lending to developers and so Thai developers are seeking funding from foreign partners," according to CBRE[3]. Major foreign partners are Japan, Hong Kong, Singapore and China.

Figure 2.39 shows CDB and non-CDB areas of Bangkok. The CDB area seems to expand to the east direction, and a part of "Late Sukhumvit" (around Soi Thong Lo) could say a part of the CBD, and recent housing development is expanding along Airport Rail Link (individual houses) and MRT Purple Line (Condominiums). Pahonyothin Transport Center (Bang Sue Area) is a part of the "Inner Northern Corridor". The Pahonyothin Transport Center would be a junction among SRT (Red Lines and High-Speed Railways, MRT, BTS and inter-city bus station but it is about 10 kilometers away from Bangkok's CBD.



Bangkok CBD area (defined as the area incorporating Silom, Sathorn, Rama IV Road, Ploenchit, Wireless Road, Asoke, and the early Sukhumvit area (Sukhumvit Road up to Soi 24).)



Non-CBD area (Late Sukhumvit, City South, Ratchada North, Inner Northern Corridor, Outer Northern Corridor, East Bangkok and Bangna-Trad)

Source: CBRE (Thailand) website (https://www.cbre.co.th/en/SubServices/bangkokofficerentlease)

Figure 2.39 CDB and Non-CBD areas of Bangkok

Currently, several large-scale real estate developments by private companies are planned or are under construction in Bangkok and the nearby areas. Six examples of large-scale projects including the Pahonyothin Transport Center are explained Table 2.1.

[3] P.4 2018 Asia Pacific Real Estate market Outlook Bangkok, CBRE, 2018.

Table 2.13 Large Scale Projects in Bangkok

Name of project	One Bangkok 	The Grand Rama 9 	Iconsiam 
Location	CBD (near Lumpini Park)	MRT Rama 9 station	Chaoren Nakhon Road, Khlong Ton Sai
Year of project completion	2025	n/a	2018
Commencement of the project	2018	2015	-
Completion of Phase 1	2022	2016	-
Development body	SPC (Kasemsubvadhana)	G-Land (Central Group)	SPC
Composition of the development body	TCC Asset 80.1%, Frasers19.1%	-	Siam Piwat 50%, CP 25%, MQDC 25%
Land area (ha; rai)	16.7 (104)	11.7 (73)	8.8 (55)
Gross floor area (sqm)	1.83 million	1.2 million	750,000
Green area (ha; rai))	8 (50)	-	-
Arrangement of land	Leasehold	Own land	Own land
Land owner	Crown Property Bureau	G-Land	SPC
Total investment amount and financing	THB 120 billion The source of funds for the group's investment will be partly from its own cash flow. It may also raise funds from the capital market by issuing debentures, establish a real estate investment trust or borrow from commercial banks.	THB 60 billion 60% Bank Loan and 40% company's revenue from other projects	THB 50 billion Own fund and loan from commercial banks (Kasikorn Bank and Thanachart Bank)
Land use	Red Zone* (commercial land: Type 3 or Type 5)	Orange Zone (Residential zone with high density: Type 9)	Orange Zone (Residential zone with high density: Type 8)
Floor area ratio	Type 3 FAR 7:1, Type 5 FAR 10:1	FAR 7:1	FAR 6:1
Sublease scheme of land	- Kasemsubwattana (under TCC Group) lent land from CPB - Kasemsubwattana leases out to the SPC. SPC sub-lease to zone developers. - One Bangkok Holdings will manage the project after completion of the construction works.	-	-
Leasing period	30 years (option of 30 years-extension) Grace Period for construction and development: 9 years	-	-
Office	Applicable: five A ranked office tower	Applicable	Applicable
Hotel	Applicable: 5-star hotel	Applicable	Not applicable
Residence	Applicable: three Luxury condominium	Applicable	Applicable
Commercial facilities	Applicable: 4 zones shopping areas	Not applicable	Applicable
Others	- Art & Culture Space - 1ha of public plaza in the green area to organize events	-	Art&Culture space
Remarks	- Hitachi Consulting (Thailand) was selected to be in charge of designing and planning of smart service in ONE Bangkok - Plans to install regional cooling/heating. - Main contractors for construction are SEAFCO and Thai Bauer.	- G-Land also raised funds by issuing corporate bonds (around 4,000 mil THB). - GLAND had planned to build the Super Tower, the Asian tallest tower with 615-meter height, 125 floors. However, the building plan was postponed after Central Pattana takeover GLAND.	- Developing a giant composite facility with shopping malls, recreational facilities, conference halls, tourist attractions (museums etc.), and cultural facilities on Charoen Nakhon Road (along Chao Phraya river) - Japanese companies built the facilities, and a Japanese department store operates commercial business as a tenant. - Plans to invest 3.8 billion THB to construct the Gold line in order to secure connections with BTS Krung Thon Buri Station

Note: *According to the city plan map from Department of Public Works and Town & Country Planning, it is quite hard to identify whether the area of One Bangkok is located in the land for commercial use type 3 or type 5 which will affect the rate of FAR.
Source: Compiled by JICA Study Team

Table 2.14 Large-scale Projects in Bangkok (2)

Name of project	PARQ 	Samyan Mitrtown 	Pahonyothin Transport Center 
Location	CBD (MRT Queen Sirikit National Convention Centre Station)	CBD (MRT Sam Yan Station)	SRT & MRT Sang Sue Station; BTS
Year of project completion	2023	End of 2019	2032
Commencement of the project	2017	2016	2017
Completion of Phase 1	2020	-	2019
Development body	TCC Asset and Frasers Property	Golden Land	-
Composition of the development body	-	Kasemsubbhakdi: Golden Land (49%) and TCC (51%)	-
Land area (ha; rai)	3.8 (24)	2.1 (13)	232.5 (1,453.1) Zone A: 5.1 (32)
Gross floor area (sqm)	320,000	220,000	n/a
Green area (ha; rai))	7000 sqm. (Sky Park 3,400)	n/a	n/a
Arrangement of land	Leasehold	Leasehold	Leasehold
Land owner	Crown Property Bureau	Chulalongkorn University	SRT
Total investment amount and financing	THB20 billion	THB8.5billion	-
Land use	Red Zone (commercial land: type 3)	Red Zone (commercial land: Type 5)	Red Zone (commercial land: Type 8)
Floor area ratio	FAR 7:1	FAR 10:1	Zone A: FAR 8:1
Sublease scheme of land	-	PPP scheme	Bidding by zones; The process for Zone A will start January 2019
Leasing period	30 years (option of 30-year extension)	30 years (option of 4-year extension) under PPP scheme	30 years (waiting for TOR of Zone A that will indicate extension period)
Office	Applicable; 2 office towers; 2,300-5,000 each floor/ 13 floors; total 60,000 sqm.	Applicable; 35 floors, GFA: 65,000 sqm.	Applicable
Hotel	Not applicable	Not applicable	Applicable
Residence	Not applicable	Applicable; 35 floors; 36,000 sqm.; Condominium 554 rooms + SA 104 rooms	Applicable
Commercial facilities	Applicable; 12,000 sqm (1-3rd floor)	6 floors, GFA: 65,000 sqm.	Applicable
Others	Not applicable	Applicable: Learning Center	Applicable
Remarks	- A Japanese construction company is the main contractor for this project.	- CBRE is the main realtors who is in charge of office rental space. - Anchor tenant in retail podium is Big C. - Planning to employ AI system to integrate the facilities within office tower. - MBK also extended their land leasing contract with Chula to another 20 years and paid around 20 billion THB (To extend the contract, the extension needed to be approved by Cabinet.).	

Source: Compiled by JICA Study Team

From interviews with four Japanese/Japanese-affiliated companies which are joint ventures with Thai companies, the following opinions are collected on the real estate development in Bangkok as of May 2019. Note that the opinions below are the ones that were commonly raised.

- Demand on residence is shifting from speculative purpose to real demand. For example, demand on individual houses is strong demand in Eastern Bangkok area including the area along Airport Rail Link, and demand on condominiums is strong areas near stations of MRT Purple line.
- In general, demand on offices are still strong in Bangkok. In terms of minimizing risks, mixed-development is the most favorable one.
- Location of Bang Sue area is good in particular for Thai people.
- It is rare for Thai companies in doing the same business to form a joint venture for real estate development. Large-scale real estate development conducted by a joint venture which is observed in Japan is not observed in Thailand.
- Due to limitation of investment portion of foreign companies, forming a joint venture within Japanese companies would not occur.
- With a fixed lease period of 30 years, it is difficult to make a condominium for sale or for a detached house (because the right to use land after 30 years is unclear). Residence lease could be possible if the land's lease period extends to 50 years.

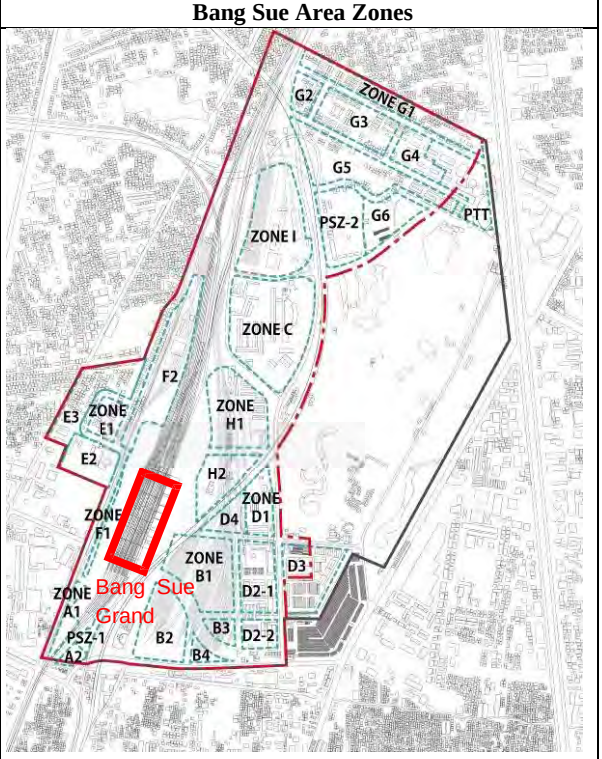
2.5 Current Situation of the Bang Sue Area

2.5.1 Land Use

Zoning plan and functions that was set in the previous JICA Study is shown below.

Zone		Urban Functions to be Assigned
Zone A	1	Office/ commercial/ hotel
	2	Commercial
Zone B	1,2	Residential, commercial, office
	3,4	Commercial
Zone C		Super arena or MICE facilities of the same kind
Zone D	1	Hotel/ residential/ office/hospital (high-end constructions in expectation of the increase of foreign guests)
	2	Residential/ commercial/ hotel/ office
	3	Residential/ commercial/ hotel/
	4	Residential/ office
Zone E (SRT Land)	1,2	Office/ commercial (including a high- rise which will be one of the main landmarks of Bang Sue Area, Knowledge center and incubation office space) Civic center (future headquarters of MOT)/ residential
	3	Residential
Zone F	1	Commercial (retail shops to be constructed under skydecks around Bang Sue Grand Station)
	2	Office /commercial (including amusement facility) /residential/ hotel
Zone G (KM 11)		High-end residential (garden city with abundant greenery space)/ commercial/ office/ hospital/ school
Zone H	1	Office/commercial/residential
	2	Office/commercial/residential/hotel
Zone I		Residential (high-rise condominiums)/ commercial

Bang Sue Area Zones



Source: JICA "Data Collection Survey on Urban Redevelopment in Bang Sue Area"

Figure 2.40 Zoning plan and functions for Bang Sue Area

Although Bang Sue Area development is widely regarded as a green field project on a large piece of land, currently there are some existing facilities and ongoing construction projects in the area. These should be monitored and taken into consideration, as they may potentially influence the development plan and its implementation. The Study Team has thus reviewed the current situation regarding usage of the land in the Bang Sue Area.

■ Zone A

Temporary huts

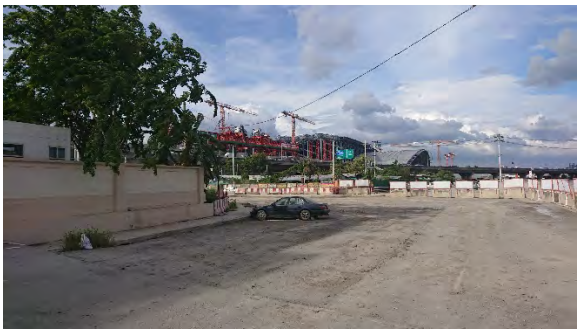
Zone A is adjacent to the elevated railroad

Zone A, located at the corner of the area boundary on the south side of Grand Station, will be the first zone to be developed in Bang Sue Area. The development of the zone will synchronize with the development of Grand Station which is planned to open in 2021. Divided by the elevated railroad which is under construction, Zone A is a relatively small and fragmented zone.

Zone A is planned to have a commercial facility, hotel, and office buildings, so as to meet the needs of users of Grand Station when it is opened. The tendering process was initiated in April 2019.

■ Zone B

Depot for railway vehicle is under construction



Zone B is located in front of Grand Station

Zone B, located in front of Grand Station, will be one of the last pieces of land to be developed in the Area. The zone, according to the master plan, will be developed in the third phase which is scheduled from 2028 to 2032.

Zone B is planned to be developed as mixed use land with residential, commercial, and office facilities. Due to the zone's strategic location and its land size, it is expected to be the key piece for the Bang Sue Area. Currently, the land is largely occupied by the railway depot which is still under construction.

■ Zone C

Mo Chit Bus terminal is one of the largest in Bangkok

The long distance buses mainly go north-ward and north-east-ward

Zone C, located in the center of the area, will be developed in the second phase which is scheduled from 2023 to 2027. The zone, according to the master plan, will accommodate an arena, or a MICE facility.

Currently, Zone C is used as a bus terminal operated by Transport Company Limited. The bus terminal serves as a hub for long distance buses going north and north-east as well as middle distance van-type buses. With more than 130 berths, respectively, for long distance and middle distance buses, the terminal is one of the largest in Bangkok.

■ Zone D

JJ outlet mall is a well-known market in the area

Low rise buildings currently occupy the land

Zone D, a long slice of land along Kamphaeng Phet 2 Road, will be developed step by step through the first phase to the third phase. The zone, according to the master plan, will be developed as a mixed use land with hotel, commercial, residential, office, and hospital functions.

Currently, the land is occupied by a commercial facility and low-rise shops. It is worth noting that JJ Outlet shopping mall, locally well known as a place where people can buy affordable daily products, is also located in the zone. The land is leased from SRT to the business owners but the status of the land in this zone is somewhat complicated due to land lease contracts each ending at a different timing, with one contracted until 2032. Also, some of the lease contracts are currently being negotiated, or a lawsuit is in process.

■ Zone E


Low-rise and dense residential area


Low-rise and dense residential area

Zone E, located at the back of Grand Station, will mostly be developed in the first phase by 2022, while the remaining portion will be completed in the second phase by 2027. Zone E, according to the master plan, will be developed for office, residential, and commercial facilities.

It is currently occupied by small low-rise houses. The streets are narrow in this densely built-up area. The zone is said to be home to the residences of relatives of SRT employees.

■ Zone F


Space behind Grand Station (Zone F-1)


Space behind Grand Station (Zone F-2)

Zone F, a thin slice of land between Grand Station and the existing railway station, according to the master plan will be developed throughout the first phase (Zone F-1) and the second phase (Zone F-2). Zone F-1 will be developed as a commercial zone with retail shops using the space under the skywalk, whereas Zone F-2 will be developed as an office, commercial, residential, and hotel area.

Currently, there is a railway station with tracks that are in operation.

■ KM 11 (Zone G)


Low –rise small shops and residences


Low –rise small shops and residences

KM 11 Zone (Zone G), located at the north end of the boundary, will be developed as a mixed

use area with offices, hospital, school, and high-end residences. According to the master plan, the area will be developed in the second phase, scheduled until 2027.

Currently, the zone is occupied by small low-rise houses, and the zone is a densely built-up area. Adjacent to KM 11, there is an area where the Ministry of Energy, PTT, the Energy Complex (ENCO) building is located. Several advanced energy-saving technologies are introduced in the area, such as district cooling, PV, and BAS (Building Automation System). These initiatives are highly compatible with Smart City concept that is pursued in Bang Sue. Therefore, the area may function as a satellite hub, or a backup center for energy management.

- Zone H

There are some small buildings on the land

Zone H occupies vast area between the Grand Station and Chatuchak Park

Zone H, located in the center of Bang Sue Area in front of Grand Station, will be developed as a mixed use area with office, residential, commercial and hotel facilities. According to the master plan, the zone will be developed in the third phase which is scheduled until 2032.

The construction office for the Red Line and Bang Sue Grand Station currently occupies the zone.

- Zone I

There are some existing facilities on the land

Construction machines for the railway at Zone I

Zone I will be developed as a high-rise residential area. According to the master plan, the area will be developed in the third phase, scheduled until 2032.

Currently there are some existing facilities and equipment in Zone I, mainly related to ongoing construction of the railway.

Figure 2.41 Current land use in Bang Sue Area

Source: Compiled by JICA Study Team

2.5.2 Infrastructure

Along with the land use, the conditions regarding the infrastructure and facilities around the area should also be taken into account so as to efficiently and effectively realize the Smart City development in Bang Sue Area. The Study Team has thus reviewed the current situation regarding usage of the land in Bang Sue Area.

- Bang Sue Station (SRT)

Located around 8 km north of Hua Lamphong, the terminal station for the SRT railway line, the current Bang Sue SRT Station is a way station for trains connecting Bangkok and destinations in the northern region. The station platforms and the tracks will be transferred to Grand Station which is currently under construction.

- Bang Sue Station (MRT)

Bang Sue MRT Station is an underground station, the roadside exit of which is located on the west side of Grand Station. The MRT Station will be connected directly to Grand Station when construction is completed via an underground passage.

- Chatuchak Park Station (MRT)/ Mo Chit Station (BTS)

Chatuchak Park MRT Station is an underground station, the roadside exit of which is located on Phahon Yothin Road. Mo Chit Station is the last station for the BTS Skytrain, the station platform of which is an elevated structure over Phahon Yothin Road. On the east side of the station, there is a large flat parking area.

- Sirat Expressway

Sirat Expressway is a dedicated motorway that runs in the longitudinal direction over Bang Sue Area on an elevated structure. According to SRT, there is a plan for off-ramp and on-ramp development in the area for access to the expressway.

- Kamphaeng Phet 2 Road

Kamphaeng Phet 2 Road also runs across Bang Sue Area with some sections of the road running under Sirat Expressway. Since the bus terminal is located in the zone designated as Zone C, long distance buses and vans run along the road. The traffic volume of the road is relatively high.

- Flyover/ Access road

A flyover and access road connecting Zone C to Grand Station are currently being constructed by SRT. Another access road connecting Zone H and Grand Station is also planned to be developed.

- Business district for energy-related industry

Adjacent to KM 11 Zone, there is a small business district for energy-related industries where the PTT head office, Energy Complex building and Ministry of Energy are located.

- Gas pipeline

The existence of a gas pipeline is a unique attribute of the area. The gas pipeline extends along the Red Line which is under construction.

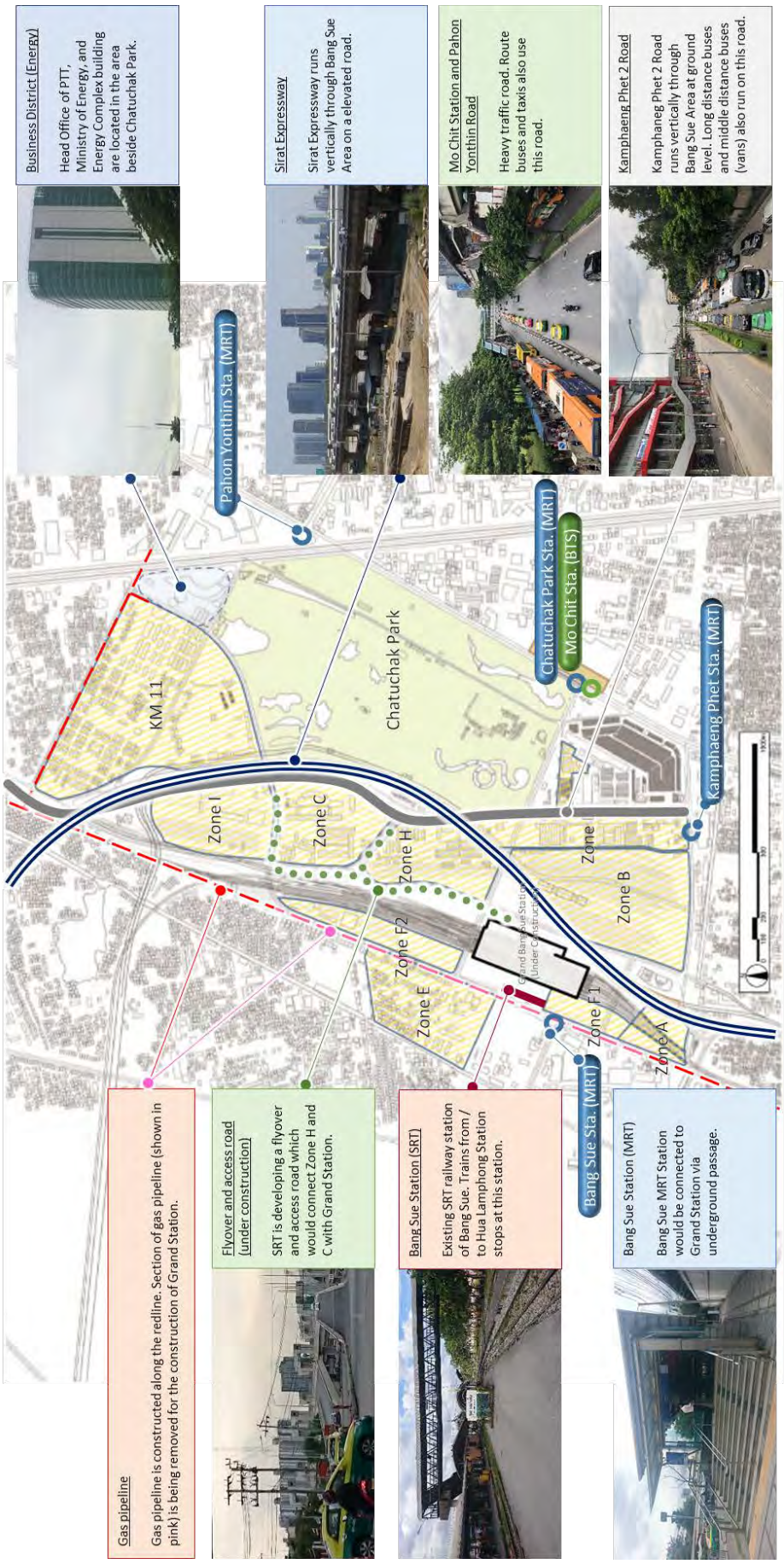


Figure 2.42 Current infrastructure and facilities in Bang Sue Area

Source: Compiled by JICA Study Team

2.5.3 Existing and Ongoing Facilities and Projects

(1) Bang Sue Grand Station

Construction for the development of Bang Sue Grand Station is currently being implemented with completion planned in 2020. The station will cover 300,000 m² in the center of the designated area, with the total construction cost estimated at around 16 billion Thai Baht.

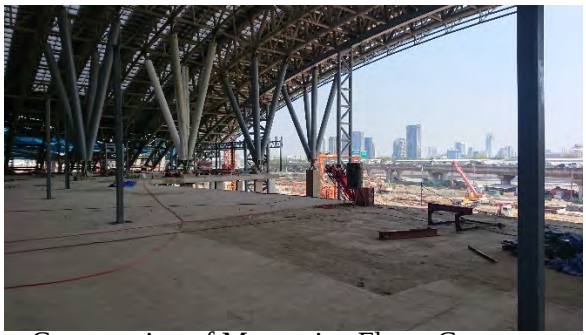
Grand Station shall be a four-storied structure. The ground floor shall be the concourse and the ticketing area, while also accommodating retail shops. The second floor shall accommodate the platforms for commuter trains and inter-city trains. There will be a mezzanine floor as a concourse and retail space. The third floor will accommodate the proposed high-speed railway and the three-airport rail link. The underground space will be used as a parking lot, while there will be an underground passageway connecting to Bang Sue MRT station.


Façade of the Grand Station


Construction at the station facade


Construction of First Floor : Concourse and retail space


Construction of Second Floor : Inter-city and commuter train platform


Construction of Mezzanine Floor: Concourse and retail space


Construction of Third Floor: High Speed Railway and Airport Link

(2) Red Line Project

It has been reported that SRT is indebted for about 100 billion THB (338 billion JPY) and has been requested by the State Enterprise Policy Office (SEPO) of the Ministry of Finance to formulate and execute a restructuring plan. It is expected that SRT will have a certain amount of returns from the development of Bang Sue area. Therefore, it is necessary to examine the financial status and capability of the SRT when considering the project implementation structure and finance scheme for the Bang Sue development project.

It should also be noted that the Red Line, which is planned to start operating in 2021, may have some delay in its completion, and thus attention must be paid when considering short-term project plans.

(3) Other railway projects

As stated above, currently, BTS Sukhumvit line and MRT Blue line is in operation. The Red Line is to be opened by 2021 and would be extended in sequence. The Airport Link line is targeted to be opened by 2023, while the High Speed Rail is currently being planned.

(4) Road construction projects around Bang Sue Area (Ramp and U-turn road)

Construction of ramps are planned around Bang Sue Area for connection to Sirat Expressway that runs over the area.

Source: Material provided by SRT

Figure 2.43 Plan of ramps and U-turn road around Bang Sue Area

In addition, elevated roads which enable access to Sirat Expressway from the Grand Station, and a U-turn road which enable access to the expressway.

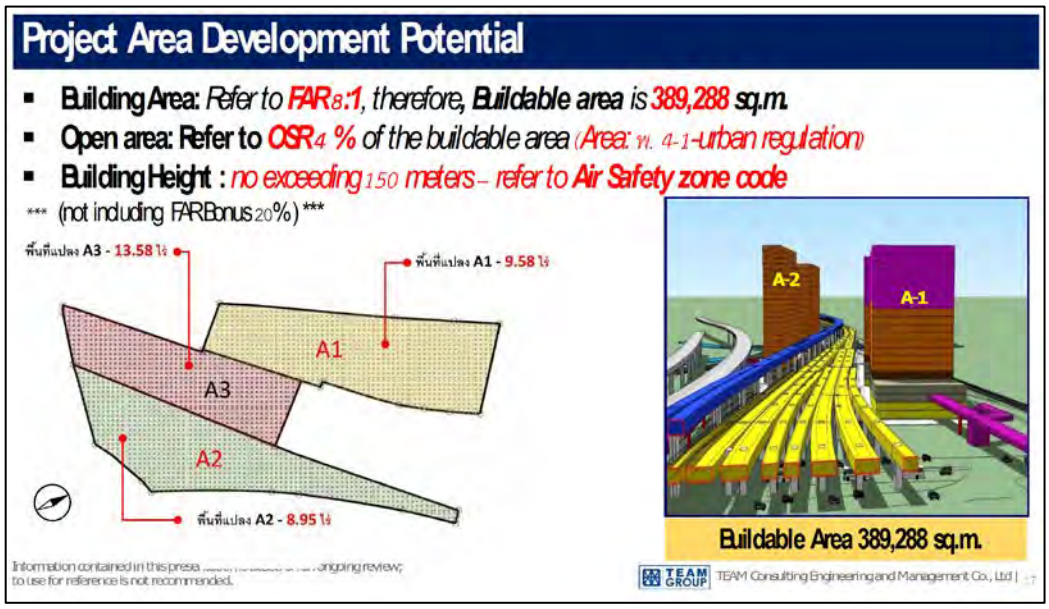
Source: Material provided by SRT

Figure 2.44 Plan of ramps and U-turn road to access Sirat Expressway

(5) Zone A Development

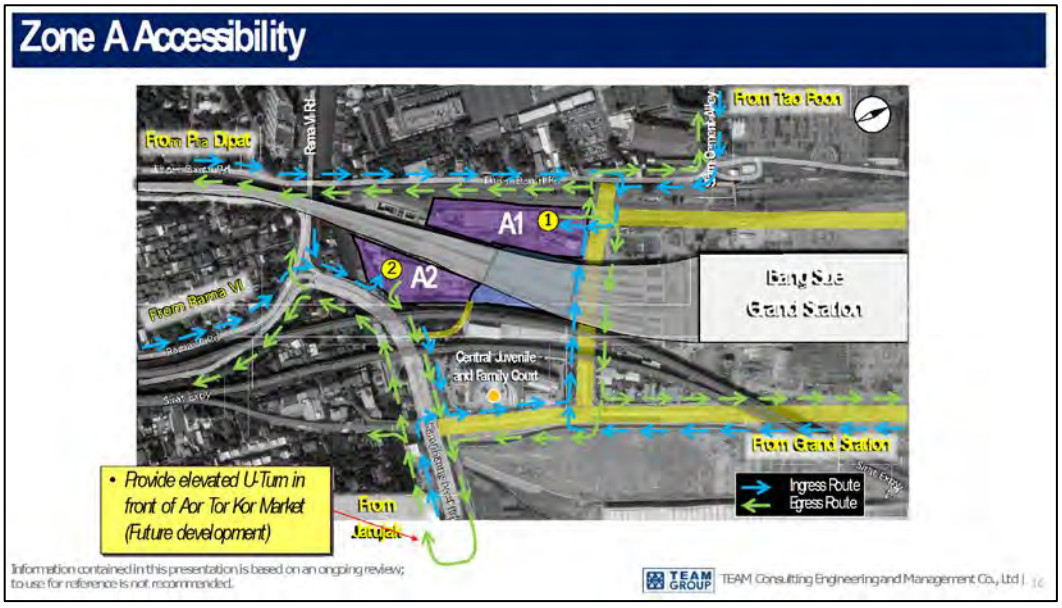
■ General information on Zone A development

Zone A covers 32 rai (5.1 ha) for a Smart Business Complex. The zone will be the first zone to be tendered. The development of Zone A will precede the development of other zones so its completion will coincide with the opening of Bang Sue Grand Station and the Red Line. Zone A is planned to have a commercial facility, hotel, and office buildings, the functions required to meet the needs of users of Grand Station when it is opened.



Source: Market Sounding Land Development Project for Commercial Area Development at PahonyothinTransport Center, Zone A Wednesday 17, October 2018

Figure 2.45 Zone A Project Area



Source:Market Sounding Land Development Project for Commercial Area Development at Pahonyothin Transport Center, Zone A Wednesday 17, October 2018

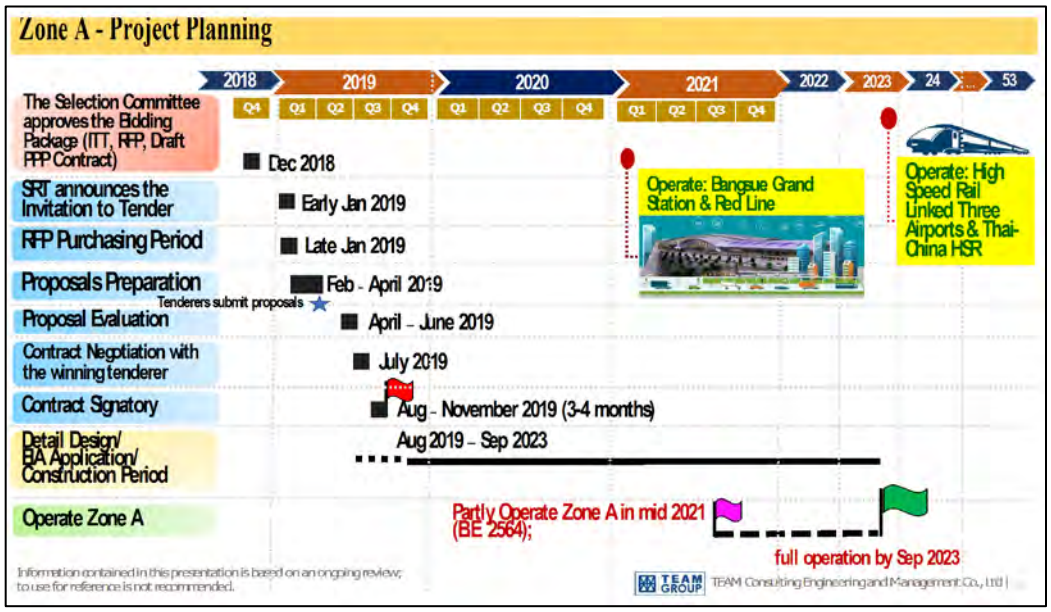
Figure 2.46 Zone A Accessibility

- Recent Activities regarding the Zone A tender

The first market sounding was conducted on October 17th 2018, when SRT revealed the outline of the background of the project, the scope and physical characteristics of Zone A, the project development concept, the commercial development potential of Zone A, the model for private partnership, the allocation of duties and responsibilities, and the project implementation plan.

The second market sounding was conducted in mid-December 2018, and interviews were held with individual investors and business operators.

It is reported that the TOR document that was published in April 2019 has been bought by several companies including major Thai developer.



Source:Market Sounding Land Development Project for Commercial Area Development at Pahonyothin Transport Center, Zone A Wednesday 17, October 2018

Figure 2.47 Project Schedule of Zone A Development

The general terms for the tender for Zone A are as follows:

- The project comes under the "DBFOT (Design, Build, Finance, Operate, and Transfer)" PPP scheme, and SRT shall provide the land only.
- The construction period is 4 years, and the design concept shall follow the TOD Principles. The zone would have function of retail shopping area, hotels, and office tower.
- The concession period is 30 years and investors have to pay a rental fee and share revenue with SRT.
- Investors shall transfer buildings and project assets in good working order after the concession period by technological transfer (management).

(6) Zone E Development

■ Outline of Zone E Development

Zone E, also known as the "Red Building Area" in the zonal development plan, will be developed on a land of 120 rai (19.2 ha) just to the west of Bang Sue Central Station. It is to have multiple functions where office facilities such as the SRT headquarters and homes will be built in the lush atmosphere with pedestrian decks and open spaces.

The site plan of Zone E is shown in figure below.

Source: Pahon Yothin Zone E Market Sounding material

Figure 2.48 Site Plan of Zone E

An office tower is planned to be built in Zone E-A, the 20.4 rai (3.3 ha) section within Zone E denoted as A1~A3 in the figure. Meanwhile, SRT's headquarters is to be built in Zone E-S, the 15.6 rai (2.5 ha) section denoted as S, and shall become a building that embodies energy saving as a building representing the area. Zone E-B, the 55.8 rai (8.9 ha) section denoted as B1~B3, will be developed as a residential area with green open spaces and small commercial facilities. In Zone E-C, the 28.2 rai (4.5 ha) section denoted as C1~C4, there will be housing built for SRT staff.

Source: Pahon Yothin Zone E Market Sounding material
Upper Left: Sky walk and walkways, Upper Right: Bicycles/Busses, Lower Left: Bus Routes, Lower Right: Vehicle Roads flow

Figure 2.49 Traffic Line Planning Within/Around Zone E

The traffic line planning within and around Zone E is shown in Figure 2.49. Buses have been proposed as a public transportation to connect the inner and outer area of the section while the Skywalk and Bicycle paths are being planned as a means to travel within the zone.

(7) Zone D1 Development

Preceding the other block of Zone D, the Department of Medical Services under the Ministry of Public Health is planning to build a Medical Complex in Zone D1 based on a PPP system. A memorandum of understanding has been signed between the Ministry of health and the SRT regarding the project.

Detailed plans for the Medical Complex are yet to be decided. The facility is expected, however, to have around 510 beds installed, serve about 2500 outpatients per day, and function would include: an intensive care unit; operating theater; and a treatment room for patients with acute diseases.

Source (Left):"DMS Medical Complex" Concept Paper (From OTP), (Right): Complied by the Study Team
Left: The Functions of the Medical Complex, Right: The Location of Zone D1

Figure 2.50 Plans for the Medical Complex in Zone D1

2.5.4 Organizational Change

(1) Establishment of SRT Asset Management Company

While SRT has an accumulated debt of over 100 billion THB (as of 2015), it owns about 6,300 ha of land which is not used in the railway business. When converted with the rate of 4700THB/m^2, the land value exceeds 300 billion THB. Nevertheless, the land is not appropriately managed by SRT, making only about 240 million THB per year from the land. Due to such circumstances, SRT has decided to establish an asset management company with a 100% SRT subsidiary, in order make more effective use of these lands to increase profits. The income from effectively using such assets is expected to help eliminate the accumulated debt of the SRT.

The main business activities are as follows:

- Management of lease contracts for the lands owned by the SRT
- Allocation and negotiation of development areas
- Land development business (Lease/purchase land from the SRT and conduct land development businesses)

The scheme is approved by the Superboard of the Thai government, and the asset management company is officially underway.

(2) Plans for Smart city development by the PTT/SRT

PTT has made contributions such as conducting their own surveys in their efforts to realize a smart city in Bang Sue. In November 2018, a memorandum of understanding has been signed between SRT and PTT towards the cooperation for realizing a smart city in the Bang Sue area.

Thereafter, PTT, EGAT, MEA, and SRT have been examining the energy service businesses in the Bang Sue area, and are planning to examine the provision of other infrastructure services and business models. A joint action plan, including plans such as the establishment of new entities, is expected to be formulated by 2019.

(3) Absence of a Steering Body to Promote the Bang Sue Smart City Development

The development of the smart city in Bang Sue will be led by Ministry of Transport, with Office of Transport and Traffic Policy and Planning (OTP) as the department in charge.

On the other hand, coordination between the relevant ministries and agencies is necessary in order to realize the smart city development. As of June 2019, however, a steering body to bring relevant agencies together has yet to be established.

Taking the case of Japan for example, committees have played an important role in bringing relevant agencies together, formulating basic policies, and facilitating coordination amongst related organizations, in promoting such large-scale redevelopment and smart city development.

Similarly, the coordination among the many related organizations is essential in the Bang Sue area development as well, in order to realize integrated development/smart city development. An early establishment of such steering body is desirable.

(4) (Reference) Establishment of “Department of Railway Transport”

The management of rail transport in Thailand had been conducted by the Rail Project Development Office attached to the Office of Transport and Traffic Policy and Planning in the Ministry of Transport

As there had been no government agency that oversees the railway project, the Thai government decided to upgrade the Rail Project Development Office attached to the Office of Transport and Traffic Policy and Planning in the Ministry of Transport to the extent that it is established as the Department of Rail Transport within the Ministry of Transport, so that management of rail transport is more efficient.

All businesses, property, budgets, rights, debts, obligations, civil servants, staff, employees, and manpower of the Office of Transport and Traffic Policy and Planning in the Ministry of Transport shall be transferred to the Department of Rail Transport in the Ministry of Transport.

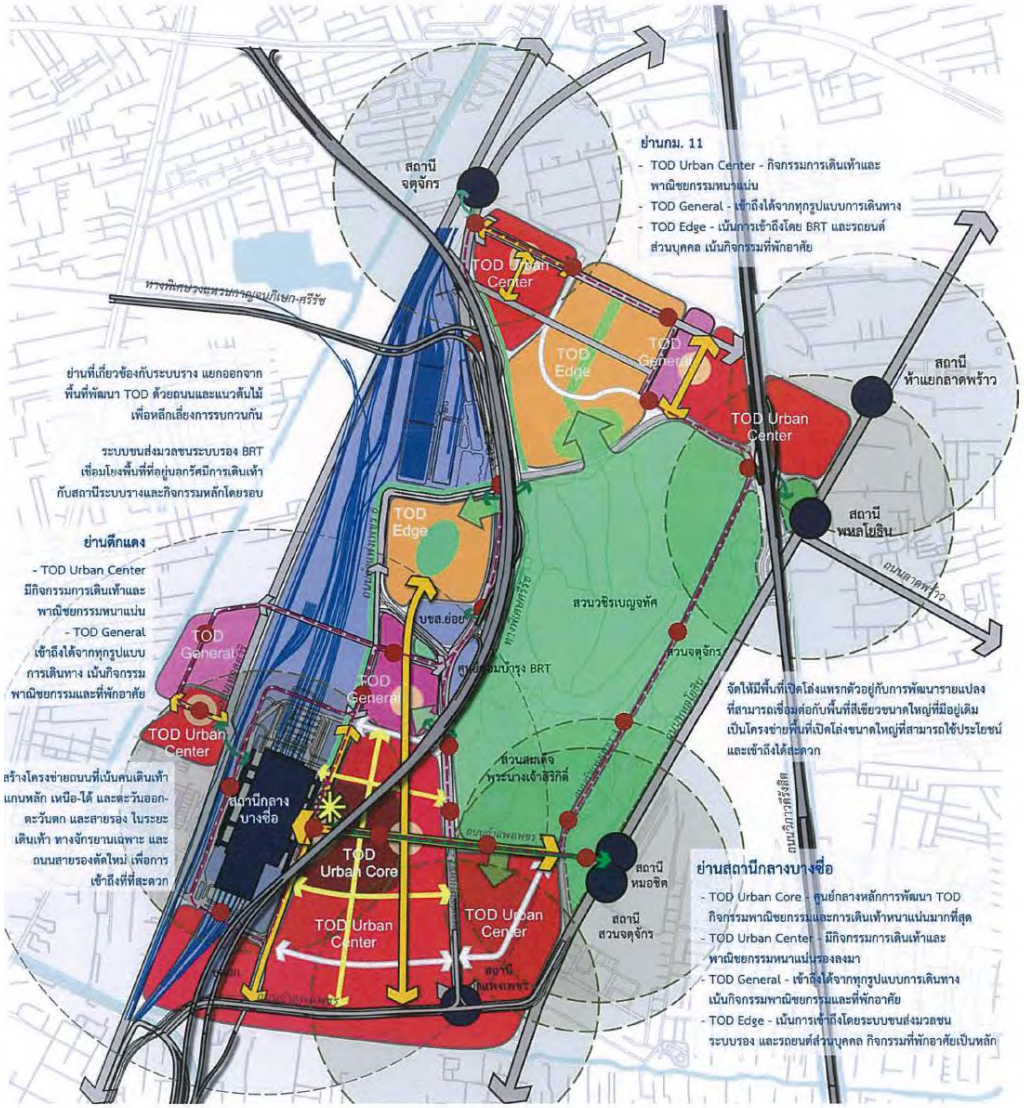
There will be no changes regarding the Bang Sue Project which comes under the Office of Transport and Traffic Policy and Planning in the Ministry of Transport. However, railway projects such as the Red Line Project will come under the Department of Railway Transport. When considering the Bang Sue Project, coordination with the Department of Railway Transport might be needed for some of the issues.

2.6 Review of the Existing Master Plan and Relevant Studies

2.6.1 Development Plan by SRT and OTP

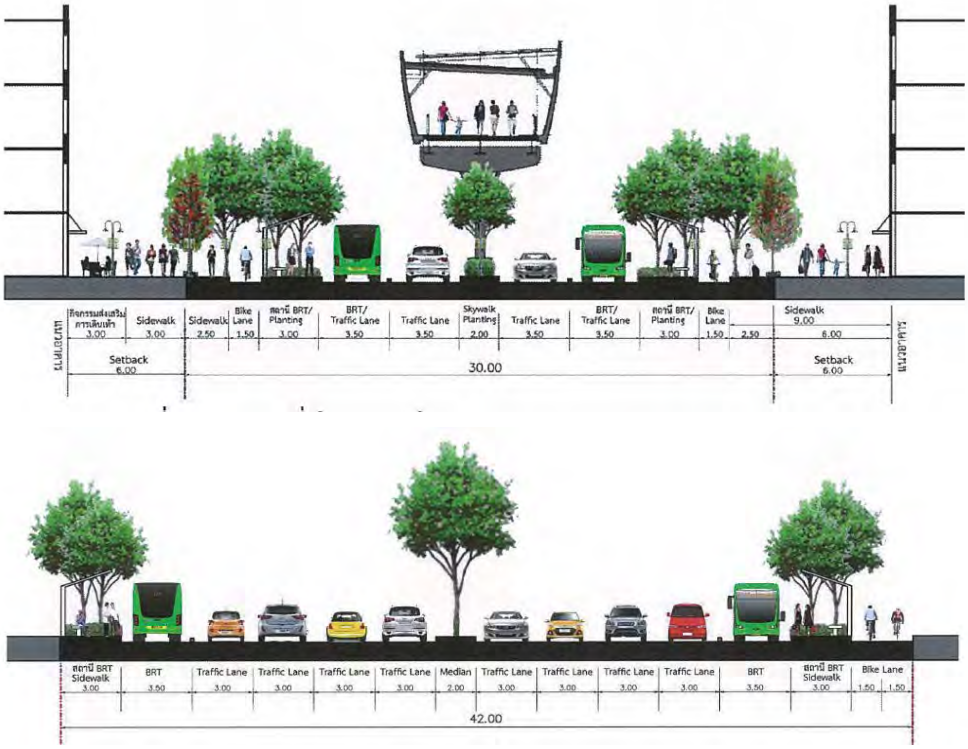
SRT and OTP implemented studies for the development plan of the Bang Sue Area in 2016. In the study by SRT, the development concept and direction were considered for Zones A, B, C and KM11 in order to realize the ASEAN HUB. The study proposed the concepts for each zone, such as Zone A as a Smart Business Complex; Zone B as the ASEAN Commercial and Business Hub; and Zone C as a Smart Healthy and Vibrant Town. Besides that, the financial plan for the development was also investigated on the basis of the concepts.

In the OTP study in 2016, the development plan for Zone D and the regional traffic plan based on the concept of TOD were compiled. Using the results of the traffic survey and demand forecast, the road development plan, pedestrian and cycling road plan and Bus Rapid Transit (BRT) plan were formulated.



Source: OTP (2016)

Figure 2.51 Regional development plan and BRT network by OTP study



Source: OTP (2016)

Figure 2.52 Sectional view of the road by OTP Study

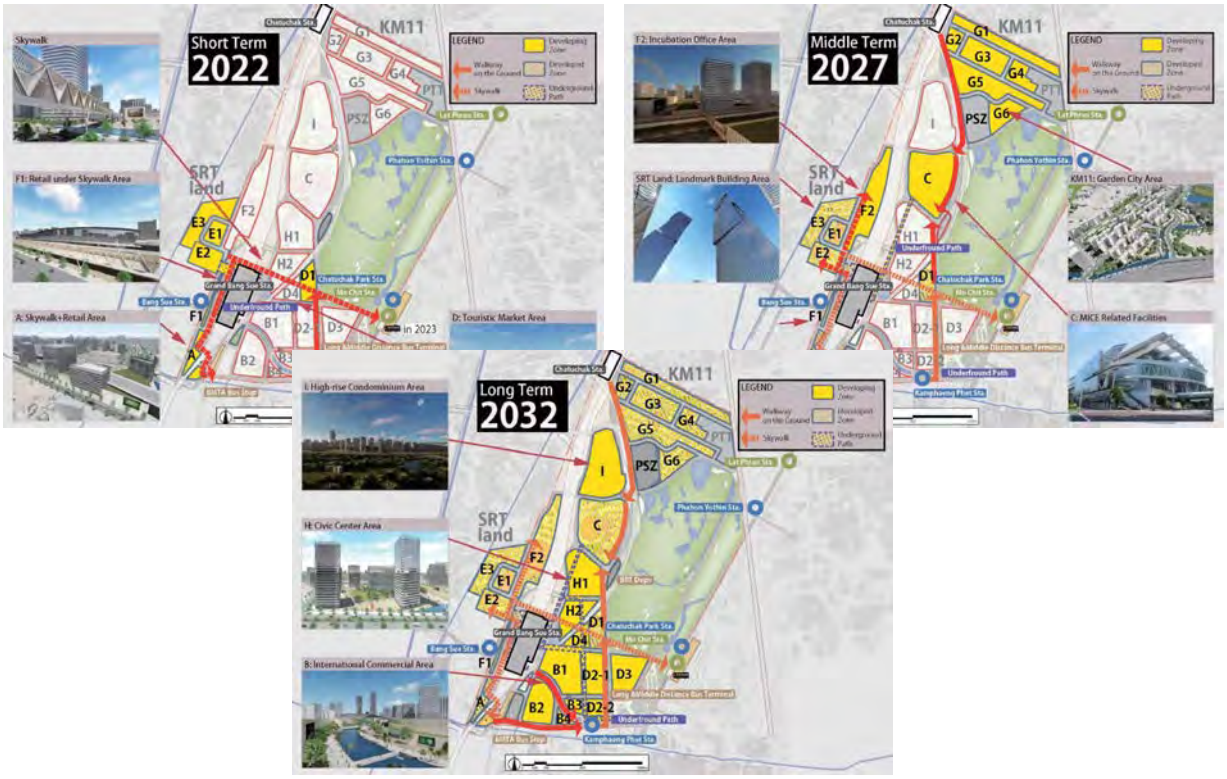
2.6.2 Urban Development Plan for Bang Sue Area

In the previous JICA study, 'Data collection survey on urban redevelopment in Bang Sue Area in the Kingdom of Thailand', the development concept and the development plan for the Bang Sue Area were formulated considering the results of these studies. The basic policies proposed for the Bang Sue Area development were summarized as follows: 1) to grow up to a centripetal urban core in Bangkok Metropolitan Area which plays important roles in the international community, 2) to create an eternally beloved new central district full of various attractiveness, 3) to create a visitor-friendly traffic terminal area comfortable for everyone. In addition, the future demand of railway passengers and properties based on the Bang Sue development plan was forecasted in the study. For example, the number of passengers using Bang Sue Grand Station was estimated at more than one million in 2032. In this study, two types of development scenarios were compared from different perspectives. Scenario 1 was 'Individual Development' and Scenario 2 was 'Integrated Development' as shown in Figure 2.53. In the result, Scenario 2 is recommended in terms of effectiveness and sustainability. Figure 2.54 shows the phased development plan for the Bang Sue Area that is proposed based on the scenario in the study.

Development Framework/ Investment Condition		Scenario 1: Individual Development	Scenario 2: Integrated Development
Development Framework	M/P Positioning	M/P approved by SRT Board	M/P approved by Cabinet, designated as special development district
	M/P Contents	Primarily private development of office/retail/ residential area, wherever feasible	Model case of TOD/Smart City with both public infrastructure and private development, orchestrated to maximize land value
	Implementation Structure	Implementation between SRT and Private	Implementation between Gov't. SRT and Private
	Coordination Process	Coordinate separately with each related agency	Establish "One Stop" window for accelerated coordination within special district
	Development Steps	Develop primarily based on availability of land	Step-wise development to maximize land value
Investment Condition	PPP Tender Process	Tender conditions and documents are developed top-down	Tender conditions and documents are developed interactively with inputs from private, so as to ensure bankability
	Leasehold Period	30 years	50 years（based on BMA special zone regulation）
	Government Support	Nothing specific	Tax incentives and longer grace period as part of special development district support
Expected Results		Usual private development. Profitability and economic effects are changed depending on developer's tendency.	Many bidders, A grade development, high profitability, significant economic benefit

Source: Data collection survey on urban redevelopment in Bang Sue Area in the Kingdom of Thailand, (2017). JICA

Figure 2.53 Comparison between Integrated Development and Individual Development



Source: Data collection survey on urban redevelopment in Bang Sue Area in the Kingdom of Thailand, (2017). JICA

Figure 2.54 Stepwise development plan

In terms of the smart city, several potential aspects and technologies related to a smart city were briefly argued in the study, namely the district cooling system and cogeneration, the energy management system by communication infrastructure and smart grid, energy infrastructure including common ducts, and smart transportation such as traffic information provision and

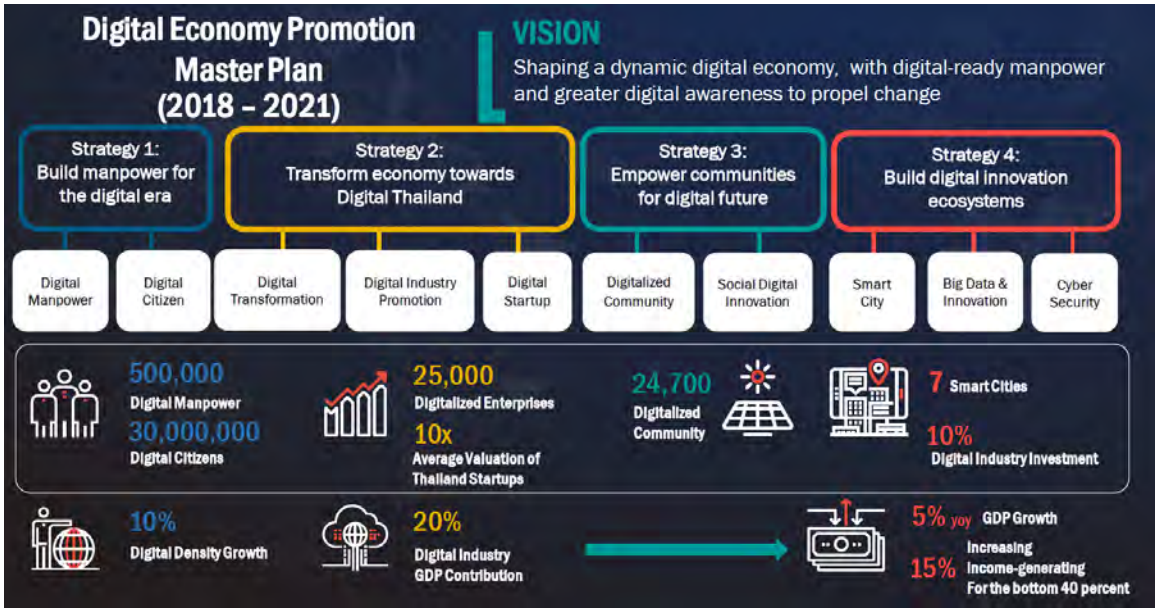
public transportation priority system (PTPS). However, the detailed concepts and implementation methodologies to make the Bang Sue Area into a smart city were not deeply explored in the study.

According to SRT, the plan was approved by the board committee of SRT and submitted to NESDC in 2018. The plan is expected to be endorsed by the Cabinet of Thailand in the near future.

2.6.3 Smart City Promotion by Government of Thailand

Thailand Government is supporting smart city development projects that are led by local authorities and private sector through support for basic infrastructure development and institutions. The government aims to make 70 smart cities in Thailand within the next five years, according to interviews with DEPA. As described before, the government established the Smart City Steering Committee, and appointed DEPA, OTP and EPPO as the secretariat. In addition, local governments, local and global companies, the academic sector and city development companies are expected to be key players in the planning and development of actual smart cities. Smart city development is promoted on the basis of five strategic pillars, which are; 1) master plan, 2) legal system, 3) PPP mechanism, 4) city data and security, and 5) R&D innovation.

In terms of digital economy promotion, DEPA formulated the Digital Economy Promotion Master Plan (2018 - 2021) as shown in Figure 2.55. DEPA established a funding mechanism not only for digital industries but also for the development of smart cities, which supports smart services and infrastructure development by the private sector. Moreover, there is a soft-loan scheme for local governments and the private sector which provides smart technologies and services. Recently these schemes have been frequently updated.



Source: DEPA (2016)

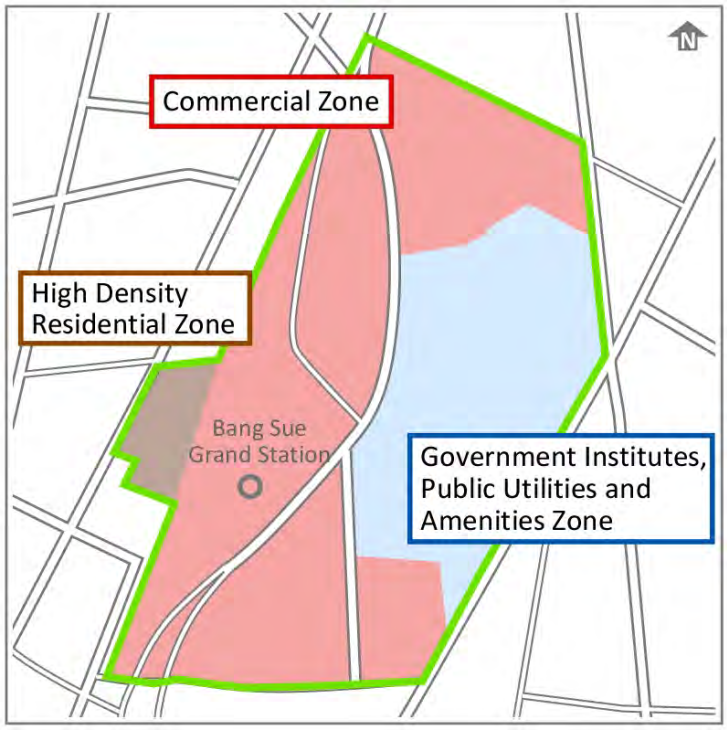
Figure 2.55 Digital Economy Promotion Master Plan (2018-2021)

2.7 Outline of the issues of laws and regulations on the urban development, real estate development and Smart City development

As mentioned in the previous study by JICA, two major regulations should be strongly related for the Bang Sue development: “Bangkok Comprehensive Plan 2013” and “Bangkok Building Control Regulation 2001”. In this study, detailed information of these two regulations was further examined.

2.7.1 Comprehensive Plan 2013 (3rd Edition)

According to “The Bangkok Comprehensive Plan 2013 the 3rd Edition”, the land use zoning of Bang Sue area consists of three types: commercial, residential and public utilities zones. The west side of Bang Sue Grand Station, same as Zone E, consists of “high density residential zone”. The east side of the study area, contains three parks Wachirabenchat Park, Rod Fai Park and H.M.Queen Sirikit Park, and is defined as “government institutes, public utilities and amenities zone”. The rest of the study area, which accounts for majority of the development area, is covered by “commercial zone”.



Source: JICA Study Team based on “The Bangkok Comprehensive Plan 2013 3rd Edition” by BMA

Figure 2.56 Zoning by Comprehensive Plan 2013 in the Study Area

The summary of these three zones are described as following table.

Table 2.15 Summary of the Zoning in the Study Area

Zoning Category	Sub Category	Floor Area Ratio (FAR)	Maximum FAR	Open Space Ratio (OSR)*	Major Land Use
Commercial Zone	C.4	8 times (800%)	9.6 times (960%)	5 %	Large sized commercial usage
High Density Residential Zone	R.8	6 times (600%)	7.2 times (720%)	4 %	Residential and commercial usage

Government Agencies, Public Utilities and Amenities Zone	G.22	n.a.		n.a.	Government agencies, public utilities, parks and so on

Note: OSR=uncovered area is divided by the total floor area
Source: "The Bangkok Comprehensive Plan 2013" by BMA

(1) Floor Area Ratio in the Study Area

As the Bangkok Comprehensive Plan 2013 shows, floor area ratio (FAR) ranges from 600% to 800% in the study area. The current plan has a system of FAR bonus which obtains 20% extra privilege at maximum if the development considers the following cases.

- Case 1: The development includes low income houses
- Case 2: The development provides green open space
- Case 3: The development provides the public parking space
- Case 4: The development provides natural green open space and rain water storage
- Case 5: The development encourages green building construction concept approved by Thai Green Building Institute (TGBI)

Since the capacity of basic infrastructure in Bangkok such as water supply and sewage system is not enough to accommodate a large population, the 20% of extra FAR is considered as the maximum by BMA. Accordingly the policy of maximum FAR will be meant to stay the same in the next comprehensive plan under preparation unless there is a drastic change of infrastructure capacity in Bangkok.

(2) Development under Current Zoning System

1) Installation of Cogeneration Power Plant

Installation of a cogeneration power plant in the Bang Sue area is one important measure to develop as a smart city with advanced technologies. However the expected installation areas, both high density residential and commercial zones, are not allowed to build any power plant according to the comprehensive plan 2013. The system of "minority use" which allows a small area, less than 10% of the plot, incompatible with the zoning is no longer able to adopt in current and further comprehensive plans. Therefore installation of a cogeneration power plant requires permission from BMA. According to BMA, SRT needs to submit the proposal with formal decision of the relevant government ministry for obtaining the approval as mentioned in the previous study[4].

2) Development in the Parks

Existing parks should be kept as open spaces in order to maintain the living and social environment. On the other hand, small developments, construction of a pedestrian deck (skywalk) or monorail, passing through the existing three parks could be planned in consideration with the convenience of access inside the study area. As mentioned above, the three parks are categorized as the government agencies, public utilities and amenities zone. Therefore development activities needs a permission from BMA even the parks belong to the land of SRT. Besides all sizes of rail systems including monorail require EIA according to the Ministry of

[4] "Data Collection Survey on Urban Redevelopment in Bang Sue Area in the Kingdom of Thailand" by JICA

Natural Resources and Environment (MONRE)[5]. However skywalk development is exempt from it[6].

2.7.2 New Comprehensive Plan (4th Edition)

Comprehensive Plan 2013 will expire, and the new Comprehensive Plan is currently under revision by the Department of City Planning in BMA. According to them, the new plan is already drafted and is going to take public hearings in 2019. The plan is supposed to be finalized and published around the end of 2019 or the beginning of 2020[7]. The concept of compact city will continue to be employed in the new comprehensive plan. The zoning shall keep the green belt in the fringe to avoid urban sprawl and define some urban centers inside Bangkok. The Bang Sue area is considered to be an "intermodal transport hub" in the comprehensive plan which takes a role of the major gateway of Bangkok in likewise other two areas with Makkasan station and Wongwian Yai station in Thon Buri.

The new comprehensive plan adds further conditions for applying FAR bonus in following cases. Thus in total eight cases would enjoy the bonus system. However the amount of additional bonus will stay at 20% same as the current regulation.

- Case 6: The development includes mass transit facilities
- Case 7: The development improves the water front area
- Case 8: The development provides the facilities for the elderly in consideration with aging society

Besides, two new measures will be taken into the comprehensive plan.

- Transfer Development Right (TDR):
  TDR could allow to transfer FAR from agricultural land, historical and cultural areas to promotional areas such as commercial area and high-density areas. This measure is aimed at protecting the potential agricultural land and heritages and making urban developments to be concentrated.
- Planning Unit Development (PUD):
  PUD could allow to transfer FAR with flexibility inside the designated district. This measures is aimed at securing open spaces and improving urban environment by increasing flexibility of building design[8].

The Bang Sue area could apply to both systems of FAR bonus and PUD however the maximum extra FAR will be 20% only due to limited capacity of basic infrastructure as mentioned above.

2.7.3 Building Act

In the study area, following consideration could be necessary by BMA Building Control Regulation 2001 when the development plan will be designed.

[5] Enhancement and Conservation of National Environment Quality Act (1992)

[6] Notification of the Ministry of Natural Resources and Environment regarding the type and size of the project or business which must prepare an environmental impact analysis report

[7] As of December 2018

[8] Similar idea to "Comprehensive Building Design System" in Japan

Table 2.16 Summary of the Requirement by BMA Building Act 2001

Category	By Type	Regulation
Required Open Space	Residence	30% at minimum
	Commercial and Public Building	10% at minimum
Required Setback	Road width < 10m	setback form the center of road is 6 m at minimum
	Road width between 10 and 20m	setback form the center of road is 10% of the road width at minimum
	Road width > 20 m	setback form the center of road is 2 m at minimum
Required parking spot	Theater	1 spot per 10 seats
	Hotel	10 spots for the first 30 rooms, 1 spot per 5 rooms (the 31st room to 100th room), 1 spot per 10 rooms (from the 101st room)
	Condominium	1 spot per room unit
	Restaurant	10 spots for the first 150 sqm., then 1 spot per 20 sqm
	Department store, and exhibition hall	1 spot per 20 sqm
	Office	1 spot per 60 sqm
	Market and Hospital	1 spot per 120sqm
	School	1 spot per 240 sqm

Source: BMA Building Control Regulation 2001

With regard to installation of rooftop solar power in order to encourage renewable energy in the Bang Sue development, the other regulation shall be adopted. According to "Ministerial Regulations No.65 (2005)", the rooftop panel must not exceed 160 sqm with the maximum weight of 20 kg/sqm. The installation must be checked and certified by an engineer for safety, and must be informed to the local government office in advance.

2.7.4 Scheme of BOI

The Board of Investment (BOI) provides incentive schemes for a variety of development in Thailand so as to enhance both domestic and foreign investments. Recently BOI announced to establish a new scheme for "smart city development". According to the investment review in March 2019[9], the scheme supports a project categorized as any one of following three categories: 1) Smart City Development, 2) Smart City System Development, or 3) Smart Industrial Estate or Smart Industrial Zones Business. In order to apply this scheme and obtain the incentive, the development needs to at least provide a "Smart Environment" and one or all out of six smart city platforms defined by Smart City Committee. The incentive supposes to provide 8-year of corporate income tax exemption in case the project could cover all seven platforms, while other case could be adopted 5-year of exemption. In addition to the corporate income tax exemption, customs and VAT for importing machines shall be applied. The development of Bang Sue area could claim this scheme, however it could apply to other schemes such as "activity-based incentives" and "technology-based incentives". Selection of a scheme should be considered in the implementation.

For the time being, the scheme for the Eastern Economic Corridor (EEC) seems to have the most attractive incentives for investors and project owners however the Bang Sue area is not selected as a part according to the criteria by BOI.

[9] Thailand Investment Review (TIR) Vol.29, No.3, March 2019, Smart City a Solution to a more livable future, BOI

2.7.5 Regulatory Sandbox

Regulatory sandbox is usually used as a deregulation system for enhancement of development projects. In case of Thailand, regulatory sandbox was launched for the financial sector such as fintech by the Bank of Thailand (BOT) in end of 2016. The applicants include financial institutes, financial business groups, fintech firms and technology companies. The main benefit is that BOT allows the applicants to test their innovate financial products or/and services in a limited environment. This scheme seems to not adopt urban redevelopment but to encourage innovation of financial services.

2.7.6 Others

The period of real estate leasehold for commercial and industrial properties is raised as one of the issues for the Bang Sue development in the previous study. The lease period is still 30 years according to "the Lease of Immovable Property for Commercial and Industrial Purposes Act 1999". Although the current lease period is limited to 30 years, two 10-year extensions are allowed. The increase to a 50-year granted period is expected by amendment of the law by the ministry of finance, however a tangible schedule of the amendment has not decided yet.

According to the interviews with real estate developers, the 30-year lease period seems to not be enough for housing developments. The developers consider that 50-years would be necessary at least. Some contracts therefore have been made with conditions of extension. In the case of ONE BANGKOK which is developing a new urban agglomeration next to Lumpini Park and Rama IV road with 16.7 ha of total land will be accomplished by 2025. The project owner, TCC, won a 30-year extension for this commercial area. Therefore this example shows that the negotiation to win a longer year lease period could be possible.

In the Bang Sue development, the zone including housing developments will need a 50-year lease period. Discussions need to be continued with The State Enterprise Policy Office (SEPO) who is concerned with the lease condition for each zone.

2.8 Issues for Development in the Bang Sue Area

2.8.1 Zoning Change

Zoning change for installation of the cogeneration system is critical for the Bang Sue development. Thailand had a previous precedent to give the approval for installation of a power plant in an unqualified zone by the government order. In practice the Order 4/2559, Article 44 of interim constitution, "the Order of the National Council for Peace and Order (NCPO)" facilitates necessary development of a power plant by decreasing legal limitations such as zonings and city plans. By this Order, Electricity Generating Authority of Thailand (EGAT) has been permitted to develop Krabi Coal-fired Power Plant and Thepa Coal-fired Power Plant (unit 1 & 2) proposed in the power development plan[10]. These power plants are located in partly restricted areas, however the NCPO provided the approval in order to cope with power shortages in the southern part of Thailand. In addition, the Energy Regulatory Commission (ERC) has carried out the feed-in-tariff (TiF) program[11] on ground-mounted solar power generation in 2015. This program was

[10] Thailand Power Development Plan 2015-35, Ministry of Energy

[11] Program on Ground-mounted Solar PV Generation for Government Agencies and Agricultural Cooperatives 2015

also adopted by the NPCO in order to enhance the solar power generation by utilizing the fallow lands[12]. Thus the procedure for zoning modification in order for installation of cogeneration power plant deems to not be complicated by referring to the Order 4/2559.

In addition, BMA agreed with the importance of the Bang Sue area as a gateway of Bangkok. In fact the study for making a development master plan was conducted a decade ago by BMA itself however the plan was not accomplished. Making the plan of the Bang Sue area consulting with BMA is important and could be expected to obtain efficient guides including the zoning change of the comprehensive plan.

2.8.2 FAR

Although obtaining 20% of extra bonus, the FARs in the study area are relatively low compared to other international cities. For example, central Tokyo, in front of Tokyo Grand Station, obtained roughly between 1,200% and 1,700% of FAR[13]. However according to BMA the capacity of basic infrastructure does not allow to accommodate extremely high density. Thus higher FAR than 960% is not expected due to this physical barrier at this moment. The new Comprehensive Plan will be unveiled after being published within one year.

2.9 Findings and Recommendation

With regards to the study area, in terms of law and regulation for urban development, there are no serious issues to jeopardize the Bang Sue development. As mentioned above, the challenges could be dealt with respectively by taking appropriate procedures along the relevant lows and regulations such as changing the zoning system and taking FAR bonus. However the procedures to take time to resolve them since Thailand does not have comprehensive measures to encourage urban redevelopment smoothly and quickly at this moment. In order to reduce the process time, to obtain consensus of the stakeholder is necessary by explanation and opinion exchange with them in the early stages. In particular BMA is a principal organization for obtaining the permission of project development, installing cogeneration system and applying FAR bonus. From the planning stage, involvement of BMA is essential for smooth implementation.

Table 2.17 Major Required Procedure for the Development in Bang Sue Area

Item	Current regulation	Required procedure	Relevant Organization
Installation of Cogeneration Power Plant	Comprehensive Plan	To attain the approval for change the zoning based on "NCPO Order 4/2559, Article 44"	BMA
FAR Bonus	Comprehensive Plan	To apply the FAR Bonus (20% maximum) by meeting the requirement of Case defined in Comprehensive Plan	BMA
Buildings and facility - General	BMA Building Control Regulation 2001	To follow the existing regulation and to obtain the approval	BMA
- Solar Panel	Ministerial Regulations No.65	To follow the regulation and obtain the permission of installation by local authority	Local Authority Bang Sue District Office

Source: JICA Study Team

[12] Annual Report 2016, Energy Regulatory Commission and Office of the Energy Regulatory Commission

[13] Bureau of Urban Development, Tokyo Metropolitan Government

Long-Term Recommendation

Cities tend to have an increased need for renovation or redevelopment in response to social requirements and changes such as renewal of infrastructure, improvement of disaster prevention, introduction of advanced technologies, and alteration of the social structure including aging society, and strengthening of international competitiveness. Therefore not only the Bang Sue area but also other area might need redevelopment in Bangkok and other cities. Notably the improvement of law and regulation for the new technologies and services is sometime difficult to catch up due to the innovation of technologies are constantly improving day by day. The idea of "regulatory sand box" is one of the solutions for adopting such rapid changes.

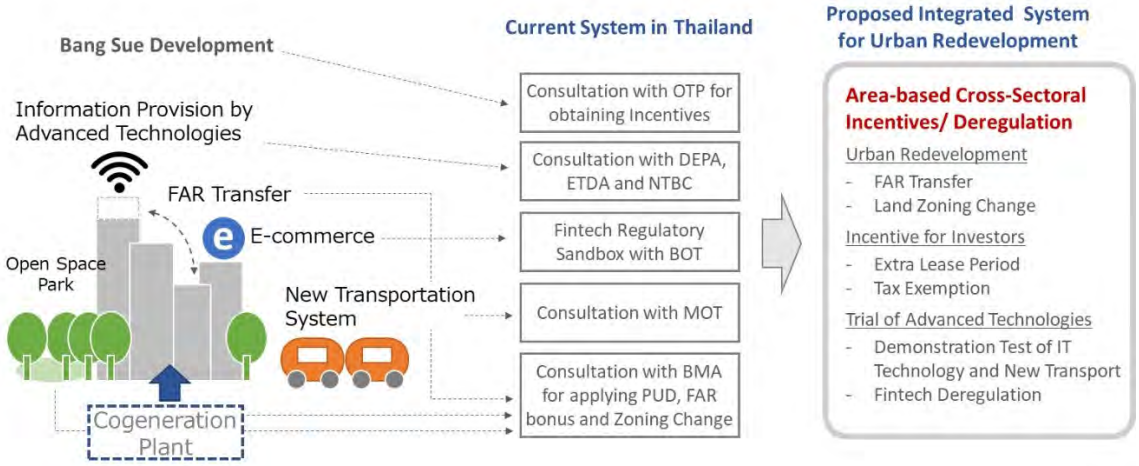
In the case of Japan, urban redevelopment is considered to be important for providing more comfortable living environment taking into account the aging society and strengthening the urban competitiveness to stimulate the economy. For this, some area-based measures for urban redevelopment are implemented in Japan. For example the following three measures namely "Urgent Urban Renewal Area", "International Strategic Zone" and "National Strategic Zone" could designate the area as "special zone" where it could be designed with a basis of unique proposals from project owners and investors.

Once the area is defined as a "special zone", it could benefit from advantages such as simplified procedure and quick implementation, deregulation of zoning and FAR, and financial incentives including financial supports and tax exemption. Such regulatory circumstances could contribute to create smart cities in Japan.

Source: JICA Study Team based on Office for Promotion of Regional Revitalization, Cabinet Office, Japan

Figure 2.57 Area-based Cross Sectorial Incentives and Deregulation System in Japan

Since Thailand has been preparing the master plans of smart city development in 40 cities by 2021, the following proposed system could contribute to efficient and quick implementation. This system is area-based cross sectorial regulatory sandbox based on the examples in Japan.



Source: JICA Study Team

Figure 2.58 Proposed Area-based Cross Sectorial Incentives and Deregulation System

3. Analysis of the Potential and Challenges of the Bang Sue Area

3.1 Problem-solving Approach

"Smart City" has become a common term and it can be said that there is general recognition of the key values and norms it relates to, such as liveability, sustainability, and balanced development. However, from a practical point of view, its focus area and approach are wide ranging and extensive, and thus defining or evaluating Smart City is not a straightforward task. Nonetheless, as long as Smart City development is interpreted within the context of urban development, it should strive to satisfy the needs of the people in the area, and solve actual issues that the region faces. One definition of Smart City, given by the Ministry of Land, Infrastructure, Transport and Tourism of Japan (MLIT) is: "*a sustainable city or region which aims for overall optimization through the application of technologies (ICT etc.) to solve urban issues, as well as management (planning, maintenance, management/administration etc.)*" (cited from the Ministry of Land, Infrastructure, Transport and Tourism, City Department "Towards realizing a smart city <Interim Report>". August 2018.).

When revisiting Smart City development from the viewpoint of a solution-oriented approach to the urban issues Bangkok city faces, as well as the context of the functionalities necessary for Bang Sue area, the specific image of a Smart City in Bang Sue can be summarized as below;

Table 3.1 The Challenges for Bangkok city and outline of measures for Bang Sue area

Challenges	Measures for the Bang Sue area (example)
Smooth transit between the lines/ public transportations (busses to railways etc.)	➢ Physically seamless and efficient transit with comprehensible transit information ➢ Platforming of public transportation related data integration and analysis. ➢ Transportation service for the first/ last mile
Chronic traffic jam	➢ Optimum management of the traffic flow /introduction of advanced traffic countermeasure technologies ➢ Smooth parking in the urban areas
Deterioration of urban environment including air, water, and noise pollution	➢ Reduction of NO_X, CO_2 through electric cars, self-driving, and efficient distribution etc. ➢ Public space planting management with the application of smart agriculture technologies ➢ Smooth transport of logistics trucks
Unstable electricity supply (e.g. Momentary power failure)	➢ Stable electricity supply through energy management
Lack of walking space Barrier-free as a city	➢ Securing sufficient space specially for pedestrians, separation of sidewalks with roads ➢ Supplying a road for bicycles ➢ Developing a barrier-free city
Waste/garbage disposal issues	➢ Building a regional logistics system using a multi-functional utility tunnel ➢ Waste management（the promotion of the 3R's etc.）
Steps towards a low-carbon society（SDGs）	➢ Total management of CO_2 emission in Bang Sue area
Innovations in information technology（installation of 5G etc.）	➢ Acquisition and application of *all* data ➢ Data platforms, data center ➢ High-speed internet (Free Wi-Fi) ➢ Inducing innovation based on sharing big data
Chronic floods	➢ Securing retention basins, enhancing drainage capacity
Lack of housing for the low-income	➢ Institutional improvement to enhance accessibility for the low-

Challenges	Measures for the Bang Sue area (example)
population	income population

Source: Study Team

While adopting the problem-solving approach as an underlying proposition for the Bang Sue Smart City, it is also worthwhile to consider its advantages and potential taking into account the contemporary situation and ASEAN context when outlining the general direction for Bang Sue Smart City development.

In Bang Sue's case, SRT solely owns the vast 300ha of land that it covers, and thus the development of the area could be managed as a whole. Hence, the area has a great potential in taking advantage of the policies for Thailand 4.0, as well as the incentives, while also actually implementing the cutting edge technologies in advance to other cities.

To analyze Bang Sue Area's advantages and its potential, it is beneficial to take into account the urban development situations regarding other ASEAN cities, Thai cities, and in Bangkok. In the following sections, Bang Sue Area development project and its Smart City concept is redefined through analyzing the attributes from the context of three distinct levels of: ASEAN, Bangkok metropolitan area, and Bang Sue district.

3.2 Outline of Bang Sue Area Development

3.2.1 Outline of Bang Sue Area development in context of ASCN

(1) Relative position of Bangkok within ASEAN cities

Quantitative data and literature were collected and reviewed to understand the current standing of Thailand's economy and business climate, as well as the competitiveness of Bangkok as a city.

The table below shows the score for ease of doing business provided by the World Bank.

Table 3.2 Doing Business Index (2019) for ASEAN and other Asian Countries

Economy	Ease of doing business score global (DB17-19 methodology)	Score-Starting a business	Score-Dealing with construction permits (DB16-19 methodology)	Score-Getting electricity (DB16-19 methodology)	Score-Registering property (DB17-19 methodology)	Score-Getting credit (DB15-19 methodology)	Score-Protecting minority investors (DB15-19 methodology)	Score-Paying taxes (DB17-19 methodology)	Score-Trading across borders(DB16-19 methodology)	Score-Enforcing contract (DB17-19 methodology)	Score-Resolving insolvency (DB15-19 methodology)
Singapore	85.2	98.2	84.7	91.3	83.1	75.0	80.0	91.6	89.6	84.5	74.3
Hong Kong SAR, China	84.2	98.2	88.2	99.3	73.6	75.0	78.3	99.7	95.0	69.1	65.7
Taiwan	80.9	94.4	87.1	96.3	83.9	50.0	75.0	85.1	84.9	75.1	77.1
Malaysia	80.6	82.8	87.0	99.3	80.4	75.0	81.7	76.1	88.5	68.2	67.2
Thailand	78.5	92.7	71.9	98.6	69.5	70.0	75.0	77.7	84.7	67.9	76.6
Shanghai (China)	73.7	93.4	67.7	92.0	79.7	60.0	60.0	66.3	83.1	78.9	55.8
China	73.6	93.5	65.2	92.0	80.8	60.0	60.0	67.5	82.6	79.0	55.8
Beijing (China)	73.6	93.7	62.1	92.0	82.2	60.0	60.0	69.0	82.0	79.1	55.8
Brunei Darussalam	72.0	94.9	73.5	86.6	51.5	100.0	65.0	74.0	58.7	61.0	55.1
Vietnam	68.4	84.8	79.1	87.9	71.1	75.0	55.0	62.9	70.8	62.1	34.9
Indonesia	68.0	81.2	66.6	86.4	61.7	70.0	63.3	68.0	67.3	47.2	67.9
Mongolia	67.7	86.9	78.2	54.9	74.1	80.0	68.3	77.3	66.9	61.4	29.4
ASEAN average	66.1	79.8	71.4	80.3	64.7	62.0	57.0	70.2	72.2	53.5	50.0
Philippines	57.7	72.0	68.6	87.5	57.6	5.0	43.3	71.8	69.9	46.0	55.2
Cambodia	54.8	52.8	44.2	57.0	55.2	80.0	50.0	61.3	67.3	31.8	48.4
Lao PDR	51.3	60.9	67.9	52.8	64.9	60.0	31.7	54.2	78.1	42.0	0.0
Myanmar	44.7	77.3	70.4	55.7	52.3	10.0	25.0	63.9	47.7	24.5	20.4

Source: World Bank "Doing Business Index 2019"

The criteria mostly relate to issues at national level, such as laws or business customs. However, as the data is mostly collected from businesses in the capital city, the scores are, to some extent, a reflection of the easiness of conducting business in the capital city.

According to the data, Thailand ranks third among ASEAN countries in overall score, behind Singapore and Malaysia. While Thailand outscores the ASEAN average in all the criteria, Thailand is perceived to be relatively low in "Permission for construction", "Registering properties", and "Enforcing contracts" when compared to fellow competitors such as Singapore and Malaysia.

The table below shows the liveability of cities in Asia provided by the Economist Intelligence Unit.

Table 3.3 Cities Liveability Index 2012

rank	Country	Spatial Adjusted Liveability Index	Stability (18.75%)	Healthcare (15%)	Culture and Environment (18.75%)	Education (7.5%)	Infrastructure (15%)	Spatial Characteristics (25%)
1	Hong Kong	87.8	95	87.5	85.9	100	96.4	75
10	Tokyo	84.3	90	100	94.4	100	92.9	53.3
20	Seoul	79.1	80	83.3	85.6	100	89.3	58.8
22	Singapore	78.2	95	87.5	76.6	83.3	100	46.7
30	Beijing	70.5	80	66.7	72.2	83.3	85.7	51.5
33	Shanghai	66.8	80	62.5	75	75	75	46.1
34	Shenzhen	66.7	85	62.5	63.7	66.7	82.1	48.5
37	Kuala Lumpur	64.6	80	62.5	67.8	91.7	76.8	36.6
39	Guangzhou	63.1	80	62.5	61.1	66.7	76.8	42.9
46	New Delhi	58.6	55	58.3	55.6	75	58.9	58.6
48	Manila	58	60	58.3	63.2	66.7	64.3	46.1
49	**Bangkok**	**57.8**	**50**	**62.5**	**64.4**	**100**	**69.6**	**36.3**
52	Mumbai	55.7	60	54.2	56.3	66.7	51.8	52.1
56	Jakarta	51.5	50	45.8	59.3	66.7	57.1	42.3
57	Hanoi	50.2	55	54.2	53.7	58.3	51.8	38.4
60	Ho Chi Minh City	48.1	55	50	49.5	66.7	48.2	35.1
64	Phnom Penh	44.6	60	37.5	49.3	58.3	53.6	24.1
68	Dhaka	37.9	50	29.2	43.3	41.7	26.8	35.7

Source: Economist Intelligence Unit

According to the data, Bangkok ranks 49th in the global ranking, and 4th among ASEAN cities behind Singapore, Kuala Lumpur, and Manila. When compared to these rival cities, Bangkok appears to have lower scores in Stability - consisting of indicators related to crime and civil conflict - and in Spatial Characteristics - consisting of indicators related to urban form (sprawl, green area), geographic attributes (natural assets, connectivity), and pollution.

Looking at both Doing Business Index and Liveability Index, it could be said that Bangkok ranks relatively high in business aspect and living environment aspect. However, when compared to rival cities such as Singapore and Kuala Lumpur, Bangkok is inferior in areas related to law and contract enforcement in business domain, whereas it also falls behind in areas related to urban form and geographic attributes in living environment domain.

(2) Relative position of Bang Sue Area within ASCN

Combining these statistical data and the Smart City projects in ASCN which is mentioned in the previous section, the distinctive characteristics of Bangkok's approach to Smart City projects are outlined. Table below shows the business environment index, liveability, and the priority projects registered in ASCN.

Table 3.4 Attributes of other main cities in ASEAN Smart City Network

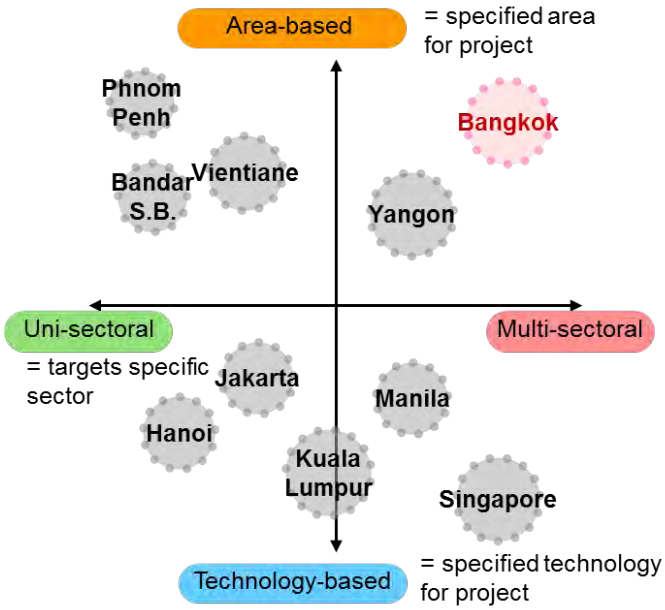
City	Business Environment	Liveability Index	Priority Projects
Singapore	85.24	78.2	E-Payments National Digital Identity (NDI)
Kuala Lumpur (Malaysia)	80.6	64.6	Kuala Lumpur Urban Observatory Kuala Lumpur Pedestrian and Bicycle Lane
Bangkok (Thailand)	**78.45**	**57.8**	**Transport Hub Development at Bang Sue Area** **Smart City Plan**
Bandar S.B. (Brunei)	72.03	N/A	Revitalization of Kampong Ayer (Water Village) Clean River Management Project
Hanoi (Vietnam)	68.36	50.2	Intelligent Operation Centre (IOC) Development of Intelligent Transportation
Jakarta (Indonesia)	67.96	51.5	Job Creation Linking Research Institutes and Entrepreneurs OK OTrip Integrated Transit Cashless System
Manila (Philippines)	57.68	58	Command Centre Upgrade (Transport/ Disaster Prevention/ Security) E-Education
Phnom Penh (Cambodia)	54.8	44.6	11 Sidewalks Rejuvenation Project Improving Efficiency of Phnom Penh Public Transit
Vientiane (Lao PDR)	51.26	N/A	Establishment of Drainage System Sustainable Transport Plan
Yangon (Myanmar)	44.72	N/A	Conservation of Yangon City Downtown Area Low Cost Rental Housing and Transit Oriented Development

Source: Compiled by the Study Team based on Economist Intelligence Unit, World Bank, ASCN

Overviewing the Smart City projects in other ASEAN cities, it could be pointed out that Bangkok's approach for Smart City development is unique in two ways. Firstly, it is area-based, that is specific area (Bang Sue Area) is designated as an area to be developed as Smart City. The other cities such as Singapore or Kuala Lumpur does not necessarily specify an area to implement Smart City development, but rather specify a smart technology which is to be implemented (technology-based approach). Secondly, it is multi-sectoral, meaning that the project is targeted to solve various urban issues by linking with urban and spatial planning. The other cities such as Phnom Penh or Hanoi targets specific issue to be targeted (uni-sectoral approach).

The approaches of Bangkok and the other ASEAN cities could be summarized as shown in the below figure.

Bang Sue could become a model city which demonstrates the solution-oriented Smart City by combining urban planning method and Smart City concept.



Source: Compiled by the JICA Study Team

Figure 3.1 Comparison of approaches to Smart City development among ASEAN cities

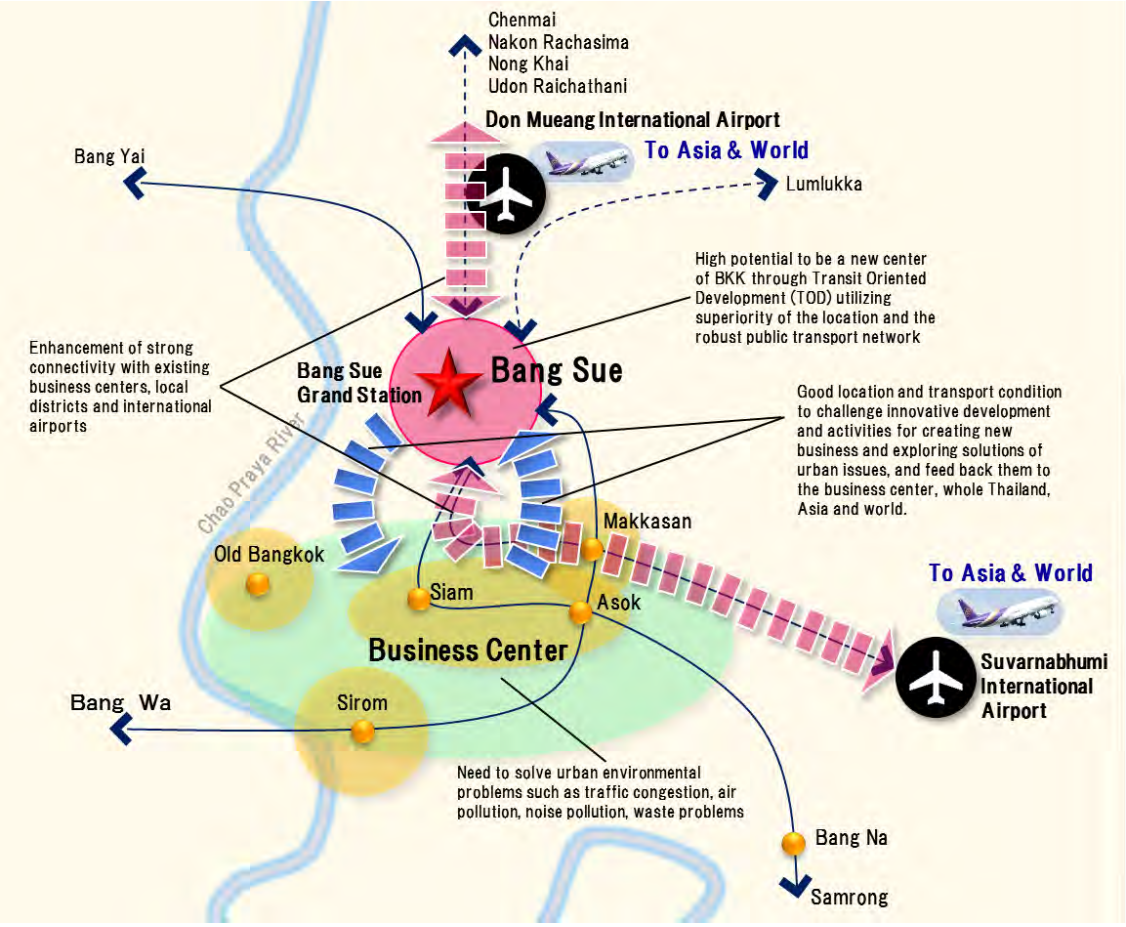
3.2.2 Outline of the current situation in context of regional level

(1) Bang Sue from viewpoint of spatial position attributes

Looking at the urban development of Bangkok, one may notice that Siam, the outskirts of Silom, and the area along Chao Phraya near the royal palace are the center of commerce; and that the north side of Siam is developing into a commuter town.

Bang Sue Area, which is about 10 km away from the center of Bangkok, is slightly distant from the center of commerce. On the other hand, the area is also at about 10 km from Don Mueang International Airport, which means that it is midway between central Bangkok and the airport.

Commercial facilities in the suburbs of Bangkok have mainly developed along arterial roads, yet such development has been quite limited around train stations. The distinctive characteristic of Bang Sue, however, is that it is a place where various railways/roads intersect and that it is highly convenient when using public transportations. By taking full advantage of this characteristic, Bang Sue Area has a great potential in becoming a new central city area of Bangkok. The key to this would be in creating a city in which its society does not rely on automobiles, but instead on public transportations – a Transit Oriented Development (TOD) and Walkable City.



Source: JICA Study Team

Figure 3.2 Potential of Bang Sue development regarding urban development in Bangkok

(2) Bang Sue from viewpoint of historical development attributes

Referring to the "Histories of Urban Development in Bangkok" in the previous chapter, if one were to picture the scale of the Bang Sue Area and draw an analogy with historical development projects such as Ratchamnoen or Suan Dusit, the Bang Sue smart city development could be regarded as a flagship project which symbolizes transformation of the urban form. Bang Sue development could be a pilot project that accelerates "Thailand 4.0" or "The Fourth Industrial Revolution".

In doing so, it is imperative to adopt measures and technologies for the improvement of Bangkok's urban issues such as traffic congestions and urban environments, for example: next generation traffic systems, traffic management measures, energy saving technologies, and provision of environmental friendly urban space. On the other hand, in order to strengthen Bangkok's competitiveness as a city, establishing new industries and global standard business environments are critical aspects as well.

3.2.3 Outline of Bang Sue Area development in context of local level

Looking at the current state of Bang Sue Area, there are several facilities which already attracts people into the area: the offices, hotels, and commercial buildings around Mochit station; Chatuchak park (museums, sport facilities, bikeways, etc.); Chatuchak Weekend Market; Energy Complex building (where the PTT has its main office) on the north side of the park; and MRT

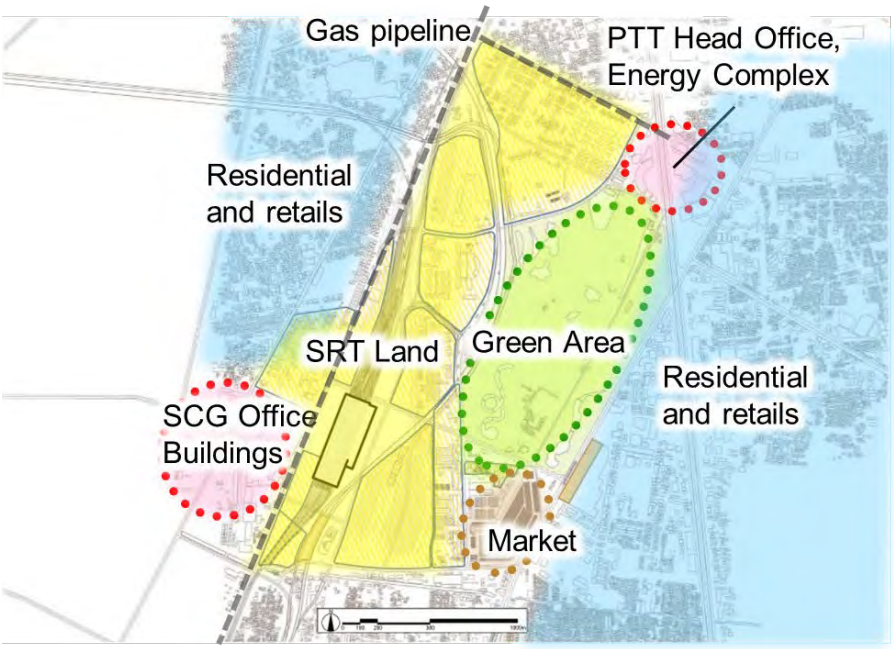
Bang Sue Station where the SCG headquarters is at.

In the same area, however, elevated highways/interchanges runs over the area, and railway depot occupies wide space which separates the area.

On the other hand, Bang Sue Area, especially to the west and south of the station, is a residential area with many houses, which are home to many low/middle-income people.

By connecting these facilities in an organically coordinated manner, we can unlock the entire area's potential, and establish a vast commercial area that puts homes and workplaces in close proximity to each other.

Bang Sue already seems to attract various people but is expected to experience a greater diversity with the development of the transportation network and urbanization. People of diverse backgrounds, including foreign people, may come to meet, work, and live in the area. The interaction of diverse people in Bang Sue Area would lead to creating new values. This would be a distinctive feature for the Area.



Source: JICA Study Team

Figure 3.3 Bang Sue Area and vicinities

3.2.4 Outline of Bang Sue Area development in context of residents and people

As mentioned, various kinds of people will come and go at the Bang Sue area. Some characteristics of each user category is elaborated as followings.

(Expected users of Bang Sue area)

Railway Passengers	; Users of Railways (SRT, Red line, MRT, BTS, Airport Rail Link, in future: High Speed Railway (Bangkok-Chenmai), Dark Redline, Light Red Line)
Users of Long and Middle Distance Bus Service	; From/to rural areas
Leisure use	; Shopping, By Train, By Private Car
Residents	; SRT Housing for employees (SRT Land, KM 11), Condominium, Rental Mansions
Workers	; Office workers in office buildings
Labours	
Tourist	; Foreigners

Table 3.5 Types of Users of Bang Sue Area

Type	Transportation Mode	Volume	Generation	Income Level	Activities	Note
Railway Passengers (Transit)	Rail	High	Various	Middle ~ Upper-Lower	Travelling, Visiting	Red Line-MRT/BTS
Bus Passengers	Bus/Taxi/Bike	Middle	Various incl. aged and children	Upper-lower ~ Lower	Travelling, Visiting	
Leisure Use	Rail /Private Car	Middle	Young ~ Family	Middle ~High	Shopping, Entertainment	
Residents	Rail /Private Car	Middle	Young ~ Family	Middle ~High	Living	
SRT Staff Houses	Bike	Middle ~ Low	Various	Upper-lower ~ Lower	Living	
Office Workers	Rail /Private Car	Middle	Young ~ Middle age	Middle ~High	Working	
Labours	Bike	Middle	Young ~ Middle age	Upper-lower ~ Lower	Working	
Tourist	Rail	Middle ~ Low	Young ~ Family	Middle ~High	Travelling, Visiting	

Source: JICA Study Team

The functions and potential of the Bang Sue area have been organized from the three aspects of livelihood, business environment, and visitor attraction in shopping, tourism, and leisure.

(1) Livelihood

The residents in the Bang Sue Area is expected to consist of workers commuting to offices in central Bangkok, as well as those who live close to work and commute to companies within the area. The parks in the Area contributes to environmentally friendly atmosphere. With the development of visitor attractions such as commercial or MICE facilities, not only would the area be a place in which one can feel the nature from the Chatuchak Park and the greenways but also a place which would offer convenient and exciting urban life.

Meanwhile, the Ministry of Public Health plans to have their medical complex built in the Bang Sue area during the initial phase. Healthy lifestyles are expected to be promoted by collaborating with Chatuchak Park and its bike paths/sport venues.

(2) Business Environment

Dominant firms of Thailand are accumulated in the Bang Sue area — Energy Complex Building (PTT's headquarters) and the Ministry of Energy's office to the north, and SCG's headquarters near the MRT Bang Sue station. There are plans to build the SRT's headquarters and a building for the Ministry of Transport to the west of the station, and it is assumed that the Bang Sue area would become a new business district for Bangkok.

It is also worth noting that Thailand is working for the creation of new industries and the promotion of innovation as part of their policy. By realizing a serene urban space while making most of the district's diversity through integrated development with the Grand Station, the area is expected to provide a business environment that is attractive for knowledge-intensive industries (IT and R&D related fields etc.) and start-up companies.

(3) Visitor Attraction in Shopping, Tourism and Leisure

The Bang Sue area has unique location characteristics as it is to the north of Bangkok and is easily accessible by public transportation such as railways. The area is already a distinguished visitors' destination with the Chatuchak weekend market and the park. However, with the upcoming opening of the Bang Sue Grand Station and highways including the airport rail link line, further increase in the visiting population can be assumed.

Various facilities with myriad functions such as commercial facilities, cultural facilities, and MICE facilities are to be located in the Bang Sue Area. By securing the area's spatial continuity through integrated development, Bang Sue can establish connectivity between the various functions. Such connectivity can bring prosperity in town and act as a catalyst that attracts people.

3.2.5 Bang Sue Development from the Viewpoint of Real Estate/Urban Development Investment

(1) Responsibility for Sustainable Development Goals (SDGs) and ESG

In recent years, there has been a global trend for investors – mainly institutional investors – to select investment from the perspective of ESG (Environment, Society, Governance), and also to require commitments to the SDGs for the invested companies. This trend is strong in Europe and the United States, and in investments for long-term asset management. ESG investments generally incorporate E: Environment, S: Social, and G: Governance perspectives into long-term investment decision-making, aim to improve risk management, and increase sustainable and long-term returns. Guidelines on ESG investments have been set out in the Principles for Responsible Investment (PRI) proposed by the United Nations in 2006.

The Sustainable Development Goals (SDGs) are 17 global goals for sustainability, including actions for poverty reduction and climate change, set by the United Nations in 2015 for the year 2030. The spread of actions for the SDGs into private businesses, especially after 2015, has encouraged the expansion of ESG.

In the actual management of ESG investments, major equity evaluation organizations, such as S&P Dow Johns Indices, are evaluating companies in the light of ESG based on company disclosure information. These organizations provide stock price indicators comprised of companies that have acquired excellent ESG evaluations, and also operate investment trusts linked to them. Such indexes will become more and more important in real estate investment as

well.

Smart city development in the Bang Sue area is consistent with the goals set out in the SDGs. If its contributions to the SDGs as well as positive impacts are evaluated highly from the ESG aspect, the project could attract investment funds from a wider variety of source, which could be an incentive for companies doing smart service businesses in the Bang Sue Area. .

Table 3.6 The SDGs and the possible contributions by the Bang Sue Development

SDGs	SDGs Target (abstract)	Bang Sue Area's Commitment for the SDGs (example)
 3. Good health and well-being	3.6 Halve the number of death/injuries from road traffic accidents 3.8 Universal Health Coverage	▪ Pedestrian oriented, walkable city ▪ Providing health services linked to the medical complex facilities (planned to be built in Zone D1)
 4. Quality education	4.4 Improvement of technical/vocational skills, nurturing entrepreneurship 4.7 Global citizenship, and appreciation of cultural diversity	▪ Creation of learning opportunities through impetuses such as satellite campuses ▪ Creating an international atmosphere and promoting cultural exchange as a gateway to Bangkok
 7. Affordable and clean energy	7.2 Increase the share of renewable energy 7.3 Improve energy efficiency	▪ Promote the installation of renewable energy, such as the PV ▪ Introduction of cogeneration technology, district cooling system, and energy management
 8. Decent work and economic growth	8.2 Promote high-value added and labour-intensive sectors 8.3 Support job creation, entrepreneurship, and innovation	▪ Promote location of high-value added industries such as knowledge-intensive industries ▪ Development as a new business district of Bangkok
 9. Industry promotion and infrastructure	9.1 Sustainable and resilient infrastructure 9.5 Promoting innovation	▪ Installing high quality and flexible infrastructure as a smart city ▪ Supporting start-up companies and implementation of new technologies
 11. Sustainable cities and communities	11.2 Expanding public transport and sustainable transport systems 11.3 Enhance participatory, inclusive, and sustainable planning/management	▪ Development of an environmentally-friendly public transportation system ▪ Development as a walkable city that does not depend on automobiles ▪ Realization of participatory city planning and management
 12. Responsible consumption and production	12.2 Sustainable management/efficient use of natural resources 12.6 Encourage companies to adopt sustainable practices	▪ Promoting local production and local consumption (including energy) ▪ Encouraging companies to make sustainable efforts ▪ Ensuring transparency by disclosing information on corporate initiatives

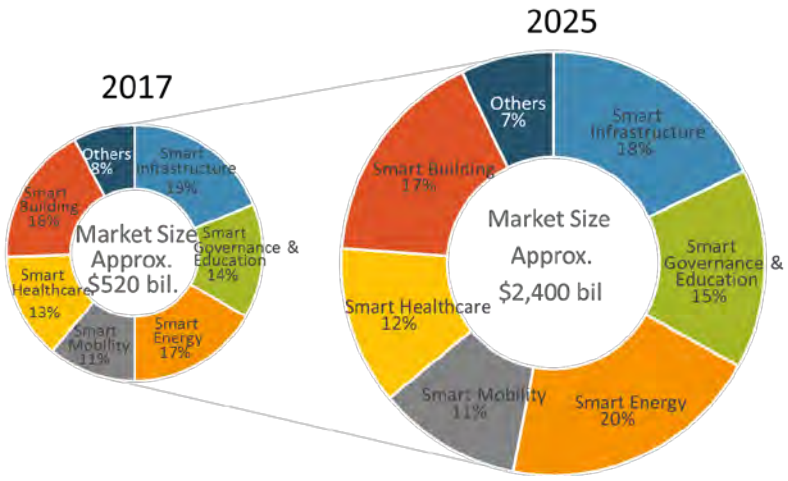
Source: Compiled by the JICA Study Team

(2) Market Potential for Smart City Technologies/Services

Through the spread of smartphones and the rapid progress of IoT technology, new technologies such as 5G communication and automatic driving technology have formed a large market worldwide, starting in Europe and the US, and are still in the research and development stage. Markets related to smart cities are expected to further expand as these new technologies are put

into practical use.

According to market research firm estimates, Smart City's market size is expected to grow to approximately $ 2.4 trillion by 2025, compared to $ 520 billion in the global market as of 2017. The market segments in this estimate are defined by 7 sectors: Smart Infrastructure (transport infrastructure, water infrastructure, stadiums, safety and security infrastructure, lighting, etc.); Smart Governance and Smart Education; Smart Energy (power generation, storage, smart grid, etc.); Smart Mobility (ticketing systems, parking systems, etc.); Smart Healthcare (telemedicine, connected healthcare, etc.); and Smart Buildings (building management systems, building safety and security equipment, etc.). According to the same survey, the Asian region is the number one market expected to grow in the future. The current situation and future estimates for the smart city market are as shown below.



Source: Allied Market Research “Smart Cities Market by Functional Area”, compiled from the Study Team

Figure 3.4 Market Size Estimation Related to Smart Cities

(3) The Potential of bang Sue Smart City as an Investment Destination

Global attention for smart city development, social demands for SDGs, and capturing the current trends of the international community such as the expansion of ESG investment are essential in realizing the potential of Bang Sue district as a smart city. In this regard, the following three factors can be the key to competitiveness of the Bang Sue area within ASEAN's competing smart cities;

- Public Awareness of “Bang Sue”, Established Reputation:

  The Bang Sue area will become a smart city with Bang Sue Grand Station, the largest station in Southeast Asia, at its core. Once the Central Station is completed, the airport connection line is connected, and the transboundary high-speed railway concept has been realized, *Bang Sue* will be widely recognized not only in Thailand but also internationally.

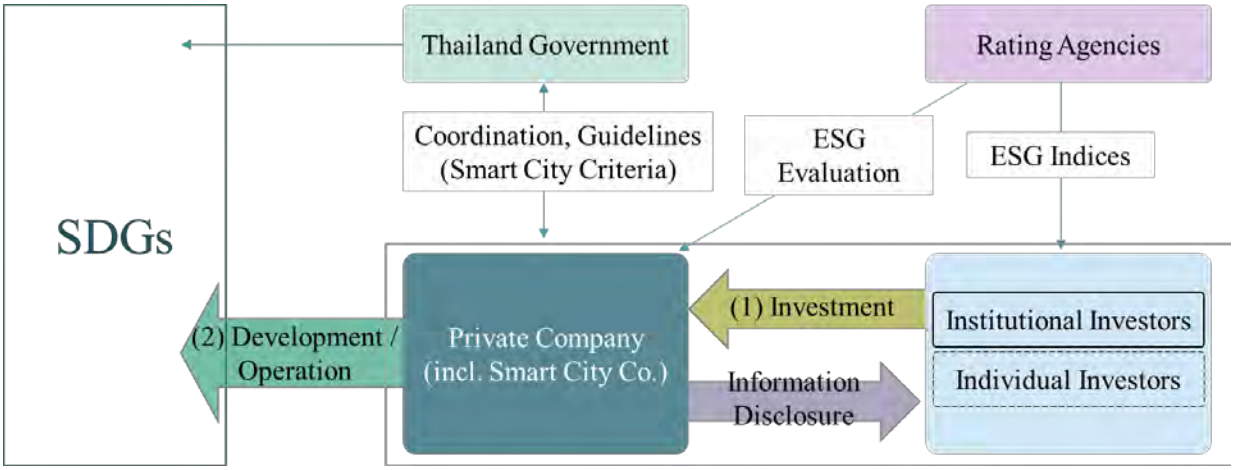
- Integrated Development with Inclusive Approaches at the District Level:

  As mentioned in the section, comparison of smart city development in ASEAN cities, Bang Sue Smart City is unique for being designated a relatively large land area, and for being defined a direction to comprehensively address urban issues. As shown in the following figure, the Bang Sue area has the potential to introduce smart technology and services in various ways. In addition, promoting integrated development is an important point in making the most of the *established reputation* as mentioned in the above.

- The Smart City Criteria as an Evaluation/Monitoring Indicator:

  The Smart City Criteria, which is set by the Thai government for the purpose of examining the adequacy of tax exemptions from BOI, can be an indicator for securing the suitability as an ESG investment as well.

The figure below shows an example of an application of ESG investment in the Bang Sue area;



Source: MLIT "Interim Report on directions for ESG investment for real estate", Compiled by the Study Team

Figure 3.5 Examples of ESG Investment in the Bang Sue Area

3.3 SWOT Analysis

Based on the above-mentioned information and the ASEAN Smart City Network projects outlined earlier, a SWOT analysis was conducted to identify the potential and challenges of Bang Sue Area development especially as a development project in Bangkok. Also, SWOT analysis for the 7 Smart component is done from the viewpoint of necessary function as Smart City.

3.3.1 SWOT Analysis: comparison with ASEAN Smart City Projects

SWOT analysis was conducted based on case study on ASCN projects, to identify the potential and challenges of Bang Sue Area development especially as a development project in Bangkok.

(1) Strengths

- *Linkage with the national development strategy - Thailand 4.0*

  Thailand has set up an extensive national development strategy in Thailand 4.0 which aims to shift its industry to enhance added value, while realizing sustainability and balanced growth. The Smart City development is in line with this strategy.

- *Robust government commitment to Smart City projects*

  A steering committee is set up within the government to coordinate and promote Smart Cities, indicating the degree of commitment by the government.

- *Incentive scheme for Smart City businesses*

  Under the current scheme, the Board of Investment of Thailand permits special tax exemption treatment for approved Smart City businesses. Such kind of incentive measures are expected to contribute to promoting investment.

- *Designated area for Smart City*

While typical cities that are listed for ASCN are registered as technology-based (such as e-payment system introduction in Singapore, or the Command Center upgrade project in Manila), Bangkok's plan is an area-based project (Bang Sue area). This ensures that the smart technologies or services to be embedded in the area then bring benefits to the local residents.

- *Relatively high education level*

  The education level in Bangkok is regarded as being of the highest level according to the Economist Intelligence Unit data. Businesses can benefit from the highly educated work force.

- *Relatively easy to start up a business*

  According to Doing Business data, starting up a business in Thailand is regarded to be relatively easy, as the hurdle for administrative procedure and required capital when starting up a business is relatively low.

  The ease of starting up a business contributes to opening up business opportunities and laying the foundation for an environment geared to innovation.

(2) Opportunities

- *International attention towards Smart City development in Thailand*

  As Thailand will host the ASEAN Smart City Summit in 2019, it can be said that Smart City development is an important policy agenda in Thailand.

- *Support from international communities*

  International cooperation agencies including JICA support the Smart City development.

- *Stable growth of real estate market*

  There are many large-scale developments in Thailand, and a number of domestic and international companies are engaged in real estate development projects. The land price in Bangkok is growing at a rate of around 5-7% annually.

(3) Weaknesses

- *Uncertainty and complexity for business*

  As implied in the doing business indicator, there is some uncertainty and complexity in the procedures and customs, which hampers business.

- *Difficulty of business for foreign companies*

  There are some stumbling blocks for foreign companies to enter urban development project, or Smart City development project, as it is stipulated in the Thai law that the company should form a JV with a Thai company. Also, the short land lease period of 30 years means it is difficult to ensure financial feasibility. The foreign companies needs to adapt to Thai business culture and customs.

- *Uneven urban form*

  Urban sprawl, lack of green space and pollution are significant issues in Bangkok.

(4) Threats

- *Social and political instability*

  As implied in the doing business indicator, there is some instability in the political climate which may affect business.

- *Vulnerability to natural disasters and other contingencies*

  Bangkok is considered to be vulnerable to natural disasters such as floods.

(5) Strategies for Smart City project in Bangkok

Given the above-mentioned attributes regarding Smart City projects in Bangkok, the implications for preferable strategies are drawn up as shown below:

[Strengths – Opportunities Strategy]
To shift towards knowledge-intensive industry (high-value-added industry) through utilization of abundant and high standard human capital and industrial technology.
[Strengths – Threats Strategy]

To realize a city which could flexibly adapt to needs and challenges by introducing a regulatory sandbox.

[Weaknesses - Opportunities Strategy]

To set a clear policy for Smart City development which will assure private business activities

[Weaknesses - Threats Strategy]

To adopt a problem-solving approach and to address urban issues.

The SWOT analysis results can be summarized as shown below.

Table 3.7 SWOT analysis for Smart City project in Bangkok – in comparison with ASEAN cities

External Factors **Internal factors**	Opportunities - International attention towards Smart City in Thailand - Support from international communities - Stable growth of real estate market	Threats - Social and political instability - Vulnerability for natural disasters and other contingencies - Competition with other ASEAN smart cities
Strengths - Linkage with the national development strategy - Government commitment - Incentive scheme for Smart City businesses - Designated area for Smart City	**S-O strategies** - To shift towards knowledge-intensive industry (high-value-added industry) through utilization of abundant and high standard human capital and industrial technology.	**S-T strategies** - To realize a city which could flexibly adapt to needs and challenges by introducing a regulatory sandbox.
Weakness - Uncertainty and complexity for business - Difficulty of business for foreign companies. - Uneven urban form	**W-O strategies** - To set a clear policy in Smart City development which would assure private business activities	**W-T strategies** - To adopt problem-solving approach and to address urban issues

Source: JICA Study Team

3.3.2 SWOT Analysis: comparison with Smart City Projects and Urban development projects in Thailand

The SWOT analysis was conducted to identify the potential and challenges of Bang Sue Area development especially in comparison with other Smart City projects in Thailand.

(1) Strengths

- *Plan for the biggest terminal station in South East Asia - Grand Station, Red Line, Three-Airport Rail Link, and High Speed Railway*

Bang Sue Area will incorporate the Red Line, Three-Airport Rail Link, as well as the High Speed Railway while at the same time incorporating a terminal for long and middle distance buses. When fully developed, it will be a transport hub used by a wide variety of people ranging from locals to tourists and from the young to the elderly.

- *Existence of unique infrastructure and operator*

The land is owned by SRT, and will host Grand Station which will be developed as a new transport hub for Bang Sue Area. In the adjacent area, there is the energy complex building and

PTT head office, to which the gas pipeline extends. Moreover, there is a large bus terminal in the area from which long distance and middle distance buses depart.

- *Existence of prominent company in Thailand*

  Besides the energy complex and PTT head office, SRT plans to have their head office in one of the zones in Bang Sue. Also, Siam Cement Group has located their office in the adjacent area. Thus, Bang Sue is expected to function as a new business district.

- *Availability of large expanse of land for development*

  A large expanse of SRT land – 360ha– is available for development. This is another unique attribute which differentiates Bang Sue from other Asian cities in which the land for development is often segmented and involves long and costly negotiations and coordination with many landowners. With comprehensive and integrated planning, the Area can become a harmonized and liveable city.

(2) Opportunities

- *Potential as a new business district with an innovation-enabling environment*

  Bang Sue Area will be an area that promotes and incorporates Smart technologies and services. Various new businesses related to smart technologies such as the information and communication industry can be promoted in the Area.

- *Connection with Eastern Economic Corridor (EEC)*

  With the railway connecting Bang Sue with the Eastern Economic Corridor, there is potential for a linked economy creating synergy.

(3) Weaknesses

- *Long development period until completion*

  The development of Bang Sue Area will not be completed until 2032. The developer must be able to commit to the project for a long time.

- *Costly investment and difficulty for projection of return*

  Since the Bang Sue project is a green field project, the investment amount is significant, while the profitability of the project is difficult to judge. A legitimate and coherent plan for the development will be needed to convince the investors and business operators.

(4) Threat

- *Lack of integrated and coherent plan and strategy, and disjointed implementation of the project*

  The TOR for the first zone to be developed is currently being discussed and will be finalized soon without an integrated plan that oversees the whole development, or a coherent set of specifications and requirements for the designs, functions, and conditions. This may lead to disjointed and incomplete implementation.

- *Lack of government budget*

  Various investment sources should be explored, due to the budget constraint for the government for infrastructure development.

(5) Strategies for Smart City projects in Bangkok

Given the above-mentioned attributes regarding Smart City projects in Bang Sue, the

implications for preferable strategies are drawn up as shown below:

[Strengths – Opportunities Strategy]

To develop the area as a transit-oriented Smart-City, enabling seamless mobility inside the area while attracting a wide range of people

[Strengths – Threats Strategy]

To establish project implementation structure incorporating Thai leading companies in Bang Sue Area.

[Weaknesses - Opportunities Strategy]

To promote the area as a field for demonstration, where new smart technologies are demonstrated for commercialization.

To promote and attract start-up companies to Bang Sue Area as innovation promotion district.

[Weaknesses - Threats Strategy]

Realization of harmonized development through an area management approach

The SWOT analysis results are summarized as shown below.

Table 3.8 SWOT analysis for Smart City project in Bang Sue

External Factors **Internal factors**	Opportunities - Potential as a new business district with innovation enabling environment - Connection with Eastern Economic Corridor (EEC)	Threats - Lack of integrated and coherent plan and strategy, disjointed implementation of the project - Lack of government budget
Strengths - Plan for the biggest terminal station in South East Asia - Existence of unique infrastructure and operator - Existence of prominent company in Thailand - Availability of large bulk of land for development	**S-O strategies** - To develop the area as Transit-Oriented-Smart-City, enabling seamless mobility inside the area while attracting wide range of people	**S-T strategies** - To establish project implementation structure incorporating Thai leading companies in Bang Sue Area.
Weakness - Long development period until completion - Costly investment and difficulty for projection of return	**W-O strategies** - To promote the area as a field for demonstration, where new smart technologies are demonstrated for commercialization - To promote and attract start-up companies to Bang Sue Area as innovation promotion district.	**W-T strategies** - Realization of harmonized development through an area management approach

Source: JICA Study Team

3.3.3 SWOT Analysis for 7 Smart Components

When considering the Smart elements which can be incorporated into Bang Sue, the ideas were aligned along 7 Smart Components - Environment, Energy, Mobility, Economy, Governance, Living, and People – set up by the Thailand Government. SWOT analysis was conducted for each Smart Component to determine the respective direction and strategy.

(1) Smart Mobility

SWOT analysis on Smart Mobility is as shown below.

Table 3.9 SWOT analysis for Smart Mobility viewpoint

External Factors **Internal factors**	Opportunities - Global trend for low carbon society, rise in environmental awareness - New ideas and technology is being promoted (eg. MaaS, Autonomous Cars)	Threats - High demand density, which could potentially cause heavy traffic in the area - Disjointed planning for transport and land use
Strengths - Bang Sue to become a new Transportation hub for Bangkok - Existing transportation infrastructures such as BTS, MRT, and bus terminal - Large bulk of land for development owned by SRT – transport service operator	**S-O strategies** - To establish a Smart Mobility system which enable seamless mobility inside Bang Sue Area - Collaboration with key stakeholders from public and private sectors	**S-T strategies** - Realization of TOD through integrated transport measures, introducing parking policy and transport management policy.
Weakness - Heavy traffic on the existing road - The area not walkable for transit - Existing infrastructure spatially diving the area (elevated roads)	**W-O strategies** - To introduce and demonstrate new transport technology and service embodying the MaaS concept. - To enhance spatial connectivity through integrated design.	**W-T strategies** - Formation of a valid transportation plan and land use plan for the area.

Source: JICA Study Team

(2) Smart Energy

SWOT analysis for Smart Energy is as shown below.

Table 3.10 SWOT analysis for Smart Energy viewpoint

External Factors **Internal factors**	Opportunities - Thai gov. policies for sustainability - Global trend for low carbon society, rise in environmental awareness - No current infrastructure – opportunity for an alternative system	Threats - Long term for development phase - Zone A opening at very early stage
Strengths - Existence of energy complex and dominant player in the energy sector in Bang Sue - Availability of oil / gas pipeline	**S-O strategies** - Establishment of Smart City network consisting of gas cogeneration system and renewable energy, which is controlled by ICT.	**S-T strategies** - Establish a network system which allows flexibility for phased development. - Establishment of a decentralized energy network with ICT-controlled gas cogeneration and renewable energy.
Weakness - The current Smart City incentive scheme supports only PV - The current regulatory framework do not allow co-generation plants in the city	**W-O strategies** - Establishing a regulatory framework and incentive system which allow more flexibility for alternative energy system.	**W-T strategies** - Formation of a plan which defines the energy supply system requirement, which also takes into account the phased development.

Source: JICA Study Team

(3) Smart Environment

SWOT analysis on Smart Environment is as shown below.

Table 3.11 SWOT analysis for Smart Environment viewpoint

External Factors / Internal factors	Opportunities - Thai gov. policies for sustainability - Global trend for low carbon society, rise in environmental awareness - Bangkok Climate Change Master Plan to be revised (JICA)	Threats - Preference for economic profitability over environmental value - Weak enforcement of environmental regulations
Strengths - Huge green area with notable parks - Almost no current built area (green field project) - Existence of energy complex nearby	**S-O strategies** - To develop to be a model district for "Ecologically and Environmentally Friendly City" - Urban design & building design for eco-friendly city (eg. green area networking, wind trail)	**S-T strategies** - To develop as a district for show-casing advanced eco-friendly technologies by private companies.
Weakness - Developed to be a busy transport hub - Disjointed development, lack of development principle	**W-O strategies** - Collaborative initiative among public, private companies, and local community.	**W-T strategies** - To establish institutional and regulatory framework towards sustainable urban development (eg. Area Management Concept) .

Source: JICA Study Team

(4) Smart Economy

SWOT analysis on Smart Economy is as shown below.

Table 3.12 SWOT analysis for Smart Economy viewpoint

External Factors / Internal factors	Opportunities - Thailand 4.0 Policy - Government support for Smart City (Incentives)	Threats - Competition among cities in Asia - Competition with other commercial development in BKK
Strengths - To be a transportation hub - To be a new commercial center (New CBD : Central Business District) - Huge plot of land	**S-O strategies** - To attract high-value-added industries and start-up companies - To attract tourism - To be a new urban development area	**S-T strategies** - To attract knowledge intensive industry by promoting the area as innovation promotion district.
Weakness - Distance from Bangkok downtown (around 10 km) - Currently low interaction in the area	**W-O strategies** - To aspire globalization by leveraging connection with the airport and EEC.	**W-T strategies** - To enhance interaction among existing facilities (eg. Chatuchak market, Park) and newly developed area.

Source: JICA Study Team

(5) Smart Governance

SWOT analysis for Smart Governance is as shown below.

Table 3.13 SWOT analysis for Smart Governance viewpoint

External Factors **Internal factors**	Opportunities - Government support for digital technology	Threats - Low citizen participation - Low transparency in the governmental procedure
Strengths - The place where people coming and going - Different kinds of people living and working (diversity)	**S-O strategies** - Provision of various governmental services for people coming to Bang Sue	**S-T strategies** - Establishment of a city management committee in which citizen could discuss issue regarding city management.
Weakness - Complex administrative procedures for private businesses in the area	**W-O strategies** - Introduction of on-line public utility management/ administration communication tool	**W-T strategies** - Introduction of One Stop Service Center which handles various kind of permission and contracts management.

Source: JICA Study Team

(6) Smart People

SWOT analysis for Smart People is as shown below.

Table 3.14 SWOT analysis for Smart People viewpoint

External Factors **Internal factors**	Opportunities - Thailand 4.0 Policy; Social Well-being, Raising Human Values - Government support for Smart City (Incentives)	Threats - Social disparity - Weak Social welfare system - Aging society
Strengths - To be developed as place where lots of people come and go - Rich in diversity, with various people living and working - Big companies (e.g. PTT,SCG) - Green area with cultural facilities	**S-O strategies** - To enhance cultural interactions making use of existing facilities and new facilities.	**S-T strategies** - To introduce universal design through barrier-free design and digital infrastructure - To enhance interaction of people through events
Weakness - Few educational facilities	**W-O strategies** - Life-long educational facilities - E-learning with ICT infrastructure	**W-T strategies** - Education-research-exchange activities.

Source: JICA Study Team

(7) Smart Living

SWOT analysis for Smart Living is as shown below.

Table 3.15 SWOT analysis for Smart Living viewpoint

External Factors **Internal factors**	Opportunities - Rise in health awareness - Rise in environmental awareness - Thai gov. policies to promote health and environment	Threats - Aging society - Social disparity - Weak Social welfare system - Various safety issues
Strengths - Huge green area with sports and other facilities (Cycling road, etc.) - Plan for Medical Complex facility at Zone D1 - Not far from Chao Phraya river and surrounded by small canals	**S-O strategies** - To become "health care hub" applying digital tools or attracting a health center in Bang Sue	**S-T strategies** - New (or unique) concept for people attraction from the viewpoint of health and safety
Weakness - Less connection between green area and Bang Sue area (divided by elevated express way)	**W-O strategies** - Networking green, walkable spaces, cycling roads as a place to promote healthy lifestyle. - To establish a network with hospitals and health care facilities.	**W-T strategies** - Introducing universal design policy - Introducing city management policy

Source: JICA Study Team

(8) Directions for Smart Factors in Bang Sue Area

Overviewing the major strategies for the above seven smart components, the directions for approaches regarding smart city development in Bang Sue are set as follows.

Table 3.16 Direction for Smart City Development in Bang Sue

Smart components	**Basic strategy, based on attributes**	**Basic direction**
Smart Mobility	- Introduce advanced mobility system and achieve seamless transfer within the Bang Sue Area. - Realize TOD through comprehensive transport policy such as parking/traffic management.	- Secure more comfortable, convenient transportation systems for residents, workers and visitors that enable smooth mobility and create a lively atmosphere. - Introduce ever advancing mobility technologies at its early stage to realize a new traffic hub for Bangkok.
Smart Energy	- Demonstrate global standard business environment with sophisticated energy technologies, etc. - Establish decentralized energy network, consisting of ICT-controlled gas cogeneration system and renewable energy.	- Set the Area as a field to introduce energy system friendly both to the environment and to society, in order to shift to low carbon and ecological society. - Establish sustainable, resilient energy system suitable for a new business district for Bangkok.
Smart Environment	- Develop the Area as a model area for "environmentally friendly city."	- Realize Area development that harmonize with natural environment. - Raise awareness on the environment issues among companies located in Bang Sue and

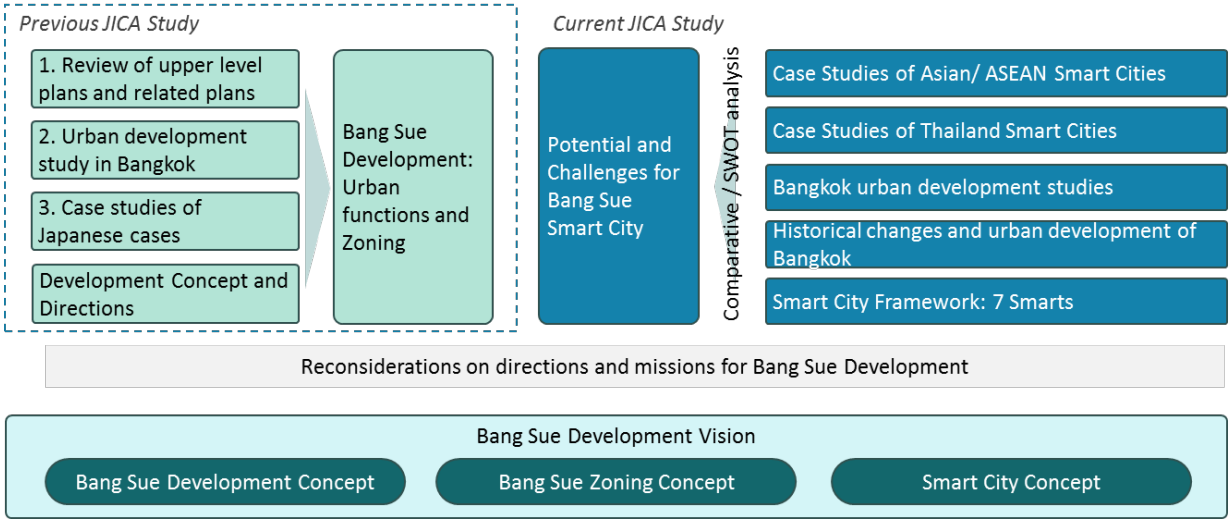
Smart components	Basic strategy, based on attributes	Basic direction
		people to encourage environmentally friendly activities.
Smart Economy	- Attract high-value-added industries and new enterprises. - Enhance interaction among the existing resources (eg. Chatuchak Park market and parks) and new development to vitalize the area.	- Realize diverse and connected area which would be a foundation for new industries and innovation. - Create lively atmosphere.
Smart Governance	- Achieve effective administrative management with the introductions of online public utility management and communication tools.	- Enhance effectiveness of urban operation, utilizing data through digital infrastructure and IT devices.
Smart People	- Encourage integration of the existing resources (eg. Chatuchak Park market and parks) with new culture facilities (MICE facility or exhibition facility, etc.)	- Encourage learning and inspiration experiences through interactions with diverse people, goods and information.
Smart Living	- Develop, the Area as health promotion district, by developing green network connecting with parks and surrounding facilities, walking space and cycling road.	- Promote area development and lifestyle that aims to realize healthy life and symbiosis with the nature.

Source: JICA Study Team

4. Smart City Concept for the Bang Sue Area

4.1 Vision and Concept

Urban functions, zoning, and general plans presented in the past fiscal year's research are referred to as a basis in considering the vision and concept for Bang Sue's smart city development. Specifically, the essences and directions of the development vision and concept set forth in the past study were followed and thus elaborated, while smarts city elements were incorporated into them to set a new concept and a vision.



Source: JICA Study Team

Figure 4.1 Flow for the Vision and Concept

4.1.1 Existing Master Plan

(1) Vision and Concept of the Existing Master Plan

The concepts and vision proposed in the past fiscal year's research are as shown below. Terms such as "International", "Diversity", "Transportation Hub", and "Public-Private Integration" have been advocated as keywords.

Table 4.1 Essence of the Draft "Development Concept Paper"

Essence	Contents
Vision	Gateway to "City of Angels"
Basic Concept	Concept 1: To grow up to a centripetal urban core in Bangkok Metropolitan Area, which plays important roles in the international community. • To form an international and regional business and interaction center. • To ensure sustainability including safety and environmental friendliness. Concept 2: To create an eternally beloved new central district full of various attractiveness. • To create various attractions of urban life, from old to new, from a bustle of market places to ultramodern skyscrapers. • To create a comfortable walking space so that everyone would enjoy strolling along decks and paths in the area. Concept 3: To create a visitor-friendly traffic terminal area comfortable for everyone.

Essence	Contents
	• To create a world-class traffic terminal area comfortable for both Thai and foreign visitors. • To upgrade the user-friendliness in terms of transfer by creating public spaces. Concept 4: To stepwisely realize the conceptual plan by both public and private sectors. • To enhance all kinds of partnership between public-private and private-private, beside a strong initiative by the public, in order to properly realize the conceptual plan.

Source: JICA "Data Collection Survey on Urban Redevelopment in Bang Sue Area"

Table4.2 Plan Formulation Policies

Policy	Matters for Care and Consideration
(1) To grow up to a centripetal urban core in Bangkok Metropolitan Area which plays important roles in the international community	• To elaborate an integrated master plan for successful redevelopment of the entire area. • To place core facilities including a landmark tower building, a smart city, etc. • To introduce attractive urban functions that boost development potential of the entire area.
(2) To create an eternally beloved new central district full of various attractiveness.	• To introduce the main facility to connect and organize each zones • To develop infrastructure and public spaces that make the entire area more attractive. • To prepare a guideline to promote a well-balanced area development. • Introduce upgraded infrastructure and facilities that will contribute to increasing the potential of the district. • Place (and guide people to) applications and functions that will increase the potential of the entire area. • Introduce guidelines for driving planned urban development.
(3) To create a visitor-friendly traffic terminal area comfortable for everyone.	• To ensure comfortable transfer between railway stations and other transport modes. • To construct pedestrian decks and plazas. • To introduce a feeder transport mode (ex. BRT) and make the best use of ITS in the area.
(4) To stepwisely realize the conceptual plan by both public and private sectors.	• To elaborate a stepwise implementation plan ensuring feasibility and viability. • Consider an appropriate division of labor to ensure a "win-win" To introduce vitality and resources of private sector. • To consider the best role-sharing system that ensure a win-win partnership for both public and private sectors.

Source: JICA "Data Collection Survey on Urban Redevelopment in Bang Sue Area"

In the "International" aspect, Bang Sue area has been conceptualized as an international hub for Bangkok in The Twelfth Five-Year National Economic and Social development Plan (2017 - 2021).

(Reference) The Twelfth Five-Year National Economic and Social Development Plan (2017 – 2021)

"To promote Bangkok to be the center of international business hub; educational center; international health and medical center, with high standard information and communication technology, in intermodal nodes, e.g., ***Bang Sue. Cities should be developed with adequate allocation of land use, public utilities and facilities, social services, and housing.*** *In order to respond to the demand from increasing population, it shall consider solving urban environmental problems such as traffic congestion, solid waste, wastewater, air pollution, as well as providing better townscape, green areas, and public parks."*

With regards to "Transportation Hub" aspect, in comparing and considering role sharing with Makkasan and Mae Nam, the urban and transport functions required in Bang Sue were outlined as follows.

Table4.3 Urban and Transport Functions for Three Locations Owned by SRT

Area	Required Urban Functions	Required Transport Functions
Bang Sue	• Office facilities accumulated around Bang Sue Grand Station • Interaction, tourism, and hotel facilities linked to existing tourism resources such as Jatujak Market and parks • Other urban functions including commercial and residential facilities	• Good connectivity among Bang Sue Grand Station, MRT Bang Sue Station, and SRT Bang Sue Station. • Relocation of Mochit Bus Terminal and local bus stops • Intra-area transport such as BRT • Walkways
Makkasan	• Office facilities accumulated around Makkasan Station • Functions as national and international information center • Functions for visitors such as conferences rooms and hotels	• Boosting demand for Airport Rail Link (ARL), land use, and population distribution along ARL • Ensuring walkway connecting Makkasan Station and buildings • Controlling traffic in the area
Mae Nam	• Residential, office and commercial facilities with an image of water front for branding • Commercial function for the people living around the stations • Open space for interaction	• Improvement of connectivity to SRT Mae Nam Station and BTS Gray Line Station • Ensuring walkway connecting Mae Nam Station and buildings

Source: JICA "Data Collection Survey on Urban Redevelopment in Bang Sue Area"

Furthermore, the following urban functions are proposed for "Diversity" aspect in the Bang Sue area.

(Reference) Approaches with the Industrial Promotion in Bang Sue Area (extracted from the previous JICA's study report)

Bang Sue is a large-scale redevelopment district fully accessible from the airports and the existing central business district (CBD). In addition, considering the specific fields mentioned in the superior plans (the 20-year National Strategic Plan, the 12th National Economic and Social Development Plan, Thailand 4.0 etc.), it seems that an ideal industrial promotion in the area shall focus on sectors such as **MICE, tourism, medicine/health, and research and development (R&D).**

More specifically, Thailand can aim to further strengthen its MICE industry — which the country has expanded and predominates within the ASEAN countries — along with its medical/health tourism industry and biotechnology R&D industry. In this attempt, the country could consider integrating their **large scale MICE venues, advanced medical care, health-related industries/universities, and research institutions**, as well as develop medical/health related human resources/industry under their collaboration.

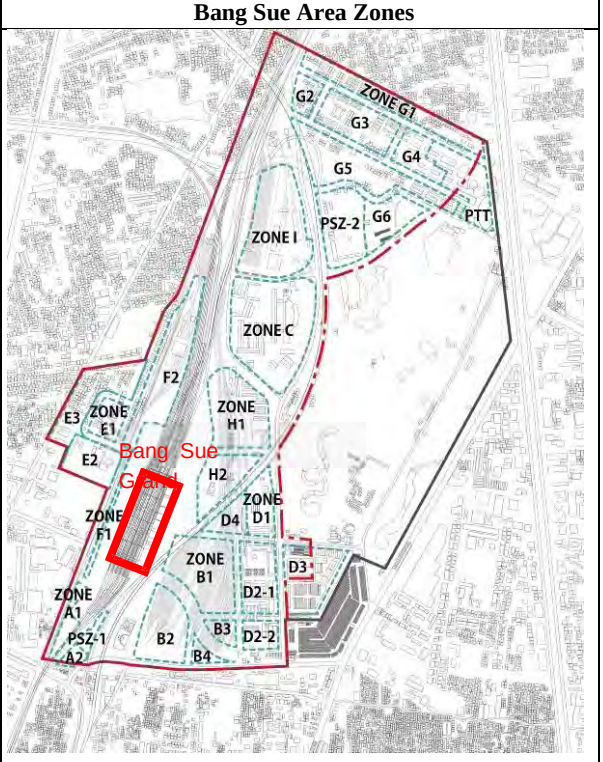
(2) Development Plan of the Existing Master Plan

The zoning and urban functions of Bang Sue Area are as summarized below.

Table4.4 Urban Functions to be assigned by Zone

Zone		Urban Functions to be Assigned
Zone A	1	Office/ commercial/ hotel
	2	Commercial
Zone B	1,2	Residential, commercial, office
	3,4	Commercial
Zone C		Super arena or MICE facilities of the same kind
Zone D	1	Hotel/ residential/ office/hospital (high-end constructions in expectation of the increase of foreign guests)
	2	Residential/ commercial/ hotel/ office
	3	Residential/ commercial/ hotel/
	4	Residential/ office
Zone E (SRT Land)	1,2	Office/ commercial (including a high- rise which will be one of the main landmarks of Bang Sue Area, Knowledge center and incubation office space) Civic center (future headquarters of MOT)/ residential
	3	Residential
Zone F	1	Commercial (retail shops to be constructed under skydecks around Bang Sue Grand Station)
	2	Office /commercial (including amusement facility) /residential/ hotel
Zone G (KM 11)		High-end residential (garden city with abundant greenery space)/ commercial/ office/ hospital/ school
Zone H	1	Office/commercial/residential
	2	Office/commercial/residential/hotel
Zone I		Residential (high-rise condominiums)/ commercial

Bang Sue Area Zones



Source: JICA "Data Collection Survey on Urban Redevelopment in Bang Sue Area"

4.1.2 Direction of the Bang Sue Development

The basic direction for development are summarized as follows. This is based on the potential and obstacles of Bang Sue as a smart city (from the previous chapter) and the visions, concepts, and basic plan presented in the past fiscal year's research (from the previous section).

(1) Summary of attributes and potentials for Bang Sue Area development

Following the considerations in the previous sections, attributes and potentials of Bang Sue Area development could be outlined as below:

1) ASEAN regional context

- **Area-based approach:** A specific Smart City development site is designated in the Bang Sue Area
- **Multi-sectoral approach:** The Smart City development project is targeted to solve various urban issues by urban and spatial planning

2) Bangkok urban context

- **TOD approach:** Various roads and railways intersect while the existing bus terminal connects the suburban and regional areas. There is a huge potential for becoming a highly convenient transit hub.
- **New urban core development:** The area is distant from the traditional urban core and business center, which presents a huge potential for becoming a new CBD in Bangkok.
- **New urban form:** Away from the busy and dense built area of the traditional urban area, Bang Sue could present a new urban form for Bangkok.

3) Bang Sue district context

- **Existence of prominent Thailand companies:** PTT and Energy Complex, offices of SCG is located in the area, and there is a plan to establish Head Office of SRT. There is a potential for formation of new business district by agglomeration of these prominent Thailand companies.
- **Large green area:** Chatuchak Park is known for one of the largest parks in the city and place for rest.
- **Unique infrastructures:** Existence of gas pipeline, as well as transport related infrastructures such as train station, bus terminal, and highways constitute a unique infrastructure setting.
- **Traditional urban lifestyle:** Chatuchak Weekend market and residential areas are representative of traditional urban lifestyle in Bangkok.

4) People and user-wise context

- **Diversity of people:** People of wide age range and income level, with various purpose, different place of residence, nationality is expected to come to the area.

(2) Mission for Bang Sue Smart City Development

The mission for Bang Sue Smart City Development could be outlined as below:

- ❖ To create a new urban core which would be a hub for business, living and recreation.
- ❖ To fulfill the potential of the "Largest Station in South East Asia" Through TOD approach.
- ❖ To propose a new urban lifestyle by merging the traditional and modern global trend.
- ❖ To serve as a show case model for ASEAN cities by embodying problem-solving approach.

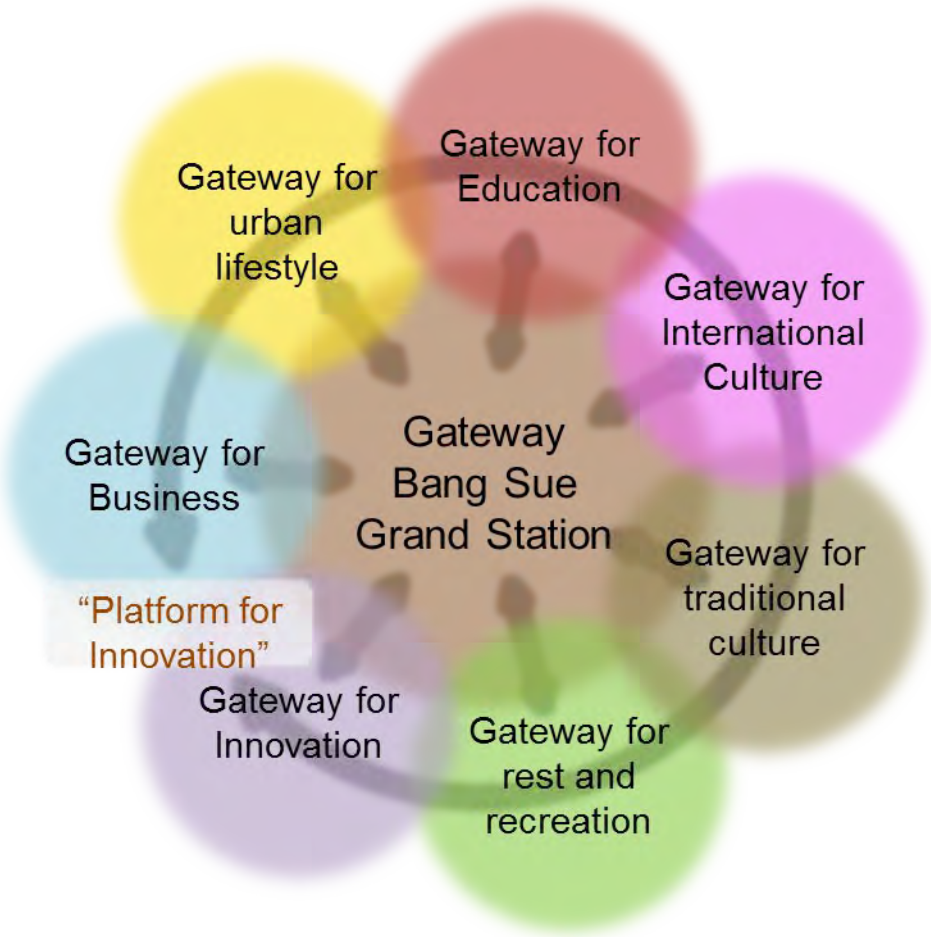
4.1.3 Bang Sue Smart City Development Vision and Concept

(1) Development Vision: “Global Gateway Bang Sue”

The development vision that the Study Team propose is:

“Global Gateway Bang Sue”

The Area is envisioned to become a city where new businesses and industries, educations, lifestyle and culture come together, merge and take-off.



Source: JICA Study Team

Figure4.2 Development Vision: “Global Gateway Bang Sue”

The future Bang Sue Area will be an innovative city in which lifestyles can be diverse, prosperous, and progressive than was ever before in Thailand. Smart city features such as Smart Mobility, Smart Economy, and Smart Education will accelerate people’s activities across the office, residential, educational, and commercial areas centering Bang Sue Station. The existing resources and culture in the Bang Sue area – for example the park and Chatuchak market – will synchronize with the new features to create a whole new vibe.

The coordinated smart city technology and services will nurture both the city and the people who work and live there. The Bang Sue-born-technologies and urban systems that could be become a successful model to which other cities in Thailand, and Asia could refer.

There are seven gateway components to support this vision:

- **Gateway for Business** to create new type of industries by connecting globally established companies with local/ start-up companies.
- **Gateway for Urban Lifestyle** to promote a sustainable and convenient lifestyle by connecting people with smart lifestyle technologies.
- **Gateway for Education** to enabling young generation to learn, or get inspiration by the new and trending ideas, while encouraging all generation for lifelong learning by promoting interaction with new technologies, educational facilities including schools, and other learning opportunity.
- **Gateway for International Culture** to promote encounter with various culture and global or modern trend by facilitating interactions among local and international people, events and commodities.
- **Gateway for Traditional Culture** to facilitate and set out Thailand or Bangkok's culture by promoting interactions between local and international people, events and commodities.
- **Gateway for Rest and Recreation** for people to come and relax, have time off from the urban clamour by connecting people with green open spaces, recreational facilities, and recreational events.
- **Gateway for Innovation** to spread new ideas and technologies created by interaction among industry, public, and academia.

Weaving together each of the seven gateway function is the Smart City function – the "Platform for Innovation" which catalyse connection and interaction to support the continuously evolving city.

(2) Bang Sue Smart City Concept: "Platform for Innovation"

The Smart City function would be the foundation on which the vision of "Global Gateway Bang Sue" would stand. The Bang Sue Smart City shall be developed embodying the concept of "Platform for Innovation", a platform which catalyze connection and interactions among people, businesses, social needs, technologies and culture. Through connections and interactions, Bang Sue would become a place where people get inspired. innovative ideas would be generated and thus implemented and demonstrated in the Area to enhance living comfort or to solve urban issues.

Source: JICA Study Team

Figure4.3 Bang Sue Smart City Concept: "Platform for Innovation"

The stations in and around Bang Sue area are the platform for people to come and go physically. At the same time, Bang Sue area itself will conceptually function as the "platform" to create innovations as a whole.

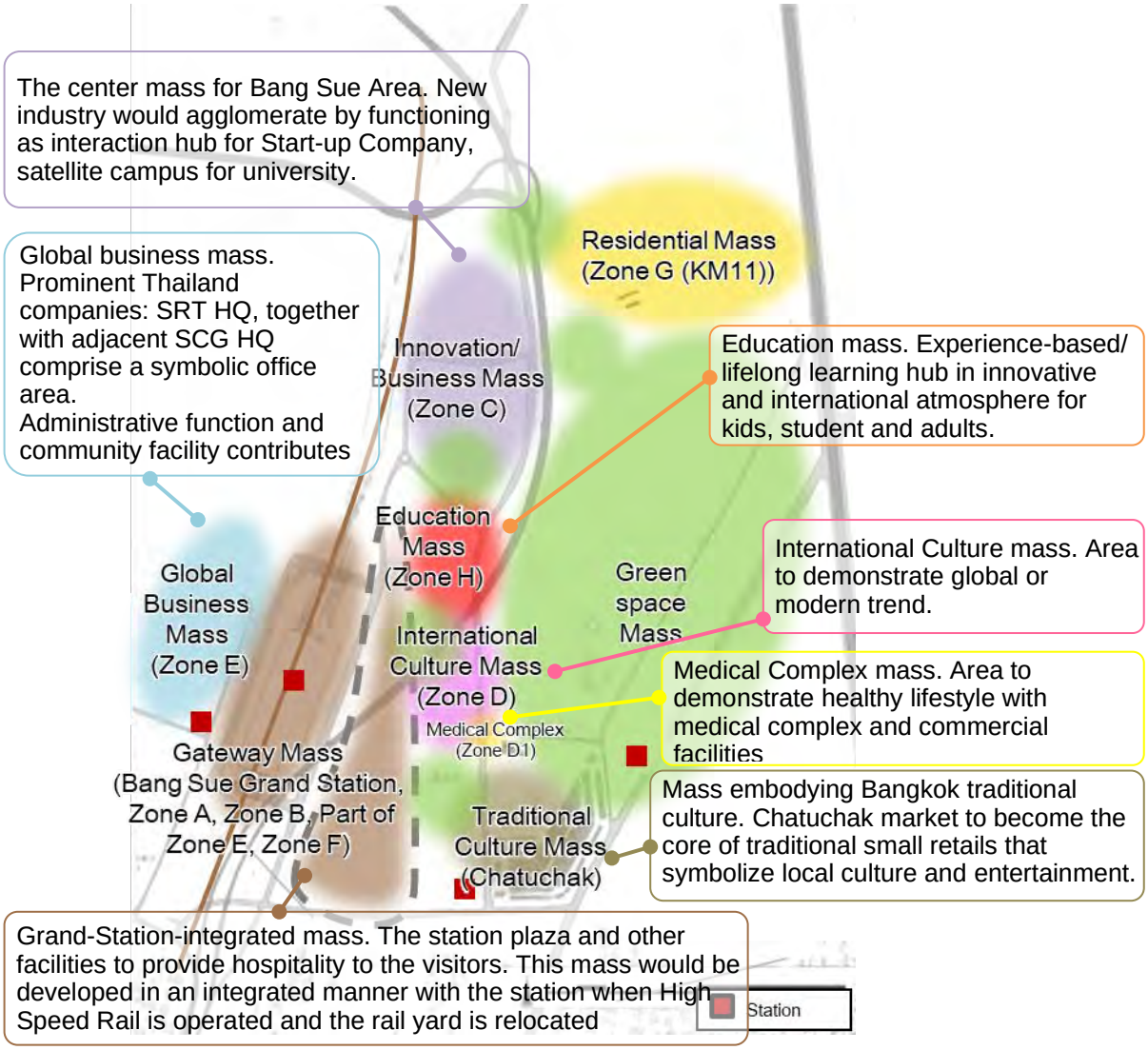
In a more concrete term, people, who has multiple missions and problems get on and off the train at the Bang Sue Grand station, have a chance to come across the good partner with good idea for innovations on the "platform". Bang Sue area is the place where they can share the problem and make an innovation with their own ideas and technologies with a lot of innovative start-ups and labs, Bang Sue will become the global business hub in Asia.

(3) Bang Sue spatial planning concept

The zoning of the area is redefined to embody the concept.

Zones are reorganized to a larger unit of a mass. A distinct function is assigned to each mass so that the activities inside the zone are promoted and enhanced, while effectively interlinking with each other to catalyze a "chemical reaction", which further vitalize activity and inject new element to the area.

Meanwhile, a sky deck network and public transport network would be developed to enable active movement and interaction of people. Bang Sue Development Concept and Smart City Criteria of Thailand.

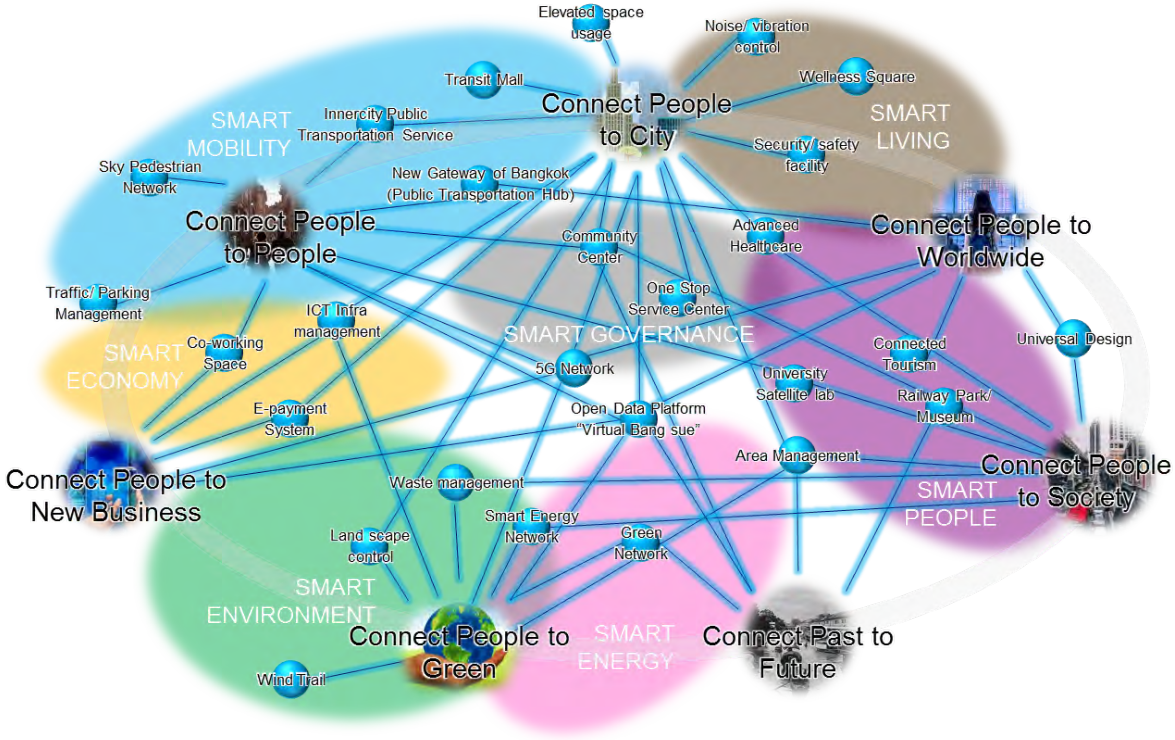


Source: JICA Study Team

Figure4.4 Bang Sue spatial planning concept

(4) Bang Sue Smart City Concept application

Smart technologies and services function as the applications for realizing connection. The proposed smart technologies and services conforms to Thailand's Smart City Framework of "Seven Smarts".



Source: JICA Study Team

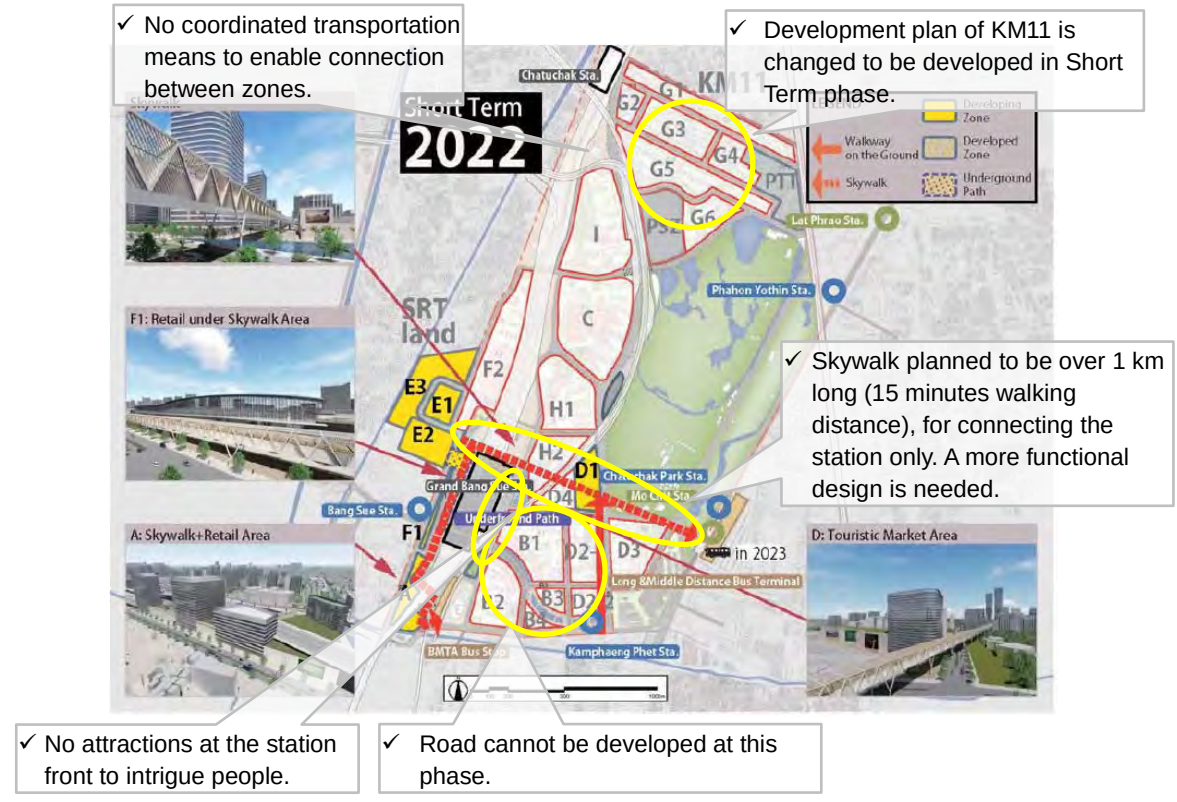
Figure4.5 Bang Sue Smart City Concept and Smart City Criteria of Thailand

4.2 Integrated Spatial Planning

4.2.1 Issue on spatial planning for Bang Sue regarding current situation and master plan

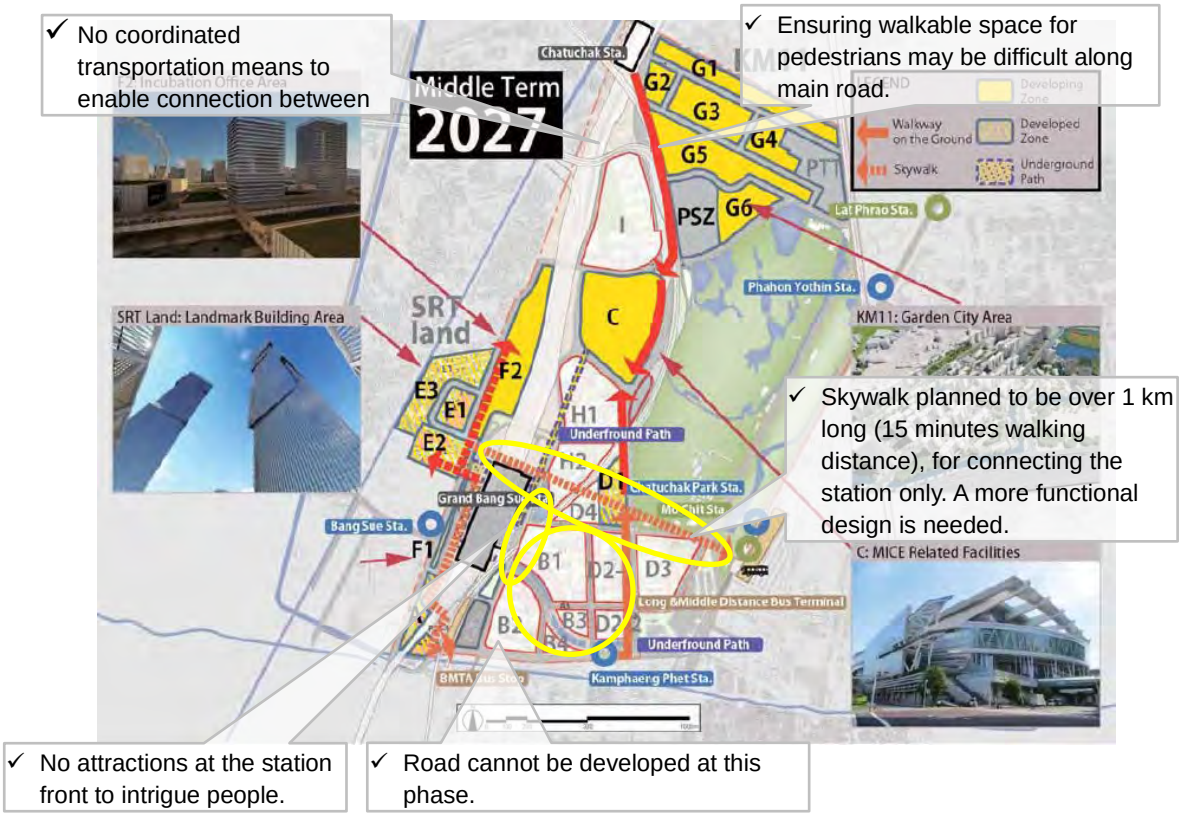
Listed below are the issues of spatial planning for Bang Sue with respect for the current situation and the masterplan.

- The existing railway, the elevated railway currently under construction, the trunk roads, and the elevated expressway spatially divides the area. To enable access between eastern zones and western zones, overpass or underpass would be necessary at crossings with railway and roads.
- Measures are needed to enable smooth mobility of the people, especially given that distance between stations and zones are longer than five-minute-walking distance.
- Overall design for built environment is needed to be considered, taking into account natural environment such as wind flow, sunlight while also harmonizing with adjacent areas such as Chatuchak Park. The current plan proposes buildings standing higher than 100m.
- Consideration of connection and interactions within the area, and with outside the area is needed.
- Back bone infrastructure to promote real estate private investment would be needed to be established in early stage. The infrastructure system should allow for phased development for usage over 100 years.
- Universal design should be introduced so as to enable comfortable living, working and transport for all people.



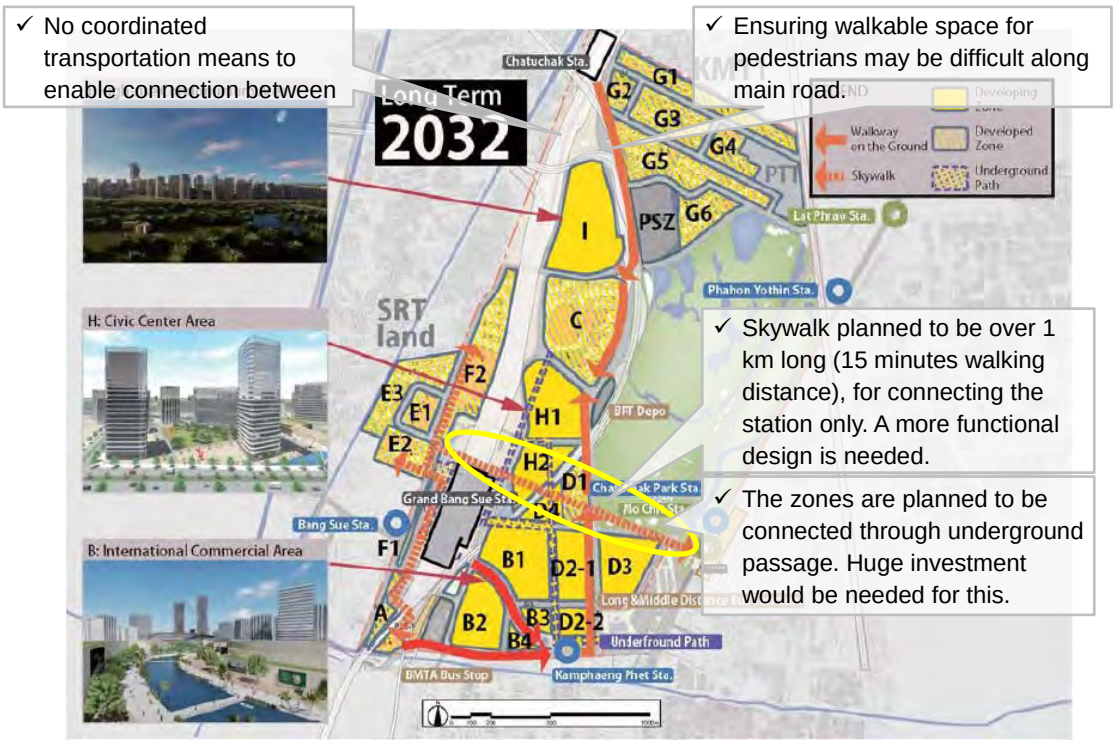
Source: JICA Study Team

Figure4.6 Issues of spatial planning: short term development plan



Source: JICA Study Team

Figure4.7 Issues of spatial planning: middle term development plan



Source: JICA Study Team

Figure4.8 Issues of spatial planning: long term development plan

4.2.2 Direction for measures and integrated design concept

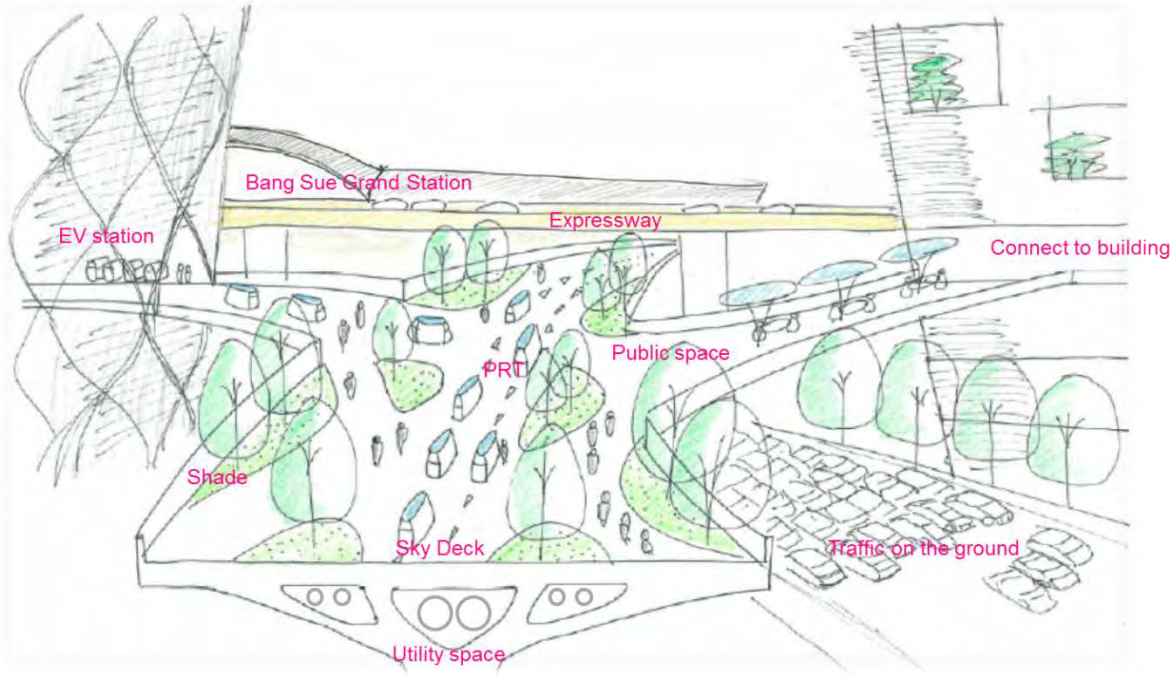
(1) Directions for integrated design concept

To resolve the issues raised in the previous section and to enhance attractiveness as an urban space, directions for measures are outlined below:

- Development of an Mobility Network consisting of Sky Deck Network and Public Transport Network which covers the whole area and connects main area and facilities
- Ensuring integrity as an urban space by establishing a policy (guideline) which would orient private investment in a coordinated manner, for example, securing green building and green spaces, ensuring good access and connection to the above mentioned Mobility Network; introduction and utilization of green/ efficient energy.
- Coordination with the currently existing infrastructures.
- Phased infrastructure development which synchronizes with the planned development scenario, especially the railway depot and bus terminal facility.

(2) Infrastructure system for integrated design concept

The utility, transport and other infrastructures are proposed to be implemented in the whole area as one system. This would contribute to enhancing the efficiency as a whole, while producing and directing an integrated area development in both functional and perceptional sense. As infrastructure systems to support the integrated design the Study Team proposes systems such as: sky deck network, the utility network, and data platform. The figure below indicates the conceptual image of integrated design for the Bang Sue Area.



Source: JICA Study Team

Figure4.9 Conceptual image of integrated design for Bang Sue

Based on these spatial design concept, the image perspective of the Bang Sue Area after full phase development is elaborated as follows.

Source: JICA Study Team

Figure4.10 Perspective view of the Bang Sue Area under integrated design

1) Sky deck network

The development of sky deck network is proposed as a key concept which could enhance the connectivity between separated zones and realize the integrated development of Bang Sue. Although the proposed concept of sky deck network and transport network including PRT (Personal Rapid Transit) is described in detail in a later section, the sky deck network could create public spaces with greens and realize Walkable City with eco-friendly transport.

2) Common utility connecting network (Common duct)

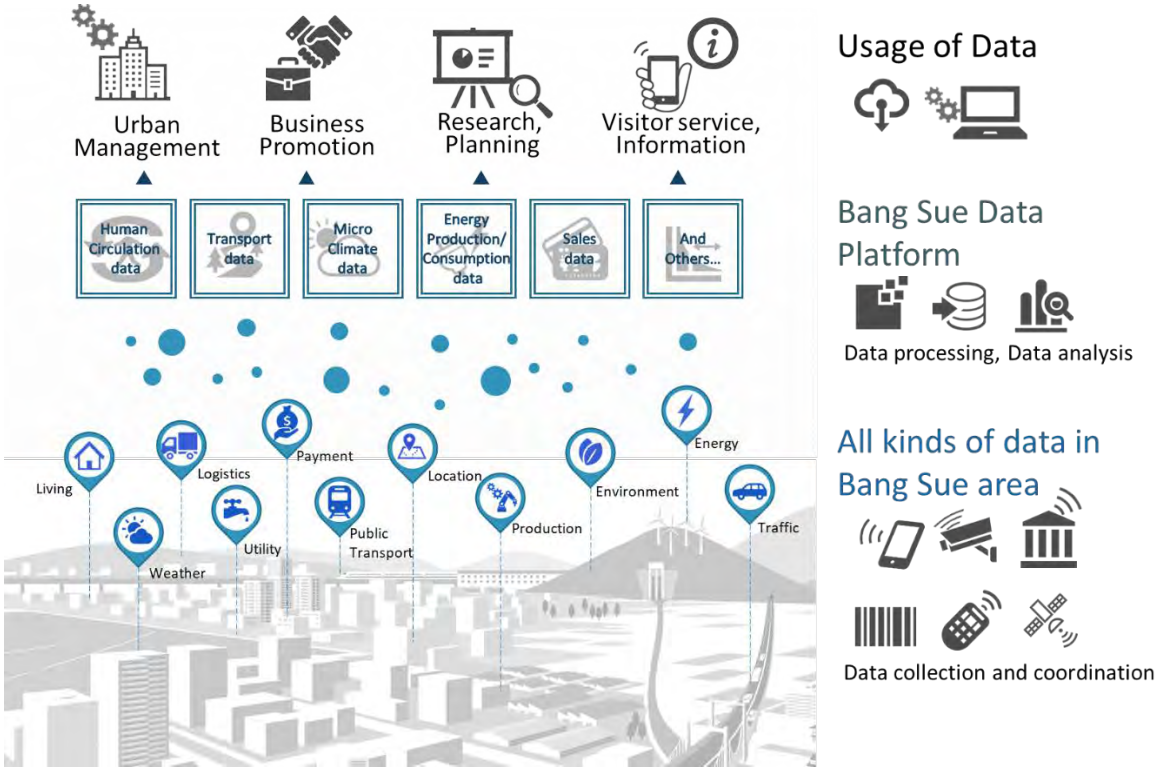
The development of common utility infrastructure network, which could accommodate different utility supply pipelines such as electricity, gas, cooling water pipe and communication cable, is proposed as an indispensable infrastructure for the Band Sue Area. In Japan, for example, the installment of common ducts in main roads has been contributing to realize efficient operation and maintenance of utility supply pipelines in the urban development areas. This is because those common ducts is designed to have enough spaces enabling engineers and mechanics to go through for maintenance and rehabilitation works. In addition, expansion of infrastructure networks according to the phased development of zones becomes easier by installing common ducts in advance. Furthermore, the construction of common ducts will also enhance the resilience of the city and improve city scape and efficient land use. Those common ducts have been constructed with appropriate cost sharing between public and private sectors in Japan.

3) Data platform

Establishing a framework and system to collect and utilize the various kinds of data generated in the city is becoming a recent trend for Smart City development across the globe. In Bang Sue area, all kinds of data ranging from: people's activity data (e.g., transport data, payment data,

other activity data), facility and infrastructure operational data (e.g., energy usage data, public transport operation data, facility service operation data), and external data (e.g., weather data, environment data, and other relevant data) could be collected and aggregated in a database. Through a data platform – "Bang Sue Data Platform", these data could be extracted, analysed and thus be utilized for many purposes depending on users' needs, such as: optimized operation planning; business promotion and marketing; or application for adaptive maintenance of infrastructures and facilities.

The early development of data platform would be expected to providing foundation on which big data would be collected, analysed, and then utilized for integrated and effective management and development of the city.



Source: JICA Study Team

Figure4.11 Conceptual image of Bang Sue Data Platform

Three Smart Component of: Smart Mobility, Smart Energy, and Smart Environment are focused in this study, as these three components were identified as focal area following consultation with Thailand Government and stakeholders. The project concepts are described in the following sections based on the three focal Smart Components.

4.3 Smart mobility

Through discussions with government agencies and related organizations in Thailand, it was confirmed that the Bang Sue area, which has a new terminal station, is expected to serve as a major transportation base in the Bangkok region and the priority of smart mobility planning which becomes a model of other cities is high. In the Bang Sue area development, how to respond to the diverse transportation needs of people inside and outside the area and how to think of smart mobility as a solution in such a response has been discussed as an important issue.

In this section, the concept design of smart mobility in the Bang Sue area based on these discussions and analysis of traffic around the Bang Sue area is examined.

4.3.1 Current Mobility Situation around the Bang Sue Area

Following the motorization in Bangkok, traffic congestion in the area has deteriorated, while many countermeasures have been implemented by different actors. For example, according to a report by the Traffic and Transportation Department of BMA, the average speed on main roads dropped from 22km/h in 2009 to 19km/h in 2012, whereas the number of vehicles in Bangkok increased from 6.1 million units to 7.5 million units. On the other hand, the modal share of Mass Transit is estimated to increase from 5.8% in 2015 to 20.7% in 2029 (BMA), since the mass transit network will be expanded in Bangkok.

The increase of car use has caused various environmental degradation such as noise pollution, air pollution and increase of Green House Gas (GHG) emission. In fact, the transport sector is estimated to account for more than 30% of GHG emission in Bangkok in 2013. In addition, the percentage would increase in 2020, if an effective countermeasure would not be applied (The Bangkok Master Plan on Climate Change 2013-2023).

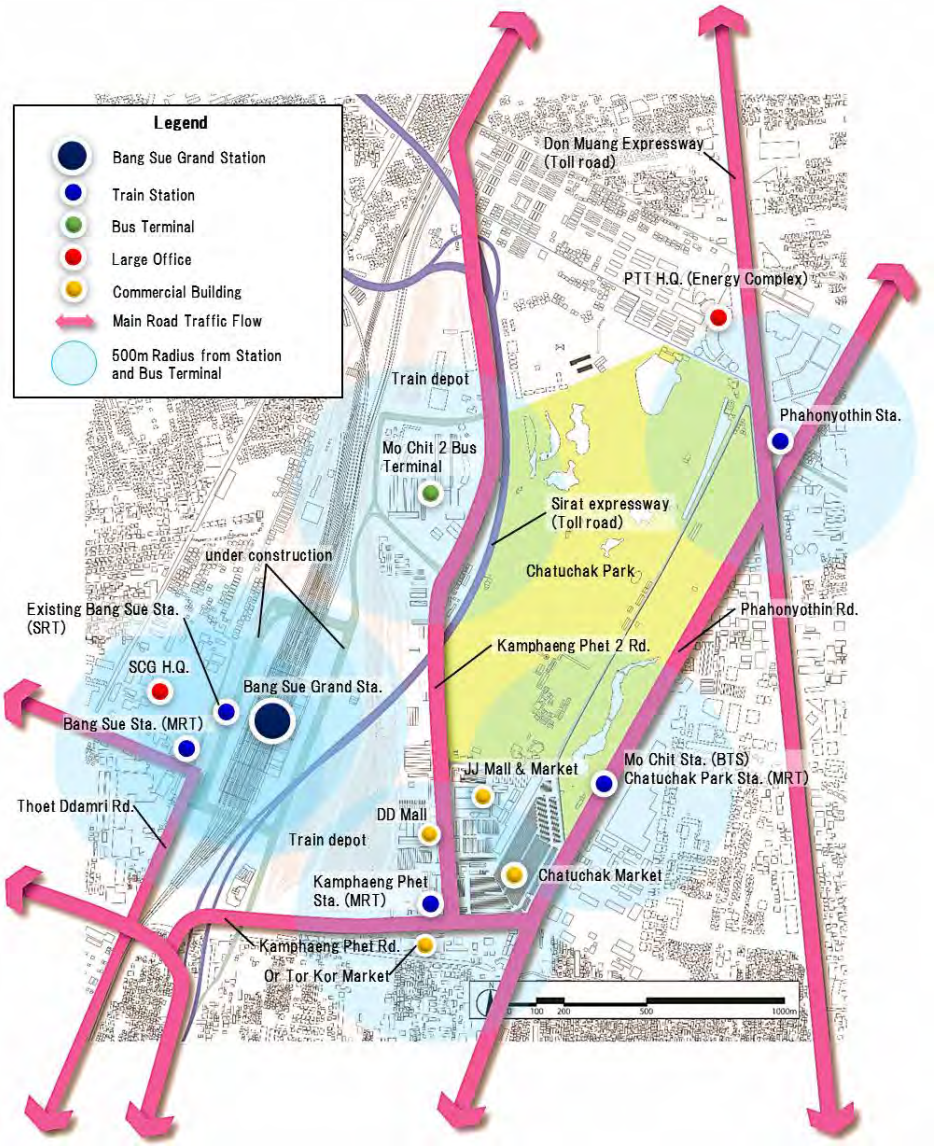
Source: JICA Study Team

Figure4.12 Traffic congestion in Bangkok (left: near Asok Station, right: Bang Sue Area)

There are several important transport facilities around the Bang Sue Area. For instance, there are several operating railway stations, such as Bang Sue Station for local long distance trains of SRT; Bang Sue Station; Kamphaeng Phet Station and Chatuchak Park Station of MRT; and Mo Chit Station of BTS. According to the last JICA Study, Chatuchak Park Station and Mo Chit Station each have more than 40,000 passengers per day. Besides, the Mo Chit 2 Bus Terminal works as a terminal for both long distance and short-distance buses, operated by Transport Co., Ltd, a state company under the MOT. It has different bus routes to the northern and northeastern Thailand and neighbor countries. Bangkok Mass Transit Authority (BMTA) operates another terminal for

the buses of inner-city routes in the Mo Chit 2 Bus Terminal. The Mo Chit 2 Bus Terminal serves 38 million passengers and 2.3 million bus trips in a year (from October 2015 to September 2016). It means there are more than 100,000 passengers and 6,000 arrivals and departures of buses on average every day.

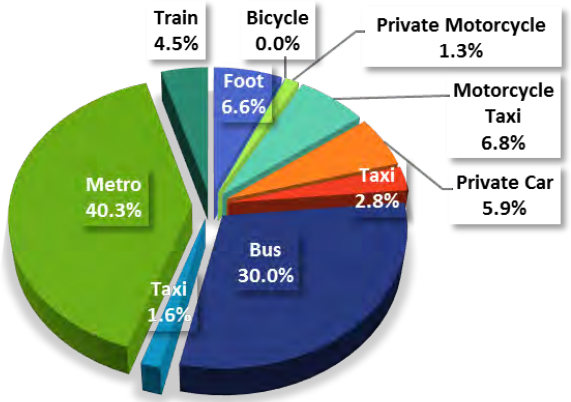
In addition, a number of trips is generated by office workers, residents and visitors around the Bang Sue Area. Head Quarters of PTT and SCG have many commuters on weekdays. Many people visit the Chatuchak market, Or Tor Kor Market and go shopping at commercial buildings such as JJ Mall, JJ Market and DD Mall, especially on the weekends. Furthermore, the Bang Sue Development Area includes some residential areas, which are Zone E (SRT Land) with 509 households and Zone G (KM11) with 1,931 households, according to SRT. The last JICA Study estimated that the numbers of residents are approximately 2,000 in SRT Land and 7,000 in KM11. Hence, regarding the transport to the Bang Sue Area and inner transport in the area, various people used different modes of transport, such as bus, MRT, BTS, Motorcycle Taxi, Private Car and Foot, for their different purpose. Main road traffic flow and facilities around the Bang Sue Area would be shown in the following figure.



Source: JICA Study Team

Figure4.13 Road traffic flow and key facilities around Bang Sue Area

The figure below indicates the modal share based on the interview survey in the Bang Sue Area implemented by OTP in 2016. Metro and bus seem to be often used to visit the area with the share of 40.3% and 30.0% respectively.



Source: OTP, 2016

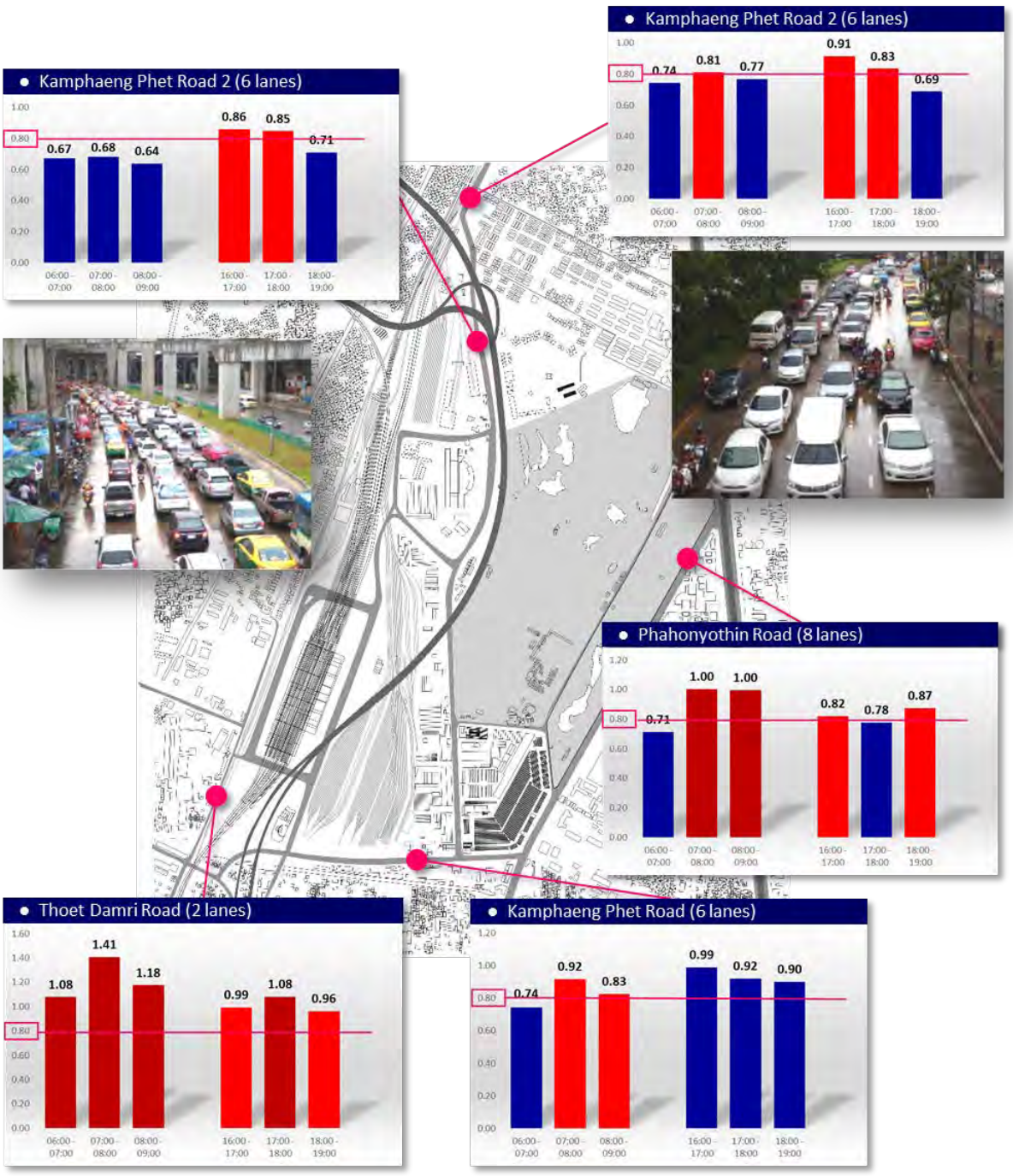
Figure4.14 Modal share in Bang Sue Area based on OTP interview survey (2016)

Regarding road traffic condition around the Bang Sue Area, there are arterial roads with a lot of daily traffic volumes. Kampaeng Phet Road with 6 lanes and Phahonyothin Road with 8 lanes are respectively located in the southern fringe and the eastern fringe of the Bang Sue Area. Kamparng Phet 2 Road longitudinally runs in the area with 6 to 8 lanes. These roads seem to have important roles not only for short trips but also long-distance traffic flows from the city-center of Bangkok to northern part of the city and north-western local regions.

The following figure shows the Volume-to-Capacity Ratio (VCR[1]) of arterial roads around the Bang Sue Area in rush hours, calculated using the result of the traffic survey conducted by OTP in 2016. As shown in the figure, all arterial roads around the Bang Sue Area most likely have rush hours with traffic congestion, reaching more than VCR 0.8. Although those roads have more than 6 lanes, current number of vehicles are quite intensive. For instance, the traffic volume of Phahonyothin road reaches around 10,000 PCU in a peak hour. Kamphaeng Phet 2 Road has more than 6,000 PCU/hour in rush hours. Thoet Damri Road, a local road located in the western side of the Bang Sue Grand Station would be mostly congested in rush hours, as its VCR is remarkably high.

In terms of spatial characteristics of traffic flow on the ground level in the Bang Sue Area, it is noted that the whole area is separated in eastern-western direction by the Sirat Expressway, Kamphaeng Phet 2 Road and railways connecting train depots which lie north and south.

[1] VCR is one of the most used indicator to evaluate the level of service (LOS) of road traffic status for a roadway or an intersection. If VCR is greater than 0.8, traffic condition is likely inappropriate with traffic congestion.



Source: JICA Study Team based on the traffic survey by OTP in 2016

Figure4.15 Volume to Capacity Ratio (VCR) of arterial roads around Bang Sue Area

Figure4.16 Kamphaeng Phet Road (left) and Kamphaeng Phet 2 Road (right)

4.3.2 Future Transport Demand and Existing Mobility Plan

It is expected that there would be a vast amount of railway passengers using the Bang Sue Grand Station and other surrounding stations with the expansion of railway networks and the urban development. The table below shows the future demand of daily passengers for the Bang Sue Grand Station and other stations forecasted by OTP. According to the estimate, the passengers of the Bang Sue Grand Station would be about 1.2 million passengers per day by the year 2032.

Table4.5 Passenger demand of Bang Sue Grand Station and other stations estimated by OTP

Station		2022 (people/day)		2032 (people/day)		2037 (people/day)	
		Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
Bang Sue Grand Station	Dark Red Line	105,600	106,100	185,200	185,100	217,100	218,000
	Light Red Line	65,400	65,900	89,000	88,500	96,900	96,900
	Long Distance Train	29,300	29,600	86,100	86,100	106,500	106,100
	High Speed Rail	38,600	38,600	69,200	69,100	85,700	86,100
	Airport Rail Link	30,700	30,800	48,400	48,600	60,300	60,100
	Blue Line	56,700	56,500	121,500	121,300	145,400	144,600
Subtotal		326,300	327,500	599,400	598,700	711,900	711,800
		653,800		1,198,100		1,423,700	
Kamphaeng Phet Station		33,000	33,100	67,000	67,300	82,900	82,900
Chatuchak Station		78,200	77,900	169,400	170,000	195,600	195,500
Mo Chit Station		95,600	95,500	170,600	171,200	184,900	185,700
Total		533,100	534,000	1,006,400	1,007,200	1,175,300	1,175,900
		1,067,100		2,013,600		2,351,200	

Source: OTP, 2016

Based on the study of Bang Sue development plan, passenger demand of the Bang Sue Grand Station is forecasted as shown in the following table by the previous JICA study. Although passengers of Blue Line is not included, the number of passengers is estimated at approximately 1.0 million. The future increase of passengers using the Bang Sue Grand Station will certainly cause the rapid rise of terminal trips around the Grand Station from inside and outside of the development area.

Table4.6 Passenger demand of Bang Sue Grand Station estimated by JICA

Station		2022 (people/day)		2027 (people/day)		2032 (people/day)	
		Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
Bang Sue Grand Station	Dark Red Line	58,352	58,352	94,702	94,702	144,755	144,755
	Light Red Line	101,989	101,989	132,421	132,421	169,598	169,598
	Long Distance Train	13,389	13,389	14,303	14,303	14,954	14,954
	High Speed Rail	0	0	35,170	35,170	40,374	40,374
	Airport Rail Link	0	0	86,586	86,586	137,188	137,188
	Blue Line	–	–	–	–	–	–
Total		173,730	173,730	363,182	363,182	506,870	506,870
		347,460		726,364		1,013,740	

Source: Data Collection Survey on Urban Redevelopment in Bang Sue Area in the Kingdom of Thailand, 2017, JICA

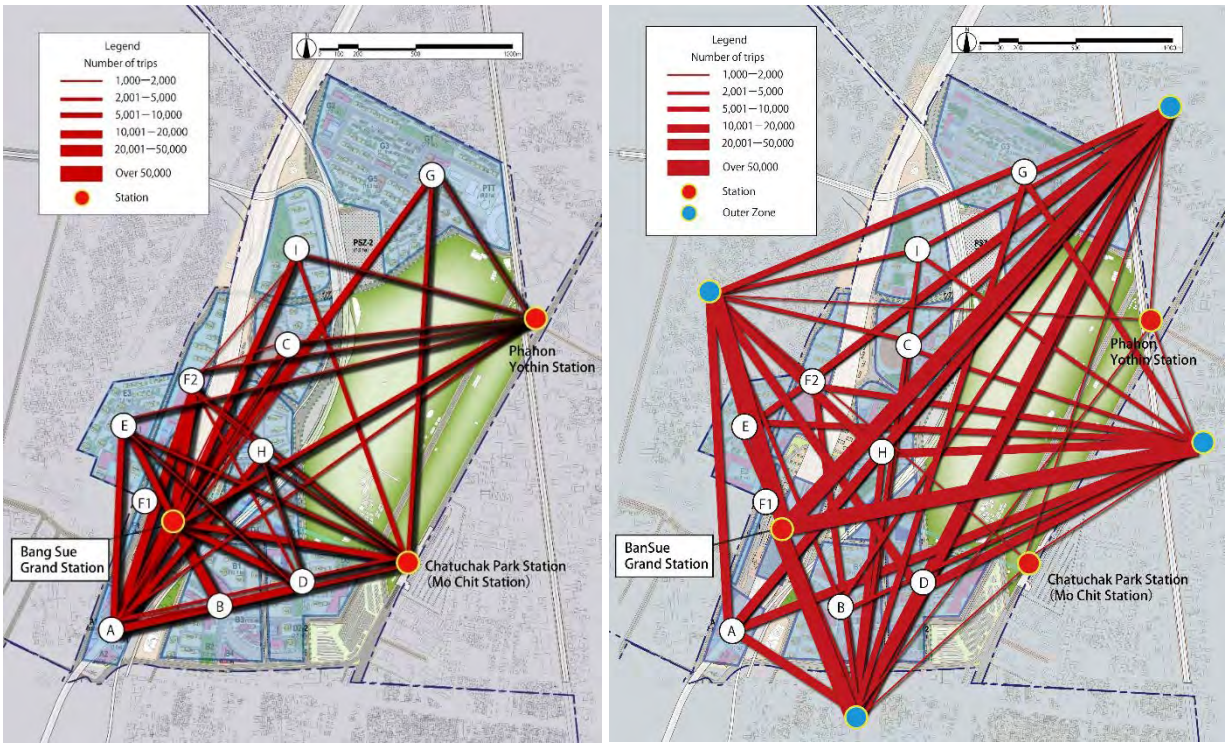
Additionally, the number of trips between inside and outside of the Bang Sue Area and between

inner zones of the Bang Sue Area will increase through the Bang Sue development. The following table indicates the number of generated trips in the Bang Sue Area in each development phase predicted by the previous JICA study[2]. Based on this prediction, more than 600,000 trips per day will be generated in the area in 2032. The figure below describes transport flows between inner zones and flows between inner zones and outer zones in 2032. As shown in the figure, traffic movement around the Bang Sue Grand Station would be highly intensive with a large number of trips which has different characteristics such as short or long distance trips. For example, the trips between Zone A and the Bang Sue Grand Station in 2032 is estimated at more than 600,000 trips per day, whereas the total transport volume of the links between Zone A and the station will be more than that, due to the trips piling up between Zone A and other northern zones.

Table4.7 Generated Trips in the Bang Sue Area

Zone	2022 (trips/day)	2027 (trips/day)	2032 (trips/day)
SRT Land & Zone F	113,600	233,800	233,800
Zone A	17,500	17,500	17,500
Zone B	0	0	97,600
Zone C & Zone I	0	49,800	67,400
Zone D	4,500	4,500	117,400
Zone H	0	0	36,300
KM11	0	54,000	54,000
Total	135,600	359,600	624,000

Source: Data Collection Survey on Urban Redevelopment in Bang Sue Area in the Kingdom of Thailand, 2017, JICA

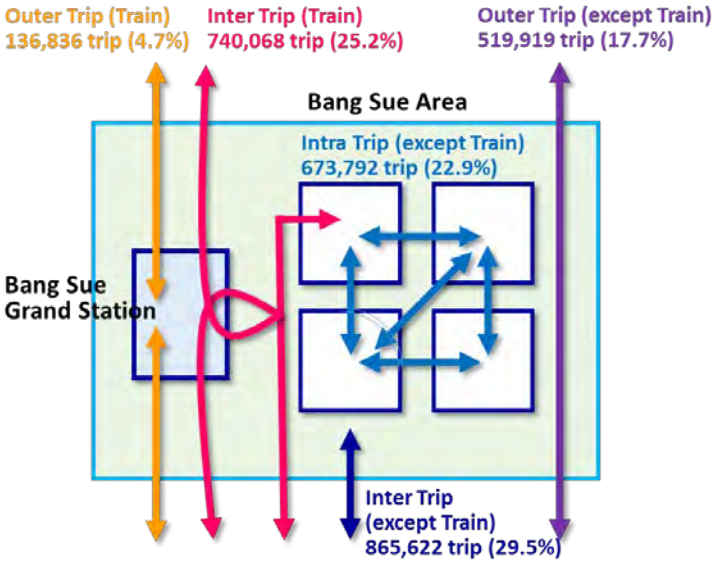


※ Walking and BRT trips in the area and railway trips are excluded, since those OD trips were not predicted in the previous JICA study.
Source: JICA Study Team (Result of demand forecast by Data Collection Survey on Urban Redevelopment in Bang Sue Area in the Kingdom of Thailand, 2017, JICA)

Figure4.17 Transport flows between inner zones(left) and transport flows between outer zones and inner zones (right) per day in 2032

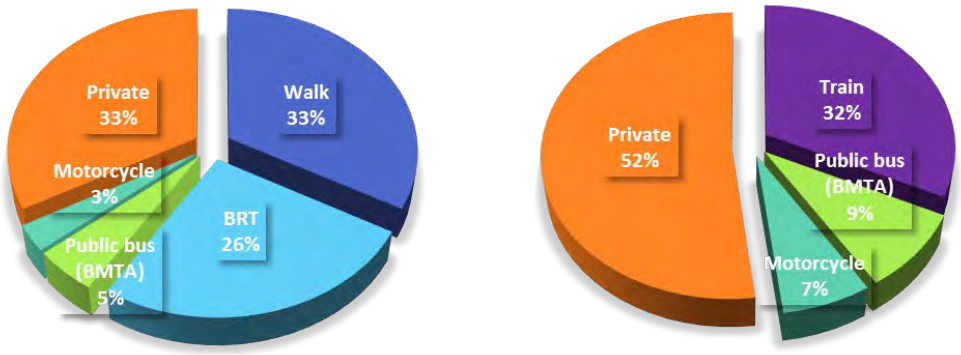
[2] In the previous JICA study, the number of generated trips were calculated based on the planned floor area in the development plan. In the Bang Sue development plan, the relocation of the Mo Chit 2 bus terminal from Zone C to the neighbor land of the Mo Chit station of BRT is taken into account.

The trip numbers in the Bang Sue Area including trips by passing through vehicles and modal share in 2032 were estimated by the previous JICA study as shown in following figures. According to the prediction, more than 800,000 inter trips and more than 500,000 outer trips are forecasted for 2032. In addition to the intra trips, these large movement needs to be considered for the Bang Sue development. Regarding the modal share, while both walk and private account for 33% of inner trips, private occupies more than 50 % of inter trips, since inter trips tend to be more long distance movement than inner trips.



Source: JICA Study Team (Result of demand forecast by Data Collection Survey on Urban Redevelopment in Bang Sue Area in the Kingdom of Thailand, 2017, JICA)

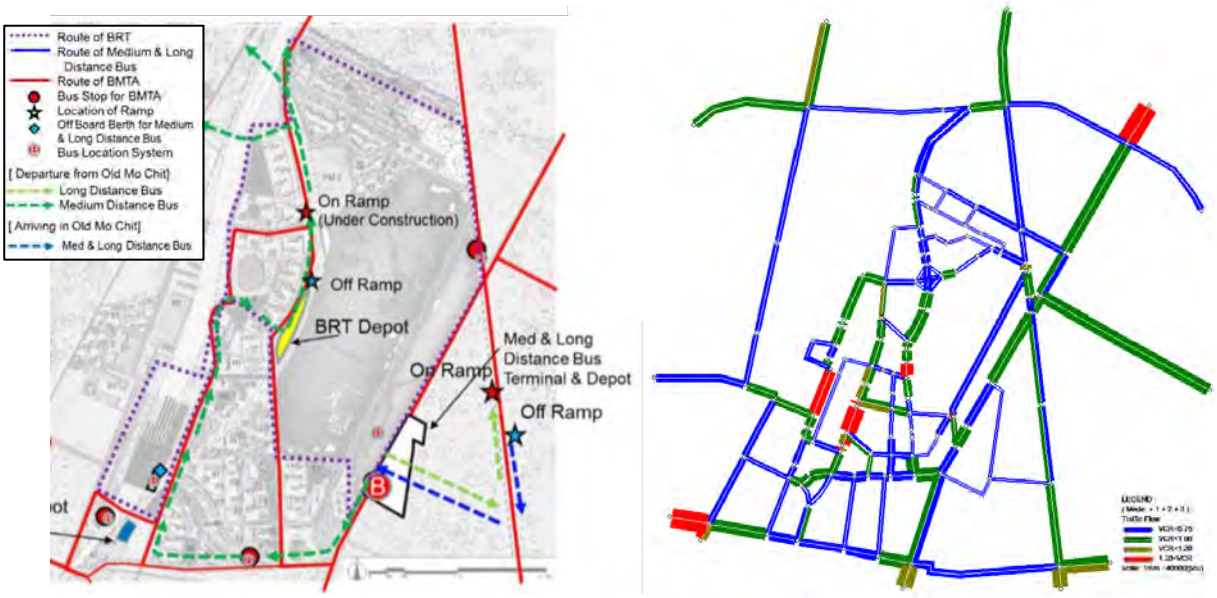
Figure4.18 Trip number in Bang Sue Area in 2032 estimated by previous JICA study



Source: JICA Study Team (Result of demand forecast by Data Collection Survey on Urban Redevelopment in Bang Sue Area in the Kingdom of Thailand, 2017, JICA)

Figure4.19 Inner trip modal share (left) and inter trip modal share of Bang Sue Area in 2032 estimated by previous JICA study

In order to manage the increasing traffic, the public transport planning including the BRT network plan for the Bang Sue Area was considered in the previous JICA study. However, based on the result of traffic assignment by the study, even if the BRT plan is implemented, traffic congestion of the road network, particularly around the Bang Sue Grand Station, seems to still remain as shown in the following figure.



Source: Data Collection Survey on Urban Redevelopment in Bang Sue Area in the Kingdom of Thailand, 2017, JICA

Figure4.20 Public transport planning (left) and result of traffic assignment in 2032 for the Bang Sue Area in previous JICA study

4.3.3 Mobility Issues for Bang Sue Development

Based on the above situation and analysis of future traffic demand, following mobility issues would be highlighted.

(1) Management of increasing traffic

The development of the Bang Sue Grand Station and the Bang Sue Area will cause dramatic increase of traffic demand around the area. The mobility for different people, who move to/from the Bang Sue Grand Station and developing facilities, such as commuters and residents of development zones and railway users need to be considered. On the other hand, existing road network is already suffering with traffic congestion. Therefore, if effective countermeasures are not implemented, those increasing traffic will seriously deteriorate the traffic condition not only in the Bang Sue Area but also the surrounding areas. In addition to the road network plans and transport services for inside the area, the connectivity between inside and outside of the Bang Sue Area needs to be well considered. Furthermore, comfortable last/first one mile transport system and network connecting zones and stations should be developed.

(2) Securement of accessibility inside the Bang Sue Area

The circulation lines of people in the Bang Sue Area would be split in eastern-western direction by railways of different levels, elevated expressways and Kamphaeng Phet 2 Road, which run north and south. Moreover, distances between each zone seem to be fundamentally larger than the walking sphere, which is roughly assumed around 400m or five minutes by walking. These characteristics of the existing transport network and traffic conditions could hinder the circulation of urban activities. Thus, the securement of accessibility between zones and facilities in the area, in particular in eastern-western direction, should be tackled in order to vitalize urban activities and realize the integrated Bang Sue development. In addition, for general roads in Bangkok,

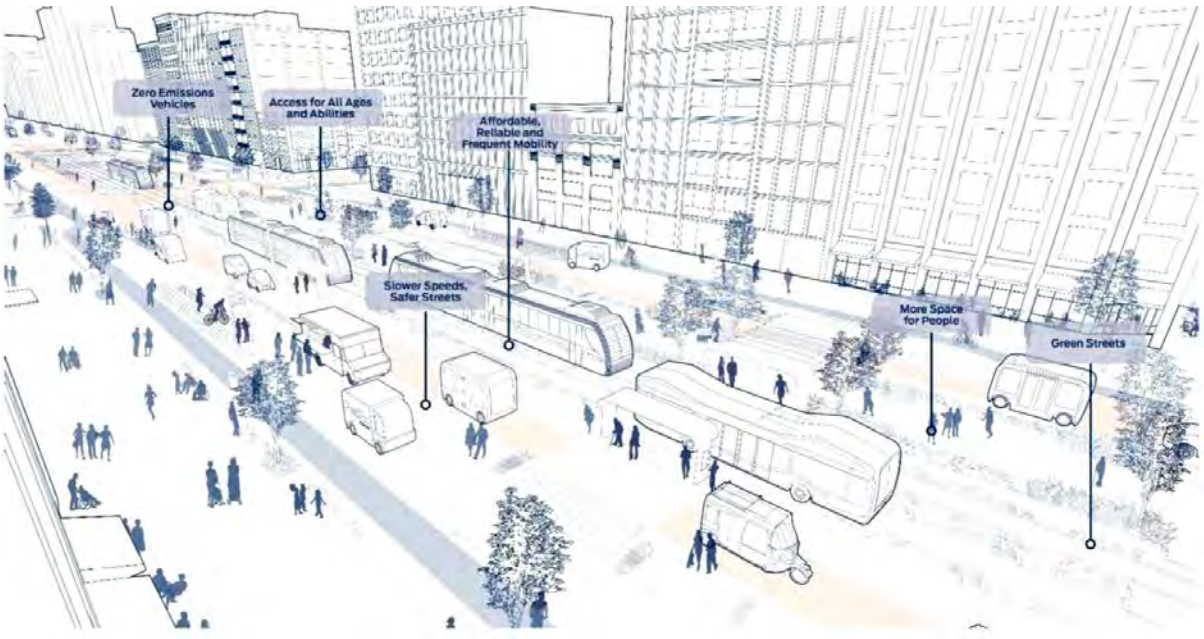
pedestrian spaces are not sufficiently secured, and pedestrians are often unable to walk comfortably. Responding to an aging society is also an important social problem, and it is necessary to develop a barrier-free traffic environment that allows everyone to walk comfortably and move.

(3) Response to staged development of the Bang Sue area

Since the development of the Bang Sue area is promoted in stages by dividing the development zones, it is necessary to flexibly and carefully examine the treatment of existing facilities and the prospects of traffic demand in accordance with the gradual development plan. Traffic systems that require large-scale infrastructure development, such as monorails and track systems such as AGT, for example, need to be carefully considered because it is not considered easy introducing them in accordance with such phased development.

(4) Creation of attractive mobility and urban space

As a New Gateway of Bangkok and the platform for innovation, one of the key development issue for the Bang Sue area is how to realize the attractive urban environment in terms of urban activity, living and economic investment. Therefore, creative and attractive mobility and urbanism which contribute to increasing the city value and enhancing the regional economy need to be pursued for the Bang Sue Area. Recently, new street design and urban planning principles considering autonomous vehicles has been developed worldwide. For instance, as shown in the following figure, principles of new urban planning proposed by National Association of City Transportation Officials (NACTO) in 2017 includes ensuring several transport choice through the city, street design considering autonomous vehicles, real-time traffic operation and management, constraints of car use in the area and so on.



Source: NACTO, (2017). Blueprint for autonomous urbanism

Figure4.21 Blueprint of street design with new mobility systems proposed by NACTO

(5) Pursuing affordable, flexible, comfortable, reliable and safe transport

In Thailand, there are different types of transport modes in terms of size, affordability and flexibility of movement. Each mode has its role in supporting the daily lives of the local people. In addition, comfortability, reliability and safety of transport system are also important factors. Hence, affordable, flexible, comfortable, reliable and safe transport system and infrastructure for all of the people visiting the Bang Sue area need to be pursued.

(6) Building a transportation system that is friendly to the natural environment and urban environment

Increase of traffic movement could affect the natural environment and urban environment, through greenhouse gas emissions, air pollution and noise issues. In the development of the Bang Sue area, which aims to be a model of other cities as a smart city, low carbon and environmentally-friendly transport system should be promoted for the Bang Sue Area.

(7) Establishment of economically sustainable urban transportation system

In order to realize an economically sustainable transport for the Bang Sue Area, it would be indispensable to consider the development and implementation structure and financial scheme for the mobility system in the Bang Sue Area. A sustainable structure could be realized only through the collaboration and partnership of related actors including public and private sectors. This is because the quality of service and the financial feasibility of the mobility would often face a trade-off. In addition, it is important to establish a structure which can continually improve the transportation system by reflecting opinions of diverse stakeholders such as end users and local residents.

4.3.4 Concept of Smart Mobility for Bang Sue Development

These urban transportation issues in the Bang Sue area cannot be solved by simple measures such as introducing a new mode of transportation. In addition to considering urban traffic policies that have been mainstream, such as road planning, BRT and mobility management, it is necessary to pursue an integrated and innovative traffic system that meets the challenges of the Bang Sue area.

In addition, various technological advances and changes have been made in recent years regarding urban mobility, and it is important to examine the mobility in view of the trends in the world and future possibilities. Global trends in urban mobility include the development and introduction of new technologies and concepts such as automated-driving, ride-share, and MaaS[3], the expansion of applications (such as Grab and Uber), electronic toll collection (E-payment), the development of public transport-oriented development (TOD), the analysis of big data, and the development of real-time traffic control technology.

In this context, ‘smart mobility’ in the Bang Sue area is considered as a comprehensive concept: " the sustainable mobility balanced socially, environmentally and economically which provide solutions for urban transport challenges in the Bang Sue development, using remarkably advancing technologies ." The following shows the direction of smart mobility to overcome

[3] MaaS, Mobility as a Service, is a notion to provide a more comfortable mobility service through integrating different transport modes by using advancing technologies, recognizing mobility as a service, originated from Finland.

mobility challenges in the Bang Sue area.

a) Creating attractive urban place, public transport network and pedestrian network
b) Realizing affordable, flexible, comfortable, reliable and safe mobility for all of the people with consideration for innovative transport systems such as MaaS and autonomous vehicles
c) Ensuring several transport choice through the Bang Sue area including innovative mobility
d) Promoting low carbon travelling and decreasing environmental impact
e) Incorporating utilization of real-time dynamic data of urban activities and transport movements using IoT technologies into management and planning of the city and mobility
f) Establishing sustainable structure and financial scheme for the mobility

From the point of view of smart mobility, the following key concepts of the Bang Sue area are proposed.

- A city where people can walk around comfortably and safely: Walkable City
- A city where people can move comfortably, easily, and environmentally-friendly
- A city where people can enjoy the abundant space with proper management of multimodal transportation systems

4.3.5 Concept of Smart Mobility for Bang Sue District

Smart mobility for the Bang Sue Development is not only to introduce a new mobility system using advancing technologies, but also to create sustainable transport and attractive urban places, managing traffic increase by the development. In order to realize this, it would be important to accurately analyze the regional characteristics, future demand, and traffic problems of the Bang Sue area using advanced IoT technology. Then, the detailed transport plan of the Bang Sue area needs to be examined. Measures such as transport demand management as well as hardware measures such as roads and urban traffic infrastructure should be addressed with consideration for utilization of advanced technology.

In this section, the concept and measures of smart mobility in the Bang Sue area will be examined as a concept design. Based on the results of this study, it is recommended to conduct more detailed surveys and analyses in order to precisely implement road traffic flow analysis including road networks outside the Bang Sue area and future transport demand forecasts. In addition, it is important to formulate detailed measures and plans and to promote various actions comprehensively.

Based on the urban vision to be aimed at from the viewpoint of smart mobility mentioned above, the main concepts on smart mobility in the Bang Sue area are set as follows:

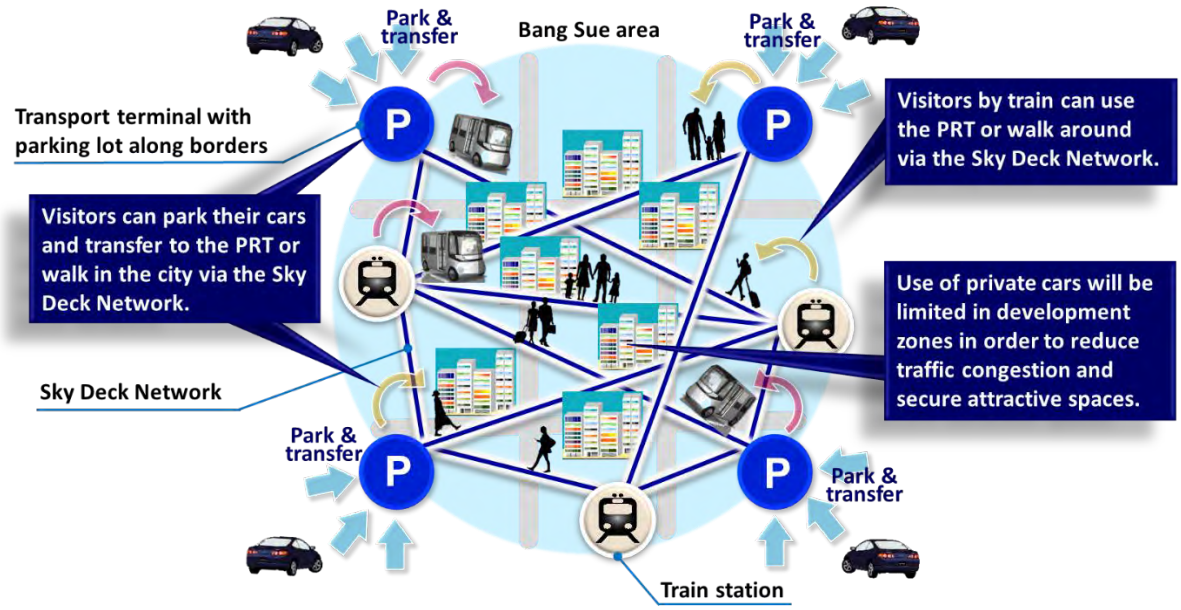
- Development of multilayered transport infrastructure and introduction of environmentally-friendly regional public transportation services
- Congestion alleviation and expansion of public spaces by developing parking lots at boundary areas and managing traffic flow in the area
- Traffic management using IoT

In order to respond to traffic demand that increases with development and to alleviate traffic congestion, to separate moving lines by automotive traffic from pedestrians and public transport, to realize a Walkable City that is easy for everyone to move, and to establish last one mile transport, a sky deck network will be developed to connect the Bang Sue Grand station, development zones, and transport bases.

On top of this, an automated driving system called PRT (Personal Rapid Transit) could be

introduced on the sky deck in the future, and public transport services using small, environmentally friendly EVs could be established using IoT. In addition, a parking lot will be installed at the outer edge of the development area, and visitors from outside the area will stop their private cars there and be able to move inside the Bang Sue area by foot or PRT. On the other hand, for roads in zones, the congestion of roads will be alleviated by suppressing the inflow of automobiles and promoting the use of public transportation.

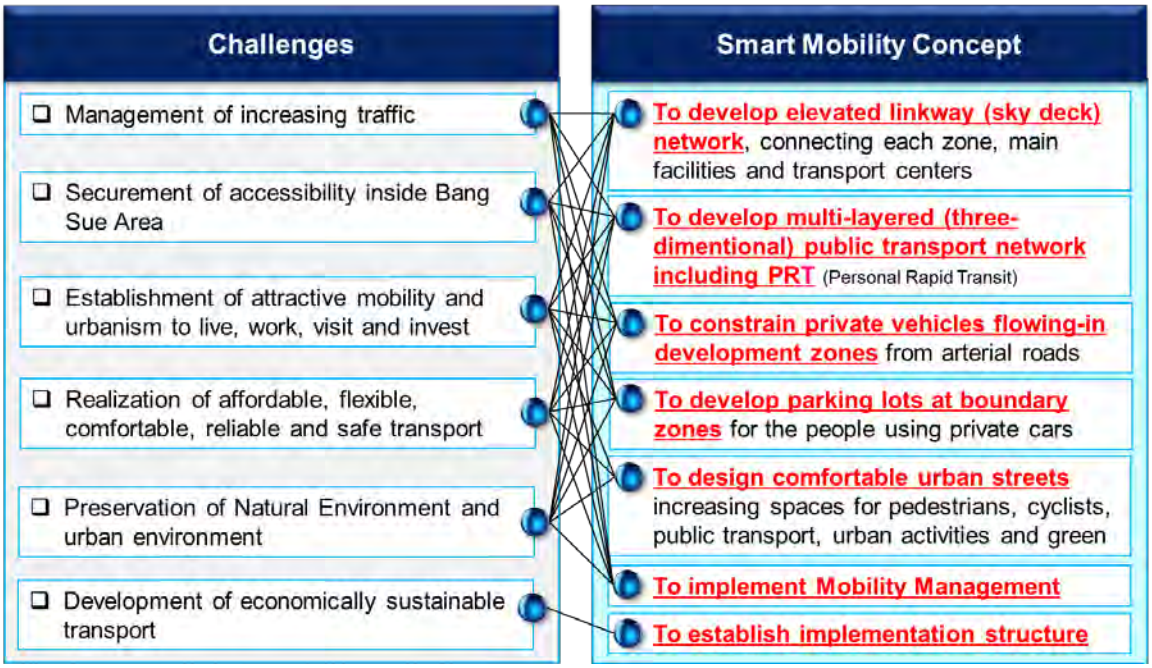
Roads in zones with reduced traffic volume due to vehicle inflow restraint form attractive urban spaces by redistributing road spaces and expanding spaces for pedestrians, bicycle roads, public spaces, and green planting belts. The following figures show images of the main concept of smart mobility in the Bang Sue area.



Source: JICA Study Team

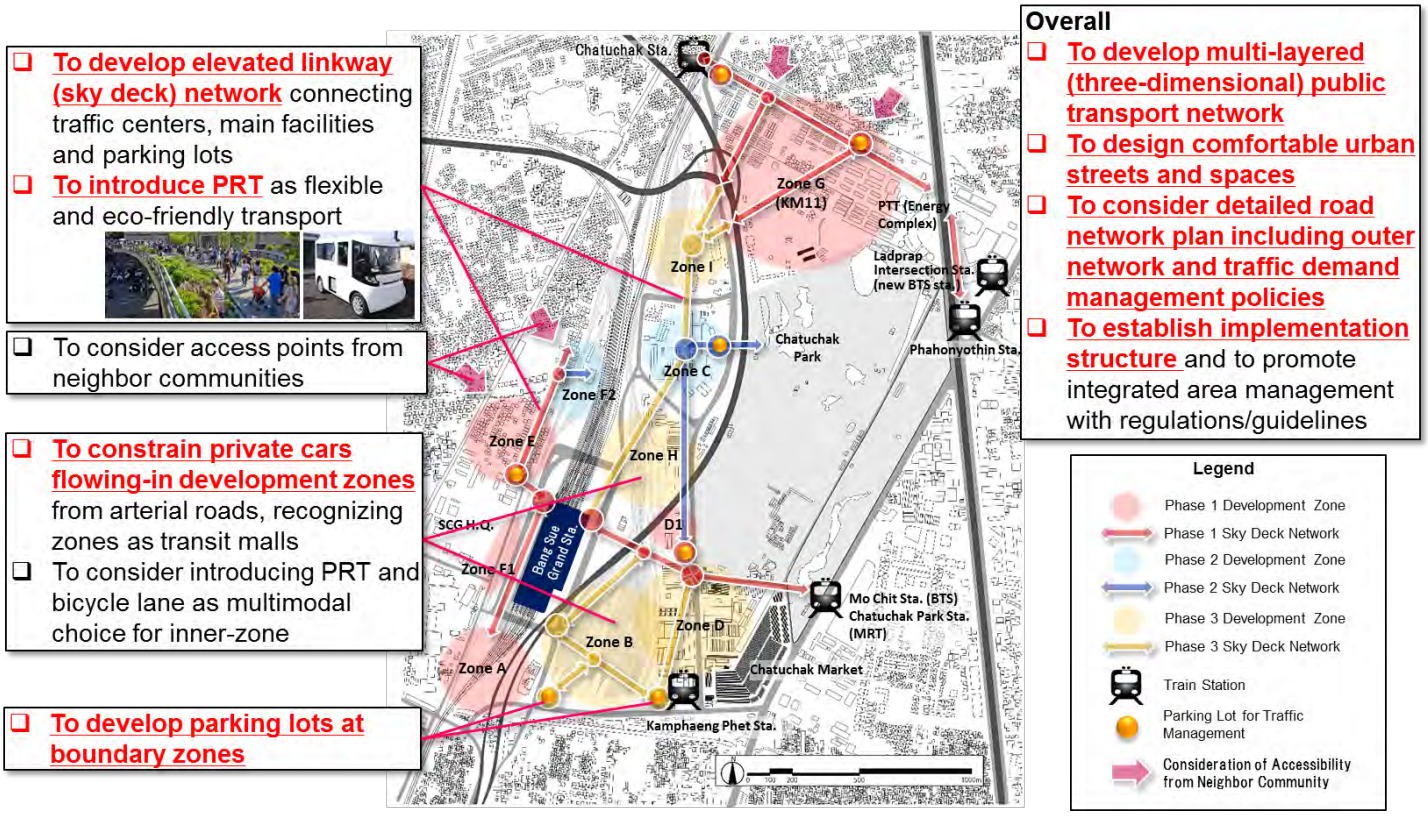
Figure4.22 Conceptual Image of Smart Mobility in the Bang Sue Area

The following figure indicates the correspondence between urban transport challenges and smart mobility initiatives in the Bang Sue area.



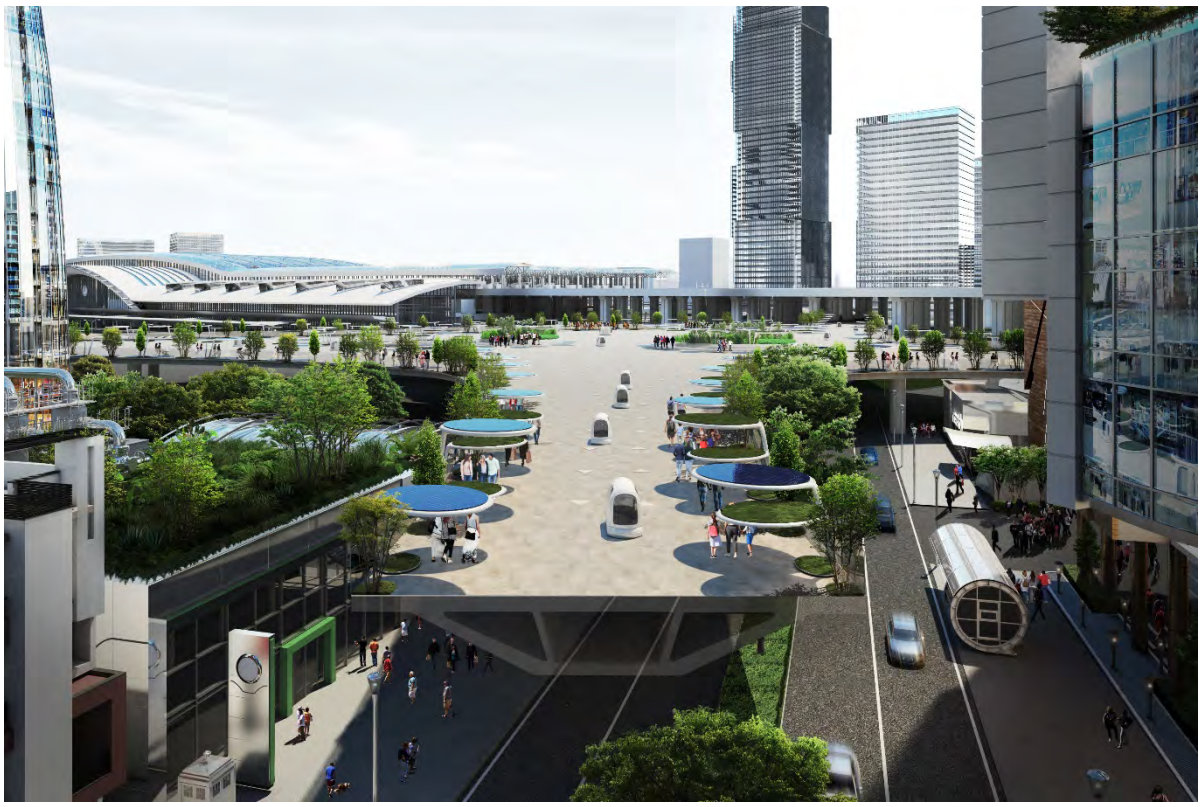
Source: JICA Study Group

Figure4.23 Transport Challenges and Smart Mobility Concept of Bang Sue Development



Source: JICA Study Team

Figure4.24 Concept of Smart Mobility of Bang Sue Development



Source: JICA Study Team

Figure4.25 Conceptual Image of Sky Deck Network and PRT

The following shows the concept design of the main smart mobility policies.

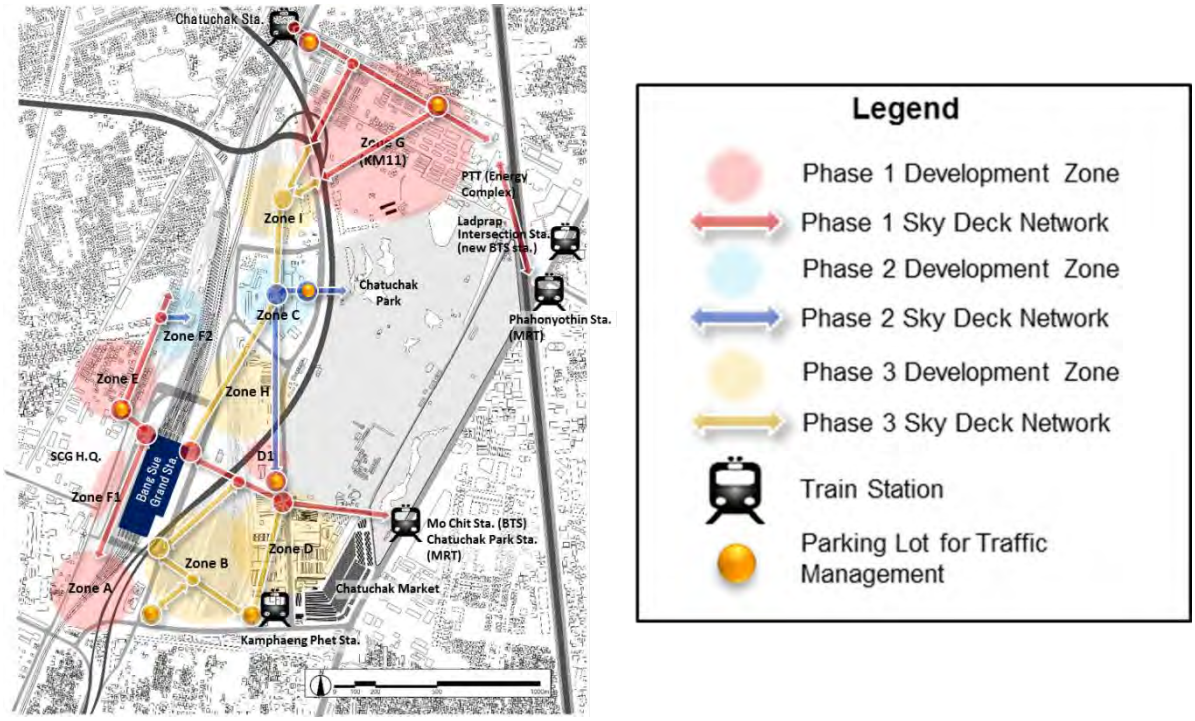
(1) Sky Deck network

As described above, traffic demand in the Bang Sue area will increase as a result of development. In particular, there are concerns that traffic congestion will deteriorate and traffic services will decline in the future. In addition, since the circulation in the development area would be separated by the Sirat expressway and the Kamphaeng Phet 2 Road and railways, the east-west connectivity should be enhanced to realize integrated development for the Bang Sue Area.

As a solution for these issues, “the development of elevated linkway network as a sky deck network connecting transport centers, main facilities and parking lots located in boundary zones is proposed”. Then, “modes on sky deck network could be limited in pedestrians, bicycles and new small transport”. The sky deck network will enable to vertically segregate automobiles and pedestrians and to realize smooth inter-and-inner zone trips as a ‘Walkable City’. The main functions and roles of the sky deck network are as follows. The detailed basic policy of the plan is described in the Development Project Plan on Chapter 5.

- Forming traffic lines that enable people to move safely and comfortably as a Walkable City, by separating car and pedestrian traffic lines and alleviating road congestion on the ground
- Connecting Bang Sue development zones, strengthening access between zones and facilities, and enhancing the convenience and real estate value of the entire development area
- Introducing an environmentally friendly public transport system on the sky deck network to provide flexible and comfortable transport services that can be used by everyone
- Promoting the use of public transport and other transport modes by creating a traffic environment that does not depend on the use of automobiles on roads

- Enhancing barrier-free mobility that is easy for everyone to move, such as the elderly and disabled
- Contributing to the creation of attractive urban spaces by utilizing them as greenery spaces and lively activities



Source: JICA Study Team

Figure4.26 Conceptual Design of the Sky Deck Network

Source: JICA Study Team

Figure4.27 Good Example of Pedestrian Network in Bangkok (National Stadium Station)

Source: JICA Study Team

Figure4.28 Conceptual Image of Bang Sue Development and Sky Deck Network: Night View

(2) Smart Public Transport: PRT (Personal Rapid Transit)

In the Bang Sue area, enhancement of public transport system would be indispensable in order to manage the trips from stations and parking lots at fringe areas to development zones and inter-zone trips. The following table shows the comparison of the functions of each urban transport system. This study proposes the introduction of an environmentally friendly compact EV called PRT system on a sky deck network, based on the characteristics and challenges of Bang Sue development described above and the comparison of urban transport systems.

Track-based public transport systems such as monorails and AGT are considered to be difficult to cope with gradual development in the Bang Sue area because of the large construction cost, construction period and the difficulty of partial introduction. Furthermore, since the route is only on the track to be constructed, it is not suitable for public transport which bears short-distance traffic demand and last mile mobility deployed in the area. There is a high possibility that the BRT system will be in conflict with the road traffic. Chronic road congestion could reduce service levels and could easily lead to new traffic congestion. Installation of special lanes may ensure a certain level of service, but in this case, the construction cost and construction period may increase, and it may become a new factor that spatially divides the whole town.

On the other hand, introduction of the PRT system on the sky deck network has a low overall introduction cost and a short introduction period even considering the construction cost of the Sky Deck. It can be introduced in accordance with the gradual development, and it is also possible to provide the traffic service to flexibly respond to the traffic demand which differs depending on the development situation and the time zone.

Table4.8 Comparison of Urban Public Transport Systems

	MRT	Monorail/AGT	LRT	BRT	PRT
Image					
Quick-Deliverability	✓✓	✓✓	✓✓	✓	✓
Construction Cost, Time	Heavy construction & long time are needed (×)			✓	✓✓
Phased Development	×	×	✓	✓✓	✓✓
Operation Flexibility	×	×	×	✓	✓✓
Transport Maximum (PPHPD*)	✓✓ 60,000	✓✓ 18,000 - 26,000	✓ 14,000	✓ 2,500 - 4,000	✓ 7,200 - 9,600
Cover Distance	Long	Long-Middle	Middle	Middle	Short
Eco-friendly	✓✓	✓✓	✓✓	✓	✓✓

*PPHPD: Passenger Per Hour Per Direction

Source: JICA Study Team

The main functions and roles of the PRT installed on the sky deck network are shown below. The basic policy of the plan and the draft plan in accordance with the phase development plan shall be described in detail in the Development Project Plan, Chapter 5.

- By separating car and public transport flow lines, alleviating road congestion on the ground and safe and providing comfortable moving flow lines and transport services
- Along with the development of the sky deck network, connecting development zones, increasing the accessibility between zones and facilities, and improving the convenience and real estate value of the entire development area
- Providing flexible, comfortable and affordable transport services that can be used by anyone
- Promoting the use of public transport and other transport modes by creating a traffic environment that does not depend on the use of automobiles on roads
- Enhancing barrier-free mobility that is easy for everyone to move, such as the elderly and disabled
- Improving future service levels while incorporating advanced technologies such as autonomous driving technologies
- Providing efficient public transport services in response to demand, such as platoon-driving services with specified routes for routes and time zones where demand is high, and demand-responsive services for time zones where demand is low
- Becoming a symbol of smart mobility
- Convenient payment service using e-payment will be introduced

It should be noted that the PRT system is considered as one of environmentally friendly and desirable transport mode as a public transport system not only on the sky deck network but also on the road. Especially, in a road section in which a vehicle inflow restriction is performed, which will be described later, it is considered as a transport mode flexibly corresponding to a short distance trip demand.

(3) Restriction of Vehicle Inflow into Development Zones and Development of Fringe Parking Lots

Traffic congestion is already occurring on roads in the vicinity of the Bang Sue area, and there is a concern that further deterioration will occur due to the increase in traffic demand associated with urban development. Especially, the existing transport plan is supposed to be most likely insufficient to secure smooth traffic in the road network around the Bang Sue area. In order to cope with such problems, it is considered necessary to investigate and study wider-area road network plans and to examine measures to promote the use of public transportation in the future. For example, it would be important to consider the development of a bypass, the development of an underpass for passing traffic, and the improvement of crossing points at bottlenecks of the road network as medium-and long-term solutions.

Meanwhile, traffic condition in the development area is also concerned about road congestion as a result of the development of each zone. In this study, restrictions on the inflow of automobiles into development zones and the development of fringe parking lots at the outer edges of the development area along main roads are proposed, in order to respond to such increased traffic demand to development districts, alleviate traffic congestion in the zones, and create attractive urban spaces.

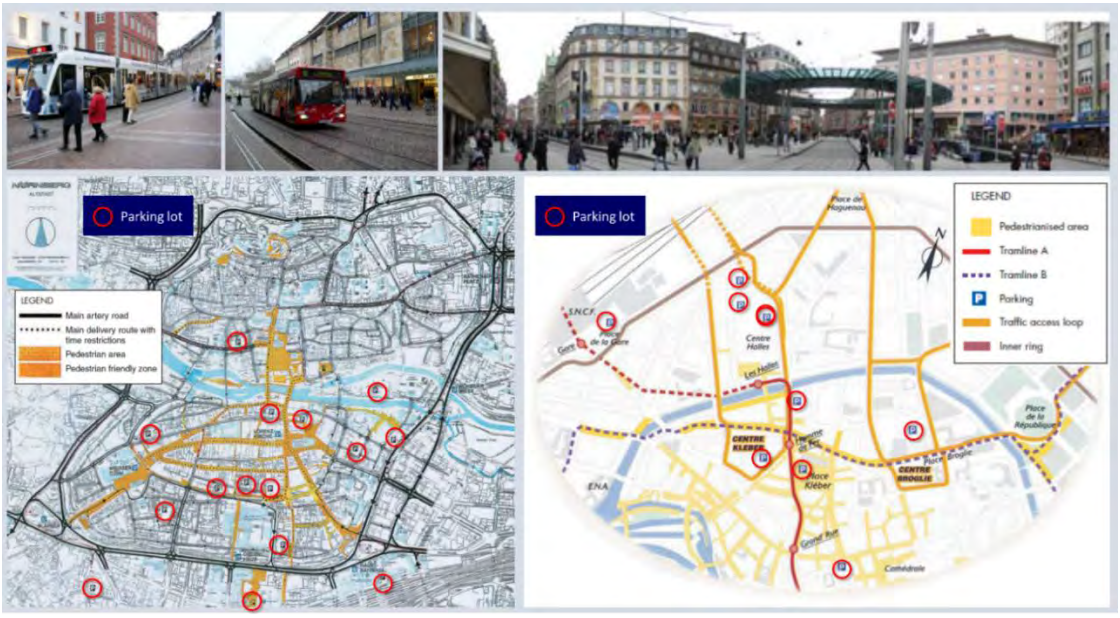
It is assumed that restrictions on the inflow of automobiles into the development area are mainly applied to ordinary visitors, except residents, disabled persons, logistics vehicles, emergency vehicles, maintenance and construction vehicles of in-zone facilities, and waste collection vehicles. In addition, it is important to promote the use of public transport by restraining the use of automobiles through package measures which consist of fringe parking lots, sky deck network development, provision of public transportation services. Furthermore, it would not be necessary to regulate the passage of the Kamphaeng Phet 2 road and the Kamphaeng Phet road, which are currently responsible for a large number of traffic passes, however it is important to suppress the inflow of traffic from existing arterial roads into development zones. It is assumed that automatic gates are installed at the entrances to and from roads in the development zone so that pre-registrants can smoothly enter and exit. Besides, it is necessary to formulate rules to promote these mechanisms in cooperation with related actors.

In addition to restricting the inflow of automobiles into the zone, a fringe parking lot will be installed as a facility for receiving automobile traffic of ordinary visitors inside and outside the zone and for switching to other transport modes. In order to prevent traffic congestion in the vicinity of a parking lot, priority shall be given to the location of parking lot buildings, real-time information provision systems for parking conditions, user registration systems, automatic gates, electronic toll collection systems, and traffic countermeasures in the vicinity of parking gates. Moreover, when introducing these measures, it is necessary to reconsider the way of the mandatory parking lot to be attached and design improvement policies in town development guidelines and zone development plans. Main functions and roles of restricting the inflow of automobiles into the development zones and developing the fringe parking lot are shown below.

- Reducing traffic congestion around the development area by suppressing the inflow of passing traffic visitors by private vehicles into development zones
- Reducing the use of vehicles by visitors and promote the use of public transport through the development of fringe parking lots, tariff measures, sky deck network and provision of public transport services which support last mile trips from parking lots as a package of measures
- Examining the restrictions of inflow traffic, the reduction in the number and width of lanes, and

the reallocation and design of road spaces, and considering roads in the development zones as urban place for abundant urban activities

The policy which constrain the traffic inflow to the urban center developing parking lots at fringe zones of the center was implemented in many cities, especially in European region such as Strasbourg, France; Munich, Nurenberg; and Freiburg, Germany. The following figure shows pedestrian areas limiting car use in Nurenberg and Strasbourg. Strasbourg, for example, developed LRT network and banned car use at the center of the city. A number of parking lots along the LRT and at fringe zones of the car restraining area was delivered through public-private partnership. As a result, “the removal of cars from the city center allow space for pedestrians and cyclists has improved the quality of life everyone, for those living and working in the city, and tourists” (European Commission, 2004).



Source: European Commission, (2004). Reclaiming city streets for people: Chaos or quality of life (Edited by JICA Study Team)
Top photograph: 2 left; Transit mall at Freiburg, Germany (MLIT, Japan), right; Pedestrian area at city center of Strasbourg, France (The Prince's Foundation, (2015). Strasbourg: Regaining the public realm)

Figure4.29 Pedestrian area with limitation of car use in Nuremberg (left) and Strasbourg (right)

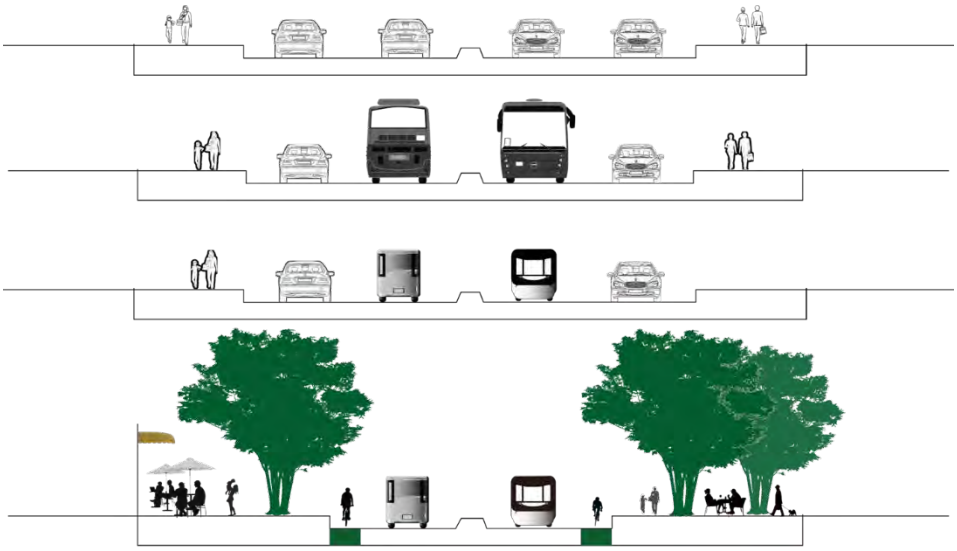
Source: JICA Study Team

Figure4.30 Conceptual image of fringe parking lot

(4) Street design

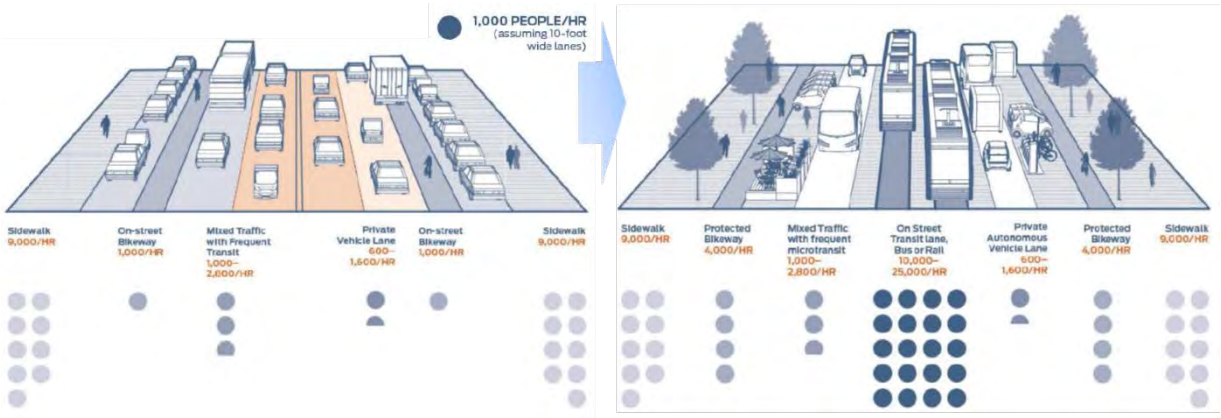
By restricting the inflow of automobiles, the spaces for road traffic in the Bang Sue area could be reallocated and redesigned from traffic oriented road to urban public places for connecting people to people, society, green and so on. On the basis of this road space reallocation, more comfortable urban streets increasing spaces for pedestrians, cyclists, public transport, different urban community activities and green spaces, decreasing spaces for private vehicles should be addressed.

The following figures show images of road space reallocation and redesign. Constraining private vehicles and introducing the fittest transport mode corresponding to the trip demand by routes and areas, more green and human places can be created.



Source: JICA Study Team

Figure4.31 Image of reallocation of road space



Source: NACTO, (2017). Blueprint for autonomous urbanism

Figure4.32 Redesign of roadside space by introduction of MaaS and autonomous vehicle

(5) Other Smart Mobility Related Measures

1) Transport information management system

In addition to monitoring and managing local transport information in real time through GPS and CCTV, the introduction of transport information management and provision systems that provide traffic information to users in real time will be sought. Details are summarized in the Smart City Platform section along with other information management systems.

Source: JICA Study Team

Figure4.33 Smart City Center managing urban transport information in Seoul City

2) Bicycle lanes and personal mobility lanes

Many roads in Bangkok City do not have sufficient road space for bicycle using, and it seems that bicycle use is not much at present. However, the potential demand for bicycle use as an environment-and health-friendly urban transport mode like green mobility may increase in the future. Actually traffic measures such as Share Cycling are expanding worldwide, and are also set in the Thai government's smart criteria. Besides, not only bicycles, but also small-sized personal mobility such as electric kickboards, electric scooters and segways are spreading rapidly.

In the Bang Sue area, which aims to become a gateway of new technology development, it would be essential to develop new personal mobility and technology development related to these sharing services, and to improve traffic environments with a view to future development. Therefore, it is proposed to address the transport environment of bicycles and other personal mobility by providing a personal mobility lane in the road space.

3) Car sharing and ride share

It is expected that the promotion of car sharing and ride share will contribute to the decrease of traffic congestion and effective utilization of urban space by reducing the ownership of automobiles, restraining the use of automobiles, reducing the number of parking facilities, and increasing the use of other transport modes. In the Bang Sue area, the experimental introduction could be examined for zones where the housing development which the resident expects to demand is promoted at high density.

4) Sustainable implementation structure and area management of smart mobility

In order to promote smart mobility measures in the Bang Sue area, cooperation among various related organizations is indispensable. On the one hand, it would be necessary to establish an organizational structure for implementing and managing the smart mobility policies on a proactive basis and to establish a framework and rules for the implementation. Besides, it would be also important to consider not only smart mobility but also the entire development of the Bang Sue area as a whole, in order to establish such an implementation system and framework. The implementation structure proposed in this study and the mechanism for financial procurement and management will be described later in the Development Project Plan, Chapter 5.

5) Exploration of detailed road and urban transport plans and implementation of necessary measures

In the future, traffic congestion is expected to worsen in road networks including areas around Ban Sue Grand station and outside the Ban Sue area due to the increase in traffic demand caused by the Bang Sue development. On the other hand, as the development of each zone is going to proceed, consideration of necessary countermeasures would be an urgent issue. On top of that, it is recommended that Thai government carefully carries out transport demand forecasting in more detail with survey and analysis of latest conditions in the future. Based on the proposal of smart mobility in this study, it would be important to formulate comprehensive and detailed measures and plans, and to promote various actions comprehensively.

4.3.6 Evaluation of Smart Mobility Policies by Traffic Simulation

(1) Outline of Traffic Simulation

Traffic simulation analysis was carried out for the Bang Sue area in order to quantitatively evaluate smart mobility policies. Target policies to be evaluated were development of sky deck network, introduction of PRT system, restriction of vehicle inflow into development zones and development of fringe parking lots. Effects of these measures on road traffic flow at peak times and alleviation of traffic congestion were examined.

The year to be evaluated is 2032, when the development of each zone and the development of infrastructure were expected to be completed. Traffic simulations are performed for the following three scenario cases, and the results are compared and analyzed to verify the effect.

- Case 1: Without smart mobility measures in 2032
- Case 2: Sky deck network and PRT system installed in 2032
- Case 3: Sky deck network and PRT system, vehicle flow restrictions into development zones and fringe parking installed in 2032

(2) Conditions for Traffic Simulation

Setting of basic conditions of traffic simulation is shown in the following table.

Table4.9 Basic condition for traffic simulation

Item	Setting basic conditions
Target year	・ 2032
Target time	・ 1 hour at peak in the morning (assuming that the peak rate is 6% based on the actual situation of road traffic in Bangkok)[4]
Scenario	・ Case 1: Without Smart Mobility Measures in 2032 ・ Case 2: Sky Deck Network and PRT system installed in 2032 ・ Case 3: Sky Deck Network and PRT system, Vehicle Flow Restrictions into Development Zones and Fringe Parking Installment in 2032
Zoning	・ Traffic zone setting are based on previous JICA study (see Chapter 7 of the previous report)
OD Table (Distributed Transport Volume)	・ Established based on the results of previous JICA study (see Chapter 7 of the previous report) ・ Supplementary predictions were made for OD table by transport modes which was estimated in the previous JICA study (refer to the following table in detail).
Traffic network	・ Established for roads in and around the entire Bang Sue Development Area, assuming that the road network in the development plan has been developed.

Source: JICA Study Team

With respect to OD data by transport estimated in the previous JICA study, supplementary predictions were made since OD tables (traffic volume distribution) of walking trips and BRT were not predicted in the development areas in the previous JICA study, and the OD table data as a base was prepared. Based on this assumption, OD table data for each scenario was prepared and used as input data. The following table describes the setting conditions for each complementary prediction including PRT and each scenario.

[4] Set based on interviews with Thai traffic planning consultants (around 10% in urban areas of Japan in many cases; however, throughout-day traffic including night time tends to be large in Bangkok).

Table4.10 Complementary forecasting method for distributed transport volume (OD table)

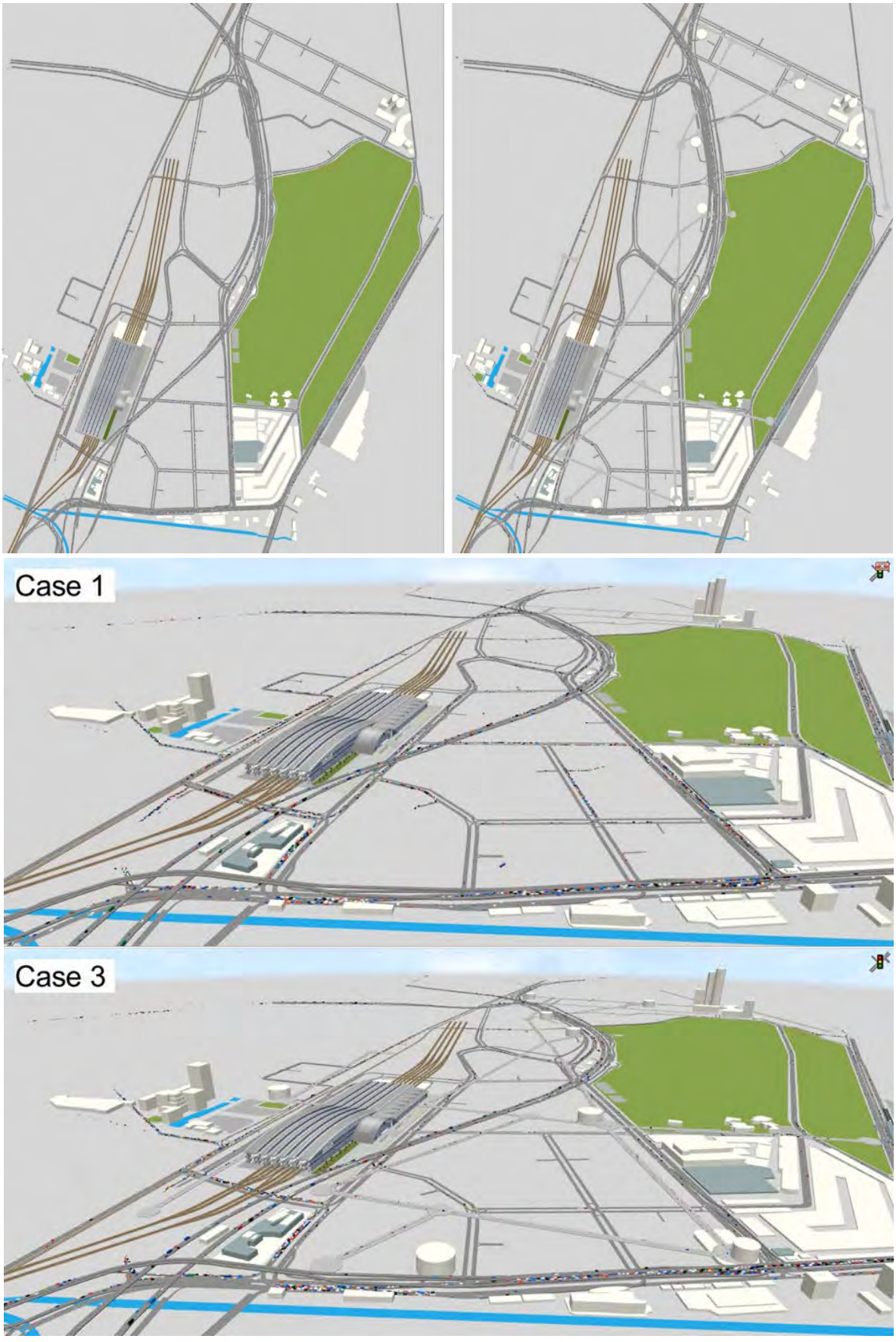
Item	Complementary method
1) OD table of BRT	・ In the previous JICA study, BRT was estimated to have a trip share of 26% in the Bang Sue area. ・ For this reason, the number of BRT trips for each OD pair is calculated in proportion to the total number of trips for each OD pair of automobiles, motorcycles, and route buses for which data are available, using the total number of trips of 26% of the total number of trips in the district as the total number of trips.
2) OD table of PRT	・ The Smart Mobility Plan of this study proposes the introduction of PRT, not BRT, as a means of local public transportation, but assumes that the role and use characteristics of PRT are close to those of BRT. ・ It is also assumed that the PRT is responsible for the OD trip of the complementary BRT as described above because of the lack of data for constructing the traffic sharing rate model, etc.
3) OD table of Walking	・ Estimated number of OD trips on foot using the pedestrian share curves ($y=-0.464\ln(x)+3.5309$) examined in the previous JICA study, and corrected the total number of known pedestrian trips as a control total.

Source: JICA Study Team

Table4.11 Setting Conditions for Traffic Simulation by Scenario

Scenarios and items		Setting condition
Case 1	OD table	・ For trips within the development area, the amount of distributed traffic supplemented by the method described above is applied. ・ Distributed traffic volume of PRT is distributed according to the ratio of automobiles, motorcycles, and route buses. ・ Domestic and external trips are based on the data estimated at the time of the previous survey.
	Network	・ Network in which the road network in the development plan has been developed
Case 2	OD table	・ It is assumed that the traffic environment of pedestrians is greatly improved by the development of the sky deck network, and that the number of walking trips between zones increases by 30%, and the number of trips is converted from automobile trips by the same amount. ・ Assuming that the development of sky deck networks and the introduction of PRT will increase the speed and comfort of movement in the development area, it is assumed that 20% of automobile trips between inside and outside development area will be converted to railway trips. ・ For external trips, the estimates from the previous JICA survey are applied.
	Network	・ Network in which the road network in the development plan has been developed
Case 3	OD table	・ For internal trips, it is assumed that the number of walking trips between zones increases by 30% when there is no sky deck, as in the case of Case 2, and the number of trips changes from car trips. ・ Assume that 30% of the remaining inter-zone vehicle and motorcycle trips are converted to PRT because of restrictions on vehicle use within each zone. ・ For trips between in and outside development area, it is assumed that the development of sky seck networks and the introduction of PRT will increase mobility within the development area. In addition, it is assumed that the use of automobiles is restricted in each zone, parking lots will be developed in the fringe area (parking lot fee measures will be considered at the same time), and road space will be reallocated in the vehicle inflow control section. Assume that 40% of automobile trips between in and outside the development area will be converted to railway trips by such urban development that prioritizes pedestrians and public transport. ・ At this time, it is assumed that 70% of the vehicle trips in the development area and the vehicle trips between in and outside the developed area are restricted from flowing into the zone (26% of the residential population according to the type of facilities in the previous JICA study) and that the parking lot in the fringe area of each zone is used to accommodate those trips (in the zone where the fringe parking lot plan is planned, 70% of the vehicle trips in which the inflow is restricted are set as trips to the fringe parking lot (sub-zone)). ・ For external trips, the estimates from the previous JICA study are applied.
	Network	・ Network in which the road network in the development plan has been developed ・ Set fringe parking lots in the basic development plan (set as sub-zones) ・ Establishment of automobile inflow control section described in the basic development plan (see Chapter 5)

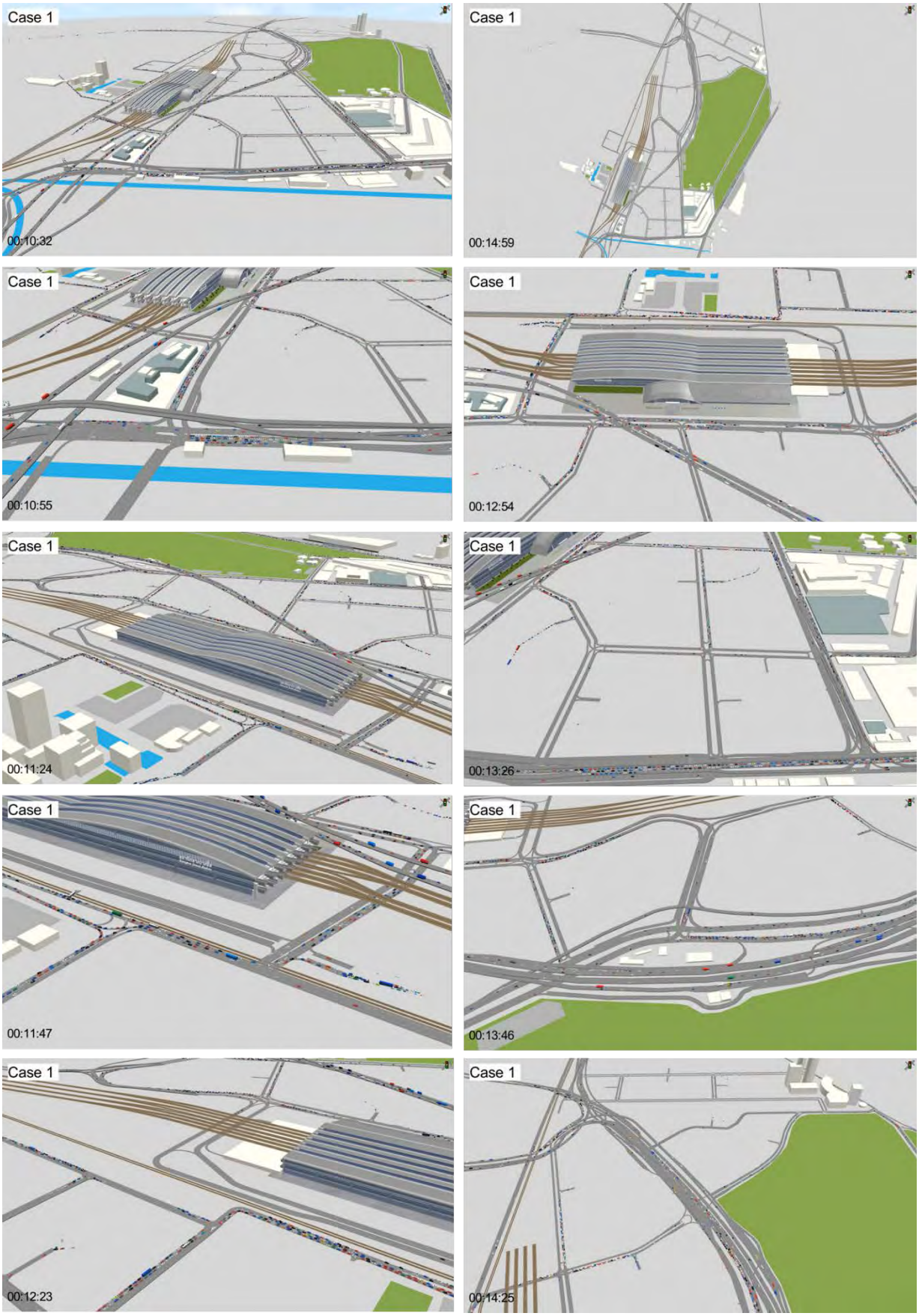
Source: JICA Study Team



Source: JICA Study Team

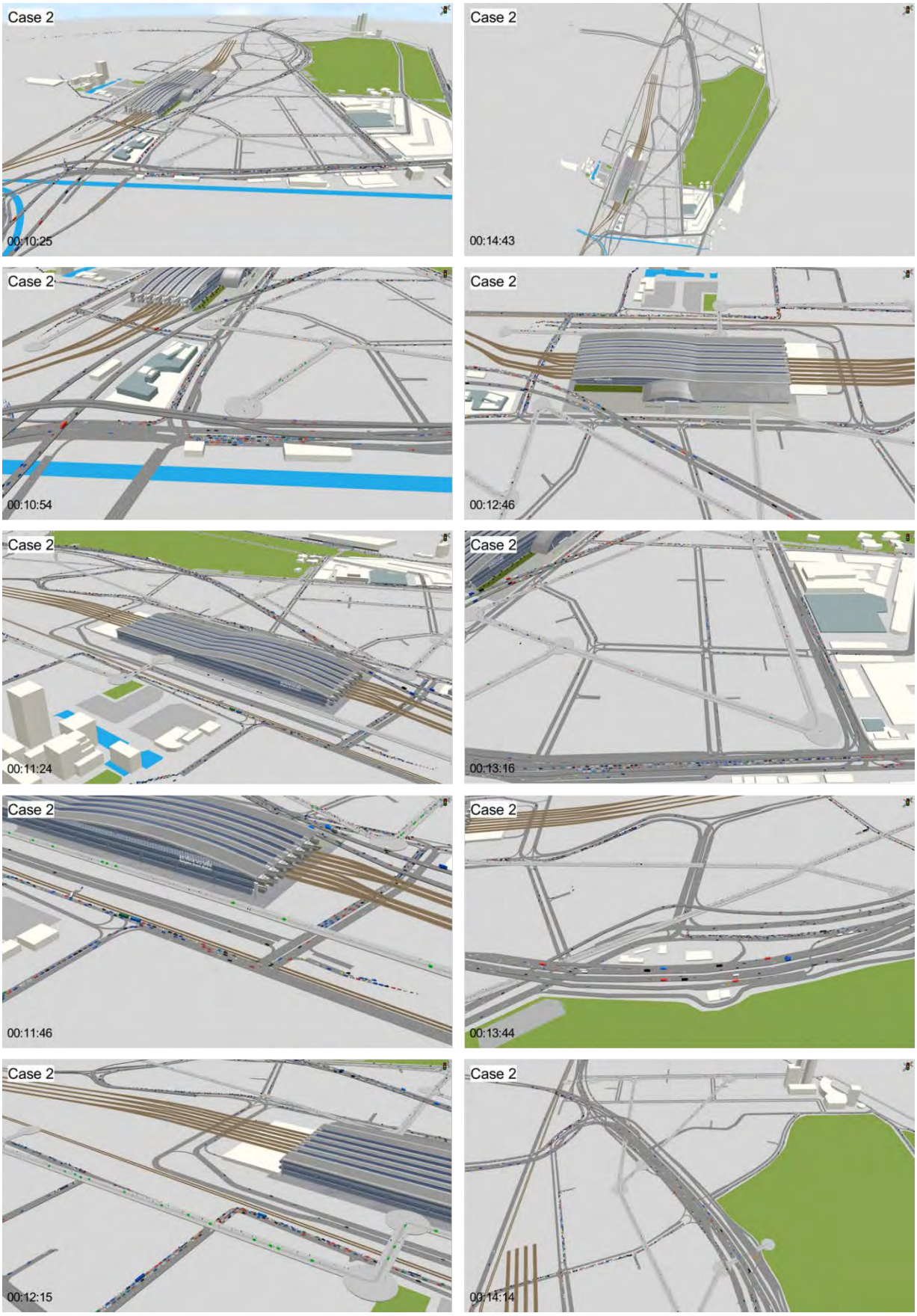
Figure4.34 Formulation of Traffic Simulation Network

(3) Traffic simulation results



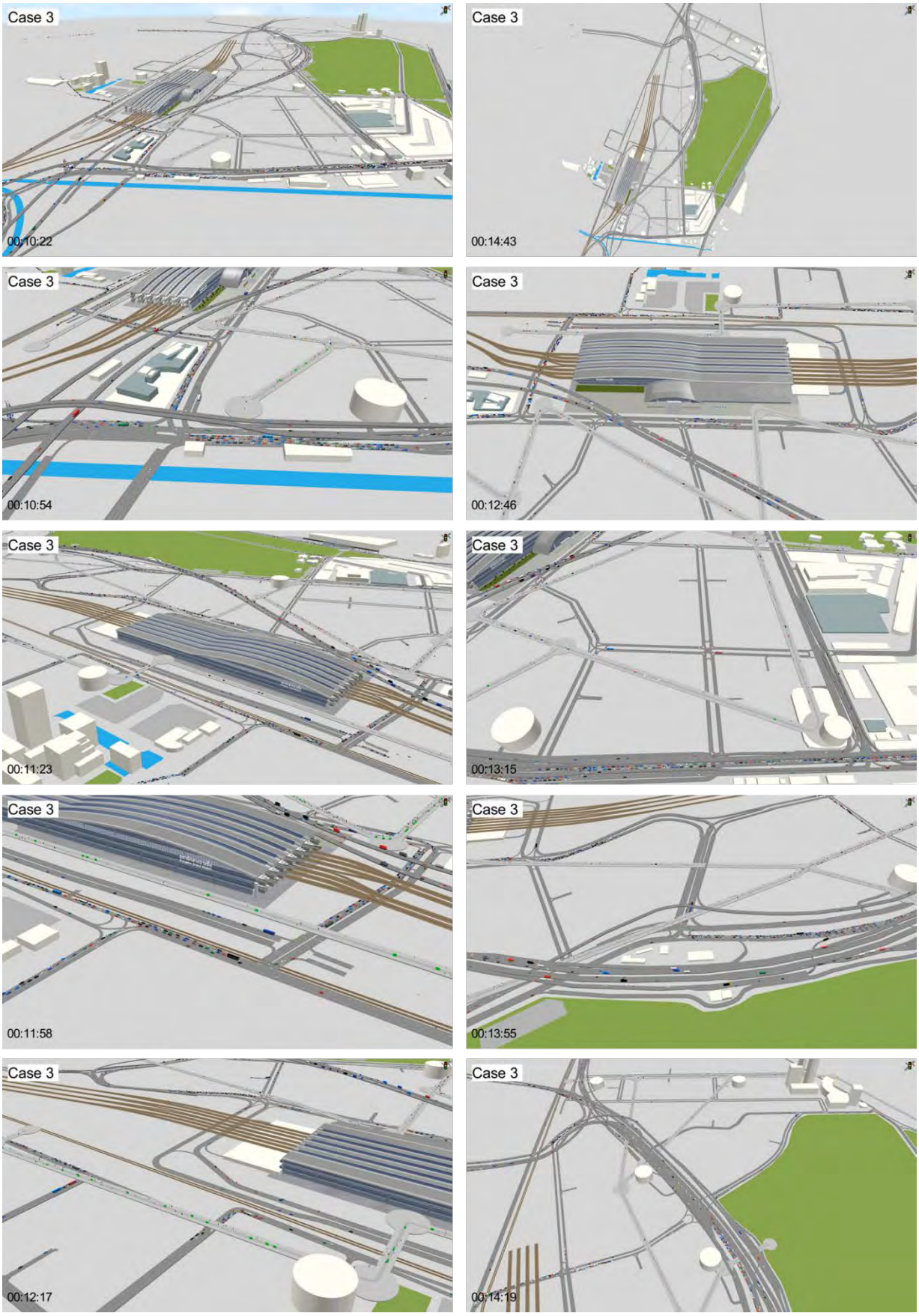
Source: JICA Study Team

Figure4.35 Traffic Simulation (Case 1)



Source: JICA Study Team

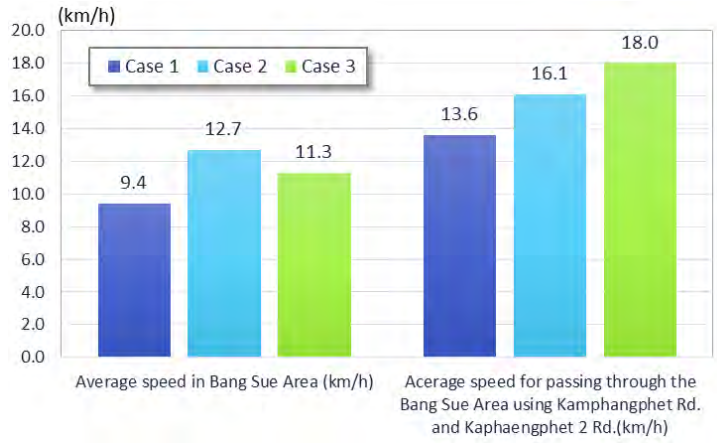
Figure4.36 Traffic Simulation (Case 2)



Source: JICA Study Team

Figure4.37 Traffic Simulation (Case 3)

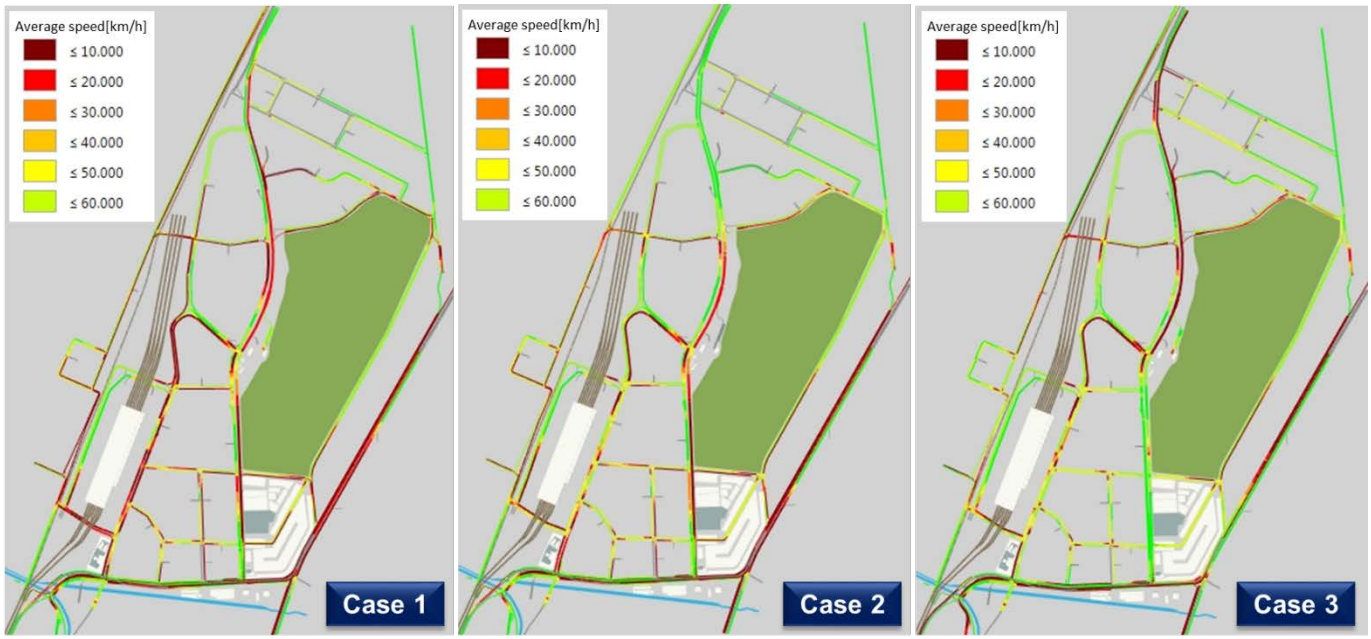
A comparative graph of the average travel speed according to the result of the traffic simulation is shown in the figure below. Looking at the average travel speed of cars in the Bang Sue area (left in the figure below), the travel speed increased more in Case2・Case3 than in Case1. Travel speed of Case2 is higher than Case3, this is because the vehicle inflow control sections in zones are installed in Case3, and the traffic congestion alleviation circumstance differs depending on the place. As shown in the right side of figure below), average travel speeds at the time of north-south crossing of the Bang Sue area on the main roads (Kamphaeng Phet road and Kamphaeng Phet 2 road) are 16.1km/h for Case2 and 18.0km/h for Case3 compared to 13.6km/h for Case1. The Case3 scenario is designed to restrain the use of automotive traffic in cities and aim for high-quality urban spaces and Walkable City. In addition to these effects, it is expected that traffic congestion will be alleviated.



Source: JICA Study Team

Figure4.38 Comparison of average travel speed (average speed in Bang Sue area (left) and average speed for north and south passing through the area (right))

The following figure indicates the average travel speed chart for each road section. There are many sections with low travel speeds in Case 1, and chronic traffic congestion occurs in sections with low travel speeds of 10km/h or less. On the other hand, in Case2 and 3, the average travel speed is improved in many sections.



Source: JICA Study Team

Figure4.39 Comparison of average travel speed in each section

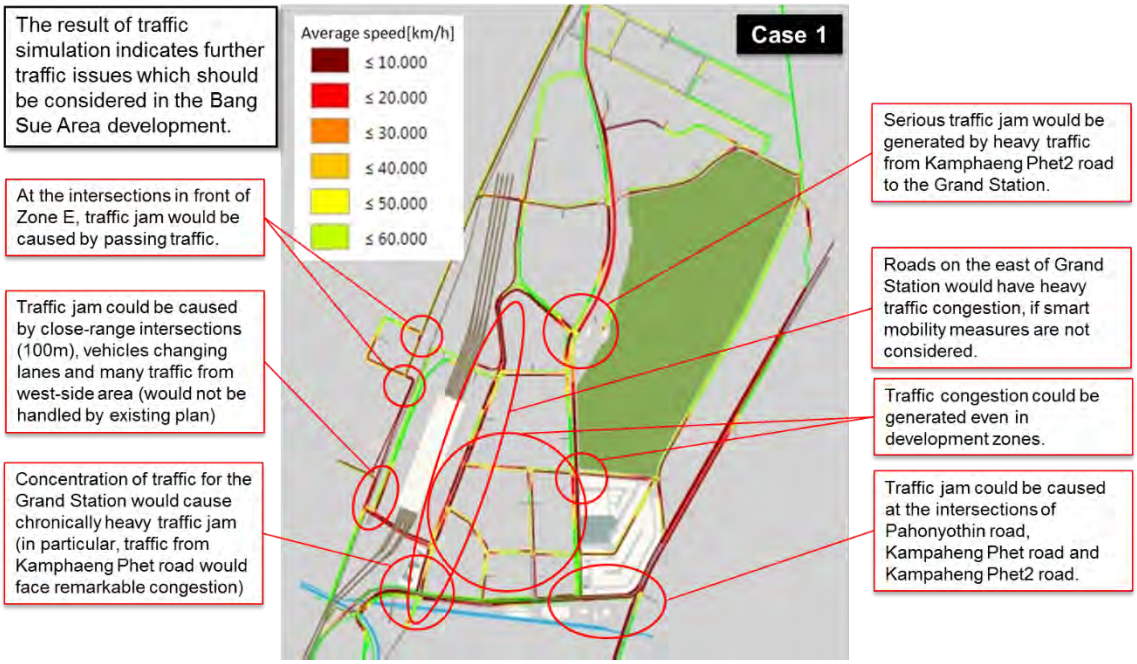
Comparison of the area around the Bang Sue Grand station is shown in the figure below. In the roads around the Bang Sue Grand station, the decrease in travel speed due to traffic congestion was remarkable in Case1, however in Case3 in particular, the decrease in travel speed section is reducing. It can also be seen that traffic congestion on roads in the development zone has been almost eliminated by restraining the inflow of vehicles into development zones, particularly in Case3. Travel speeds on Kamphaeng Phet2 roads have also been improved in Case 3.

Source: JICA Study Team

Figure4.40 Comparison of average travel speed by scenario (around Bang Sue Grand station)

In order to grasp the traffic problem in the Bang Sue area and to obtain the implications for future countermeasures consideration, the road traffic congestion points were verified on the basis of the result of the Case1. As shown in the figure below, traffic congestion is a concern particularly in road sections around the Bang Sue Grand station. As described above, the promotion of smart mobility policies can be expected to have a positive effect of alleviating areal traffic congestion, while it is not possible to eliminate all of these bottleneck points. Therefore, it is important to

formulate a road network plan including a traffic network outside the development area and a comprehensive transport master plan including measures to promote the public transport use in line with a detailed development plan in the future.



Source: JICA Study Team

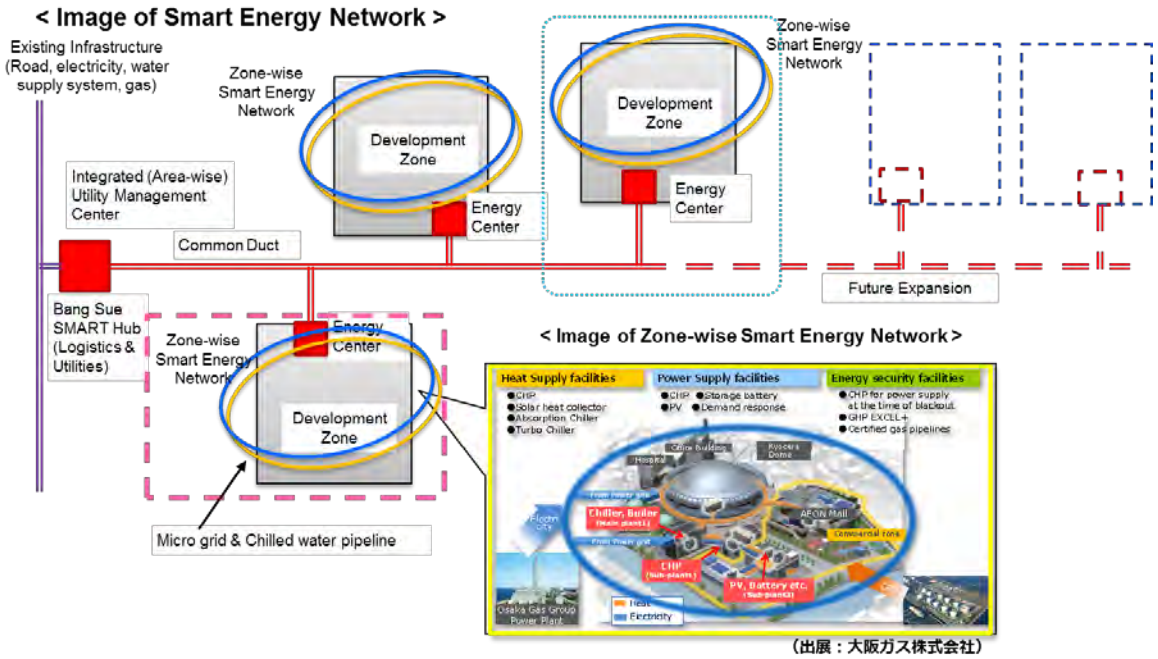
Figure4.41 Assumed road traffic bottleneck points

4.4 Smart Energy

4.4.1 Overview

As PTT-owned gas pipeline has already been installed underground near the existing SRT railroad in the Bang Sue area, the establishment of urban-type power supply/cold heat supply network is expected as an energy source from gas pipeline.

This urban-type power supply/cold heat supply network system, as shown in the following figure, includes the development of urban infrastructure by zone including energy supply points or power network and cold water pipeline, on the sidelines of stepwise development plans in the Bang Sue area. In this system, these energy supply points will be connected, as a network, to power network and cold water pipelines in the future to make the entire area function more effective with energy-saving efforts, aiming to build an energy supply system favorable for smart city.



Source: JICA Study Team.

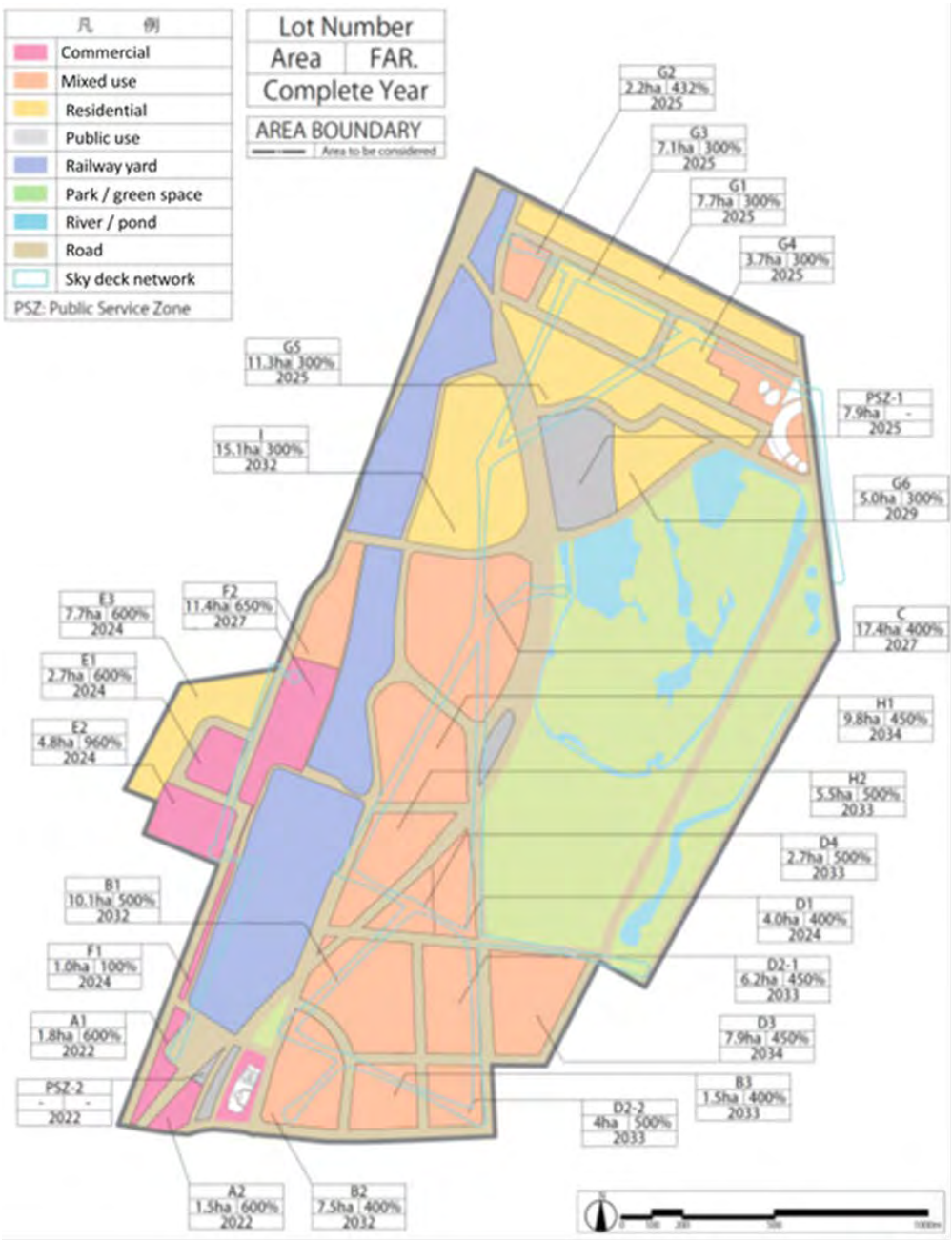
Figure4.42 Smart Energy Network Image in Bang Sue

4.4.2 Conditions for Plan

Planning conditions are organized for urban development in the Bang Sue area before examination on smart energy network in Bang Sue.

(1) Plan for Land Use

Multiple land use is planned on approximately 100 ha of the Bang Sue area, consisting of commercial, business and complex facilities, and residential houses, etc. Figure4.43 shows a land use plan in Zones A to H considered in the study in the past fiscal year.



Source: JICA Study Team.

Figure4.43 Land Use Plan

Figure4.44 shows a layout plan by building use in the Bang Sue area considered in the study in the past fiscal year.

Source: Report produced in the past fiscal year

Figure4.44 Layout Plan by Building Use

(2) Total Development Floor Area by Use

The following table shows the total development floor area by use, drawn up in each zone of the Bang Sue area.

Table4.12 Total Floor Area by Use (m^2)

Zone	Office	Retail	Residential	Hotel	Public Facility	Total of floor space according to the zone
ZONE A	80,000	20,200	13,800	50,400		164,400
Subtotal	80,000	20,200	13,800	50,400	0	164,400
ZONE B1	80,000	40,000	257,900			377,900
ZONE B2	39,900	30,020	154,430			224,350
ZONE B3		44,100				44,100
ZONE B4		32,400				32,400
Subtotal	119,900	146,520	412,330	0	0	678,750
ZONE C		29,600	493,000		50,000	572,600
Subtotal	0	29,600	493,000	0	50,000	572,600
ZONE D1			45,360	73,000		118,360
ZONE D2-1		59,850	109,620	41,400		210,870
ZONE D2-2	30,090	20,000	44,100	0		94,190
ZONE D3		60,000	145,060	60,000		265,060
ZONE D4	35,020		64,260			99,280
Subtotal	65,110	139,850	408,400	174,400	0	787,760
ZONE E1 (SRT LAND)	80,080	83,400				163,480
ZONE E2 (SRT LAND)	201,000	50,700	213,900			465,600
ZONE E3 (SRT LAND)			344,320			344,320
Subtotal	281,080	134,100	558,220	0	0	973,400
ZONE F1		9,700				9,700
ZONE F2	119,700	195,130	335,800	90,240		740,870
Subtotal	119,700	204,830	335,800	90,240	0	750,570
ZONE G1		5,000	168,640			173,640
ZONE G2	64,500	6,000				70,500
ZONE G3		5,010	154,750			159,760
ZONE G4		5,000	80,020		6,000	91,020
ZONE G5		5,000	249,870		8,400	263,270
ZONE G6		5,000	107,940			112,940
Subtotal	64,500	31,010	761,220	0	14,400	871,130
ZONE H1	80,000	10,000	239,210			329,210
ZONE H2	75,620	10,050	73,080	50,400		209,150
Subtotal	155,620	20,050	312,290	50,400	0	538,360
ZONE I		5,000	335580			340,580
Subtotal	0	5,000	335,580	0	0	340,580
Total Amount	885,910	731,160	3,630,640	365,440	64,400	5,677,550

Source: JICA Study Team on the basis of the report produced in FY2018.

(3) Zone Development Schedule

As stepwise development is planned in Phases 1 to 3 in Bang Sue, as shown in Figure4.45, Figure4.51 and Figure4.52, development policies and consideration points are summarized in accordance with development for each phase.

1) Development Plan for Phase 1 (from 2022 onwards)

In Phase 1 to start business by 2022, SRT publicly solicited Zone A developers in July 2019 and future development work includes Grand Station set to open in 2022, Zone E covering SRT head office and Zone F1 near Zone E. In Grand Station, development work for central air conditioning system (2,000 USRT x 5 = 10,000 RT, 1 unit for spare), as cooling system of each building and for emergency generator has been started. When smart energy network is considered in the Bang Sue area, it is effective to examine the entire energy collaboration method with BCP measures for key facilities in mind.

Zone D1, located in the southwest side of Chatuchak Park, east of Bang Sue Grand Station, is to be leased to Department of Medical Services (DMS), Ministry of Public Health, which has promoted the procedure for the development of complex facility "DMS Medical Complex," consisting of a specialized medical center, a small-scale shopping mall, a restaurant district, etc.

In addition to the above, in Zone G (KM 11), located in the north side of the Bang Sue area, the development schedule has been changed from Phase 2 to Phase 1 and thus its development concept is being considered by SRT. As this Zone G has a certain distance with Zones A, E, F1 and D1 to be developed at the same time with Zone G, economic or geographical restrictions need to be considered at the time of reviewing smart energy network development. Figure4.45 shows development zones scheduled for Phase 1.

Source: JICA Study Team.

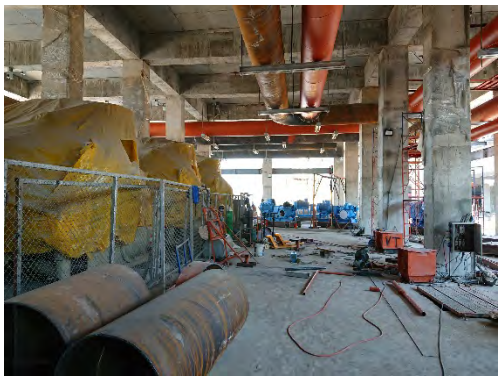
Figure4.45 Development Plan in Phase 1

① Bang Sue Grand Station

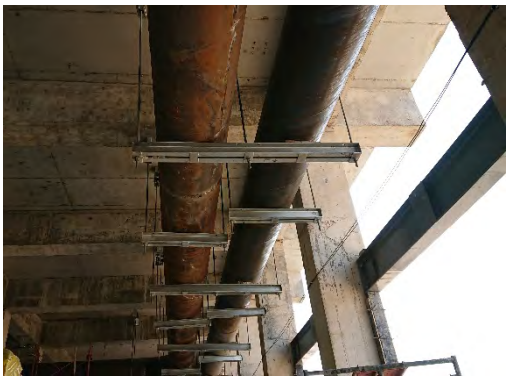
The following photos taken in December 2018 show construction work status for heat source equipment for Bang Sue Grand Station. The machine room is to be constructed in the west side of Bang Sue Grand Station with refrigerating machines to the tune of 10,000 USRT in total.

Main entrance in the east side of the station

Exterior of the machine room



Status in the machine room



Pipework for cold water

Motor-driven turbo chiller
（2,000 USRT x 5 units）

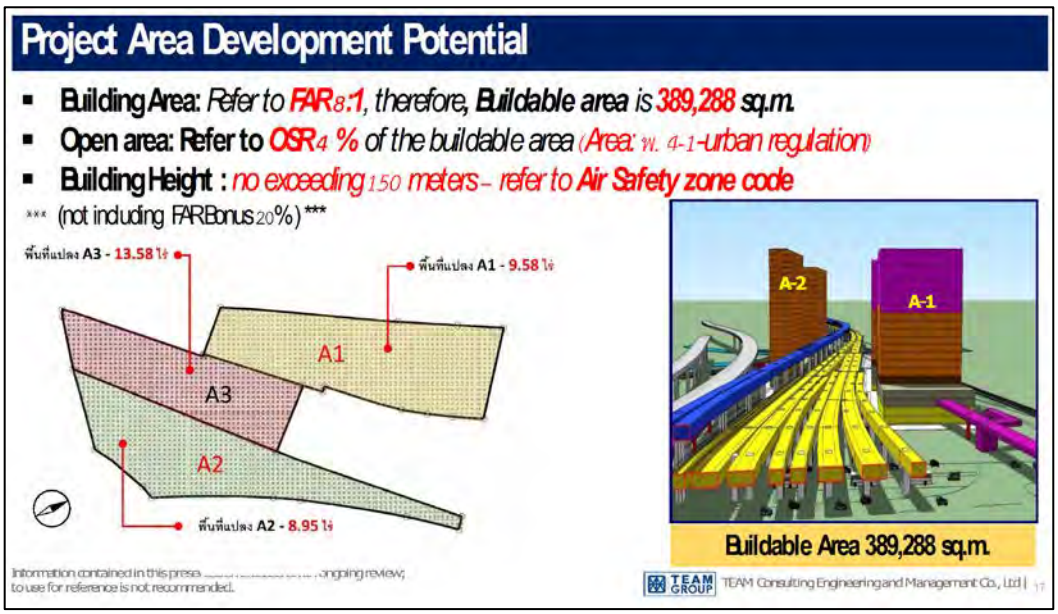
Water pump

Source: JICA Study Team.

Figure4.46 Construction status of Bang Sue grand station

② Planning Overview for Zone A

A 5.1-ha area in Zone A is to be developed as a smart business complex facility. In this zone, commercial facilities, hotels and office buildings are to be built and the zone is closer to Bang Sue Grand Station with possibly high energy demand and to Zone E to be developed coincidently with Zone A. Therefore, Zone A development can be recognized as a touchstone for the development of wider energy network through zone collaboration.



Source: Material for Zone A market sounding study held on Wed., Oct. 17, 2018

Figure4.47 Development Outline for Zone A (as shown earlier)

③ Planning Overview for Zone E

In Zone E, a 19.2-ha area, located in the west side of Bang Sue Grand Station, is planned to be developed. As this area is close to SRT's head office or other offices, commercial facilities, relatively high-rise housing and SRT's company residence are to be developed.

As SRT's head office is located as a landmark for Bang Sue redevelopment in Zone E, the central function operation, even in the redevelopment process of the Bang Sue area, is expected, consisting of the smart city center controlling the entire city as a core function, together with its head office function, and Smart Energy Management Center (SEMC), integrating and managing energy supply system.

Source: Material for Pahon Yothin Zone E market sounding study

Figure4.48 Development Plan for Zone E (As shown earlier)

Source: Material for Pahon Yothin Zone E market sounding study

Figure4.49 Image Perspective for Zone E

④ Planning Overview for Zone D1

Zone D1 development plan includes a medical complex facility "DMS Medical Complex," consisting of a small-scale shopping mall and a restaurant district. The medical complex will accommodate around 510 beds for hospital patients and address 2,500 outpatients per day, and equip emergency power source from cogeneration equipment. The following figure shows an image perspective supplied by Thai's authorities.

Source: Concept paper on "DMS Medical Complex" supplied by OTP.

Figure4.50 Image Perspective on Medical Complex Facility in Zone D1

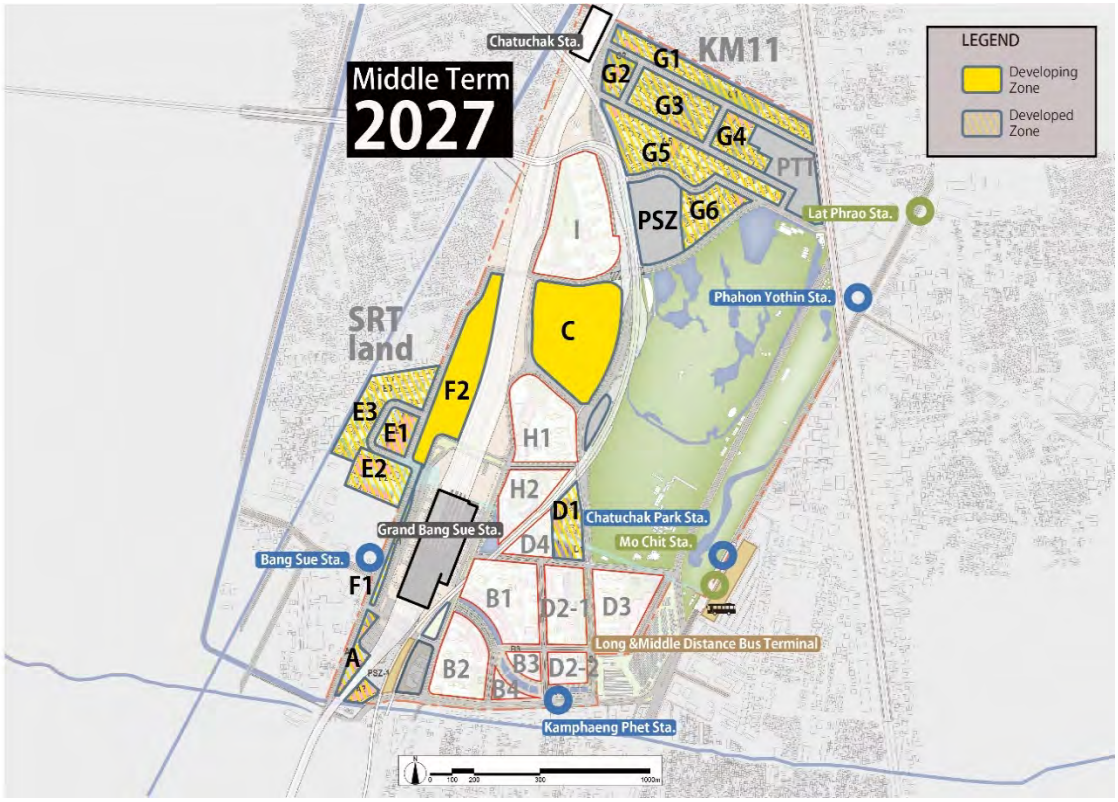
2) Phase 2 (From 2027 onwards)

Phase 2 to start business by 2027 includes Zone F2 with relatively large development work,

located in the west side of Bang Sue Grand Station and Zone C with the current bus terminal in the west side of Chatuchak Park.

In Phase 2, considering zone location features or geographical restrictions and energy demand concentration, etc., the expansion method for energy supply infrastructure (gas pipeline, conduit pipe for cold water, power transmission and distribution network) to be supplied by the energy plant developed in Phase 1 or the location of new energy supply plant need to be considered if necessary.

Figure4.51 shows scheduled development zones for Phase 2.



Source: JICA Study Team.

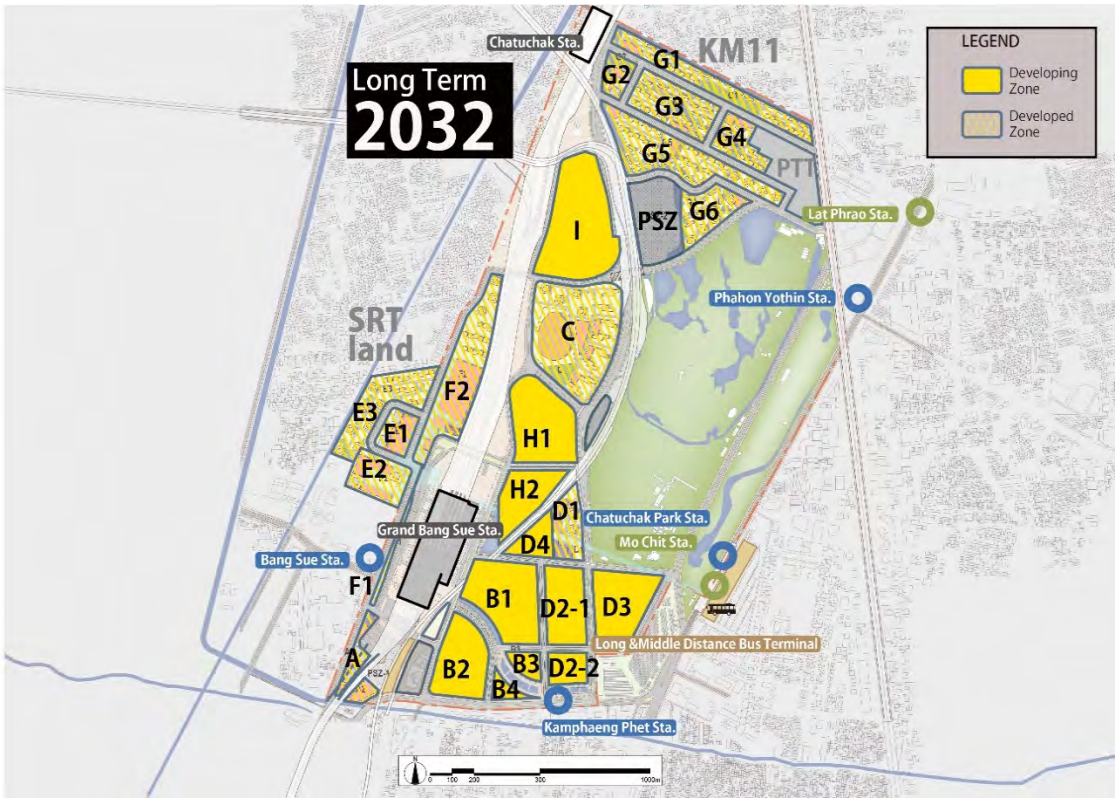
Figure4.51 Development Plan in Phase 2

3) Phase 3 (From 2032 onwards)

Phase 3 development plan to start business by 2032 mainly covers the east side of Bang Sue Grand Station.

Phase 3 plan includes many business or commercial facilities with relatively high energy demand in Zones B or D2 (D2 to D4). Therefore, if this area can collaborate energy network with the areas in Zones 1 and 2 which have already completed development, it is possible to achieve more efficiency across the entire Bang Sue area.

Figure4.52 shows scheduled development zones for Phase 3.



Source: JICA Study Team.

Figure4.52 Development Plan in Phase 3

4) Planned Total Floor Area for Each Phase

Table4.13 shows total floor areas by use to be developed in each phase. In the subsequent considerations, energy demand and others are calculated, based on zone description in the red frame of the table.

Table4.13 Planned Total Floor Area on Basis of Land Use Status for Each Phase (m^2)

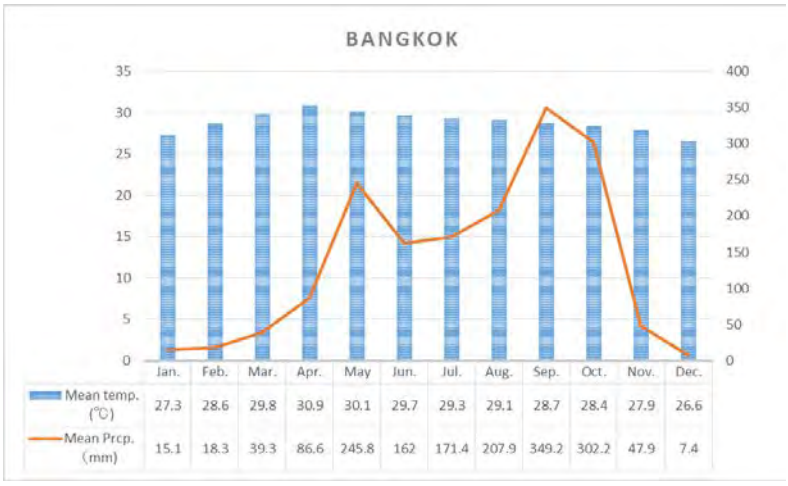
	Zone		Office	Retail	Residential	Hotel	Public Facility	Total of floor space according to the zone
Phase1	Zone A		80,000	20,200	13,800	50,400		164,400
	Zone D1				45,360	73,000		118,360
	Zone E	E1 (SRT LAND)	80,080	83,400				163,480
		E2 (SRT LAND)	201,000	50,700	213,900			465,600
		E3 (SRT LAND)			344,320			344,320
	Zone F1			9,700				9,700
	Zone G1	G1		5,000	168,640			173,640
		G2	64,500	6,000				70,500
		G3		5,010	154,750			159,760
		G4		5,000	80,020		6,000	91,020
		G5		5,000	249,870		8,400	263,270
		G6		5,000	107,940			112,940
	Phase1 Subtotal		425,580	195,010	1,378,600	123,400	14,400	2,136,990
Phase2	ZONE C			29,600	493,000		50,000	572,600
	ZONE F2		119,700	195,130	335,800	90,240		740,870
	Phase2 Subtotal		119,700	224,730	828,800	90,240	50,000	1,313,470
Phase3	ZONE B	B1	80,000	40,000	257,900			377,900
		B2	39,900	30,020	154,430			224,350
		B3		44,100				44,100
		B4		32,400				32,400
	ZONE D2	D2-1		59,850	109,620	41,400		210,870
		D2-2	30,090	20,000	44,100	0		94,190
		D3		60,000	145,060	60,000		265,060
		D4	35,020		64,260			99,280
	ZONE H	H1	80,000	10,000	239,210			329,210
		H2	75,620	10,050	73,080	50,400		209,150
	ZONE I			5,000	335580			340,580
	Phase3 Subtotal		340,630	311,420	1,423,240	151,800	0	2,227,090
Phase 1+2+3 Total Amount			885,910	731,160	3,630,640	365,440	64,400	5,677,550

Source: JICA Study Team, based on study reports created in FY2018

(4) Location Features

1) Weather Conditions

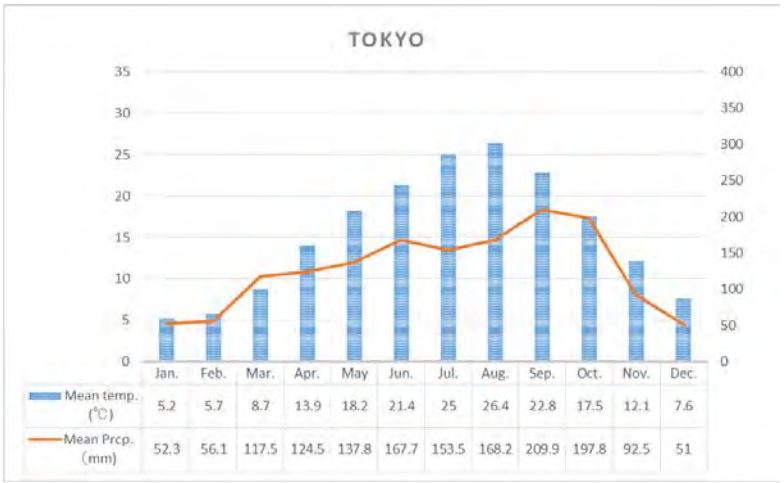
Thailand, classified as tropical monsoon climate, has three seasons: hot season from March to May, rainy season from June to October and dry season from November to February. Bangkok's climate features high temperature and high humidity with small annual temperature changes at an annual average temperature of 29 degrees C and an annual average humidity of 73%. Thailand has annual demand for cooling equipment, as its seasonal structure is different from that of Tokyo with autumn and spring seasons as moderate climate. The following charts show monthly average temperatures and precipitation amount in Bangkok and Tokyo.



	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean temp. (℃)	27.3	28.6	29.8	30.9	30.1	29.7	29.3	29.1	28.7	28.4	27.9	26.6
Mean Prcp. (mm)	15.1	18.3	39.3	86.6	245.8	162	171.4	207.9	349.2	302.2	47.9	7.4

Source: Produced on basis of statistics data sourced from Japan Meteorological Agency

Figure4.53 Weather in Bangkok City



	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean temp. (℃)	5.2	5.7	8.7	13.9	18.2	21.4	25	26.4	22.8	17.5	12.1	7.6
Mean Prcp. (mm)	52.3	56.1	117.5	124.5	137.8	167.7	153.5	168.2	209.9	197.8	92.5	51

Source: Produced on basis of statistics data sourced from Japan Meteorological Agency

Figure4.54 Weather in Tokyo

2) Insolation Conditions

The average insolation volume (241 W/m^2) in Bangkok City is about 1.4 times larger than that of Tokyo (169 W/m^2). Although care should be taken in consideration of cooling loads, etc. per unit floor area brought by transmission heat against the building, the potential for solar power generation as regional natural energy can be said to be high. Source: Solar GIS published by the World Bank

Figure4.56 shows isolation distribution in Thailand.

Source: Solar GIS published by the World Bank

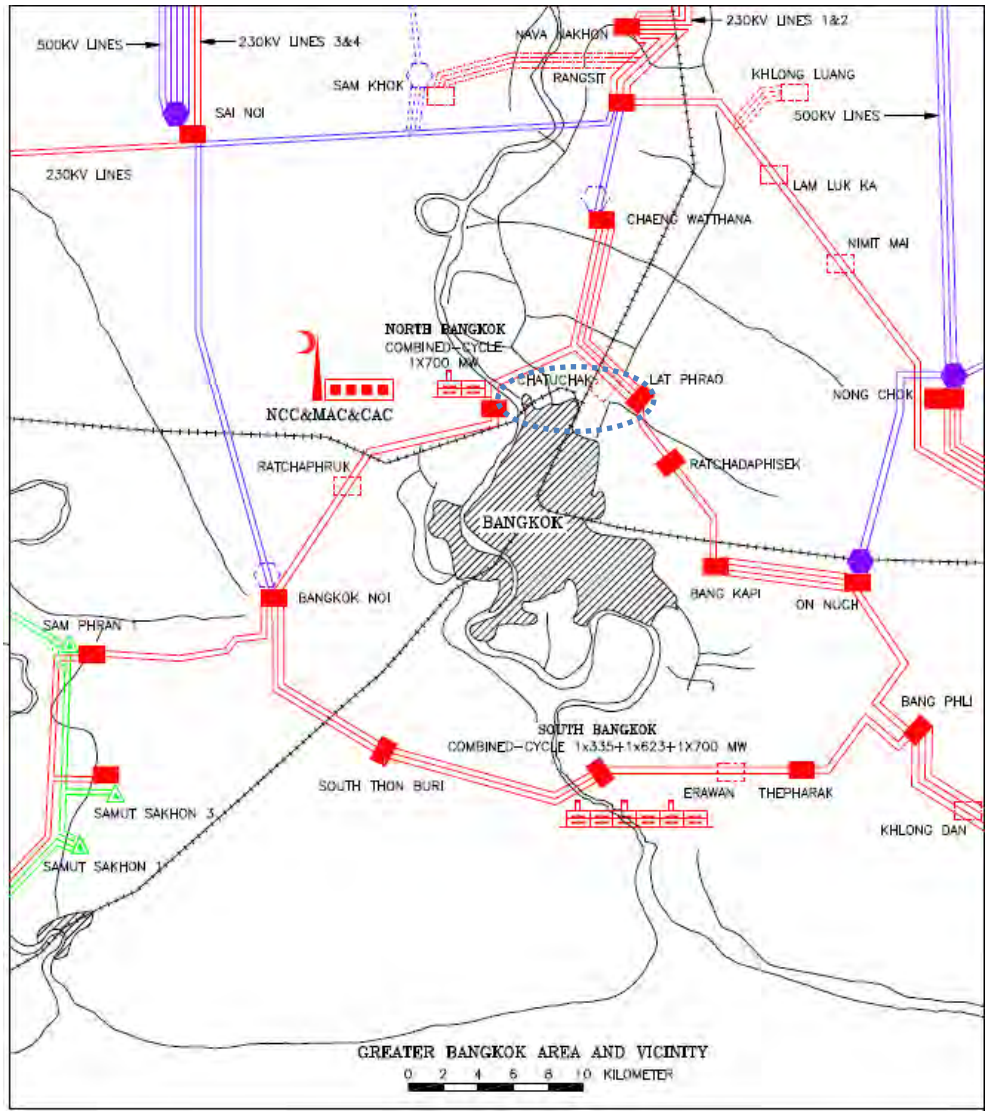
Figure4.55 Isolation Distribution in Thailand

Source: Solar GIS published by the World Bank

Figure4.56 Isolation Distribution in Japan

3) Development Status for Electric Power Grid

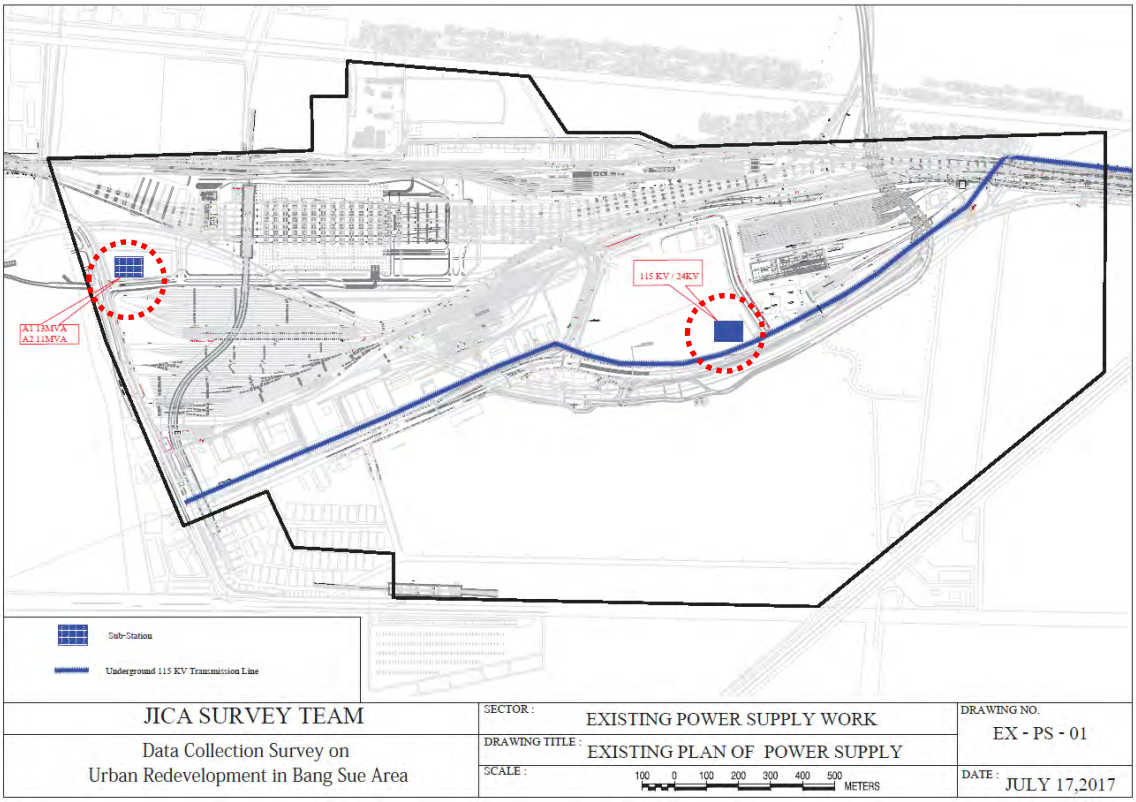
As shown in Figure4.57, 230 kV power grids are installed around Bangkok City and EGAT plans to develop Chatuchak substation near the Bang Sue area.



Source: Power Development Plan 2015 released by MOE

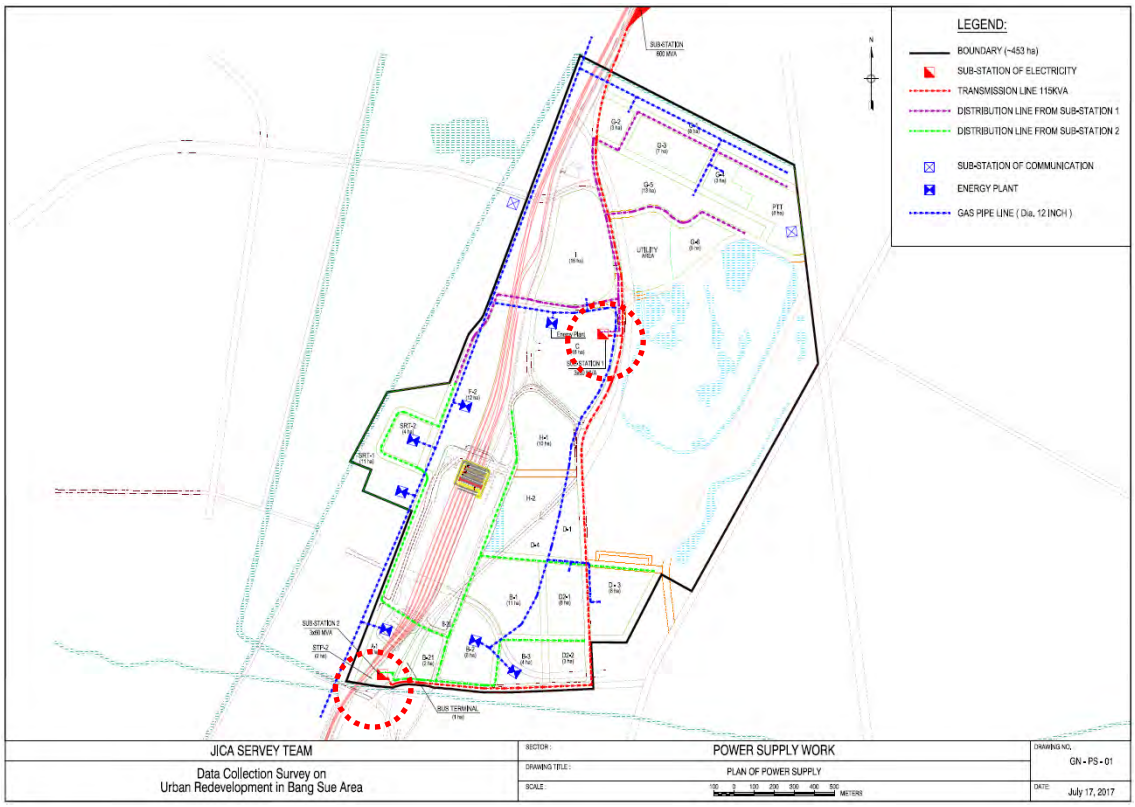
Figure4.57 Power Transmission Network around Bangkok City

In addition, two substations are to be developed for Zones A and C under the agreement between SRT and MEA in the Bang Sue area. Figure4.58 shows the location of substations planned by the MEA.



Source: JICA study reports produced in the past fiscal year, added partially by JICA Study Team.

Figure4.58 Substation Development Plan in Bang Sue (As built drawing)



Source: JICA study reports produced in the past fiscal year. (Location of energy plants in the Bang Sue area was considered at the time of studies done in the past fiscal year.)

Figure4.59 Substation Development Plan in Bang Sue (Drawing reflecting development zones)

Table4.14 Substation Development Status/Plan around Bang Sue Area

No.	Facility Name	Status	Volume	Operation rate	Remarks
1	Lard Phrao Substation	In operation	40 MVA	50%	The total free space for two facilities is 40 kVA.
2	Chatuchak Substation	In operation	40 MVA	50%	
3	EGAT Chatuchak Substation	Planned		—	
4	MEA Substation (Redline, for ARL use)	In the process of producing detail plan	600 MVA	—	Started construction in 2017.
5	MEA Substation (for Bang Sue Station vicinity)	Planned	600 MVA (+300 MVA)	—	・ +300 MVA as spare capacity ・ Electric power cables for Zones B, C and D are to be installed under the public road. ・ 115 kV for power cable

Source: JICA Study Team, based on study reports created in FY2018

4) Development Status for Gas Pipeline

PTT-owned oil and gas pipelines are installed underground in the Bang Sue area and the gas pipeline is laid near SRT's current railroad. Table4.15 indicates burial conditions of existing gas pipelines and Figure4.60 shows the location of oil and gas pipelines.

Table4.15 Burial conditions of existing gas pipelines

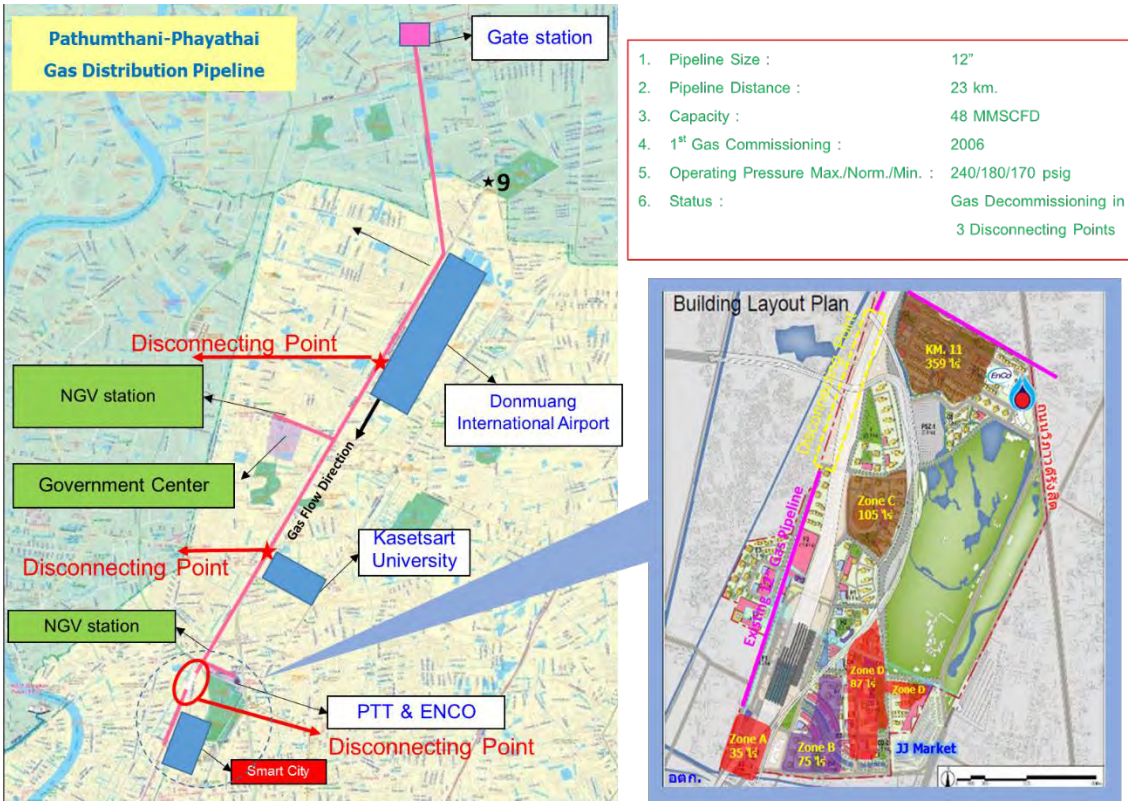
Category	owner	Burial conditions
Compressed natural gas pipeline	PTT	Buried underground pipe Diameter 300mm Pressure 300MMscfd (1.17MPa)

Source: JICA Study Team, based on study reports created in FY2018

Source: Report produced in the past fiscal year.

Figure4.60 Location of Oil/Gas Pipelines in Bang Sue Area

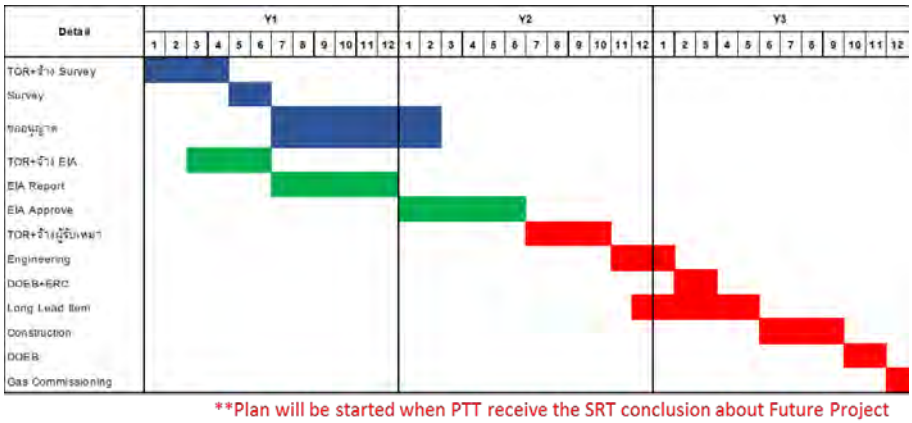
In addition, as the gas pipeline is diverged in the northwest side of the Bang Sue area, the gas pipeline can be brought into the Bang Sue area from the diverging point. However, according to PTT, as some of the gas pipeline routes are planned to be changed in the future, care should be taken. As detail surveys are possibly needed on reconnection and route change between Rangsit and Bang Sue due to construction work for Redline and high speed rail, coordination is needed with the SRT. But PTT mentioned that these gas pipeline routes can be utilized tentatively in the Bang Sue area. The branch points (Disconnecting Point) that can bring the gas pipeline into the Bang Sue area are shown below.



Source: Material supplied by PTT.

Figure4.61 Pathumthani-Phayathai Gas Pipeline

And furthermore, PPT points out that it takes about three years to bring gas pipeline to the Bang Sue area, including survey, design and environmental impact assessment, based on the current regulation. In Phase 1, especially, special measures are needed to facilitate the Bang Sue development plan in parallel with gas pipeline development through the mutatis mutandis application of Thai EEC system or special district certification. The rough schedule for the gas pipeline connection and installation is shown below.



Source: Material supplied by PTT.

Figure4.62 Pathumthani-Phayathai Gas Pipeline

4.4.3 Basic Policy and Concept

(1) Trend for Energy Policy and Urban-type Energy System

1) Policy Status in Thailand

In response to National Strategy “Thailand 4.0” released in May 2016 in Thailand, the country aims to develop smart city or smart grid under the banner of 1. Stable energy supply, 2. Well-balanced energy price and 3. Energy efficiency in the energy sector. And furthermore, a new Power Development Plan (PDP) has been published to advance the strategy in January 2019. This new PDP describes that renewable energy (hereinafter referred to as “RE”) accounts for 37% of the entire energy for 2037. (Approx. 15% as of 2018) Based on the new PDP, Thai Ministry of Energy (MOE) indicates that new construction of large-scale power plants is difficult due to growing environmental awareness in the country and small-scale power plant (SPP: Small Power Plant) will be a mainstream for future renewable energy or industrial complex, and also points out that systems need to be introduced to store or share excessive power.

And moreover, Energy Policy and Planning Office (EPPO) under the MOE has formulated Smart Grid Development Master Plan 2015-2036 and subsequently MEA, PEA and EGAT under the plan have produced a specific roadmap, which describes that smart grid will be achieved with the introductions of renewable energy or smart meter (AMI: Advanced Metering Infrastructure), power storage system (ESS: Energy Storage System), and electric vehicle (EV).

In addition, MOE considers a platform for renewable energy transactions or for power transactions with no restrictions through microgrid system, aiming to open up a power market furthermore in the future. As an advanced effort, the MEA has worked together with an Australian company to start a demonstration project for block chain technology in Bangkok and other smart city projects have been promoted under public-private collaboration.

2) Development Trend for Urban Energy System

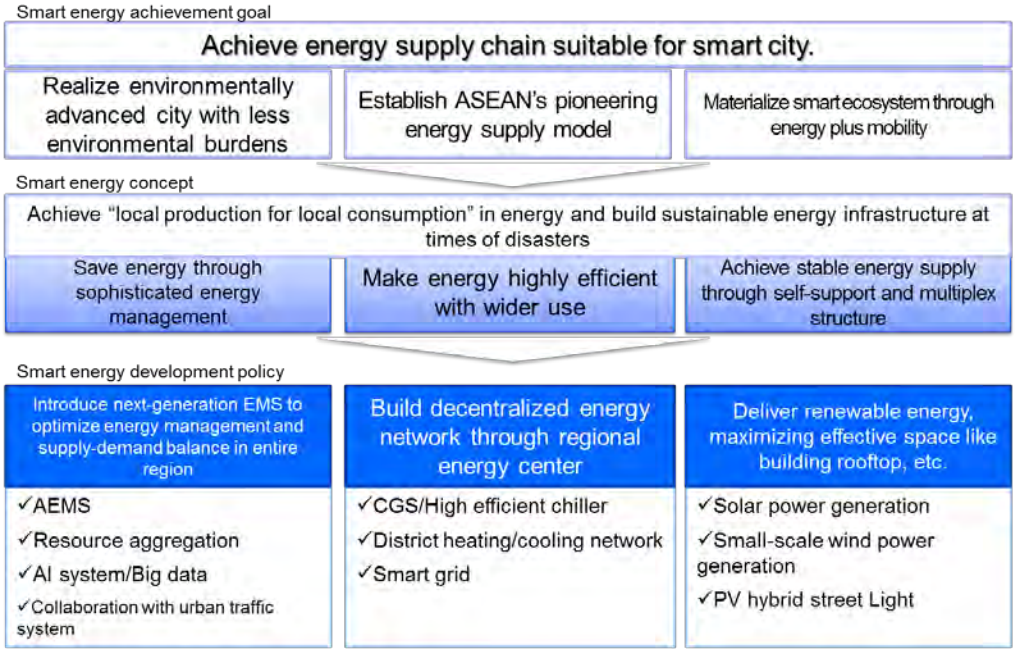
The global community tries to shift drastically to a low carbon society in order to tackle global environmental problems like global warming, climate change and environmental pollution. In the urban area with large energy consumption, in particular, demanded are a reduction in environmental loads through energy efficiency, promotion to introduce renewable or unused energy and sustainable energy supply system as reliable energy source at time of disasters.

As one method to achieve them, attention is drawn to the use of distributed energy system, including renewable energy as regional energy sources, in the area close to the consumption place, in addition to the traditional energy supply system. In the densely built-up urban area, especially, as the potential for renewable energy is not sufficient in most cases, cogeneration-based regional air conditioners play a pivotal role as a more energy-efficient mechanism to use energy across the entire area. Therefore, if distributed energy sources like renewable energy are combined with district cooling system through sophisticated management, the high-efficient, low carbon-based urban energy system will be frequently introduced with reliable supply in the future.

(2) Smart Energy Concept in Bang Sue Area

Based on the above, Figure4.63 shows a smart energy concept and a development policy as a

basic policy for the development of smart energy network in Bang Sue in order to achieve an energy supply chain desirable for smart city.

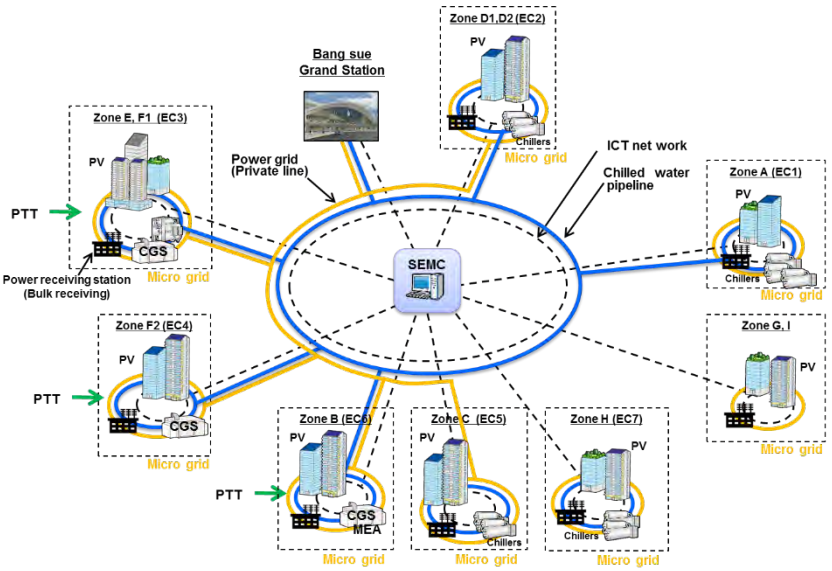


Source: JICA Study Team.

Figure4.63 Smart Energy Concept in Bang Sue

(3) Concept for Smart Energy Network

The Bang Sue area achieves a sophisticated management system for intraregional power supply network, including regional heat supply network and renewable energy, with ICT technology, and attains an urban energy system with high-efficient, reliable supply and less environmental loads. Figure4.64 organizes a basic concept for smart energy network to be achieved in the Bang Sue area.

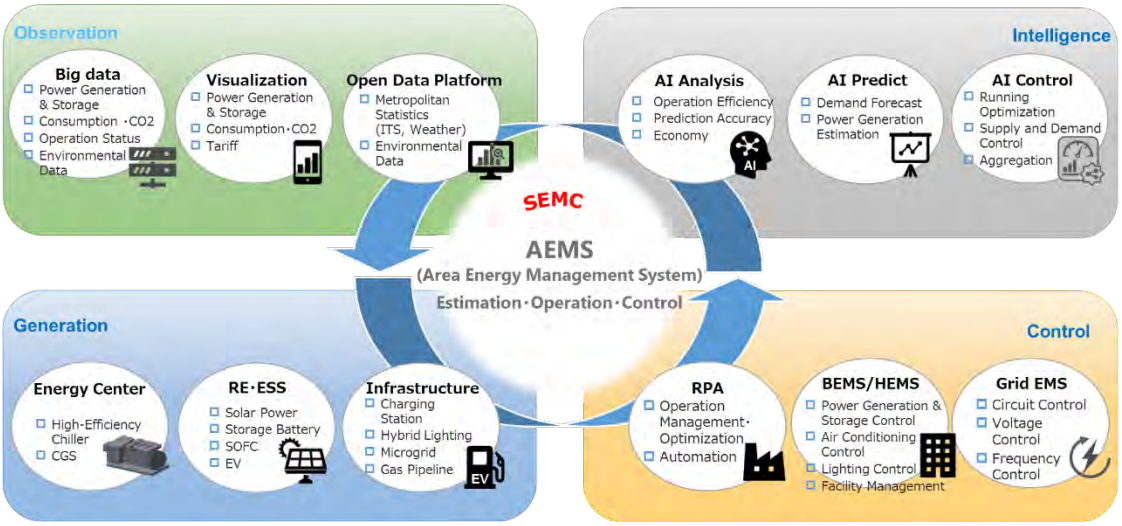


Source: JICA Study Team.

Figure4.64 Concept for Smart Energy Network

(4) Area Energy Management System (AEMS)

Smart Energy Management Center (SEMC) introduces Area Energy Management System (AEMS) to make sophisticated management of distributed energy resources like respective energy centers or renewable energy, and achieves optimal energy supply and demand with AI system in Bang Sue. Figure4.65 organizes a concept for AEMS.



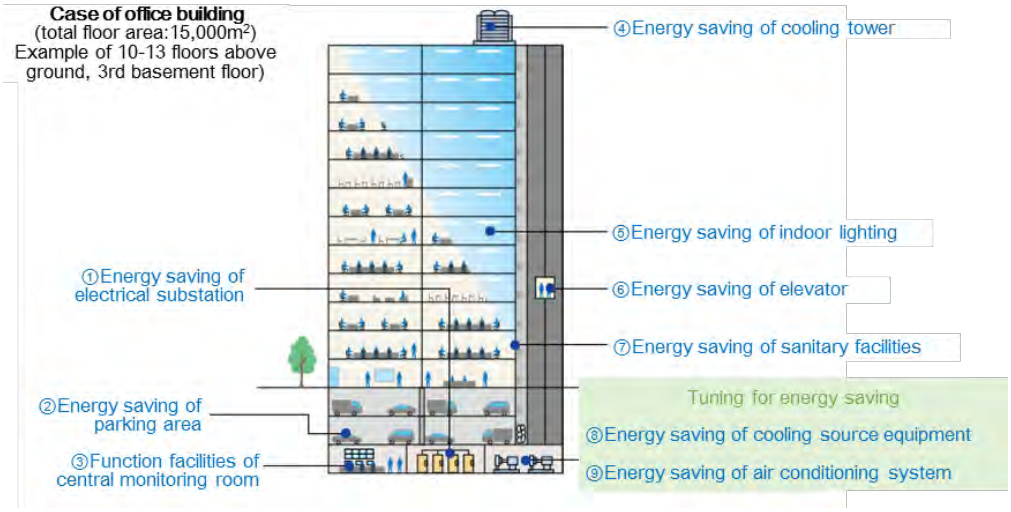
Source: JICA Study Team.

Figure4.65 Concept for AEMS

(5) Building Energy Management System (BEMS)

As many business facilities (office, commercial facility, hotel, public facility, etc.) are to be built in Bang Sue, Building Energy Management System (BEMS) is proactively introduced to manage energy by facility unit and save energy.

This BEMS system allows optimal control chiefly for air conditioner, heat source equipment and ventilatin volume, etc., and automated/optimal operation, including lighting intensity and adjustment/automatic lighing and lights-out for comfortability, in the entire facility, contributing to energy saving and labor-saving for facility managemnet. Figure4.66 shows BEMS overview.



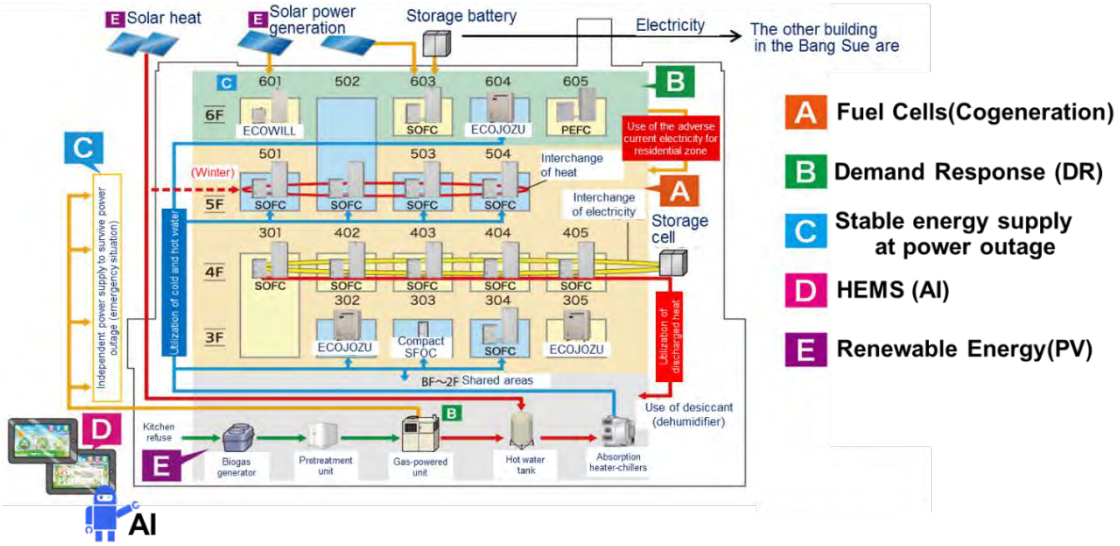
Source: Published by Osaka Gas Facilities Corporation (English translation of JICA Study Team)
(http://www.ogfa.co.jp/business/office-building.html)

Figure4.66 BEMS Overview

(6) Home Energy Management System (HEMS)

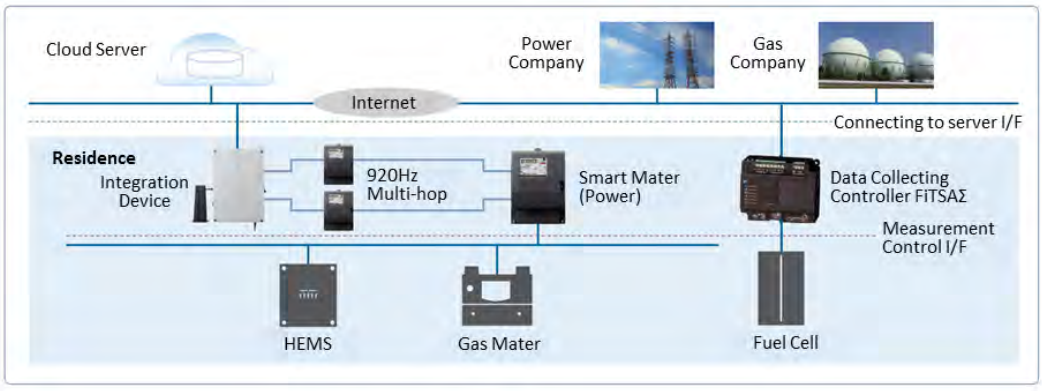
As many residential houses are located in the Bang Sue area, if energy consumption is efficient for each household, they can contribute to a low carbon society in the entire area. The use of Home Energy Management System (HEMS) can be considered as an effective energy management system for residential building. The introduction of HEMS allows each household to “visualize” power consumption or generation, reserve cell volume, gas/water consumption through management, and also to effectively manage or control smart household appliances for HEMS or energy resources like solar power or reserve cells. It is expected to raise awareness about energy-saving or reduce energy costs by monitoring energy consumption status in each household or the entire residential building.

The use of HEMS allows users to select power charge menus flexibly in collaboration with advanced metering infrastructure (AMI), collaborate with the open data platform with HEMS and obtain synergy effects with a wide range of services like surplus power trade. Figure4.67 organizes a concept for HEMS and Figure4.68 shows a system overview for remote metering with smart meters.



Source: NEXT 21 (experimental multi-family housing complex) tackled by Osaka Gas Co. Ltd.
(https://www.osakagas.co.jp/company/efforts/next21/index.html)

Figure4.67 HEMS Overview

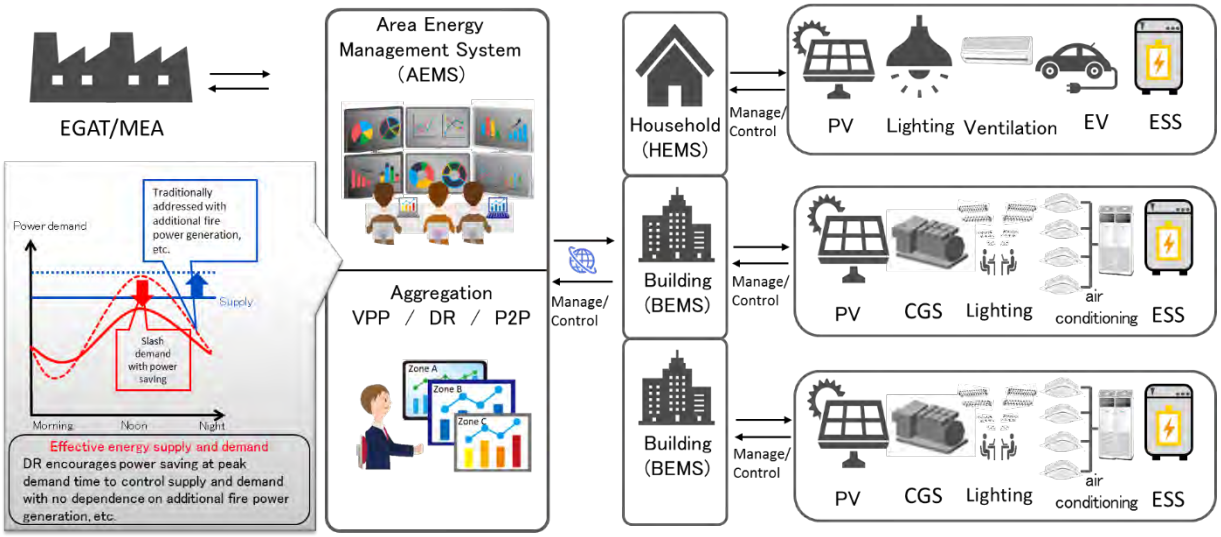


Source: Released by Fuji Electric Co., Ltd. (English translation of JICA Study Team)
(https://www.fujielectric.co.jp/products/whm/about/box/doc/61A1-J-0005.pdf)

Figure4.68 Remote Metering System with Smart Meter

(7) Collaboration between EMS and AEMS

If EMS for user facilities like BEMS or HEMS is collaborated with AEMS for energy management in the entire Bang Sue area, it can help optimize and stabilize supply and demand across the area through energy management for individual facilities, zone-based demand control (DR), virtual power plant (VPP) and peer-to-peer (P2P) energy trading. Figure4.69 shows an image for collaboration between EMS and AEMS for individual user facilities.



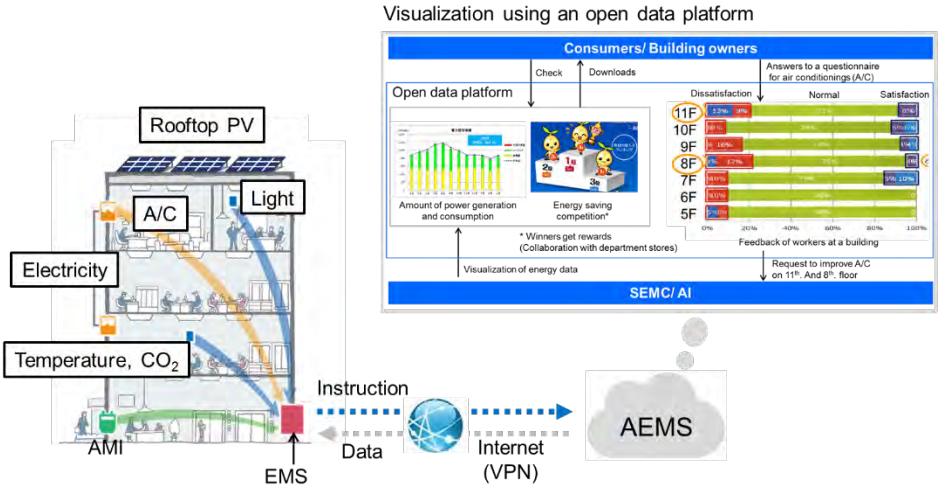
Source: JICA Study Team.

Figure4.69 Demand Control through Collaboration between EMS and AEMS in User Facilities

(8) Open Data Platform

Users can utilize energy data collected in the Bang Sue area to confirm energy consumption status or reduction goal.

In addition, data accumulated in the open data platform can be shared regionally and used for new innovation. Figure4.70 shows a concept to visualize energy with the use of the open data platform.



Source: JICA Study Team.

Figure4.70 Energy Visualization through Open Data Platform

(9) Establishment of Ecosystem

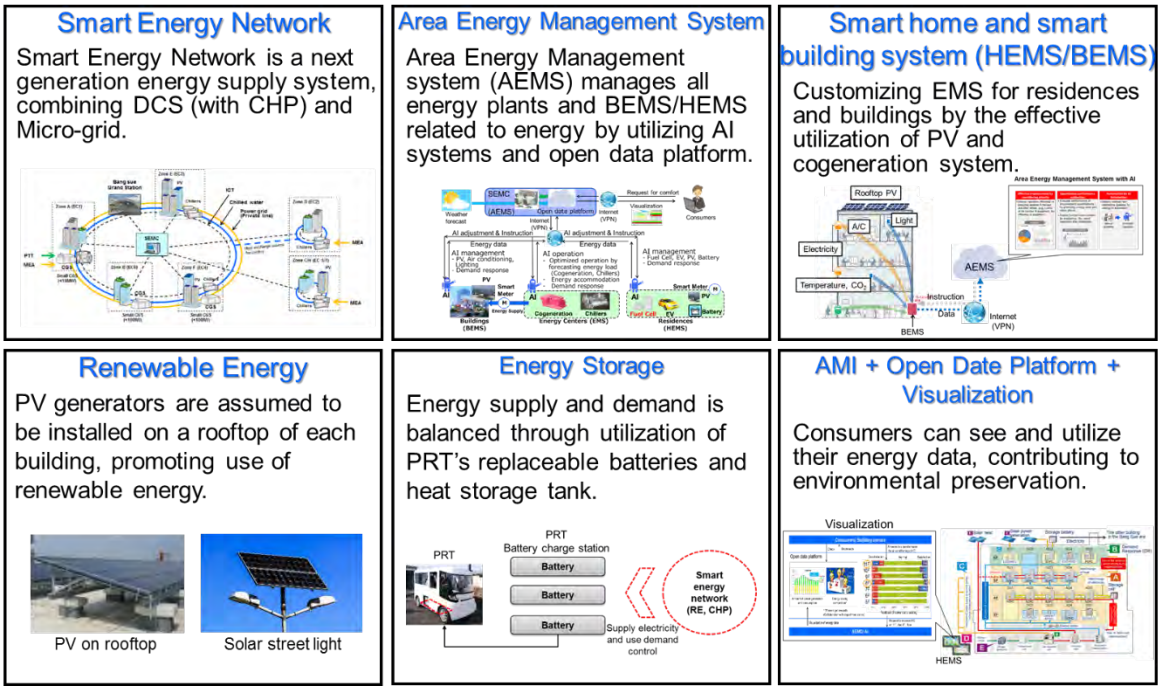
In order to collaborate smart mobility with smart energy to be considered in Bang Sue, distributed energy power sources in the area is used to charge a next-generation pubic traffic system PRT (EV) under consideration for the establishment of public traffic system with low environmental loads. Meanwhile, EV like PRT can contribute to energy efficiency or stability, if it is used as a reserve cell to store power instead of recognizing EV as mere traffic means. Therefore, with a focus on reserve cells for PRT, though PRT is used as power sources for the traditional traffic means for single use, it can be changed to multipurpose uses as energy resources to contribute to system stability, achieving the ecosystem.

Source: JICA Study Team.

Figure4.71 Collaboration between Smart Energy System and Smart Mobility System

(10) Smart Energy Contents

Figure4.72 organizes smart energy contents in the Bang Sue area, based on the above considerations.



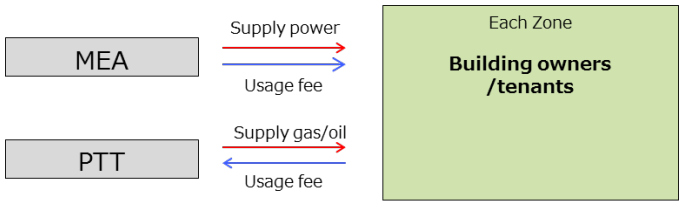
Source: JICA Study Team.

Figure4.72 Smart Energy Contents

(11) Energy Supply Model in Bang Sue Area

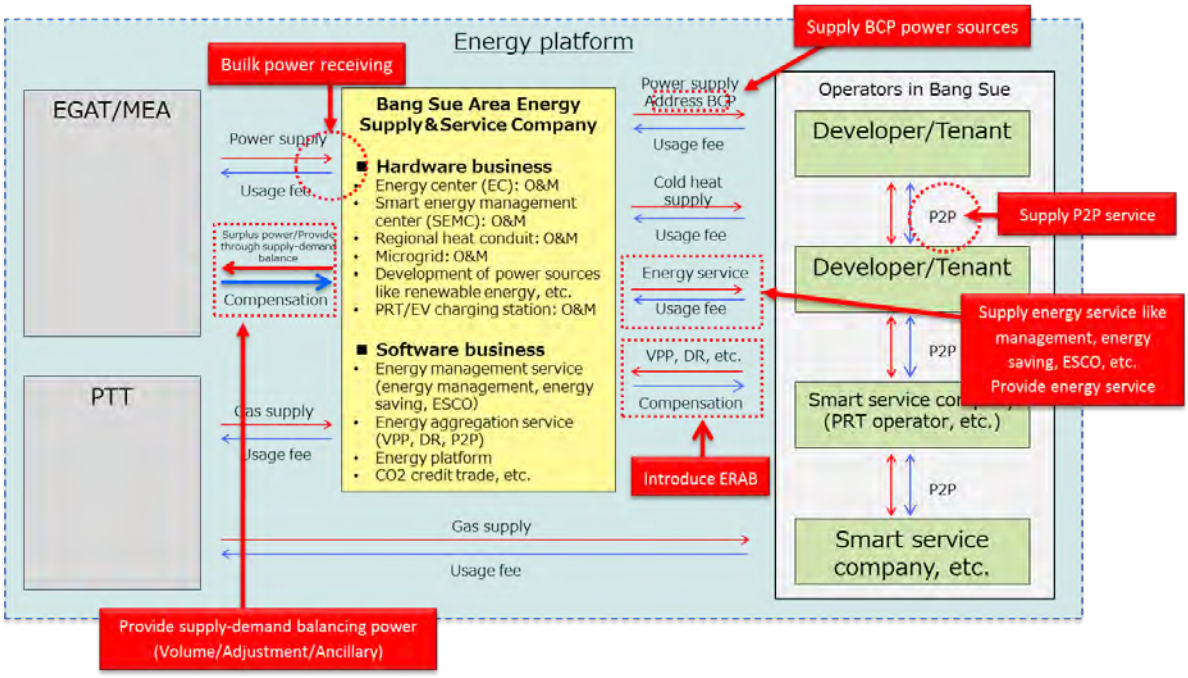
In order to achieve an energy supply chain suitable for smart city in Bang Sue, the establishment of new energy supply system, which is different from the traditional one, is needed.

Not only knowledge on energy supply hardware development, but also software-based service information need to be gathered to realize a new energy supply system. The traditional one-way energy supply model should be shifted to an interactive energy supply model with sophisticated hardware and software businesses combined, aiming at income diversification and innovation creation. This can facilitate electric power deregulation in Thailand, achieving pioneering business models in ASEAN.



Source: JICA Study Team.

Figure4.73 Traditional Energy Supply Model



Source: JICA Study Team.

Figure4.74 New Energy Supply Model in Bang Sue

4.4.4 Energy Demand Forecast (Power/Cooling) in Bang Sue

In this chapter, energy demand volume, expected for each zone, is calculated and is organized by development phase toward the development of smart energy network in the Bang Sue area.

(1) Energy Demand by Zone

Table 4.5 shows calculated results on expected power and cooling demand by zone in building use (office, hotel, commercial facility, public facility, residential house, etc.).

In this calculation, cooling loads are subject only to business/commercial facilities (office, hotel, commercial facility, public facility), and those for residential house is calculated as power load[5].

As for Zones D and F where development periods are different in the same zone, Zone D1 to be developed for Phase 1 is separated from Zones D2 to D4 to be developed for Phase 3 (hereinafter referred collectively to as "D2") and Zone F is divided into Zone F1 to be developed for Phase 1 and Zone F2 to done for Phase 2.

Table4.16 Demand Forecast for Power and Cooling Load

Zone	Site Area (m^2)	Power Load		Cooling Demand	
		Max. Load[6] (MW)	Annual Demand[7] (MWh/y)	Max. Load [8] (MW)	Annual Demand [9] (MWh/y)
A	164,400	5,898	24,722	15,465	50,675
B	678,750	25,118	68,398	32,878	95,338
C	572,600	18,247	31,097	8,922	23,763
D1	118,360	3,614	17,004	7,704	38,303
D2 (D2 to D4)	669,400	24,502	80,695	37,719	135,585
E	973,400	34,274	85,928	45,245	117,185
F1	9,700	572	2,766	1,475	4,925
F2	740,870	28,470	98,487	49,773	167,333
G	871,130	27,365	43,992	11,692	29,527
H	538,360	17,430	42,848	22,130	63,807
I	340,580	10,363	13,507	760	2,539
Total	5,677,550	195,854	509,444	233,761	728,978

Source: JICA Study Team.

[5] In this consideration the central cooling system for residential use is excluded. The city area for many business or commercial use or the high-rise multifamily building for such multiple uses as business or commercial purpose achieves the reasonable central cooling supply system through the systems, including warmer environment improvement for smart housing, effective use of CGS heat waste, energy-saving demand control with HEMS/smart meter, application to flat-rate fees and simplified measurement. Consideration is desirable together with residents' intention surveys in the future in Thailand.

[6] Max. Power Load = Σ (Floor area by use x Max. power load unit)

[7] Annual power demand = Σ (Floor area by use x Annual power demand unit)

[8] Max. cooling load = Σ (Floor area by use x Max. cooling load unit)

[9] Annual cooling demand = Σ (Floor area by use x Annual cooling demand unit)

The respective load units shown above are set, based on exterior surface performance for building, ventilation power unit, calorific values gained inside equipment, elevator or escalator operation conditions, standby power and building type by use, etc.

(2) Energy Demand by Development Phase

As stepwise development is planned in Bang Sue, the energy supply plant needs to be developed and expanded in accordance with demand scale for each phase in an effort to build smart energy network. The following table shows calculated maximum power load and cooling loads for each phase.

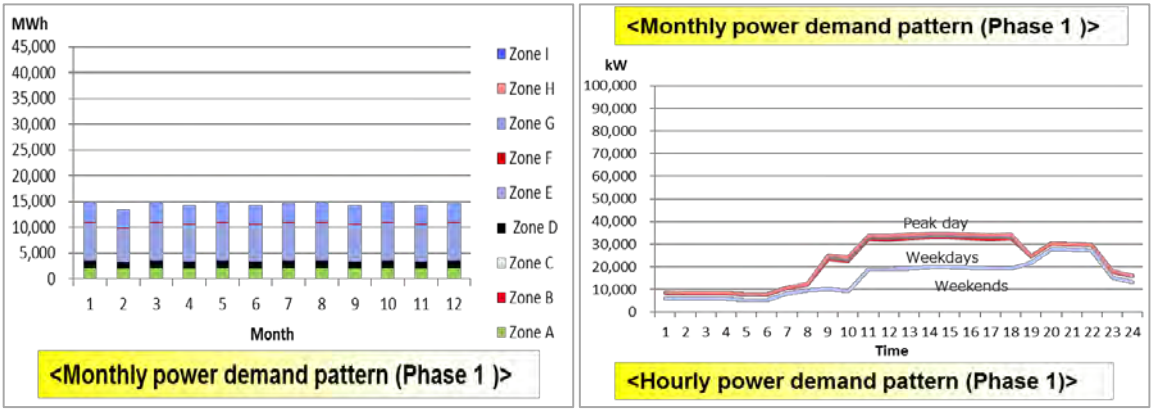
Table4.17 Energy Demand by Development Phase

Phase	Developed Zone	Total Floor Area (㎡)	Max. Power Load (kW)	Max. Cooling Load (kW)
Phase1 (From 2022 onwards)	A	164,400	5,898	15,465
	D1	118,360	3,614	7,704
	E	973,400	34,274	45,245
	F1	9,700	572	1,475
	G	871,130	27,365	11,692
	Subtotal	**2,136,990**	**71,724**	**81,580**
Phase2 (From 2027 onwards)	C	572,600	18,247	8,922
	F2	740,870	28,470	49,773
	Subtotal	**1,313,470**	**46,717**	**58,695**
Phase3 (From 2032 onwards)	B	678,750	25,118	32,878
	D2	669,400	24,502	37,719
	H	538,360	17,430	22,130
	I	340,580	10,363	760
	Subtotal	**2,227,090**	**77,413**	**93,487**
Total		**5,677,550**	**195,854**	**233,761**

Source: JICA Study Team.

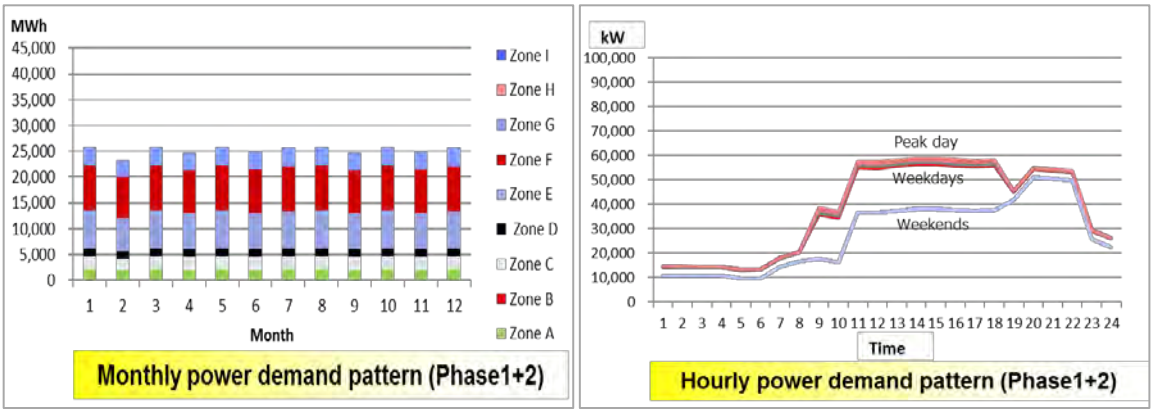
(3) Energy Demand Pattern by Development Phase

Figure4.75 and Figure4.77 show monthly and hourly demand volume patterns for power load by development phase.



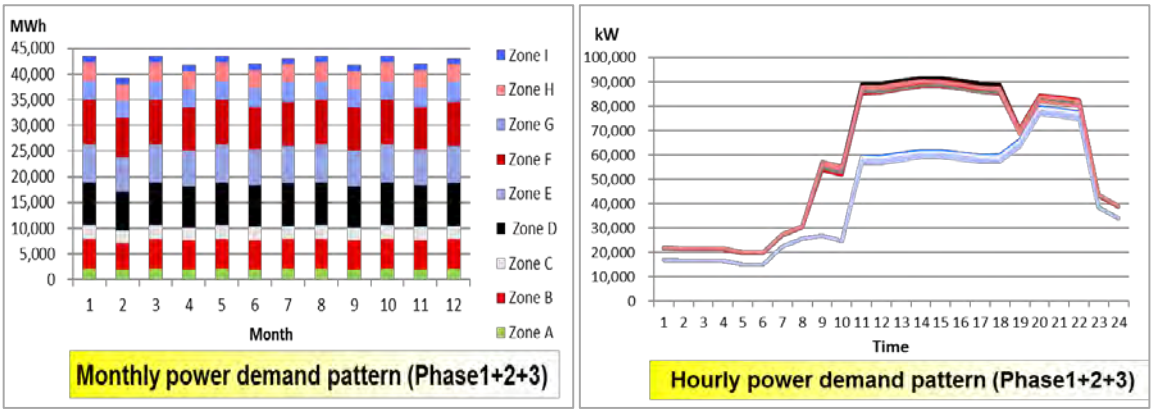
Source: JICA Study Team.

Figure4.75 Monthly/Hourly Demand Pattern for Power Load (Phase 1)



Source: JICA Study Team.

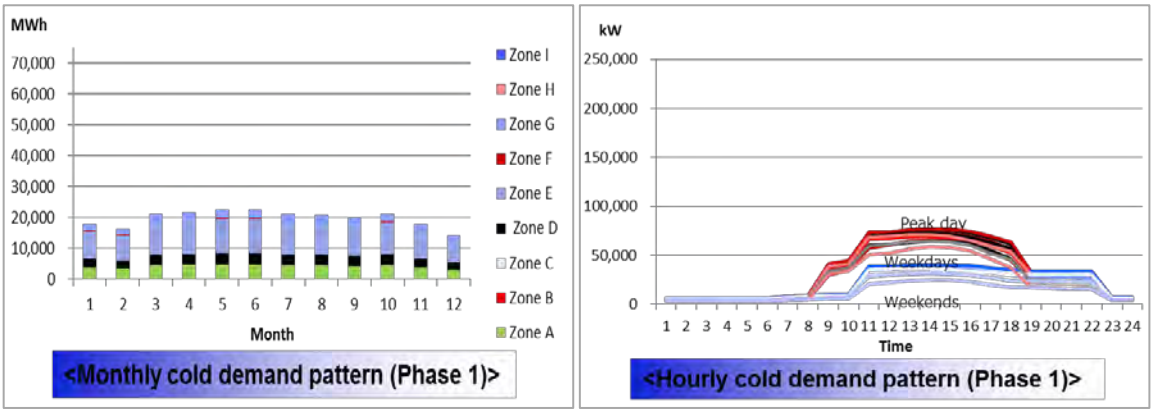
Figure4.76 Monthly/Hourly Demand Pattern for Power Load (Phases 1 + 2)



Source: JICA Study Team.

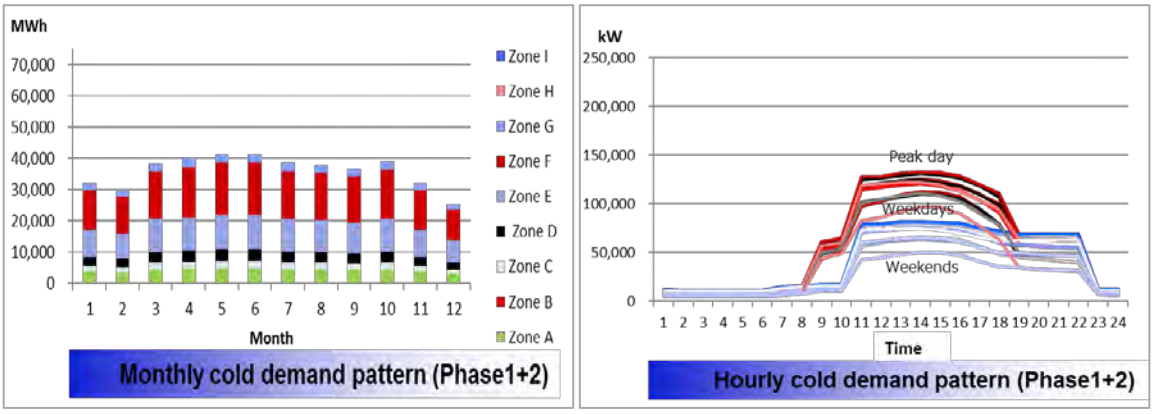
Figure4.77 Monthly/Hourly Demand Pattern for Power Load (Phases 1 + 2 + 3)

Figure4.78 and Figure4.80 show monthly and hourly demand volume patterns for cooling load by development phase.



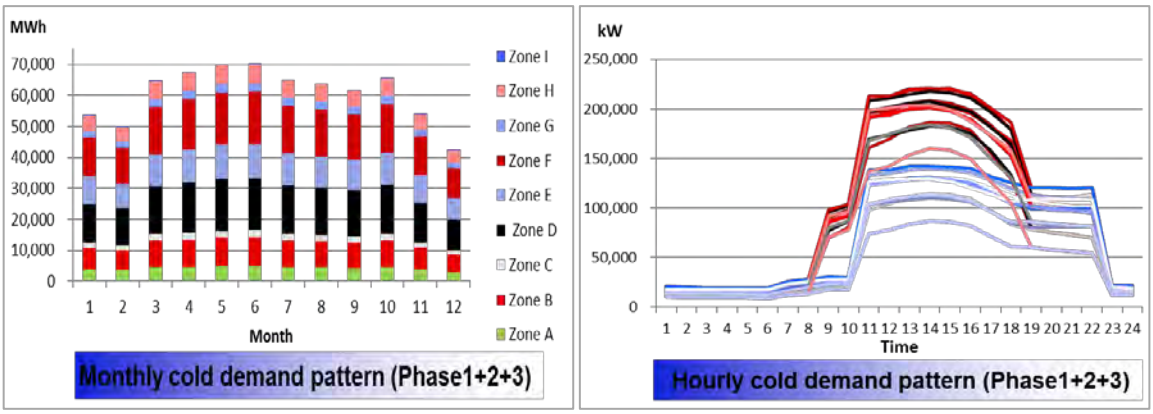
Source: JICA Study Team.

Figure4.78 Monthly/Hourly Demand Pattern for Cooling Load (Phase 1)



Source: JICA Study Team.

Figure4.79 Monthly/Hourly Demand Pattern for Cooling Load (Phases 1 + 2)



Source: JICA Study Team.

Figure4.80 Monthly/Hourly Demand Pattern for Cooling Load (Phases 1 + 2 + 3)

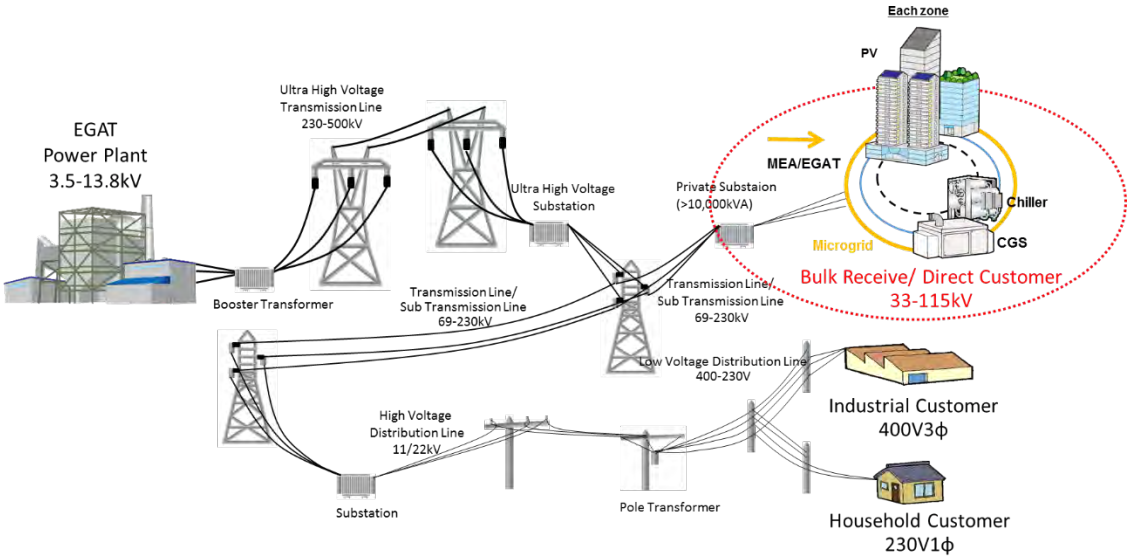
4.4.5 Proposed Development for Smart Energy Network

(1) Area Selection for Smart Energy Network

In order to develop a smart energy network, as shown in this chapter, energy supply plants need to be developed in accordance with the development scale for each phase and the network is built with energy supply plants for a new phase for smart energy network expansion. The following sections organize consideration results.

1) Target Area for Microgrid

Two substations to be developed by the MEA supplies power collectively to each zone in the Bang Sue area to build a cluster-type microgrid system by zone. This can optimize energy supply and demand with efficient management, and make energy supply and demand efficient and optimal across the area through the networked cluster-type microgrid system. Therefore, all the areas are subject to the microgrid system.



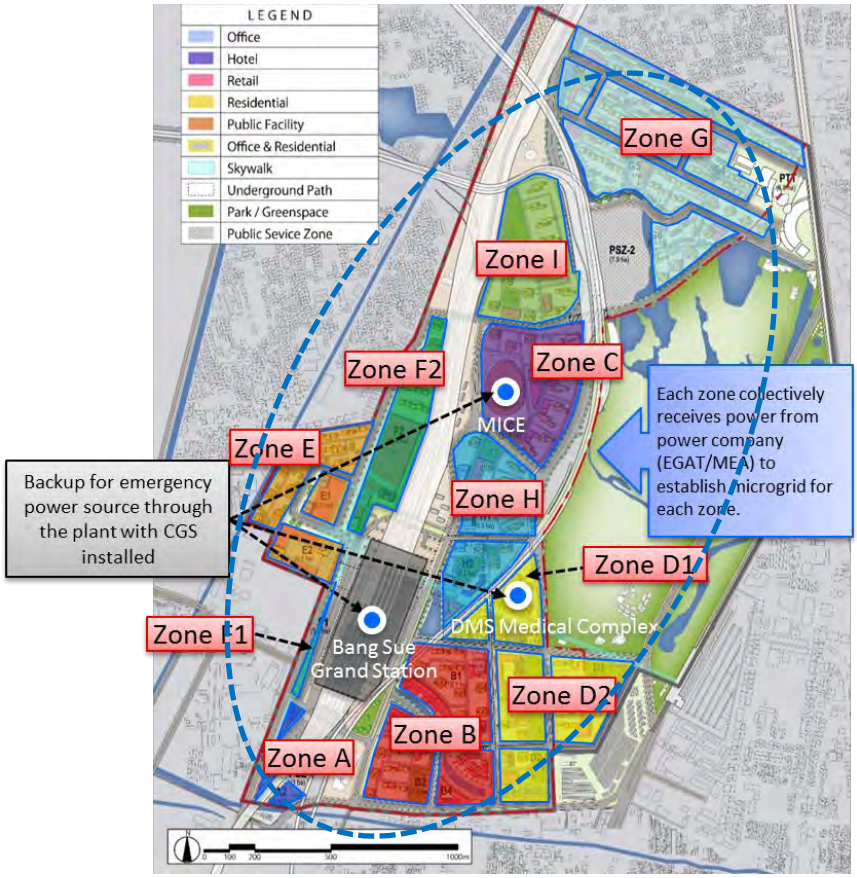
Source: JICA Study Team.

Figure4.81 Collective Power Distribution Image

And furthermore, as key public facilities like Bang Sue Grand Station is located in the Bang Sue area, a backup system for emergency power sources is developed in key facilities through cogeneration, not only from the perspective of efficient energy supply and demand, but also from that of business continuity plan (BCP) at time of disasters. As for the key facilities except for Bang Sue Grand Station, a medical complex (DMS) is to be built in Zone D1 and MICE facilities for many visitors are considered in Zone C. Therefore, as BCP measures are needed for these important facilities at time of disasters, the backup system for emergency power sources is established through cogeneration in order to enhance energy security.

In addition, regarding the backup for heat source and emergency power supply to Bang Sue Grand Station, it is required that prompt confirmation of design conditions and specifications of some facilities (substation, private power generator, heat source facility, etc.) that are planned to be installed into Bang Sue Grand Station which is currently under construction. Together with it, plan and design adjustment with Bang Sue Grand Station for systematic connection and operation

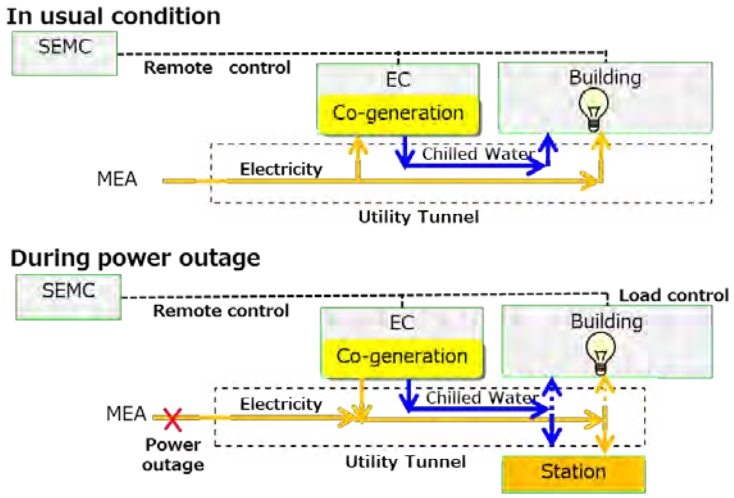
is also needed. In addition, as described later in Chapter 4.4.8, the operation management needs to be coordinated in the initial phase in order to shift, to SSC, the management on emergency power generation facilities and heat source equipment for Bang Sue Grand Station, from the efficient perspectives through integrated management operation.



Source: JICA Study Team, based on study reports for FY2018.

Figure4.82 Target Area for Microgrid

Figure4.83 shows a power supply flow in case of emergency through cogeneration.



Source: JICA Study Team.

Figure4.83 Sustainable Energy Supply Image by CGS

2) Target Area for District Heat Supply

In order to secure both energy efficiency and business profitability in the district heat supply business, preconditions are a certain degree of cooling demand and demand density in the target area. Table4.18 shows calculation results for energy demand in each zone.

Based on the calculation results, as cooling demand density is low at 0.08 GWh /㎡.h) and 0.02 GWh /㎡.h respectively for Zones G and I, the selection of common building-based cooling system is supposed, considering installation costs for cold water conduit pipe.

In Zones C and H, though a certain degree of cooling demand density is confirmed, it is not judged realistic to build a large-scale network with other zones, considering installation costs for cold water conduit tube. Therefore, “block cooling” system is selected for business and commercial facilities in the zones.

As Zone D includes two separate development phases consisting of Phases 1 and 3, “block cooling” system is selected in Zone D1 to be developed earlier for Phase 1 and “district cooling” system is done in Zone D2 to be developed for Phase 3. In Phase 3 when Zone D2 is to be developed, the renewal timing[10] of heat source equipment is likely to get closer, facility volume is optimized at the time of the equipment renewal and the zone is connected with the district cooling network for more efficient planning.

As there are no legal requirements[11] on business division in Thailand, as shown in Heat Supply Business Act stipulated in Japan, in this report for the purpose of convenience, networking for heat supply business beyond the zone is defined as “district cooling,” and heat supply within the zone is done as “block cooling”.

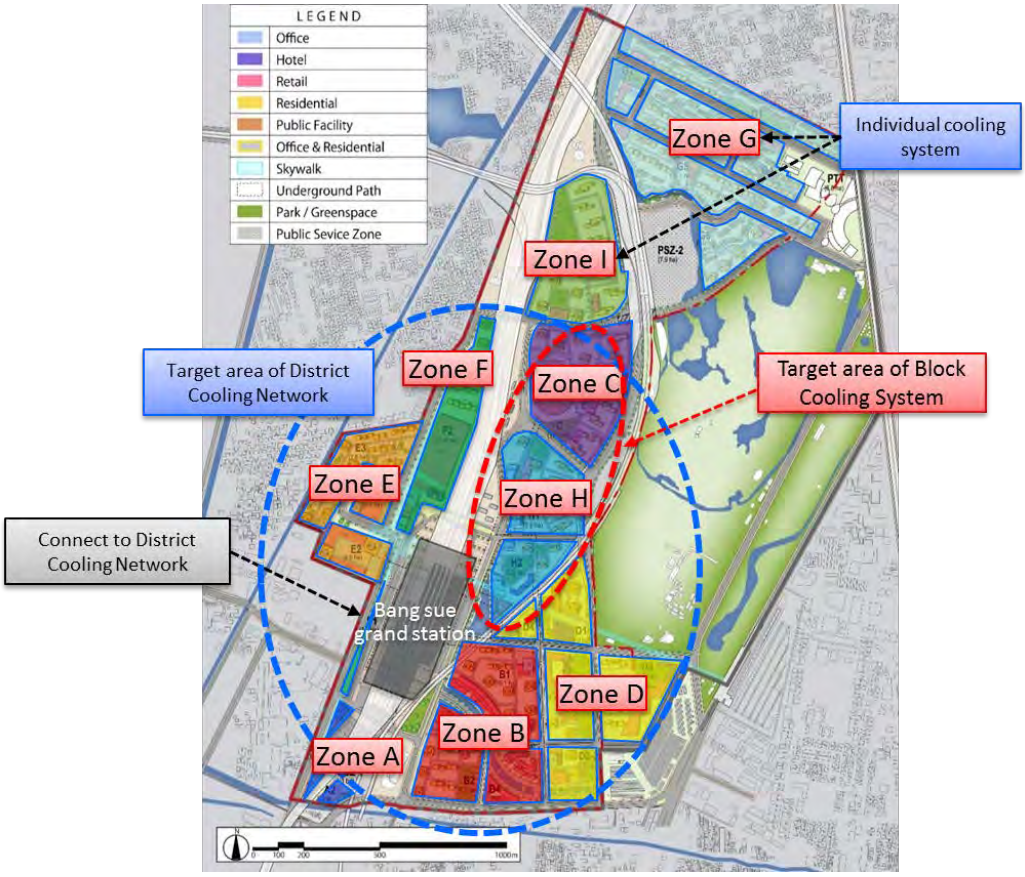
Table4.18 Cooling Demand Density and Cooling System by Zone

Zone	Site Area (m^2)	Cooling Load		Annual Cooling Load per Area ($MWh/m^2 \cdot y$)	District Heat Supply		Building-based Cooling System
		Max. Load (kW)	Annual Demand (MWh/y)		District Cooling System	Block Cooling System	
A	27,300	15,465	50,675	1.86	Yes		
B	201,000	32,878	95,338	0.47	Yes		
C	174,400	8,922	23,763	0.14		Yes	
D1	39,500	7,704	38,303	0.97	(Scheduled)	Yes	
D2	192,400	37,719	135,585	0.70	Yes		
E	152,000	45,245	117,185	0.77	Yes		
F1	9,700	1,475	4,925	0.51	Yes		
F2	113,900	49,773	167,333	1.47	Yes		
G	370,800	11,692	29,527	0.08			Yes
H	152,900	22,130	63,807	0.42		Yes	
I	151,300	760	2,539	0.02			Yes
Total	1,585,200	233,761	728,978	0.46	—	—	—

Source: JICA Study Team.

[10] The general renewal period for heat source equipment is considered to be 15 to 20 years.

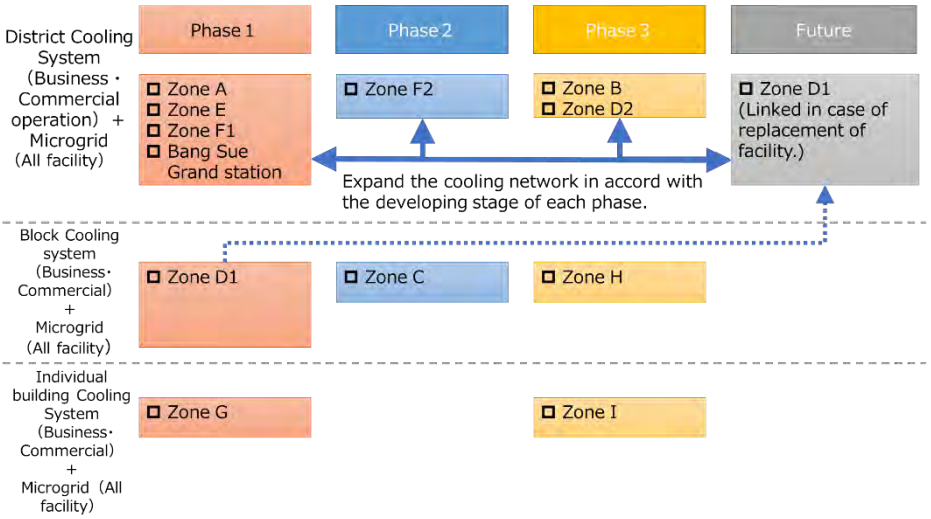
[11] Application to Heat Supply Business Act in Japan requires a general user operating a business to supply heat to two or more buildings with thermal capacity at 21 GJ/h or larger.



Source: JICA Study Team, based on study reports for FY2018.

Figure4.84 Target Area for District Cooling System

And furthermore, Figure4.85 organizes cooling system results for respective zones and expansion in accordance with development phases.



Source: JICA Study Team.

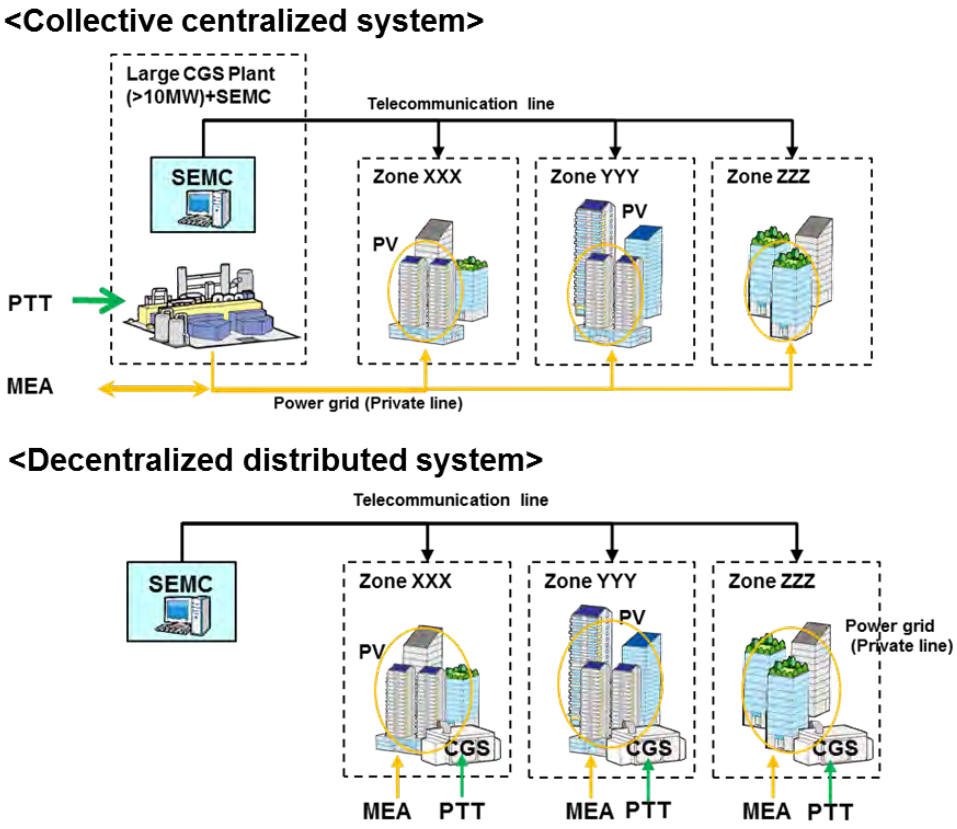
Figure4.85 Cooling System and Expansion by Phase

(2) Target Development Area for Cogeneration System (CGS)

1) Comparison between Centralized System and Distributed System through Cogeneration

The Bang Sue area aims, as a smart energy network, to establish the cogeneration system and the highly effective energy supply system with power supply and waste heat-based cooling systems. And also, it tries to improve energy self-sufficiency rate and energy security, and needs to consider setting up the scale of cogeneration system.

The following figure compares, the collective centralized system to introduce large-scale cogeneration system into one plant, with the decentralized distributed system to introduce the cogeneration system to each zone.



Source: JICA Study Team.

Figure4.86 Centralized and Distributed Systems

The following table compares and considers the centralized system with the distributed one. As shown in Table4.19, stepwise development is planned. As a suitable scenario, it is considered that energy supply plants are to be developed by zone in accordance with the development scale for each phase and a smart energy network is expanded through networking with energy supply plants to be built for a new phase. Table4.19 organizes consideration results by comparing centralized and distributed systems for energy supply plants.

Table4.19 Comparison between Centralized System and Distributed System

	Centralized System	Distributed System
Outline	・ Power is supplied collectively to the entire Bang Sue area and is supplied to each zone through self-employed power transmission and distribution network. ・ Cogeneration is operated at a rated value and excess power is sold to power companies.	Cogeneration system is dispersedly introduced to zones with a certain degree of cooling demand and profitability for power supply.
Consideration	・ Excess power sales to power companies are not acceptable under the current regulation. Therefore, legal system change or special measure is needed for execution. ・ Environmental impact assessment is needed to introduce large-scale cogeneration at 10 MW or larger. (Need to have regional residents understood) ・ As the installation of cogeneration is illegal in the place except for industrial areas irrespective of size, legal revision is needed. (Challenging issue in common with distributed system)	・ Sufficient power cannot be supplied to all zones at power outage. ・ As the installation of cogeneration is illegal in the place except for industrial areas irrespective of size, legal revision is needed. (Challenging issue in common with centralized system)
Continuity at Disaster	✔✔ Continuous power supply to the entire area is possible through cogeneration.	✔✔ (Limited) Continuous power supply is possible to key facilities (Bang Sue Grand Station, etc.) from the energy center with cogeneration system.
Introduction Cost	✔✔	✔
Feasibility	✔ ・ Excess power from cogeneration cannot be sold to power companies under the current regulation. (If power sales is possible, the feasibility is high.) ・ The business risk factor is huge, depending upon demand fluctuations.	✔✔ ・ It is possible to set up development volume in line with intraregional demand. ・ The business risk factor is small, depending upon demand fluctuations.
Suitability for Bang Sue Area	✔ ・ It takes longer time to conduct environmental impact assessment. ・ As Zone A development is proceeded earlier, its schedule cannot be possibly set at the same time with the development schedule for gas pipeline. ・ As there are obstacles for procedure and permit or approval, special district certification is needed as a precondition.	✔✔ ・ Development is realistically considered, as sequential expansion is possible in line with zone development schedule. ・ As power supply is possible for key facilities at emergency, operators' needs can be met within the zone.

Source: JICA Study Team.

2) Target Development Area for Cogeneration System (CGS)

Out of zones with district heat supply system, as cooling load density is relatively high in Zones A, B, D, E and F, considering the mutual distance with respective zones, the introduction of cogeneration is considered suitable in these zones. In Zone A, however, as the solicitation of developers has already been started, it is judged unrealistic to introduce the cogeneration system, considering a timeframe[12] for the development of gas pipeline.

In Zone D, too, as the development project is divided into Phases 1 (Zone D1) and 3 (Zone D2), it is judged unsuitable to introduce cogeneration.

Based on the above examination, the targeted development areas for cogeneration are Zones B, E and F. In the other district cooling areas, the energy supply system will be considered with high-efficient motor-driven turbo chiller as a major heat source. Waste heat from cogeneration is utilized in the zones which are planned to be networking by district cooling system,.

Table4.20 Targeted Development Area for Cogeneration System

Zone	Site Area (m^2)	Cooling Load		Annual Cooling Load per Area ($MWh/m^2 \cdot y$)	District Heat Supply		Area to Introduce CGS
		Max. Load (kW)	Annual Demand (MWh/y)		District Cooling System	Spot Heat Supply System	
A	27,300	15,465	50,675	1.86	Yes		
B	201,000	32,878	95,338	0.47	Yes		Yes
C	174,400	8,922	23,763	0.14		Yes	
D1	39,500	7,704	38,303	0.97	(Scheduled)	Yes	
D2	192,400	37,719	135,585	0.70	Yes		
E	152,000	45,245	117,185	0.77	Yes		Yes
F1	9,700	1,475	4,925	0.51	Yes		
F2	113,900	49,773	167,333	1.47	Yes		Yes
G	370,800	11,692	29,527	0.08	—	—	—
H	152,900	22,130	63,807	0.42		Yes	
I	151,300	760	2,539	0.02	—	—	—
Total	1,585,200	233,761	728,978	0.46	—	—	—

Source: JICA Study Team.

(3) Proposed Development Plan for Energy Center and Cold Water Conduit

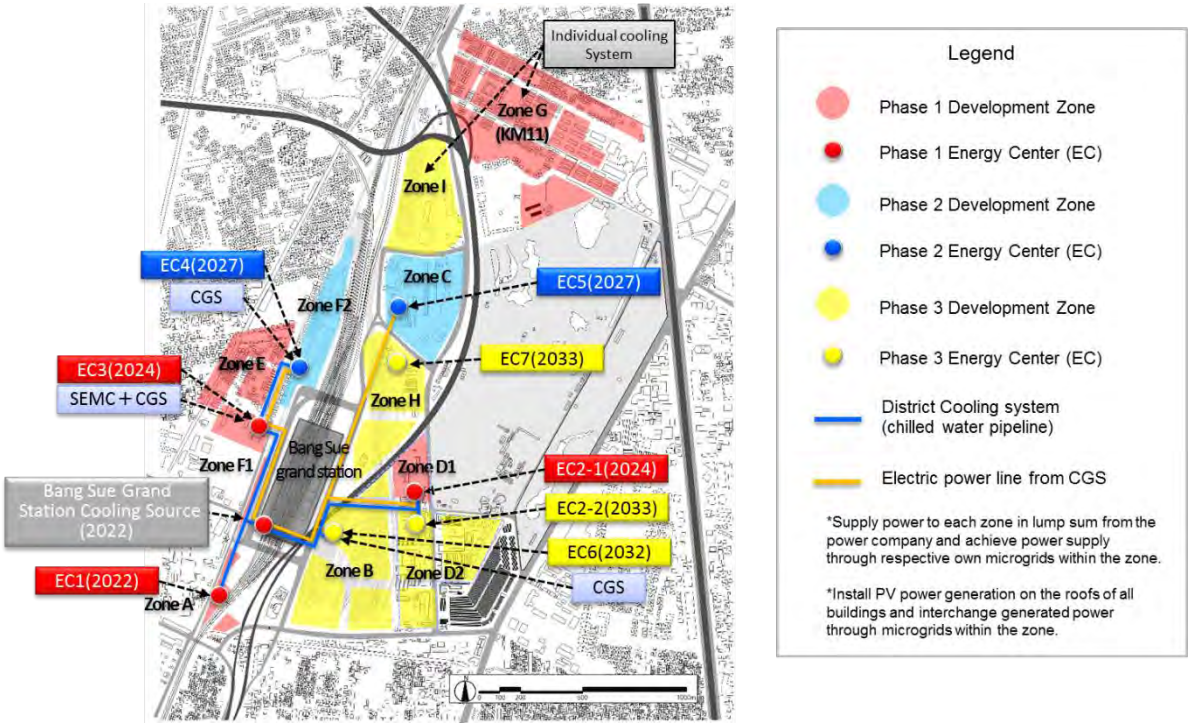
Based on the above consideration results, Figure4.87 organizes a proposed development plan for energy center layout and cold water conduit.

Energy centers are allocated respectively in Zones A, B, C, E, D1, D2, F2 and H. Cold water conduit network, as a district cooling system, is connected with Zones A, B, E, D1, D2 and F2, and a network is built with heat source equipment to be developed in Bang Sue Grand Station. In Zones C, D1 and H, meanwhile, the block cooling business is operated within respective zones, which does not need networking with cold water conduit beyond zones.

Cogeneration is also brought to Zones B, E and F2, from which through the cogeneration the

[12] PTT indicates that it takes about three years under the current regulation. See details on "4.4.2 (4) 4) Gas pipeline development status".

backup system for emergency power sources is installed from BCP perspectives in Bang Sue Grand Station as a key facility for the area, the medical complex planned in Zone D1 and MICE in Zone C.



Source: JICA Study Team.

Figure4.87 Proposed Development Layout for Energy Supply Plant and Cold Water Conduit

Table4.21 organizes energy centers and supply areas.

Table4.21 Energy Center and Supply Area

Energy Center	Operation Start	Supply Area	District Heat Supply		Area to Introduce CGS	Remarks
			District Cooling System	Block Cooling System		
EC 1	2022	Zone A	Yes			
EC 2-1	2024	Zone D1	(Scheduled)	Yes		Connect with district cooling network on the sidelines of future equipment renewal.
EC 2-2	2033	Zone D2	Yes			
EC 3	2025	Zones E, F1	Yes		Yes	Zone F is closer to Zone E, which supplies.
EC 4	2027	Zone F2	Yes		Yes	
EC 5	2027	Zone C		Yes		
EC 6	2032	Zone B	Yes		Yes	
EC 7	2033	Zone H		Yes		

Source: JICA Study Team.

(4) Supply Capability and Annual Supply Volume for Power and Cooling by Energy Center

1) Max. Power Supply Capability and Max. Supply Volume

Table4.22 and Table4.23 show max power supply capability and max supply volume by energy sector.

Table4.22 Max. Power Supply Capability by Energy Center

Energy Center	Operation Start	Supply Area	Max. Load (kW)	Simultaneous Usage Rate[13] (%)	Max. Supply Capability[14][15] (kW)
EC1	2022	Zone A	5,898	94%	5,821
EC2-1	2024	Zone D1	3,614	61%	2,315
EC2-2	2033	Zone D2	24,502	93%	23,926
EC3	2025	Zones E, F1	34,847	78%	28,539
EC4	2027	Zone F2	28,470	88%	26,306
EC5	2027	Zone C	18,247	92%	17,627
EC6	2032	Zone B	25,118	87%	22,945
EC7	2033	Zone H	17,430	75%	13,726
—	2025	Zone G	31,263	92%	30,200
—	2032	Zone I	10,616	100%	11,147

Source: JICA Study Team.

Table4.23 Max. Power Supply Volume by Energy Center

Energy Center	Operation Start	Supply Area	Annual Demand (MWh/y)	Annual Transmission Loss[16] (MWh/y)	Max. Supply[17] (MWh/y)
EC1	2022	Zone A	24,722	1,236	25,958
EC2-1	2024	Zone D1	17,004	850	17,854
EC2-2	2033	Zone D2	80,695	4,035	84,729
EC3	2025	Zones E, F1	88,695	4,435	93,129
EC4	2027	Zone F2	98,487	4,924	103,412
EC5	2027	Zone C	31,097	1,555	32,652
EC6	2032	Zone B	68,398	3,420	71,818
EC7	2033	Zone H	42,848	2,142	44,990
—	2025	Zone G	53,834	2,692	56,526
—	2032	Zone I	14,353	718	15,071

Source: JICA Study Team.

[13] Simultaneous usage rate is set at “peak load for each EC/total peak load for each building supplied by each EC” and the load pattern by time is considered and calculated by each building use.

[14] As Zones G and I adopt a building-based cooling system, system COP to meet cooling demand is supposed as 3.0 and calculations are made.

[15] Transmission loss (including loss in the transformer) is set at 5% across the board.

[16] Transmission loss (including loss in the transformer) is set at 5% across the board.

[17] As Zones G and I adopt a building-based cooling system, system COP to meet cooling demand is supposed as 3.0.

2) Max. Cooling Supply Capability and Max. Supply Volume

Table4.24 and Table4.25 show calculation results for maximum cooling supply capability and maximum supply volume by energy center.

Table4.24 Max. Cooling Supply Capability by Energy Center

Energy Center	Operation Start	Supply Area	Max. Load (kW)	Heat Loss[18] (kW)	Max. Supply Capability[19] (kW)
EC1	2022	Zone A	15,465	195	15,660
EC2-1	2024	Zone D1	7,704	14	7,718
EC2-2	2033	Zone D2	37,719	1,091	38,810
EC3	2025	Zones E, F1	46,719	105	46,824
EC4	2027	Zone F2	49,773	364	50,137
EC5	2027	Zone C	8,922	151	9,073
EC6	2032	Zone B	32,878	405	33,283
EC7	2033	Zone H	22,130	389	22,519

Source: JICA Study Team.

Table4.25 Max. Cooling Supply by Energy Center

Energy Center	Operation Start	Supply Area	Annual Demand (MWh/y)	Annual Heat Loss[20] (MWh/y)	Max. Supply (MWh/y)
EC1	2022	Zone A	50,675	1,709	52,384
EC2-1	2024	Zone D1	38,303	120	38,423
EC2-2	2033	Zone D2	135,585	9,559	145,144
EC3	2025	Zones E, F1	122,110	917	123,027
EC4	2027	Zone F2	167,333	3,190	170,523
EC5	2027	Zone C	23,763	1,327	25,090
EC6	2032	Zone B	95,338	3,551	98,889
EC7	2033	Zone H	63,807	3,407	67,214

Source: JICA Study Team.

[18] Piping ambient temperature for calculation is set at 30 ℃ for heat loss from district piping in the cold water supply system.

[19] The simultaneous usage rate is set at 100% across the board.

[20] Piping ambient temperature for calculation is set at 30 ℃ for heat loss from district piping in the cold water supply system.

(5) Equipment Volume for Heat Source

1) Equipment Volume for Chiller

Table4.26 organizes chiller volume needed for respective energy centers and heat storage tank volume for cold water used for backup system.

Heat storage tanks are introduced to energy centers as a backup system for chiller from the perspectives of effective use of waste heat through cogeneration, fluctuation absorption of power loads and levelling of partial loads. The building frame under the installation space for heat source equipment, etc. is used, as a precondition, for the heat storage tank for cold water, and volume for heat storage tank is set at 10,000 USRTh, considering volume for possible installation.

Water for heat storage tank for cold water can also be used for fire-fighting or daily life water, contributing to enhanced disaster prevention functions in the urban area.

Table4.26 Chiller Volume

Energy Center	Operation Start	Supply Area	Max. Cooling Supply Capability (kW)	District Heat Supply <District Cooling/Block Cooling >	
				Chiller Volume[21] (USRT)	Heat Storage Tank for Cold Water for Backup[22] (USRTh)
EC 1	2022	Zone A	15,660	4,900	10,000
EC2-1	2024	Zone D1	7,718	2,500	10,000
EC2-2	2033	Zone D2	38,810	12,200	Share with EC2-1
EC 3	2025	Zones E, F1	46,824	14,700	10,000
EC 4	2027	Zone F2	50,137	15,700	10,000
EC 5	2027	Zone C	9,073	2,900	10,000
EC 6	2032	Zone B	33,283	10,500	10,000
EC 7	2033	Zone H	22,519	7,100	10,000

Source: JICA Study Team.

[21] Allowance rate for chiller volume is set at 10% across the board.

[22] Heat storage tanks are used for the backup use of district heat supply system.

2) Equipment Volume for Cogeneration System

The 4 MW-class gas turbine for cogeneration volume is set, considering effective use of waste heat, total device efficiency and equipment prices, in addition to boilers for backup use.

Table4.27 organizes overviews for cogeneration and boiler as backup use.

Table4.27 Cogeneration Volume

Energy Center	Operation Start	Supply Area	CGS Volume (kW)	Boiler Volume (t/h)
EC 1	2022	Zone A	—	—
EC 2-1	2024	Zone D1	—	—
EC 2-2	2033	Zone D2	—	—
EC 3	2025	Zones E, F1	4,440	10
EC 4	2027	Zone F2	4,440	10
EC 5	2027	Zone C	—	—
EC 6	2032	Zone B	4,440	10
EC 7	2033	Zone H	—	—

Source: JICA Study Team.

(6) Rough Area for Energy Center

Table4.28 organizes rough floor area needed for the installation of each energy center. SEMC overview is described later.

Table4.28 Area Needed for Energy Center and SEMC

Energy Center	Operation Start	Supply Area	Heat Source Equipment (m^2)	CGS (m^2)	Area for Heat Storage Tank [23][24][25] (m^2)
EC 1	2022	Zone A	1,225	—	2,000
EC 2-1	2024	Zone D1	625	—	2,000
EC 2-2	2033	Zone D2	3,050	—	Share with EC2-1
EC 3	2025	Zones E, F1	3,675	1,500	2,000
EC 4	2027	Zone F2	3,925	1,500	2,000
EC 5	2027	Zone C	725	—	2,000
EC 6	2032	Zone B	2,625	1,500	2,000
EC 7	2033	Zone H	1,775	—	2,000
SEMC	2022	Subject to all areas			300

Source: JICA Study Team.

[23] The pit height is set at 2 m across the board, considering construction costs.

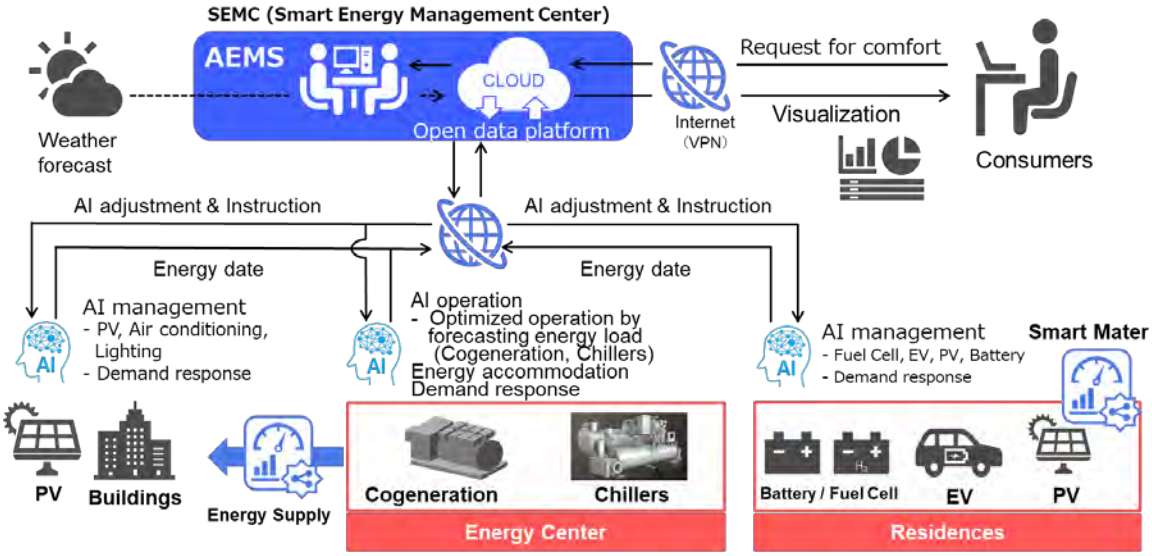
[24] Supply temperature for cold water is set at 7 ℃ and return temperature is set at 15 ℃ ($\Delta t = 8$℃).

[25] Heat storage tank efficiency is set at 87%, assuming double-pit system.

(7) Overview of Smart Energy Management Center (SEMC)

1) Overview of Area Energy Management System (AEMS)

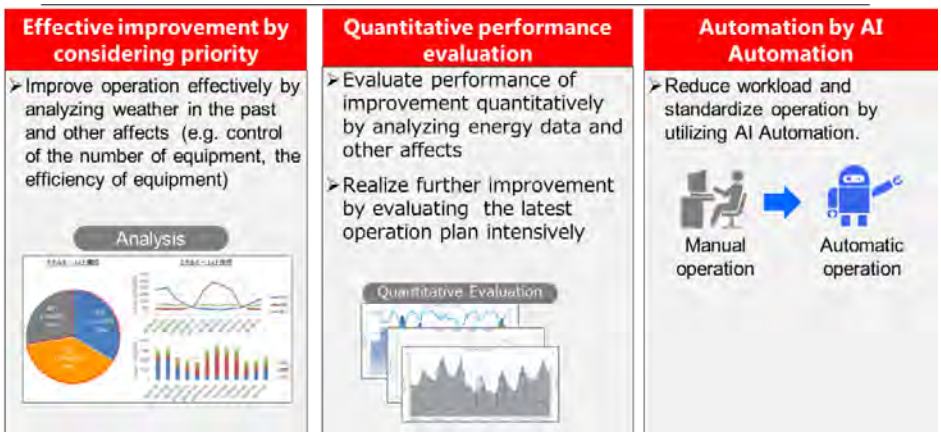
The Smart Energy Management Center (SEMC) adopts Area Energy Management System (AEMS) which manages operation for all energy centers and controls energy across the Bang Sue area. AEMS collects and analyses data including renewable energy from respective energy centers and solar power stations, energy from respective facilities and weather information in order to optimize the entire regional energy with AI system and visualize collected or accumulated energy data through the open data platform. Figure4.88 shows a function overview for AEMS.



Source: JICA Study Team.

Figure4.88 Concept for AEMS

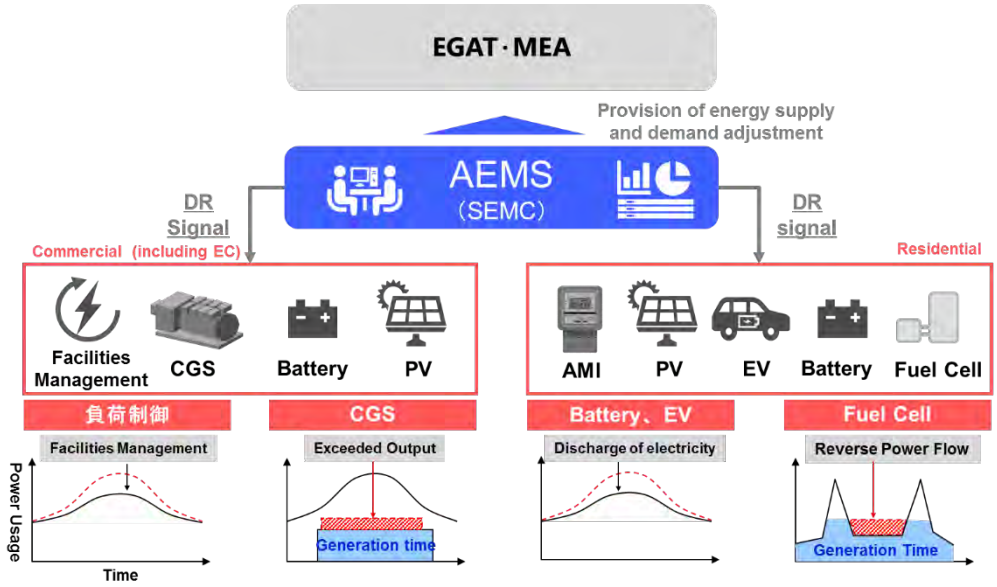
The AI system to be mounted on AEMS collects and analyses the past weather data and equipment operation data in an effort to optimize energy center operation and achieve labor-saving for operation supervision with robotic process automation (RPA). Figure4.89 shows a concept for energy improvement approach with the AI system in addition to optimal operation.



Source: JICA Study Team.

Figure4.89 Energy Management with AI System

Moreover, based on directions from Thai electricity authorities (EGAT/MEA), AEMS addresses supply and demand adjustment through virtual power plant (VPP) or demand response (DR) with intraregional energy resources, aiming to optimize energy across the Bang Sue area and make energy supply and demand effective and stable in a wider range. Figure4.90 shows a concept for AEMS demand control.



Source: JICA Study Team.

Figure4.90 Concept for Demand Control

2) Rough Area for Smart Energy Management Center (SEMC)

The SEMC is to be installed in or near the smart city center planned in Zone E. The SEMC includes an operation room, monitoring devices and servers[26] for AEMS operation in each energy center, together with an office room for operation managers, meeting rooms and a stockroom (devices, tools, etc.), and it needs an approximately 300 m^2 [27] space in total.

Table4.29 Rough Area for SEMC

	Operation Start	Needed Area (m^2)	
SEMC (Zone E)	2022	Operation room	100
		Office room for operation managers, meeting rooms, stockroom (device, tools), etc.	200
Total			300

Source: JICA Study Team.

[26] Excludes servers for open data platform, which is included in the smart city center.

[27] Excludes area needed for head office functions (general affairs, finance, legal) for the smart service company.

(8) Introduction of EMS (BEMS/HEMS)

In order to visualize and save energy across the Bang Sue area through the open data platform, the EMS like BEMS/HEMS is introduced to facilities at a certain degree of scale or larger.

Although the BEMS is subject mainly to business facilities, its functions or requirements are not necessarily clarified. Therefore, the system is roughly divided into (1) energy data collection system and (2) energy control system. (1) is introduced to all facilities in the Bang Sue area and (2) implementation is handled as BEMS.

The way to consider the introduction of EMS like BEMS/HEMS is summarized and Table4.30 organizes the number of introduced facilities.

- Introduce business facilities at 50,000 m^2 or larger, considering cost-effectiveness for BEMS.
- Introduce HEMS to all residential facilities.

Table4.30 Number of Introduced Facilities for EMS

Phase	Zone	BEMS (No. of Buildings)	HEMS[28] (No. of Houses)
Phase1 (From 2022 onwards)	A	2	197
	D1	1	648
	E	3	7,975
	F1	0	0
	G	0	10,875
	Subtotal	**6**	**19,694**
Phase2 (From 2027 onwards)	C	0	4,797
	F2	4	7,043
	Subtotal	**4**	**11,840**
Phase3 (From 2032 onwards)	B	2	5,186
	D2	0	5,890
	H	0	4,461
	I	0	4,794
	Subtotal	**2**	**20,332**
Total		**12**	**51,866**

Source: JICA Study Team.

(9) Introduction of Solar Power Generation

1) Potentiality for Solar Power Generation

In order to make effective use of empty space for unnecessary cooling towers by adopting district cooling system in the Bang Sue area, solar power generation is installed on the roofs of all buildings to achieve energy supply system with low environmental loads.

As the rooftop space for solar power generation is set at 80% of the standard floor area, possible power generation volume is calculated[29] on the basis of such condition.

[28] The figure 70 m· per house is used to calculate the number of houses. .

[29] The rooftop space is supposed to address solar power generation = building area by building x 0.8 in the study reports

The following table shows equipment volume for solar power generation by zone.

Table4.31 Solar Power Generation Volume

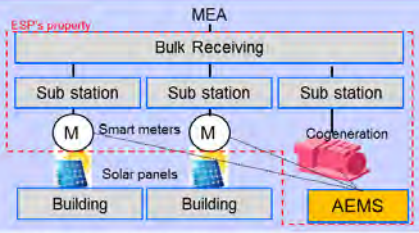
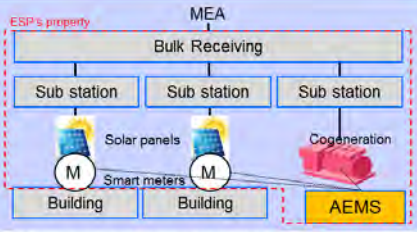
Phase	Zone	Building Area (㎡)	Solar Power Generation Volume (kW)	Renewable Energy Volume Ratio against Max. Power Load (%)
Phase1 (From 2022 onwards)	A	19,320	2,164	37
	D1	8,170	915	25
	E	56,780	6,359	19
	F1	9,700	1,086	190
	G	85,700	9,598	35
	Subtotal	**179,670**	**20,123**	**28**
Phase2 (From 2027 onwards)	C	51,600	5,779	32
	F2	383,450	6,149	22
	Subtotal	**435,050**	**11,928**	**26**
Phase3 (From 2032 onwards)	B	84,130	9,423	38
	D2	55,150	6,177	25
	H	32,560	3,647	21
	I	21,800	2,442	24
	Subtotal	**193,640**	**21,688**	**28**
Total		**808,360**	**53,739**	**27**

Source: JICA Study Team.

2) Business Model to Facilitate Solar Power Generation

Business models are compared and reviewed to facilitate solar power generation. Energy suppliers need to own solar power generation facilities and pay rental fees to the facility owners to advance solar power generation in the Bang Sue area.

Table4.32 Energy-Saving Effect and CO_2 Emission Reduction

The purchasers of Solar Panels	Building owners	ESP
Image		
Concept	- Building owners purchase solar panels - The power output is utilized in their own buildings primarily - The surplus of power output is sold to the ESP	- ESP invests solar panels instead of building owners - The power output is sold to building owners - The surplus of power is bought and sold to the other building owners by the ESP
Pros & Cons	- It is possible that building owners hate to install solar panels because of its installation cost - Building owners must maintain solar panels and repair them if necessary - Building owners fully enjoy the cost reduction obtained by solar panels	- Building owners need not invest the installation costs of solar panels - Building owners need not maintain solar panels - Building owners should share the cost reduction obtained by solar panels with the ESP

Source: JICA Study Team.

produced in FY2018 for the calculation of solar power generation output.

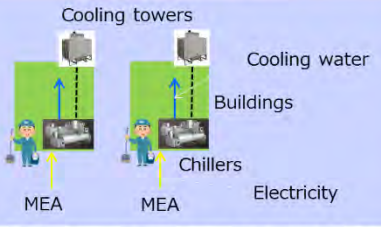
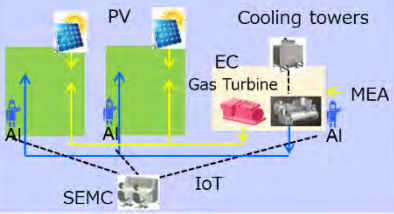
4.4.6 Comparison between Smart Energy Network and Conventional System

(1) Comparison between Smart Energy Network and Conventional System

The following table shows a comparison between the conventional system and the smart energy network. The traditional system needs the installation of heat source equipment tailored to demand for each building, and secures machine room or space for rooftop cooling tower, and arrangement for operators.

Meanwhile, as the smart energy network, suggested in the Bang Sue area, does not need heat source equipment for each building, the effective space is expanded, SEMC remotely monitors each EC status and manages day-to-day operation and maintenance for equipment in an effort to save labor in operation management. And also, AI system is used to optimize operation in the facility operation across the area.

Table4.33 Comparison between Smart Energy Network and Conventional System

	Conventional System	Smart Energy System
System Image		
Outline	- Building owners buy electricity from MEA. - Building owners have their own chillers in their building. - They operate and maintain them by themselves.	- Explained previously

Source: JICA study team.

(2) Energy-Saving Effect and CO_2 Emission Reduction

Table4.34 shows calculation results on energy saving effects and CO_2 emission reduction through the introduction of smart energy network. Based on the calculation results, approximately 28% of CO_2 emission is expected to be reduced in comparison with the traditional building-based cooling system.

In this calculation, considerations are made on high-efficient district heat supply system and energy-saving brought by solar power generation and by the EMS[30].

Table4.34 Energy-Saving Effect/ CO_2 Emission Reduction

		Phase1	Phase1+2	Phase1+2+3
Energy Consumption with Traditional Building-based Cooling System (MWh/y)		254,618	447,901	752,437
Energy Consumption at Adoption of Smart Energy Network	Power Consumption (MWh/y)	181,275	346,443	501,012
	Gas Consumption (MMBTU/y)	458	458	1,299
CO_2 Reduction (t-CO_2/y)	Power	- 41,512	- 57,425	- 142,306
	Gas	23,177	23,177	65,733
	Total	- 18,334 (Reduction 7%)	- 80,602 (Reduction 18%)	- 208,039 (Reduction 28%)
CO_2 Emission Unit		Gas 50.6 t-CO_2/MMBTU Power 0.566 t-CO_2/MWh		

Source: JICA Study Team.

Table4.35 shows expected equipment volume for the traditional building-based cooling system to compare with the smart energy network for reference.

Table4.35 Chiller Volume in Case of Building-Based Cooling System (Reference)

Energy Center	Operation Start	Supply Area	Cooling Supply Capability (kW)	Traditional System <Reference>	
				Chiller Volume[31] (USRT)	Backup[32] (Cold Source Equipment USRTh)
EC 1	2022	Zone A	15,660	4,900	1,000
EC2-1	2024	Zone D1	7,718	2,500	500
EC2-2	2033	Zone D2	38,810	12,200	2,500
EC 3	2025	Zones E, F1	46,824	14,700	3,000
EC 4	2027	Zone F2	50,137	15,700	3,200
EC 5	2027	Zone C	9,073	2,900	600
EC 6	2032	Zone B	33,283	10,500	2,100
EC 7	2033	Zone H	22,519	7,100	1,500

Source: JICA Study Team.

[30] Energy-saving effects brought by EMS is set here at 10% across the board, referring to Japan's case (Survey research report on energy-saving effects brought by IT, released by Japan Electronics and Information Technology Industries Association).

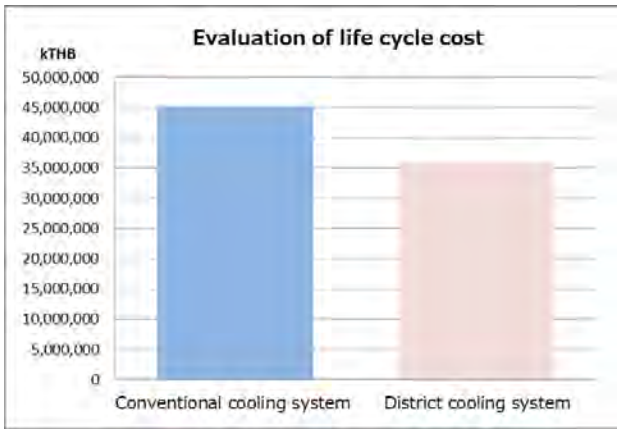
[31] Allowance rate is set at 10% across the board, as done in the smart energy network.

[32] The traditional system with backup devices is set at 20% of chiller volume, considering allowance rate.

(3) Advantage in Smart Energy Network

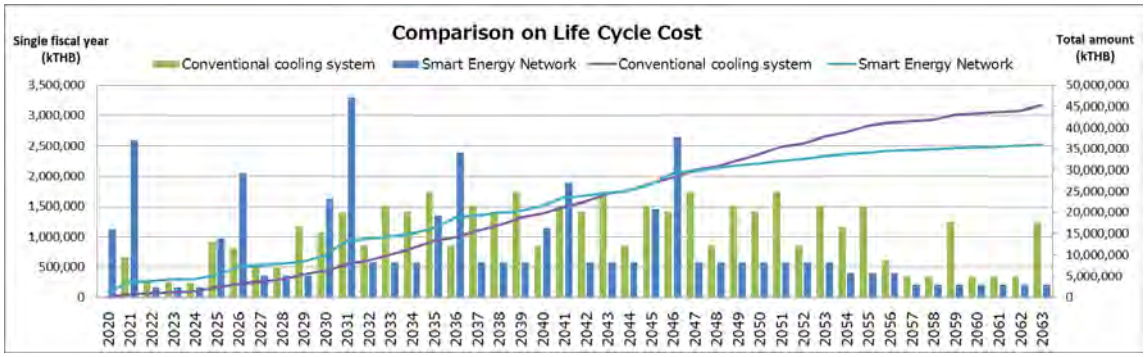
1) Energy Conservation/Environmental Performance/Life Cycle Cost

The district cooling system features better life cycle cost performance and higher energy consumption efficiency than those of individual heat source system and less impact on the environment like air pollution. The following figure compares the case of district cooling system and conventional cooling system in the Bang Sue are.[33]..



Source: JICA Study Team.

Figure4.91 Comparison on Life Cycle Cost ①



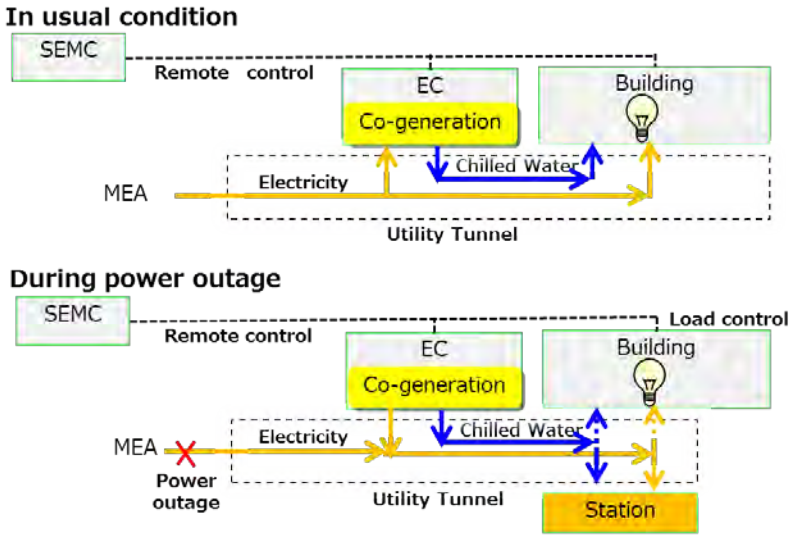
Source: JICA Study Team.

Figure4.92 Comparison on Life Cycle Cost ②

[33] See the calculation conditions for comparison in "5.5.3 Consideration on Smart Energy Business Profitability."

2) Reliable Supply

As EC or energy supply system achieves stable energy supply, it uses cogeneration at power outage to continue energy supply for key facilities or equipment. The following figures show power supply flows under normal circumstances and at time of emergency.

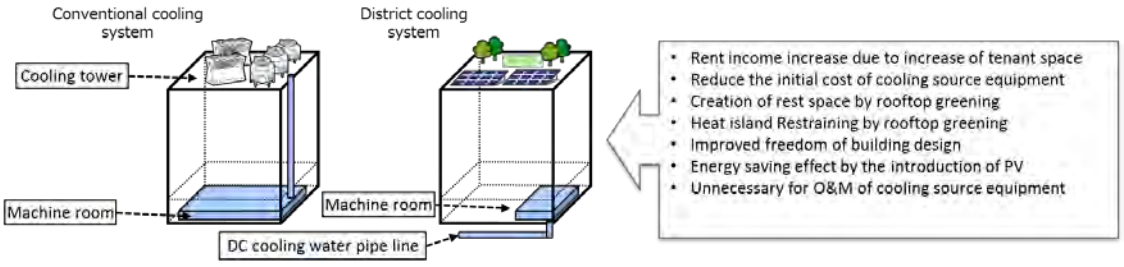


Source: JICA Study Team.

Figure4.93 Power Supply Flow at Emergency through Cogeneration (as shown earlier)

3) Use of Effective Space and Labor-Saving for Operation Management

- The smart energy network operates or handles heat source equipment through SEMC's intensive management and saves maintenance and other work for concentration on the core business.
- As each building does not need to secure the installation space for heat source equipment, building owners can lease the space to tenants and use it for warehouse or parking lot.
- As cooling towers are not needed, more flexible building design is possible with relaxation space production like rooftop greenery and the use of solar power generation.



Source: JICA Study Team.

Figure4.94 Effective Use of Space

4.4.7 Legal System/Regulation related to Development of Smart Energy Network

(1) Legal Framework and Regulation related to Energy Conservation

1) The Energy Conservation Promotion Act

Thailand enacted the Energy Conservation Promotion Act B.E.2535, in 1992, which was enforced in 1998 and revised in 2007. The act requires the owner of Designated Building or Designated Factory, 1) at 1,000 kW or larger as contracted power demand, 2) at 1,175 kVA or larger as total volume for installed reformers, or 3) at 20 million MJ or larger as annual power and vapor consumption, to implement the following:

- Appoint Person Responsible for Energy (PRE)
- Report energy consumption volume and energy saving activities
- Submit energy saving goal and plan

2) Building Energy Code

The Building Energy Code, taken effect in 2009, stipulates, for newly built or renovated buildings with the total floor area at 2,000 m^2 or larger, the following six items: 1) outer surface of building, 2) lighting equipment, 3) air conditioning equipment, 4) hot water equipment, 5) renewable energy use and 6) building energy performance.

The building with the site area of 10,000 m^2 or larger need to comply with Building Energy Code (BEC) newly enacted in mid-2018. The code applies to nine kinds of newly built large-scale construction structures, including hotel, office, hospital, department store, theater, gasoline station, hall for conference, campus building and condominium. The factors for new building subject to the code include 1) building materials, 2) air conditioning equipment, 3) lighting, 4) hot water, 5) renewable energy and 6) building structure.

In addition, the code aims to reduce power consumption by approximately 10% or 13.7 billion kWh for the next two decades, which is equivalent to 48 billion baht of power costs. The code is enforced in a stepwise fashion with the following three procedures. With the code enforcement, the Department of Alternative Energy Development and Efficiency (DEDE) facilities efforts described in the following table.

- The code applies to newly built structures with the site area of 10,000 m^2 from 2018 onwards.
- The code applies to newly built structures with the site area of 5,000 m^2 to 10,000 m^2 from 2019 onwards.
- The code applies to newly built structures with the site area of 2,000 m^2 to 5,000 m^2 from 2022 onwards.

Table4.36 Building Energy Code

Effort	Outline
Facilitate Code Execution	・ Secure BEC execution. ・ Nurture BEC auditors. ・ Tighten BEC. (Stepwise regulation expansion)
Support Energy-Saving Construction	・ Establish certification system for energy-saving construction. (LEED, TREES and other green certifications) ・ Provide financial support like government subsidy or low-interest rate personal loan, etc.

Zero Energy Building	・ Validate green building design, economic value and climate change in Thailand. ・ Work out zero energy building plan. ・ Goal: Newly built public and private structure with the site area of 2,000 m^2 or larger.

Source: JICA Study Team.

3) New Energy Efficiency Development Plan

On January 23, 2019 the National Energy Policy Council in Thailand approved revised Power Development Plan 2018 (PDP 2018), as a revision for PDP 2015, to secure future power sources. As PDP 2018 stipulates the promotion of renewable energy or cogeneration for 20 years from 2018 to 2037, larger investments are expected on renewable energy or cogeneration.

In PDP 2018, in comparison with PDP 2015, power generation volume is raised by approximately 10% and the degree of dependence on coal power is slashed by about 10%. Meanwhile, the dependence level on natural gas remains. In order to encourage private operators to enter the power generation market for efficiency, PDP 2018 describes a policy to reduce EGAT's current power generation rate to mid-20%.

(2) Legal System/Regulation on Cogeneration Business

As there is no legal system/regulation on cogeneration business itself in Thailand, the legal system/regulation chiefly on power supply or gas cogeneration development is organized. Meanwhile, under current Legal System/Regulation, cogeneration system can be constructed only in industrial area (called purple zone). Therefore, deregulation (Special zone certification, etc.) is required for installing cogeneration system into the Bang Sue Area.

1) Permit for Power Supply Business

In Thailand, if power generation, power transmission or distribution, or power retail business and power operation exceeds 1,000 kVA, permit or approval, stipulated in Energy Industrial Act, B.E.2550 (2007), is needed.

2) License on Power Generation

The power generation operator, running a power plant at 1,000 kVA or larger, has to gain Electricity Generation License, irrespective of Industrial Power Supplier (IPS), Very Small Power Producer (VSPP) or In-Plant Utility (IPU).

3) Power Purchase Agreement

Although it was possible to sell generated power to power transmission and distribution companies like EMA or specific suppliers' customers, sales of excess power produced by cogeneration is currently suspended.

4) Factory Operation License

As the power plant is classified as “type-3 factory,” ERC-issued Factory Operation License needs to be gained.

5) Building Construction Permit

Before the start of construction, Building Construction Permit needs to be gained. After the end of construction, the operator needs to gain Building Permit.

6) Energy Production Permit (Por Kor 2)

The power plant with 200 kVA or larger volume needs to gain Regulated Energy Production Permit.

If natural gas is used for power generation, as the business is classified as “type3 regulated business” under the Fuel Control Act, the operator also needs to gain a license under the act.

And also, if Small Power Producer (SPP) operates renewable energy power generation, it needs to submit company registration documents, wiring or device design drawings, necessary warranties and related certificates, requests for power sales to EGAT and application documents in the license application process.

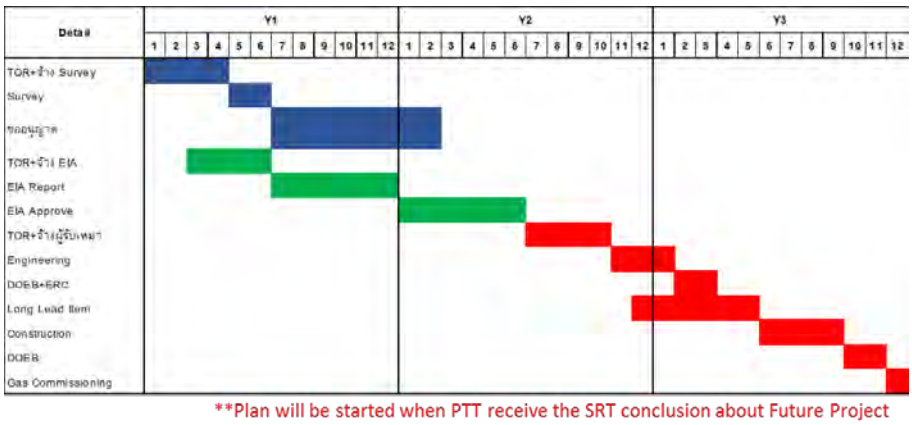
7) Environmental Impact Assessment

After the Enhancement and Conservation of National Environment Quality Act (NEQA) was enacted in 1992, the Notification of Ministry of Natural Resources and Environment under NEQA stipulates project classification and scale needed for environmental impact assessment (EIA), and regulations or procedures (screening, EIA report production, screening process/time, environmental preservation measures, monitoring, etc.).

Under Constitution Article 67 for 2017, if projects are likely to have a serious impact on environmental quality, natural resources or health in the community, Environment and Health Impact Assessment (EHIA) is needed.

Based on the above, in the case of a power station with the output of 10 MW or larger, EIA is needed. In the case of a power station with coal as fuel and the output of 100 MW or larger, EHIA is needed. This regulation is also applicable to cogeneration system.

In the case of gas-fired power generation at less than 10 MW, Environmental and Safe Assessment (ESA), based on Factory Act, or Initial Environmental Examination (IEE), in line with local rules, is required. Furthermore, installing or prolonging gas pipeline also subject to environmental impact assessment. The rough schedule for the gas pipeline connection and installation is shown below.



Source: Material supplied by PTT.

Figure4.95 Pathumthani-Phayathai Gas Pipeline (Reprint)

8) Air Quality Standards

Thai gas emission-related standards need to be met before the development of cogeneration. Regulations for air pollution prevention in Thailand stipulate general or comprehensive standards on environmental air and standard concentration on contained materials by generated source, including fixed emission source like factory or mobile source like vehicle or two-wheel vehicle. As cogeneration is classified as fixed emission source, the following emission standards need to be met.

Table4.37 Emission Gas Standards from Fixed Source in Thailand

No	Harmful Material	Unit	Standard Value
1	Total suspended particulates	mg/Nm3	320
2	Antimony	mg/Nm3	16
3	Arsenic	mg/Nm3	16
4	Copper	mg/Nm3	24
5	Lead	mg/Nm3	24
6	Mercury	mg/Nm3	2.4
7	Chlorine	mg/Nm3	24
8	Hydrogen chloride	mg/Nm3	160
9	Hydrogen sulfide	ppm	80
10	Carbon monoxide	ppm	690
11	Carbon dioxide	ppm	60
12	Nitrogen oxide	ppm	200

Source: JICA Study Team.

9) Permit/Approval toward Development of Smart Energy Network

Table4.38 shows permits and approvals on the development of smart energy network.

Table4.38 Permit/Approval Overview

Rule/Regulation	Administration	Remarks
Factory license	ERC	Product: Power, heat
Investment promotion	BOI	Tax benefit

Rule/Regulation	Administration	Remarks
Building construction permit	ERC (Power Plant) & BMA	Building
Building use permit	ERC (Power Plant) & BMA	Building
Gas use permit	ERC (Power Plant) & DOEB	Gas use facility
ERC Package	ERC	Cogeneration
ERC POK KOR 2	ERC	Cogeneration
Grid connection	MEA	Cogeneration
Power purchase contract	EGAT/MEA	District power source supply system
EIA/ ESA	ONEP	EIA: Cogeneration ≧10MW ESA: Cogeneration <10MW Installation and extension of gas pipeline

Source: JICA Study Team.

(3) Certification Standards on Smart City in Thailand

If operators meet smart city requirements stipulated by Thai Board of Investment (BOI), they are given to tax privileges or other benefits. Therefore, this study aims to satisfy certification standards in the energy sector and achieve a smart city network suitable for a new gateway for Bangkok. The following describes comparison between smart energy certification standards and response status. As specific standard values are not set in the screening process for the certification standards, screening is done individually, depending on application.

Table4.39 Smart Energy Certification Standards and Response Status

No	Item	Consideration Standards	Response Status
1	Specific Energy Consumption (Mandatory)	All buildings and enterprises within the smart city have to meet the energy consumption average reference criteria for each type of buildings and enterprises.	・Smart energy network is expected to reduce CO_2 emission by 28%, compared with the traditional air conditioning system. ・The Thai government sets an international goal to slash emission by 25% (compared with 2005).
2	Energy Generation	Renewable energy production (mandatory)	Install solar power generation on the roofs of all facilities.
		Onsite power generation	Generate onsite power generation through cogeneration.
		Energy storage	・Introduce heat storage tanks to each EC. ・Store power in PRT's reserve cells to use at either peak cutting or supply and demand adjustment.
3	Energy Distribution	District cooling or district heating system	Build district cooling system in the area with high energy demand density.
		Promoting the usage of environmental friendly vehicles (Eco-vehicle)	Operate PRT and introduce EV-sharing service.
4	Greenhouse Gas Reduction	Greenhouse gas reduction target throughout the project period. Greenhouse gas reduction target in the first year for the project	・Reduce CO_2 emission by 28%, compared with the traditional system. (Phase 1: 7%, Phase 2: 18% and Phase 3: 28%)

No	Item	Consideration Standards	Response Status
5	SMART Grid System	Area energy management system (AEMS)	Aim to be high efficiency by introducing AEMS to collaborate with PRT's smart service or environmental monitoring data.
		SMART Meters	Introduce smart meters to all facilities in order to visualize energy demand and realization of effective charge collection.
		Micro-grid system	Build microgrids in all areas to improve energy security.
		Smart Home / Smart Building system	・Introduce BEMS to facilities with a certain degree of scale or larger. ・Introduce HEMS to all residential facilities.
6	Other Innovative Proposal for Smart Energy (SMART Energy Innovation)	Presenting the innovations that can support the development of smart city in Smart Energy field.	Integrate energy management through SEMC and create innovation through the open data platform.

Source: JICA Study Team.

4.4.8 Consideration and Challenge towards Business Execution

(1) Consideration in Business Execution

1) Conduit Pipe Maintenance for Development Business Site

If cold water conduit pipes are installed in the commercial land to lease to operators like developer, as facility maintenance is likely to be difficult (at building rehabilitation, removal, etc.) due to a change in operators and others, risk factors in the redevelopment of cold water conduit pipe are higher than those for public space. Therefore, they need to be reduced by using public space like utility conduit to the extent possible to be developed in the land for road.

2) Scalable Facility Development

In order to expand the energy network in a stepwise fashion in accordance with each development work, facilities need to be developed with the future demand scale in mind. As for facilities that are difficult to expand facilities with cold water conduit pipes, development work needs to be facilitated, based on facility plans devised in line with the future demand size to the extent possible.

In addition, in order to secure plant space in the zone in the mid-stage in accordance with the stepwise development, expandable plant space needs to be secured beforehand, considering the maximum demand. Therefore, plant space needs to be considered together with public preferential treatment like excluding plant space from the calculation of floor space ratio for building.

3) Peak Load Expansion Brought by Users with Similar Industry Sectors

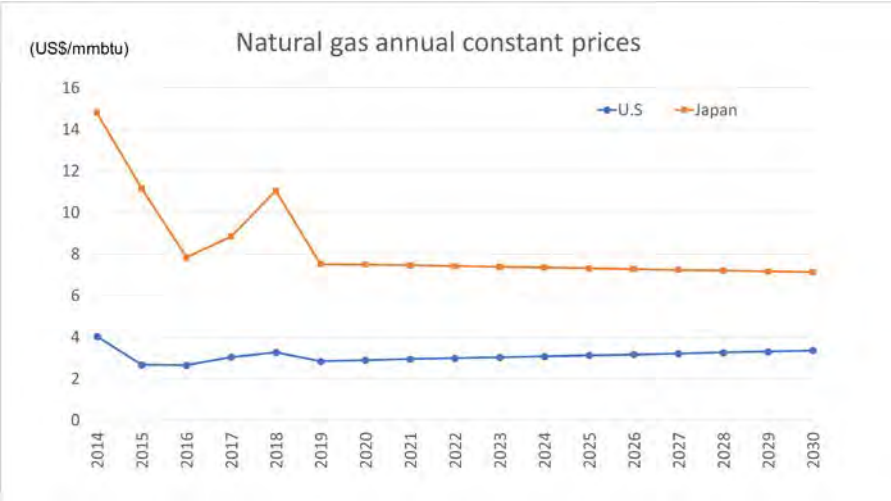
In the case of users with similar business sectors like commercial or business facility, the maximum load is especially likely to be large at peak hour. As energy suppliers need to secure facilities to meet peak load for respective users, the initial cost on facility introduction is risen. It is therefore effective to attract users like hotel or hospital whose demand patterns are different.

4) Encouragement to Use Smart Energy Network

In order to encourage to use smart energy network, awareness/understanding is expanded on advantage brought by use of energy network or on energy conservation in the Bang Sue area, and incentives are given to zone developers or users except for energy cost reduction. To this end, government policies are encouraged including preference policies or privilege expansion, based on land price growth evaluation through added values as smart city, revenue increase and social benefits.

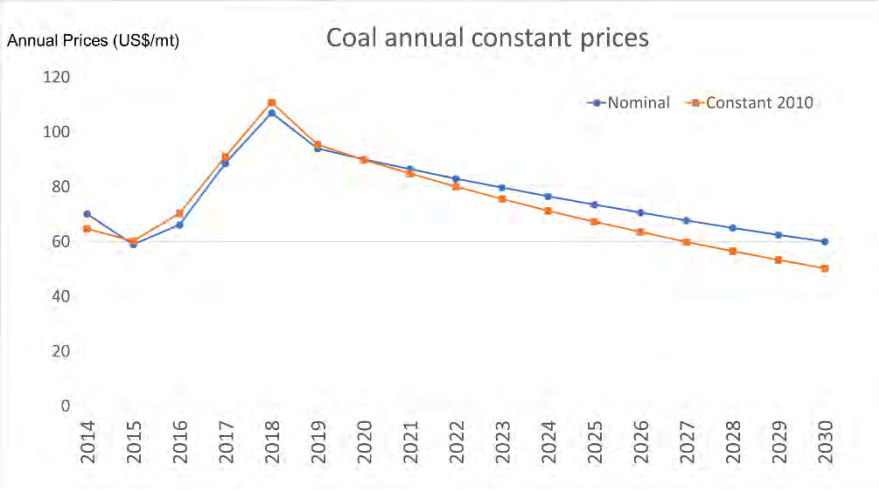
5) Unit Price Fluctuations for Gas and Power

As fluctuation risks for primary energy sources like gas and power are caused by fuel adjustment prices, the cost structure needs to be considered so that these unit price fluctuations can reflect to direct heat costs. In general, fuel adjustment prices are added to commodity charges.



Source: World Bank Commodity Markets Outlook April 2019

Figure4.96 Natural Gas Price Trend and Future Forecast



Source: World Bank Commodity Markets Outlook April 2019

Figure4.97 Coal Price Trend and Future Forecast

6) Business Risk Reduction

As it is common to take a long period to develop a wider energy network in the Bang Sue area, one of large business risk factors for energy suppliers is delay in the development of demand facilities or planning change.

In order to avoid development delay attributable to users, at the time of concluding supply and demand contracts, actions can be considered including settlement with capped late payment charge.

Assuming that actual usage volume falls below demand forecast due to planning change, it is important to hedge risks between energy suppliers and users, including basic charge setup on the basis of the demand size in the initial plan.

Table4.40 Energy Cost Setup (Example)

Charge	Breakdown
Basic charge	Fixed cost (Depreciation/ Interest/ Labor cost/ Maintenance cost/ Insurance premium) + Profit
Usage charge	Cold water usage volume x unit price＋Ft (Fuel adjustment)

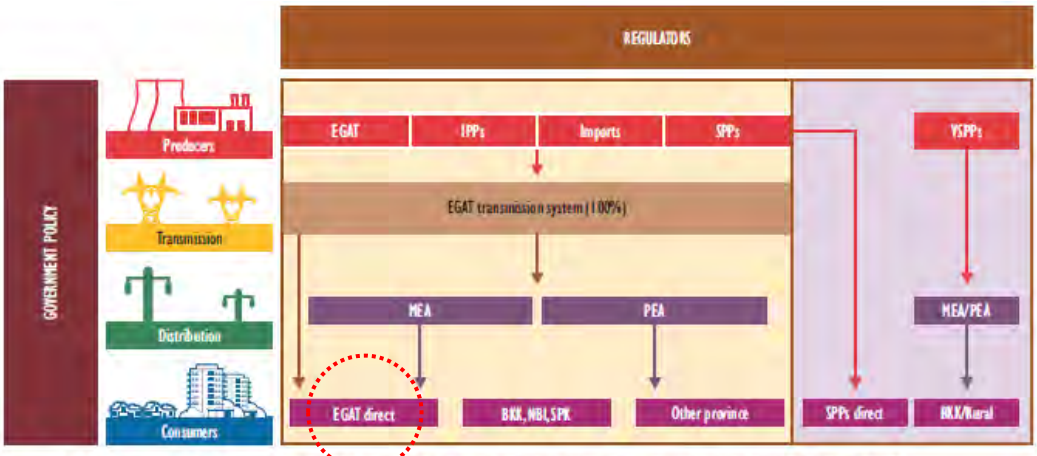
Source: JICA Study Team.

7) Regional Power Network Development in Preparation for Disasters

As the microgrid installed for each zone needs to be separate from the existing power transmission and distribution network, the power system management needs to be established, in an effort to achieve independent energy supply at time of disasters.

8) Wholesale Procurement Price for Power

In the Bang Sue area, power is distributed collectively to respective zones and energy suppliers established in the area make retail sales to respective users. At that time, prior negotiations are needed on power wholesale prices to be procured by EGAT or the MEA. Wholesale procurement prices need to be set, considering running costs generated by operation or equipment renewal for microgrid or secondary substation together with business profits in Bang Sue.



Notes: BKK = Bangkok; NBI = Nonthaburi; SPK = Samut Prakan; these three provinces make up the service area of MEA.
Source: Added partially by JICA Study Team, based on Thailand Questionnaire conducted by IEA in 2015.

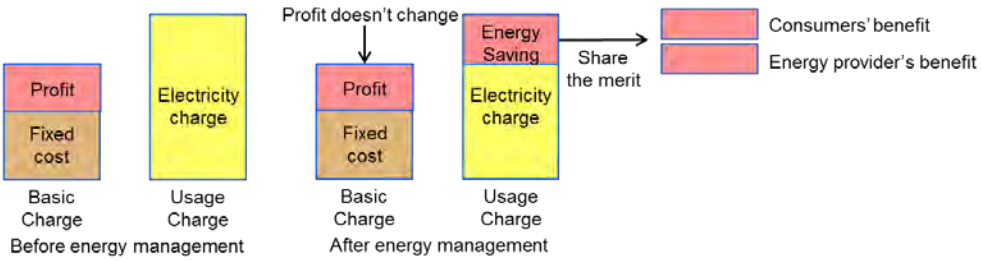
Figure4.98 Power Supply System in Thailand

9) Revenue Sharing for Energy Conservation

If EMS to be introduced to business facilities is used to reduce energy costs, energy suppliers can properly share profits with developers or building users to enjoy incentives mutually as an effective system[34].

The following figure organizes a way to consider profit sharing, when energy costs for users are slashed through energy management or energy-saving services delivered by energy suppliers.

[34] Energy suppliers are expected to deliver energy services for energy conservation.



Source: JICA Study Team.

Figure4.99 Revenue Sharing Concept through Energy Conservation

10) Requirements on smart energy clarified in the bid document for zone developers

The issues to be described in bid requirements for each zone are as follows:

- Developers shall confirm requirements on utility development and management given by the SSC and cooperate with the SSC.
- Developers shall clearly describe, in the bid document, connection obligations to the smart energy network, including microgrid and district heating network.
- Developers shall supply Smart Energy Company (SSC) with energy demand volume and energy investment plans in order to secure the proper joint design performance on energy management.
- Developers shall implement the HEMS and the BEMS, based on data collection requirements for the AEMS managed by the SSC, in an effort to make energy management effective and sophisticated in the Bang Sue area.
- In order for developers to consider investments on renewable energy, they shall discuss investment schemes beforehand with the SSC, including additional installation of storage batteries or sales to smart energy network.
- Developers or private zone operators shall consider investments in EV battery charger, after consultations with the SSC.

11) Management shift of heat source equipment for Bang Sue Grand Station

It is desirable to shift, to the SSC, operation and management for heat source equipment and emergency power generators for Bang Sue Grand Station in order to connect Bang Sue Grand Station with the smart energy network and make the integrated management operation effective.

(2) Challenge on Business Execution

1) Restriction for Use District in Introduction of Cogeneration

The cogeneration system cannot be installed in the commercial district under the current regulation. Therefore, efforts are needed to encourage the government to ease restrictions including special district system or use district.

2) Deregulation on Power Sharing or Transaction for Power Supply and Demand Balancing

Flexible deregulation is needed on power sharing or transaction for power supply and demand balancing capability in an effort to facilitate effective use of smart energy network integrated with town development in the area. Although some demonstration cases have been given in Thailand, flexible deregulation, like special district certification to encourage advanced efforts for smart city, is needed due to no specific business market no legal system.

4.5 Smart Environment

4.5.1 Goals and Objectives / Performance Indexes in Thailand

The goals established for the Smart Environment initiatives by the Thai government are listed below. Based on these broad-ranged goals, detailed objectives and performance indexes are proposed. Most of these objectives shall be standardized in the City Development Guidelines described in the previous section, and the effort to achieve these objectives shall be undertaken accordingly within the Bang Sue Area.

Table4.41 Summary of Performance Indexes and Strategies for the Smart Environment

No	Goals	Objectives/Performance Indexes	Proposed Strategies and Methods
Solid Waste Disposal			
1	GOAL 1: Reduced Load on Solid Waste Disposal Infrastructure through Implementation of Reduce/Re-Use/ Recycle (3R) Program	(1) Increased Percentage of Total Solid Waste Output to be Processed for 3R Programs within Bang Sue Area by Implementation of Waste Separation and Collection (2) Measurable Reduction in Quantity of Solid Waste Materials Going Directly to Landfill for Final Disposal	◆ **Establishing Standards and Regulations on Solid Waste 3R Program :** Upon coordination with Bangkok authorities, the operational standards for Bang Sue Area's waste separation/collection, 3R and composting programs shall be standardized and made enforceable via Urban Area Management Guidelines ◆ **Implementing Waste Separation at Source by Residents :** 1) Facilitate public education on benefits of solid waste separation/collection at source through resident meetings, pamphlets, etc.; 2) Facilitate self-management practice on waste separation at source by individual building managers, residents groups, etc.; 3) Implement separated waste collection and 3R programs by public or private-sector service providers ◆ **Operating Composting Program :** 1) Plan and implement facility development and operation for organic waste composting as a financially-viable private-sector project (i.e. profit-generating from waste collection fees, compost sales, and other fees and subsidies); 2) Implement separation and collection of organic wastes at source (e.g. at cafes and restaurants, residential buildings, etc.) ; 3) Buy-back compost as fertilizer for in-area urban gardens and parks, for purpose of facilitating residents' understanding and active participation in recycling ◆ **Reducing Waste Materials Sent Unprocessed to Landfill :** 1) Achieve quantifiable reduction in solid waste materials going directly to the landfill for final disposal; 2) Utilize public announcements on positive results to encourage increased community participation

No	Goals	Objectives/Performance Indexes	Proposed Strategies and Methods
2	GOAL 2: Clean and Sanitary Urban Spaces	(1) Standardized Maintenance Service for Clean Urban Spaces to Ensure Resident Satisfaction (2) Standardized Waste Collection Service in Public Urban Spaces to Ensure User Satisfaction	◆ **Managing Service Level for Public Space Cleaning and Maintenance :** 1) Establish service performance standards for public or private-sector cleaning service provider; 2) Collect resident/user feedbacks on service performance level using smart phones ◆ **Managing Service Level for Waste Collection in Public Spaces :** Upon coordination with Bangkok authorities, establish service performance standard for waste collection in public spaces; Collect resident/user feedbacks on service performance level using smart phones
3	GOAL 3: Environmently Safe Methods for Final Disposal of Solid Waste Materials	Standardized and Enforced Separation of Solid Waste Disposal into Landfill Disposal, Incineration and Re-Use / Recycle	◆ **Establishing Standards and Regulations on Solid Waste Disposal :** Upon coordination with Bangkok authorities, operational standards for Bang Sue Area on separation, collection, and final disposal of general household wastes, large-sized household wastes (appliances, etc.), and medical / industrial wastes shall be made enforceable via City Development Guidelines ◆ **Disposal of Large-Sized Household Wastes :** 1) Upon coordination with Bangkok authorities, standardize separation, collection, 3R, and final disposal operations by public or private-sector service-provider; 2) Develop implementation structure and related facilities for 3R programs; 3) Encourage rule-based disposal practice by residents through public education and monitoring; 4) Facilitate self-management practices by individual building managers and residents groups ◆ **Medical/Industrial Waste Disposal :** Municipal authority shall develop implementation structure and related facilities; As well as implement effective monitoring and enforcement

No	Goals	Objectives/Performance Indexes	Proposed Strategies and Methods
Water Provision and Urban Drainage			
4	GOAL 4: Improved Water Provision Services	Infrastructure Development as per Service Standards Established by State and Municipal Water Authorities	◆ Upon coordination with Bangkok authorities, implement development of water provision infrastructure and maintenance structure as per standards established by State and Municipal Water Administration

No	Goals	Objectives/Performance Indexes	Proposed Strategies and Methods
5	GOAL 5: High Quality Water Provision Service	(1) Increased Efficient in Water Usage and Management by Introduction of Smart Infrastructure at 100% of Households (2) Uninterrupted Water Provision Service during General Water Outage (3) Energy Conservation by Use of Solar Water Heater System (4) Water Resource Conservation and Reduced Load on Infrastructure by Recycling of Gray Water (5) Flood-Resistant Water Provision Infrastructure	◆ **Smart-Upgrading for In-Area Water Provision Infrastructure :** 1) Establish target index and guidelines for introduction of smart meters via City Development Guidelines; 2) Aim for 100% installation rate at all households in the area ◆ **Water Outage Countermeasures :** 1) Establish target index for installation of rooftop emergency water tanks via City Development Guidelines; 2) Aim for 100% installation rate at all buildings in the area ◆ **Solar Water Heater System :** 1) Establish target index for installation of rooftop solar water heaters by individual building via City Development Guidelines; 2) Energy conservation and reduced load on power and gas infrastructure is aimed; 3) Aim for 100% installation rate at all buildings in the area ◆ **Re-Use of Rain Water and Used Water :** 1) Establish target index for rain water harvesting and gray water re-use (toilets, landscape irrigation, etc.) by individual building or zone via City Development Guidelines; 2) Aim for 100% installation rate at all buildings in the area ◆ **Flood-Resistant Water Provision Infrastructure** : Upon coordination with Bangkok authorities, install flood-resistant water provision infrastructure (e.g. sealed utilities conduit, etc.) which effectively prevents contamination by storm water and sewage during flood events
6	GOAL 6: Standardized Quality Management on Drinkable Water Provision	(1) Drinkable Water Supply by In-Area Water Service Infrastructure (2) Automated and Regular Monitoring of Drinking Water Quality (3) Standardized Installation of Drinking Water Filters	◆ **Quality Standards :** 1) Establish drinking water quality standards for Bang Sue Area via City Development Guidelines; 2) Provide superior water quality (drinkable) supply to all in-area buildings ◆ **Quality Monitoring :** 1) Install water quality sensors at individual building or zone in order to implement regular monitoring of water quality; 2) Publish results to build residents ◆ **Drinking Water Filters :** 1) Install drinking water filters to 100% of in-area buildings; 2) Maintenance shall be standardized and made enforceable via City Development Guidelines
7	GOAL 7: Standardized Management on Urban Drainage Treatment	(1) Standardization for Sanitary Treatment of Sewage (2) Standardization for Treatment of Storm Water	◆ Establishment of Urban Drainage Treatment Standards : Upon coordination with Bangkok authorities, standardize proper treatment of storm water and sewage before discharge into river system

No	Goals	Objectives/Performance Indexes	Proposed Strategies and Methods
8	GOAL 8: Improvement on Urban Drainage System by Upgrading of In-Area Drainage Infrastructure	(1) Reduced Load on Sewage Treatment Infrastructure by Separated Storm Water and Sewage Systems (2) Flood-Resistant Sewage System (3) Reduced Load on Storm Water Infrastructure by Incorporation of Green Infrastructure (4) Active Drainage Systems to Prevent Flooding at Underground Facilities (5) Underground Storm Water Tanks by Private-Sector Facility Owners to Prevent Local Area Flooding	◆ **Separated Drainage Infrastructure Systems for Storm Water and Sewage**：Upon coordination with Bangkok authorities, set up efficient urban drainage treatment by separating storm water and sewage systems ◆ **Flood-Resistant Sewage System**：Upon coordination with Bangkok authorities, install flood-resistant sewage infrastructure which effectively prevents leakage and contamination during flood events ◆ **Incorporation of Green Infrastructure**：Utilize rain gardens along roadways to cleanse run-off water through filtration and to percolate directly into the ground, reducing excess load on storm water system ◆ **Active Drainage System for Underground Facilities**：1) Reduce risk of flooding at underground facilities during heavy rain by installation of active and high-performance drainage systems; 2) Install automated water-proof gates at entry points ◆ **Underground Storm Water Tanks by Private-Sector Facility Owners**：1) Develop localized flood-retention capacity by incorporating underground storm water tanks below all buildings; 2) Installation of tanks shall be encouraged through tax benefits and other incentives for developers, or made mandatory via City Development Guidelines
9	GOAL 9: Improvement on Urban Drainage	Provision of Urban Drainage Performance that is Superior to Rest of Bangkok	◆ **Separated Urban Drainage Systems**：Install separate urban drainage systems for storm water and sewage across 100% of Bang Sue Area

No	Goals	Objectives/Performance Indexes	Proposed Strategies and Methods
Air Quality			
10	GOAL 10: Better Living Environment through Active Air Quality Management by Residents Participation	ICT-based Air Quality Management	◆ Regular Monitoring and Publication of Air Quality : 1) Install ICT devices to automatically measure level of local air pollution; 2) All monitoring results shall be published; 3) Public notices shall be issued during high pollution period to recommend non-automobile modes of transport via variable public message boards, etc. ◆ Citizen Feedbacks and Management : Enforcement of uninspected polluting vehicles, large-sized trucks in prohibited areas and hours, illegal burning of wastes, etc. based on citizen feedbacks and reporting via smart phones
11	GOAL 11: Reduced Roadway Traffic and Emission Gas Level through Development of In-Area Public Mobility Systems	(1) Increased Percentage of Public Transportation Use among Residents (2) Increased Area Coverage by In-Area Mobility Systems (3) Consolidated Parking Facilities around Peripheral Areas to Establish Car-Free Core Zone	◆ Operate Area Shuttle Buses (Hybrid/EV) and/or On-Demand Buses to increase station accessibility ◆ Introduce In-Area Personal Mobility Systems (e.g. Segways, bicycles, etc.) ◆ Pedestrian-Priority Areas : 1) Distribute consolidated structured parking facilities around periphery of development area; 2) Link peripheral parking facilities to pedestrian core zone via skywalks, underground passageways, and sidewalks
Others			
12	GOAL 12: Improved Quality of Life by Development of Green Space Network within Bang Sue Area	Target Index for per capita Area of Green Space is 10 m^2 as per Thai Government Standard,	◆ Hierarchical Park and Open Space Network : 1) Establish hierarchical structure of 'Regional', 'Area', 'Zone', and 'Neighborhood' parks with designated park functions and uses within overall network of parks; 2) With Chatuchak Park at the apex, Regional Parks for cleansing urban environment including air and water, Area Parks for sports and recreation, Zone Parks for passive uses and community interaction, and Neighborhood Parks for toddlers, children, old-aged, pet-walking, etc.

No	Goals	Objectives/Performance Indexes	Proposed Strategies and Methods
13	GOAL 13: Strategic Distribution of Land Use Pattern with Consideration for Environmental and Ecological Health		◆ Strategy for Green Network Development：Recreate 'Nodes' and 'Corridors' in natural ecology using parks and landscaped streets as green network in urban environment; Using Chatuchak Park as the source node, make linkages between the station, major area destinations and parks via green nodes and corridors; Establish landscape design standards for public parks, roadway spaces and adjacent-to-road, privately-owned set-back spaces via City Development Guidelines ◆ Suppression of Heat Island Effects：1) Strategically distribute green spaces and parks across the development area to utilize evaporative cooling effects for lower ambient temperature in urban spaces; 2) Consider prevalent wind direction to orient buildings for better air circulation; Specify these cooling strategies in City Development Guidelines ◆ Mixed-Use Urban Nodes：Integrate Work, Live, Learn and Leisure functions into a single mixed-use urban development in order to reduce load on transportation infrastructure for commuting elsewhere in the city, and to create a low-carbon footprint society

No	Goals	Objectives/Performance Indexes	Proposed Strategies and Methods
14	GOAL 14: Formation of Safe and Disaster-Resilient City	(1) Utilizing Area Parks, Public Facilities and Private-Sector Commercial Buildings as Forward Base of Rescue Operations and Emergency Refuge for Residents and Workers / in Severe Disaster Situations (2) Introducing Real-time Weather Forecasting and flooding Sensors for Automated Early Warning and Road Closure Systems	◆ Public Parks as Forward Base for Disaster Rescue and Relief Operations : 1) Establish standards and performance indexes via City Development Guidelines for multi-purpose use of park spaces as forward base for disaster rescue/relief operations; 2) Incorporate emergency heliport, large vehicle parking spaces, temporary tent village spaces, emergency goods storage facility, etc. into park design; 3) Implement facilities development and preparation as public-private partnership projects as per specified in City Development Guidelines ◆ Public Facilities as Emergency Evacuation Centers in Disaster Situations : Establish standards and performance indexes via City Development Guidelines for use of schools and other public facilities as evacuation centers for area residents in disaster situations ◆ Private-Sector Commercial Properties as Refuge Center for Stranded Workers Unable to Reach Home : 1) Establish standards and performance indexes via City Development Guidelines for use of private-sector commercial buildings as emergency refuge for stranded workers and visitors in disaster situations; 2) Standardize preparation methodology for refugee management and storage of emergency goods and rations; 3) Establish coordination bodies between area managers, tenant companies and resident groups to facilitate preparation ◆ Early Warning and Automated Closure Systems for Underground Facilities and Underpasses : Integrate local weather data and sensor inputs from flood-susceptible areas to establish an effective early warning system and automated closure systems for underground facilities

Source: Proposed and summarized by JICA Study Team based on official documents provided by the Thai Government

4.5.2 Strategies for Smart Environment Initiatives

(1) Solid Waste Disposal

1) Current Conditions

Solid waste disposal in Bangkok is administered by the Department of Environment, Bangkok Metropolitan Administration (BMA). The city's solid wastes are classified into general household wastes, industrial wastes, and biohazard wastes, and the final disposal methods can vary between 1) direct landfill disposal, 2) incineration before disposal, and 3) recycling.

For the purpose of solid waste management, City of Bangkok is separated into 50 districts. The household wastes are collected at designated locations around the city between the hours of 20:00 and 3:00 by circulating collector trucks. The collected wastes are temporarily consolidated at the processing facilities in Sai Mai, Nongkhaem or On Nut districts as general household wastes, industrial wastes, and biohazard wastes, and are processed for compaction, incineration, and recycling. Afterwards, the processed wastes are sent to Kamphaeng Saen (Nakhon Pathom Province) or Panomsarakan (Chachoengsao Province) landfills for the final disposal.

In Bangkok, as in most of the major ASEAN cities, the rapidly dwindling capacity of the existing landfills poses an urgent problem in the near future, and the effective management of disposal volume and quantity at the landfills is a critical necessity for achieving sustainable urban development. Currently, a large portion of the disposed solid wastes is constituted by otherwise recyclable mass if properly processed (e.g. organic wastes, plastic, aluminum cans, and pulp, etc.). A large percentage of such recyclable materials, however, reach the landfills without being separated and processed for 3R (Reduce, Re-use, and Recycle). In particular, the organic wastes tend to be heavy in transporting, spread unsanitary conditions, and cause groundwater pollution by leaching at improperly constructed landfills. For these reasons, the implementation of waste separation/collection at source, as well as the 3R and composting programs are deemed critically necessary.

2) Strategies to be implemented in Bang Sue Area

In Bang Sue area, as in other districts in Bangkok, the collection and the final disposal of solid wastes are conducted by the Department of Environment, BMA. The following goals shall be achieved in Bang Sue Area through a close coordination with the municipal authority: (1) reduced load on solid waste disposal infrastructure through implementation of 3R Program; (2) environmentally safe methods for final disposal of solid waste materials; and (3) clean and sanitary urban spaces.

- **Reduced Load on Solid Waste Disposal Infrastructure through Implementation of Reduce/Re-Use/ Recycle (3R) Program**

Upon coordination with the Bangkok authorities, the operational standards for Bang Sue area's waste separation/collection, 3R and composting programs shall be standardized and made enforceable via City Development Guidelines. The implementation of solid waste separation at source shall be implemented based on self-management principle by the individual building managers and residents. Such self-management is only possible by active participation of the residents and the tenant companies in the area. Thus, public education campaign through the resident/tenant meetings and distribution of pamphlets shall be utilized to facilitate understanding of public benefits from such efforts by the community. The clear rules shall be established to give guidance on proper waste separation practices at source. The municipal or the private-sector

service-provider shall implement waste collection service according to these established standards.

Regarding composting, the facility shall be developed and the program be operated as a financially-viable PPP project by way of collected service fees, compost sales, and other subsidies as revenue for the service providers. The overall quantity of solid wastes going to the landfills will be significantly reduced if the organic waste materials can be properly separated at the sources (e.g. restaurants, residential buildings, etc.). The compost products can be sold back to the community for use in the area urban gardens and parks.

- **Environmentally Safe Methods for Final Disposal of Solid Waste Materials**

Upon coordination with the Bangkok authorities on operational standards for solid waste disposal, the performance index for separation/collection of general household wastes, large-sized household wastes, and biohazard wastes shall be established and made enforceable. In particular, the implementation structure and the processing facilities shall be developed for collection, recycling and reuse, and final disposal of large-sized household wastes by public or private-sector service providers. The solid waste separation at the source shall be implemented based on self-management principle by the individual building managers and residents, as standardized in the City Development Guidelines. Thus, public education and monitoring shall be used to ensure rule-based practices by the participants. Furthermore, the disposal of bio-hazard and industrial wastes shall be operated as per the established municipal regulations. The disposing of such materials shall require formal application and approval by the governing authority, with proper monitoring and enforcement by the municipal government.

- **Clean and Sanitary Urban Spaces**

In managing the service level of cleaning the public spaces, the service level standard for the public or private-sector maintenance service providers shall be established upon coordination with the Bangkok authorities. The resident feedback shall be collected via smartphone application in order to bring accountability to evaluating and managing the performance level. Similarly, for garbage collection on public spaces, the service level standard shall be established upon coordination with the Bangkok authorities. The resident feedback will be collected via smartphone application in managing the actual performance level by public or private-sector service-providers. At specific areas, street-cleaning responsibilities can be assigned to commercial operators at on-street cafes and other commercial facilities in exchange for use of public spaces, as per PPP schemes established in the City Development Guidelines.

- **Waste Separation Utilizing ICT on Public Spaces**

In order to implement the garbage collection service on public spaces with maximum efficiency, the ICT-equipped trash bins may be installed around the zones. For example, the introduction of smart trash bins (as shown below) that can recognize and separate disposed trash into bottles and cans, and monitor the quantity of disposed wastes to notify the manager when full can cut down on human maintenance hours.

(2) Water Provision and Sewage Services

1) Current Conditions

The water provision service is under the responsibility of the Metropolitan Waterworks Authority

(MWA), and the Bang Sue area is located in the jurisdiction of the Phaya Thai District Office (Region 2). By subscribing to the MWA's water provision services, a sufficient level of basic service can be assured in terms of infrastructure, reliable service and water quality standard. The drinkable water quality, however, is deemed unattainable with the current infrastructure and service level.

The sewage service is under the responsibility of the Department of Drainage and Sewerage, Bangkok Metropolitan Administration. There are two operating sewage treatment facilities near the project area. The facility that is most likely to be designated for the Bang Sue area, the Bang Sue Sewage Treatment Facility, is already at full designed capacity as of December 2018, and there is no extra room for additional load. As such, the sewage from the station building will be directed to a newly constructed sewage facility within the project area, where it is treated to meet the environmental standard before discharge into the storm water drainage system. Furthermore, the area development plan stipulates that each zone will have its own sewage treatment facility where the raw sewage is treated to meet the environmental standard before discharge into the storm water drainage system.

2) Strategies to be implemented in Bang Sue Area

The water service in the Bang Sue area is to be provided by the MWA.

The current drainage planning for the same area is the result of studies conducted in the past years, and is constituted as follows:

- For the purpose of urban sewage management, the Bang Sue area is bisected into North and South areas. The sewage output from the Northern area is to be directed to the existing Bang Sue Sewage Treatment Facility, while the output from the Southern area is to be directed to the new sewage treatment facility adjacent to Zone A.
- The planned sewage quantity is 80% of the supplied water quantity.
- The drainage infrastructure is separated into sewage and storm water systems, and only the sewage is sent to the treatment facility. The drainage infrastructure is to be installed underneath the sidewalk surfaces within the width of designated utilities corridors. Where the depth of drainage infrastructure is to be below 4m from the ground surface, a pump facility will be installed.
- The drainage system shall utilize the HDPE pipes. Manholes will be installed at every 40m, and drainage infrastructure from each development plot will be linked with a manhole. The primary sewage treatment at the source plot is not deemed necessary.

Greater service efficiency and reliability is aimed for the water provision and urban drainage services in the Bang Sue area as compared to the surrounding city districts. To achieve these general aims, the following goals by the Thai Government are to be the target indexes: (1) High Quality Water Provision Service; (2) Standardized Quality Management on Drinkable Water Provision; and (3) Standardized Management on Urban Drainage Treatment. Strategies are developed for each of these goals, to be carried out in partnership with the MWA in the Bang Sue area on a trial-basis, and later to be expanded into the rest of the city upon successful trial operation.

■ **High Quality Water Provision Service**

Upon coordination with MWA, the target index for digitalization and functional enhancement of water service management systems shall be established. In particular, the introduction of smart meters shall be implemented on a trial-basis, gradually expanding the network to ultimately aim for 100% installation rate at all household within the Bang Sue area. The full coverage will enable

accurate data collection on the area demand and supply patterns for the water service, and the user-friendly visualizatipon of such water usage pattern will facilitate greater user awareness for water conservation, as well as pinpointing water loss through leakage and illegal tapping.

For the purpose of ensuring uninterrupted water provision service during general water outage, the target index for installation of emergency water storage tanks, to be placed on the building rooftops, shall be established via the City Development Guidelines. The basic policy is to make installation mandatory by building developers, particularly in public facilities, commercial complexes, office buildings, and high-rise residential buildings.

Similarly, the target index for installation of rooftop solar water heaters by individual building shall be established via the Urban Area Management Guidelines. As with the water storage tanks, the basic policy is to make installation mandatory by building developers. The mandatory installation of solar heaters will facilitate the formation of a low-carbon-footprint society by way of energy conservation and reduced load on power and gas infrastructure.

For the purpose of reducing the load on the water supply and drainage infrastructure, the recycling of rainwater and "gray" water (i.e. non-sewage, once-used water) shall be promoted. The collection and reuse of rainwater and gray water at each building or zone (e.g. for toilet use, landscape irrigation, etc.) shall be standardized and made enforceable via the City Development Guidelines. In particular, a mandatory policy shall be implemented across the Bang Sue area for developers to collect rainwater on rooftop and to use gray water treatment and reuse systems on public facilities, commercial complexes, office buildings, and high-rise residential buildings.

In Bangkok, where localized inundation (due to torrential rains exceeding the capacity of local drainage infrastructure) and wide-area flooding (due to levee breach) occur fairly frequently, the target index shall be established in coordination with the Bangkok authorities for the installation of water provision infrastructure that is **impervious to cross-connection** (contamination of portable water flow by sewage and/or storm water) during flood events (e.g. sealed utilities corridors, etc.). The basic policy shall be to achieve 100% coverage by such flood-proof infrastructure in the area.

- **Standardized Quality Management on Drinkable Water Provision**

In the Bang Sue area, in coordination with the Metropolitan Waterworks Authority, water quality standards in the area shall be standardized in the City Development Guidelines to ensure higher quality water when compared to the rest of the city districts. Based on the existing services by the MWA, the building developers in the area shall be obliged to install additional filtering equipment (e.g. **drinking water filters**) that are designed to enable direct drinking of tap water in each building. In addition, the introduction of water quality sensors will enable automatic and regular inspection the quality of tap water, and by making the results public, will ensure transparency and confidence regarding water safety in the area.

- **Standardized Management on Urban Drainage Treatment**

The proper treatment level for storm water and sewage shall be standardized for the Bang Sue area upon coordination with the Bangkok authorities. In order to achieve maximum efficiency of urban drainage infrastructure in the area, the sewage and storm water systems shall be separated, with only the sewage going through the sewage treatment process, to reduce load on the related facilities.

In Bangkok, where localized inundation and wide-area flooding occur fairly frequently, the target index shall be established in coordination with the Bangkok authorities for the installation of sewage infrastructure system that is **impervious to stormwater mixing and leakage** during flood events (e.g. sealed utilities corridors, etc.). The basic policy shall be to achieve 100% coverage by such flood-proof infrastructure in the area.

In regards to the storm water drainage infrastructure, the target index shall be established for the installation of various green infrastructure, such as the **rain gardens** that utilize filtration and percolation effects to reduce load on storm water drainage system along roadways, and underground storm water retention tanks that are buried beneath the park surface. Both public and private-sector developers shall be guided and incentivized to install such green infrastructure in their areas as per the standards established in the City Development Guidelines.

Additionally, tax benefits in combination with appropriate development incentives (e.g. relaxation of floor area ratio and land use restrictions, etc.) shall be utilized to incentivize developers to install **basement rainwater retention tanks** and **rooftop gardens** that function to delay the storm water runoff during torrential rains, so that local drainage system is not overwhelmed beyond its capacity. Such strategy will promote the successful implementation of effective public-private partnerships that result in formation of flood-resistant development area.

At underground malls and pedestrian underpasses, the installation of **high-performance active drainage systems**, **automated waterproof gates** at ground-level entrance ways and **facility closure and evacuation systems**, both designed to reduce the risk of loss of lives and properties during the torrential rain, shall be made mandatory via the City Development Guidelines.

(3) Air Pollution

1) Current Conditions

In Bangkok, the three major sources of air pollution in the capital's atmosphere are: automobile exhaust from the city's roadways, factory smoke from nearby suburbs, and cremation smoke from temples. According to a recent study conducted by the National Development Administration Center (NIDA), the level of heavy metals in the atmosphere in Bangkok is at a dangerous level for humans (cadmium, tungsten, arsenic, polycyclic aromatic hydrocarbons). (Straits Times, January 26, 2019 article). In particular, the PM2.5 micro-particles, when inhaled by the human body, enter the bloodstream from the respiratory system and directly into internal organs, thus posing a serious threat to protecting the health of citizens.

2) Strategies to be implemented in Bang Sue Area

As the Bang Sue Area is to be developed as a cutting-edge, transit-oriented urban district, this would be remarked as a project that aims to move away from the dependence on automobiles. Therefore, new technologies or methods need to be introduced earlier than in other projects so as to serve as a pilot project. From this perspective, various initiatives shall be implemented in the area, based on the following policies: (1) Disclose information on air pollution to residents; (2) Collect air pollution-related complaints from residents; (3) Develop intraregional transport system; and (4) Install pedestrian priority zones in the central district.

■ **Disclose information on air pollution to residents**

The Thailand Government currently stipulates standards for the impact of lead in the atmosphere on safety for human body, among heavy material-related micro-particles. On the other hand, cadmium, tungsten, arsenic, and polycyclic aromatic hydrocarbons (PAHs) are other substances that are especially recognized as carcinogenic substances which could cause serious health problems. Given the observed volume in the air of Bangkok, this could be an urgent issue for residents in Bang Sue. If heavy material-related micro-particles in the atmosphere is observed on a periodic basis within the area, and real-time information on pollution level is provided to residents through smartphone or devises installed in the area, environmental awareness can be raised among residents to help them improve lifestyle habits. The information disclosure is considered to bring huge impact in facilitating the modal shift to public transportation by combining with active campaign programs like restrictions of private vehicles in the area, or incentives for public transportation users.

■ **Collect air pollution-related complaints from residents**

In order to foster the proactive behavior of residents on air pollution, it is desirable to establish a management system with residents' participation through smartphone or other devices. Coordination shall be needed with Bangkok City authorities to stipulate intraregional air pollution standards under the City Development Guidelines. Complaints are collected through smartphone applications from residents or visitors, and crackdown efforts shall be implemented to restrict vehicles with exhaust gas emission that do not comply with the guideline (incomplete combustion, poor catalytic converter, long-time idling, etc.). Also, heavy-duty tracks entering the no-entry zone and illegal waste disposal shall be the target of crackdown as well.

■ **Develop intraregional transport system**

As part of initiatives to reduce the number of private vehicles used in the area and reduce the carbon emission, hybrid-engine or EV-powered shuttle buses shall be introduced on the main road. In addition to this, an on-demand bus or personal mobility system (rental cycle, mini EV vehicles, etc.) shall be introduced for to enhance door-to-door accessibility.

■ **Install pedestrian priority zones in central district**

Multilevel parking facilities shall be collectively installed in the fringe area, in order to secure pedestrian priority zones in the central district, which helps to form safe, comfortable urban space. Regulations for pedestrian priority zone could be flexibly enforced, depending on time zone or day of week, etc. These measures could contributing to improving the atmosphere at a local scale.

(4) Parks and Green Network Development

1) Current Conditions

Bangkok City has been ranked 132nd out of 231 cities in the world's most liveable city ranking whose evaluation criteria includes public transportation, natural environment and air pollution. The ranking indicates that Bangkok remarkably lags behind others on measures to secure residents' life quality. In addition, the greenery area is extremely small at 3.3 m^2 per population, compared with 23.1 m^2 in New York and 66 m^2 in Singapore. (Source: News article dated Feb. 11, 2019 released by Reuters)

2) Strategies to be implemented in Bang Sue Area

Although Bangkok City has extremely small greenery area in the global standards, Chatuchak Park in Bang Sue is a precious environmental natural asset to be passed down the generations. The environmental and urban features for the park shall be maximized in the Area, leveraging on this unique natural environment. The basic strategies are set as follows: (1) form a functional ecological network; (2) develop a functional park system to improve residents' living quality; (3) mitigate heat island phenomenon; and (4) develop park as rescue or evacuation base for urban disasters. These shall be applied to facilitate multipurpose and multifunctional development in collaboration with the private sector, as described later.

■ **Formation of functional ecological network**

Ecological network development shall be advanced with park, street trees on the road space and green belt in order to embody "node (hub)" and "corridor" system in the urban space as the components for basic ecosystem in the nature. The term "ecological network" refers to a network of urban axis, which is comprised of a continuous space a hub formed with greenery or with water. These spatial extension of the network would contribute to leveraging various functions of the water and the greenery (cited from "Water and greenery network" released by the Ministry of Land, Infrastructure, Transport and Tourism). The ecological network would nurture healthy symbiosis with a wide variety of flora and fauna in urban space.

As a specific development method in the Bang Sue Area, consultations are firstly needed with the Bangkok City bureau in order to identify Chatuchak Park as a core hub for the ecosystem, from which the green corridor (street trees and green belt) and green node (small and large park system) in the development area are systematically laid out under the green network plan. In the road space for the green corridor, the layered system shall be set, depending on respective road

functions or width. The typical spatial cross-section drawing would be produced for respective road types to set the location or width of street trees and green belt. In addition, indicators related to the width or grass establishment are set for setback of neighboring privately owned area. In the park space for publicly and privately owned area composed of green nodes, the layered system shall be set in line with respective park functions, as mentioned later, to stipulate landscape design guidelines for respective park types. The public and private sectors shall respectively design, develop, maintain and manage parks, street trees and green belts at the time of green network development, based on these guidelines. As for ecological network formation, a wide variety of reference examples would be covered in “Basic greenery plan” issued by the city or the town in line with “Water and greenery network” released by the Ministry of Land, Infrastructure, Transport and Tourism. In the case of Japan, there are several cases in which the local administrations have established collaboration between business operators and other entities under the basic greenery plan to form water and greenery network, leveraging local features. Therefore, in the Bang Sue Area, it is expected that not only technical support, but also institutional knowledge such as business scheme or maintenance system could be provided to support the promotion of green network development under public-private cooperation. The following figure shows a network concept for green corridor and hub, consisting of river beds and national parks prepared by the Tokyo Metropolitan Government. This concept could also be applied to a specific development zone as well.

Figure4.100 Node and Corridor system in Tokyo Metropolitan Park

- **Development of functional park system to improve residents’ living quality**

A layered structure for Bang Sue Area is proposed, in which Chatuchak Park would be positioned at the top as a regional park, followed by park facilities for “district,” “zone” and “neighborhood,” as a subordinated layer. Each layer would be assigned with specific functions according to the land use. For example, the regional park includes purification functions (air and water) for urban environment, while the district park covers sports and recreational functions, and the zone park

has communication and recreation space for a wide range of users. And also, the neighborhood park contains functions for neighboring senior people, parenting generations, children and dog owners with dog walk. The parks for the respective layers shall have a distinct functions and spatial roles for improving the living environment for the residents. As for the park development and maintenance scheme, leveraging of private capital through tax incentives deregulation on floor space ratio and land use for developer could be considered.

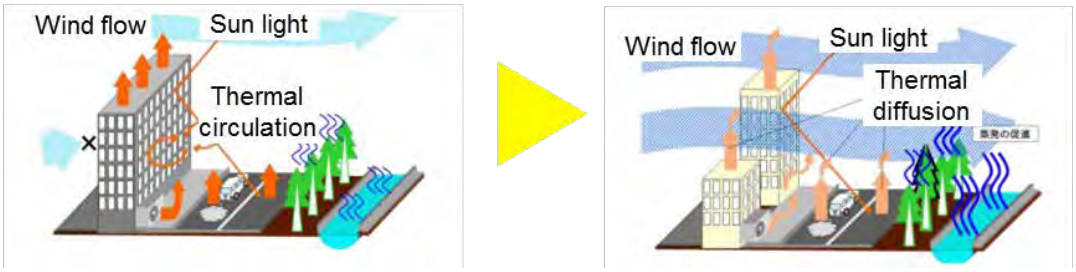
■ **Mitigation of Heat Island Phenomenon**

In Bangkok City, the maximum temperature exceeds 40 degrees Celsius for many days in the summer season (especially April to May). In the urban area covered with asphalt, concrete and glass, solar reflection, heat emission and retained heat air in closed space bring health issues for human body such as heat stroke. Development of green network could have a mitigating effect on heat island phenomenon in urban areas, as indicated in the following table. Effective location of the greenery and parks would promote natural cooling functions for urban space through vaporization. It is proposed that the strategic layout of green network or design indicators for building construction policies, together with floor-area ratio or height limitations for building in the development area, to be stipulated in the City Development Guidelines, for the formation of desirable urban structure.

Table4.42 Environmental effects of green corridor

Mitigation of Heat Island Phenomenon and Improvement of Urban Heat Environment	
Approx. 1ha of greenery	Approx. 0.2 degrees Celsius lower than the surrounding urban area within the 40m range.
Street tree	0.5 to 1.5 degrees Celsius difference inside and outside the shade.

Source: Compiled by JICA Study Team, based on materials by the Ministry of Land, Infrastructure, Transport and Tourism



Source: Osaka City (http://www.city.osaka.lg.jp/kankyo/page/0000123906.html)

Figure4.101 Mitigation effects of Heat Island Phenomenon through thermal diffusion

■ **Development of parks as rescue or evacuation base for Urban Disasters**

The most notable urban disaster for Bangkok City is flooding. River flooding are caused by massive rainfall in the Chao Phraya River basin while submergence in the hinterland could be attributed to excessive load on urban drainage infrastructure in times of torrential downpour. As for earthquake, as an active geographic fault is found chiefly on the national border of northern and western Thailand. Bangkok could be affected when large-scale earthquakes erupts in Myanmar. Although building standards have been enhanced in 2007 in Bangkok, there are risk factors for some buildings that had been constructed in the years before earthquake protection for magnitude 5 was obligated to large buildings. It is also pointed out that typhoon could cause some serious disaster damage to Bangkok.

At the time of such a large-scale disaster, wider open space would be needed to address residents' safe evacuation in the urban area, which could also be used as a rehabilitation and reconstruction activity bases. In Japan, park facilities which is equipped with disaster prevention functions have been developed nationwide. The parks serve as a tentative evacuation venue for neighboring residents at the time of disasters and use as a hub for firefighting and rescue operation. It is desirable to strategically develop the parks as multifunctional facilities. For this, basic park policies needs to incorporate disaster prevention aspects including wider evacuation base functions in the park; installation of quake-proof water storage tanks; broadcasting and information communication facilities; a helipad; parking space for large-sized vehicles; a tentative tent base and sprinkler system for fire spread prevention. The following table shows classification and roles for disaster prevention parks in Japan.

Table4.43 Classification and roles for disaster prevention parks in Japan

Park Classification	Major Role
Wide park (Large-scale park)	Wider disaster prevention hub as an area for wide area evacuation, emergency vehicle base or helipad, etc., with the objective of serving as area for final evacuation, rescue operation for the injured or restoration and reconstruction.
Urban core park (Comprehensive park/ Athletic park)	Regional disaster prevention hub as a front-line base for rescue operation for the injured, and goods transportation hub.
Urban park (Neighboring park/District park)	Emergency evacuation venue for neighboring residents, gathering spot in emergencies, and relay point for evacuation, etc.

Source: Compiled by JICA Study Team, based on materials on disaster-proof park released by the Ministry of Land, Infrastructure, Transport and Tourism

(5) Noise

1) Current Conditions

Bang Sue Area is envisaged to serve as a transport hub with various urban transportation systems. Major noise sources in the area include Sirat Expressway traversing the center of the area in a north-south direction, and the elevated track for high-speed railway that is under construction. Especially, as Sirat Expressway would be adjacent to business and residential building groups in the development site, its road noises would have an adverse impact on urban space, and thus effective noise measures would be needed.

2) Strategies to be implemented in Bang Sue Area

After coordination with Bangkok City bureau, it is proposed that the City Development Guidelines stipulates the noise indicators in the Bang Sue Area. The possible measures shall be considered by the responsible entity to mitigate the noise from the elevated road and the railway tracks.

In Japan, as shown in metropolitan highways and other cases, elevated highways are installed intricately between densely built buildings in the urban area. The sophisticated noise measures and technologies for the highway in Japan could be introduced in Bang Sue as well. Specific countermeasure system for noise includes noise barriers that are installed in the both sides of road, sound absorption treatment for the surface layer of concrete building, and noise insulation treatment for road surface joint part, as shown in the following figure.

Source: Metropolitan Expressway Company Limited (https://www.shutoko.co.jp/efforts/environment/roadside/noise/)

Figure4.102 Countermeasures for noise on the highways

Source: JICA Study Team.

Figure4.103 Sirat Expressway in Bang Sue Area

(6) Urban Disaster Prevention

■ **Establishing evacuation facilities under cooperative framework for private and public**

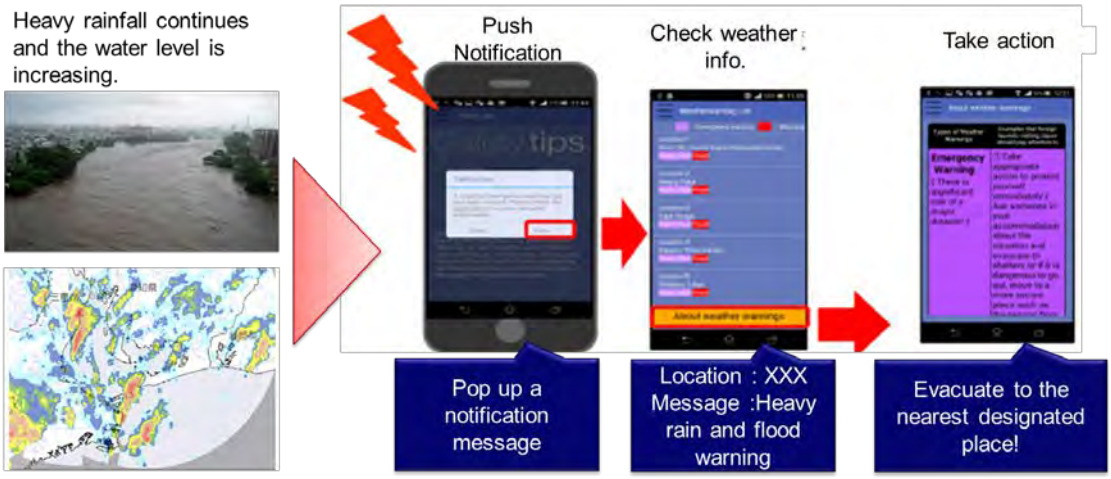
In addition to the previously outlined disaster prevention park, it is necessary that a framework for evacuations should be established in case of emergencies. Specifically, public facilities in the area, such as schools should be equipped to serve as evacuation centers at the time of large-scale disasters. It is important to specify necessary equipment and accordingly manage the stockpile, and establish cooperation system with the firefighting and medical institutions. It is proposed that these hardware measures and software measures for disaster prevention to be stipulated in the City Development Guidelines. The public administration shall take the initiative in the establishment of the evacuation in public facilities.

Meanwhile, most large-scale facilities are to be developed with private investment in the Bang Sue area. Therefore, system need to be formed so that commercial and office facilities would be capable of accepting people unable to return home after expected large-scale disasters, under the

cooperation of facility owners and zone developers. Also, indicators regarding stockpile storage and management would be needed to be stipulated in the City Development Guidelines. Preparedness shall be strengthened under the cooperation of the community and companies.

■ **Introduction of interlocked Early Warning System**

As Bangkok City prone to submergence and flooding, Early Warning System could be proposed, in which the warning is issued when the predicted water-level at Chao Phraya River exceeds the predefined level. The real-time water-level prediction model would be developed in association with tabulated weather observation data covering the Chao Phraya River basin. The flood warning needs to be issued at an early stage when precipitation reaches a dangerous level. Especially, a system needs to be established to issue an evacuation advisory warnings to underground malls or underpass, etc. In addition, as a measure for flood, floodwalls or road closure barriers are to be operated automatically, linking with the system, and the data collected with sensor installed in the submergence risk area or on CCTV image analysis. Furthermore, Smartphone and others device shall be used to notify evacuation information to residents in the area.



Source: Compiled by JICA Study Team.

Figure4.104 Evacuation warning with Push Notification for Smartphone

(7) Area Management

In the Bang Sue Area, residents and tenant companies shall separate and dispose the garbage, conduct 3R (Reuse, Reduce, Recycle) activities, and clean public space in line with indicators which is to be stipulated in the City Development Guidelines. At the time of emergency, office buildings and commercial facilities need to accept people unable to return home. It is important that the residents of the area and the tenant companies are actively involved in the activity and the process to improve the living environment.

With regards to urban management, “Area Management,” is an urban management initiative in Japan which aims to “facilitate autonomous urban/ city management under the initiative of private sector in a specific area” (definition given by the Cabinet Office in Japan). The notable features for this “Area Management” is that the various private entity (including the local community) are entrusted to actively participate in the city planning and management process,

as opposed to the conventional arrangement in which the public administration are the main management entity. The scope of the Area Management could include planning and implementing measures to vitalize cities and promoting positive image to brand the city. Knowledge could be drawn from the Japanese cases to the Bang Sue Area, with regards to the introduction of Area Management system and establishment of the implementation body.

As for the potential structure for the council on Area Management, land owner SRT shall serve as chairman while Bangkok Metropolitan Administration, developers, and tenant companies shall participate. Developers and tenant companies shall take initiative to conduct various activities which may include: management and operation of the intra-regional transport system, cleaning and maintenance for public space, keeping hygienic living environments, security and safety management, disaster prevention preparation, and planning of community events. The council also shall be in charge of coordination among stakeholders including the local community and the NGOs.

(8) City Development Guidelines

Under the integrated development concept and Smart City development initiative, Bang Sue Area is envisaged to become a high standard city in the following aspects: urban infrastructure and services, comfortable and safe living environment, convenient mobility system, and preparedness for urban disasters. In order to realize the high standard city, the establishment of a council or a committee to implement Area Management would be desirable. It is proposed that the council or the committee, based on voluntary agreements with stakeholder companies and residents, shall formulate the City Development Guideline. The Guideline shall clarify the way in which the stakeholders and local communities would be responsible for the development and maintenance of the city.

The Smart Environment-related items, outline in this section, could be specified in detail in the City Development Guideline, with regards to: (1) target indexes and standards; (2) implementation methods and design guidelines, (3) implementing body, and (4) maintenance system.

(9) Integrated Smart Environment Activities

The activities described above are the activities to meet with Smart Environment criteria. In the long term, to be a model city for Smart Environment, it is desirable to aim to be “Carbon neutral society” in Bang Sue, meaning that having a balance between emitting carbon and absorbing carbon. In order to realize “Carbon neutral society”, other activities are also expected to be considered.

In addition, to realize environmental-friendly life style in Bang Sue, promotion to use green product is also expected.

On the other hand, in order to realize “Carbon neutral society”, lots of investment have to be made and investment return should be carefully considered.

4.6 Other Smart Technologies and Services

This section illustrates smart services and technologies that may solve urban problems in Thailand from the perspectives of "Smart Economy," "Smart Governance," "Smart People," and "Smart Living," as the other smart city features. Care should be taken that this proposal in this section is merely an example, and the specific introduction is not considered.

4.6.1 Smart Technology and Service for Smart Economy

(1) Establishment of Co-working Space for Innovation (Entity: Zone developer)

The installation of co-working spaces has been expanded in the corner of office buildings or commercial facilities in foreign countries including Thailand in order to provide the place to generate the force for business revolution. Although services to supply co-working space are different, depending on operators, their features in most cases are as follows.

- Provide free work desks
- Provide private rooms and conference rooms
- Provide counters to promote communication
- Hold events on a regular basis
- Register corporation and provide address

As it is difficult for entrepreneurs to secure office rental fees in the prime locations especially in the process of corporate registration, this co-working space supply service can help attract entrepreneurs.

It is important to collaborate with developers that can supply working spaces, and to develop a city attractive to entrepreneurs in the Bang Sue office and commercial areas (which fall under Zones A, B, D, E, F, KM11 and H, based on JICA pre-survey.).

(2) Interoperable IC Card (Entity: central government)

Although public traffic system companies operate their own IC cards across Japan, the IC cards are interoperable and used as electric money. In Thailand, Rabbit Card and MRT Card are used, though they are not interoperable. .

It is desirable to introduce a new IC card system to secure interoperability for Smart Economy, including the previously cited PRT or Red Line to be launched in the future.

(3) Digital Signage for Tourists (Entity: Smart service company)

Many tourists visit Thailand known as a tourism-oriented country. It is important for the country to provide attractive tourist spots and multi-language road directions in raising hospitality.

A demonstration project for digital signage has been implemented since 2018 in Kyoto, Japan for interactive information exchange with tourists in multi languages. Some of the project costs are covered by advertising costs.

With the opening of Bang Sue Grand Station, as many tourists visit the Bang Sue area, it is effective to provide information to them in boosting attractiveness for Bang Sue.

4.6.2 Smart Technology and Service for Smart Governance

(1) Innovation through Open Data (Entity: Central government)

If 3D data for real-world buildings or infrastructure facilities are created and are released to entrepreneurs or citizens, it is expected to create new services with them and improve transparency on administrative efforts.

As Virtual Singapore is a real-time 3D model, its data platform can be shared with many stakeholders. Planning or decision making for new business can be supported through the digital reproduction of real cities. Model data or its operating services can be used in the process of business execution and citizens can confirm interregional development status.

Virtual Singapore is currently under development, and once its model is complete, it is available to anyone including the government, companies or citizens.

Source: National Research Foundation of Singapore

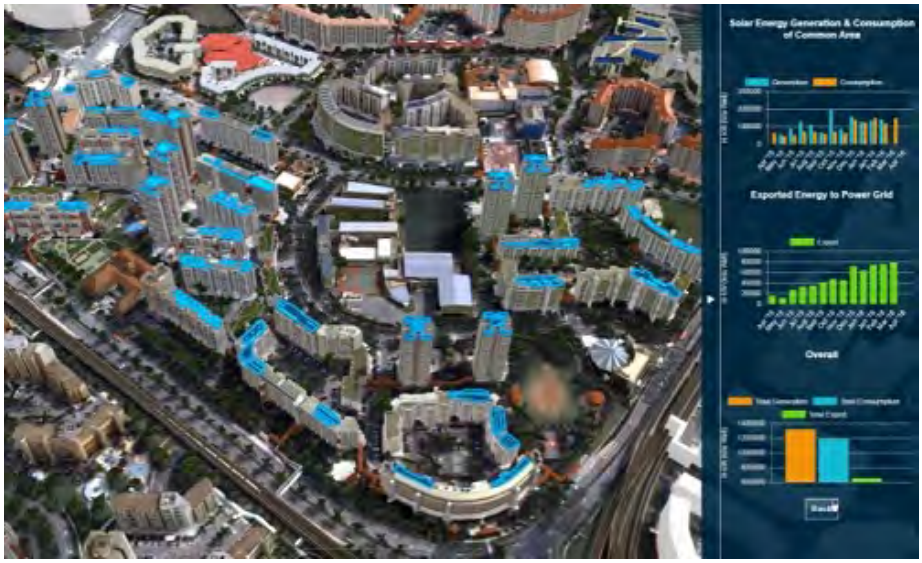
Figure4.105 3D Model of Virtual Singapore

The project development costs 54 million US dollars for five years. The model has been developed chiefly by NRF (National Research Foundation) under government organizations SLA (Singapore and Authority) and GovTech (Government Technology Agency of Singapore) in cooperation with private companies. Virtual Singapore is said to achieve:

- Simulation for solar energy panel demand: As Virtual Singapore can supply information on building height or rooftop surface area, it allows engineers to analyze the installation place for high-efficient solar power panel.
- Analysis for temperature and sunlight: The simulation model allows urban planners to estimate how sunlight and ambient temperature affect new buildings in the specific region, using heat and sunlight data provided by the platform. This can help planners to create a cooler living environment for residents.
- Improved accessibility: As the advantages for Virtual Singapore include visualized terrain attributes and its recognition, the elderly or disabled is expected to find the optimal barrier-free route.
- Communication and visualization: The 3D model environment allows planners to easily communicate or share future development ideas or concepts.
- Collaboration in virtual environment: This platform can help various authorities test project

compatibilities with no additional costs in the planning process in the city.

- Research-related: Researchers from university study rooms or research institutes can promote development, using the model and 3D tools integrated with affluent data.



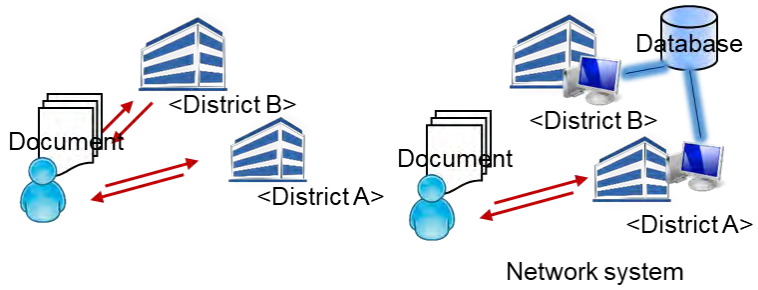
Source: National Research Foundation of Singapore

Figure4.106 Potentiality Analysis of Solar Power Generation in Virtual Singapore

In the Bang Sue area too, design data is expected to be produced with the use of BIM and others in the process of redevelopment. The data can be realized by collecting and sharing these model data and used as a base for open data platform. It is therefore desirable to stipulate data requirements in bid invitation documents, town development guidelines or others in order to encourage detail designers or other operators to submit 3D model data for each zone.

(2) Centralized Contact Points for Administrative Applications (Entity: Central government)

If a one-stop service center is set up to accept applications from residents or private companies or issue permits or approval through collaboration with administration data base on the network, residents or private companies can lessen burdens of application procedures. As a similar scheme the basic resident register network is adopted in Japan.

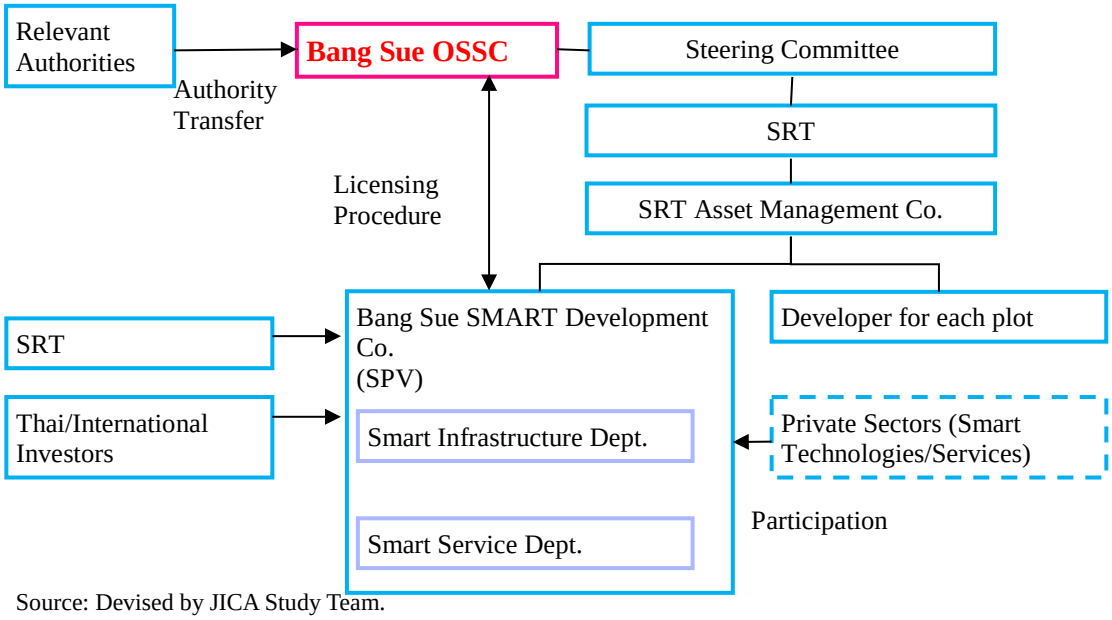


Source: Produced by JICA Study Team

Figure4.107 Networked Registration System

It is vital to achieve the one-stop application center towards Smart Governance in the Bang Sue area. Considering the integration and collaboration of data base held by each administrative institution, the center is not only an issue of the Bang Sue area, but also it needs efforts tackled by Bangkok City or the entire country.

To this end, it is necessary to consider the center within a realistic function range in Bang Sue. The following figure shows a structure scheme for one stop service center (OSSC) that handles applications for smart service business in an integrated fashion. The details for OSSC is considered in the section of business execution system.



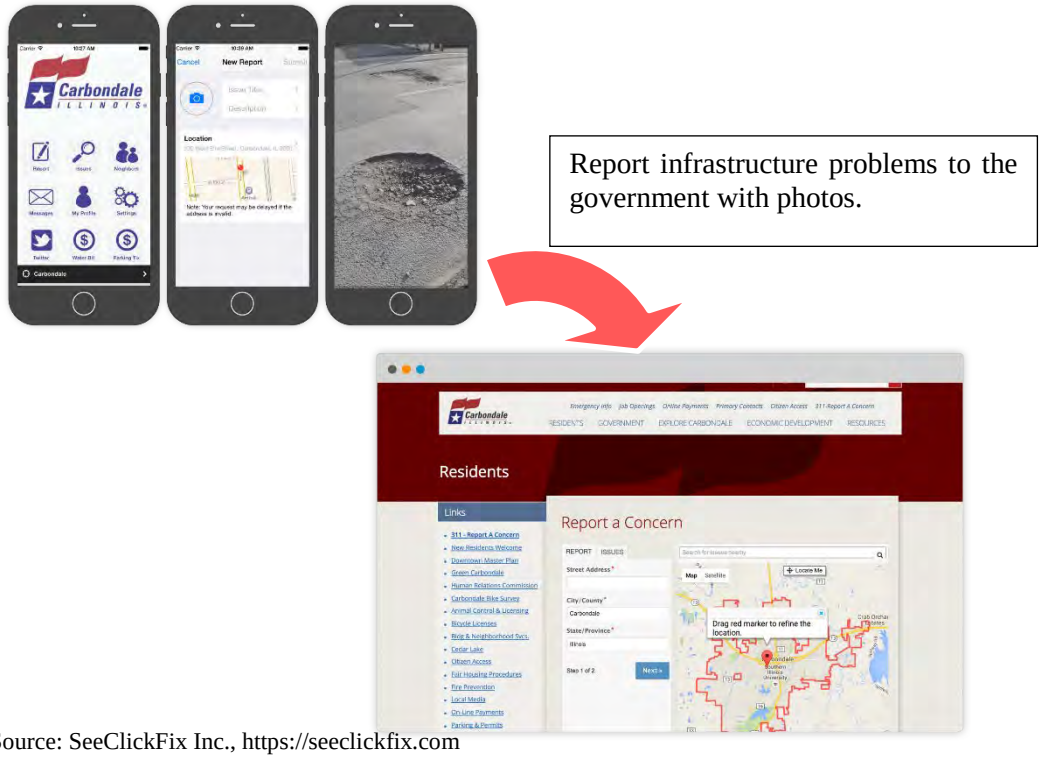
Source: Devised by JICA Study Team.

Figure4.108 OSSC Structure in Bang Sue

(3) Public Infrastructure Management with Resident Participation through Smartphone (Entity: Local governments)

The following figure shows an application where users can ask the government online to repair broken roads or sewerage. (The photo shows “SeeClickFix,” which is used by some cities in the United States.) The application allows local governments to repair infrastructure in response to requests, encouraging resident participation and achieving effective maintenance and management for public service.

In order to realize Smart Governance, as shown previously, in Bang Sue, the introduction of such application is desirable.



Source: SeeClickFix Inc., https://seeclickfix.com

Figure4.109 Online Complaint Management Tools

4.6.3 Smart Technology and Service for Smart People

(1) Establishment of Satellite University in Residential Area (Entity: Research institutes)

For instance, Satellite Laboratory Ageo under Shibaura Institute of Technology is set up as an extracurricular or after-school activity base for students or as a community hub for residents. Research activities include urban planning and regional community development where students or regional residents conduct practical onsite surveys. In addition, it serves as communication and cultural exchange places among NGO, companies, local governments and residents.

It is important to vitalize communication with local people through collaboration with universities and others towards the fulfilment of Smart People in Bang Sue. To this end, such a venue to exchange information is needed.

(2) Establishment of Center for Lifelong Learning and Intercultural Exchange (Entity: Local governments)

Some local autonomies and universities provide spaces or services to facilitate leaning or intercultural exchange for people motivated to learn. Local governments currently supply more than 500 facilities for that purpose. Specific services are as follows:

- Information center
- Library
- Lounge space for beverages or snacks
- Consultation service center
- Organization of events and seminars, etc.

It is vital to provide lifelong learning space towards the achievement of Smart People in Bang Sue.

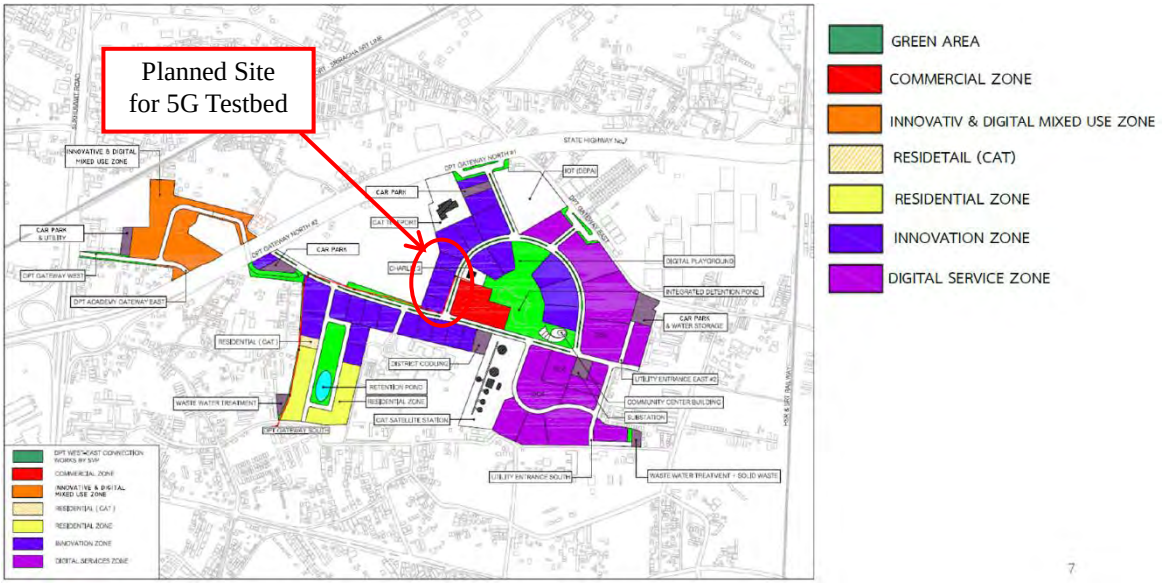
(1) Establishment of Next-Generation Telecommunications Infrastructure through 5G Networks (Entity: Central government)

In recent years, attention has been drawn to 5G networks as a next generation ICT infrastructure. In comparison with the present 4G networks, 5G networks improve the following performance features.

1. mMTC: Large-scale simultaneous device processing (100 billion links)
2. eMBB: High-speed mobile broadband communication (10 Gbps throughput)
   *Peak theoretical throughput for 4G is 1 Gbps (Actually 150 - 185. 5 Mbps or less)
3. URLLC: Ultrahigh reliability and 1-ms processing speed
   * The 4G generates a latency of 10 ms or more.

As 5G networks are expected to create many innovations, many countries have been promoting research and development on 5G. In Thailand too, Deputy Prime Minister Somkid Jatusripitak has announced that the NBTC directed preparation for the complete adoption of 5G by 2020.

Communication operators are expected to install 5G base stations in the future. To this end, it is important to develop 5G networks and support 5G-driven innovation for the promotion of “Smart People” and “Smart Economy.” The DEPA plans to establish Digital Park Thailand in Siracha of EEC in order to build the environment for 5G test bed.



Source: Added partially by JICA survey team, based on interview surveys on land use for Digital Park Thailand (example)

Figure4.110 Land Use Example for Digital Park Thailand

However, as 5G covers the area between base stations and mobile terminals, unless optical fiber or other communication equipment is installed to tolerate allowable capacity between base stations and between base stations and servers, 5G’s convenience cannot be gained. Therefore, the Bang Sue area needs to install optical fibers to connect between base stations and the data center. Although redevelopment work is implemented by 2030 in Bang Sue, as 6G or other next generation communication technologies are expected to emerge by 2030, the environment needs to be developed so that innovation can be generated in a sustainable manner.

4.6.4 Smart Technology and Service for Smart Living

(1) Establishment of Medical Hub (Entities: Government, medical institutions)

Establishment of Intraregional Referral System

The importance of preventive care or primary care is growing with aging society in Thailand. Based on eHealth Strategy promoted by Thai Ministry of Health, if "intraregional referral system" is established to improve access to medical institutions with remote medical care technology, it is possible to contribute to health promotion and primary care for residents in the area.

The Bang Sue area has Kasemrad Hospital and other secondary medical care institutions. However, if tertiary medical centers are needed, patients need to be transferred to hospitals outside the area. In order to attain healthcare/health tourism and medical hub under Thailand 4.0, it is proposed to introduce remote medical care technologies with next-generation communication networks to instantly transfer large amount of diagnosis data like picture image or video in the area and also suggested to build "next-generation referral system" for close collaboration between local hospitals and superior ones outside the Bang Sue area with the introduction of the previously cited smart energy network or ZEB for energy independence and business continuity.

And furthermore, a medical hub is installed in the Bang Sue area regarded as a gateway for railroad transportation due to unreliable road traffic infrastructure caused by traffic congestion. It is also proposed to build a network for patients to be immediately taken to hospitals with the use of reliable, punctual railroad system.

Table4.44 Medical Hub Functions Centered on Remote Medical Care

Function	Service Flow	Example
Preventative Medical Care	Hospitals to patients/residents	・Doctors supply health promotion services, based on collected data on exercise and diet with smartphone or ITC devices. ・Submit necessary information to medical institutions with POCT devices. * Remote medical consultation service between doctor and patient
Primary Care	Hospitals to patients Pharmacy to patients	• Provide one-stop service, ranging from online diagnosis reservation to web consultation, drug delivery and remote drug administration guidance. * Remote medical consultation service between doctor and patient
Medical Collaboration	Hospitals to advanced medial hospitals	• Implement remote medical care to share patient's condition with healthcare workers between local hospital and advanced medical hospital. Ask medical specialists in advanced medical institutions to diagnose patients if needed. • Transfer patients to advanced medical hospitals, depending on their conditions. Upon recovery, transfer them to a local hospital from advanced hospital. * Doctor to Doctor remote medical consultation services

Source: JICA Study Team.

Note 1: ICT-based Primary Care (Remote Doctor)

Patients use a smartphone application “Remote Doctor” developed by AISOL Inc., to undergo a medical checkup, purchase and delivery a prescription[35].

Note2: Support for ICT-based Primary Care (Remote Diagnosis through 5G Network)

“Remote diagnosis” is a system which allows doctors in remote areas to diagnose patients through 5G networks. 5G networks can instantly provide big data or video data. NTT Docomo has been currently validating the efficiency of “remote diagnosis”[36].

Note3: Initiatives in Bangkok Hospital

Bangkok Hospital implements remote diagnosis, using the system “ROBODOCTOR” or “Remote Presence System,” which is specially designed to make the treatment process more efficient.

As it is possible to give patients proper standard medical treatment with no medical specialists, the initiative is facilitated for prompt treatment.

Source: Bangkok Hospital, https://www.bangkokhospital.com/index.php/en/service-excellences/robodoctor

Figure4.111 Remote Medical Care Initiative in Bangkok Hospital

[35] Source: https://remodoc.net/

[36] Source: NTT DoCoMo., https://robotstart.info/2018/12/04/5g-docomo-vr.html

(2) Establishment of Comprehensive Healthcare Facility (Entity: Local governments, medical institutions)

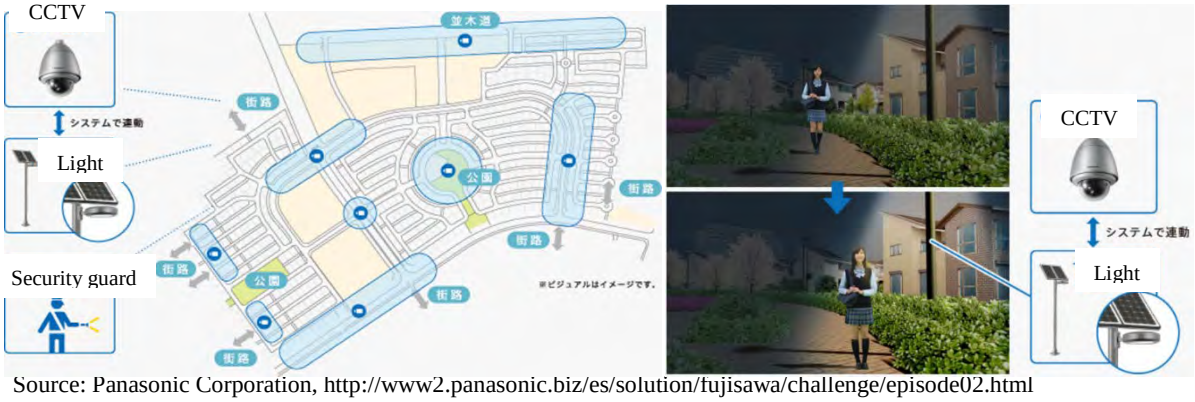
The private companies[37] established a town management company in Fujisawa city, called "Fujisawa SST". The company has built a comprehensive healthcare facility "Wellness SQUARE." This facility consists of special elderly nursing home, home for the aged, pharmacy, clinic, nursery school, private school and convention hall, aiming to deepen the relationships with residents beyond generations. It is vital for the Bang Sue area to build such a comprehensive facility for the achievement of "Smart Living."

Source: Fujisawa SST Council,
https://fujisawasst.com/JP/service/healthcare.html

Figure4.112 Exterior View of Wellness SQUARE

(3) Security Efforts as Town Management (Entity: Local government, developer)

Fujisawa SST installs cameras and radio wave sensors. If the radio wave sensor detects pedestrians, LED light turns on automatically and the camera monitors them even at night. Although the installation of such monitoring equipment is considered not only safety but also privacy protection[38].



Source: Panasonic Corporation, http://www2.panasonic.biz/es/solution/fujisawa/challenge/episode02.html

Figure4.113 Camera and LED Automatic Lighting in Fujisawa SST

[37] Invested companies: Panasonic Corp., Panasonic Homes Co., Ltd., Mitsui Fudosan Residential Co.,Ltd., Mitsui & Co., Ltd, Dentsu Inc., Nihon Sekkei Inc., Tokyo Gas Co., Ltd, Nippon Telegraph and Telephone East Corp., Sumitomo Mitsui Trust Bank, Ltd. *No particular order

[38] In FujisawaSST, the purpose of the installed cameras is to watch from afar in the town. Although the recorded camera data for a limited time period is owned for proof of accidents, no one can watch it excluding FujisawaSST management company. Additionally, some favorable opinions in term of safety were recieved by the residences. *Based on an interview with Fujisawa SST Council.

(4) Security Performance with Surveillance Camera (Entity: Local government, medical institutions)

With improved AI technologies, in the recent years, security applications have been rolled out to detect specific persons or objects from picture images in the surveillance camera. They can detect a “specific person (for example, criminal)” from the surveillance camera installed in the building or the roadside, and also confirm residents with identification card or face recognition technology. Applications are expected to:

- Serve as crime prevention.
- Enable residents to live with security.
- Streamline management procedures.

In addition to the above security measures, the commercial facility expects to help the applications contribute to Smart Economy including:

- Customer marketing analysis
- Monitoring in the parking lot and backyard.
- Sales improvement through upgraded layout, based on pedestrian flow analysis

Source: Fujitsu Corporation, https://www.fujitsu.com/jp/solutions/business-technology/tc/sol/greenages-cs/

Figure4.114 Fujitsu’s Urban Monitoring Solution in Complex Facility:

“Smart Living” can be achieved with the introduction of security system in collaboration with such a surveillance camera.

4.7 Open Data Platform

As prerequisite conditions for smart city in Thailand, data management system is established to connect with open data platform and data storage is supplied.

In this section it is proposed to supply smart technology services to be implemented in the area and establish a composite facility “Smart City Center” as a service distribution hub.

4.7.1 Basic Concept

(1) Fundamental policy

The following fundamental policies are shown below with the introduction of smart technology/service and infrastructure facility.

1. Based on the concept “Platform for Innovation,” establish the environment for the use of collected data and raise motivation for entrepreneurs located in the Bang Sue area to improve asset values in the commercial area.
2. Develop the environment which allows residents to live comfortably from hardware/software aspects to raise asset values in the residential area.
3. Support sustainable development in the Bang Sue area in time with redevelopment work through sustainable business operation for administrative staff or smart service providers.

(2) Service Introduction

Based on the above policies, smart services to be introduced in the Bang Sue district are proposed as follows.

Table4.45 Smart Service Policies

Items	Action	Notes
Policy 1.	Installation of data center	Establish Smart City Center, as a facility to manage smart services comprehensively, where a small-scale data center is installed.
	Development of open data platform	Compile data (3D model data, traffic data, energy data) handled in Bang Sue to develop software for publication.
	Deployment of communication infrastructure for 5G networks	Install optical fibers to secure communication quality from base stations to the data center.
Policy 2.	Construction of complex facility for community	Establish Smart City Center, as a facility to manage smart services comprehensively, in order to secure lifelong learning center, and communication or administrative consultation spaces.
	Construction of complex facility for urban surveillance with CCTV	Develop CCTV-based urban surveillance application to secure safety.
Policy 3.	Construction of complex facility for surveillance with CCTV	Develop CCTV-based urban surveillance application to monitor and ease traffic jam.
	Installation of administrative customer service	Establish Smart City Center, as a facility to manage smart services comprehensively, where an integrated administrative consultation service section is installed to facilitate smart services.

Source: JICA Study Team.

As described before, though there are many smart services except for the previously cited policies, the services to be developed or operated chiefly by entrepreneurs are excluded, considering that they can encourage smart city formation and sustainable development.

From the perspectives of smart city operators, it is proposed to collect big data like 3D model or CCTV-based image data and to establish the platform environment, which is difficult for only entrepreneurs to achieve and yet can motivate entrepreneurs.

4.7.2 Consideration on Function Introduction

(1) Construction of Complex Facility (Smart City Center)

In order to realize a smart city, its management facility is needed with the space for community formation. To this end, “Smart City Center” is proposed as a complex facility. As there are similar complex facilities like Kashiwa-no-ha smart city or Fujisawa smart city sustainable town in Japan as well as others in South Korea and China, they are used as reference.

Source: Kashiwanoha Smart City, https://www.gardenhotels.co.jp/kashiwanoha/

Source: Smart City Operation Center in Inchoen, Republic of Korea

Figure4.115 Smart City Center

Smart City Center Structure

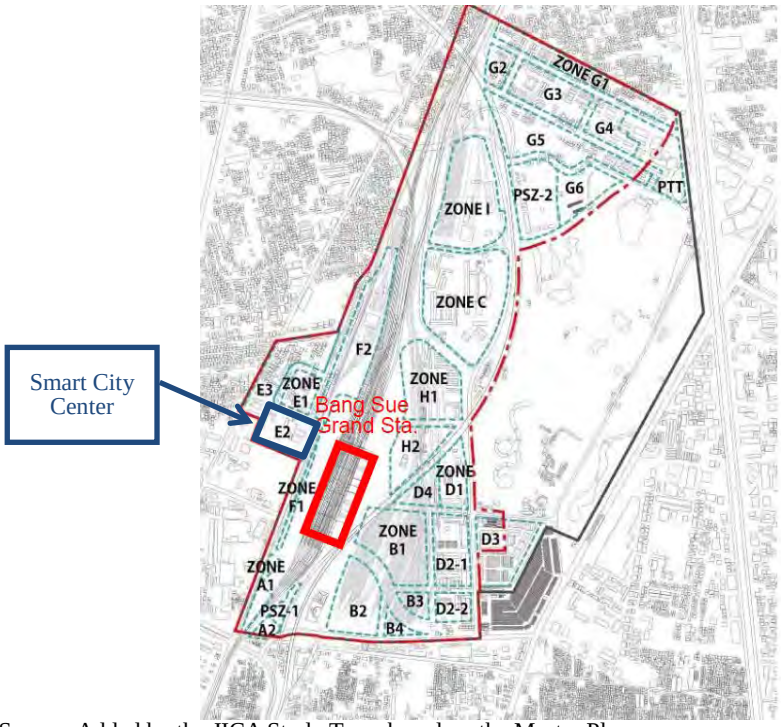
The following table shows Smart City Center structure and proposed execution entities (to consider entity details later.). The Smart City Center includes energy plants to be installed in respective zones for Smart Energy and PRT’s charging facilities and parking lots for Smart Mobility.

Table4.46 Proposed Smart City Center Structure

Item	Role	Proposed Execution Entity
Monitoring room	Space (control rooms) to display CCTV and collected data on large monitors	BMA, RTP
Data Center	Server room to store software and data needed to implement the smart service business	DEPA/CAT
Exhibition Room	Exhibition room to introduce smart city service	DEPA/CAT
Work/Conference Space	Work/Conference space to address staff and visitors	DEPA/CAT
Energy Plant	Facilities to achieve cogeneration and cooling systems	Smart service operator
Community Space	Space for lifelong learning center or administrative consultation service	BMA
PRT Parking Lot	PRT parking lot, inspection, and recharging space	Smart service operator

Location of Smart City Center

As Smart City Center needs to be built before the launch of PRT or Grand Station, it is proposed to be constructed in "Zone E," as a candidate site, where development is finished by Phase 1. And also, the installation of Smart City Center is desirable in Zone E, considering that SRT head office is to be constructed there.



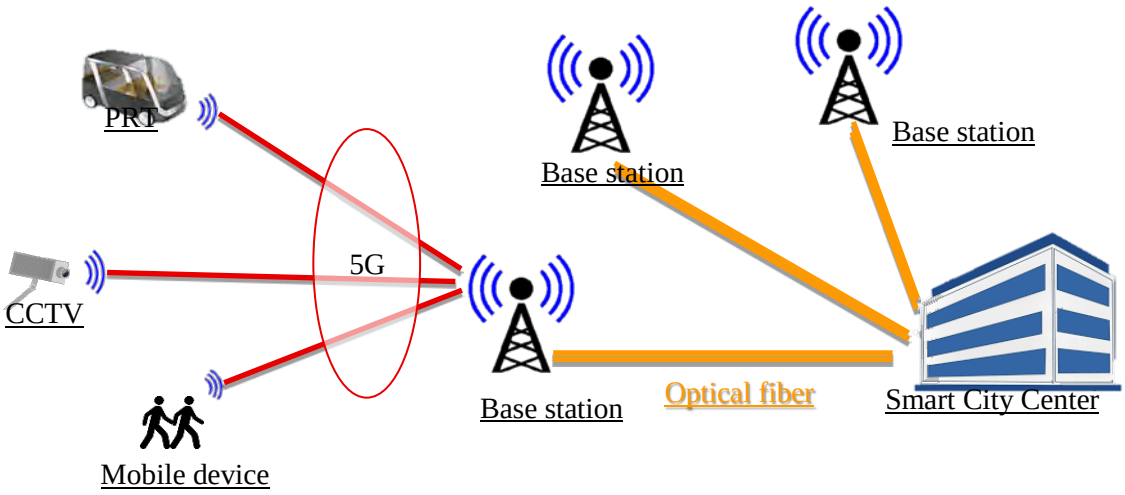
Source: Added by the JICA Study Team based on the Master Plan.

Figure4.116 Proposed Location of Smart City Center

(2) Installation of Optical Fiber for Next-Generation Wireless Network Communication

The Thai government has committed a task to develop 5G networks by 2020. Therefore, as the installation of 5G networks has been facilitated earlier than scheduled in cooperation with Chinese companies, it is highly likely to implement them earlier than the opening of Bang Sue Grand Station in 2022.

Meanwhile, the 5G network covers the area between base stations and mobile terminals. Therefore, mMTC, eMBB and URLLC cannot be effectively utilized as 5G features, unless optical fiber communication equipment is installed to address communication channel capacity between base stations and between base stations and data center. The Bang Sue area therefore needs to install optical fibers connecting base stations with the data center. Moreover, as redevelopment work in Bang Sue is implemented by 2030, considering the launch of 6G or other next-generation communication technologies, the environment is needed to cope with sustainable innovation.



Source: JICA Study Team.

Figure4.117 Optical Fiber Development

Installation Place of Optical Fiber

It is proposed to install optical fibers in sky deck observation space and utility conduits, in order to connect them between zones and between buildings in the zone.

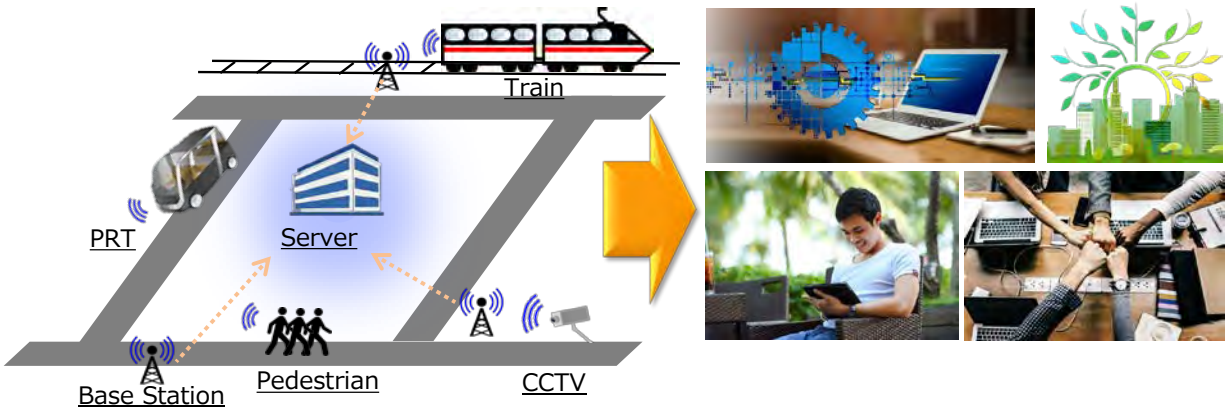
And furthermore, outside the Bang Sue area, leveraging the railroad network as SRT's advantage, optical fiber networks are installed on the other railroad networks to be launched in the future. Through the railroad, wider fiber networks can be deployed, and also 5G-based high-speed wireless communication network services can be smoothly installed on the other stations along the railroad line, as implemented in Bang Sue. The network can be deployed in the future to ECC, Chiang Mai and Khon Kaen. This is considered as a huge attractive feature for entrepreneurs and private companies that develop services. As the SRT has been installing optical fibers in the area near their railroad in collaboration with TOT, it is desirable to enhance necessary optical fiber networks after calculating the currently used throughput and future potential one.

Execution Entity

It is proposed that the SRT should have an initiative in installing optical fibers in collaboration with TOT or telecommunications companies.

(3) Development of Open Data Platform (Virtual Bang Sue City)

It is proposed to collect 3D model data for buildings in the Bang Sue area and dynamic data like CCTV or human flow. And it is also suggested to supply such data to entrepreneurs in the area and develop a platform “Virtual Bang Sue City” for the development of new smart services like innovative applications, big data analysis or optimization.



Source: JICA Study Team.

Figure4.118 Virtual Bang Sue City Scheme

Data Collection

The following data is to be collected for Virtual Bang Sue. Although a main focus is on smart service business to be implemented this time, it is desirable to enlarge it, depending on new urban challenges, etc. in the future.

1) Static Data (mainly 3D model data)

As urban redevelopment work is scheduled in Bang Sue, the development cost should be slashed on 3D model data as a base for Virtual Bang Sue City, leveraging BIM data (Building Information Modeling) produced in redevelopment work. Therefore, developers or infrastructure design consultants are required to submit BIM data in the deliverables for specifications. As for data for the established or completed buildings, data need to be measured and produced with drones and other devices, though location data or others are less accurate.

Table4.47 Data Collection for Virtual Bang Sue City (3D model data)

No	Item	Data Collection	Location of Sensor	Data Owner	Data Supplier
1	Topographical Data	Photo survey by drone, etc.	-	SRT/BMA	Smart service provider
2	Infrastructure Data (e.g., road, bridge, utility conduit, etc.)	BIM data or photo survey with drone, etc.	-	SRT/BMA	Smart service provider
3	Architectural Data (e.g. building, building equipment)	BIM data or photo survey with drone, etc.	-	Developer	Smart service provider

Source: JICA Study Team.

Source: Maintenance and management using BIM data, produced by Pacific Consultants, Co., Ltd.

Figure4.119 BIM-based Data Management

2) Smart Environment Data

Not only the Bang Sue area, but also the entire Bangkok City needs to consider data on Smart Environment. Although it is possible to collect data from the sensors installed independently by operators in the Bang Sue area, consideration is needed in the future on the way to exchange data mutually with the system managed or operated by BMA.

Table4.48 Data Collection for Virtual Bang Sue City (Smart Environment Data)

No	Item	Data Collection	Location of Sensor	Data Owner	Data Supplier
1	Air Quality Data	Air pollution monitoring system, etc.	(Installed by BMA)	BMA, smart service provider, and zone developer	Smart service provider
2	Weather Data	Weather information system, etc.	(Installed by TMD)	BMA, smart service provider, and zone developer	Smart service provider
3	Accumulated Waste Data	Waste monitoring system, etc.	-	BMA, smart service provider, and zone developer	Smart service provider

Source: JICA Study Team.

3) Smart Mobility Data

SRT or PRT operators chiefly own Smart Mobility data. The provision of CCTV needs to be considered with the after-mentioned security measures in mind.

Table4.49 Data Collection for Virtual Bang Sue City (Smart Mobility Data)

No	Item	Data Collection	Location of Sensor	Data Owner	Data Supplier
1	Operation Data	Traffic operation control system	In vehicle	SRT, PRT, and bus operator	Smart service provider
2	O/D Data	Railway IC card system	In vehicle	SRT and PRT operator	Smart service provider
3	Traffic Data	CCTV	Road intersection, etc.	Smart service provider	Smart service provider
4	Parking Lot Data	Parking lot management system	In parking lot	Smart service provider	Smart service provider
5	Human Flow Data	CCTV	In the Bang Sue area	Smart service provider	Smart service provider
		Base station, Wi-Fi router	In the Bang Sue area	Telecoms operator and smart service provider	Smart service provider
		GPS smartphone application	-	Application developer	Smart service provider

Source: JICA Study Team.

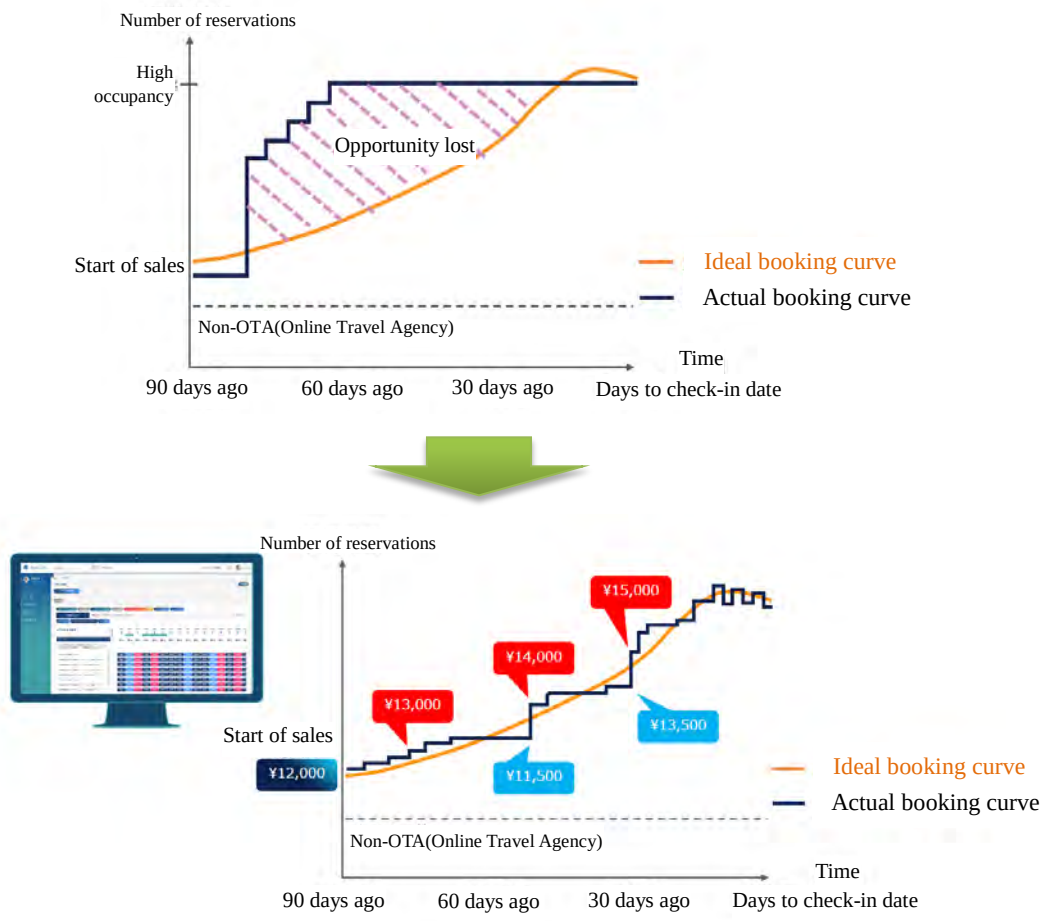
It is proposed that SRT in particular should make railway car's information such as location and operation information, as well as customer information collected at ticket gates (after anonymization so individual cannot be identified), available to system developers. The data will enable development of new smart services such as to notify users of train operation status[39], and dynamic pricing system. Not only will such initiative raise an interest among entrepreneurs, but also improve customer experience and contribute to SRT's revenue growth.

*Note: Dynamic Pricing

Dynamic pricing is to adjust prices in accordance with the change in demand and is being used for pricing of flights and hotels.

Metro Engines Inc. has the technology to automatically calculate highly accurate dynamic pricing by using analysis technologies of AI and Big-Data (i.e. seasons, tourism, event data etc.).

Its service can reduce the cost needed to set optimal pricing manually, and prevent opportunity loss such as selling at low price when high occupancy (demand) is expected.



Source: Metro Engines Inc.

Figure4.120 Dynamic pricing by using Bid-Data and AI

[39]The SRT now operates the tracking system. (URL: http://tts.railway.co.th/passenger/view.php) If the operation data are released as a reusable system, the development of new applications can be facilitated with them.

4) Smart Energy Data

Smart Energy-related data are explained in the section of Smart Energy. However, as the data include important asset data for smart energy service operators, consultations are needed to confirm released open data range.

Table4.50 Data Collection for Virtual Bang Sue City (Smart Energy Data)

No	Item	Data Collection	Location of Sensor	Data Owner	Data Supplier
1	Demand Data (Electricity, cold water, heat)	EMS, AMI	Each building	Developer and smart service provider	Smart service provider
2	Consumption Data (Electricity, cold water, heat)	EMS, AMI	Each building	Developer and smart service provider	Smart service provider
3	Equipment Operation Conditions	EMS	Each energy plant	Smart service provider	Smart service provider
4	Equipment Operation Status	EMS	Each energy plant	Smart service provider	Smart service provider
5	Operation Status of Charging Station	EMS	PRT station	Smart service provider	Smart service provider
6	Output Status of Renewable Energy	EMS	Each building	Developers and smart service provider	Smart service provider
7	Battery Storage/Consumption	EMS	Each building	Smart service provider	Smart service provider
8	Power Generation and Consumption	EMS	SEMC	Smart service provider	Smart service provider
9	Weather data	TMD	SEMC	Smart service provider	Smart service provider

Source: JICA Study Team.

Execution Entity

The DEPA chiefly builds a data platform. As shown in the above table, it is proposed that each execution entity should collect data.

(4) Introduction of Urban Surveillance Service

It is proposed to mount CCTV-based urban surveillance applications in an effort to secure residents' safety in Bang Sue, monitor traffic conditions and ease traffic jam. Major Chinese cities now adopts face or image recognition technologies with CCTV and AI in order to detect criminals, monitor traffic violation and ease traffic jam through signal control system. The Chinese public administration, mainly the police, adopts an application with CCTV and map data to give directions to the site if needed from their control room. As there are face or image recognition technologies, as described earlier, in Japan, limited surveillance services are being implemented on a trial basis in commercial facilities or parking lots.

Before the introduction of monitoring applications to the Bang Sue area, the agreement with local residents and security action are proposed.

An individual's activity at a specific location can be recognized by the face recognition technology, which causes a privacy problem. As Thailand has not enacted regulations like the EU General Data Protection Regulation (GDPR), the technology will be regulated with the enactment of legislation in the future, which is considered as a risk factor.

And also, though Google has implemented a demonstration project to redevelop a smart city in Toronto, Canada, residents are suing the government over Google's plan[40]. Meanwhile, in China the surveillance technology allows criminals to be arrested for residents' safety and to ease traffic jam as an urban solution.

Therefore, before the introduction of the technology, it is desirable to discuss with the town development council in Bang Sue, consult with experts and reach an agreement. And also, in the consultation process, discussions are needed on the location of surveillance technologies, methods, monitored targets, people with access to CCTV, specific range disclosed as open data and security measures to address threats like unauthorized access from outsiders.

Execution Entity

It is proposed that the DEPA should have an initiative in developing urban monitoring services, and both the BMA and RTP should operate them together. As police officers manually switch traffic signal lights onsite to control the traffic condition in Bangkok, if remote control is difficult, information delivery measures are needed for local police officers.

If CCTV is installed in the commercial facility building with the objective of marketing analysis or human flow analysis, except for security measures, developers are responsible for the installation as execution entities. As described earlier, it is suggested to discuss and decide if CCTV-based image data are collaborated with the control room of Smart City Center.

[40] Source: BBC news: https://www.bbc.com/japanese/47957788