

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	♦ <u>Establishing Standards and Regulations on Solid Waste 3R Program</u> : 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 ♦ <u>Implementing Waste Separation at Source by Residents</u> : 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 ♦ <u>Operating Composting Program</u> : 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 ♦ <u>Reducing Waste Materials Sent Unprocessed to Landfill</u> : 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	<u>GOAL 2:</u> 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	♦ <u>Managing Service Level for Public Space Cleaning and Maintenance :</u> 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 ♦ <u>Managing Service Level for Waste Collection in Public Spaces :</u> 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	<u>GOAL 3:</u> Environmentally 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	♦ <u>Establishing Standards and Regulations on Solid Waste Disposal :</u> 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 ♦ <u>Disposal of Large-Sized Household Wastes :</u> 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 ♦ <u>Medical/Industrial Waste Disposal :</u> 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	<u>GOAL 4:</u> 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	♦ <u>Smart-Upgrading for In-Area Water Provision Infrastructure</u> : 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 ♦ <u>Water Outage Countermeasures</u> : 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 ♦ <u>Solar Water Heater System</u> : 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 ♦ <u>Re-Use of Rain Water and Used Water</u> : 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 ♦ <u>Flood-Resistant Water Provision Infrastructure</u> : 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	♦ <u>Quality Standards</u> : 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 ♦ <u>Quality Monitoring</u> : 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 ♦ <u>Drinking Water Filters</u> : 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	♦ <u>Establishment of Urban Drainage Treatment Standards</u> : 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	<u>GOAL 8:</u> 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	♦ <u>Separated Drainage Infrastructure Systems for Storm Water and Sewage</u> : Upon coordination with Bangkok authorities, set up efficient urban drainage treatment by separating storm water and sewage systems ♦ <u>Flood-Resistant Sewage System</u> : Upon coordination with Bangkok authorities, install flood-resistant sewage infrastructure which effectively prevents leakage and contamination during flood events ♦ <u>Incorporation of Green Infrastructure</u> : 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 ♦ <u>Active Drainage System for Underground Facilities</u> : 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 ♦ <u>Underground Storm Water Tanks by Private-Sector Facility Owners</u> : 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	<u>GOAL 9:</u> Improvement on Urban Drainage	Provision of Urban Drainage Performance that is Superior to Rest of Bangkok	♦ <u>Separated Urban Drainage Systems</u> : 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	<u>GOAL 10:</u> Better Living Environment through Active Air Quality Management by Residents Participation	ICT-based Air Quality Management	♦ <u>Regular Monitoring and Publication of Air Quality</u> : 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. ♦ <u>Citizen Feedbacks and Management</u> : 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	<u>GOAL 11:</u> 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.) ♦ <u>Pedestrian-Priority Areas</u> : 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	<u>GOAL 12:</u> 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,	♦ <u>Hierarchical Park and Open Space Network</u> : 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	<u>GOAL 13:</u> Strategic Distribution of Land Use Pattern with Consideration for Environmental and Ecological Health		♦ <u>Strategy for Green Network Development</u> : 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 ♦ <u>Suppression of Heat Island Effects</u> : 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 ♦ <u>Mixed-Use Urban Nodes</u> : 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	<u>GOAL 14:</u> 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	♦ <u>Public Parks as Forward Base for Disaster Rescue and Relief Operations</u> : 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 ♦ <u>Public Facilities as Emergency Evacuation Centers in Disaster Situations</u> : 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 ♦ <u>Private-Sector Commercial Properties as Refuge Center for Stranded Workers Unable to Reach Home</u> : 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 ♦ <u>Early Warning and Automated Closure Systems for Underground Facilities and Underpasses</u> : 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 visualization 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 devices 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 trucks 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 m² per population, compared with 23.1 m² in New York and 66 m² 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.

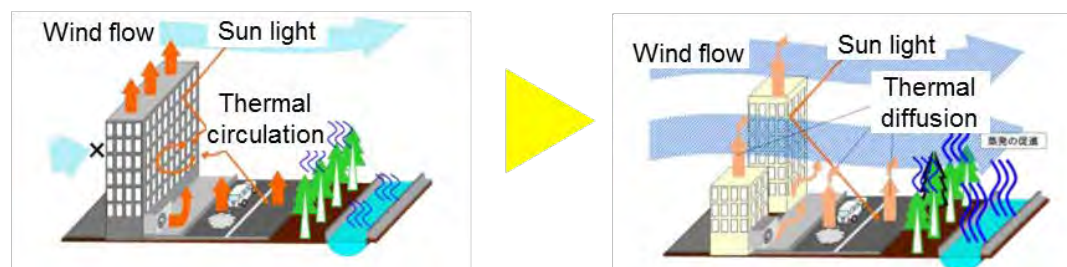
■ Mitigation of Heat Island Phenomenon

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.

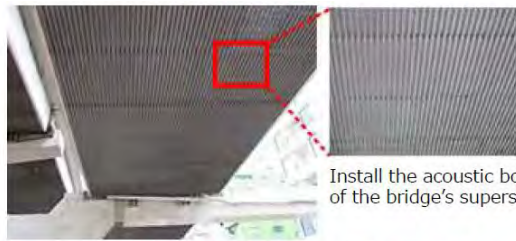
2) Strategies to be implemented in Bang Sue Area

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.

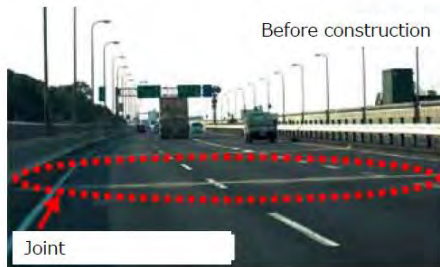


Advanced improvement noise barrier

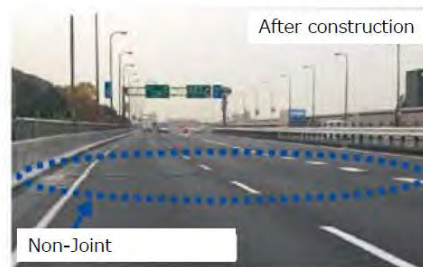


Install the acoustic boards to back of the bridge's superstructure

Nose control: installation of “advanced improvement noise barrier” and “acoustic board”



Joint



Non-Joint

Vibration control: improvement of expansion joint of bridge

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.



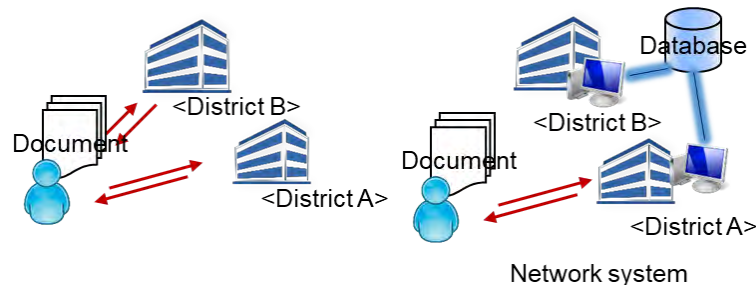
Source: National Research Foundation of Singapore

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.

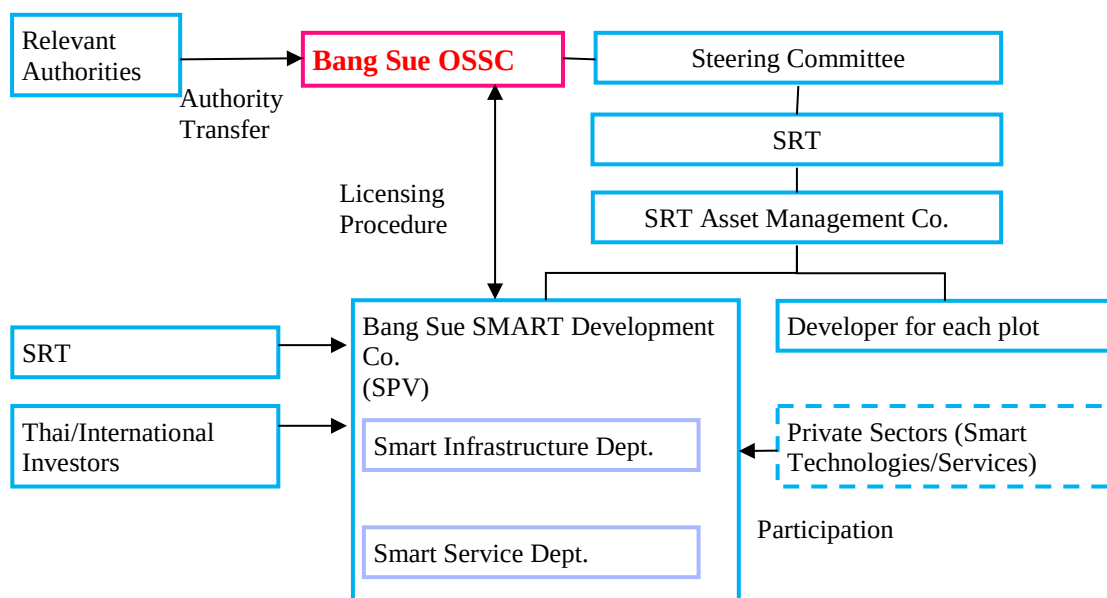


Source: Produced by JICA Study Team

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.



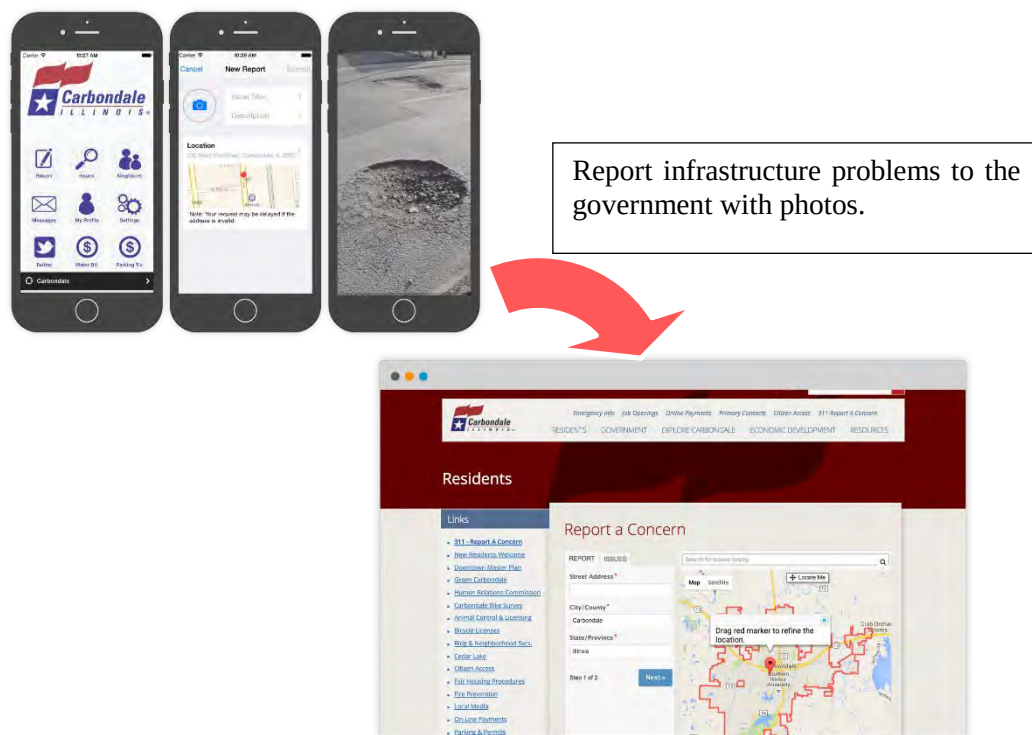
Source: Devised by JICA Study Team.

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.

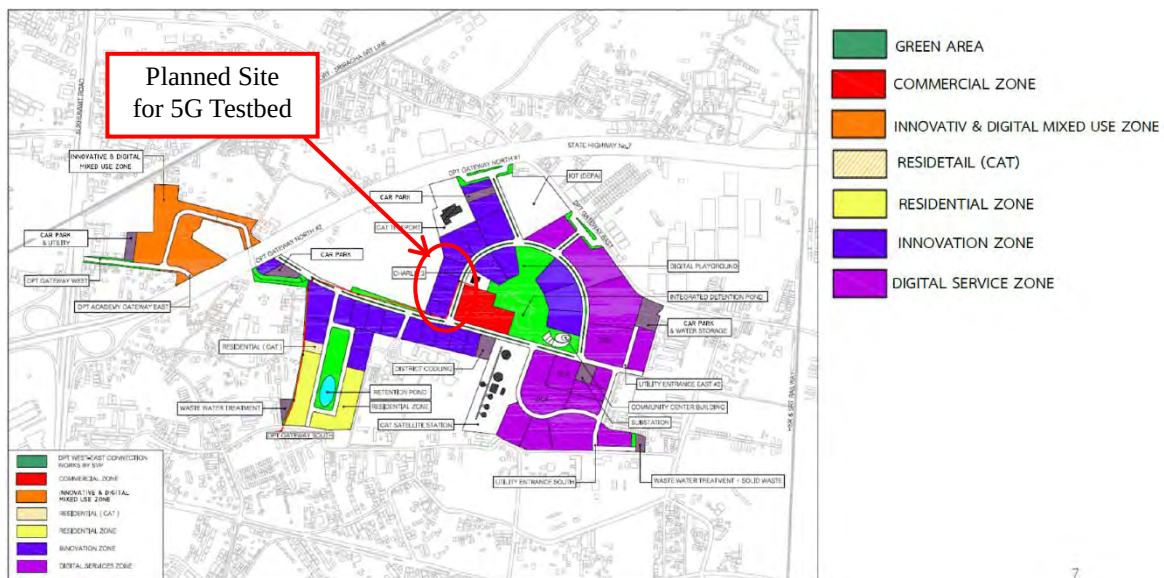
(1) Establishment of Next-Generation Telecommunications Infrastructure through 5G Networks (Entity: Central government)

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 prescription³⁵.

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 companies³⁷ 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 protection³⁸.



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.

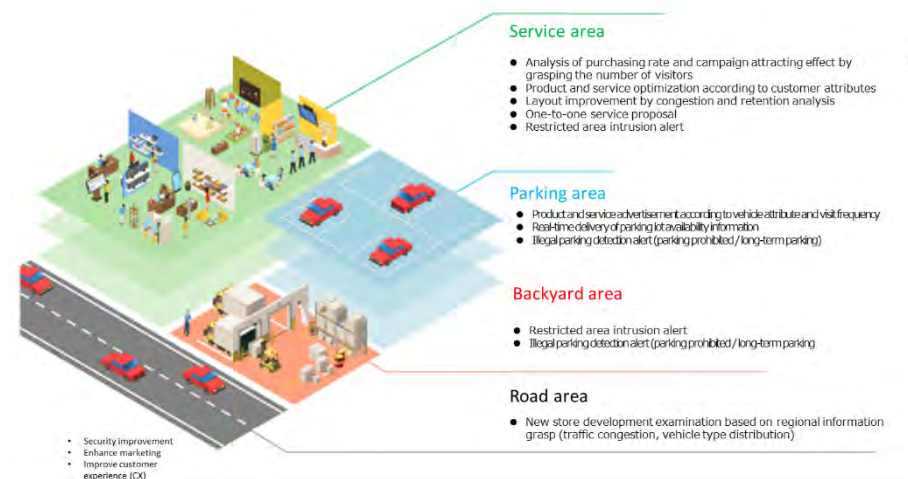
(4) Security Performance with Surveillance Camera (Entity: Local government, medical institutions)

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.

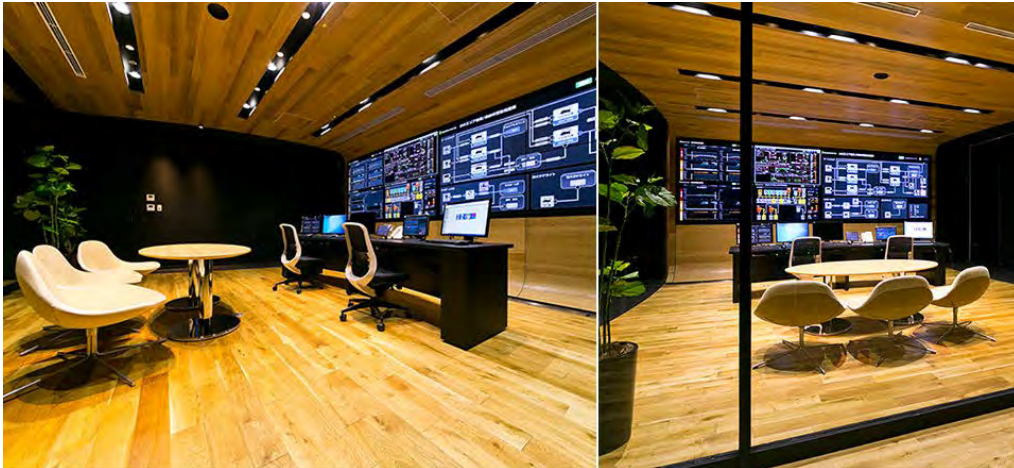
As described before, though there are many smart services except for the previously cited policies, the services to be developed or operated chiefly by entrepreneurs are excluded, considering that they can encourage smart city formation and sustainable development.

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 Incheon, Republic of Korea

Figure4.115 Smart City Center

Smart City Center Structure

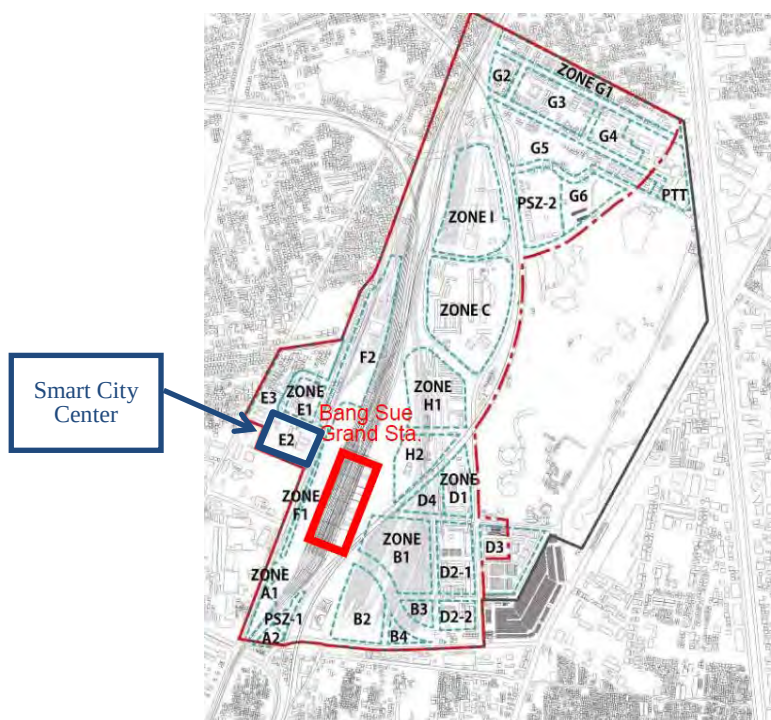
The following table shows Smart City Center structure and proposed execution entities (to consider entity details later.). The Smart City Center includes energy plants to be installed in respective zones for Smart Energy and PRT's charging facilities and parking lots for Smart Mobility.

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.



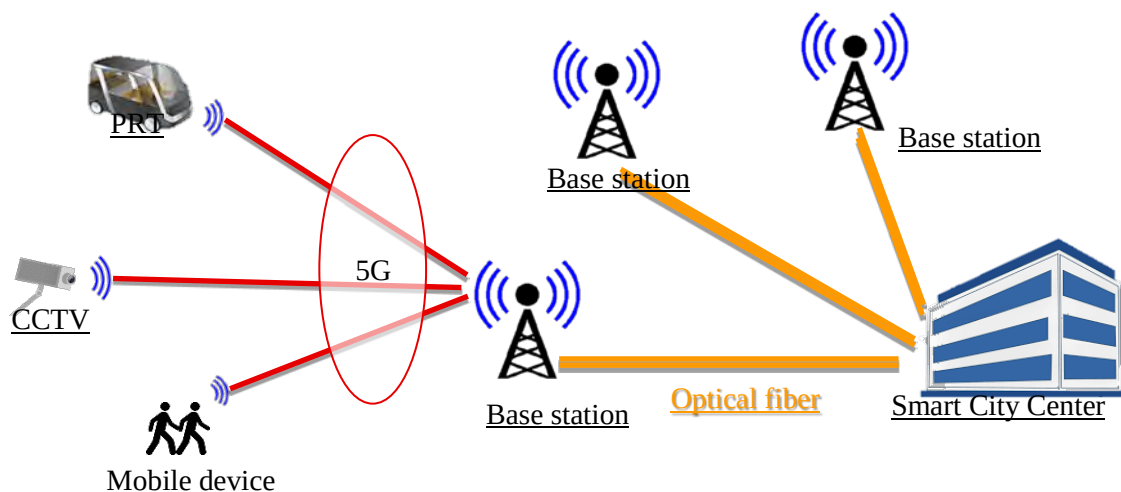
Source: Added by the JICA Study Team based on the Master Plan.

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.

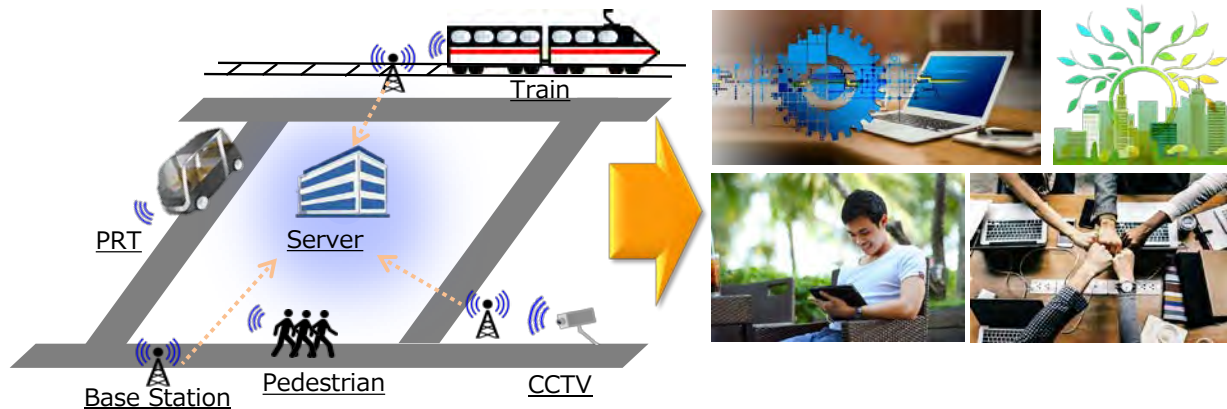
And furthermore, outside the Bang Sue area, leveraging the railroad network as SRT's advantage, optical fiber networks are installed on the other railroad networks to be launched in the future. Through the railroad, wider fiber networks can be deployed, and also 5G-based high-speed wireless communication 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.

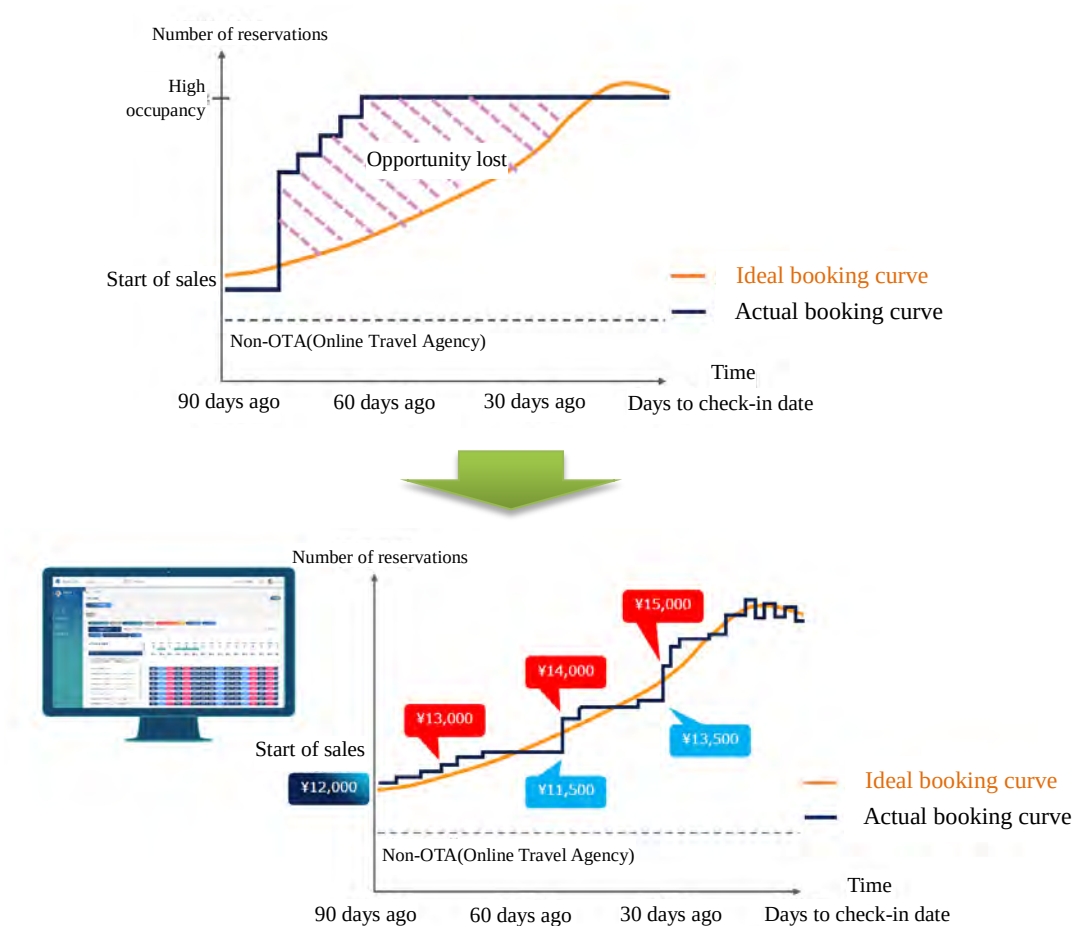
It is proposed that SRT in particular should make railway car's information such as location and operation information, as well as customer information collected at ticket gates (after anonymization so individual cannot be identified), available to system developers. The data will enable development of new smart services such as to notify users of train operation status³⁹, 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

³⁹The 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 plan⁴⁰. 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>

5. Proposal for Project Scheme on Bang Sue Smart City Development

5.1 Basic Approach for the Smart City Development Plan

5.1.1 Basic policies for the Formulation of Project Plan

Following the Smart City development concept and described in the previous sections, the basic plan for Bang Sue Smart City Development, estimation of the project cost, project implementation structure, financing and business schemes were studied. The spatial plan and land use plan builds upon the Bang Sue District Development Plan (hereinafter referred to as the Development Plan) formulated in the previous JICA Study (Data Collection Survey on Urban Redevelopment in Bang Sue Area in the Kingdom of Thailand), while also reflecting the results of consultations with relevant organizations and field surveys.

With regards to the approach for the study on the plan, the basic policies of the Development Plan will be taken into account for the overall development. Specifically, the basic policies for Smart City development plan are summarized in the following table.

Table 5.1 Basic policies for Smart City development plan

Item	Basic Policies
Development of urban infrastructure facilities	• Building urban infrastructure and public spaces that enable integrated development of the Bang Sue area to enhance the potential and value of the city as a whole • Development of infrastructure facilities for connecting and networking individual blocks • Establishing urban foundation on which everyone can live and visit comfortably
Smart City Development	• Promotion of pioneering and focused initiatives in the field of Smart Mobility and Smart Energy based on regional characteristics and needs • Promotion of comprehensive urban transport management in response to increased traffic demand associated with development • Development of multilayered transport networks and eco-friendly local public transportation systems • Development of high-mobility environments and pedestrian transport networks • Development of sustainable decentralized energy networks to respond to emergencies such as disasters • Introduction of renewable energy facilities such as PV facilities • Urban management using IoT, AI technology, etc., and realization of an advanced urban environment with high convenience
Business implementation structure and financing arrangement	• Formulation of realistic and effective phased development plans • To actively introduce private sector investment • Study of the cooperative framework in which the public and private sectors could mutually benefit from WIN-WIN structure.

Source: JICA Study Team

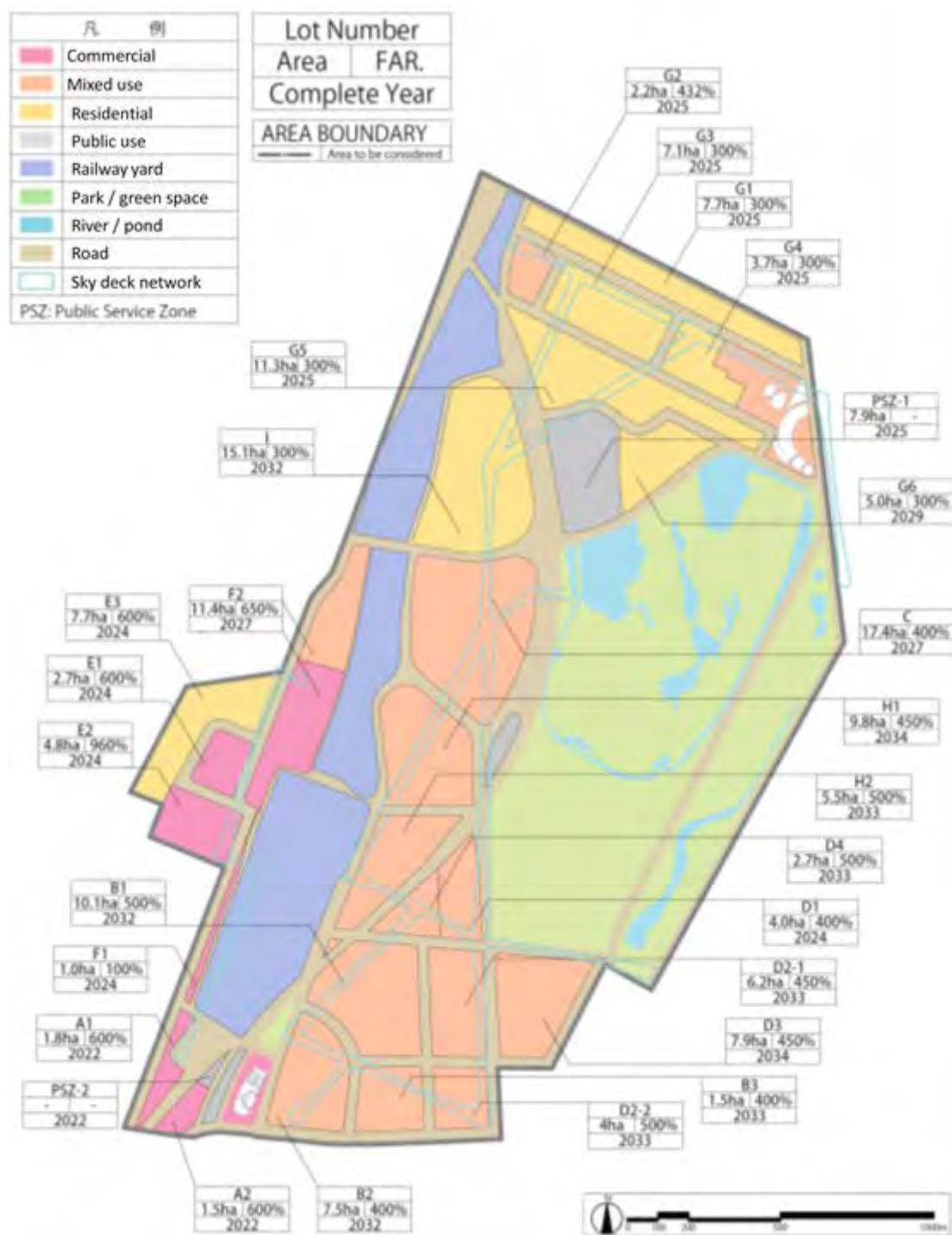
5.1.2 Project Area

The conditions regarding project area, such as floor area, land use, and demand would mainly be based on the previous Development Plan. The plan considers integrated development of areas including Bang Sue Grand Station, Chatchuck Park, and public roads.

5.2 Basic Plan

5.2.1 Land Use Plan

The land use plan shall be based on the content of the Development Plan. For skywalks and underground sidewalks that have been considered as upgrade facilities in the development plan, development of skydeck network to link the zones is proposed.



Source: JICA Study Team

Figure 5.1 Land use plan

Table 5.2 Total land area and floor area by zones

Term (Phase)	Sub-Zone	Land Area		Total Floor Area (Gross m ²)			
		(m ²)	(ha)	Retail	Office	Residence	Hotel
1	A	27,300	2.7	20,000	80,000	13,800	50,000
1	D1	39,500	4.0	0	0	45,500	73,000
1	E1	27,200	2.7	83,200	80,000	0	0
1	E2	48,300	4.8	50,000	200,000	213,700	0
1	E3	76,500	7.7	0	0	344,300	0
1	F1	9,700	1.0	9,700	0	0	0
1	G1	77,200	7.7	5,000	0	168,700	0
1	G2	21,900	2.2	6,000	65,000	0	0
1	G3	70,900	7.1	5,000	0	154,500	0
1	G4	37,300	3.7	5,000	0	79,000	0
1	G5	113,400	11.3	5,000	0	250,100	0
1	G6	50,100	5.0	5,000	0	107,700	0
1	PSZ-1 G	79,000	7.9	0	0	0	0
1	PSZ-2 A	9,000	0.9	0	0	0	0
2	C	174,400	17.4	30,000	0	493,200	0
2	F2	113,900	11.4	195,000	119,600	335,700	90,000
3	B1	100,600	10.1	40,000	80,000	257,200	0
3	B2	74,800	7.5	30,000	40,000	154,400	0
3	B3	14,800	1.5	44,400	0	0	0
3	B4	10,800	1.1	32,400	0	0	0
3	D2-1	62,400	6.2	60,000	0	109,100	41,500
3	D2-2	25,000	2.5	20,000	30,000	43,700	0
3	D3	78,500	7.9	60,000	0	144,900	60,000
3	D4	26,500	2.7	0	35,000	64,300	0
3	H1	97,600	9.8	10,000	80,000	239,400	0
3	H2	55,300	5.5	10,000	75,000	72,300	50,000
3	I	151,300	15.1	5,000	0	335,400	0
Total		1,673,200	167.4	730,700.0	884,600.0	3,626,900.0	364,500.0

Source: JICA Study Team

5.2.2 Development of Urban Infrastructure Facilities

Urban infrastructure facilities (roads, water supply and sewerage, communications, etc.) are also based on Development Plan, but will be partially updated based on the consideration of the design of the Smart City concept and latest situations regarding development of the zones. Specifically, the plans for proposed sky deck network and energy networks are elaborated. Basic plans for each urban infrastructure facility are summarized below.

(1) Land formation plan

As described in the Development Plan, the land for development shall be set at 1m or higher than the height of road surface so that the road pavement surface would function as a drainage channel in emergencies such as floods. Establishment of important facilities (substations, water purification plants, sewage treatment plants, etc.) shall be set at a height of 1.5m or higher than the surface of roads. The height of land shall be considered and specified in the Bang Sue Area city development guideline, which will be described later. Based on the guideline, the private developers shall implement the land development, coordinating with the pedestrian flows, etc., and in accordance with development plan for the zones.

(2) Road planning

1) Road network planning

The roads that form the outline of the zones shall be arranged according to the Development Plan. The underpass connecting Zone C and Zone G in the Development Plan is also considered to be important for ensuring connectivity in the Area, since the Kamphaeng Phet road II, which separates the zones, has a very heavy traffic volumes to the east and west. In addition, the Thoet Damri road on the west side of Bang Sue Grand Station is planned to be extended to Ranshit Station along the elevation of Red Line and also expanded to four lanes by SRT. However the according to the plan, the 400m road section near Zone A is planned at two lanes, which would be a concern for traffic congestion, as the traffic volume would likely to increase. Therefore, it is preferable that four lane road is planed at an early stage. The following figure shows the basic plans for roads, improvement plans for each phase, proposed road classification, and proposed points for private vehicle traffic control measures.

This plan is an update plan for the previous Development Plan. However, it needs to be noted that the traffic demand is expected to increase rapidly, particularly in the area around Bang Sue Grand Station, due to the increase in railway users and visitors. The development of the Bang Sue Area is also expected to have a large impact on the traffic flow of the surrounding road network. Therefore, it is important to promptly conduct a detailed traffic survey and formulate traffic master plan in the Bang Sue Area, which includes transport plan and traffic management measures for the surrounding area. Subsequently, a comprehensive approach should be taken, including implementation of the software measures such as traffic demand management, as well as the hardware measures such as road network and traffic light development.



Source: JICA Study Team

Figure 5.2 Road development plan (Basic Plan)

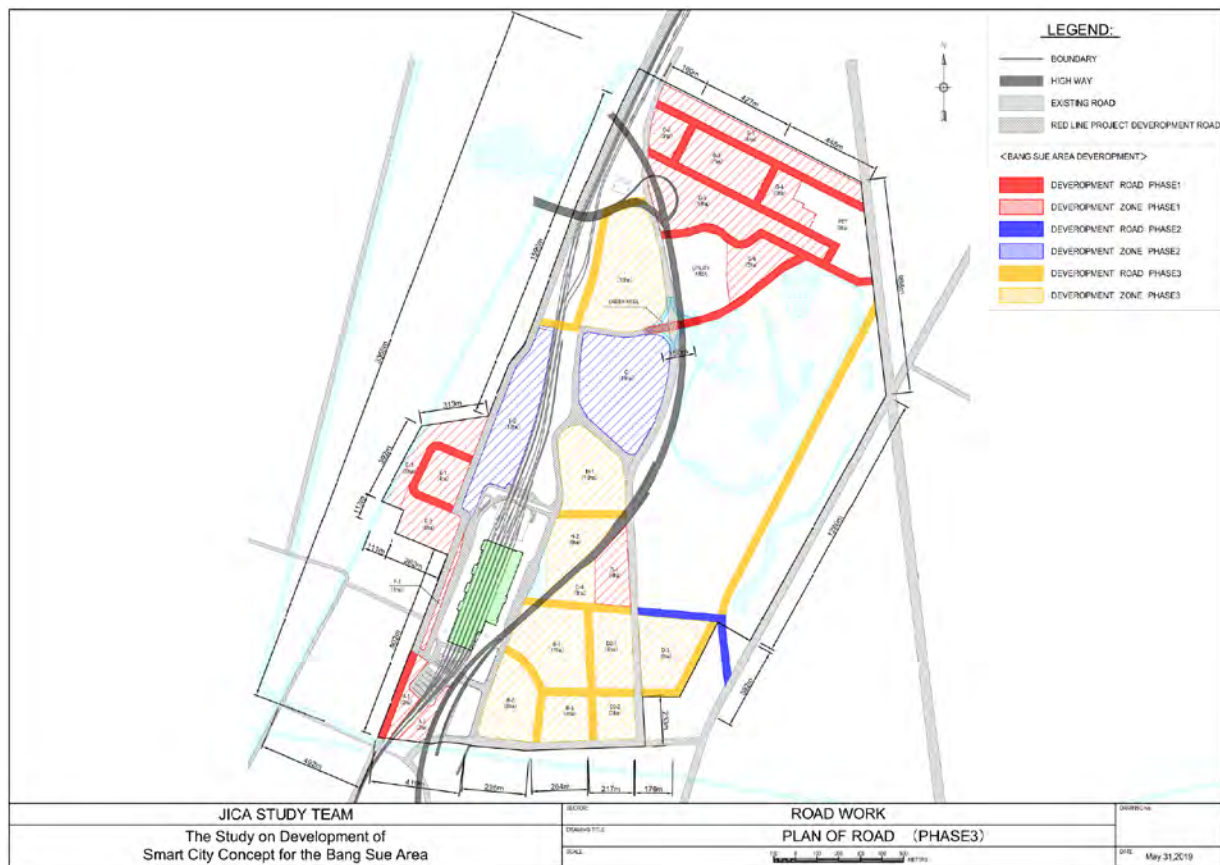


Source: JICA Study Team

Figure 5.3 Road development plan (Phase 1)

Source: JICA Study Team

Figure 5.4 Road development plan (Phase 2)



Source: JICA Study Team

Figure 5.5 Road development plan (Phase 3)

Source: JICA Study Team

Figure 5.6 Proposed road classification



Source: JICA Study Team

Figure 5.7 Examination of measures to control traffic inflow for general vehicles

2) Standard road design

Regarding the road standard road design, the specifications of the components shown in the table below shall be used as a basis for the newly constructed road section in which vehicle inflow control is not implemented. The total width shall be 35m, based on the Development Plan in the previous Study. In particular, a width of 7m for the sidewalk shall be secured from the viewpoint of ensuring adequate space for pedestrians and the spatial function of roads (including: environmental conservation space, disaster prevention space, utility accommodation space, urban landscape development). In addition, a space for bicycles and personal mobility vehicles would be provided.

Table 5.3 Standard cross-section of road (sections without private vehicle inflow control)

Item	Width
Lane width (2 lanes on one side)	16m (4m×4)
Center strip	2m
Bicycles and personal mobility lanes	3m (1.5m×2)
Sidewalks, public spaces, and utilities	14m (7m×2)
Total	35m

Source: JICA Study Team

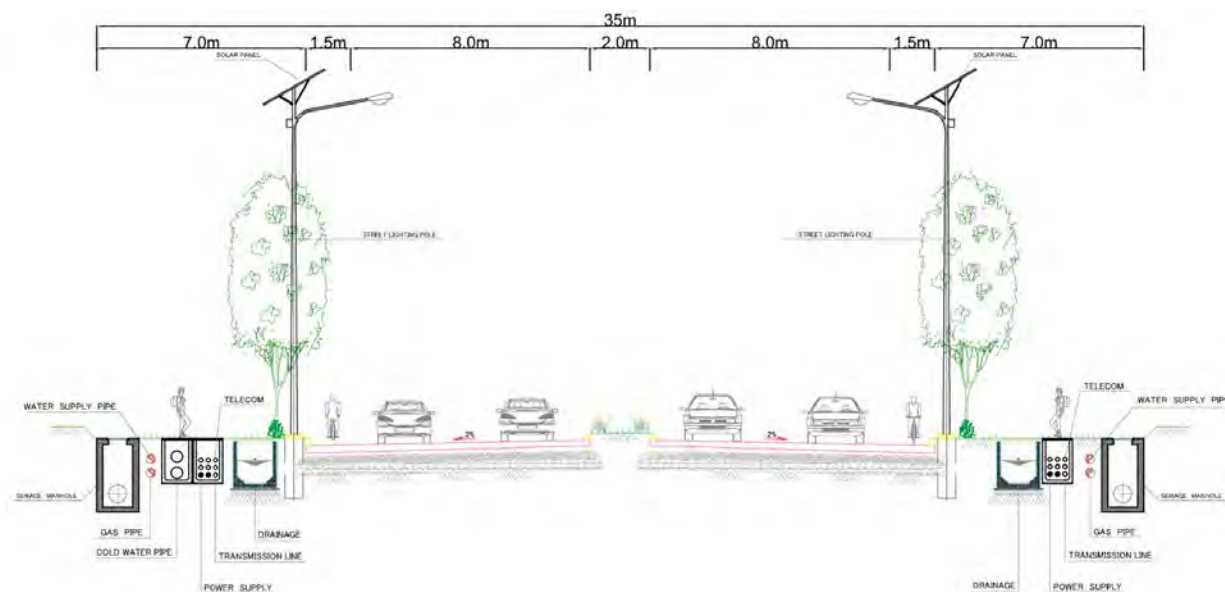
Regarding the zones where automobile inflow control measures are proposed to be implemented, as shown in the project plan for Smart Mobility in the Bang Sue Area, restraining the inflow of private vehicles in the development zone would allow restructuring of the road space. The restructured road standard cross-section is as shown in the table below. The entire width is set to one lane on one side, with 28m as a base, and a space for bicycles and personal mobility vehicles

is provided. By narrowing the space for automobiles, one-sided 8m space can be used as a public space, and sufficient space for trees and pedestrian space could be obtained to create attractive urban space.

Table 5.4 Standard cross-sections of roads (sections with private vehicle inflow control)

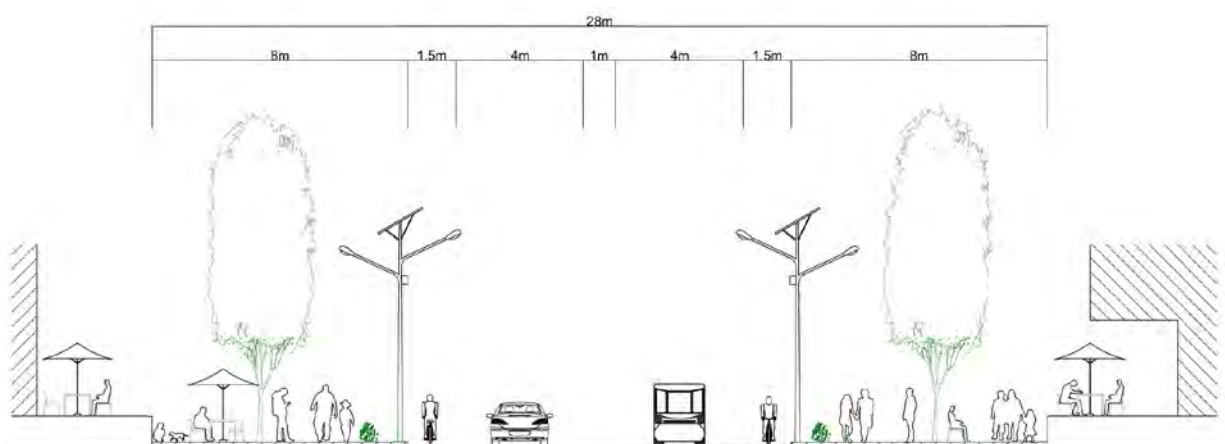
Item	Width
Lane width (2 lanes on one side)	8m (4m×2)
Center strip	1m
Bicycles and personal mobility lanes	3m (1.5m×2)
Sidewalks, public spaces, and utilities	16m (8m×2)
Total	28m

Source: JICA Study Team



Source: JICA Study Team

Figure 5.8 Standard cross-sectional view of road section without vehicle inflow control



Source: JICA Study Team

Figure 5.9 Standard cross-sectional view of road section with vehicle inflow control

- (3) Rainwater drainage plan, water supply plan, sewerage plan, electric power plan, communication plan
- The plans for drainage, water supply system, sewerage, electricity supply, and telecom system would be based on the content specified in the Development Plan.

(4) Sky deck network plan

As discussed in the previous chapter, the sky deck network will be developed in the Bang Sue Area to alleviate traffic congestion around stations, promote integrated development, and secure space for the pedestrians and public transportation so that people could move around comfortably within area without being obstructed by existing facilities or automobile traffic. The following table shows the basic policies for the sky deck network plan.

Table 5.5 Basic policies for sky deck network plan

Item	Basic Policies
Network planning	• Achieve integrated development in the Bang Sue area and seamlessly link the individual development zones to increase the potential and value of the city as a whole. • Connect traffic hubs such as Bang Sue Grand Station, BTS/MRT Station, Red Line Station, commercial and operational clustering zones, and the parking lots to be built at the fringe of development area. • Consider direct connections to buildings such as commercial facilities and paths passing through buildings, to increase the mobility and the attractiveness of the city.
Elevation plan	• Development of an elevated sky deck network that is vertically separated from automobile traffic to form a multilayered traffic network. • Secure a leveled deck, set approximately at 6m above the ground level, to develop a barrier-free environment that is comfortable for everyone, including the elderly and the disabled. (The minimum clearance of 5m at ordinary road intersections should be considered, while the deck is proposed to go under the elevated expressway where it intersects). • Consider connectivity with pedestrian ways on the ground.
Method of development	• The sky deck shall not be provided as a single unit, but shall be provided as an integral part of the facilities in each zone.
Functions	• Traffic functions: pedestrians, PRT transport, access • Spatial functions: urban district formation, environmental space (tree planting zone, etc.), disaster prevention space, storage space, urban landscape formation • Improve accessibility to facilities, utilize deck space as a place of interactions, and create a lively atmosphere (as function for urban district formation) • Reduction of utility construction and maintenance costs by attaching utility facilities to the lower part of sky deck (utility accommodation space)
Width composition	• Lanes dedicated for PRT would be set. Consideration should be made to allow pedestrians to cross the lane when necessary (PRT driving lanes are divided by painting and marking of pavement on decks, and fences are installed beside the driving lanes only in the necessary sections)*Standard width is shown in the table.
Attached equipment	• Install roofs to cover from rainfall and sunlight • Install a handrail and fence on the outer side to prevent falling • Plant trees and other greenery to create an attractive natural environment • Installation of fences, color pavement, and PRT running lane marking, where necessary, to avoid intermixing of pedestrians and PRT, and improve safety.

Source: JICA Study Team

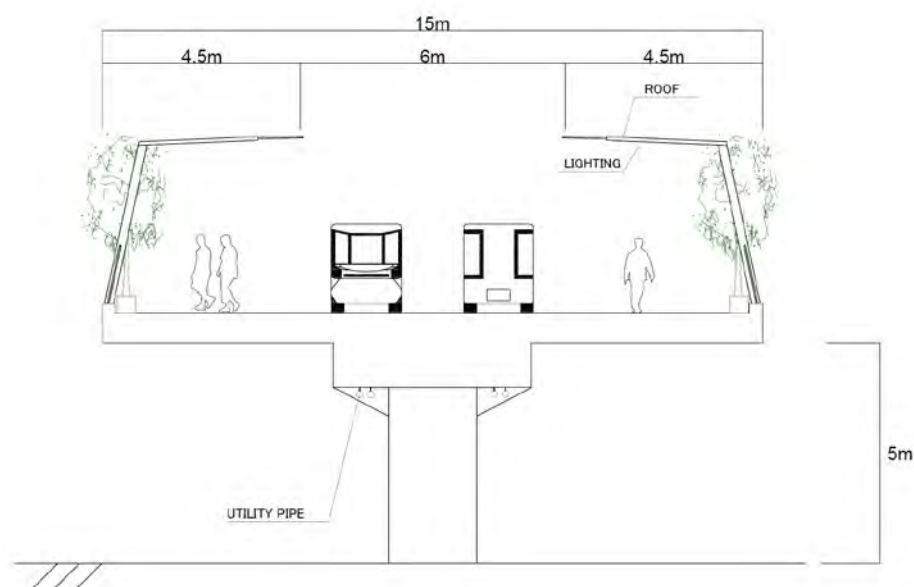
The standard cross-section and the proposed phased development plan for the sky deck are shown below. For the development plan of each section, detailed study is necessary based on the detailed plan for each zone development. The standard cross-section image below shows the minimum required width. As would be described in the following section, the transport demand for PRT and walking on the deck is forecasted to increase in the future, particularly on the west side of the Bang Sue Grand Station. In such circumstance, measures such as expanding the PRT lane to two lanes on one side, as well as expansion of the pedestrian space would be necessary. The detail plans needs to be formulated based on the progress of the development and the situation of each zone.

Regarding the development method, the sky deck shall not be developed as a single unit – it shall be developed together with the facilities in the zones at the phase of each zone development. The conceptual image of the sky deck is shown below. Large sections of sky deck network shall be installed (between development zones) on roads, but could also be developed to connect the spaces between buildings, sidewalks of buildings, or connected directly to buildings. PRT vehicles would be relatively lightweight EVs and could be driven in the buildings. The traveling speed of the PRT is proposed to be about 20km/h, so that it is possible to be operated alongside pedestrians. A more detailed study is needed in the future on the detail design and alignment of the sky deck.

Table 5.6 Standard sky deck network cross section

Item	Width
Pedestrian space (roofing and planting)	9m (4.5m×2)
PRT running space	6m (3m×2)
Total	15m

Source: JICA Study Team



Source: JICA Study Team

Figure 5.10 Standard cross-sectional view of skydeck network



Source: JICA Study Team

Figure 5.11 Plan for sky deck network development (Phase 1)

Source: JICA Study Team

Figure 5.12 Plan for sky deck network development (Phase 2)



Source: JICA Study Team

Figure 5.13 Plan for sky deck network development (Phase 3)

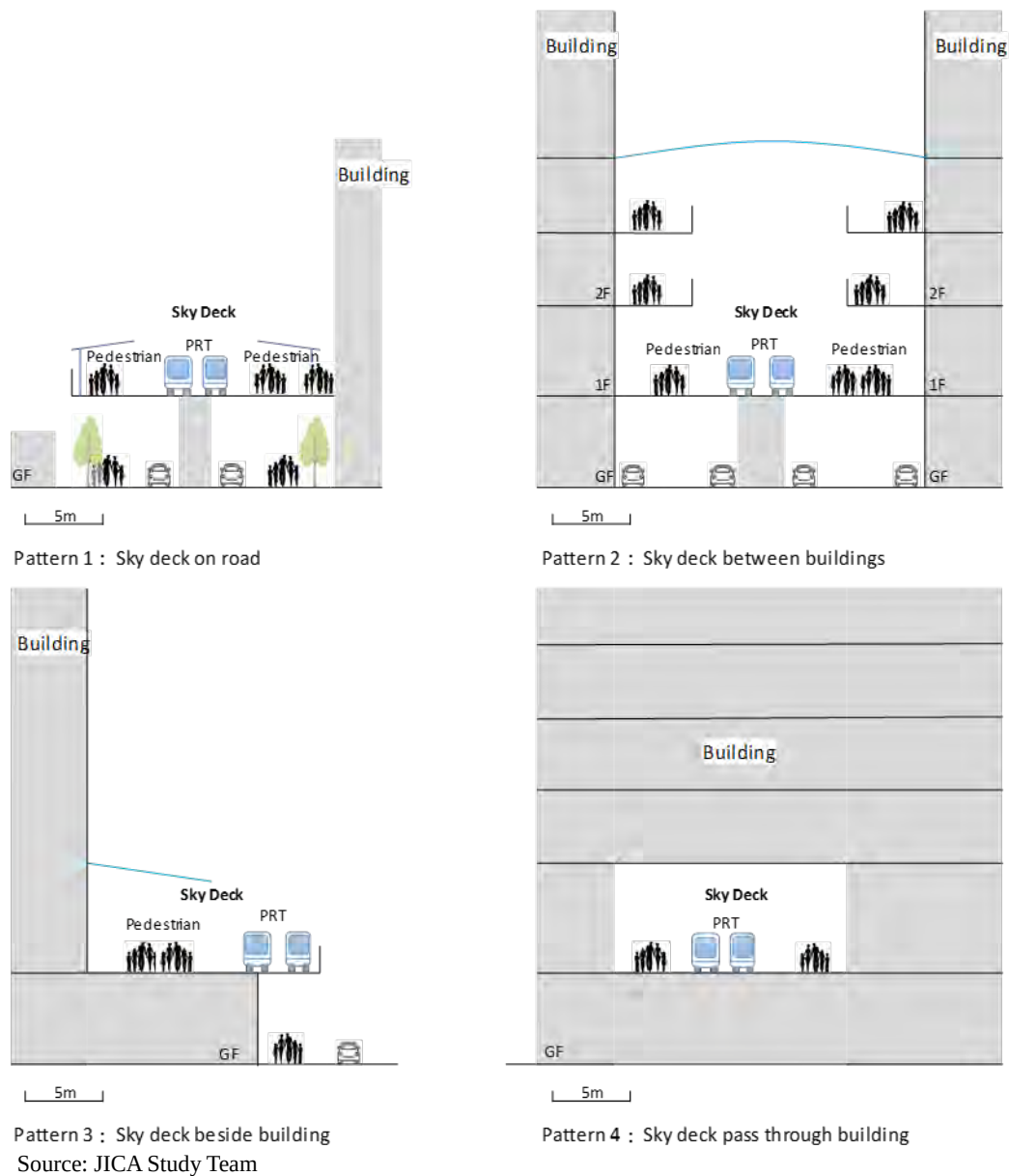


Figure 5.14 Development image of sky deck network

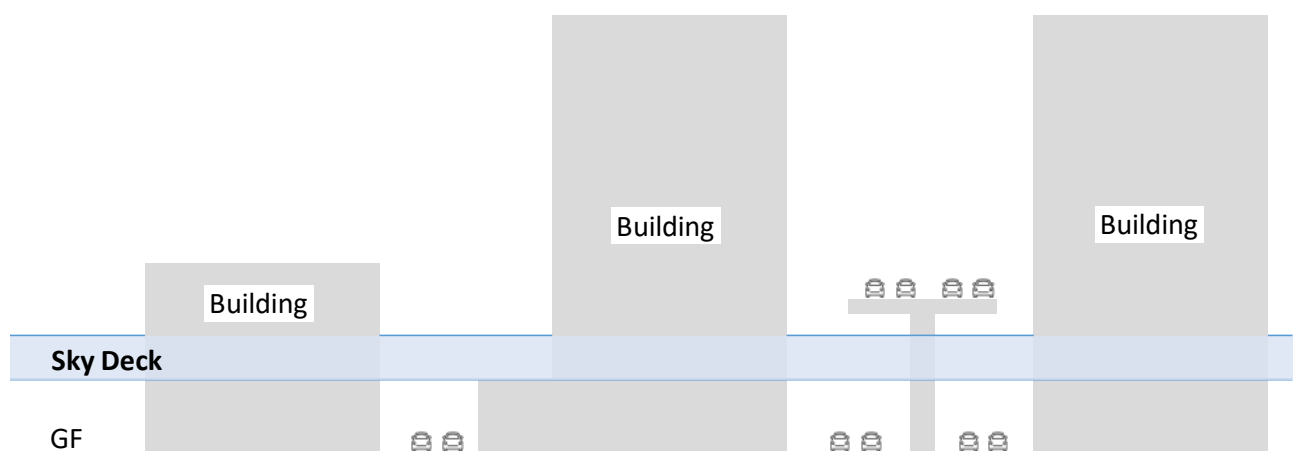


Figure 5.15 Longitudinal view of sky deck (Concept image)

5.2.3 Smart Mobility

In order to provide basic material for calculation of estimated project cost, PRT operation plan (estimated demand and number of vehicles by route) was examined based on estimation of future traffic demand and parking lot scale in the fringe of the development area.

This study is based on provisional traffic demand forecast based on available data and assumptions, including the results of the previous JICA study. In order to formulate a detailed operation plans, transport plans with a more detailed demand forecast at zone level would be needed.

(1) PRT operation plan

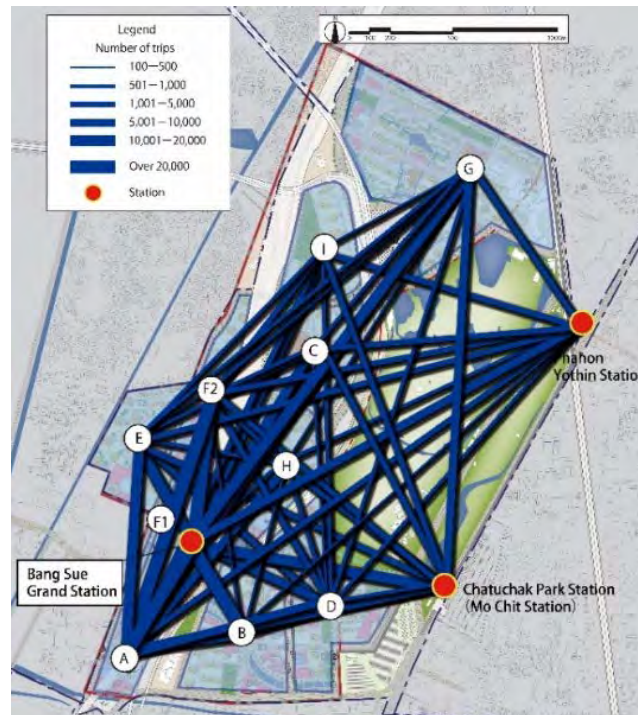
1) Estimation of future traffic demand

In examining the estimated number of PRTs to be operated on the skydeck network, the peak traffic volume distribution by the PRT in Phase1 (2022), Phase2 (2027) and Phase3 (2032) was estimated, and subsequently the number of PRTs needed to manage the demand was estimated. The following table shows the conditions for peak traffic demand forecast for PRT. The following figure shows trip demand for PRT in 2032.

Table 5.7 Conditions for projection of future traffic demand of the PRT

Item	Conditions
Target year	• Phase1 2022, Phase2 2027, Phase3 2032
Target time	• 1-hour peak rate (assuming that the peak rate is 18% based on case studies of other cities)
Trial calculation procedure	• Estimation of the distribution of PRT traffic per day in 2032 (see Chapter 4 for detail) • Peak-time traffic distribution is calculated by multiplying PRT distribution of traffic per day by the above peak rate. • Peak-time traffic distribution for years 2022 and 2027 is calculated based on the peak traffic distribution in 2032. A coefficient for adjusting development stage was set through estimated passenger number at Bang Sue Grand Station. This factor is then multiplied to the number of trips in 2032 by the number of trips for development zone pair in each phase.
Setting of coefficient for adjusting for development stage	• Estimated numbers of passengers at Bang Sue Grand Station (unidirectional/day) according to the previous JICA study, from 506,870 in 2032, 363,182 in 2027, and 173,370 in 2022, the coefficients were set to 100.0%, 71.7%, and 34.2%.

Source: JICA Study Team

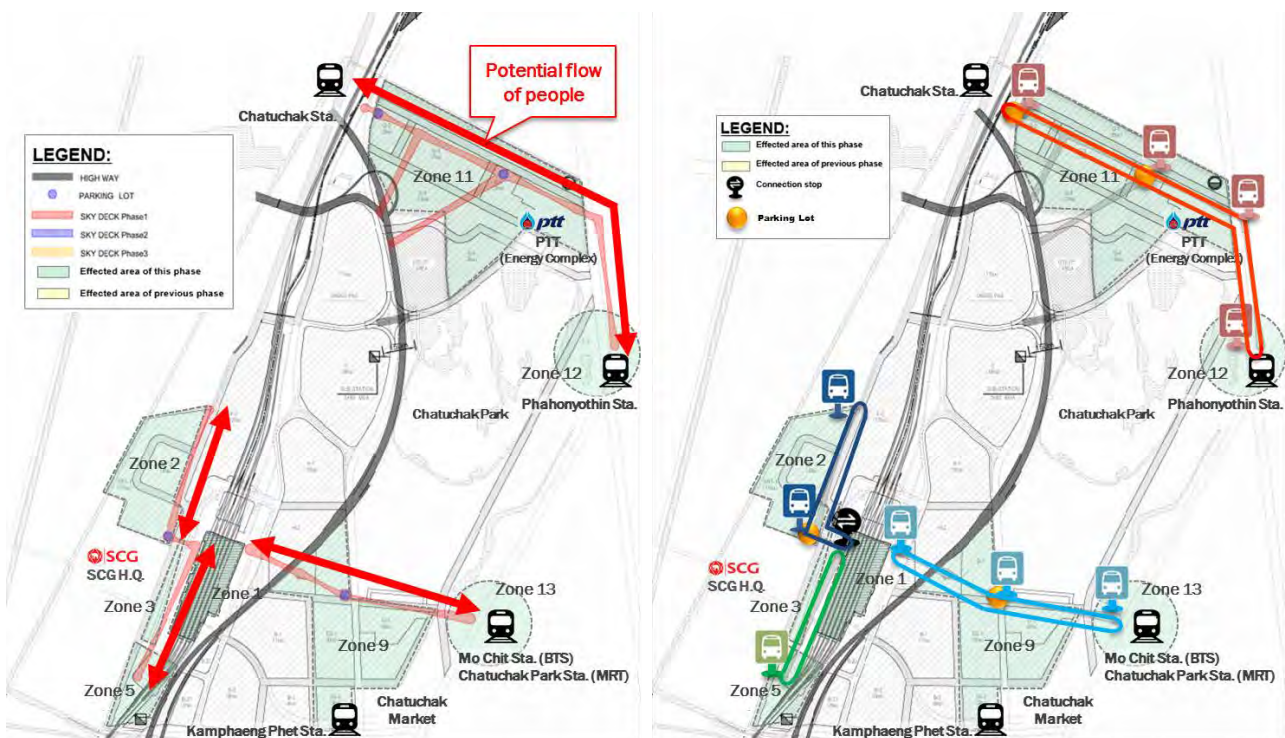


Source: JICA Study Team

Figure 5.16 Trip Demand for PRTs in 2032 (trip/day)

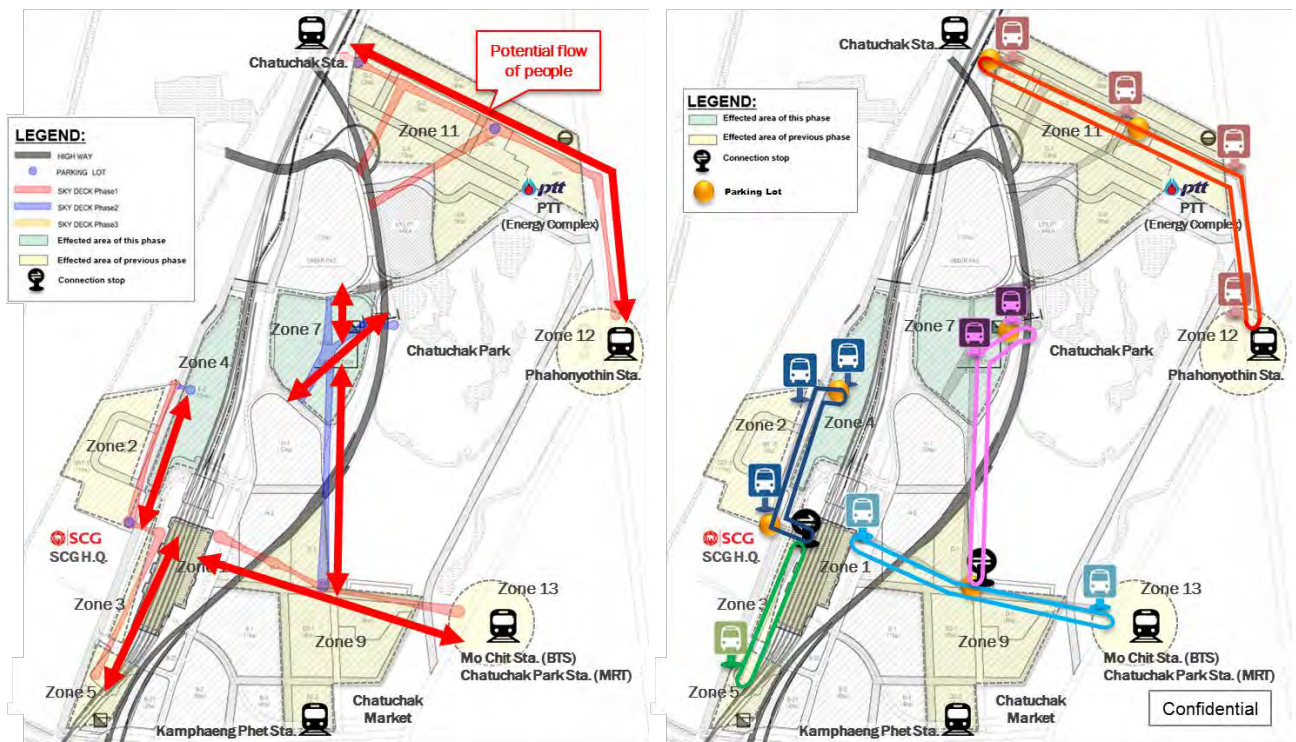
2) PRT operation plan

Sky deck network plan, future transport demand, and PRT service routes were examined based on the phased development plan.



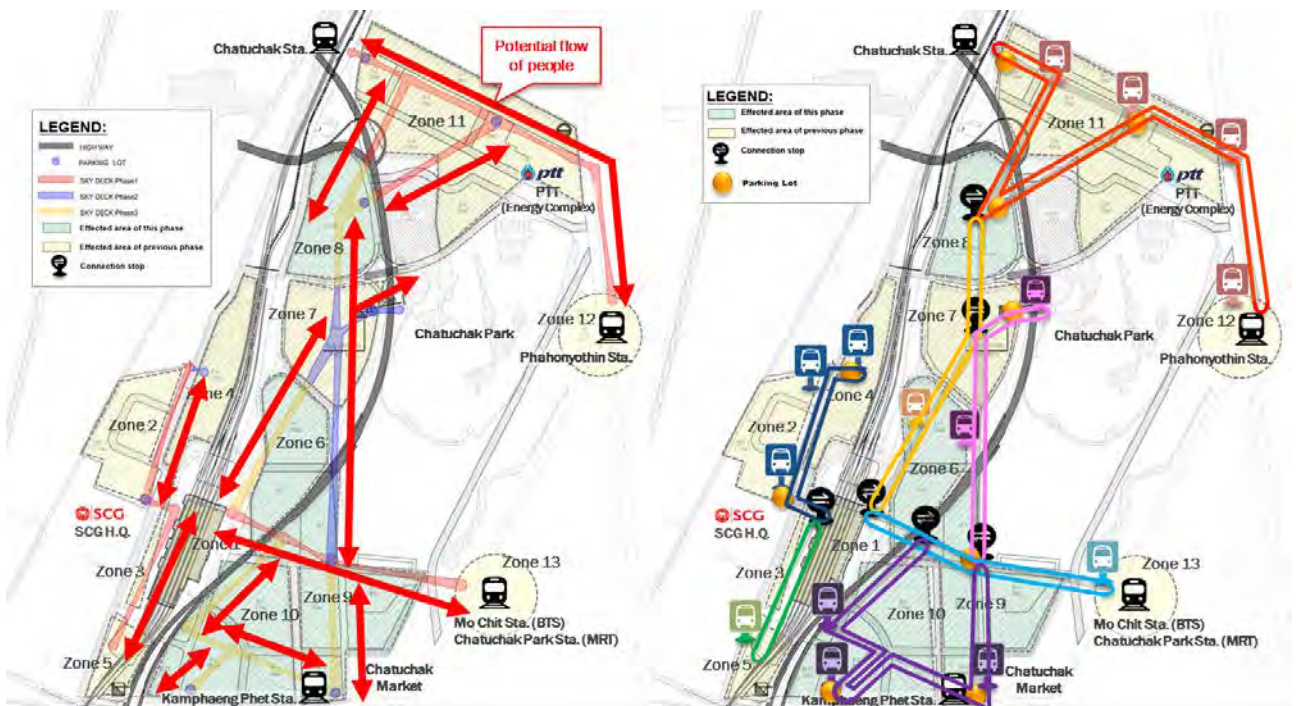
Source: JICA Study Team

Figure 5.17 Settings for transport demand and PRT service route: Phase 1 (2022)



Source: JICA Study Team

Figure 5.18 Settings for transport demand and PRT service route: Phase 2 (2027)



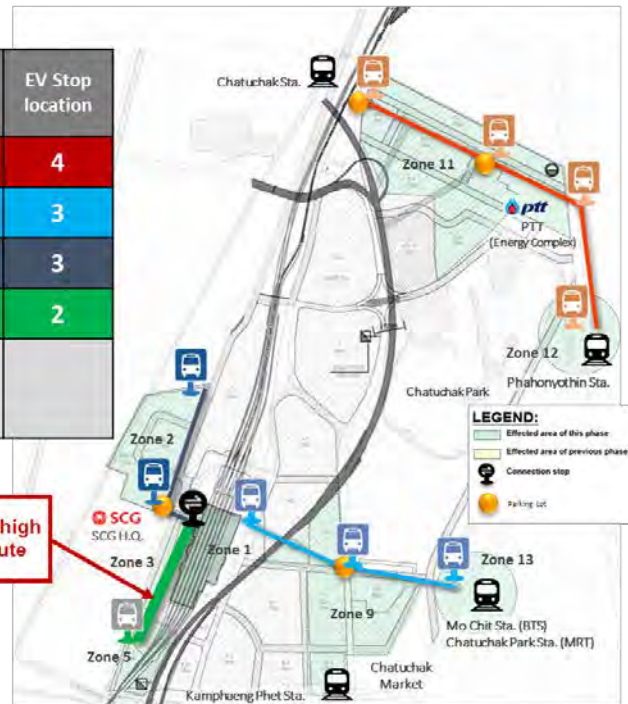
Source: JICA Study Team

Figure 5.19 Settings for transport demand and PRT service route: Phase 3 (2032)

Based on the future demand at the peak time in the set service route, the number of PRT vehicles to be introduced in each development phase were examined. The peak demand for each service route by development phase is shown in the following figure.

Potential transport demand per route

Route Name (Origin – Destination)	Peak hour trip demand (trip/hour) *Both directions total	Total Distance (round trip)	EV Stop location
11 - 12	86	3.36 km	4
1 - 9 - 13	756	2.32 km	3
2 - 1	750	1.54 km	3
1 - 3 - 5	2,858	1.54 km	2
Total peak hour trip demand (trip/hour)	4,450		

Comparably high
demand route

Source: JICA Study Team

Figure 5.20 Peak demand for PRT service route: Phase 1 (2022)**Potential transport demand per route**

Route Name (Origin – Destination)	Peak hour trip demand (trip/hour) *Both directions total	Total Distance (round trip)	EV Stop location
11 - 12	182	3.36 km	4
1 - 9 - 13	5,016	2.32 km	3
4 - 2 - 1	12,112	2.06 km	4
1 - 3 - 5	11,952	1.54 km	2
7 - 9	2,232	2.94 km	3
Total peak hour trip demand (trip/hour)	31,496		

Comparably high
demand route

Source: JICA Study Team

Figure 5.21 Peak demand for PRT service route: Phase 2 (2027)

Potential transport demand per route

Route Name (Origin – Destination)	Peak hour trip demand (trip/hour)	Total Distance (round trip)	EV Stop location
11 – 8 – 12	6,716	5.9 km	6
4 – 2 – 1	18,784	2.06 km	4
1 – 3 – 5	20,512	1.54 km	2
7 – 6 – 9	3,412	3.04 km	4
1 – 6 – 7 – 8	12,022	3.06 km	4
1 – 9 – 13	13,740	2.32 km	4
9 – 10	5,144	4.44 km	5
Total peak hour trip demand (trip/hour)	80,330		

LEGEND:

- Effected area of this phase
- Effected area of previous phase
- Connection stop
- Parking lot



Source: JICA Study Team

Figure 5.22 Peak demand for PRT service route: Phase 3 (2032)

The route with the highest demand in 2032 is assumed to be the route connecting Zone F2, Zone, E, Grand Station, and Zone A on the west side of Bang Sue Grand Station, with demand about 20,000 people per hour (for both directions) at peak times. When demand at peak time for one direction becomes extremely high, it would be difficult to sufficiently meet the demand, since the maximum transport volume of PRT system in one lane is expected to be approximately 9,600 people per hour for one direction. Therefore, it shall be proposed that the sky deck on the west side of the Grand Station needs to be planned with a broader width than that of the standard cross section indicated above (21m or more), so that PRT vehicle could be operated in two lanes on one side.¹

Based on the above examination, the number of PRT vehicles required to meet peak demand by service route estimation is as shown in the following table.

Table 5.8 Number of PRT Vehicles Operated

Item	The first phase	Second phase	Phase 3
PRT vehicles	66	301	910

Source: JICA Study Team

¹ Under the condition that sufficient boarding/ unboarding space is secured (adequate boarding/ unboarding space for four units of three connected PRT vehicles).

(2) Parking facility plan at the fringe of the Bang Sue Area

In examining parking facility plans at the fringe of the Bang Sue Area, the required size of the parking facility (total floor area) was set based on the estimated number of vehicles that would park in the parking facility at peak time in Phase1 (2022), Phase2 (2027), and Phase3 (2032). The following table shows the conditions for estimation and the results. As the basis of the estimation, the vehicle inflow restrictions measures to be introduced to the area are targeted mainly for ordinary shoppers, and thus excludes residents, persons with disabilities, logistics vehicles, emergency vehicles, construction-and-maintenance-related vehicles, and waste collection vehicles (the basic concepts are described in Chapter 4).

The proposed plan for the location of parking facilities at the fringe is shown in the aforementioned figure. However, it should be noted that the location is provisional and thus the actual location should be determined based on detailed study on impact on the traffic, and also considering the progress of the zone development.

Table 5.9 Conditions for estimation on the size of parking facilities at the fringe

Item	Conditions
Target year	• Phase1 2022, Phase2 2027, Phase3 2032
Target time	• Parking demand at peak time (Average parking time is assumed to be 3 hours based on several case studies for parking lots)
Parking facility location	• Facility locations are indicated in the aforementioned figure. *The proposed location is provisional and thus the actual location should be determined based on detailed study on impact on the traffic, and also considering the progress of the zone development.
Calculation procedure	• Traffic volumes are based on estimated vehicle traffic distribution per day in 2032 (see Chapter 4 for detail). • 70% of vehicle trips inside the area and in-out vehicle trips are restricted from flowing into the zone (as 26% of the expected population in the area are residents of the Area, according to the previous JICA study). It is assumed that the restricted vehicles would use the fringe parking facility. (In the zones with fringe parking facility, 70% of vehicle trips whose inflow is restricted are set as trips to the fringe parking facility (sub-zone)). • Based on the above, the size of each parking facility (total floor area) is estimated by multiplying the average parking time (3 hours), on the average number of vehicles for the parking facility in the peak time at 2032. For parking lot area per vehicle, 20 m² per vehicle is applied citing the Road Design Standard. • Development for parking facility is set based on the zone development schedule.

Source: JICA Study Team.

Table 5.10 Parking facility plan at the fringe of the Bang Sue Area

		Phase1		Phase2		Phase3	
		Peak Hour Capacity (vehicle)	Floor Area (m ²)	Peak Hour Capacity (vehicle)	Floor Area (m ²)	Peak Hour Capacity (vehicle)	Floor Area (m ²)
Zone D	Parking-1	1,575	31,500	0	0	0	0
	Parking-2	0	0	0	0	1,575	31,500
Zone E		1,422	28,440	0	0	0	0
Zone G	Parking-1	705	14,100	0	0	0	0
	Parking-2	705	14,100	0	0	0	0
Zone C		0	0	1,836	36,720	0	0
Zone B		0	0	0	0	840	16,800
Zone I		0	0	0	0	1,041	20,820
Total		4,407	88,140	1,836	36,720	3,456	69,120

Source: JICA Study Team.

5.2.4 Smart Energy

(1) Proposed Development Plan for Smart Energy

1) Proposed Development Plan for Phase 1

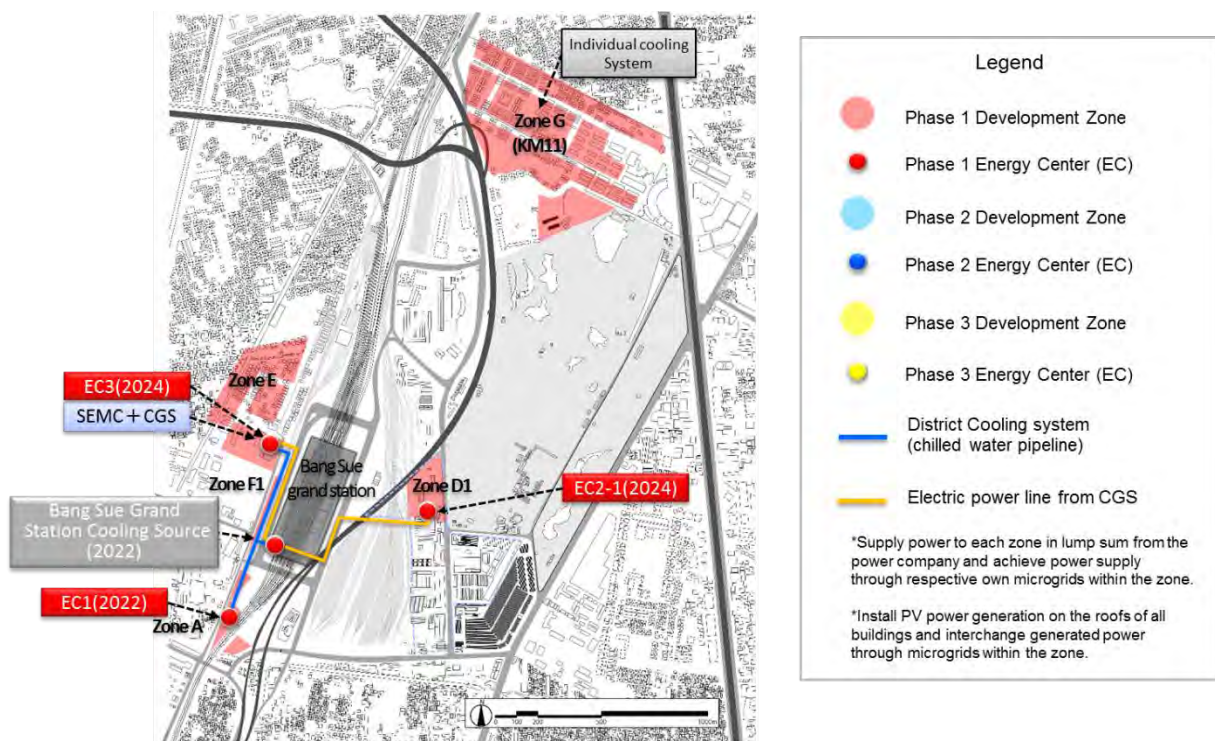
The following describes development overview and a layout plan on energy supply plants and cold conduit pipes for Phase 1 from 2022 onwards.

As a scenario, in Zone A to be developed earlier, energy supply plants chiefly for motor-driven turbo chiller are developed, and heat conduit pipes are extended on the sidelines of Bang Sue Grand Station or Zone E development with possible huge demand, and a network is built with Bang Sue Grand Station and energy supply plants planned for Zone E.

In addition, considering energy demand scale and development costs on heat conduit pipe, Zone D1 adopts spot heat supply system in the initial phase of Phase 1 opening. However, as a large-scale development is planned both in Zones D2 and B for Phase 3, a network is established with energy supply plants to be developed in time with equipment renewal for EC2-1 located in Zone D1. As the medical complex is planned in Zone D1, electric power lines are laid to supply power from CGS at time of emergency.

Meanwhile, as Zone G (KM11) is used mainly for residential purpose, building-based cooling system is adopted due to low cooling load density.

In the smart energy network in the Bang Sue area, solar power generation is introduced with the use of roofs of all buildings in order to develop a city with low environmental loads through renewable energy.



Source: JICA Study Team.

Figure 5.23 Layout Plan for Energy Supply Plant (Phase 1)

Table 5.11 organizes facility features for smart energy network for Phase 1.

Table 5.11 Development Overview (Phase 1)

Phase 1 (up to 2022)	
Target Zone	Zones A, D1, E, F1 and G (KM 11)
Details	Zone A • EC1 (Energy Center 1) Chiller: 4,9000 USRT Heat storage tank: 10,000 USRTh Cogeneration: 4,040 kW • Solar power generation: 2,164 kW *Total volume for each building. • Cold conduit pipe: 230 m • Electric power cable: (100 sq) 840 m • Substation equipment (supplied collectively): 11,500kVA Zone D1 • EC2-1 (Energy Center 2-1) Chiller: 2,500 USRT Heat storage tank: 10,000 USRTh • Solar power generation: 915 kW *Total volume for each building. Zones E, F1 • EC3 (Energy Center 3) Chiller: 14,700 USRT Heat storage tank: 10,000 USRTh Cogeneration: 4,040 kW Boiler for backup: 10 t/h • Solar power generation: 6,359 kW (Zone E) *Total volume for each building. 1,086 kW (Zone F1) *Total volume for each building. • Cold conduit pipe: 70 m • Electric power cable: (100 sq) 14,550 m • Substation equipment (supplied collectively): 54,500 kVA • SEMC (Smart Energy Management Center) x 1 Zone G (KM11) • Solar power generation: 9,598 kW *Total volume for each building. • Electric power cable: (100 sq) 50,000 m • Substation equipment (supplied collectively): 37,500 kVA

Source: JICA Study Team.

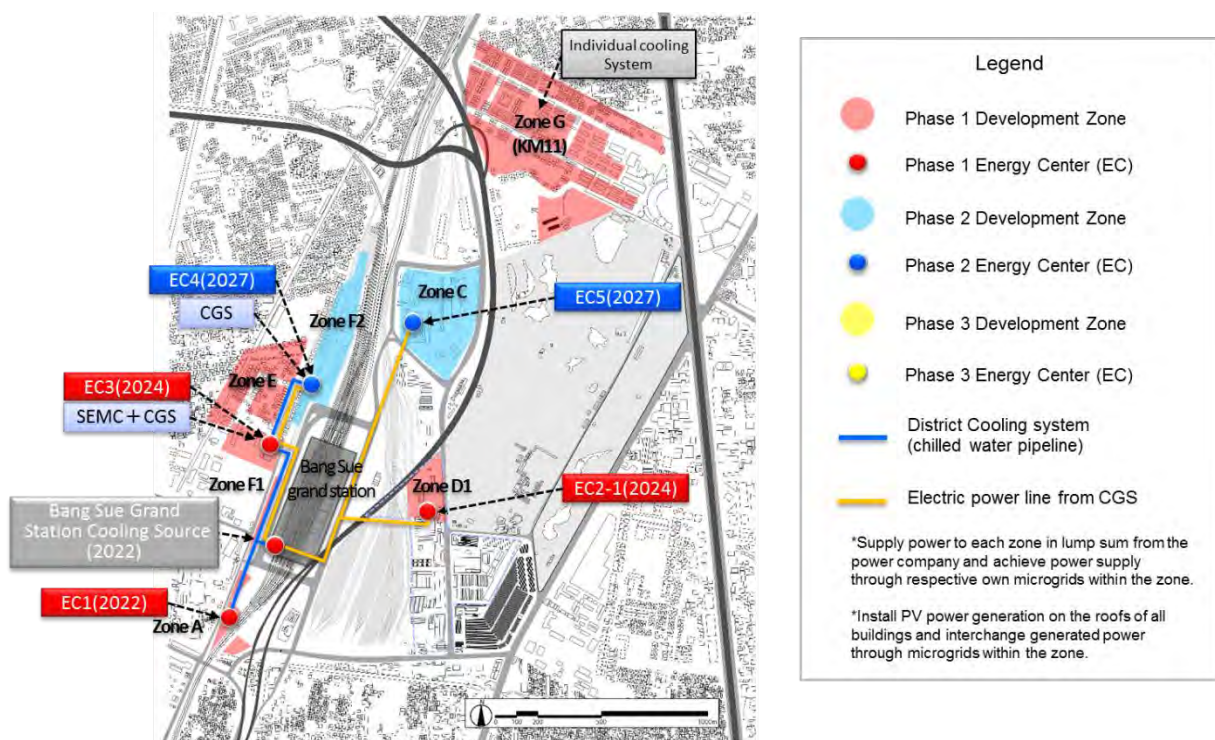
2) Proposed Development Plan for Phase 2

The following describes development overview and a layout plan on energy supply plants and cold conduit pipes for Phase 2 from 2027 onwards.

As a scenario, as Zone F2 with relatively huge energy cold demand is closer to Zone E to be developed for Phase 1 and additional efficiency is expected through networking, a network is built with EC1 in Zone A and EC3 in Zone E.

In addition, considering energy demand volume and development costs on heat conduit pipe, Zone C to be developed for Phase 2 adopts spot heat supply system. Meanwhile, as Zone C includes MICE development plans with many potential visitors, the zone adopts power supply system at time of emergency from CGS to be developed at ECs 3 and 4, based on BCP perspectives as shown in Bang Sue Grand Station.

As shown in Phase 1 with the adoption of solar power, Zones C and F2 plan to install solar power generation on the roofs of all buildings.



Source: JICA Study Team.

Figure 5.24 Layout Plan for Energy Supply Plant (Phase 2)

Table 5.12 organizes facility features for smart energy network for Phase 2.

Table 5.12 Development Overview (Phase 2)

Phase 2 (up to 2027)	
Target Zone	Zones C and F2
Details	Zone C • EC5 (Energy Center 5) Chiller: 2,900 USRT Heat storage tank: 110,000 USRTh • Solar power generation: 5,779 kW *Total volume for each building. • Cold conduit pipe: 270 m • Electric power cable: (100 sq) 5,040 m • Substation equipment (supplied collectively): 25,500 kVA Zone F2 • EC4 (Energy Center 4): Chiller: 15,700 USRT Heat storage tank: 10,000 USRTh Cogeneration: 4,040 kW Boiler for backup: 10 t/h • Solar power generation: 6,149 kW *Total volume for each building. • Cold conduit pipe: 300 m • Substation equipment (supplied collectively): 548,000 kVA

Source: JICA Study Team.

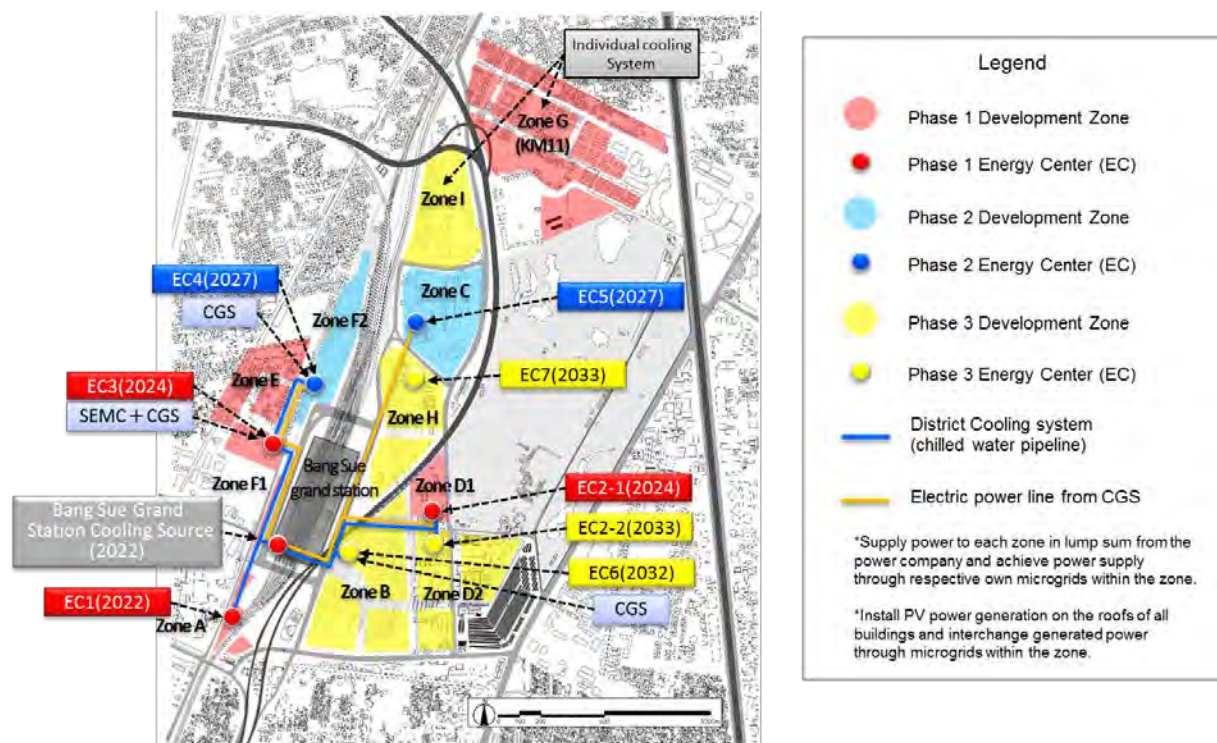
3) Proposed Development Plan for Phase 3

The following describes development overview and a layout plan on energy supply plants and cold conduit pipes for Phase 3 up to 2032.

As a scenario, in Phase 3 a conduit pipe for cold water is extended furthermore from Bang Sue Grand Station to build a network with EC6 to be developed for Zone B. The district cold pipe network is extended and a new energy supply plant EC2-2 in Zone D2 is developed to connect mutually to EC2-1 in Zone D1 on the sidelines of equipment renewal for EC2-1 in Zone D1 that is used as spot heat supply for Phase 1.

Meanwhile, Zone H to be developed in Phase 3 adopts spot heat supply system, considering a certain distance between Zone H and other energy supply plants and installation costs on cold water conduit pipe.

This zone adopts solar power generation on all the buildings, based on the way to consider on the installation of solar power generation described earlier.



Source: JICA Study Team.

Figure 5.25 Layout Plan for Energy Supply Plant (Phase 3)

Table 5.13 organizes facility features for smart energy network for Phase 3.

Table 5.13 Development Overview (Phase 3)

Phase 1 (up to 2032)	
Target Zone	Zones B, D2, H and I
Details	Zone B • EC6 (Energy Center 6) Chiller: 10,500 USRT Heat storage tank: 10,000 USRTh Cogeneration: 4,040 kW Boiler for backup: 10 t/h • Solar power generation: 9,423 kW *Total volume for each building. • Cold conduit pipe: 560 m • Electric power cable: (100 sq) 16,060 m • Substation equipment (supplied collectively): 40,000kVA Zone D2 (D2 to D4) • EC2-2 (Energy Center 2-2) Chiller: 12,200 USRT • Solar power generation: 6,177 kW *Total volume for each building. • Cold conduit pipe: 960 m • Electric power cable: (100 sq) 23,790 m • Substation equipment (supplied collectively): 547,500 kVA Zone H • EC7 (Energy Center 7) Chiller: 7,100 USRT Heat storage tank: 10,000 USRTh • Solar power generation: 3,647 kW *Total volume for each building. • Cold conduit pipe: 450 m • Electric power cable: (100 sq) 11,360 m • Substation equipment (supplied collectively): 27,500 kVA Zone I • Solar power generation: 2,442 kW *Total volume for each building. • Electric power cable: (100 sq) 3,600 m • Substation equipment (supplied collectively): 13,500 kVA

Source: JICA Study Team

(2) Proposed Business Execution for Smart Energy

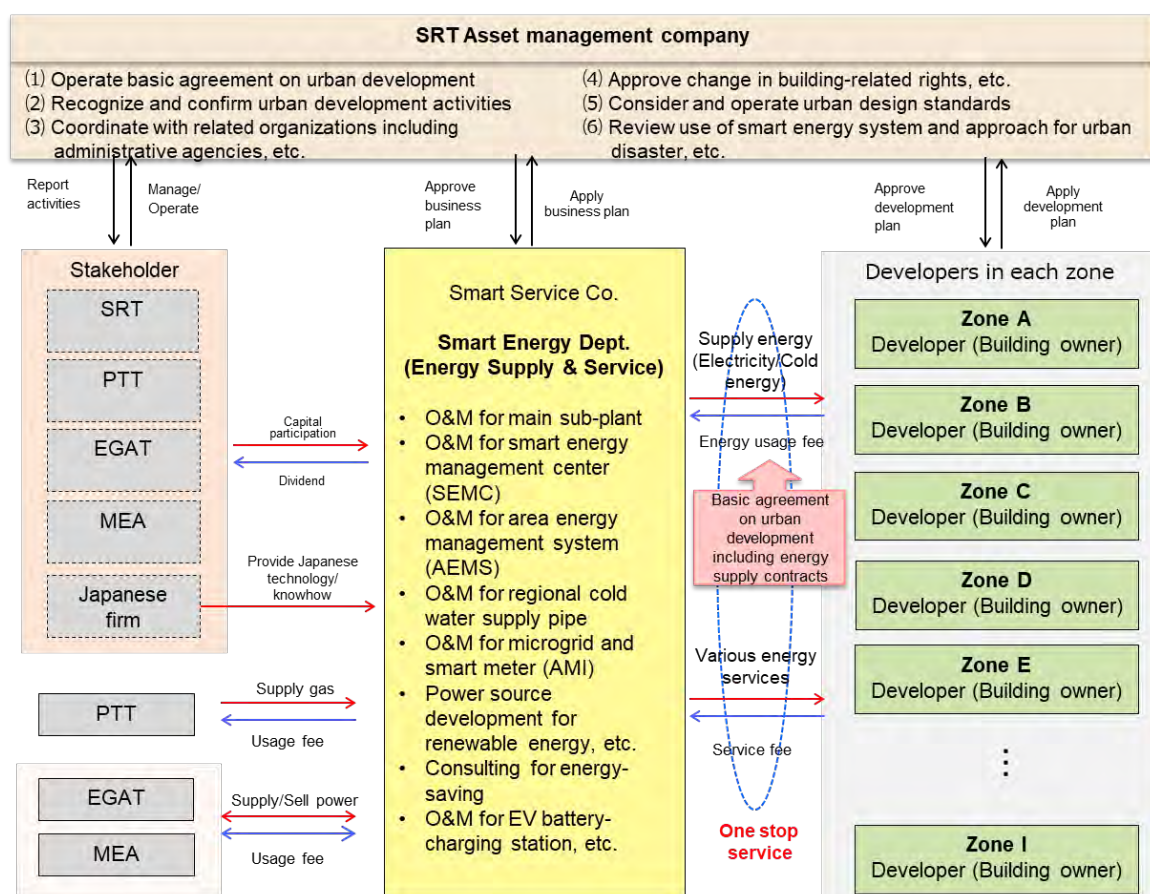
For instance, SRT or zone developers, and energy operators like PTT, MEA and EGAT and other stakeholders would join in the smart energy project for Smart Service Company (SSC) and SRT's asset management company needs to set up a system to encourage zone developers to use smart energy network, while managing and operating basic agreements for town development.

Furthermore, regarding the refinement of the smart energy project action team, it is desirable to clarify respective stakeholders' roles, including the execution of SEMC and AEMS, operation management of each EC, microgrids and AMI in the Bang Sue area and operation management of regional cold water conduit. And it is also necessary to make the smart energy business more feasible through the support from the Japanese government and the participation from Japanese private companies which have achieved many smart energy projects in Japan and overseas.

SSC will serve as a role of one stop service to coordinate with all the state enterprises or private companies, realizing the interregional smart solution.

The following figureSource: JICA Study Team

Figure 5.26 shows a proposed business execution system for smart energy.



Source: JICA Study Team

Figure 5.26 Proposed Business Execution for Smart Energy

5.2.5 Smart Environment

Most of the various strategies and approaches that were proposed in Chapter 4 would be the items to be stipulated in the City Development Guideline for the respective zone developers or public entities to follow and coordinate.

In this section, items which shall be proposed for the Smart Service Company to implement as business are outlined.

(1) Solid waste management system

1) Approaches for implementation

Solid waste management system shall be established by the opening year of Bang Sue Grand Station (year 2021).

It is proposed that the system be developed through collaboration with a Thailand start-up company. Introduction of a ready-made system such as Bin-e system is also an option, however it would be preferable to developed as a tailored system that is customized to Thai language and optimized through machine learning of the unique attributes of the waste in Thailand.

It is proposed that this system be funded and procured by BMA, while the companies in the area would develop and operate the system.

2) Specification of functions

The expected specifications for the functions are as follows.

Table 5.14 Specifications for functions (Solid waste management system)

Items	Outline of functions
Dust Box side	To separate and dispose the waste automatically with the sensor
	To issue notifications to the server when waste amount exceeds certain level
	To notify the server other information such as locational information or operational information
Server side	To accumulate data that is sent from the dust box
	To issue alert to client
Client side (Smart phone is assumed)	To indicate the location and operational information on the map
	To issue alert information by Push Notifications

Source: JICA Study Team

3) Locations to be installed

The system shall be installed at places where it is accessible to electricity, as it would need power supply. The number of bins that would be installed shall be set at 100, assuming that it would be installed every 250m on the sky deck (electricity would be distributed though the sky deck), and Bang Sue Grand Station.

(2) Air pollution data observation and monitor system

1) Approaches for implementation

The system for observing and monitoring air pollution shall be established by the opening year of Bang Sue Grand Station (year 2021). With regards to the particles to be observed – varying

from PM2.5, PM10, CO2, and NO2 – it is proposed that the target particles be specified, so that the area could be covered with less expensive sensor, as the priority should be placed on the spatial coverage. The data to be observed should be coordinated with the system that Bangkok City would apply.

Currently, the sensor and application for observing a specific particles, such as PM 2.5 could be introduced with less than 50,000 JPY (roughly 450 USD). However, the system should be calibrated to be able to observe the areal data, as the currently available device could only show the actual value which is observed by a single sensor.

It is proposed that this system be funded and procured by BMA, while the companies in the area would develop and operate the system.

2) Specification of functions

The expected specifications for the functions are as follows.

Table 5.15 Specifications for functions (Air pollution observation system)

Items	Outline of functions
Sensor side	To detect air pollution information with regards to PM2.5, PM10, CO2, or NO2
	To send data observed by the sensor to the server
Server side	To accumulate data sent by the sensor
	To send an alert or atmosphere information to the client side
	To send the data to the observation system managed by the Bangkok City
Client side (Smartphone is assumed)	To indicate the location and operational information on the map

Source: JICA Study Team

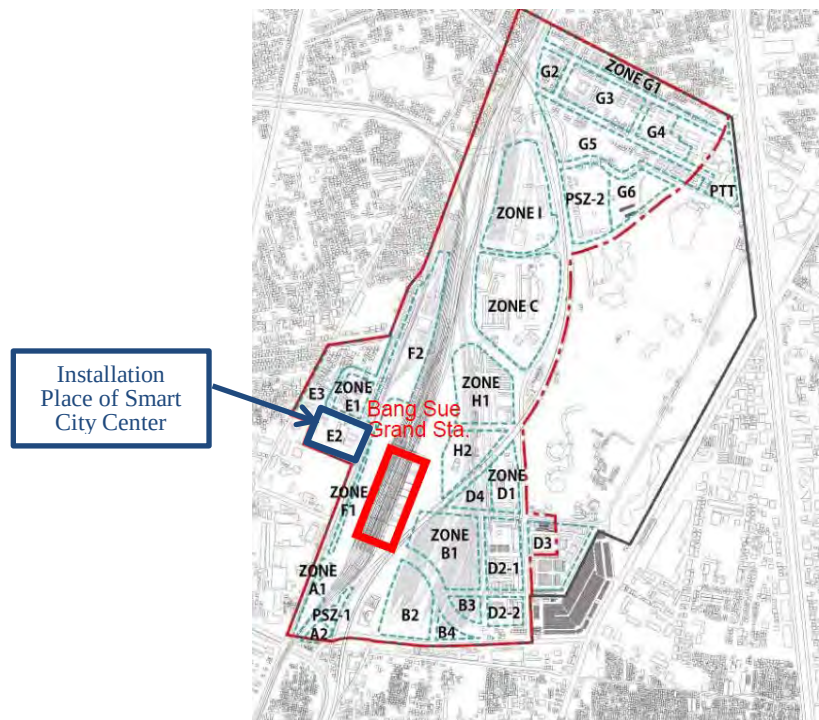
3) Locations to be installed

The conditions shall be the same as the CCTV camera which would be outlined later. The number of the sensor shall be 100, assuming it would be installed at crossings where heavy traffic is expected, and at every 500m on the sky deck or the road, as well as at the Grand Station.

5.2.6 Smart City Center

(1) Development Plan

The Smart City Center is to be located in the site of SRT head office in Zone E.



Source: Compiled by JICA Study Team based on the previous JICA Study

Figure 5.27 Proposed site of Smart City Center

(2) Building Plan

The following table shows the components of the Smart City Center, and its proposed floor areas, assuming that the Center would be an independent building. If the Center is to be installed inside SRT head office, coordination with SRT would be needed.

Table 5.16 Proposed Smart City Center components

Items	Role	Floor area	Floor
Monitoring Room	Space (control rooms) to display CCTV and collected data on large monitors	500 m ²	2F and 3F
Data Center	Server room to store software and data needed to implement the smart service business	500 m ²	2F or 3F
Exhibition Room	Exhibition room to introduce smart city service	500 m ²	1F
Work/Conference Space	Work/Conference space to address staff and visitors	500 m ²	3F or 4F
Energy Plant	Facilities to achieve cogeneration and cooling systems	5,725 m ²	Basement floor (5425 m ²), 2F (300 m ²)
Community Space	Space for lifelong learning center or administrative consultation service	1,000 m ²	1F
PRT Parking Lot	PRT parking lot, inspection, and recharging space	3,000 m ²	1F – 4F
Total			
	Energy Plant	5,425 m ²	
	Parking	3,000 m ²	
	Others	3,300 m ²	

Source: JICA Study Team.

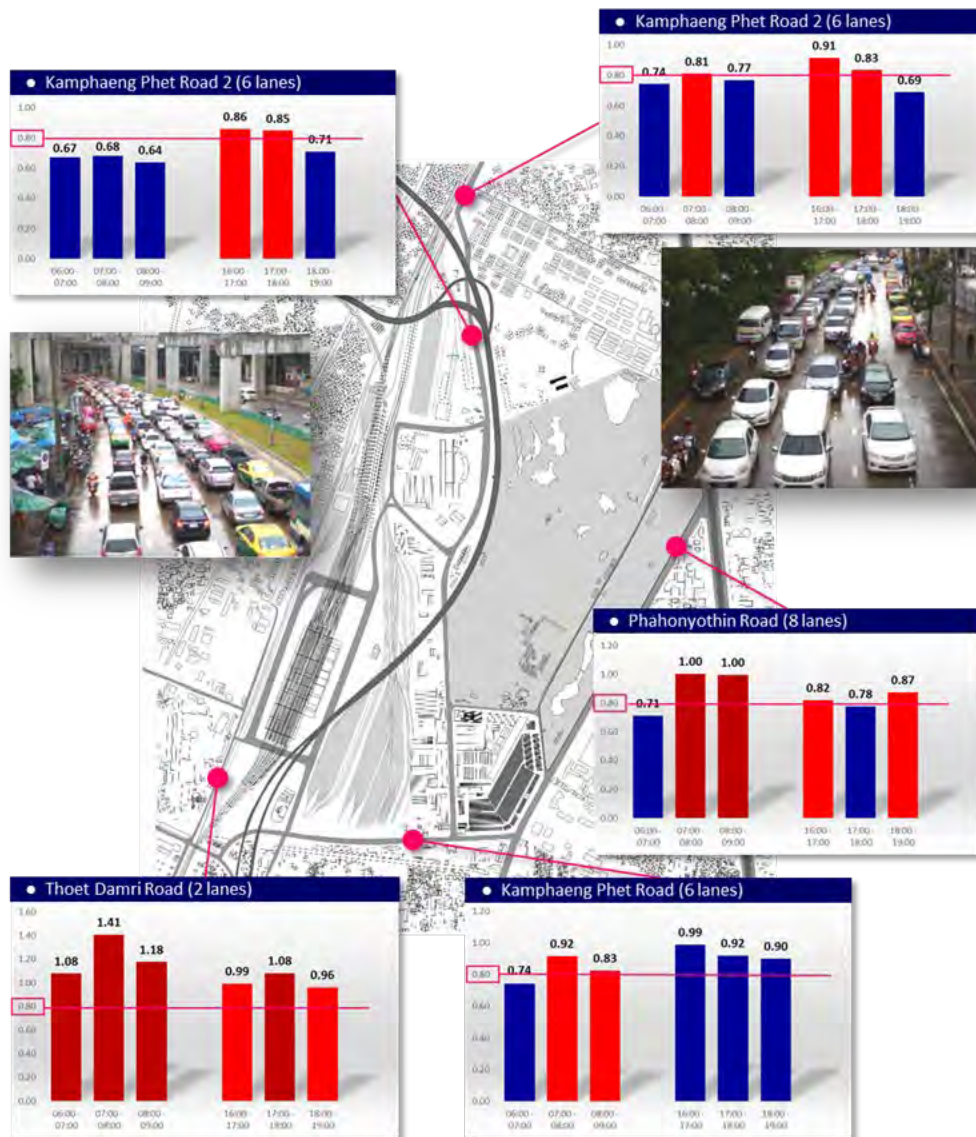
(3) Plan for Data Center

The small-scale data center is built to install 100 racks. Each rack is expected to include servers mainly, including switch or monitor.

(4) Plan for Control Room

In the monitoring room criminals are detected or traffic jam is monitored through surveillance camera. The surveillance camera is installed in the following locations.

- Intersections prone to traffic jams in the Bang Sue area (See the below figure.)
- Roads and SkyDeck (500-m interval)
- Bang Sue Grand Station
- Commercial facilities



Source: JICA Study Team (Elaborated on the basis of traffic survey conducted by OTP in 2016)

Figure 5.28 Congestion level on arterial road around Bang Sue Area (shown in the previous section)

As police officers manually switch traffic signal lights onsite to control the traffic condition in Bangkok, if remote control is difficult from control room, information delivery measures are needed between the control room and local police officers.

The number of installed surveillance cameras is expected to be 300 units (100 units per phase) in total in the Bang Sue area. Note that this number excludes the surveillance camera which would be installed into commercial facilities by the zone developers for their use. Vehicles can be detected by a surveillance video camera with similar performance to a commercially available one at around 100,000 yen, (approximately 28,000 bahts) as installed in some Chinese cities. For cost estimation, the unit price for the camera is set at 150,000 yen (approximately 42,000 bahts), to have a cover for dust and water. Also, training data for AI's image detection and its validation work (Proof of Concept or PoC) is needed. As the work is needed coupled with an increase in installation places, the cost are allocated per phase.

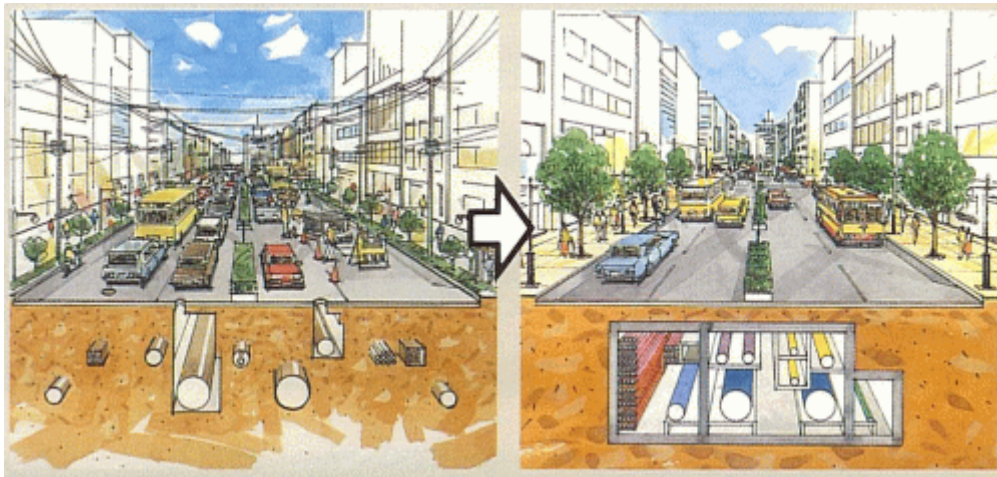
The BIM data which would be created by the administrative institutions and developers for the design work for infrastructure or commercial facilities. The data could then be used to produce maps or 3D model data as a base for Virtual Bang Sue City.

The space for monitoring room is to monitor commercial facilities, and thus cost estimation are calculated, based on the building area of commercial facilities. As described previously, however, consultations are needed with developers to decide if the monitoring function would be needed or not.

5.2.7 Common Duct

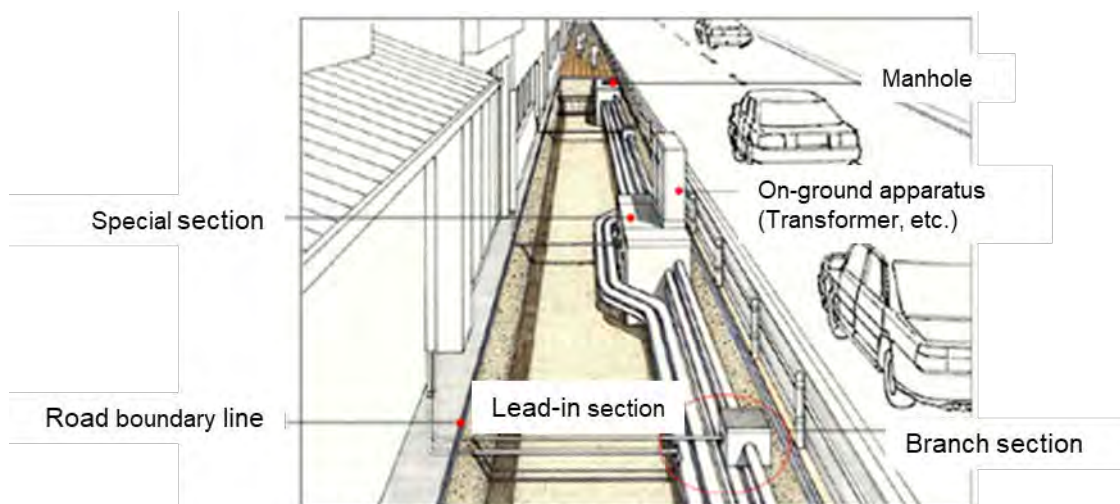
(1) Outline of Common Duct

The utility common duct for joint underground burial covers electricity, gas, water supply pipe, cold water pipe for regional cooling system and communication cables, which are considered as one of necessary infrastructure in the Bang Sue area. In Japan such utility common duct is installed under the main arterial road, contributing to effective maintenance and management for respective utility facilities, attractive urban landscape formation and enhanced urban disaster prevention functions.



Source: Yokohama City Office, Kanagawa Prefecture (<https://www.city.yokohama.lg.jp/kurashi/machizukuri-kankyo/doro/anzenshisetsu/yasashii/kyodoko/ccb.html>)

Figure 5.29 Utility Common Duct Image



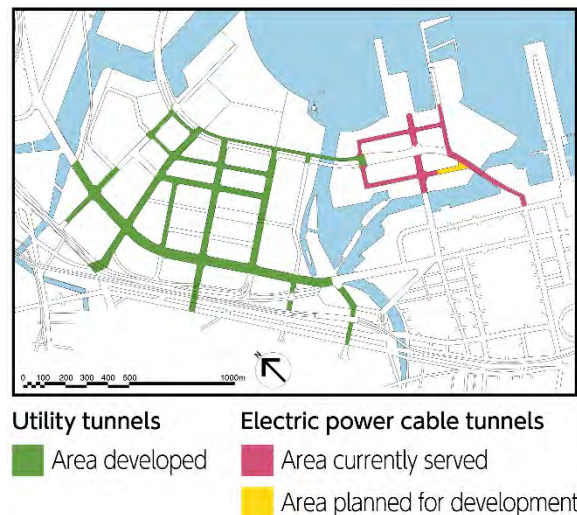
Source: Ministry of Land, Infrastructure, Transport and Tourism (https://www.mlit.go.jp/road/road/traffic/chicyuka/gaijimu_01.htm) (English translation of JICA Study Team)

Figure 5.30 Common Cable Duct Image (CC BOX)

The common duct is classified roughly into common duct and CC BOX (community or communication, compact box). The common duct is a structure to secure enough space for engineers or others to enter respective utility facilities for maintenance and management, while the CC Box is a relatively small duct to install communication or electric cables. If such utility ducts are constructed in the underground of road space before respective facility development

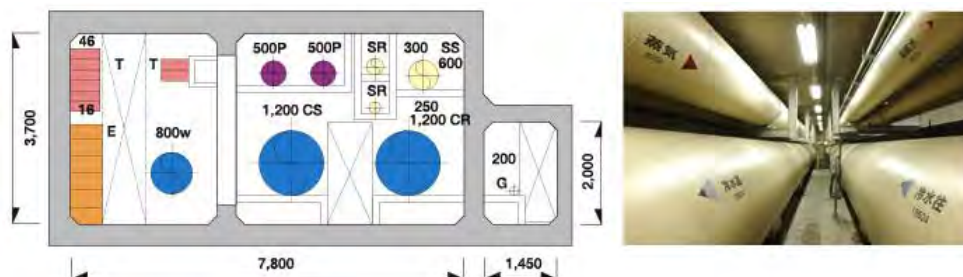
work for urban development projects under the initiative of private sectors in the area, it is easier to install utility equipment in a stepwise manner. And also, the development of utility ducts helps use land effectively, secure safe, comfortable pedestrian space, form attractive urban landscape and enhance urban disaster prevention.

The following figure shows common duct and CC BOX examples in Yokohama Minato Mirai, Kanagawa Prefecture, Japan.



Source: Minato Mirai area management documents (<https://www.ymm21.jp/disa/ditch.html>)

Figure 5.31 Common Duct Development Example in Minato Mirai



Common Duct	
Extended distance	Approx. 7.0 km
Auxiliary facility	Drainage, ventilation, lighting, power receiving and distribution facilities, notification apparatus, grounding, disaster prevention safety system, monitoring equipment
Installed equipment	Electricity, gas, telecommunication, water supply, industrial water, CATV, DHC

Source: Released by MM21 DHC Co., Ltd. (<http://www.mm21dhc.co.jp/owner/kyodoko.php>) (English translation of JICA Study Team)

Figure 5.32 Typical Cross-Section for Common Duct in Minato Mirai



Figure 5.33 Attractive Urban Landscape with Common Duct development in Minato Mirai

The common duct plays a vital role especially in the urban disaster prevention aspect. As the Bang Sue area includes Bang Sue Grand Station and other key wider urban facilities, consideration to BCP measures is needed for basic infrastructure in the area. As for utility service rehabilitation after flooding or submergence highly likely to occur in Bangkok City, compared with the traditional direct burial installation of utility facilities, superior advantage points can be provided to identify failure parts in the systems of tap water, electricity and communication in the common duct and conduct reconstruction work. And furthermore, at the time of typhoon and other severe storms, the underground electric and communication network is overwhelmingly more resilient than the conventional cable network installed on the ground. Therefore, common duct development with no utility pole is meaningful, from the perspectives of smart energy network development contributing to energy security improvement.

The following photos show collapsed electric poles caused by a natural disaster in Japan.



Source: “Recent approach on the promotion of no electric poles,” released by the Ministry of Land, Infrastructure, Transport and Tourism

Figure 5.34 Collapsed Electric Poles Caused by Typhoon in Japan

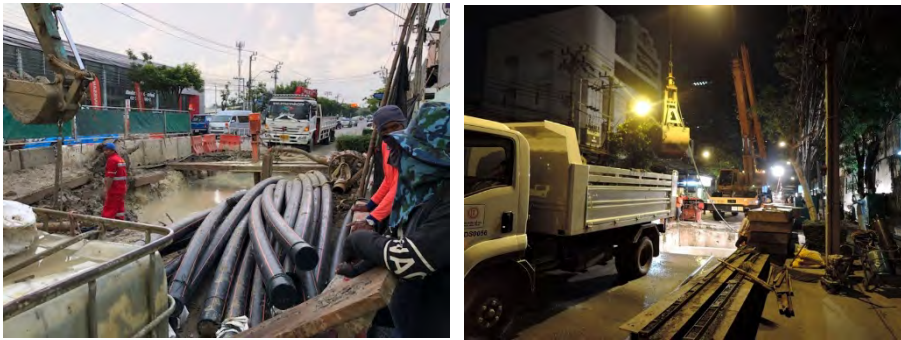
In addition, as Metropolitan Electricity Authority (MEA) in Thailand focuses on landscape aspects, safety and supply reliability, it has facilitated a project with no electric poles in the main road for sightseeing destinations or business districts. In the Bang Sue area which has promoted advanced smart city, too, no electric pole development is desirable with the construction of common duct and others. The following photos show the current electric poles and underground burial installation of electric poles in Bangkok. As a noteworthy aspect, the underground burial

installation of electric poles is effective in the prevention of unauthorized power connection or stealing electricity.



Source: “Consideration on the promotion of no electric poles in Japan on the basis of comparison with overseas cases,” released by the Civil Engineering Research Institute for Cold Region

Figure 5.35 Current Electric Pole in Thailand



Source: GeoRhizome Co., Ltd. (<https://www.georhizome.com/archives/column/2701>)

Figure 5.36 Underground Burial Installation of Electric Poles in Thailand

(2) Proposed Development Plan for Common Duct

1) Development Objective and Policy for Common Duct

Based on the above consideration, the objectives and policies for common duct and CC BOX are organized in the Bang Sue area.

<Development objective>

- Create attractive urban landscape (Create superior urban landscape with no electric poles)
- Rationalize maintenance work for urban infrastructure (Effective maintenance management)
- Make effective use of road space (space saving, eased traffic jam coupled with road drilling work, etc.)
- Secure safe, comfortable pedestrian space (Accident prevention with no excavation, no height difference with sidewalks)
- Enhance urban disaster prevention functions (Preserve urban lifeline and enhance disaster prevention power)
- Advantage in identifying failure areas or conducting reconstruction work at disaster recovery
- Respond to long-term and stepwise development plans (Secure smooth expansion/renewal and easiness)

<Development policy>

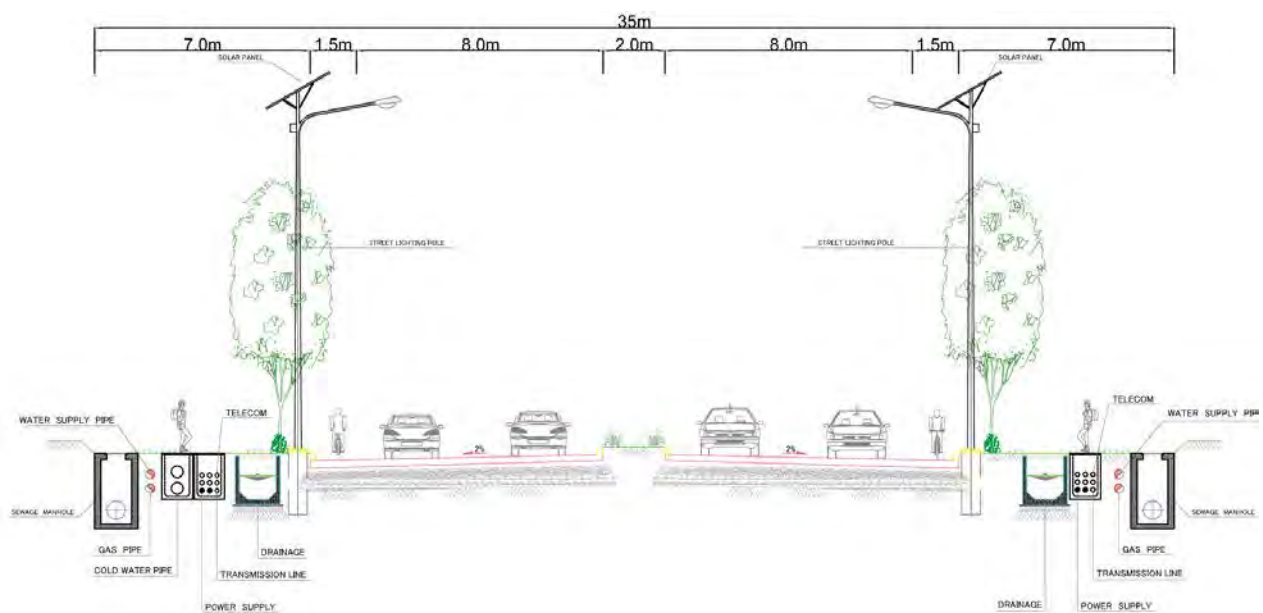
- Develop CC BOX under all the roads (Complete underground burial installation of electric and communication cables)
- Develop common duct in the area where cold water ducts are to be installed for regional heat supply.

2) Development Method for Common Duct

As cited earlier, in order to work out a development plan for common duct, the outer shell needs to be installed with proper volume and specifications in the road space earlier than land plot development. To this end, as indispensable conditions, land use for neighboring land plot or floor area ratio needs to be decided beforehand in the common duct development, which is suitable for development work in line with the master plan, etc.

As development work for common duct needs huge amount of the initial investment cost before development revenues are brought, innovative ideas are needed to procure development funds, including PPP scheme or collection models for usage fees. And also, in order to secure development space for common duct and CC BOX, consideration is needed on the installation space for rainwater or sewer pipes and street trees, etc. in the limited width for road space, and the underground space needs to be properly allocated to avoid interfering with other utilities. In the development space between common ducts, ground equipment needs to be installed to store ground transformers or switches at regular intervals, together with special parts section to store communication closures, etc., which is a common method in the area with no electric poles in Bangkok and has been already facilitated onsite.

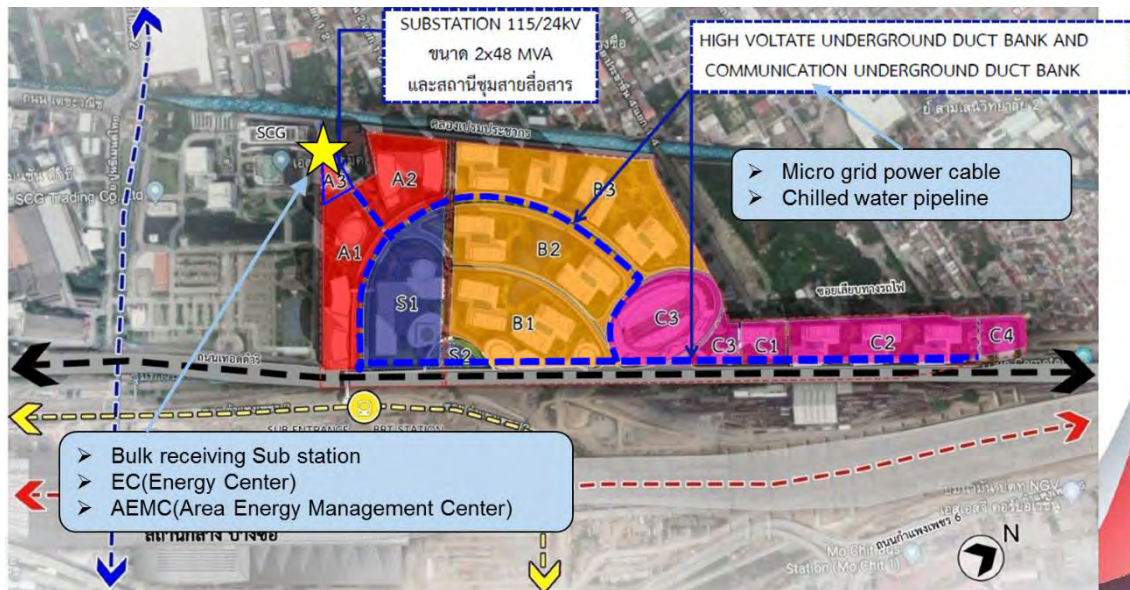
As an example to develop common duct and CC BOX in the road space, the following figure shows a cross-section example to use underground pedestrian space.



Source: JICA Study Team

Figure 5.37 Typical Cross-Section Drawing for Road Development Area (Posted previously)

Based on Zone E case, the development locations for common duct are organized in the road space. Although SRT is considering development plans for Zone E, the underground burial installation of electric and communication cables is expected as shown in the following figure.



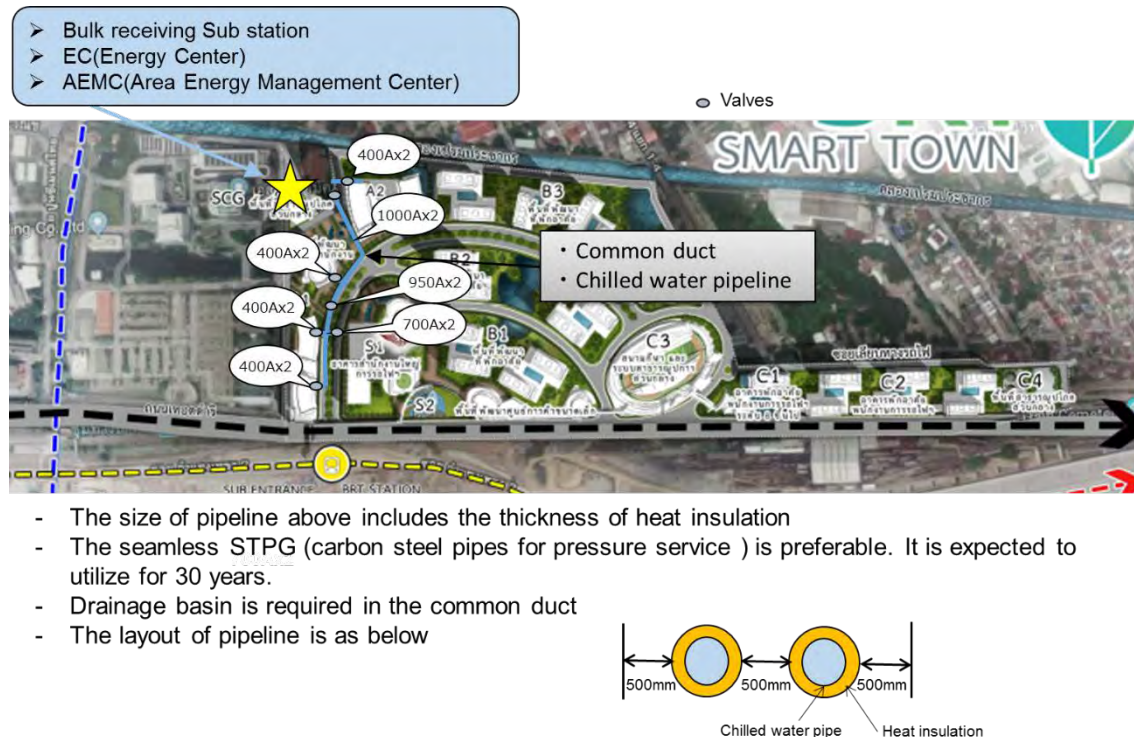
Source: SRT's documents revised partially by JICA Study Team.

Figure 5.38 Underground Burial Installation of Electric Poles for Zone E under Consideration

In the area where cold water pipes are installed for regional cooling, CC BOX needs to be expanded as shown in the above figure and common duct development is needed to install cold water pipes.

The following figure shows necessary space for common duct development area and cold water pipe diameter. Similarly in other zones, common duct development is needed in the area where cold water pipes are to be installed within the zone from EC.

In order to work out detail development plans for respective zones, consideration is needed effectively, aligning development plans for common duct and CC BOX with ones for cold water pipe network for regional cooling use and microgrid system.

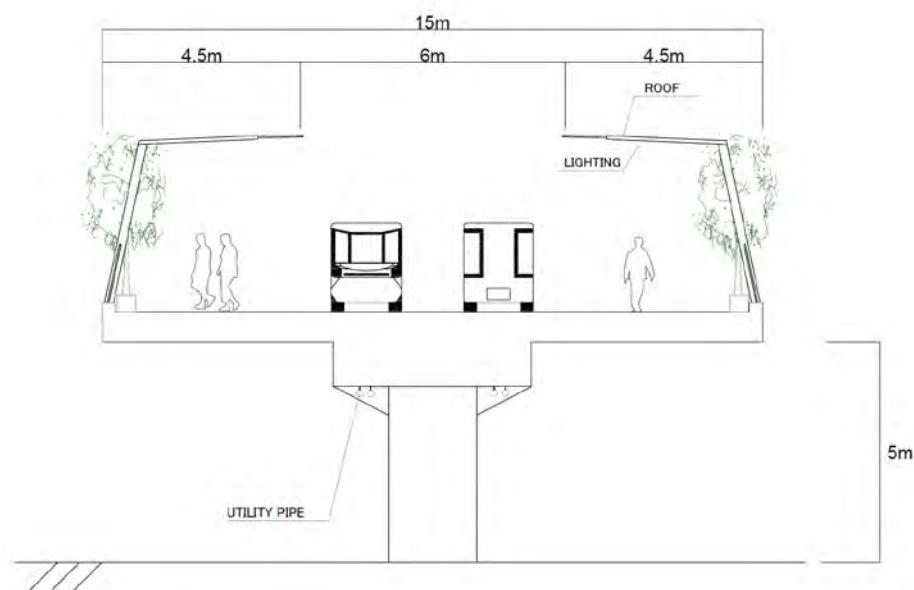


Source: SRT's documents revised partially by JICA Study Team.

Figure 5.39 Proposed Common Duct Development in Zone E

As the sky deck network is planned to connect with respective zones in the Bang Sue area, the utility network crossing the area can be installed on the sky deck. Although detail consideration is needed in the future, the utility network can be developed at more reasonable costs than in the underground utility tunnel development.

The following figure shows an example to install piping, etc. with the use of effective space for the sky deck.

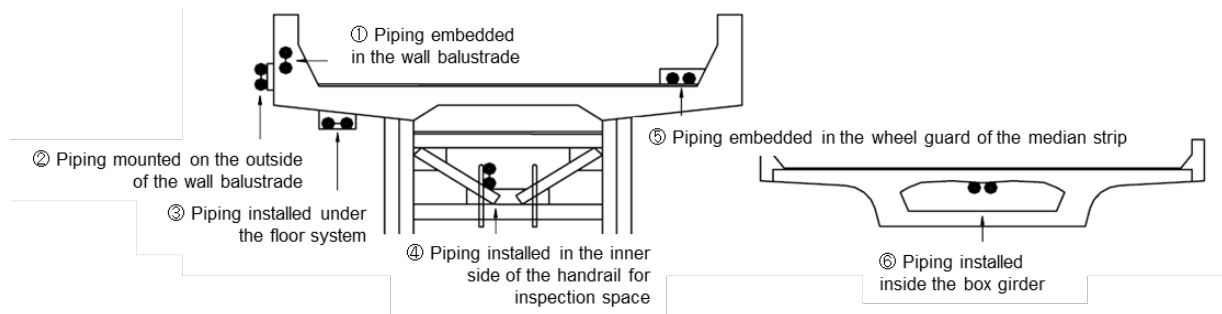


Source: JICA Study Team

Figure 5.40 Typical Cross-Section Drawing for Sky Deck Network (Posted previously)

In order to mount on the elevated structure like sky deck, the optimal installation method need to

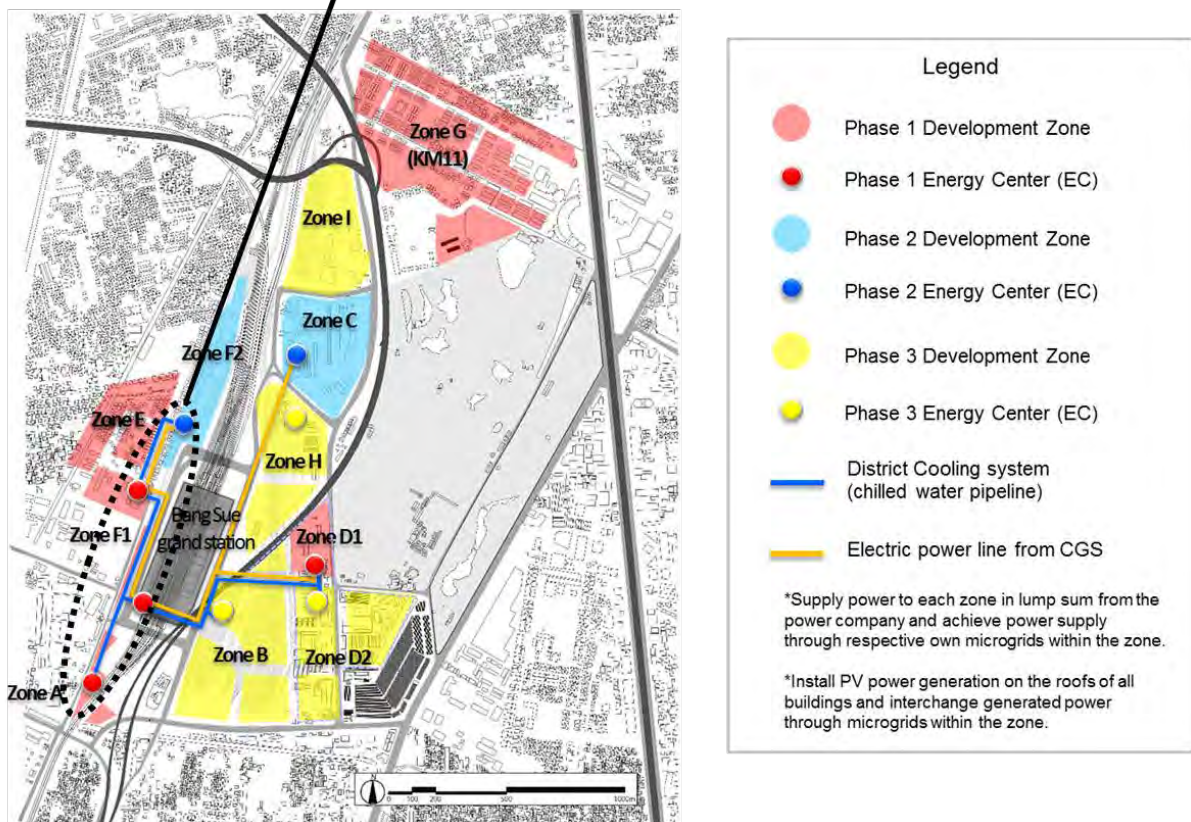
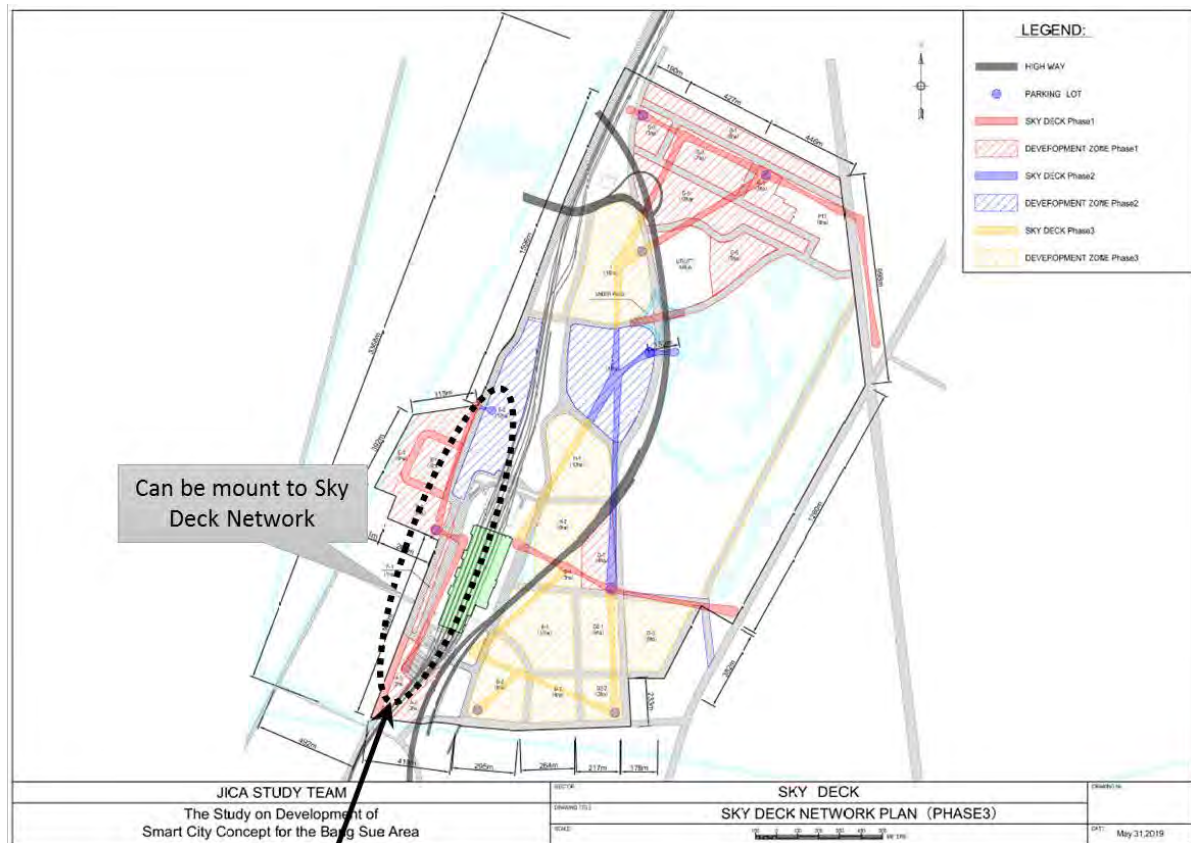
be examined, considering piping installation location, onsite construction conditions (workability, landscape, straightness, maintainability, safety, profitability and legal isolation conditions depending on use, etc.). The following figure shows a piping installation example on the elevated structure.



Source: “Version No. 5 Telecommunication part in the road design guideline in Hokkaido Regional Development Bureau for FY2019,” released by Hokkaido Regional Development Bureau, the Ministry of Land, Infrastructure, Transport and Tourism (English translation of JICA Study Team)

Figure 5.41 Piping Installation in Elevated Bridge Part

Based on the proposed sky deck network development for Bang Sue, as shown in the following figure, cold water pipes for regional cooling are to be connected with the area from Zone A to Bang Sue Grand Station and with the area from Bang Sue Grand Station to Zone E through the instalment on the sky deck network. As a noteworthy point, the utility common duct to mount on the sky deck network can protect electric or communication wires and tap water supply pipes from flooding or submergence.

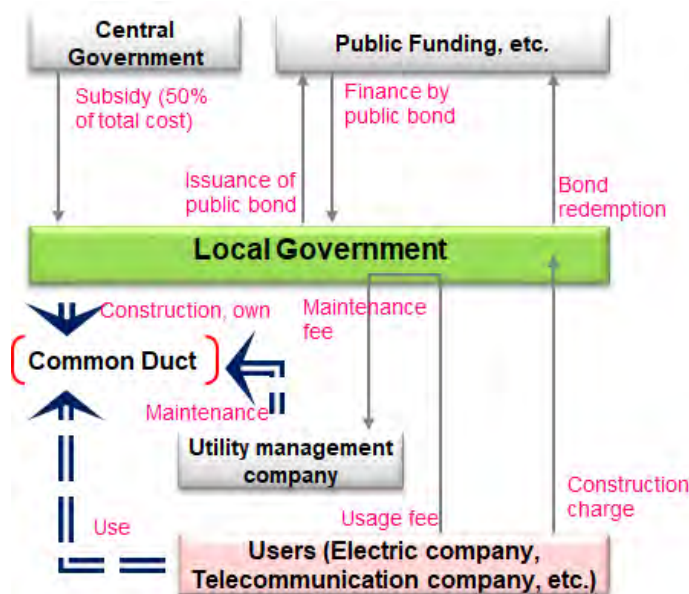


Source: JICA Study Team

Figure 5.42 Point to Install on Sky Deck Network

(3) Development Entity for Common Duct

While the public and private sectors are to develop these utility common ducts cooperatively, it is imperative especially for the public sector to cover the facility development costs. The following figure shows a project scheme for a utility common duct development case (CC BOX) in Japan. In Japan, the local government is the main responsible entity to develop the facility, while they require utility tunnel users to cover costs in proportion to their usage rate, and 50% of the development costs is covered by national subsidies.



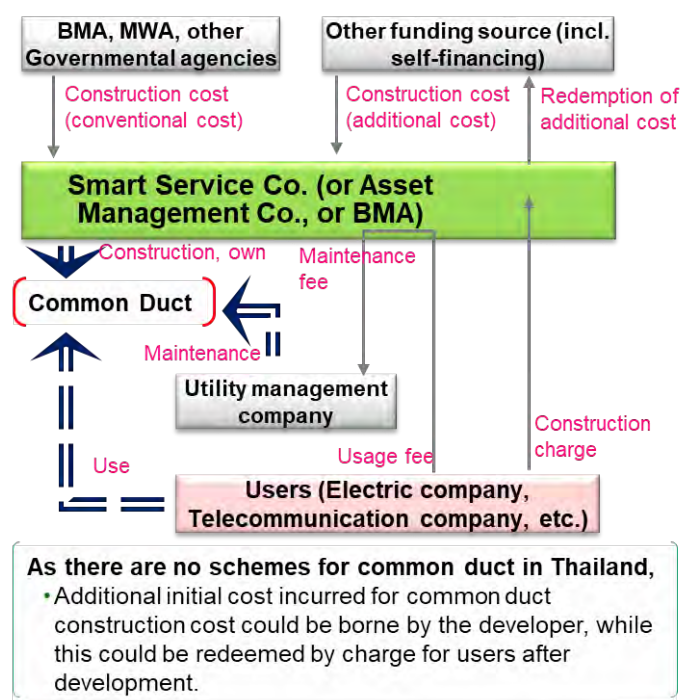
Source: JICA Study Team

Figure 5.43 Utility Common Duct Development Scheme in Japan

The following two cases are considered in common duct development in Bang Sue.

- When the common duct is constructed within the development zone: respective zone developers develop the facility as part of their infrastructure development for their zone.
- When the common duct is constructed outside the development zone (under the main road or in the case of crossing zones): either SSC (or AMC, or BMA) develops the facility

In the latter case, the greatest challenge is how to raise the investment capital. The following figure shows a proposed common duct development scheme, based on Japan's scheme.



Source: JICA Study Team

Figure 5.44 Proposed Common Duct Development Scheme in Bang Sue

Legal systems or support schemes have not yet been established for common duct construction in Thailand. Therefore, further considerations into such issues as coordination with related organizations and development scheme are needed to take forward the plan.

Occupation fees are not generated for the cable with 10 mm or smaller in diameter in Thailand, which causes unused communication cables, etc. to be left unattended with no removal from electric poles and brings problems for management or unnecessary cable treatment, etc. Therefore, installation regulations for common duct and CC BOX need to be stipulated and rules are needed on fair cost coverage for users (occupation fee, etc.).

In addition, the proper space needs to be secured to develop various utilities (public infrastructure including electricity, gas or water) and detail consideration is also needed to devise utility master plans (electricity, regional cold water conduit pipe, water and sewerage, communication wire, etc.) for development and expansion in a planned fashion.

5.3 Estimated Project Cost

(1) General conditions regarding project cost estimation

Based on the basic plan, estimated project costs for each development stage are calculated using the construction unit price adopted by the international contractor.

(2) Project cost index

As described in the basic plan, cost estimation are made separately in civil works and building works. The project scope follows the phasing plan set forth in the development plan, and thus the project cost covers first phase to the full phase development. The cost index related to Bang Sue Station construction for Red Line development were excluded from the cost estimation, as well as other facilities which shall be constructed regardless of Bang Sue development project. The project cost also excludes the land fee as it is owned by SRT.

(3) Timing of the valuation

The costs are based on the valuation as of May 2019, while the exchange rate for Thai baht is set at 1 USD = 31.72 THB, which is the currency exchange rate as of 15th May 2019.

(4) Unit price for cost estimation

The construction unit prices for the development plan were set following a review by construction consultants based in Thailand. The unit prices include materials, construction, and general administrative costs.

(5) Estimated project cost

Taking into account the above mentioned unit price and basic plan, project cost were estimated by infrastructure type and facility type. The estimations are shown in the following pages.

Table 5.17 Project cost estimate for Bang Sue Area development

Approximate Cost Estimate for Bang Sue Area Development: Bang Sue Smart City Concept Study

Approximate Cost Estimate for Bang Sue Area Development: Bang Sue Smart City Concept Study																	USD=31.72THB as of 15 May, 2019			
Category		Item		Standard	Total Number	Unit	Unit Price (USD)	Total (USD)	Number			Price (USD)			Total (Million THB)	Price (Million THB)				
									Phase1	Phase2	Phase3	Phase1	Phase2	Phase3		Phase1	Phase2	Phase3		
Layer 1	Basic Infrastructure	Road	Major road	4 lane W=35m	2,350	m	1,800	4,230,000	420	330	1,600	756,000	594,000	2,880,000	134	24	19	91		
			Zone boundary road	4 lane W=35m, 2lane W=28m	4,850	m	1,800	8,730,000	1,940	370	2,540	3,492,000	666,000	4,572,000	277	111	21	145		
			Underpass	Intersection underpass	3,000	m ²	3,000	9,000,000	3,000	0	0	9,000,000	0	0	285	285	0	0		
			Street lighting	per20m/both side	720	point	750	540,000	236	70	414	177,000	52,500	310,500	17	6	2	10		
			Traffic signal	Multi color graphic	16	point	1,000,000	16,000,000	8	1	7	8,000,000	1,000,000	7,000,000	508	254	32	222		
		Water	Water plant	Q=6,000m ³ /dav	60,000	m ³	300	18,000,000	30,000	30,000	0	9,000,000	9,000,000	0	571	285	285	0		
			Reservoir	V=10,000m ³	10,000	m ³	130	1,300,000	10,000	0	0	1,300,000	0	0	41	41	0	0		
			Water pipe	HDPE pipe	14,400	m	200	2,880,000	4,720	1,400	8,280	944,000	280,000	1,656,000	91	30	9	53		
		Sewer	Concrete pipe	RC pipe (D=600)	14,400	m	200	2,880,000	4,720	1,400	8,280	944,000	280,000	1,656,000	91	30	9	53		
			Manhole	per 40m	360	point	1,000	360,000	118	35	207	118,000	35,000	207,000	11	4	1	7		
			Sewege treatment plant	Q=48,000m ³ /dav	48,000	m ³	300	14,400,000	48,000	0	0	14,400,000	0	0	457	457	0	0		
		Drain	Drainage	Box culvert (2m×2m)	14,400	m	1,000	14,400,000	4,720	1,400	8,280	4,720,000	1,400,000	8,280,000	457	150	44	263		
			Pumping station	Q=1m ³ /s	4	point	1,000,000	4,000,000	4	0	0	4,000,000	0	0	127	127	0	0		
		Power	Transmission cable (MEA/EGAT)	110kV(2lines)	5,000	m	3,000	15,000,000	4,500	500	0	13,500,000	1,500,000	0	476	428	48	0		
			Primary substation (MEA/EGAT)	Substation	2	point	10,000,000	20,000,000	1	1	0	10,000,000	10,000,000	0	634	317	317	0		
		Telecom	Optic fiber cable		33,600	m	10	336,000	15,420	2,100	16,080	154,200	21,000	160,800	11	5	1	5		
			Gas	Gas pipeline (PTT)		3,360	m	50	168,000	2,100	60	1,200	105,000	3,000	60,000	5	3	0	2	
		Common duct	Common duct for power and telecom cable		22,400	m	1,250	28,000,000	10,280	1,400	10,720	12,850,000	1,750,000	13,400,000	888	408	56	425		
	Common duct for utility supply pipeline			4,600	m	1,000	4,600,000	1,710	920	1,970	1,710,000	920,000	1,970,000	146	54	29	62			
	Disaster Prevention	Retention pond			10	ha	100,000	1,000,000	4	2	4	400,000	200,000	400,000	32	13	6	13		
	Green network	Green/Plantation (Park)	Park		79,300	m ²	10	793,000	30,000	14,400	34,900	300,000	144,000	349,000	25	10	5	11		
		Green network (Street tree)	Street tree		1,800	point	200	360,000	590	175	1,035	118,000	35,000	207,000	11	4	1	7		
	Layer 2	Sky Deck	Sky deck network (Outside zones)	Sky deck (Outside zones)	H=6m, W=15m, L=4,100m	60,900	m ²	1,200	73,080,000	40,300	12,000	8,600	48,360,000	14,400,000	10,320,000	2,318	1,534	457	327	
		Smart Environment	Waste management	System - Control		1	unit	272,700	272,700	1	0	0	272,700	0	0	9	9	0	0	
System - Sensor					30	unit	320	9,600	40	40	20	12,800	12,800	6,400	0	0	0	0		
Pollution management			System - Control		1	unit	272,700	272,700	1	0	0	272,700	0	0	9	9	0	0		
			System - Sensor		150	unit	320	48,000	40	40	20	12,800	12,800	6,400	2	0	0	0		
Smart City Platform		Smart city center	Utility space		3,000	m ²	551	1,652,640	3,000	0	0	1,652,640	0	0	52	52	0	0		
			Data center		500	m ²	3,800	1,900,000	500	0	0	1,900,000	0	0	60	60	0	0		
			Parking		3,000	m ²	330	990,000	3,000	0	0	990,000	0	0	31	31	0	0		
			Server	100 shelves in the 40 servers	4,000	unit	1,000	4,000,000	2,000	1,000	1,000	2,000,000	1,000,000	1,000,000	127	63	32	32		
			CCTV		300	unit	1,500	450,000	100	100	100	150,000	150,000	150,000	14	5	5	5		
			System- Infrastructure	Infrastructure	3	unit	2,863,636	8,590,909	1	1	1	2,863,636	2,863,636	2,863,636	273	91	91	91		
			System- Retail area	Retail Area	1	unit	5,909,091	5,909,091	0.39	0.23	0.38	2,320,139	1,364,052	2,224,900	187	74	43	71		
Smart Energy		Smart Energy	PRT	Vehicle, equipments	unit price- tentative	368	unit	90,900	33,451,200	66	235	67	5,999,400	21,361,500	6,090,300	1,061	190	678	193	
				System development		1	unit	9,007,390	9,007,390	1	0	0	9,007,390	0	0	286	286	0	0	
			Fringe parking	Multistory parking lot		193,900	m ²	330	63,987,000	88,100	36,700	69,100	29,073,000	12,111,000	22,803,000	2,030	922	384	723	
				Chiller set		70,500	USRT	2,252	158,766,000	22,100	18,600	29,800	49,769,200	41,887,200	67,109,600	5,036	1,579	1,329	2,129	
	Energy Center		Heat strage		70,000	USRT	225	15,750,000	30,000	20,000	20,000	6,750,000	4,500,000	4,500,000	500	214	143	143		
			Cogeneration set		13,320	kW	2,252	29,996,640	4,440	4,440	4,440	9,998,880	9,998,880	9,998,880	951	317	317	317		
	Solar power			53,739	kW	1,180	63,412,020	20,123	11,928	21,688	23,745,140	14,075,040	25,591,840	2,011	753	446	812			
	Chilled water pipeline			4,600	m	6,305	29,003,000	1,710	920	1,970	10,781,550	5,800,600	12,420,850	920	342	184	394			
	Transmission cable			128,390	m	18	2,311,020	67,190	6,390	54,810	1,209,420	115,020	986,580	73	38	4	31			
	Secondary substation (bulk receiving station)			9	point	900,740	8,106,660	3	2	4	2,702,220	1,801,480	3,602,960	257	86	57	114			
Step - down transformer		136,150	kVA	45	6,126,750	51,699	31,080	53,371	2,326,455	1,398,600	2,401,695	194	74	44	76					
EMS	SEMC		1	Set	1,801,450	1,801,450	1	0	0	1,801,450	0	0	57	57	0	0				
	BEMS		12	building	270,230	3,242,760	6	4	2	1,621,380	1,080,920	540,460	103	51	34	17				
	HEMS		51,866	house	630	32,675,580	19,694	11,840	20,332	12,407,220	7,459,200	12,809,160	1,036	394	237	406				
Layer 3	Building	Office	Office		884,600	m ²	1,500	1,326,900,000	425,000	119,600	340,000	637,500,000	179,400,000	510,000,000	42,089	20,222	5,691	16,177		
			Commercial facility		730,700	m ²	1,500	1,096,050,000	193,900	225,000	311,800	290,850,000	337,500,000	467,700,000	34,767	9,226	10,706	14,835		
			Residence		3,626,900	m ²	1,500	5,440,350,000	1,377,300	828,900	1,420,700	2,065,950,000	1,243,350,000	2,131,050,000	172,568	65,532	39,439	67,597		
			Hotel		364,500	m ²	1,500	546,750,000	123,000	90,000	151,500	184,500,000	135,000,000	227,250,000	17,343	5,852	4,282	7,208		
		Cultural facility	Arena		50,000	m ²	2,000	100,000,000	0	50,000	0	0	100,000,000	0	3,172	0	3,172	0		
			Exhibition center		50,000	m ²	500	25,000,000	0	50,000	0	0	25,000,000	0	793	0	793	0		
			Educational facility/Hospital		100,000	m ²	1,500	150,000,000	100,000	0	0	150,000,000	0	0	4,758	4,758	0	0		
		Public office	SRT Office/ Public office		100,000	m ²	1,500	150,000,000	100,000	0	0	150,000,000	0	0	4,758	4,758	0	0		
		Zone Infrastructure (Inside zones)	Zone Infrastructure (Inside zones)	Embankment	Fill	1m	1,422,050	m ³	12	17,064,600	583,950	244,800	593,300	7,007,400	2,937,600	7,119,600	541	222	93	226
	Road (Inner zones)					4,000	m	1,800	7,200,000	2,780	0	1,220	5,004,000	0	2,196,000	228	159	0	70	
	Street lighting					400	point	750	300,000	278	0	122	208,500	0	91,500	10	7	0	3	
	Water			Street tree		1,000	point	200	200,000	695	0	305	139,000	0	61,000	6	4	0	2	
				Water pipe		8,000	m	200	1,600,000	5,560	0	2,440	1,112,000	0	488,000	51	35	0	15	
				Concrete pipe		8,000	m	200	1,600,000	5,560	0	2,440	1,112,000	0	488,000	51	35	0	15	
	Sewer			Manhole		200	point	1,000	200,000	139	0	61	139,000	0	61,000	6	4	0	2	
				Drainage		8,000	m	1,000	8,000,000	5,560	0	2,440	5,560,000	0	2,440,000	254	176	0	77	
	Sky Deck			Sky deck network (Inside zones)	Sky deck (Inside zones)	H=6m, W=15m, L=6,900m	103,300	m ²	1,200	123,960,000	42,200	16,300	44,800	50,640,000	19,560,000	53,760,000	3,932	1,606	620	

Table 5.18 Project cost estimate for Bang Sue Area development by layer and category

Category		Approximate cost (Million THB)			
		Phase 1	Phase 2	Phase 3	Total
Layer 1	Basic Infrastructure	3,019	872	1,337	5,228
	Disaster Prevention	13	6	13	32
	Green Network (Park)	13	6	18	37
Layer 2	Sky Deck (Outer the Zones)	1,534	457	327	2,318
	Smart Environment	18	1	0	19
	Smart City Platform	377	171	198	745
Layer 3	Smart Mobility	1,398	1,062	916	3,376
	Smart Energy	3,905	2,795	4,440	11,140
Layer 4	Building: Office, Commercial, Residence, Hotel	100,832	60,117	105,818	266,767
	Building: Cultural facility, Public office	9,516	3,965	0	13,481
	Zone Infrastructure	643	93	411	1,147
	Sky Deck (Inside the Zones)	1,606	620	1,705	3,932
Total		122,874	70,165	115,183	308,222

Source: JICA Study Team

5.4 Project implementation structure and finance scheme

In this section, project implementation structures and finance schemes are proposed for the realization of Smart City development in the Bang Sue Area. In the subsequent section, profitability for smart city infrastructure (sky deck network, etc.) development and smart service business, which would be a key for successful smart city development, is analyzed to examine the proposed project implementation structures and the finance schemes.

5.4.1 Process of Study and Organizations Related to Bang Sue Development

Organizational structure and finance schemes were considered and proposed following discussion with the organizations related to Bang Sue Smart City development. Ideas and intentions of the related organization were reflected in the considerations, while the status of SRT Asset Management Company (AMC) and Smart Service Company (SSC) was also examined in order to propose a practical structure.

Table 5.19 Discussion on organizational structure and finance schemes with related organization

Date	Meeting	Details
Dec. 12, 2018	DEPA	• Institutional framework and support scheme for Thai smart city development
Dec. 14, 2018	SEPO (State Enterprise Policy Office)	• General explanation on Thailand Future Fund (TFF), Thai governance structure for state-owned company and SEPO's stance on Bang Sue Smart City development project
Dec. 13 to 21, 2018	Workshops for 7 Smart Components	• Workshops with the relevant organizations on development directions regarding the 7 smart components.
Feb. 13, 2019	SRT	• Discussions on zone development, structure for integrated development structure, and smart mobility/ energy service.
Feb. 14, 2019	ITR meeting	• Discussion on project implementation system and the importance of Steering Committee for Bang Sue Area development.
Feb. 15, 2019	SRT Board	• Confirmation on the importance of establishment of the Steering Committee for clarifying AMC's role and coordination among relevant organizations.
Feb. 15, 2019	Briefing to Minister of Transport	• Confirmed the importance of a body which oversees the situation of Bang Sue development and a platform on which roles among ministries would be coordinated. Also confirmed the need to consider project implementation structure assuming a specific estimate costs and potential investors.
April 23, 2019	SRT Board member	• Confirmed the need for a structure to promote integrated development in the Bang Sue Area
May 15 to 18, 2019	OTP (Invitation to Japan)	• Discussion on project promotion structure and model scheme for urban development, based on visits to Yokohama Minato Mirai development, Kashiwa-no-ha development and Umekita development sites, etc.
May 30, 2019	OTP	• Confirmed and discussed proposed measures on establishment of a committee based on Japanese experience on integrated city development.
June 5, 2019	SRT	• Discussion on: AMC's role; the need for coordination among infrastructure developers; and challenges for SRT to finance initial investment for infrastructures.
June 5, 2019	SRT Board	• Confirmed intentions to set up a Steering Body that monitors Bang Sue development. Also acknowledged the challenges for limited government budgets on public works.
Aug.-Oct. 2019	OTP/SRT/Related institutions	• Discussions on: the roles among public entities for infrastructure development based on estimate project cost; project implementation structure; and finance scheme.
Nov. 2019	OTP/SRT/Related institutions/Minister of Transport	• Discussions and confirmation on: overall project outputs, project implementation structure; and finance scheme.

Source: JICA Study Team

In considering the project implementation structure for Bang Sue development, the main organizations are summarized as below. Organization structure and the respective roles for the relevant organizations, SRT Asset Management Company, and Smart Service Companies are described later.

Table 5.20 Main organizations related to Bang Sue Area development

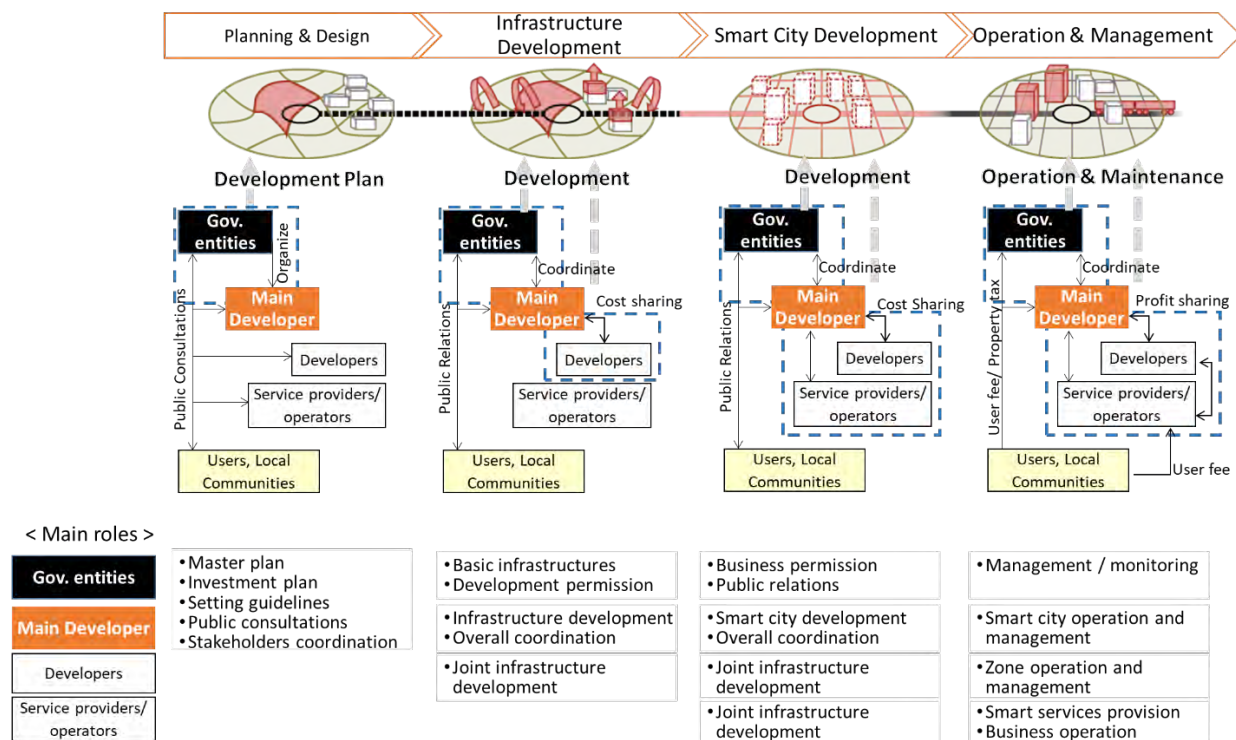
Organizations	Main roles
Ministry of Transport (MOT)	National government agency supervising SRT. Under MOT, the OTP is responsible for formulating the development plan and the Smart City development plan for Bang Sue.
National Government agencies	Enforcement of legal system and permission and approval for various projects. MoF (SEPO): SRT's financial status management MoE: Energy-related businesses MDES: Secretariat for smart city development NESDC: Formulation of national development measures, etc.
Organizations related to infrastructure services	Supply various infrastructure services MEA: Power supply business EGAT: Power generation business PTT: Gas supply business MWA: Water supply business and sewage treatment business BMA: Urban road development and waste collection/treatment in Bangkok DOH: Highway/National road development BMTA: Provide public bus service in Bangkok Transport Co., Ltd.: Mo Chit Bus Terminal Operator (State-owned enterprise)
Local government (BMA)	Formulation of urban development plan for Bangkok and land use regulations
SRT	Land owner for Bang Sue Area
SRT Asset Management Company	Proposed to set up as a SRT's wholly owned subsidiary. The main roles are as follows: ➤ Manage lease contracts for SRT-owned land ➤ Allocate and negotiate development areas ➤ Land development project (through leasing or purchasing land from SRT and implement land development.)
Smart Service Co.	Company to engage in Smart City-related businesses in Bang Sue area. Regional energy businesses and other smart service projects are being considered.
Zone Developer	Developers for respective zones. Responsible for infrastructure development in the zones as well.
Tenant	Companies, and business owners that comes to commercial or operation buildings or houses, etc. developed in the respective zones.
User	Visitors and residents in the Bang Sue Area (Railway users, visitors for commercial or buildings or residents in the residential buildings.)

Source: JICA Study Team

5.4.2 Proposed Project Implementation Structure

(1) Framework for project implementation structure for Smart City or TOD Development

In smart cities and integrated urban development projects, it is necessary to cooperate with multiple entities, including government organizations, developers, and service providing companies, depending on the stages of planning, development and operation. The following figure summarizes the general roles for related agencies, associated with the stages for planning, development and operation in urban development projects with regards to private participation.



Source: Compiled by JICA Study Team, based on "Financing Transit-Oriented Development with Land Values" (World Bank)

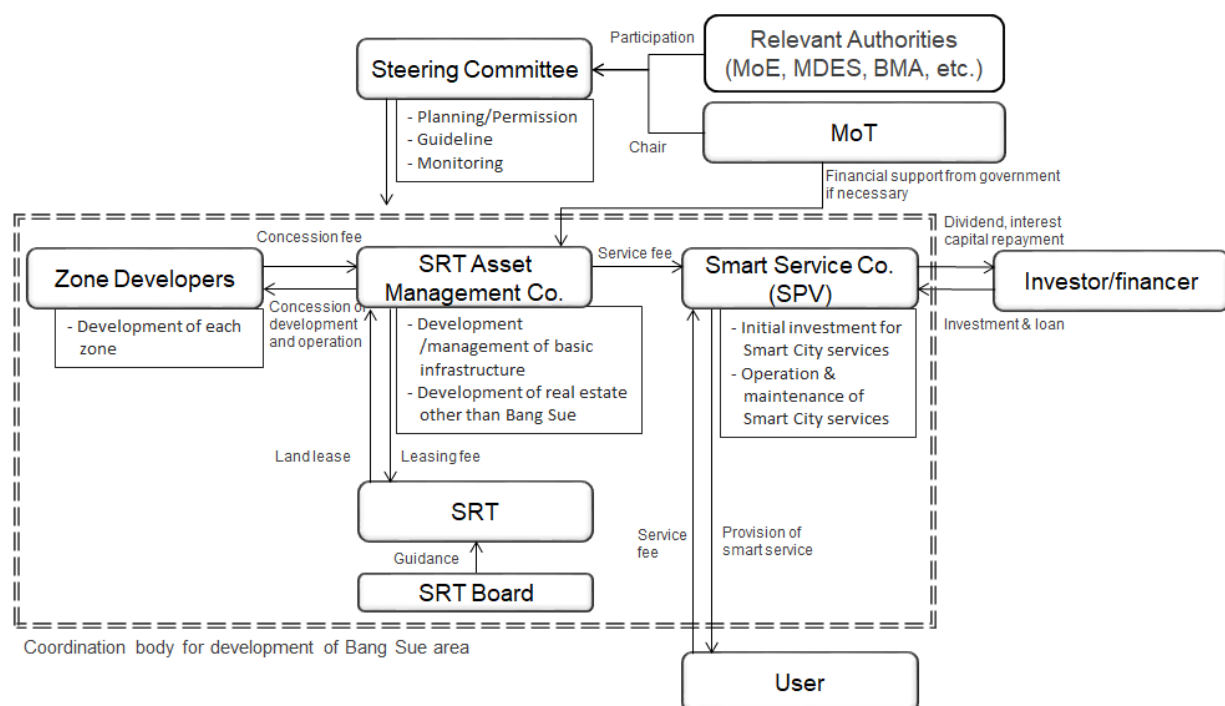
Figure 5.45 Role of main players in the Smart City development stage

As indicated above, the roles for related players are different in accordance with development stages for urban development. It is therefore necessary to ensure an institutional setup which facilitates cooperative relations with each related player in the long term. In particular, the number of relevant organizations would be larger in Smart City development project, as it relates to a wider range of fields. Therefore, it is important for a responsible developer and an agency to take an initiative and coordinate the entire project. Under the initiative of the responsible entity, a cooperative framework needs to be in place to discuss and address challenges in a cross-sectional approach.

(2) Proposed overall development structure for Bang Sue Area Development

In order to develop the Bang Sue area as an integrated smart city in the future, information should be efficiently shared among the main stakeholders while development should be implemented under an integrated development plan. The main stakeholders include: MOT and other Central Government agencies; SRT; Asset Management Company (AMC); Smart Service Company whose establishment is being proposed in this study; and Zone Developers. It is important to clarify the scope of the responsibilities of each organization and to ensure sufficient capability for each.

In this section, the overall development structure for the Bang Sue Area development is considered and proposed. This proposed structure reflects the discussion with the Thai Counterparts in the Study, as well as the current administrative roles in Thailand and status of AMC's setup. It also takes lessons from Japanese cases on project implementation structure. The following figure shows the proposed overall development structure.



Source: JICA Study Team

Figure 5.46 Proposed overall development structure for Bang Sue Area development

SRT plans to establish AMC to look after immovable assets owned by SRT. After establishment of AMC, AMC will lease the land from SRT and develop the land under PPP or sub-leasing the areas to developers. It means that AMC serve as the full responsible entity of the Bang Sue Development.

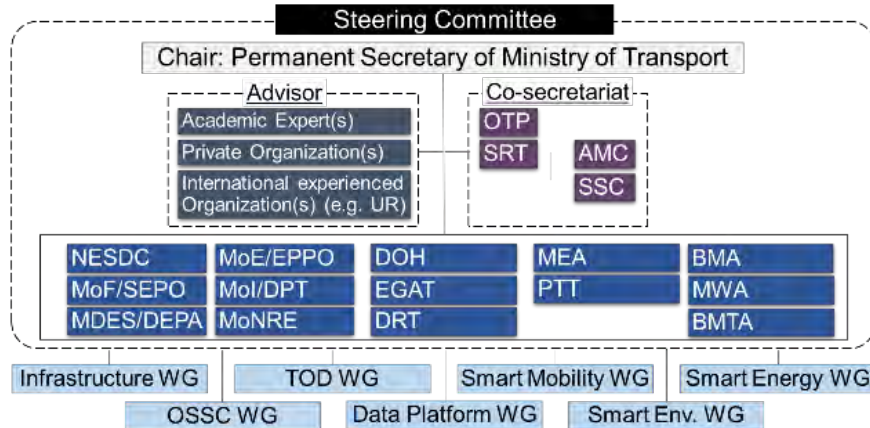
It should be noted that AMC will be established very soon and will function as planned properly, otherwise SRT shall take all responsibilities planned for AMC.

Roles and responsibilities for each organization are elaborated in the next section.

(3) Roles and responsibility for each organization in the overall development structure

The table below summarizes the roles of the concerned organizations in project implementation.

Table 5.21 Roles of the organizations for Bang Sue development (1/5)

Organization	Roles in Bang Sue Area development
Steering Committee	- SRT – the land owner of the Bang Sue Area, AMC – Asset Management Company, and the Ministry of Transport – the supervisory agency of SRT shall set up a committee in which the governmental agencies related to Bang Sue development would participate such as the Ministry of Energy and Bangkok Metropolitan Administration and other relevant agencies. The committee shall coordinate to solve political issues, authorize development plans and business plans, and arrange the management and operation system in order to realize an integrated development with Smart City services. The committee shall take an initiative in forming a consensus regarding the outline of the plan, and coordinate to promote projects, while at the same time monitor SRT and AMC's progress in developing the Bang Sue Area. - Since the Ministry of Transport is the supervisor of SRT, while also managing TOD development and Smart City development, it is recommended that the Ministry of Transport takes up the role of chairman of the committee (Permanent Secretary of Ministry of Transport would be suitable to chair), with OTP and SRT/AMC jointly participating as the secretariat. - It is proposed that the committee is to be held once every six months or so, to grasp the progress of the development, and to take necessary action. - A working group could be set up under the Steering Committee, if needed, to work on specific issues such as infrastructure development and TOD development, or smart services to work on legal issues such as deregulation and commercialization measures. - In the short term, the committee shall be held to gather relative organizations to share information on progress of the development projects and to coordinate on the imminent issues. - Building on the institutional arrangement of the steering committee, it is proposed that an organization (for example, Bang Sue One Stop Service Center (OSSC)) should be set up to manage all necessary applications and procedures for Bang Sue area development, under a one-stop system to get necessary permits or approvals. The organization would bear the responsibility for permits or approvals for Bang Sue area urban development or smart city development, accelerating the development speed. One of the obstacles it aims to overcome is the time it would require for deregulation and permits or approvals. The expected role of the OSSC is to receive all documents, which otherwise would be submitted to BMA or individual governmental organizations, and also to provide consultation for developers during the development procedure. - The members of the Steering Committee may also include academic experts, international organizations with experience in urban development (e.g. UR), or companies with knowledge in the business world as advisers. - The following figure shows the proposed structure for the Steering Committee.  The diagram illustrates the proposed structure for the Steering Committee. At the top is the 'Steering Committee' box. Below it, the 'Chair: Permanent Secretary of Ministry of Transport' is listed. To the left of the Chair is an 'Advisor' box containing 'Academic Expert(s)', 'Private Organization(s)', and 'International experienced Organization(s) (e.g. UR)'. To the right is a 'Co-secretariat' box containing 'OTP', 'SRT', 'AMC', and 'SSC'. Below these are two rows of boxes representing various departments: the first row includes NESDC, MoE/EPPO, DOH, MEA, and BMA; the second row includes MoF/SEPO, MoI/DPT, EGAT, PTT, and MWA. Below these are two more rows of boxes representing working groups: the first row includes MDES/DEPA, MoNRE, DRT, and BMTA; the second row includes Infrastructure WG, TOD WG, Smart Mobility WG, and Smart Energy WG. Below these are three more boxes representing working groups: OSSC WG, Data Platform WG, and Smart Env. WG. The entire structure is enclosed in a dashed box. <Proposed Structure for Steering Committee>

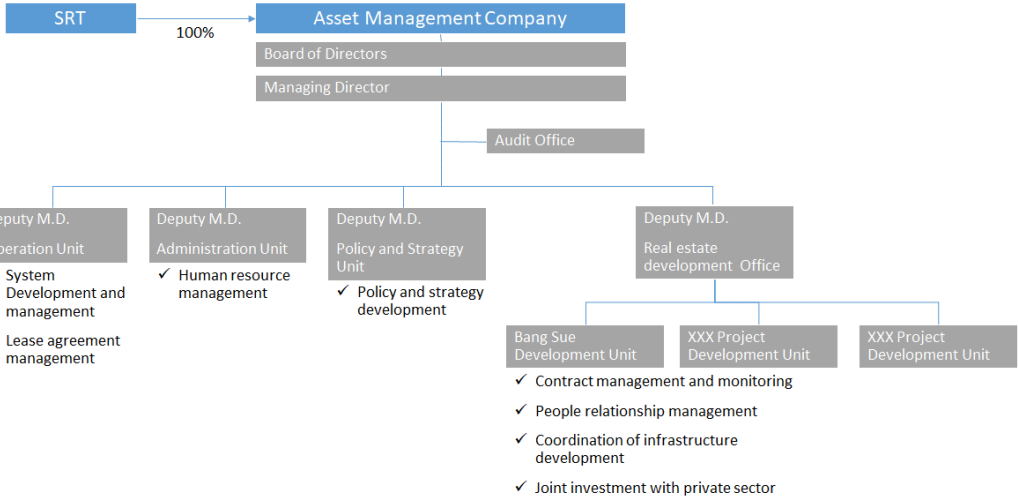
Source: JICA Study Team

Table 5.22 Roles of the organizations for Bang Sue development (2/5)

Organization	Role in Bang Sue Area Development
<i>SRT Asset Management Company (AMC)</i>	• AMC serves as the full responsible entity of the Bang Sue Development and coordinates stakeholders engaged in Bang Sue development. • AMC will lease the land from the SRT and develop the land under PPP or sub-leasing the areas to developers. The company will manage and lease contracts or service agreements, etc. between AMC and zone developers, or between AMC and Smart Service Company. • AMC also coordinates with BMA, MWA, MEA, etc. for the development of basic infrastructure in the Bang Sue area (road, drainage, water and sewerage, waste management). • AMC will pay “Service Fee” to SSC from concession fee paid by the developers, covering the cost of non-profitable smart services provided by SSC. AMC shall monitor Smart City services provided by SSC to ensure the required service level is achieved. • AMC shall engage in promotion and advertising activities in order to enhance attractiveness while forming sense of integrity for the Area. • In order to fulfil the responsibilities mentioned above, It shall be essential that a special unit dedicated to handle Bang Sue Area development is set up. This unit dedicated to Bang Sue shall engage in the following tasks under close cooperation with SRT and SSC. – Manage and monitor land lease contracts between SRT and zone developers or service provision contracts between SRT and SSC. – Promoting communication with the local community, and coordination with residents that would be subject to relocation, and enhancing public relations. – Coordinating with public entities for infrastructure development and managing the development process. • This special unit should have capable staff under a capable Managing Director of AMC. The special unit will become a subsidiary company under AMC if necessary. • Other unit may work for the formation of the organization structure, recruitment of new staff, managing land lease contracts for SRT, developing the Geographic Information Systems (GIS). The company would likely be occupied with transferred staff from SRT. • AMC shall continuously consider to provide innovative smart services together with SSC. • The figure below shows the proposed organization structure for AMC in the short-term. <pre> graph TD SRT[SRT] -- 100% --> AMC[Asset Management Company] AMC --> BD[Board of Directors] AMC --> MD[Managing Director] MD --> AO[Audit Office] MD --> DMD1[Deputy M.D. Operation Unit] MD --> DMD2[Deputy M.D. Administration Unit] MD --> DMD3[Deputy M.D. Policy and Strategy Unit] MD --> DMD4[Deputy M.D. Bang Sue Development Office] DMD1 --> SU1[✓ System Development and management] DMD1 --> SU2[✓ Lease agreement management] DMD2 --> SU3[✓ Human resource management] DMD3 --> SU4[✓ Policy and strategy development] DMD4 --> BSU[Special Unit for Bang Sue Dev.] BSU --> BSU1[✓ Contract management and monitoring] BSU --> BSU2[✓ People relationship management] BSU --> BSU3[✓ Coordination of infrastructure development] BSU --> BSU4[Planning and Contract Management Team] BSU --> BSU5[Project Coordination Team] BSU --> BSU6[Construction management Team] </pre> <Proposed Structure for AMC>

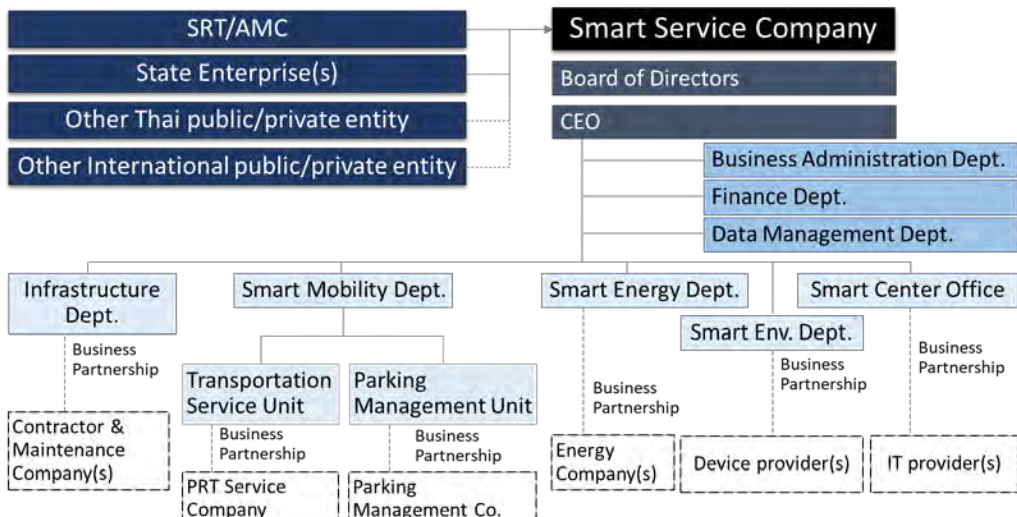
Source: JICA Study Team

Table 5.23 Roles of the organizations for Bang Sue development (3/5)

Organization	Role in Bang Sue Area Development
<i>SRT Asset Management Company (AMC)</i>	- In the long term, AMC shall also be tasked to leverage the experiences of city planning and Smart City development in Bang Sue Area for development projects in other SRT-owned lands. - The company is expected to expand the real estate development department, and expanding its business areas to real estate investment.  <pre> graph TD SRT[SRT] -- 100% --> AMC[Asset Management Company] AMC --> BD[Board of Directors] AMC --> MD[Managing Director] AMC --> AO[Audit Office] AMC --> DMO1[Deputy M.D. Operation Unit] AMC --> DMO2[Deputy M.D. Administration Unit] AMC --> DMO3[Deputy M.D. Policy and Strategy Unit] AMC --> DMO4[Deputy M.D. Real estate development Office] DMO1 --> SD[✓ System Development and management] DMO1 --> LM[✓ Lease agreement management] DMO2 --> HRM[✓ Human resource management] DMO3 --> PSD[✓ Policy and strategy development] DMO4 --> BSDU[Bang Sue Development Unit] DMO4 --> XPDU1[XXX Project Development Unit] DMO4 --> XPDU2[XXX Project Development Unit] BSDU --> CM[✓ Contract management and monitoring] BSDU --> PRM[✓ People relationship management] BSDU --> CID[✓ Coordination of infrastructure development] BSDU --> JI[✓ Joint investment with private sector] </pre> <Proposed Structure for AMC (Mid-to-long term)>

Source: JICA Study Team

Table 5.24 Roles of the organizations for Bang Sue development (4/5)

Organization	Role in Bang Sue Area Development
Smart Service Company (SSC)	- Since providing newly proposed smart services is NOT real estate businesses but is requiring private-oriented operational mind and know-hows, and the nature of the business is different from AMC, establishment of a new entity, namely “Smart Service Company” (hereinafter as SSC) is proposed. - SSC develops/operates/manages/maintains infrastructure for smart city development and provides smart city services, offering the service to zone developers and users (or visitors to the Bang Sue area) while ensuring that Smart City requirements are met. In principle, SSC shall own the infrastructures necessary to provide Smart City services as a whole. - Another function of SSC is to raise funds for smart related infrastructure and services. SRT and AMC may not have enough capacity to raise funds in the beginning stage of the development, so an entity who has enough financial capacity should be established. - There would be a few options to form the SSC: ✓ SSC could be established in the form of “SPV”. The government would decide the shareholders and the establishment of SSC as SPV shall be approved by the cabinet. ✓ SSC could be set up with investments from SRT/AMC and other entities (e.g. state owned enterprise) as a JV company. Thai’s public companies, public institutions or private companies, etc. both at home and abroad could join SSC in future. - With regards to the financial balance for SSC, the expenditure would be the investment on infrastructure for the Smart City service and the operation and maintenance fees, whereas the income would be the service fees paid by SRT or AMC, and the fees collected from the visitors to the Area. - Basically SSC will invest to infrastructure development in the area. SSC, however, would negotiate with public entities in charge of infrastructure development, such as BMA, Water works authority and Metropolitan Electric Authority (MEA) to determine the proper demarcation of roles and responsibility for the infrastructure development. - SSC shall continuously consider to provide innovative smart services together with AMC. - The figure below shows the proposed organization structure of the SSC. SSC may have several departments (or SPCs) to cover each smart infrastructure development and smart services, having business partnership with some private companies.  The diagram illustrates the organizational structure of the Smart Service Company (SSC). At the top, four entities (SRT/AMC, State Enterprise(s), Other Thai public/private entity, and Other International public/private entity) are shown as potential investors or partners, with arrows pointing to the SSC. The SSC is represented by a dark blue box containing the Board of Directors and the CEO. Below the CEO, three core departments are listed: Business Administration Dept., Finance Dept., and Data Management Dept. These departments oversee four main functional areas: Infrastructure Dept., Smart Mobility Dept., Smart Energy Dept., and Smart Center Office. Each functional area is further detailed with specific units and their business partnerships. The Infrastructure Dept. is linked to Contractor & Maintenance Company(s) via a Business Partnership. The Smart Mobility Dept. oversees a Transportation Service Unit (linked to PRT Service Company via Business Partnership) and a Parking Management Unit (linked to Parking Management Co. via Business Partnership). The Smart Energy Dept. is linked to Energy Company(s) via Business Partnership. The Smart Center Office oversees a Smart Env. Dept., which is linked to Device provider(s) and IT provider(s) via Business Partnerships. <Proposed Structure for Smart Service Company>

Source: JICA Study Team

Table 5.25 Roles of the organizations for Bang Sue development (5/5)

Organization	Role in Bang Sue Area Development
<i>SRT</i>	SRT is the sole land owner of Bang Sue area, and lease the whole area to AMC. It is assumed that AMC will be established very soon and will function as planned properly, otherwise SRT shall take all responsibilities planned for AMC.
<i>Ministry of Transport and OTP</i>	- MOT and OTP shall take responsibility for solving policy challenges of Bang Sue Development. - As the chairman of the steering committee, it will be necessary for MOT and OTP to facilitate related ministries or agencies, or local governments to tackle policy challenges that could not be solved by Ministry of Transport alone, and to fund public infrastructure development, when investment is needed for basic infrastructures.
<i>Zone developers</i>	- Zone developers, which are private real estate developer companies, will be selected in separate bidding processes for Zones A to I. - The developer concludes a contract with AMC to develop and operate the zone stipulated in the contract. - The developers will earn revenues from development in the designated zones, while paying concession fees on the basis of the contracts concluded with AMC.

Source: JICA Study Team

(4) (Reference) Consideration on Smart Service Company

The project implementation structure should reflect the existing framework for urban development in Thailand, since the Smart City development project is a project which would be incorporated into the already initiated urban development project, and also since the bidding process has already been started for Zone A. The framework to be proposed needs to incorporate a mechanism to provide smart city services, through revising the entire implementation structure in a stepwise approach, making use of the existing urban development and infrastructure development framework.

The ideas for implementation structure proposed in the previous section, that Smart Service Company shall be set up to provide services for the whole development area of Bang Sue, reflects the ideas and the intentions by the Thai counterparts.

Meanwhile, in reference to the framework and structure proposed in the previous JICA Study, and also taking into account the features of the development project, the following three cases were considered to be the potential framework for providing smart services in the Bang Sue area.

- Case 1: Centralized and integrated smart service provision. (One business entity provides smart service to the entire Bang Sue Area.)
- Case 2: Sector-based smart service provision through (several) smart city service providers.
- Case 3: Zone-based smart service provision through smart city service providers.

The framework and structure for these cases are as outlined below.

1) Case 1: Centralized and integrated Smart Service provision by one business entity

All the smart services shall be integrated and to be provided for the whole Bang Sue Area by a Special Purpose Vehicle (SPV) that would be newly established and managed under the government guidance. SPV would be the owner of the assets related to smart services.

The initial costs necessary for developing cogeneration systems or other energy facilities for Smart Energy service, and PRT system for Smart Mobility would be financed by the SPV. The SPV would earn income from Smart Service users and service fee by SRT.

Since SPV integrates smart service operations, they would be capable of introducing Smart Services according to their business strategies in a timely manner. Consolidating the service provider would contribute to ensuring equal service level across the zones

2) Case 2: Sector-based Smart Service provision

Unlike Case 1, under case 2 structure, Smart Services would be provided by different entities for respective service sectors. SRT/AMC shall be responsible for setting up Smart Service standards for each sector, selecting private companies that meet the requirements, and managing the contracts with smart service providers in each sector.

The income structure would depend on the feature of the sector, for example, user fee could be gained in energy service and mobility service, whereas in some sectors, service fees from SRT would be needed.

Since the entities are different in each sector, SRT needs to coordinate with strong initiatives to ensure coordination among the sectors.

3) Case 3: Zone-based Smart Service provision

Under this case, main developers of the zones each need to find smart service providers.

Although the burden for SRT would be minimal when compared to other cases, the timing of Smart Service introduction and the level of smart services will be different, which would likely result in ununiformed services in all zones. In addition, when infrastructure development proceeds separately, it would likely result in higher infrastructure investment costs and lower profitability for the private sector.

4) Discussions and recommendations on the structure

The following table shows the comparison of the features for the three cases.

Based on the comparison analysis and discussions with the related organizations in Thailand, Case 1 was considered to be the most reasonable and realistic structure.

Energy and mobility are considered as core sectors for smart services, and infrastructure such as energy networks and decks would need to be expanded along with the development. The development of these systems should be promoted on the basis of long-term perspectives. Based on this viewpoint, the business structure for Smart Services needs to be incorporated evenly to the entire Bang Sue Area, rather than independently to each zone.

In addition, an integrated structure for management and operation is essential for realizing effective and sophisticated management and the introduction of cutting-edge technologies. For example, with regards to energy services and mobility services, the usage of EVs could be optimised by integration of management and operation, while the bringing together large data across sectors on an integrated platform could contribute to generating new services and businesses

Based on these perspectives, it is considered desirable to establish a Smart Service Company which oversees the service for the entire area, instead of sector-based approach or zone-based approach.

However, it is difficult for private operators to forecast commercialization and profitability for the entire Bang Sue Area as the project timeframe would be 10-years or longer. In addition, under the current arrangement that the developers would be selected by zones in different timing, the overall development plan is unclear. Therefore, the developers would not be able to accurately forecast the actual demand. This would pose as a risk for the potential private companies.

Provision of Smart Services for the entire Bang Sue area at a certain controlled service level, would be attractive for private developers. Meanwhile, postponement of the development project is not desirable, as it would degrade the attractiveness for the private businesses. Therefore, participation of SRT and/or another public entity, which could see the profitability for the long term and could control the development process, is desirable for mitigating the risks associated. Moreover, it is desirable to improve the value of the entire district in the medium-to-long term by establishing a system to provide Smart Services in an early stage.

Table 5.26 Comparison of the cases for Smart Service provision

Type	Case 1: Centralized and integrated smart services	Case 2: Sector-based service provision	Case 3: Zone-based service provision
Overview	The special purpose vehicle (SPV) which is mainly driven by SRT will be established. This SPV will prepare a Smart City service plan, and provide the services such as energy management and mobility (including contract out to Smart City service providers). Infrastructures used for providing service such as automobiles and co-generation systems will be owned by SPV.	SRT will set the criteria relating to smart services, lease the land to the private sectors, and sign the outsourcing contracts with Smart City service providers in each zone. Smart City service providers will develop infrastructures and provide Smart City services based on the master plan prepared by the SRT.	Developers or SPVs in each zone will gain the right of land use through bidding and develop the infrastructure in order to provide the smart services.
Smart Service Operator	SPV (contract out to Smart City service providers)	Smart service providers will operate by own asset and provide the services while SRT will supervise and monitor the overall operation.	Developer or SPV
Special Characteristics	As the operation is integrated, it is easier to coordinate smart services beyond sectors and provide new smart services. SPV can fulfill the role as an Area Management organization	SRT needs to coordinate smart services beyond sectors to be provided by separate sectors.	SRT will provide the proposal for smart services, then select the service providers who highly evaluated and grant the right of land to them. Establishing coordination among Zones would be difficult, as it would be entrusted to discussion among Zone Developers.
Figure of Scheme			
Invitation for bidding	SPV will conduct the bidding independently for selecting Smart Service contract providers.	Outsourcing each type of smart services (Public offering)	Outsourcing smart services separately in each zone (Public offering)
Income of SRT	A part of fee for providing smart service (as a compensation for using assets from Smart City service providers)	n/a	n/a
Expenses of SRT	A portion of infrastructure investment cost needed to provide Smart Service	Outsourcing fee for smart service providers	n/a
Timing of introducing infrastructure	It is possible to introduce strategic infrastructure by SPV, which enhance the value of the area and bring more profit in long term.	Timing of introduction would likely to differ by sector.	Timing of introduction of infrastructures would be separate according to developers' plan. This may result in inconsistency between zones which mean oversupply or undersupply of infrastructures may occur in some zones. Furthermore, coordination among Zones would be difficult.
Operation and Maintenance Methods	SPV (operation and maintenance contract with Smart Service providers)	Outsourcing company	Developers or SPV
Possibilities of Japanese companies' participation	Participation to SPV, or service provider for SPV.	Smart Service contractor.	Participation as service provider for each zones. However, if the zone area is too small, there will be no merit for introducing 'smart' components. Therefore, determining the scale and the demand of smart service is very important.
Concerns on implementation of 'Smart' concept	SRT can introduce the 'smart' component easily. SPV's roles in terms of planning, financing and overall coordination of the Smart City services are the most important in the 3 cases. High-level of management capacity is needed. It is possible to provide same level of the Smart City service in each zone and management of the whole Bang Sue area would be relatively easy.	The availability of outsourcing companies that can meet service level standard that would be set by SRT. SPV does not have a role for financing for infrastructure development, however, the Smart City service would be terminated if a Smart City service provider give up providing the service.	Smart services would be structured differently in each zone, therefore the service may be different by zones. Managing development of Bang Sue as one area would be difficult.

Source: JICA Study Team

5.4.3 Financing Mechanism

(1) Layer System

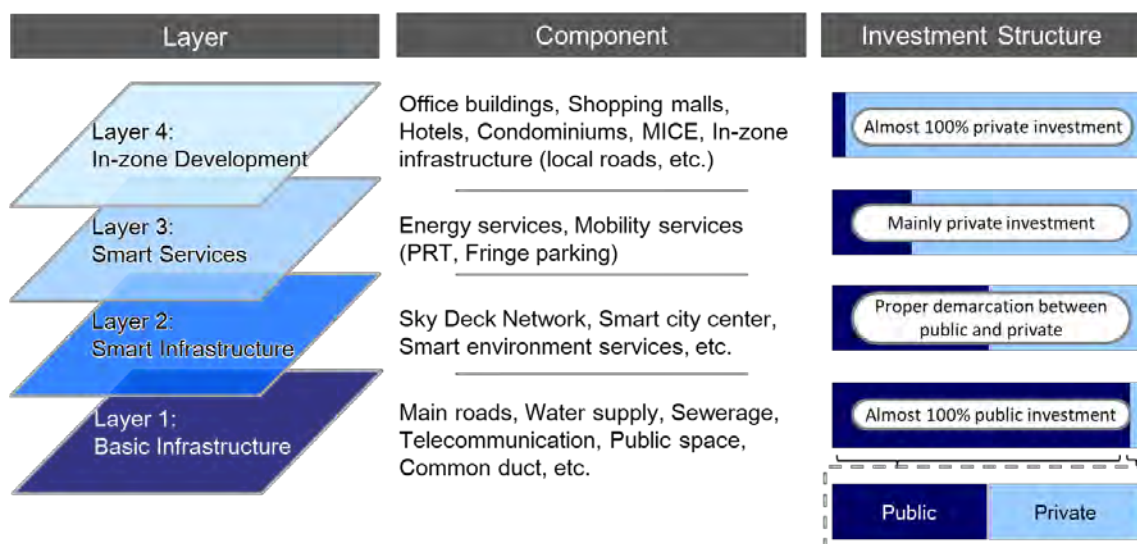
The investment fund for this development project are to be covered by combining government budgets, state-owned enterprise investment, private developer investment and smart service company investment. Financing structure with regards to development of facilities and introduction of Smart services are classified into four layers, depending on project features and the entities' responsibility.

Layer 1 corresponds to basic infrastructure which includes: arterial road, water and sewerage, electricity, communication, park and common duct. These infrastructures are regarded as basic facilities for Bang Sue Area development. Most of these infrastructure and facilities need to be developed with the government budget or funds provided by SRT as the landowner.

Layer 2 corresponds to urban infrastructures and facilities needed for Smart City development, which includes: sky deck network or Smart City Center and environment/ waste facility infrastructure. These Layer 2 facilities need to be partially covered by private companies, for example in case of sky deck development, the private developers need to raise funds for initial investment for the sky deck segment in the zone.

Layer 3 corresponds to facility development and service provision with regards to smart service businesses which shall be operated on Layer 1 and Layer 2 infrastructures. These costs shall be covered mainly by Smart Service Company (and other private companies) that operate and provide such services.

Layer 4 corresponds to commercial facilities or infrastructure in the zone. Developments in the zone shall be, in principle, implemented by respective zone developers as private investment project.



Source: JICA Study Team.

Figure 5.47 Concept on Layer System and investment structure

In order to implement infrastructure and facility development according to the development schedule and in an integrated manner, the process needs to be coordinated among the private and the public, beyond and within the Layer. Especially it is important that the opinions and request

from the potential bidder would be collected through market sounding process, and reflected to the financial structure.

Meanwhile, for appropriate cost sharing, mechanism for strengthening coordination among the private and the public would be necessary. Also to secure sufficient fund for the development project, various funding must be sought, including contribution from Smart Service Company, and subsidy from the government. For this, measures to mobilize and secure investment funds, such as fund pooling system, needs to be considered.

(2) Necessary investment

The following table shows project costs by layer and phases.

The investment cost needed for the entire project is approximately 308 billion baht. Taking a look at costs by layer, building-related cost for Layer 4 in the zone is large with about 285 billion baht, followed by approximately 14 billion baht for layer 3 smart service, about 5 billion baht for Layer 1 basic infrastructure (including bus terminal relocation) and about 3 billion baht for Layer 2 smart infrastructure.

Reviewing the cost by development phase, the necessary investments are approximately 123 billion baht for Phase 1, 65 billion baht for Phase 2 and 108 billion baht for Phase 3.

Table 5.27 Estimated investment for entire Project

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
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

Source: JICA Study Team.

(3) Basic policy for infrastructure development in Bang Sue area (Base case)

As for Layer 4, developers shall be selected by zone through tenders, and developers shall basically undertake the infrastructure development and facility construction, for each zone inside. Basic infrastructure, smart infrastructure and smart service for Layers 1 to 3 need to be appropriately developed in the Bang Sue Area, in order to encourage private developers to invest in the Area, and at the same time enhancing the value of the area through integrated development.

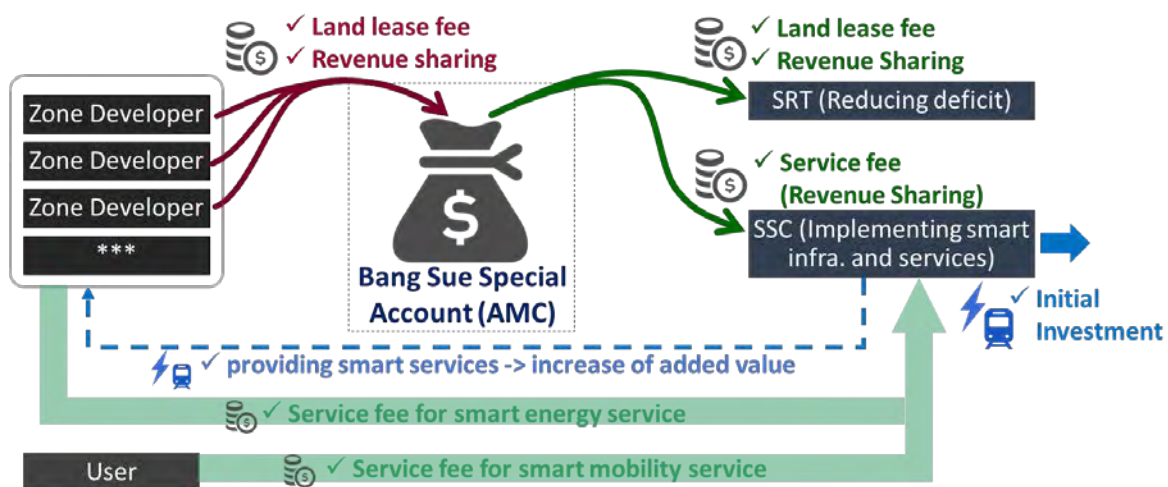
Considering the Bang Sue area, since the land of the Bang Sue area (approx. 370 ha as a whole) belongs to SRT, all the development activities including infrastructure development shall be managed by SRT basically. SRT/AMC, however, would not have enough capacity from both financial and technical aspects,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

Whereas infrastructure development itself can not generate enough income and it shall be necessary to establish a financially feasible business model for SSC.

The picture below is the conceptual image of money flow of Bang Sue smart city development.

- Initial investments for smart infrastructure and services (necessary investment for Layer 1 to 3) will be covered by SSC.
- Once AMC will secure the revenue (land lease fee) from zone developers, AMC will share the revenue as service fee to SSC, covering the initial investment.

Smart energy and mobility services could be feasible without service fee from AMC, securing revenues from users.



Source: JICA Study Team

Figure 5.48 Conceptual image of money flow of Bang Sue Smart City development

(4) Optioneering of roles for infrastructure development and cost sharing

As discussed in the last section, basically infrastructure development in Bang Sue shall be done by SRT since the land of the Bang Sue area (approx. 370 ha as a whole) belongs to SRT. However, there would be some options for the demarcation of infrastructure development. Because the area is too huge to be covered by one entity for infrastructure development, and the Bang Sue Smart City development should be recognized as a national project since the Bang Sue Smart City is one of the Flagship project of smart city development and the new gateway for ASEAN, more public involvement is expected.

The following table shows the four cases with regards to development implementation and financing patterns for Layers 1 to 3. To identify the optimal structure, advantages and disadvantages, as well as challenges in financing are summarized and compared.

The description of the four cases for development implementation and financing are summarized in the following table.

Table 5.28 Patterns with regards to infrastructure development and cost sharing

Entity	Description
Public	Invested (subsidized) by central gov. and local gov. (as public investment)
SRT	SRT raises the funds and implements the infrastructure by themselves. The cost will be recovered by future income from the zone developers.
SSC(w/ sf)	(SSC with service fee model) SSC raises the funds and implements the infrastructure. The cost will be recovered by the service fee paid by SRT with using income from the zone developers.
SSC(w/o sf)	(SSC without service fee model) SSC raises the funds and implements the project under self-supporting system
Private	Private sector (zone developer) investment

Source: JICA Study Team

Table 5.29 Comparative analysis on roles for infrastructure development and cost bearing

Category		Case1	Case2	Case3 (Base Case)	Case4	
Outline		All basic infrastructure and Sky Deck (Outside the Zones) are developed by SRT				
		All basic infrastructure and Sky Deck (Outside the Zones) are developed by Public				
		All basic infrastructure and Sky Deck (Outside the Zones) are developed by SSC				
		Proper demarcation of each infrastructure development				
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 Center		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	Intra-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)	

*See Section 5.5 on calculation results in project profitability for Smart Service Co. and SRT.

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

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

Source: JICA Study Team.

In case 1, SRT have to secure the initial investment cost before getting the revenue from zone developers.

In case 2, although the land owned by SRT, infrastructure in Bang Sue area is implemented by public (incl. sky deck).

Case 3 is the base case (all basic infrastructure and Sky Deck (Outside the Zones) are implemented by SSC) since the whole area is owned by SRT.

In Case 4, proper demarcation between public and SSC is considered. Appropriate coordination with relevant authorities shall be required when SSC implements the infrastructures in Bang Sue area, and some portion for infrastructure investment could be shared with public.

The evaluation criteria are described below.

i) Coordination in infrastructure development

Infrastructure development work needs to be properly coordinated and implemented in a harmonized manner for successful Bang Sue development. From this point of view, fewer infrastructure development entity would be desirable.

If AMC (SRT) or SSC undertakes the development of whole infrastructure, coordination process would be less complex, as the infrastructure project entity would be limited to one.

On the other hand, if public organizations develop the infrastructure, different public entities would have to develop the respective infrastructure (road, water supply and drainage, communication, etc.). This would involve attaining budgets at a necessary timing to proceed with the project. Also, this may hinder the coordination and the development of high standard infrastructure suitable for Smart City. In this case Steering Committee needs to play a vital role as a coordinator.

If SSC would develop some of the public infrastructure, SSC shall be considered to serve as a coordinator as an executing organization.

ii) Financial burden on SRT (Especially for initial cost)

If SRT are to finance the infrastructure development by themselves, SRT would be forced to cover large amount of investment at the initial development phase, even if SRT is to cover the expenses through land lease fees paid by zone developers in the operating phase. In addition, as a risk factor, whether the Thai Government would approve further deficit for SRT is unclear.

If public agencies are able to develop infrastructure as public investments, it would be the case in which SRT bears the least financial burden.

If SSC is to develop the infrastructure, the company needs to raise funds for the initial investment cost by themselves, which would require SSC to have sufficient financial capability. If a business model in which SRT pays service fees to SSC from income paid to SRT by the zone developers could be established, infrastructure could be developed with no initial investment cost coverage for SRT.

The following table shows cost coverage ratios by respective entities for the four cases.

Table 5.30 Cost sharing by respective entities (million THB, %)

Responsible	Case1	Case2	Case3	Case4
Public	0	7,615	0	5,020
SRT	7,615	0	0	0
SSC(SRT)	764	764	8,379	3,359
SSC	14,516	14,516	14,516	14,516
TOTAL	22,895	22,895	22,895	22,895
Public	0.0%	33.3%	0.0%	21.9%
SRT	33.3%	0.0%	0.0%	0.0%
SSC(SRT)	3.3%	3.3%	36.6%	14.7%
SSC	63.4%	63.4%	63.4%	63.4%
TOTAL	100.0%	100.0%	100.0%	100.0%

Source: JICA Study Team.

iii) Financial burden on Public

If public organizations develop infrastructure as public investment, this would be the case in which the financial burden for SRT and SSC would be limited. However, the concern is whether the Thai Government or the Bangkok Metropolitan Administration would approve public investment in Bang Sue Area development. Another concern is that this case involves attaining budgets at a necessary timing to proceed with the project. Also, this may hinder the coordination and the development of high standard infrastructure suitable for Smart City.

iv) Execution capability of the agency

As SRT do not have sufficient experiences in real estate development, currently SRT is not equipped with sufficient capabilities to implement infrastructure development capabilities and to deliver high standard infrastructure service suitable for Smart City. Especially, in the water supply and drainage business or the waste management business, would not only be limited to Bang Sue Area, so it may be appropriate for BMA or other capable public agencies to undertake these public services.

Though SSC would be a newly established company, if state-owned companies would participate in set up of SSC, a certain business execution capabilities would be ensured.

v) Risk distribution (too much risk on one agency)

If one entity is to undertake responsibility for the entire business execution from financing to infrastructure development, establishment of an organization with sufficient capabilities would be necessary. Also, as the business scale would be larger, it needs sound financial capacity and capable personnel. Though coordinating risk factors could be reduced, dependence on one entity would be a risk factor for project execution.

vi) Public sector involvement

It is desirable that public entities should engage in project execution to some degree in order to ensure smooth administrative procedures and legal adjustments.

vii) Private sector involvement and future prospect

To deliver high standard infrastructures and develop new smart services, it is desirable that private company is selected as infrastructure operator. From this perspective it is preferable for SSC (SRT) to engage in infrastructure projects.

Although case 3 is set as the base case, further consideration for proper demarcation is expected.

Regarding the financial analysis for SRT and SSC, the two results are presented in the table: with/without smart mobility Services, since the financial feasibility of smart mobility service is highly volatile to demand (depending on demand fluctuation). The case with Smart Mobility Services which assumes 100% demand will be realized improves the overall financial feasibility. In case SSC would earn enough revenue from smart mobility services, the service fee from AMC to SRT could be considered to change. In case SSC would not earn enough revenue from smart mobility services, some countermeasures (e.g. service fee payment for smart mobility services from SRT to SSC) shall be considered.

(5) Further consideration of cost sharing options by each infrastructure

For the infrastructure development in Bang Sue, cost sharing options for each infrastructure are analyzed in this section considering public involvement.

1) Cost sharing options by Organization

The following table shows the cost sharing for each layer and organization in the case that the public will be involved for the basic infrastructure development. Note that basically infrastructure development in Bang Sue shall be done by SRT and this is the proposed structure, and thus detail needs to be clarified among stakeholders through discussion, for example in Steering Committee.

Table 5.31 Proposed Cost sharing options by organization

Layer	Item	Central Gov.	BMA	State owned enterprises	Smart Service Company	Private companies
Layer 1: Basic Infrastructures	Main roads, Zone boundary roads	MOT	Public Works Dept.			
	Water supply	MOI		MWA		
	Sewer, drainage	MONRES	Drainage and Sewerage Dept.	MWA		
	Electricity	MOE		MEA		
	Telecom	MDES		CAT		
	Gas	MOE		PTT		
	Common duct	MOE, MOT		SRT		
	Reservoir		Environment Dept.			
	Green Network (Parks, road side trees)	MOT	Environment Dept. Public Works Dept.			
Layer 2: Smart Infrastructures	Sky deck network (Outside zone)	MOT		SRT	SSC	
	Smart Environment	MONRES	Environment Dept.	SRT/ PTT	SSC	
	Smart City Center	MDES, MOE, MOT	Traffic and Transport Dept.	SRT/ CAT/ MEA	SSC	
Layer 3: Smart Service	Smart Mobility			SRT/ PTT/ BMTA	SSC	Developers
	Smart Energy			SRT/ PTT/ MEA/ EGAT	SSC	Developers
Layer 4: Facilities and infrastructures in Zones	Office, Condominiums, Commercial, Hotel, etc.					Developers
	Public buildings, MICE, etc.	MOT, MOTS		SRT		
	Infrastructures and road inside Zones		Culture, Sports and Tourism Dept.			Developers
	Sky deck network (inside Zones)	MOT		SRT	SSC	Developers

*MOE: Ministry of Energy/ MOI: Ministry of Interior/ MOT: Ministry of Transport/ MOTS: Ministry of Tourism and Sports/ MDES: Ministry of Digital Economy and Society/ MONRE: Ministry of Natural Resources and Environment/ BMA: Bangkok Metropolitan Administration/ MWA: Metropolitan Waterworks Authority/ MEA: Metropolitan Electricity Authority

Source: Compiled by JICA Study Team.

2) Finance options for road development

With regards to road development in Bang Sue Area, an entity responsible for construction and operation and maintenance could be distinguished in accordance with three road sections consisting of: main road, zone road (the periphery road of the zone), and streets inside the zone.

Streets in the zones are expected to be designed in line with the township development guideline, as a public space which ensure comfortable walking space for pedestrians, while offering event venues or advertising space. This would contribute to creating lively atmosphere for the town, and would benefit zone developer's businesses. These road designs would be an "upgrade" from the basic road infrastructure that would typically be constructed by the public (i.e. BMA). It is suggested that additional cost for the "upgrade" portion be borne by the zone developers.

While SRT and zone developers could be the entity in charge of maintaining or managing the zone roads and streets inside zones respectively, the Smart Service Company could also become an entity to integrally maintain, manage and operate the infrastructure, as an organization to implement township management.



Figure 5.49 Road category in Bang Sue Area

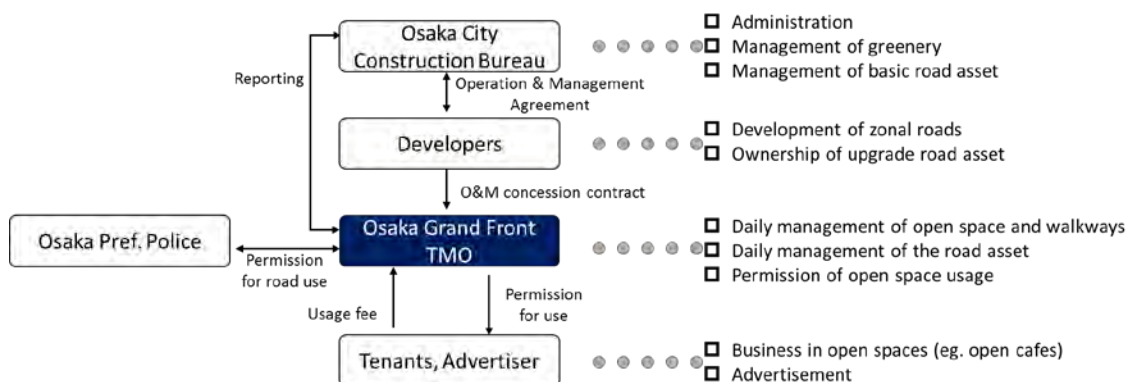
Table 5.32 Comparison of the cases for Smart Service provision

Road category	Development entity	Maintenance/ management entity	Remarks
Main Road	BMA	BMA	Arterial road like Kamphaeng Phet 2 Road
Zone Road	BMA or SSC/ SRT	SRT or Smart Service Company as township management organization	It is desirable for BMA to develop zone roads as base infrastructure.
Streets inside Zone	Zone developer	SRT or Smart Service Company as township management organization	Zone developers develop in line with town development guidelines.

Source: JICA Study Team

(Reference) Case study on Grand Front Osaka TMO in Umekita District: Street development and management

In Grand Front Osaka, the developer designed outer facilities in the site and surrounding sidewalks. The upgraded road facility costs were covered by the developer to produce high quality walking space. Grand Front Osaka TMO (Town Management Organization) maintains and manages the street facilities on road space near the development area under the framework of public and private cooperation.



Source: “Land readjustment and area management approach in Umekita project” by Urban Renaissance Agency (UR)

Figure 5.50 Public Road Management Scheme in Grand Front Osaka

3) Finance options for other basic infrastructure development

As a general approach for base infrastructure development other than the roads, the government or state-owned enterprises are to cover the cost for the main stem infrastructures, while the zone developers are to cover the cost for the sections inside the zone and connecting section to the main system. The following table shows an approach for base infrastructure development.

Table 5.33 Approach toward basic infrastructure development (other than the roads)

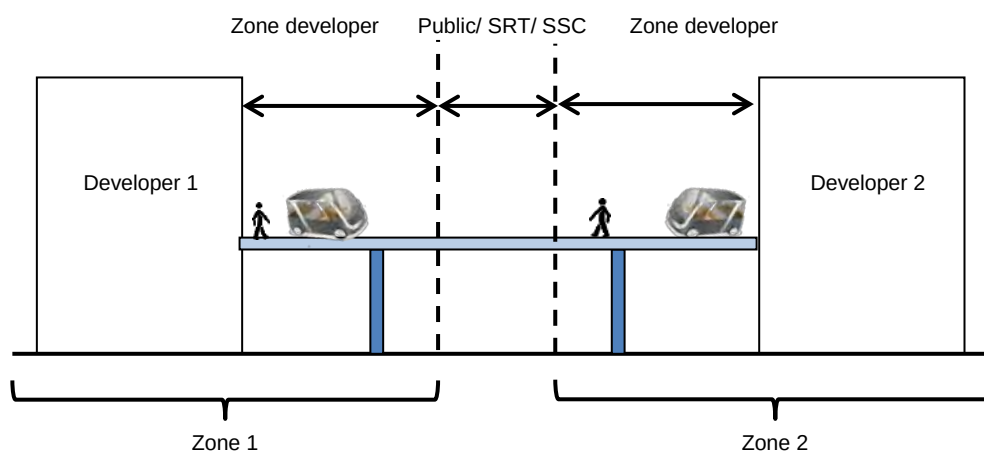
Infrastructure	Role in Bang Sue Area Development
Water supply	Metropolitan Waterworks Authority bears the development cost for the water main, while zone developers shall cover the connection cost for the connecting section and the inner zone section. The tenants for each zone pay water supply charges via the zone development company to Metropolitan Waterworks Authority.
Sewerage	BMA bears the development cost for sewer main while zone developers cover the connection cost for the sewer main. Tenants for each zone pay sewerage charges via the zone development company to BMA.
Waste	Each developer implements garbage separation and collection at the zone. BMA bears the cost to for waste collection, and necessary facilities and equipment for final disposal.
Tele-communication	Telecommunication carriers bear the development cost. Tenants for each zone pay telecommunication charges via the zone development company to telecommunication carriers.
Common duct	Common ducts would be installed in the facility under main roads between zones. The development would be funded through government budget as public works.

Source: JICA Study Team

4) Financing scheme for sky deck network development

① Basic approach for sky deck network development

As for basic approach toward sky deck network development, as shown in the below figure, zone developers shall develop the segment of the sky deck which is inside their zones. The design shall be controlled to form a consistent landscape, also having sufficient functions set in the guideline or specification. The public sector would be tasked to develop the sky deck segments which belong to the public realm, and segments connecting with development zones and with Bang Sue Grand Station.



Source: JICA Study Team

Figure 5.51 Basic Approach toward Sky Deck Network Development

② Finance options for segments inside the zones

For development of sky deck segments inside the zones, it is preferable that the private would bear the investment cost. In doing so, to mitigate risks and issues that would arise, it is vital that a clear city development plan and a sky deck network plan are formulated, and that a common guidelines are set for township development. The development shall be done in a coordinated manner with involvement of the zone developers and other relevant entities.

③ Finance options for segments outside the zones

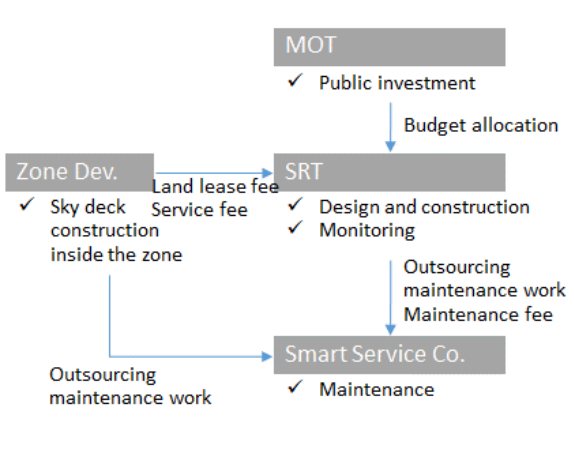
For development of sky deck segments outside the zones, it is preferable that the public (the government and the state-owned enterprises) would bear the cost. However, taking into account the limited public budget for such infrastructure project, in pragmatic sense, alternative source for funding must also be sought. Therefore, several financing patterns could be in place, depending on the development proceedings and the spatial attributes of the zones. It is indispensable that the Ministry of Transport, SRT and Smart Service Company coordinate to raise funds and promote development.

Most noteworthy issue for sky deck development would be the development of a long section connecting Grand Station and the Mochit Station. The section would be important in ensuring

connectivity for transit, and promoting demand in the initial stage of Bang Sue development. One possible pattern of financing for this section would be to have Smart Service Company to invest and develop the deck as smart infrastructure, while receiving from SRT the smart service fee, the source of which being the concession fee and profit dividend. Another possible pattern of financing would be the orthodox approach, in which the decks would be developed by public budget, considering that the development of this sky deck section is vital for catalysing construction of sky deck network as a pilot project.

Based on these considerations, three potential development patterns are considered for the sky deck network development, especially for the sections outside the zone. The potential patterns include: case 1 in which development would be implemented as public works by the Ministry of Transport; case 2: in which development would be implemented by SRT as area infrastructure development project; and case 3 in which Smart Service Company would make the initial investment whereby recovering the cost through service fee. The following table shows development entity, financing, operation and maintenance, and challenges for the respective case.

Table 5.34 Case 1: Development as public works by Ministry of Transport

Item	Approach for development of sky deck segment outside the zone: Case 1	
<i>Development and Finance</i>	- The Ministry of Transport shall be the main entity to construct sky deck as a public infrastructure investment (for the segment in public realm). - Specifically, the Ministry of Transport prepares the budget for sky deck development, which is allocated to SRT to design and construct the deck (as is the case with typical railway development project) - Zone developers cover the construction cost for sky deck in the zones. (Plans for alignment are formed under coordination with the MOT and SRT). - SRT provides the land needed for sky deck construction with no fee.	Case 1: Public investment ✓ MOT covers investment cost for Sky Deck, as public investment.  <pre> graph TD MOT[MOT] -- "✓ Public investment" --> SRT[SRT] MOT -- "Budget allocation" --> SRT ZoneDev[Zone Dev.] -- "Land lease fee" --> SRT ZoneDev -- "✓ Sky deck construction inside the zone" --> ZoneDev SRT -- "Service fee" --> ZoneDev SRT -- "✓ Design and construction" --> SRT SRT -- "✓ Monitoring" --> SRT SRT -- "Outsourcing maintenance work" --> SSC[Smart Service Co.] SSC -- "Maintenance fee" --> SRT SSC -- "✓ Maintenance" --> SSC </pre> ✓ Need to persuade MOT to invest to Sky Deck as public investment.
<i>Maintenance and Management</i>	- Operation and maintenance management for sky deck is outsourced to Smart Service Company (SSC) as a whole, including private development sections. - SSC provides intra-regional public transportation service such as PRT on the sky deck. - SRT annually pays the service fee to cover operation and maintenance management cost needed for sky deck. - The service payment that SRT pays to SSC would be raised upon the land lease fee and the service fee that the developers pay to SRT (Zone developers are requested to bear a certain degree of the cost, as they could benefit from enhanced accessibility from sky deck development).	
<i>Challenges</i>	- There is a need to develop a common understanding that the sky deck in the Bang Sue Area is an indispensable public infrastructure for the realization of Smart City, as the deck would also serve as a platform on which public transport service would be offered. The sky deck needs to be regarded as a public infrastructure that would benefit the wide range of visitors to Bang Sue, when it is developed. - As the experience of developing a large scale sky deck for Ministry of Transport is limited, forming a common understanding regarding necessity of sky decks would likely take much time. - Conditions regarding to sky deck construction needs to be carefully worked out with zone developers, and therefore a close coordination between public and private sectors are needed. The business framework explained above needs to be clearly specified at the time of selecting zone developers.	

Source: JICA Study Team

Table 5.35 Case2: Sky deck construction as infrastructure development by SRT

Item	Approach for development of sky deck segment outside the zone: Case 2
Development and Finance	Case 2: SRT investment ✓ SRT bears investment cost for Sky Deck by themselves. <pre> graph TD ZoneDev[Zone Dev.] -- "Land lease fee" --> SRT[SRT] ZoneDev -- "Service fee" --> SRT SRT -- "Design and construction" --> SRT SRT -- "Outsourcing maintenance work" --> SSC[Smart Service Co.] SSC -- "Maintenance" --> SSC Financer[Financer] -- "Fund, bond" --> SRT SRT -- "Repayment" --> Financer </pre> ✓ Sky deck construction inside the zone ✓ Design and construction ✓ Monitoring ✓ Maintenance ✓ SRT have to find finance sources to construct Sky Deck.
Main-tenance and Manage-ment	• Operation and maintenance management for sky deck is outsourced to Smart Service Company (SSC) as a whole, including private development sections. • SSC provides intra-regional public transportation service such as PRT on the sky deck. • SRT would temporarily cover construction cost for the sky deck. The construction cost and maintenance cost would be recovered through land lease fee and service fee paid to SRT by zone developers. (Zone developers shall ultimately cover all the deck construction cost, as they would be the final beneficiary of improved accessibility by sky deck development.)
Challenges	• SRT has to finance the sky deck construction, and takes risks for advance investments. • Conditions regarding to sky deck construction needs to be carefully worked out with zone developers, and therefore a close coordination between public and private sectors are needed. The business framework explained above needs to be clearly specified at the time of selecting zone developers.

Source: JICA Study Team

Table 5.36 Case3: Sky deck construction by Smart Service Company

Item	Approach for development of sky deck segment outside the zone: Case 3	
Development and Finance	- SRT would be the primary project implementation entity for sky deck construction and maintenance for enhancing land value of the Area. However in this scheme, SRT would contract the SSC to construct and operate the facility under BOT (or BTO) contract. In such arrangement, the SSC would finance, design construct, and maintains the deck. - SSC would annually receive service fee from SRT to recover the investment costs and the maintenance fee for sky deck. - This scheme would not require SRT to fund initial investment. The land lease fee and service fee from the zone developers to SRT would be allotted for the payment for the service fee for the SSC.	Case 3: SSC investment (payback by SRT) ✓ BOT contract between SRT and Smart Service Co. <pre> graph TD ZD[Zone Dev.] -- "Land lease fee" --> SRT[SRT] ZD -- "Service fee" --> SSC[Smart Service Co.] SRT -- "Sky deck construction inside the zone" --> ZD SRT -- "Contract management Monitoring" --> SSC SSC -- "Outsourcing maintenance work" --> ZD SSC -- "Design and construction Maintenance" --> ZD F[Financer] -- "Finance" --> SSC SSC -- "Repayment" --> F </pre> ✓ Smart Service Co. have to have enough capacity.
Main-tenance and Manage-ment	- Operation and maintenance management for sky deck is outsourced to Smart Service Company (SSC) as a whole, including private development sections. - SSC provides intra-regional public transportation service such as PRT on the sky deck.	
Challenges	- SSC needs to have sufficient capabilities and creditworthiness to finance the necessary investment. If a major firm is to take the initiative for setting up the company, it may be capable of funding through corporate finance. - Major risk for SSC would be SRT's ability to implement the zone development and to enforce payment of land lease from all zone developers. - Conditions regarding to sky deck construction needs to be carefully worked out with zone developers, and therefore a close coordination between public and private sectors are needed. The business framework explained above needs to be clearly specified at the time of selecting zone developers.	

Source: JICA Study Team

④ Proposed scheme for phased development

With regards to the current situations, it is assumed that it would take time for the Thai government to prepare the budget for sky deck development. On the other hand, SRT is heavily indebted which makes it difficult for SRT to finance the initial investment for the development. Given these constraints, it is proposed that case 3 would be the most plausible option for financing sky deck development. Case 3 would also be preferable option as it would allow SSC for more opportunities to provide integrated service.

With regards to the sky deck development, the section between Bang Sue Grand Station and Mo Chit Station is regarded as priority section to be constructed in an earlier stage, given its importance in ensuring connectivity in the zones. Furthermore, the development of Zone D is planned to be implemented earlier than the other projects. Since establishment of SSC would likely to take some time, and the financial arrangement for sky deck development would not be in place, case 1 could be the financial scheme to implement sky deck construction for section between Bang Sue Grand Station and Mo Chit Station, as a pilot project. After the SSC is established and the financial schemes are in place, case 3 could be applied to develop the other sections of the sky deck.

5) Finance scheme options for smart service business

① Various approaches for finance for smart service business

Various approaches could be considered to finance smart service business.

In general, smart city initiatives such as regional energy management, introduction of new mobility services, and development of data platforms are new initiatives related to urban development. It is often difficult to secure short-term business profitability, and difficult to foresee business viability since it involves introduction of new technology. Therefore, how to finance such business and what business model to apply are the questions to which technology firms are currently seeking to verify.

For example, taking a look at smart city development projects in the US, Europe and Japan, smart services are recognized as new urban infrastructure in most cases and most are also considered difficult to secure profits as a stand-alone business. With this in mind, the below listed are the funding source for smart city development projects mainly in US or Europe.

- Public fund (Tax-based public investment or subsidies for private companies): Recognized as measures to enhance land values for public asset, or to bring indirect economic effects such as increase in the number of visitors and consumption.
- Investment by private companies (including R&D): Recognized as part of promotion activities or seek secondary business opportunities, leveraging big data.
- Venture investment: New businesses promoted by start-ups.

For example, US-based IT company CISCO Systems, Inc. has developed “City Infrastructure Financing Acceleration Program²,” in which Smart City services are recognized as quasi-public infrastructure – infrastructure that offers some value added, rather than a pure public infrastructure – infrastructure that is essential for the public. Instead of the traditional “public investment – tax” mechanism which is associated with the pure infrastructure projects, “quasi-public infrastructure” could seek other business mechanisms such as user payment, public private partnership, or under “as a Service” model.

Coupled with the development of Smart City service business models, improvement for financial capacities for local governments (both revenue management and bond issuance) and the introduction of public private partnership mechanisms could be observed. Some US cities have introduced municipal bonds for Smart City services in order to strengthen financial capacity. The government of India is also making efforts to strengthen financial autonomy for city or local government.

Meanwhile, in most cases observed in Japan, the national or local governments have taken an initiative in smart city projects mostly using public funds or subsidies. However, in order to form sustainable smart cities, it is important to secure a reliable business operator who actively engage in actual projects. Therefore, to ensure sustainability of the Smart City service business it is essential that companies with sound financial base and ability to form a skilled team would aspire to execute projects.

② Approach for financing smart service business in Bang Sue Area

Local governments (BMA, in the case of Bang Sue) in Thailand faces huge needs for large-scale infrastructure development. Securing sufficient funds to implement smart city projects is common challenge that these governments face. On the other hand, SRT, who owns the land Bang Sue Area, is reported to have approximately 100 billion baht (approx. 338 billion yen) of debts.

Bang Sue Area development project is regarded as a public-led project in which SRT is situated to be take the leading role as a public entity. However, providing incentives for the private to participate in the project and establishing a strategic cooperation framework with the private sector is important to moving the project forward. There is a possibility for Japanese companies to participate in the project, as Japanese companies and Thai companies have long been closely related, though a severe competition is expected.

Thai government offers the following incentives for Smart City service businesses:

- Incentive offered by BOI: Reduction of corporate income taxes (amount equal to initial investment for five to eight years)
- Financial support from DEPA: Soft loan for Smart City service providers to develop digital infrastructure. (Support intended for small-to-mid-sized businesses)

Taking into consideration the proposed implementation structure of the smart development

² City Infrastructure Financing Acceleration Program (CIFAP) is a scheme devised by Cisco to supply one billion dollar loan and the capital to cities and city service operators for innovative smart city technologies. The way to fund city and city operator is: (i) Traditional loan and lease, (ii) Consumption-based finance, (ii) Finance “as a service feature,” (iv) Concession finance (Revenue allocation finance) and (vi) Equity finance.

<https://www.cisco.com/c/en/us/solutions/industries/smart-connected-communities/financing.html?dtdid=osscdc000283>

project in the Bang Sue Area – the provision of smart services by SSC, the following mechanisms are proposed to be introduced.

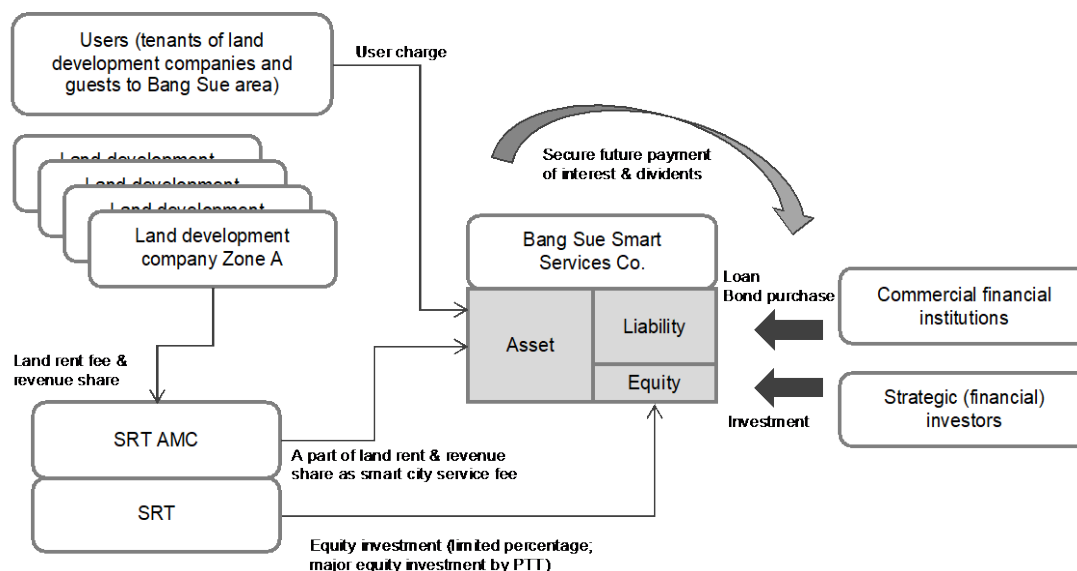
a) Appropriate allocation and use of land lease fee and income for SRT

Stable and constant cash flow for smart service providers is important in ensuring sustained service in the Area. The Material on market sounding surveys for land development project in Pahonyothin Transport Center Zone A commercial area³ specifies that SRT would earn land lease fees and a certain share of income. It is preferable to shape a business ecosystem in which the part of the land lease fees and income share to SRT (and AMC) would become the source of payment for Bang Sue SSC. This would contribute to stabilizing SSC's cash flow and support investment for infrastructure. In a conceptually similar case, companies that have offices in Bang Sue – for example PTT or SCG – could provide subsidies earmarked for a specific smart mobility service project to improve accessibility from BTS, MRT or Red Line stations to their head office buildings.

b) In-kind Contribution (as a land) from SRT to Smart Service Company

As a way of supporting SSC, SRT can make in-kind contributions (in the form of land) to Bang Sue SSC. If smart service providers need a certain land area for smart service, they need to lease land from SRT or SRT AMC. If SRT should provide the necessary land as in-kind contribution, SSC would not need to pay annual lease fees.

The following figure shows the finance structure, considering cash flow from SRT and land developers. In-kind contribution from SRT is also included in the structure.



Source: JICA Study Team

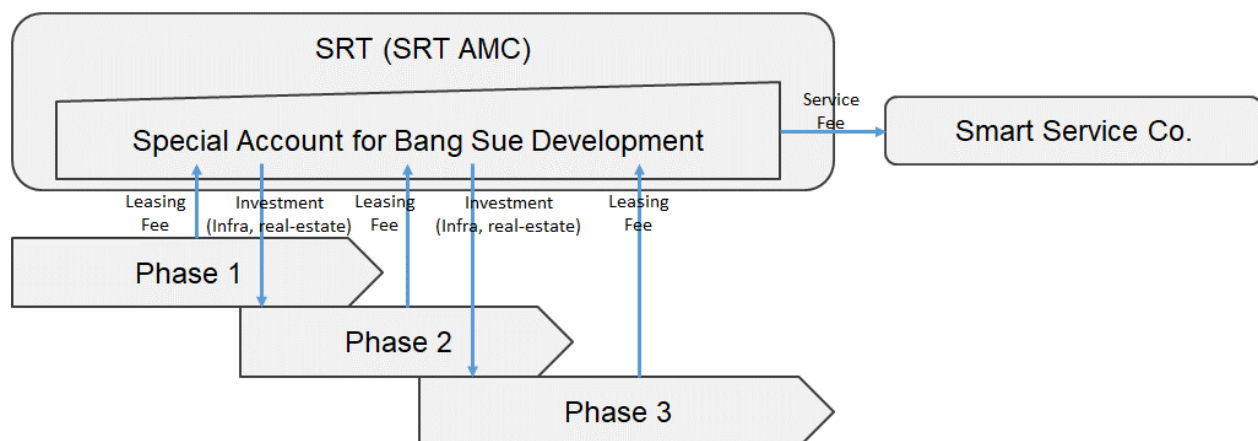
Figure 5.52 Finance structure for SSC, with regards to SRT, AMC and zone developers

³ The presentation material can download from the following SRT website.
<http://www.railway.co.th/main/activity/news.html?idnews=2018-10-18-083000>

With regards to proposed smart service business implementation structure (mainly Smart Mobility, Smart Energy, Smart Environment, and data platform), Smart Mobility, Smart Energy business are the ones whose revenues would be secured through “user charge”.

Meanwhile, as direct revenues would not be expected in the short term for Smart Environment and data platform businesses, revenues are to be secured based on service fee paid to SSC by AMC. This service fee would be based on the land lease fees paid to AMC by zone developers.

In order to ensure saving of sufficient amount for service fee payment to SSC, it is recommended that AMC set up a special account budget for Bang Sue Area development project. The figure below depicts the concept of the special account in Bang Sue. In this case, the cash flow for Bang Sue development project needs to be earmarked and separated from other SRT cash flow. The main finance source for SSC would, in principle, be lending from the financial market. However, in the long term, it is also important to consider funding through ESG investment or institutional investors in the future.



Source: JICA Study Team

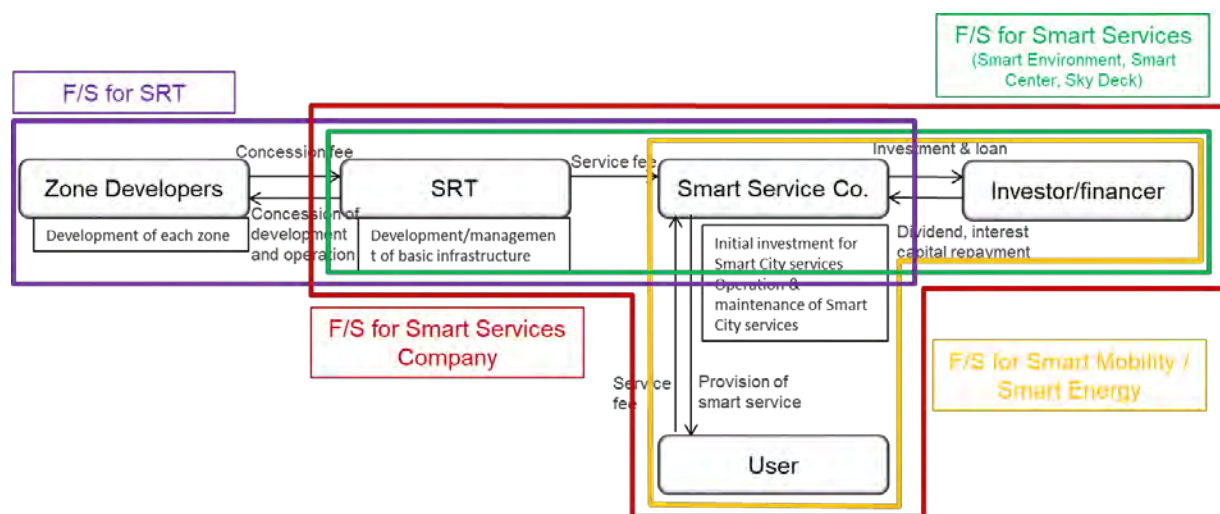
Figure 5.53 Concept on special account for Bang Sue Area development

5.5 Financial Viability Analysis

5.5.1 Scope and Objective of Financial Analysis

Based on considerations in the previous sections, a preliminary financial analysis is conducted for the following four project segment regarding the smart service, to examine feasibility of the project.

1. Feasibility study for SSC's businesses that generates revenue from user fees – Smart Mobility and Smart Energy project
2. Feasibility study for SSC's businesses that does not generate revenue from user fees – businesses excluding Smart Mobility and Energy
3. Feasibility study for SSC businesses combined
4. Feasibility study for SRT – examining income from land lease fee and payment of service fee to SSC



Source: JICA Study Team.

Figure 5.54 Scope of financial analysis

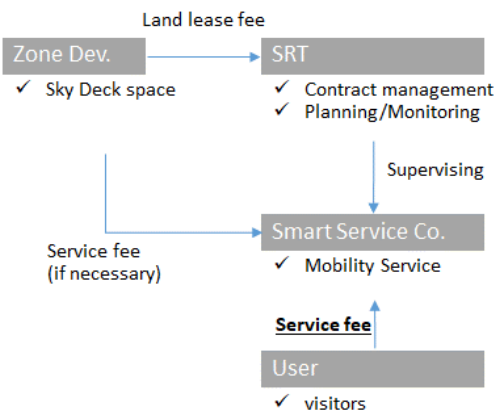
The objective of the financial feasibility study is as described below.

- (1) Objective of financial feasibility study for SSC's user fee-dependent businesses (Smart Mobility and Smart Energy business)

Feasibility analysis for Smart Mobility and Smart Energy is conducted separately, to examine whether business would be feasible on the basis of revenue from user payment. The figure below shows the business structure.

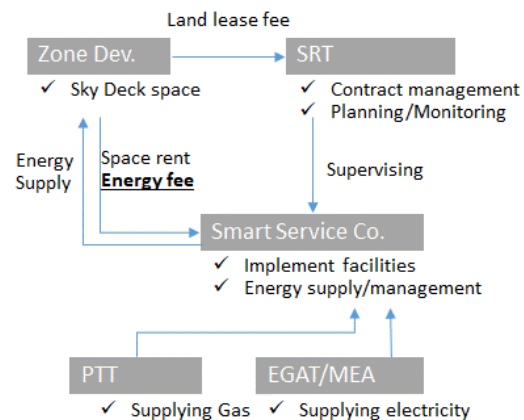
Smart Mobility

- ✓ Smart Service Co. provides mobility services on the sky deck, also provide public parking services in the area.
- ✓ Collect fees from user directly.



Smart Energy

- ✓ Smart Service Co. provides energy services to each zone developer and collect energy fee from them.



Source: JICA Study Team

Figure 5.55 Business structure for Smart Mobility and Smart Energy business

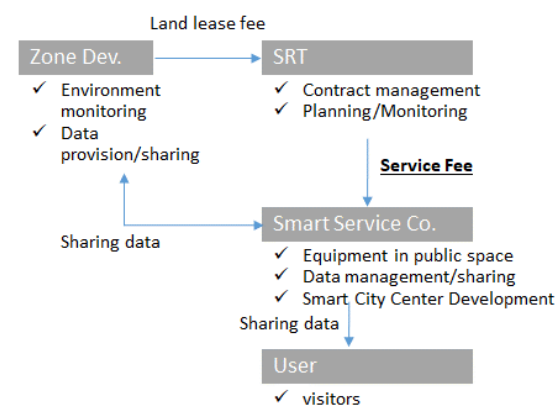
- (2) Objective of financial feasibility study for SSC's service fee-dependent businesses (sky deck development, Smart Environment, and Smart City Center development business)

Among the Smart Service Company business, the businesses except for Smart Mobility and Smart Energy – namely sky deck network development, Smart Environment-related business, and Smart City Center development – would not, in itself, generate revenues, and thus these services would be provided based on service fee from SRT.

The financial feasibility study in this section would therefore be conducted to examine the amount of service fee that would be required annually for SSC to secure business profitability for these non-revenue-generating businesses. Simply put, the question that the study aspires to answer is: what percentage of the SRT's revenue from land leasing would be needed to guarantee profitability for SSC? The figure below shows the business structure.

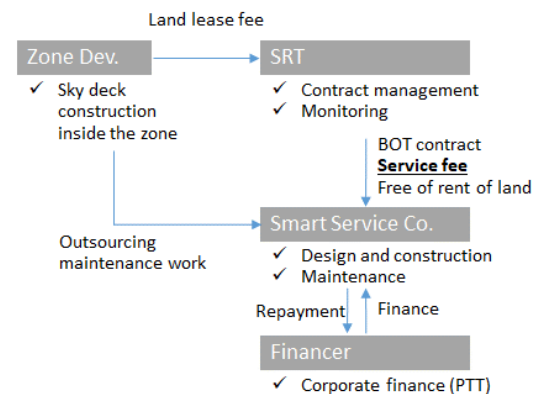
Smart Environment/Smart Center

- ✓ Each zone developer and Smart Service Co. implement environment monitoring equipment and other devices and data be gathered to SSC and shared among stake holders.



Sky Deck Construction

- ✓ BTO contract between SRT and Smart Service Co.



Source: JICA Study Team

Figure 5.56 Business structure for SSC (excluding Smart Mobility and Smart Energy business)

(3) Objective of financial feasibility study for SSC's businesses combined

All business segment for SSC (considered in (1) and (2)) is combined and its cash flow is analysed to examine the financial viability of the SSC's business as a whole.

(4) Objective of study on profitability for SRT

Primary revenue for SRT would be the land lease fee paid by zone developers. Based on the service fee calculated in the first analysis, the financial feasibility study for SRT is conducted from the viewpoint of profitability for SRT. Specifically, the question for the analysis is: how much cash would be available for SRT?

5.5.2 Financial Feasibility Study for Smart Mobility

(1) Overview of financial analysis on Smart Mobility business

The financial analysis on Smart Mobility will be examined on whether the public transportation service by Personal Rapid Transit (PRT) and fringe parking – which is proposed for introduction to the Bang Sue Area– could be financially viable as an independent business with revenue from user service fees.

(2) Financial analysis on PRT system

1) Conditions for project cost estimation

① Project cost components

Cost estimation for the PRT system service will be made on the investment cost covered by service providers for introducing PRT system. The scope is as described below.

- PRT vehicles (including battery and in-vehicle equipment for information communication) are introduced stepwise in accordance with each development stage
- Development cost for operation and management system to achieve advanced, effective system

② Timing of the valuation

- USD-THB exchange rate: 1USD=31.72THB (based on the exchange rate as of May 15, 2019)
- JPY – THB exchange rate: 1JPY=3.5THB (based on the exchange rate as of May 15, 2019)

2) Estimated project cost

The following tables summarize the estimated unit price for the PRT system introduction and the estimated operating expenses by phase.

Table 5.37 Setting of unit price

Item		Unit price	Unit
PRT System	Vehicle, equipment	2,883,348	THB/vehicle
	System development	285,714,286	THB/unit

Source: JICA Study Team

Table 5.38 Estimated operating cost by phase

		Unit price (THB)	Unit of number	Number			Price (Million THB)		
				Phase1	Phase2	Phase3	Phase1	Phase2	Phase3
Trip number		-	trip/day	42,554	150,507	295,550	-	-	-
Operationg vehicle		-	vehicle	66	301	910	-	-	-
Investment (total)	Vehicle, equipments	2,883,348	vehicle	66	235	675	190	678	1,946
	System development	285,714,286	unit	1	0	0	286	0	0

Source: JICA StudyTeam

3) Conditions for financial feasibility analysis

① Project period

- Up until 2041 (10-year period from the beginning of Phase 3 in 2032, as future traffic demand beyond the year 2032 is currently not studied)

② Evaluation indicator

- FIRR for each phase, as well as for the entire phases.

③ Investment cost

- Investments in necessary facilities are to be made in the year prior to the operation of each phase.
- The fare for the service is set at 15 baht per trip. (As a reference, transportation fare for busses with air conditioners is set at 12 to 24 baht in Bangkok and at 16 to 44 baht for BTS.)
- Vehicles are to be replaced every 10 years, and the battery cost will account for 20% of vehicle. The battery are to be replace every two years.
- For the analysis, it is assumed that 100% of investments to PRT business is self-funded.
- The operation, maintenance and management cost is set to cover the following items: vehicle and equipment replacement, battery replacement, drivers' labor cost, overhead cost, information system usage fee and fuel fee (electricity cost).

④ Conditions for estimation

The following table summarizes the conditions for the financial feasibility analysis.

Table 5.39 Conditions for financial feasibility analysis

Item		Unit Price/ Condition	
Transpiration fare	Fare for one trip (up to the intraregional destination)	15	THB/ trip
Product life	Vehicle and related item (except for battery)	10	years
	Battery	2	years
Replacement/ Maintenance and management cost	Vehicle and related item	2,883,848	THB/vehicle
	Battery	576,670	THB/vehicle
	Drivers' labor cost	15,860	THB/month•vehicle
	Operation management/ Indirect cost	15,860	THB/month•vehicle
	Information system usage fee	5	THB/passenger
	Electricity cost	137	THB/vehicle•day
Tax	Corporate tax (Tax incentive for smart city: 5-year tax reduction)	20	%
	Tax (Tax incentive for smart city: Tax exemption)	0	%

Source: JICA Study Team

(3) Results of financial analysis on Smart Mobility business (PRT system)

The table below shows the total annual investment for Smart Mobility (PRT system).

Table 5.40 Total annual investment for Smart Mobility business (PRT system)

(Million THB)																				
			2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Investment	Phase 1			476																
	Phase 2								678											
	Phase 3													1,946					678	
	Total P1 to P3			476					678					1,946					678	

*Note: All of investment for Smart Mobility business is assumed to be self-funded.

The project period is set shorter than other F/S taking into consideration of the nature of business (uncertainty and accuracy level of demand forecast).

Source: JICA Study Team

Operation and maintenance cost was calculated based on battery replacement cost, driver's salary, IT systems charge, electricity charge, and indirect cost. The cost was separated into phasing based on the number of installed vehicles at each phase.

Table 5.41 Operation and Maintenance cost for Smart Mobility business (PRT system)

		(Million Baht)																		
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
P1	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125
P2						298	366	366	366	366	366	366	366	366	366	366	366	366	366	366
P3											527	703	703	703	703	703	703	703	703	703
Total	125	125	125	125	125	423	491	491	491	491	1,018	1,194	1,194	1,194	1,194	1,194	1,194	1,194	1,194	1,194

*Note: The project period is set shorter than other F/S taking into consideration of the nature of business (uncertainty and accuracy level of demand forecast).

Source: JICA Study Team

The table below summarizes the business earnings and cash flow for Smart Mobility business (PRT system).

The result indicates that the cumulative cash flow through the project period turns positive in 2034, and thereafter it is projected to be positive even when considering equipment renewal and operation and maintenance costs. The FIRR is 15.1%.

Table 5.42 Business earnings and cash flow for Smart Mobility Business (PRT system)

		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
Cash inflow	Revenue			233	233	233	233	233	824	824	824	824	824	1,618	1,618	1,618	1,618	1,618	1,618	1,618	1,618	1,618	1,618
Cash outflow	Investment		-476					-678					-1,946					-678					
	OM			125	125	125	125	125	423	491	491	491	491	1,018	1,194	1,194	1,194	1,194	1,194	1,194	1,194	1,194	1,194
Depreciation expense				19	19	19	19	19	87	87	87	87	87	262	262	262	262	262	330	330	330	330	330
Profit before taxation				89	89	89	89	89	314	246	246	246	246	338	162	162	162	162	94	94	94	94	94
Corporate income tax									-63	-49	-49	-49	-49	-68	-32	-32	-32	-32	-19	-19	-19	-19	-19
Profit after taxation				89	89	89	89	89	251	197	197	197	197	270	130	130	130	130	75	75	75	75	75
Net cash flow			-476	108	108	108	108	-570	338	284	284	284	-1,663	533	392	392	392	-286	406	406	406	406	406
Accumulated net cash flow			-476	-368	-260	-152	-45	-614	-276	7	291	575	-1,088	-555	-163	229	621	335	741	1,147	1,552	1,958	2,364
IRR																							15.1%

*Note: The project period is set shorter than other F/S taking into consideration of the nature of business (uncertainty and accuracy level of demand forecast).

Source: JICA Study Team



Source: JICA Study Team

Figure 5.57 Single-year and cumulative cash flows for Smart Mobility business (PRT system)

It is worth noting that, demand risk is high for PRT business, since the profitability of the project would be largely affected by traffic demand fluctuation. In the case when the demand is not fully materialized, the number of PRT vehicles and the fares shall be adjusted accordingly. Several case analyses were conducted to examine the project viability when the demand was at 30%, 50%, and 75% of the base level. The following table shows the set of fare and project IRR according to the different demand level. It is indicated that when demand is less than expected, the fare should be set higher, while also reducing the number of vehicles to be introduced. For example, when the demand is 50% of the base level, the fare shall be set at 20THB to ensure IRR of 13.0%.

It is also important to note that the fare, which in the base case is set at 15 baht, would ideally be set at a reasonable price so that anyone could use the system. In order to raise business profitability while ensuring more reasonable transportation charge for all visitors to the area, various efforts are needed, such as seeking alternative revenue source such as advertising fee from companies with ad-wrapped vehicle, and collection of service fee from zone developers and tenant companies.

Table 5.43 Fare setting and IRR with regards to transport demand fluctuation

Demand for PRT	Fare (THB)	IRR
30%	27 THB	12.8%
50%	20 THB	13.0%
75%	17 THB	15.3%
100%	15 THB	15.1%

Source: JICA Study Team.

(4) Financial analysis on Fringe Parking

1) General conditions (Fringe Parking)

① Project cost components

The cost estimation will be made on the investment cost covered by the service providers for introducing Fringe Parking system. The scope is described below.

- Fringe Parking are developed stepwisely in accordance with the phased development schedule (conditions such as the scale of the parking facility are previously described in the basic plan for Smart Mobility)

② Timing of the valuation

- USD-THB exchange rate: 1USD=31.72THB (based on the exchange rate as of May 15, 2019)
- JPY – THB exchange rate: 1JPY=3.5THB (based on the exchange rate as of May 15, 2019)

2) Estimated project cost

The following table summarizes the estimated unit price for the development of the Fringe Parking facility, the estimated demand, and the total hours of parking in the year.

Table 5.44 Setting of unit price, demand, and hours of parking

		Unit price (THB)	Unit of number	Number			Price (Million THB)		
				Phase1	Phase2	Phase3	Phase1	Phase2	Phase3
Number of parking vehicle/day		-	trip/day	8,373	24,861	53,874	-	-	-
Total parking hour/year		-	hour	9,168,435	27,222,795	58,992,030	-	-	-
Investment (total)	Multistory parking lot (Construction)	10,468	m ²	88,100	36,700	69,100	922	384	723

Source: JICA Study Team

3) Conditions for financial feasibility analysis

① Project period

- Up until 2041 (10-year period from the beginning of Phase 3 in 2032, as future traffic demand beyond the year 2032 is currently not studied)

② Evaluation indicator

- FIRR for each phase, as well as for the entire phases.

③ Investment cost and revenues

- Of the total investment cost for Fringe Parking, 30% of the investment shall be made two years before the opening of the phase, and 70% of the investment shall be made one year before the opening.
- The size of the facility is as described in the previous section. The parking facilities are assumed to have five stories.
- Parking charge is set at 30THB per hour. (Based on several case studies. It needs to be noted however, that the impact of the parking price on private vehicle restriction shall also be taken in to account when determining the parking price).
- The estimation of demand for Fringe Parkings is described in Chapter 4. The demand for phase 1 and 2 is calculated by multiplying the coefficient, which set for each phase, on to the

traffic distribution in year 2032, taking into account the available Origin-Destination pair for each phase. (The coefficient is set based on the previous JICA Study in which the total trip per day is set at: 506,870 in year 2032 (100%), 363,182 in year 2027 (71.7%), and 173,370 in year 2022 (34.2%)).

- For the analysis, it is assumed that 100% of investments to Fringe Parking business is self-funded.
- The operation, maintenance and management cost is set to cover the following items: maintenance cost for Parking facility, labor cost, and overhead cost.

④ Conditions for estimation

The following table summarizes the conditions for the financial feasibility analysis.

Table 5.45 Conditions for financial feasibility analysis

Item		Unit Price/ Condition	
Revenue	Parking charge	30	THB/hour
	Average hours of usage	3	hours
	Demand by private vehicles	Above mentioned method	
Operation and Maintenance cost	Land lease fee	Set based on parking building area and unit land lease fee (refer the table of concession fee by development zones in Chapter 5.5.4)	
	Maintenance cost	5	% (Against construction cost)
	Labor cost	15,860	THB/month • person (Ten people per facility)
	Operation and overhead cost	Set as equivalent to labor cost	
Tax	Corporate tax (Tax incentive for smart city: 5-year tax reduction)	20	%
	Tax (Tax incentive for smart city: Tax exemption)	0	%

Source: JICA Study Team

(5) Results of financial analysis on Smart Mobility business (Fringe Parking)

The table below shows the total annual investment for Smart Mobility (Fringe Parking).

Table 5.46 Total annual investment for Smart Mobility business (Fringe Parking)

(Million THB)																				
			2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Investment	Phase 1		277	646																
	Phase 2							115	269											
	Phase 3												217	506						
	Total P1 to P3		277	646				115	269				217	506						

*Note: All of investment for Smart Mobility business is assumed to be self-funded.

The project period is set shorter than other F/S taking into consideration of the nature of business (uncertainty and accuracy level of demand forecast).

Source: JICA Study Team

Operation and maintenance cost was calculated based on land lease fee, labor cost, operation cost, and maintenance cost.

Table 5.47 Operation and Maintenance cost for Smart Mobility business (Fringe Parking)

		(Million Baht)																		
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
P1	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116
P2						42	42	42	42	42	42	42	42	42	42	42	42	42	42	42
P3											99	99	99	99	99	99	99	99	99	99
Total	116	116	116	116	116	158	158	158	158	158	257	257	257	257	257	257	257	257	257	257

*Note: The project period is set shorter than other F/S taking into consideration of the nature of business (uncertainty and accuracy level of demand forecast).

Source: JICA Study Team

The table below summarizes the business earnings and cash flow for Smart Mobility business (Fringe Parking).

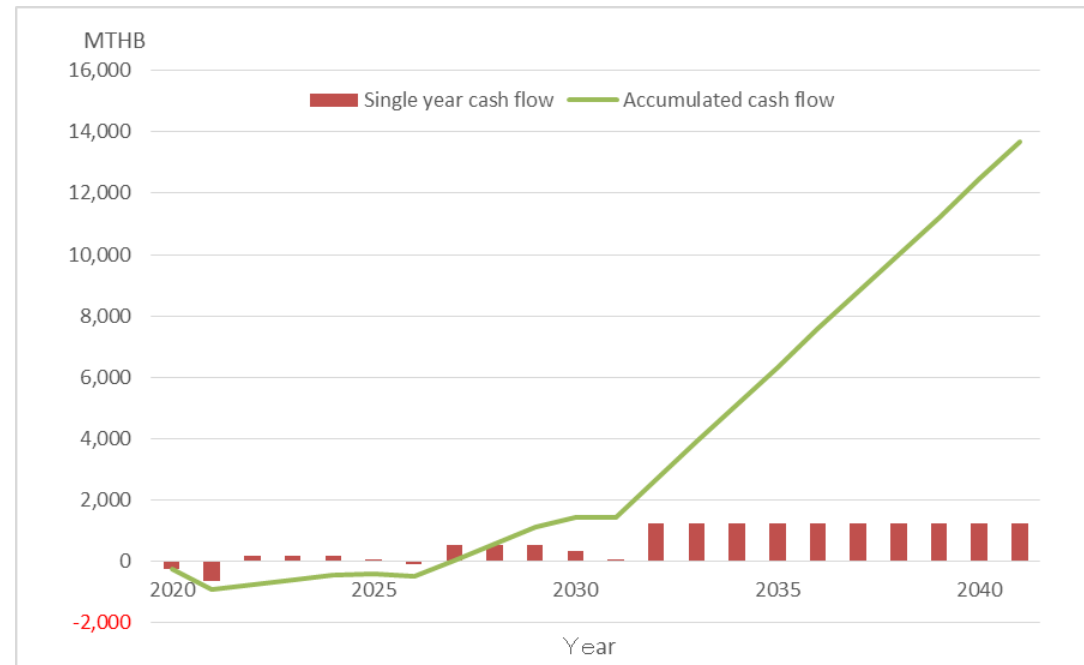
The result indicates that the cumulative cash flow through the project period turns positive in 2027, and thereafter it is projected to be positive even when considering equipment renewal and operation and maintenance costs. The FIRR is 27.2%.

Table 5.48 Business earnings and cash flow for Smart Mobility Business (Fringe Parking)

		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
Cash inflow	Revenue	0	0	275	275	275	275	275	817	817	817	817	817	1,770	1,770	1,770	1,770	1,770	1,770	1,770	1,770	1,770	1,770
Cash outflow	Investment	277	646				115	269				217	506										
	OM	0	0	116	116	116	116	116	158	158	158	158	158	257	257	257	257	257	257	257	257	257	257
Depreciation expence		0	0	31	31	31	31	31	44	44	44	44	44	68	68	68	68	68	68	68	68	68	68
Profit before taxation		0	0	128	128	128	128	128	615	615	615	615	615	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445
Corporate income tax		0	0	0	0	0	0	0	-123	-123	-123	-123	-123	-289	-289	-289	-289	-289	-289	-289	-289	-289	-289
Net cash flow		-277	-646	159	159	159	44	-110	535	535	535	318	29	1,224	1,224	1,224	1,224	1,224	1,224	1,224	1,224	1,224	1,224
Accumulated net cash flow		-277	-922	-763	-604	-445	-401	-511	24	559	1,094	1,412	1,441	2,665	3,889	5,112	6,336	7,559	8,783	10,007	11,230	12,454	13,678
IRR																							27.2%

*Note: The project period is set shorter than other F/S taking into consideration of the nature of business (uncertainty and accuracy level of demand forecast).

Source: JICA Study Team



Source: JICA Study Team

Figure 5.58 Single-year and cumulative cash flows for Smart Mobility business (Fringe Parking)

It is worth noting that, demand risk is high for Fringe Parking business, since the profitability of the project would be largely affected by traffic demand fluctuation. The results shown above are based upon the assumption that the demand would be fully materialized through successful zone development and implementation of private vehicle restriction. Several case analyses were conducted to examine the project viability when the demand is at 30%, 50%, and 75% of the base level. Note that the facility size and the operational and maintenance cost are constant for these cases. The results indicate that the IRR would be lower if the demand is small.

Table 5.49 IRR with regards to transport demand fluctuation

Demand fluctuation	FIRR
30%	2.1%
50%	12.2%
75%	20.5%
100%	27.2%

Source: JICA Study Team

5.5.3 Financial Feasibility Study for Smart Energy

(1) Overview of feasibility study on Smart Energy business

The financial analysis on Smart Energy will be examined on whether the Smart Energy business could be financially viable as an independent business with revenue from user service fees.

(2) General conditions

1) Conditions for project cost estimation

① Project cost index

Cost estimation for the Smart Energy service will be made on the investment cost covered by Smart Energy network operators. The scope is as described below.

a) Power Supply Business

- Cost for constructing the infrastructure segment on the upstream of the substation for collective power receiving for each zone are excluded from investment to be covered by the operator. (To be covered by EGAT/MEA)
- Cost for constructing the substation for each zone and its downstream infrastructure segment (micro-grid) is included in investment by the operator.
- Cost for constructing the micro-grid at each zone is included in investment by the operator.
- Cost for developing emergency power line (BCP line) to be supplied to key facilities from CGS for each EC is included in investment by the operator.
- Cost for developing PV power generation system is included in investment by the operator.

b) District cooling and heating system (District cooling and point-based heat supply)

- Cost for developing energy supply plant and pipe for cold water are included in investment by the operator.
- Cost for constructing receiving facilities for buildings for each zone is excluded from the investment by the operator. (To be covered by zone developers).
- Cost for constructing gas pipes to be connected to EC that install CGS are excluded from the investment by the operator. (To be covered by PTT)

c) Common condition

- Cost for developing Smart Energy Management Center (SEMC) and EMS for each facility are included in the investment by the operator.
- Cost for Constructing C.C.Box and Common duct are excluded from the investment by the operator. (However, the occupancy fee is taken into account in the business evaluation shown later.)

② Timing of valuation

- USD-THB exchange rate: The Thai baht to the US dollar is set at 31.72 baht, based on the exchange rate as of May 15, 2019.
- JPY – THB exchange rate: The Thai Baht to the Japanese yen is set at 3.5 baht, based on the exchange rate as of May 15, 2019.

2) Estimated project cost

The table below summarizes facility unit prices and estimated project cost for Smart Energy network by development phase.

Table 5.50 Facility unit price

	Item	Unit Price	Unit
Cold source/ Power generation equipment	Chiller	71,430	THB/USRt
	Chilled water storage tank	7,150	THB/USRt
	A set of CGS	71,430	THB/kW
	A set of PV power generation system	37,150	THB/kW
Energy transmitting equipment	Cold water pipe (Common duct installation)	200,000	THB/m
	Power cable (100 sq)	580	THB/m
	Power receiving equipment (24 kV)	28,571,430	THB/ unit
	Transformer (24 k/440 V)	1,430	THB/kVA
EMS	AEMC	57,142,860	THB
	BEMS	8,571,430	THB/ unit
	HEMS	20,000	THB/House

Source: JICA Study Team

Table 5.51 Cold Source/Power Generation Equipment by Phase 1/3

Phase	Energy Center	Supply destination	Chiller Volume (USRt)	Cold Water Storage Heat Tank (USRTh)	CGS Volume (kW)	Solar Power Generation Volume (kW)
Phase 1	EC 1	Zone A	4,900	10,000	-	2,164
	EC 2-1	Zone D1	2,500	10,000	-	915
	EC 3	Zones E, F1	14,700	10,000	4,440	7,446
	-	Zone G	-	-	-	9,598
	SEMC	Subject to All Areas	-	-	-	-
	Supply	EC3 → Station	-	-	-	-
	Supply	EC2-1 → Station	-	-	-	-
Phase 2	EC 4	Zone F2	15,700	10,000	4,440	6,149
	EC 5	Zone C	2,900	10,000	-	5,779
	Supply	EC3 - EC4	-	-	-	-
	Supply	EC2 - EC5	-	-	-	-
Phase 3	EC2-2	Zone D2	12,200	-	-	6,177
	EC 6	Zone B	10,500	10,000	4,440	9,423
	EC 7	Zone H	7,100	10,000	-	3,647
	-	Zone I	-	-	-	2,442
Total		-	70,500	70,000	13,320	53,739

Source: JICA Study Team

Table 5.52 Energy Delivery Equipment Volume by Phase 2/3

Phase	Energy Center	Supply destination	Cold Water Conduit Pipe (m)	Power Cable (100 sq)	Power-Receiving Equipment (kVA) (Incl. Transformer)	Step-Down Transformer (kVA)
				Total Extension (m)		
Phase 1	EC 1	Zone A	230	840	11,500	520
	EC 2-1	Zone D1	30	-	-	1,710
	EC 3	Zones E, F1	100	15,000	54,500	20,940
	-	Zone G	-	50,000	37,500	28,550
	SEMC	Subject to All Areas	-	-	-	-
	Supply	EC3 → Station	400	400	-	-
	Supply	EC2-1 → Station	950	950	-	-
Phase 2	EC 4	Zone F2	300	0	48,000	12,600
	EC 5	Zone C	270	5,040	25,500	18,490
	Supply	EC3 - EC4	350	350	-	-
	Supply	EC2 - EC5	-	1,000	-	-
Phase 3	EC2-2	Zone D2	960	23,790	46,500	13,620
	EC 6	Zone B	560	16,060	34,000	15,470
	EC 7	Zone H	450	11,360	27,500	11,720
	-	Zone I	-	3,600	13,500	12,590
Total		4,600	4,600	128,390	305,500	136,210

Source: JICA Study Team

Table 5.53 EMS-Related Volume 3/3

Phase	Energy Center	Supply destination	EMS		
			AEMS (No. of Location)	BEMS (No. of Buildings)	HEMS (No. of Houses)
Phase 1	EC 1	Zone A	-	2	197
	EC 2-1	Zone D1	-	1	648
	EC 3	Zones E, F1	-	3	7,975
	-	Zone G	-	-	10,875
	SEMC	Subject to All Areas	1	-	-
	Supply	EC3 → Station	-	-	-
	Supply	EC2-1 → Station	-	-	-
Phase 2	EC 4	Zone F2	-	4	4,797
	EC 5	Zone C	-	-	7,043
	Supply	EC3 - EC4	-	-	-
	Supply	EC2 - EC5	-	-	-
Phase 3	EC2-2	Zone D2	-	2	5,186
	EC 6	Zone B	-	-	5,890
	EC 7	Zone H	-	-	4,461
	-	Zone I	-	-	4,794
Total		-	1	12	51,866

Source: JICA Study Team

Table 5.54 Estimated operating cost by Phase (Investment Amount)

(Unit: Million Baht)

(Unit: Million Baht)

Phase	Energy Center	Supply destination	Cold Source/Power Generation Equipment	Energy Delivery Equipment		EMS	Total
				Cold Water	Power		
Phase1	EC 1	Zone A	502	46	30	21	599
	EC 2-1	Zone D1	284	6	31	22	343
	EC 3	Zones E, F1	1,715	20	67	185	1,987
	-	Zone G	357	-	98	217	672
	SEMC	Subject to All Areas	-	-	-	57	57
	Supply Cold Water	EC3 → Station	-	80	0.2	-	80
	Supply Power	EC2-1 → Station	-	190	0.5	-	191
	Subtotal		2,857	342	227	502	3,928
Phase2	EC 4	Zone F2	1,738	60	47	130	1,975
	EC 5	Zone C	493	54	58	141	746
	Supply Cold Water	EC3 - EC4	-	70	0.2	-	70
	Supply Power	EC2 - EC5	-	-	0.6	-	1
	Subtotal		2,232	184	105	271	2,792
Phase3	EC 2-2	Zone D2	1,101	192	62	121	1,475
	EC 6	Zone B	1,489	112	60	118	1,778
	EC 7	Zone H	714	90	52	89	945
	-	Zone I	91	-	49	96	235
	Subtotal		3,394	394	222	424	4,434
Total			8,483	920	554	1,197	11,154

Source: JICA Study Team

3) Conditions for financial feasibility analysis

① Project period

- The project evaluation periods for each phase start 30 years after the project commencement. The following table shows the business operation start timing determined at the time of project evaluation. The start timing for this project in Phase 1 corresponds to the project start timing shown in the roadmap in order to align with SSC feasibility evaluation mentioned later. The start timings for Phases 2 and 3 correspond to the development timing for the JICA survey report produced in the previous fiscal year.

Table 5.55 Operation Start Timing

Phase	Energy Center	Supply Destination	Operation Start
Phase 1	EC 1	Zone A	2022 onwards
	EC 2-1	Zone D1	2024 onwards
	EC 3	Zone E, F1	2025 onwards
	-	Zone G	2024 onwards
	SEMC	Subject to All Areas	2022 onwards
	Supply	EC3 → Station	2025 onwards
	Supply	EC2-1 → Station	2024 onwards
Phase 2	EC 4	Zone F2	2027 onwards
	EC 5	Zone C	2027 onwards
	Supply	EC3 - EC4	2027 onwards
	Supply	EC2 - EC5	2027 onwards
Phase 3	EC2-2	Zone D2	2032 onwards
	EC 6	Zone B	2032 onwards
	EC 7	Zone H	2032 onwards
	-	Zone I	2032 onwards

Source: JICA Study Team

② Analysis indicator

- EIRR for CF in each phase, as well as for the entire phases.

③ Investment cost

- Construction work is assumed to be initiated two years before the start of operation for each phase.
- It is assumed that 30% of the investments is spent in the first year and the remaining 70% is spent in the second year.
- For funding, 30% of the initial investment is covered by equity while the remainder 70% is covered from loans issued by financial institutions.
- Facilities and equipment are to be replaced in the 15th year.
- As facility replacement cost, the ratio against initial investment is 70% and 60% for Cold source equipment and PV generation, respectively. (If lack of self-financing was happened in the 15th year when updating the facilities, the shortage amount was covered by financial institution loan.)

④ Conditions for estimation

The following table summarizes the conditions for the financial feasibility analysis.

Table 5.56 Conditions for financial feasibility analysis

Item			Unit Price/ Conditions
Unit price for utility	Power unit price (22 kV on average in 2018)	Peak	4.07 THB/kWh
		Off-peak	2.45 THB/kWh
	Gas unit price (Cogeneration/average in 2018)		258.13 THB/MMBTU
Unit price for cold water	Heat unit price equivalent to conventional type (package-type) (Unit price for cold water is set at the annual cost which is calculated based on initial investment for conventional type on 5-year service life and 5% interest rate.)		2.07 THB/kWh (Phase 1)
			1.89 THB/kWh (Phase 2)
			2.02 THB/kWh (Phase 3)
Service life	Heat/ power generation facility and power transmission		15 years
	Cold water piping		30 years
Finance	Interest rate (set at 70% of initial investments)		5 %
Tax	Corporate tax (Incentive for smart city: 5-year tax reduction)		20 %
	Tax (Incentive as smart city: Tax exemption)		0 %
Rent	EC (per installation space for Energy plant)		600 THB/Month • m ²
	PV (Rooftop installation space)		Equivalent to 20% of revenues from PV power generation
	Tax (Incentive as smart city: Tax exemption)		600,000 THB/km • Year
Maintenance	Yearly maintenance cost (per initial investment)		1.1 %
Insurance	Yearly insurance cost (per initial investment)		1.1 %

Source: JICA Study Team

⑤ Other Hypothetical Conditions

- Assume that all demand is generated in line with demand calculations at the starting point for each phase and the demand volume is fixed during the business execution period in the feasibility study.
- Exclude the initial cost and maintenance cost for power transmission/distribution and retail sales within the zone, as these costs can be offset by power sales profits. (Consultations are needed with the Ministry of Energy and EGAT/MEA on power wholesale procurement price.)
- Exclude O&M-related labor costs for SEMC, as these costs can be offset as labor cost for energy management under the traditional system. (To consider details)
- Assume that energy-saving effect brought by EMS is set at 10% and the slashed energy cost is shared by 50/50 between the energy supplier and building owner.

⑥ Operating cost for feasibility analysis

The following table summarizes estimated operating costs for evaluation, based on the calculation conditions summarized in this section.

Table 5.57 Estimated operating cost for feasibility analysis

(Unit: Million Baht)

(Unit: Million Bar)

Phase	Energy Center	Supply destination	Cold Source/ Power Generation Equipment	Energy Delivery Equipment		EMS	Total
				Cold Water	Power		
Phase1	EC 1	Zone A	502	46	0	21	599
	EC 2-1	Zone D1	284	6	0	22	343
	EC 3	Zones E, F1	1,715	20	0	185	1,987
	-	Zone G	357	-	0	217	672
	SEMC	Subject to All Areas	-	-	-	57	57
	Supply Cold Water	EC3 → Station	-	80	0.2	-	80
	Supply Power	EC2-1 → Station	-	190	0.5	-	191
	Subtotal		2,857	342	0.7	502	3,257
Phase2	EC 4	Zone F2	1,738	60	0	130	1,975
	EC 5	Zone C	493	54	0	141	746
	Supply Cold Water	EC3 - EC4	-	70	0.2	-	70
	Supply Power	EC2 - EC5	-	-	0.6	-	1
	Subtotal		2,232	184	0.8	271	2,416
Phase3	EC 2-2	Zone D2	1,101	192	0	121	1,475
	EC 6	Zone B	1,489	112	0	118	1,778
	EC 7	Zone H	714	90	0	89	945
	-	Zone I	91	-	0	96	235
	Subtotal		3,394	394	0	424	3,788
Total			8,483	920	1.5	1,197	9,462

Source: JICA Study Team

(3) Results of financial analysis on Smart Energy business

The following table shows the total annual investment value and self-investment amount, loans for smart energy business. The total investment value is as shown in the calculation conditions. The facility replacement cost is added in the 15th year after the start of operation.

Table 5.58 Annual Investment Value, Self-investment Amount, Loan Deposit, Amount of Principal Interest Payment, Interest Payment for Smart Energy Business

(Unit: Million Baht)

			2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Investment	Phase 1		188	438	323	1,353	1,400											107	249	170
	Phase 2							806	1,881											
	Phase 3												1,264	2,948						
	Total P1 to P3		188	438	323	1,353	1,400	806	1,881				1,264	2,948				107	249	170
Equity investment		30%	56	131	97	406	420	242	564				379	884				107	249	170
Loan from a commercial bank		70%	131	307	226	947	980	564	1,317				884	2,064						
Loan repayment					259	259	259	259	259	447	447	447	447	447	483	483	483	483	483	295
Interest payment		5%	7	22	20	55	91	106	159	136	114	92	114	194	170	146	122	98	74	59

			2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055
Investment	Phase 1		780	896																
	Phase 2				496	1,157														
	Phase 3									772	1,801									
	Total P1 to P3		780	896	496	1,157				772	1,801									
Equity investment		30%	780	896	496	1,157				772	1,801									
Loan from a commercial bank		70%																		
Loan repayment			295	295	295	295														
Interest payment		5%	44	29	15															

			2056	2057	2058	2059	2060	2061												
Investment	Phase 1																			
	Phase 2																			
	Phase 3																			
	Total P1 to P3																			
Equity investment		30%																		
Loan from a commercial bank		70%																		
Loan repayment																				
Interest payment		5%																		

Source: JICA Study Team

Operation and maintenance cost was calculated by EC cost and rental cost for installation of solar power generation, and maintenance cost, common duct use fee, insurance fee, fuel cost, etc.

Table 5.59 Operation and Maintenance Cost for Smart Energy Business

(Unit: Million Baht)

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	...	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061
P1	50	50	91	172	172	172	172	172	172	172	172	172	172	...	172	123	123	83							
P2						186	186	186	186	186	186	186	186	...	186	186	186	186	186	186					
P3											216	216	216	...	216	216	216	216	216	216	216	216	216	216	216
Total	50	50	91	172	172	358	358	358	358	358	574	574	574	...	574	525	525	485	402	402	216	216	216	216	216

Source: JICA Study Team

The following table summarizes operating earnings and cash flow for Smart Energy business. Based on this preliminary calculation results, the cumulative cash flow for 2038 turns to positive in the whole phases, and subsequently it remains at positive growth, even considering equipment renewal and operation/maintenance and management costs. FIRR ends up with 10.3%.

Based on this calculation results, though it is evaluated that this project can be feasible in a long term, a longer investment recovery period is considered to be a huge risk factor for business operation. Therefore, it is preferable that public companies as project execution entities should invest in the project.

In addition, some added values (economic benefits or revenue growth), brought by smart city development in Bang Sue, need to be given back to operators as preferential treatment. As an example, interest repayment, subsidy issue or public support like additional tax privilege (only smart city benefits are insufficient) is considered. In addition, the utilization of Japanese government support scheme is also considered to be effective. If 20% of the initial cost is subsidized, the EIRR will improve to 14%.

Table 5.60 Business earnings and cash flow for Smart Energy Business (1)

(Unit: Million Baht)

		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
Cash inflow	Revenue			92	92	250	543	543	1,022	1,022	1,022	1,022	1,022	1,737	1,737	1,737	1,737	1,737	1,737	1,737	1,737	1,737	1,737
	Loan	131	307	226	947	980	564	1,317				884	2,064					700					250
Cash outflow	Investment	188	438	323	1,353	1,400	806	1,881				1,264	2,948				107	249	170	780	896	496	1,157
	Loan repayment			259	259	259	259	259	447	447	447	447	447	483	483	483	483	483	295	295	295	295	295
	Interest payment	7	22	20	55	91	106	159	136	114	92	114	194	170	146	122	98	74	59	44	29	15	
	OM			50	50	91	172	172	358	358	358	358	358	574	574	574	574	574	574	574	574	574	574
Depreciation expense				38	38	101	228	228	397	397	397	397	397	659	659	659	659	659	649	649	633	597	597
Profit before taxation		-7	-22	-16	-50	-33	37	-16	131	154	176	198	221	333	357	381	405	429	454	469	500	551	566
Corporate income tax									-26	-31	-35	-40	-44	-67	-71	-76	-81	-86	-91	-94	-100	-110	-113
Profit after taxation		-7	-22	-16	-50	-33	37	-16	105	123	141	159	177	266	285	305	324	343	363	375	400	441	453
Net cash flow		-63	-153	-334	-678	-611	-236	-611	54	72	90	-315	-906	443	462	481	501	520	718	730	738	743	754
Accumulated net cash flow		-63	-216	-550	-1,228	-1,839	-2,075	-2,686	-2,632	-2,560	-2,470	-2,785	-3,691	-3,249	-2,787	-2,305	-1,805	-1,285	-567	163	901	1,643	2,398
IRR																							

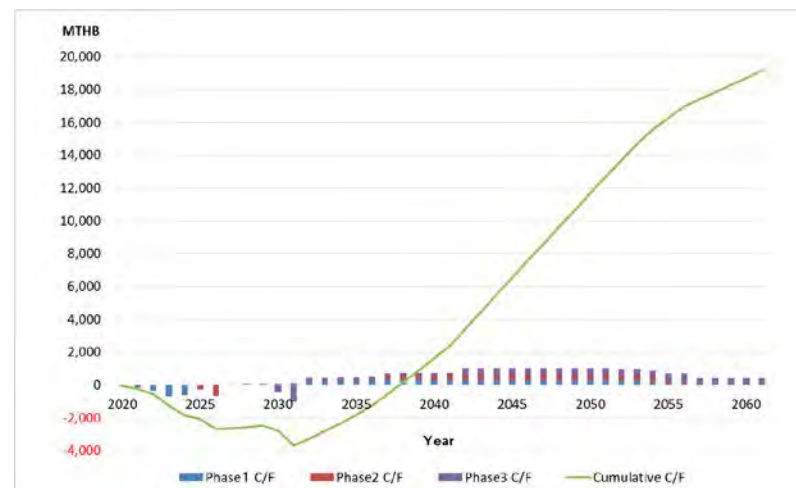
Source: JICA Study Team

Table 5.61 Business earnings and cash flow for Smart Energy Business (2)

(Unit: Million Baht)

		2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061		
Cash inflow	Revenue	1,737	1,737	1,737	1,737	1,737	1,737	1,737	1,737	1,737	1,737	1,645	1,645	1,487	1,194	1,194	715	715	715	715	715		
	Loan																						
Cash outflow	Investment				772	1,801																	
	Loan repayment																						
	Interest payment																						
	OM	574	574	574	574	574	574	574	574	574	574	525	525	485	402	402	216	216	216	216	216		
Depreciation expense		549	549	549	549	549	476	476	476	476	476	448	448	402	310	310	189	189	189	189	189		
Profit before taxation		613	613	613	613	613	687	687	687	687	687	672	672	601	481	481	309	309	309	309	309		
Corporate income tax		-123	-123	-123	-123	-123	-137	-137	-137	-137	-137	-134	-134	-120	-96	-96	-62	-62	-62	-62	-62		
Profit after taxation		491	491	491	491	491	550	550	550	550	550	537	537	481	385	385	247	247	247	247	247		
Net cash flow		1,040	1,040	1,040	1,040	1,040	1,026	1,026	1,026	1,026	1,026	985	985	882	695	695	437	437	437	437	437		
Accumulated net cash flow		3,438	4,477	5,517	6,557	7,597	8,623	9,648	10,674	11,699	12,725	13,710	14,696	15,578	16,273	16,969	17,405	17,842	18,279	18,716	19,153		
IRR																					10.3%		

Source: JICA Study Team



Source: JICA Study Team

Figure 5.59 Single-Year and Cumulative Cash Flows for Smart Energy Business

5.5.4 Financial Feasibility of SSC's Other Business

This section assesses the financial feasibility of SSC's smart city services. The following smart city services are included in this analysis:

- Sky Deck Network (outside of development zones)
- Smart Environment
- Smart City Platform

Table 5.62 indicates development costs of the smart city services mentioned above and the total (Layer 2) by development phases. The total development cost of the layer 2 amounts to THB3.1 billion and it accounts for 1% of the total development cost of Bang Sue area.

Table 5.62 Development cost of layer 2 development of Bang Sue area by development phases

	(Million THB)			
	Phase 1	Phase 2	Phase 3	Total
Sky Deck Network (outside of development Zones)	1,534	457	327	2,318
Smart Environment	18	1	0	19
Smart City Center	377	171	198	745
Total of the layer 2	1,929	628	526	3,083

Source: JICA Study Team

In order to analyze the financial feasibility of the smart city services in Layer 2, JICA Study Team sets the following conditions.

Project duration

Project duration is 41 years from 2021 to 2061. Year 2061 is the 30th year after the Phase 3 operation has begun in 2032.

Timing of investment

Investment costs for the three smart city service facilities are listed by development zones. It is assumed that the development schedule of Phase 1 follows Figure 7.2 of Chapter 7. For example, investment will start in 2021 and end in 2023 in Zone A, and commercial facilities will be partly open in 2022 and fully open in 2024. All investment activities in Phase 1 will be completed in 2025.

After development of Phase 1, investment for Phase 2 will be carried out in 2026 and 2027, and investment for Phase 3 in 2030 and 2031 respectively. The smart city service facilities will be invested in 2-years before the opening of each zone in Phase 2 and Phase 3.

Equity investment and loan from a financial institution

The second to the fifth rows of Table 5.64 show flows of annual investment amounts by phases. It is assumed that 30% of the investment cost is financed by the SSC's equity investment, and 70% by commercial bank loans. The annual flow of the SSC's equity investment is tabulated in the sixth row of Table 5.64.

The loan conditions of the commercial bank are assumed that repayment period is five years with one year of grace period. Since the SSC is a normal private company and it is assumed that one of equity method affiliates of a big state-owned company, the SSC would receive a normal

commercial loan. The financial market statistics of the Bank of Thailand website⁴ shows that the lowest rate of the Minimum Lending Rate (MLR) was 6.07% in July 2019, and year-on year consumer price index (CPI) rate as of June 2019 was 0.92%, according to Ministry of Commerce's CPI statistics⁵; therefore, real loan rate was set at 5.11% (6.03% minus 0.92%).

As a result, annual flows of the loan from the commercial bank, interest payment and loan repayment would be set as indicated in the 6th row, 7th row and 8th row of. Table 5.64

Operation and maintenance cost

Operation and maintenance cost for the three smart city services (Sky Deck Network, Smart Environment and Smart City Center) are calculated by development zones as same as the investment cost. The SSC will provide smart city services for 30 years after the completion of each zone, and operation & maintenance cost for the smart city service facilities will accounts for 5% of the investment amount every year. Operation and maintenance cost in the development zones in Phase 1 will also be listed during the partial open period. Table 5.65 indicates annual operation & maintenance cost from 2022 when development Zone A starts business (partial opening) to 2061 when development zones D3 and H1 terminate business activities. The same amount of operation & maintenance cost in 2034 will be listed in each phase during the period from 2035 to 2052.

Revenue (smart city service fee)

In the operation of the development zones in Bang Sue area, SRT will receive concession fees from zone developers. The SSC receives a part of the concession from SRT as a service fee for providing three smart city services.

Currently, SRT is preparing revenue plan from the Bang Sue development, and considering concession fees of development zones in Phase 1. The JICA Study team uses the average concession fee per hectare by development zones for the analysis of Phase 1, and adopts the same unit concession fee for each zone based on the examination of land conditions (access from Bang Sue Central Station and MRT & BTS stations, road conditions, drainage conditions, etc.) regarding Phase 2 and Phase 3. Table 5.63 shows the development phase, name of zones, area, unit concession fee, concession fee and reason of setting the unit fee.

In this financial analysis of the Layer 2, the JICA Study Team set that SRT pay will 12% of the concession fee during the investment period from 2022 (opening of Zone A) to 2033 (final year of investment to the Layer 2), and 6% of the concession fee during the O&M period after 2034 respectively.

⁴ <https://www.bot.or.th/English/Statistics/FinancialMarkets/InterestRate/Pages/StatInterestRate.aspx>

⁵ http://www.indexpr.moc.go.th/price_present/SelectProvinceIndexG_45_Country_E.asp?type_index=a&type_region=5

Table 5.63 Concession fee by development zones

Phase	Zone	Area (ha)	Unit concession fee (million THB/ha/year)	Concession fee (million THB/year)	Reason of setting unit concession fee
1	A	5.1	22.19	113	Prepared by SRT
1	D1	2.4	41.21	99	Prepared by SRT
1	E	13	24.0	312	Prepared by SRT
1	F1	1.0	24.0	24	Assumed by JICA Study Team
1	G	52.06	26.7	1,388	Prepared by SRT
2	C	17.4	26.7	464	Assumed by JICA Study Team
2	F2	11.4	24.0	273	Assumed by JICA Study Team
3	B1	10.1	41.21	416	Assumed by JICA Study Team
3	B2	7.5	41.21	309	Assumed by JICA Study Team
3	B3	1.5	41.21	62	Assumed by JICA Study Team
3	B4	1.1	41.21	45	Assumed by JICA Study Team
3	D2-1	6.2	41.21	256	Assumed by JICA Study Team
3	D2-2	2.5	41.21	103	Assumed by JICA Study Team
3	D3	7.9	41.21	326	Assumed by JICA Study Team
3	D4	2.7	41.21	111	Assumed by JICA Study Team
3	H1	9.8	41.21	235	Assumed by JICA Study Team
3	H2	5.5	24.0	132	Assumed by JICA Study Team
3	I	15.1	26.7	403	Assumed by JICA Study Team

Source: JICA Study Team

Calculation of Equity IRR and average ROE

Table 5.66 and Table 5.67 compiles the annual cash inflow and cash outflow of Layer 2 (three smart city services) from 2021 to 2061.

Equity IRR which means the internal rate of return of the SSC's equity investment is 11.0%. JICA Study Team calculates corporate profit after taxation and the Return on Equity (ROE) annually under assumption of 20 years of depreciation period for the smart city facilities at the Layer and 20% of the corporate income tax. The annual ROE is indicated in the last row of Table 5.27 and Table 5.28. Average ROE during the period from 2034 to 2061 is 6.2%. It is almost same the level as the dividend yield of the major Infrastructure Funds listed on SET⁶ as of July 2019.

⁶ JICA Study Team referred the ROE of the following funds: EGAT Infrastructure Fund, Buriram Sugar Group Power Plant Infrastructure Fund, BTS Rail Mass Transit Growth Infrastructure Fund, Digital Telecommunications Infrastructure Fund and Jasmine Broadband Internet Growth Infrastructure Fund.

Table 5.64 Investment amount, equity investment, loan from commercial bank, loan repayment and interest payment for the layer 2

(Unit: Million Baht)

			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Investment	Phase 1		67	406	839	525	92											
	Phase 2							314	314									
	Phase 3											263	263					
	Total P1 to P3		67	406	839	525	92	314	314			263	263					
Equity investment		30%	20	122	252	157	28	94	94			79	79					
Loan from a commercial bank		70%	47	284	587	367	64	220	220			184	184					
Loan repayment			0	9	66	184	257	270	305	292	174	101	125	118	74	74	74	37
Interest payment		5.11%	2	16	43	52	43	40	36	21	12	16	19	13	9	6	2	

Source: JICA Study Team

Table 5.65 Operation and maintenance cost for the layer 2

(Unit: Million Baht)

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	...	2053	2054	2055	2056	2057	2058	2059	2060	2061
P1	3	3	44	88	96	96	96	96	96	96	96	...	96	90							
P2						31	31	31	31	31	31	...	31	31	31	31					
P3											26	...	26	26	26	26	26	26	26	26	26
Total	3	3	44	88	96	128	128	128	128	128	154	...	154	147	58	58	26	26	26	26	26

Source: JICA Study Team

Table 5.66 Net cash flow of the layer 2 (1)

(Unit: Million Baht)

		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
Cash inflow	Revenue		232	288	288	288	288	321	321	321	321	321	608	608	304	304	304	304	304	304	304	304
	Loan	47	284	587	367	64	220	220			184	184										
Cash outflow	Investment	67	406	839	525	92	314	314			263	263										
	Loan repayment		9	66	184	257	270	305	292	174	101	125	118	74	74	74	37					
	Interest payment	2	16	43	52	43	40	36	21	12	16	19	13	9	6	2						
	OM	0	3	3	44	88	96	128	128	128	128	128	154	154	154	154	154	154	154	154	154	154
Net cash flow		-67	-177	-555	-281	108	-123	-121	193	193	-70	-70	454	454	150	150	150	150	150	150	150	150
Accumulated net cash flow		-67	-244	-799	-1,080	-971	-1,094	-1,215	-1,022	-829	-899	-969	-515	-61	89	239	389	540	690	840	990	1,140
Depreciation expense			16	44	61	64	64	64	64	64	73	82	82	82	82	82	82	82	82	82	82	
Profit before taxation			75	-54	-27	66	-7	-1	108	117	25	13	359	363	63	66	68	68	68	68	68	68
Corporate income tax									22	23	5		72	73	13	13	14	14	14	14	14	14
Profit after taxation			75	-54	-27	66	-7	-1	86	93	20	13	287	290	50	53	55	55	55	55	55	55
Return on Equity (ROE)															5.4%	5.7%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%

Source: JICA Study Team

Table 5.67 Net cash flow of the layer 2 (2)

(Unit: Million Baht)

		2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	
Cash inflow	Revenue	304	304	304	304	304	304	304	304	304	304	304	304	297	188	188	144	144	144	144	144	
	Loan																					
Cash outflow	Investment																					
	Loan repayment																					
	Interest payment																					
	OM	154	154	154	154	154	154	154	154	154	154	154	154	147	58	58	26	26	26	26	26	Equity IRR
Net cash flow		150	150	150	150	150	150	150	150	150	150	150	150	150	130	130	118	118	118	118	118	11.0%
Accumulated net cash flow		1,290	1,109	1,259	1,409	1,559	1,709	1,859	2,009	2,159	2,310	2,460	2,610	2,760	2,890	3,020	3,138	3,255	3,373	3,490	3,608	
Depreciation expense (30 yrs)		82	82	82	82	82	82	82	82	82	82	82	82	82	82	82	18	18	18	18	18	
Profit before taxation		68	68	68	68	68	68	68	68	68	68	68	68	68	49	49	100	100	100	100	100	
Corporate income tax (20%)		14	14	14	14	14	14	14	14	14	14	14	14	14	10	10	20	20	20	20	20	Avg.
Profit after taxation		55	55	55	55	55	55	55	55	55	55	55	55	55	39	39	80	80	80	80	80	ROE
Return on Equity (ROE)		5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	4.2%	4.2%	8.7%	8.7%	8.7%	8.7%	8.7%	6.2%

Source: JICA Study Team

5.5.5 Financial Feasibility of the Smart Service Company (Overall business)

This section handles financial feasibility of all smart city services conducted by the Smart City Service Co. (SSC) JICA Study team analyzed the four cases⁷ of smart city service options which are listed in Table 5.68. The scope of the smart city services are different in each case, and the results of the financial analysis are different. Therefore, this section shows a calculation process of Case 3, and only results of the analysis are presented for other cases.

Table 5.68 Four cases and the SSC's smart city services

Layer	Infrastructure and smart city services included in each layer	Case 1	Case 2	Case 3	Case 4
Layer 1	All components (infrastructure; disaster prevention; green network)	N	N	Y	N
	Only zone boundary road	N	N	N	Y
Layer 2	Sky Deck (outside zones) Smart Environment Smart City Center	N	N	Y	Y
Layer 3	Smart Mobility Smart Energy	Y	Y	Y	Y

Note: Y included in the SSC's scope; N not included in the SSC's scope.

Source: JICA Study Team

Table 5.69 indicates construction costs of the layers by the development phases. The percentage of the construction costs from Layer 1 to Layer 3 (THB22.9 billion) occupies only 7% of the total construction cost of the Bang Sue area (THB308.2 billion) because the proportion of Layer 4 which consists of offices, hotels, commercial facilities and residential facilities is the dominant position in the total construction cost.

Table 5.69 Construction cost of each layer for Bang Sue area by phases

(Unit: Million THB)

Layer	Phase 1	Phase 2	Phase 3	Total
Layer 1	3,045	884	1,367	5,297
Layer 1 (only zone boundary road)	111	21	145	277
Layer 2	1,929	628	526	3,083
Layer 3	5,303	3,857	5,356	14,516
Total of Bang Sue area	122,874	70,165	115,183	308,222

Source: JICA Study Team

In order to analyze financial feasibility of the Case 3 which is indicated in Table 5.68, JICA Study Team set the following conditions.

Project duration

Project duration is 42 years from 2020 to 2061. Year 2061 is the 30th year since operation of the Phase 3 has started.

Timing of investment

Investment costs for Layer 1 and Layer 2 are listed by development zones. It is assumed that

⁷ Refer to section 5.4.3 (2) for the four cases.

development schedule of Phase 1 follows the schedule described in Chapter 7. For example, investments for Layer 1 and Layer 2 will start in 2020 and in 2021 respectively in Zone A. Then investments for Layer 1 and Layer 2 will end in 2021 and 2023 respectively. Zone A will be partly open in 2022 and fully open in 2024. All investment activities in Zone A will be completed in 2025.

Following Phase 1, Phase 2 will be conducted from 2024 to 2027. Investment for Layer 1 will be carried out in 2024 and 2025, and investment for Layer 2 in 2026 and 2027. Investment for Phase 3 will be conducted during the period from 2028 to 2029 (Layer 1 from 2028 to 2031; Phase 2 from 2030 to 2033). Investment will be rendered 4-year before the opening of each zone for both of Phase 2 and the Phase 3. The Layer 1 will be developed in the first 2-years, and the Layer 2 will be developed in the second 2 years during the investment period.

Investment for Layer 3 is conducted as described in the previous sections.

Equity investment and loan from financial institutions

Out of investment costs for Layer 1, Layer 2 and the Layer 3, it is assumed that the 30% of the investment cost is financed by the SSC's equity investment, and the 70% from commercial bank's loans.

The loan conditions of the commercial bank loan are assumed that repayment period is five years with one year of grace period. It is assumed the SSC can receive normal commercial loan rates. Real loan rate was set at 5.11% (6.03% minus 0.92%) same as the analysis in section 5.5.4

However, all investment cost comes from the equity investment of the SSC only for Smart Mobility because the project will face high risk of demand. As shown in the analysis of section 5.5.2, the profitability of the smart mobility service varies a lot depending on changes in mobility and parking demand; therefore, the financial feasibility of the SSC will be analyzed in both cases with and without the smart mobility service. JICA Study Team sets the main scenario without the smart mobility service case in this analysis.

Operation and maintenance cost

Operation and maintenance cost for Layer 1 and Layer 2 are calculated by development zones. The SSC will provide smart city services for 30 years after the completion of each zone, and operation & maintenance costs for the smart city service facilities accounts for 5% of the investment amount every year. Operation and maintenance cost during the partial open period will be also listed.

Regarding Layer 3, the same operation and maintenance costs which are used in sections 5.5.2 and 5.5.3 are applied.

Revenue (smart city service fee)

The SSC receives service fees for development and O&M of Layer 1 and provision of smart city services of Layer 2 from the SRT. It is the same assumption that the JICA Study Team set in section 5.2.4.

In this financial analysis of the SSC, SRT will pay 33% of the concession fee during the investment period from 2022 (opening of Zone A) to 2033 (final year of investment), and 14% of the concession fee during the O&M period after 2034 respectively.

Calculation of Equity IRR and average ROE

Table 5.75, Table 5.76 and Table 5.77 compiles annual cash inflow, cash outflow of SSC's all business activities (district boundary road in the Layer 1, smart city services in the Layer 2 and the Layer 3) under Case 3.

Equity IRR is 10.2% during the whole project period from 2020 to 2061. The annual Return on Equity (ROE) from 2034 to 2063 was calculated under the same assumption in section 5.2.4 (30 years of depreciation period of the infrastructure and smart city facilities as 30 years and 20% of the corporate income tax is 20%). The result of the annual ROE is indicated in the final row of Table 5.75, Table 5.76 and Table 5.77. The average ROE is 5.8%, which is almost at the same level as the dividend yield of the major Infrastructure Funds listed on SET as of July 2019.

Table 5.70 indicates result of the Equity IRR (from 2020 to 2061) and average ROE (from 2034 to 61) of all cases. Since the level of Equity IRR is very high for Case 1 and Case 2, Project IRR (internal rate of return for the entire smart city service company project) instead of Equity IRR is compared in Table 5.70. Project IRR and average ROE are at the lowest level in Case 3 in which the SSC would construct and operate all components. The Project IRR and the average ROE of Case 4 in which a part of the Layer 1 will be developed is the lowest while those of Case 1 and Case 2 in which the SSC would not engage in Layer 1 are excellent level. If the Smart Mobility of Layer 3 were included in the analysis, both Equity IRR and average ROE would improve very much and even in Case 3 is enough to secure a high level of profit⁸. However, it should be noted that the result would be realized if the smart mobility has enough demand as forecasted.

Table 5.70 Financial feasibility of the SSC by cases

(Unit: percent)

	Case 1	Case 2	Case 3	Case 4
Project IRR (2020-61)	39.4 (36.2)	39.4 (36.2)	8.7 (14.9)	20.8 (26.1)
Average ROE (2034-61)	22.6 (25.8)	22.6 (25.8)	5.8 (15.1)	14.7 (21.9)

Note: The numbers in brackets are the ones when smart mobility is included.

Source: JICA Study Team

Table 5.71 indicates the SSC's financial feasibility under the four cases is in Phase 1 period only (from 2020 to 2054). The average ROEs of Case 3 have dropped to significant levels due to burdens of investment of Layer 1 and replacement investment for the power plant, a component of the Smart Energy. On the other hand, results of Case 3 would improve and could secure financial feasibility if the Smart Mobility of Layer 3 were included. It should also be noted that the result would be realized if the smart mobility has enough demand as forecasted.

Table 5.71 Financial feasibility of the SSC by cases (only Phase 1)

(Unit: percent)

	Case 1	Case 2	Case 3	Case 4
Equity IRR (2020-54)	39.4 (32.2)	39.4 (32.2)	4.1 (13.1)	17.6 (23.4)
Average ROE (2027-54)	29.3 (30.7)	29.3 (30.7)	-1.9 (14.0)	11.2 (23.2)

Note: The numbers in brackets are the ones when smart mobility is included.

Source: JICA Study Team

5.5.6 Profitability for SRT

This section analyzes profitability for SRT in the whole development of Bang Sue area. The

⁸ Equity IRR is 12.7% and average ROE is 12.9% respectively.

profitability for SRT is measured by its accumulated net cash flow in the Bang Sue area development.

SRT will receive concession fees from zone developers which are selected through bidding, and pay smart city service fees to the SSC. Similar to the financial analysis of the SSC, the profitability under the four cases in Table 5.72 are analyzed. In Case 1, SRT would invest and operate all components of Layer 1 as well as provide smart city service fees to the SSC. In other cases, SRT would just pay service fees to the SSC.

In this section, JICA Study Team shows calculation process of the Case 3 and results of the other cases.

Table 5.72 Four cases and service scopes of the SSC and SRT

Layer	Infrastructure and smart city services included in each layer	Case 1	Case 2	Case 3	Case 4
Layer 1	All components (infrastructure; disaster prevention; green network)	Y	N	S	N
	Only zone boundary road	N	N	N	S
Layer 2	Sky Deck (outside zones) Smart Environment Smart City Center	S	S	S	S
Layer 3	Smart Mobility Smart Energy	S	S	S	S

Note: Y included in the SRT's scope; N not included in the SRT's scope; S conducted by the SSC.

Source: JICA Study Team

Conditions to analyze profitability for SRT are same as that in the previous sections..

Project duration

Project duration is 42 years from 2020 to 2061. Year 2061 is the 30th year since Phase 3 operation has started in 2032. The project duration is as same as section 5.5.5.

Revenue (concession fee)

SRT receives concession fees from zone developers. The concession fees are set as the same level as the SRT's revenue plan for the Phase 1. Regarding Phase 2 and Phase 3, the JICA Study Team adopted the same unit costs for each zone based on the examination of land conditions (access from Bang Sue Central Station and MRT & BTS stations, road conditions, drainage conditions, etc.). Concession fees tabulated in Table 5.63 which is used in section 5.5.4 is also employed in this analysis.

Investment cost

When the SSC render investment from their own funds for smart city service facilities, it is assumed that SRT will pay 10% of the investment amount as a form of buying the SSC's equity; Therefore, the SRT will invest 10% of the total equity of the SSC. 50% of the SSC's total equity would be owned by a big state-owned company as one of the equity method affiliates, while SRT is a minor investor for the SSC. It is also assumed that SRT doesn't receive dividends from the SSC. It will not invest in the SSC's replacement investment.

Smart city service fee

SRT will pay a part of the concession fees which is received from zone developers as the smart

city service fee. As described in section 5.5.5, SRT will pay 33% of the concession fee to the SSC annually from 2022 to 2033, and 14% of the concession fee from 2034 to 2061 annually.

Cash flow for SRT regarding Bang Sue area development

The second rows of Table 5.78 and Table 5.79 are concession fees that SRT will receive from zone developers (cash inflow) and the 3rd and 4th rows are payment for the smart city service fee and investment to the SSC respectively. SRT is going to receive concession fees from zone developers, shortly after the contract agreement. Therefore, SRT's annual net cash flow will never be in the negative levels of the smart city service fee and investment amount to the SSC in this analysis.

The 4th and 5th rows of Table 5.78 and Table 5.79 are SRT's annual net cash flow and accumulated net cash flow respectively⁹. THB4.0 billion of net cash flow will be generated every year from 2034 where investment activity will be completed to 2054. The accumulated net cash flow will amount to THB25.5 billion in 2034, and the amount will increase to THB121.6 billion in 2063. SRT can use the accumulated net cash flow for repayment of the accumulated liability, and the amount of the accumulated net cash flow in 2063 accounts for 70% of SRT's long-term liability (THB173.1 billion).

Table 5.73 SRT's profitability by cases

(Unit: Million THB)

	Case 1	Case 2	Case 3	Case 4
Accumulated net cash flow (2034)	17,719 (17,267)	28,514 (28,062)	27,753 (27,240)	28,254 (27,802)
Accumulated net cash flow (2061)	112,185 (111,733)	131,316 (130,863)	130,554 (139,942)	131,056 (130,604)

Note: The numbers in brackets are the ones when smart mobility is included.

Source: JICA Study Team

Table 5.73 indicates SRT's accumulated net cash flow in 2034 (the 2nd row) and in 2061 (the 3rd row) in all cases. Although the accumulated net cash flow amounts have decreased in Case 1 in which SRT will invest and operate Layer 1 (basic infrastructure), changes of that in the other cases will be limited. If the Smart Mobility is included in the SSC's service scope, SRT's accumulated net cash flow amounts will decrease little in all cases because of SRT needs to invest more for the SSC's Smart Mobility service.

Table 5.74 indicates SRT's accumulated net cash flow for Phase 1 period only. It can be pointed out the same trend of the accumulated amount as in Table 5.73.

Table 5.74 SRT's Profitability by cases (only Phase 1)

(Unit: Million THB)

	Case 1	Case 2	Case 3	Case 4
Accumulated net cash flow (2026)	2,994 (2,814)	7,964 (7,784)	7,506 (7,326)	7,799 (7,619)
Accumulated net cash flow (2055)	39,566 (39,341)	50,876 (50,652)	50,418 (50,194)	50,712 (50,487)

Source: JICA Study Team

⁹ SRT sets revenue share from commercial business at the development zones as one of selection criteria in the bidding of the zone developer. Therefore, it is expected that SRT's net cash flow would be bigger than the amounts tabulated in Table 5.78 and Table 5.79. Impact of the e additional cash flow is not considered in this analysis because the amount is not sure at moment.

Table 5.75 Net cash flow of the SSC (1)

(Unit: Million Baht)

			2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Cash inflow	Revenue	From SRT			639	792	792	792	792	882	882	882	882	882	1,673	1,673
		Smart energy			92	92	250	543	543	1,022	1,022	1,022	1,022	1,022	1,737	1,737
	Loan	Layer 1 and 2	30	954	1,276	790	677	374	220	220	479	479	184	184		
		Smart energy	131	307	226	226	980	564	1,317				884	2,064		
Cash outflow	Investment	Layer 1 and 2	42	1,363	1,823	1,129	967	534	314	314	684	684	263	263		
		Smart energy	188	438	323	323	1,400	806	1,881				1,264	2,948		
	OM	Layer 1 and 2			9	9	113	227	249	324	324	324	324	324	419	419
		Smart energy			50	50	76	156	156	343	343	343	343	343	559	559
	Loan repayment	Layer 1 and 2		6	197	452	610	745	814	667	456	394	354	316	309	265
		Smart energy			187	187	187	187	187	375	375	375	375	375	483	483
	Interest payment	Layer 1 and 2	2	50	105	122	126	107	76	54	55	59	50	44	28	14
		Smart energy	7	22	24	26	65	84	141	122	103	85	110	194	170	146
Net cash flow			-77	-618	-484	-397	-846	-574	-947	-75	43	120	-110	-655	1,442	1,524
Accumulated net cash flow			-77	-695	-1,180	-1,577	-2,423	-2,997	-3,944	-4,019	-3,976	-3,856	-3,966	-4,622	-3,180	-1,656
Depreciation expense		Layer 1 and 2			106	144	176	194	194	194	194	194	203	211	211	211
		Smart energy			38	38	101	228	228	397	397	397	397	397	659	659
Profit before taxation			-77	-612	-244	60	-326	-63	-368	377	284	298	20	-572	1,363	1,401
Corporate income tax										75	57	60	4		273	280
Profit after taxation			-77	-612	-244	60	-326	-63	-368	302	227	239	16	-572	1,090	1,121
Return on Equity																

Source: JICA Study Team

Table 5.76 Net cash flow of the SSC (2)

(Unit: Million Baht)

			2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
Cash inflow	Revenue	From SRT	710	710	710	710	710	710	710	710	710	710	710	710	710	710
		Smart energy	1,737	1,737	1,737	1,737	1,737	1,737	1,737	1,737	1,737	1,737	1,737	1,737	1,737	1,737
	Loan	Layer 1 and 2														
		Smart energy														
Cash outflow	Investment	Layer 1 and 2														
		Smart energy		107	249	170	780	896	496	1,157				772	1,801	0
	OM	Layer 1 and 2	419	419	419	419	419	419	419	419	419	419	419	419	419	419
		Smart energy	559	559	559	559	559	559	559	559	559	559	559	559	559	557
	Loan repayment	Layer 1 and 2	169	74	37											
		Smart energy	483	483	483	295	295	295	295	295						
	Interest payment	Layer 1 and 2	6	2												
		Smart energy	122	98	74	59	44	29	15							
Net cash flow			689	706	626	945	349	248	663	17	1,469	1,469	1,469	697	-332	1,471
Accumulated net cash flow			-967	-262	364	1,309	1,659	1,907	2,570	2,588	4,056	5,525	6,994	7,691	7,359	8,829
Depreciation expense		Layer 1 and 2	211	211	211	211	211	211	211	211	211	211	211	211	211	211
		Smart energy	659	659	659	649	649	633	597	597	549	549	549	549	549	549
Profit before taxation			470	391	275	379	-217	-302	150	-496	708	708	708	-64	-1,093	784
Corporate income tax			94	78	55	76			30		142	142	142			157
Profit after taxation			376	313	220	303	-217	-302	120	-496	566	566	566	-64	-1,093	627
Return on Equity			7.0%	5.8%	4.1%	5.6%	-4.0%	-5.6%	2.2%	-9.2%	10.5%	10.5%	10.5%	-1.2%	-20.3%	11.6%

Source: JICA Study Team

Table 5.77 Net cash flow of the SSC (3)

(Unit: Million Baht)

			2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061		
Cash inflow	Revenue	From SRT	710	710	710	710	710	710	694	439	439	336	336	336	336	336		
		Smart energy	1,737	1,737	1,737	1,737	1,645	1,645	1,487	1,194	1,194	715	715	715	715	715		
	Loan	Layer 1 and 2																
		Smart energy																
Cash outflow	Investment	Layer 1 and 2																
		Smart energy																
	OM	Layer 1 and 2	419	419	419	419	419	419	402	170	170	95	95	95	95	95		
		Smart energy	557	557	557	557	508	508	479	401	401	214	214	214	214	214		
	Loan repayment	Layer 1 and 2																
		Smart energy																
	Interest payment	Layer 1 and 2																
		Smart energy																Equity IRR
Net cash flow			1,471	1,471	1,471	1,471	1,428	1,428	1,300	1,062	1,062	741	741	741	741	741		10.2%
Accumulated net cash flow			10,300	11,771	13,242	14,713	16,140	17,568	18,868	19,929	20,991	21,732	22,473	23,215	23,956	24,697		
Depreciation expense		Layer 1 and 2	211	211	211	211	211	211	211	211	211	18	18	18	18	18		
		Smart energy	476	476	476	476	448	448	402	310	310	189	189	189	189	189		
Profit before taxation		784	784	784	784	768	768	687	540	540	534	534	534	534	534			
Corporate income tax		157	157	157	157	154	154	137	108	108	107	107	107	107	107		Ave.	
Profit after taxation		627	627	627	627	614	614	550	432	432	427	427	427	427	427		ROE	
Return on Equity		11.6%	11.6%	11.6%	11.6%	11.4%	11.4%	10.2%	8.0%	8.0%	7.9%	7.9%	7.9%	7.9%	7.9%		5.8%	

Source: JICA Study Team

Table 5.78 Cash flow of SRT (1)

(Unit: Million Baht)

		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Cash inflow	Land concession fee	113	1,600	1,936	2,399	2,399	2,399	2,399	2,673	2,673	2,673	2,673	2,673	5,070	5,070
	Subsidy Smart City Service fee			639	792	792	792	792	882	882	882	882	882	1,673	1,673
Cash outflow	Equity investment to Smart Service Co.	23	180	215	145	237	134	220	31	68	68	153	321		
Net cash flow		90	1,420	1,082	1,462	1,371	1,474	1,388	1,759	1,722	1,722	1,638	1,470	3,397	3,397
Accumulated net cash flow		90	1,510	2,592	4,055	5,426	6,899	8,287	10,047	11,769	13,491	15,129	16,599	19,996	23,392

Source: JICA Study Team

Table 5.79 Cash flow of SRT (2)

(Unit: Million Baht)

		2034	...	2043	2044	2053	2054	2055	2056	2057	2058	2059	2060	2061
Cash inflow	Land concession fee	5,070	...	5,070	5,070	5,070	4,957	3,134	3,134	2,397	2,397	2,397	2,397	2,397
	Subsidy Smart City Service fee	710	...	710	710	710	694	439	439	336	336	336	336	336
Cash outflow	Equity investment to Smart Service Co.		...											
Net cash flow		4,360		4,360	4,360	4,360	4,263	2,695	2,695	2,062	2,062	2,062	2,062	2,062
Accumulated net cash flow		27,753		66,993	71,353	110,593	114,856	117,552	120,247	122,308	124,370	126,431	128,493	130,554

Source: JICA Study Team

5.6 Economic Benefit of the Project

5.6.1 Scope and Framework of Economic Benefit Analysis

The newly generated economic activities, brought the Bang Sue Area development project could roughly be divided into two aspects: production activity in office facilities and consumption activity in the commercial facility. The following table shows these activities in association with population classification which covers residing population, visiting population and working population, and respective features.

Table 5.80 Classification of activities by population

	Classification by Population			
	Residing Population	Visiting Population	Working Population	
Objective for Visit	Residence/ Living	Shopping, leisure, sightseeing, visit to hospital, etc.	Work	
Location Facility	Residence/ Commercial facility	Commercial facility, hotel	Commercial facility	Office building
Economic Activity	Living-related consumption activity	Consumption activity of goods and services	Work-related consumption activity	Production activity

Source: JICA Study Team

In this economic benefit analysis, based on population generated in the size of respective facilities in the area development plan, production and consumption values were calculated by multiplying basic unit for production and consumption activities. Respective facility scales were set in reference to the previous JICA study.

As for production and consumption activities, the spillover effect for the Thai economy is also analyzed through Input-Output analysis using Input-Output table for Thailand's industry.

5.6.2 Conditions set for Economic Benefit Analysis

- Facility size in Area Development

The table below shows the Gross floor areas by facility type, as explained in the previous section.

Table 5.81 Total Floor Area by Building Use

Category	Gross floor area	unit	Share
1) Office	884,600	m ²	15.80%
2) Retail	730,700	m ²	13.00%
3) Residence	3,626,900	m ²	64.70%
4) Hotel	364,500	m ²	6.50%
Total	1673,200	m ²	100.00%

Source: JICA Study Team

Setting for estimated population

The total population is estimated by multiplying gross floor area for each facility type, as mentioned previously, by basic unit. The following table¹⁰ shows estimation results and setting for basic units.

Table 5.82 Estimated Total Population and setting for basic unit

Facility Type	Population Classification	Item	Set Value	Unit	Remarks
Office	Working population	a Floor area	884,600	m ²	
		b Rentable ratio	0.60	ratio	Set based on data by Thai real estate survey firm
		c Occupancy rate	0.80	ratio	Set by JICA Study Team
		d Space per office worker	12.0	m ² /person	Set based on office layout case study ¹¹
		Population	35,384	person	a*b*c/d
Residence	Residing population	a Floor area	3,626,900	m ²	
		b Rentable ratio	0.50	ratio	Set based on data by Thai real estate survey firm
		c Occupancy rate	0.80	ratio	Set by JICA Study Team
		d Area per household	90	m ² /household	Set based on data by Thai real estate survey firm
		e Person per household	3.1	person/household	Set on the basis of household census
		Population	49,971	person	a*b*c/d*e
Hotel	Visiting population	a Floor area	364,500	m ²	
		b Rentable ratio	0.40	ratio	Set based on data by Thai real estate survey firm
		c Occupancy rate	0.80	ratio	Set by JICA Study Team
		d Area per room	60	m ² /room	Set based on data by Thai real estate survey firm
		e Guests per room	1.90	person/room	Set based on Japan Hotel Association's survey ¹²
		Population	3694	person	a*b*c/d*e
	Employee	f Employee per room	0.80	person/room	Set on the basis of Japan Hotel Association's survey
		Population	1555	person	a*b*c/d*e
Retail	Visiting population	a Floor area	730,700	m ²	
		b Usable area ratio	0.60	ratio	Set based on data by Thai real estate survey firm
		c Occupancy rate	0.80	ratio	Set by JICA Study Team
		d1 Visitor per floor area (weekdays)	0.44	person/m ² /day	Set in line with MLIT's guideline ¹³
		d2 Visitor per floor area (weekends)	0.62	person/m ² /day	Set in line with MLIT's guideline
		Visitor at weekdays (per day)	154,604	person/day	a*b*c*d1
		Visitor at weekends (per day)	216,913	person/day	a*b*c*d2
	Employee	f Employee per area	70	m ² / person	Set based on data by Thai real estate survey firm
		Employee	10,439	person	a/f

Source: JICA Study Team

¹⁰ The total floor areas refer to past survey results whereas basic unit is newly set on the basis of data supplied by Thai real estate survey firms or various survey results.

¹¹ KOKUYO Co., Ltd. (<https://www.kokuyo-furniture.co.jp>)

¹² "Consideration status on benchmark system in the hotel industry" released by Japan Hotel Association

¹³ "Large-scale development area-related traffic plan manual" released by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT)

Setting for consumer expenditure basic unit

The consumption expenditure per person (and consumption expenditure basic unit) is set in order to estimate consumption expenditure in the Bang Sue Area by residing population, visiting population and working population. The monthly expenditure by consumer item is set as a basic unit, based on household survey data.

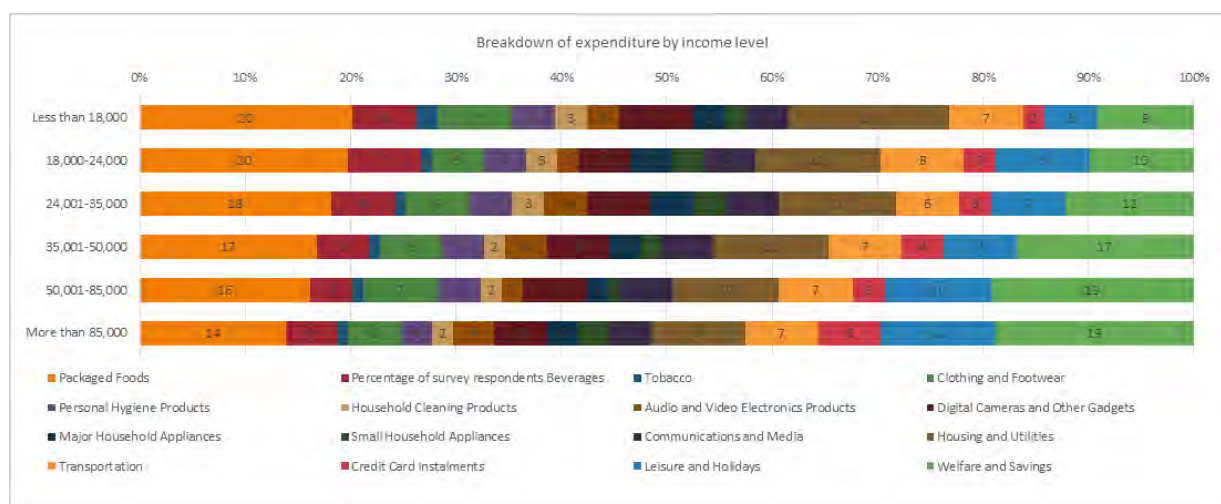
The Table below shows household income and consumption expenditure in Thai household.

Table 5.83 Household income and expenditure in Thailand household

Monthly household income, (THB)	Household distribution (%)	Monthly household expenditure (THB)
Less than 18,000	28%	12000
18,000-24,000	16%	17000
24,001-35,000	18%	22000
35,001-50,000	14%	26000
50,001-85,000	12%	37000
More than 85,000	12%	72000

Source: Deloitte “Thailand Consumer Survey 2016”

Figure below shows detail of household consumption by income level.



Source: Deloitte “Thailand Consumer Survey 2016”

Figure 5.60 Detail of household consumption by income level

In setting basic unit for consumption expenditure in the Bang Sue Area, the households with monthly income of 35,000 Thai Baht or higher is taken into account, considering the attributes for the expected population in Bang Sue Area. The basic units are as shown in the following table. The number of persons per household is set at 3.1 persons, based on the household census.

Table 5.84 Monthly average consumption expenditure by consumption item per household and per household member

Consumption Category	Monthly Average Consumption Value per Household (THB)	Monthly Average Consumption Value per Household Member (THB)
Packaged Foods	6,681	2,025
Percentage of survey respondents Beverages	2,083	631
Tobacco	440	133
Clothing and Footwear	2,529	767
Personal Hygiene Products	1,533	464
Household Cleaning Products	880	267
Audio and Video Electronics Products	1,526	463
Digital Cameras and Other Gadgets	2,413	731
Major Household Appliances	1,203	365
Small Household Appliances	991	300
Communications and Media	1,973	598
Housing and Utilities	4,268	1,293
Transportation	3,080	933
Credit Card Instalments	2,098	636
Leisure and Holidays	4,340	1,315
Welfare and Savings	8,168	2,475

Source: Deloitte “Thailand Consumer Survey 2016”

As for monthly average consumption expenditure, the proportion of individual expenditure in Bang Sue Area would vary, depending on population classification. For example, it is expected that the proportion of monthly expenditure in Bang Sue would be larger for people living in the area, while it is smaller for those visiting the area for shopping. Therefore, the consumption degree is set as shown in Table 5.85. The degree of consumption expenditure on each item by population classification is as shown in Table 5.86, considering the frequency of visit to the area and consumption activity features by population classification.

Table 5.85 Classification by degree of consumption expenditure in Bang Sue Area

Degree of expenditure in Bang Sue	Proportion of monthly expenditure (%)	Description
NA	0	No consumption expenditure in Bang Sue
1	5	Partial consumption expenditure in Bang Sue
2	30	A certain degree of consumption expenditure in Bang Sue
3	60	Most of consumption expenditure in Bang Sue
4	90	Almost all consumption expenditure in Bang Sue
5	100	All consumption expenditure in Bang Sue

Source: JICA Study Team

Table 5.86 Degree of expenditure on each consumption item by population classification

Consumption Item	Residing Population	Visiting Population		Working Population
		Commercial facility visitor	Hotel Stay	
Packaged Foods	3	1	1	2
Percentage of survey respondents Beverages	3	1	1	2
Tobacco	3	1	1	2
Clothing and Footwear	3	1	1	
Personal Hygiene Products	3			
Household Cleaning Products	3	1		
Audio and Video Electronics Products	3	1		
Digital Cameras and Other Gadgets	3	1		
Major Household Appliances	3	1		
Small Household Appliances	3	1		
Communications and Media	3			
Housing and Utilities	4		1	
Transportation	4			
Credit Card Instalments	3			
Leisure and Holidays	3		1	
Welfare and Savings	3			

Source: JICA Study Team

Setting of basic unit for production value

The technology-intensive service industry and hotel or commercial (retail) business are assumed as possible industries that would come to Bang Sue Area. For production value basic unit, Table 5.87 shows the data for industries in Bangkok, based on business office surveys in Bangkok released by the National Statistical Office of Thailand.

Table 5.87 Production Value Data by Industry in Bangkok

Code	Industry Classification	No. Companies ('000)	No. Employees (mil.)	Employee Salary (bil.)	Income (bil.)	Intermediate Expenditure (bil.)	Added Value (bil.)	Added Value per Employee ('000)	Possible industry for Bang Sue
45	Wholesale and retail trade; repair of motor vehicles and motorcycles	155	0.57	58.7	2,019.4	1,784.4	235.0	410.9	
46	Wholesale trade (except of motor vehicles and motorcycles)	88	0.67	112.4	3,341.6	2,955.9	385.6	579.2	
47	Retail trade (except of motor vehicles and motorcycles)	793	2.17	114.1	2,711.1	2,199.7	511.5	235.7	
55	Accommodation	15	0.25	38.7	153.7	81.6	72.1	293.8	
56	Food and beverage service activities	256	0.88	54.6	375.3	229.3	146.0	166.1	
59	Motion picture, video and television programme production, sound recording	1	0.01	3.4	32.5	23.0	9.4	655.3	
60	Programming and broadcasting activities	1	0.01	3.8	13.0	7.3	5.7	808.7	Y
62	Computer programming, consultancy and related activities	1	0.01	4.7	26.8	19.0	7.8	543.9	Y
63	Information service activities	0	0.00	0.9	7.6	5.8	1.8	557.9	Y
68	Real estate activities	104	0.31	30.9	255.4	138.9	116.5	374.6	
69	Legal and accounting activities	7	0.03	8.7	26.0	10.9	15.1	439.5	
70	Activities of head offices; management consultancy activities	0	0.01	1.9	11.1	8.1	3.0	451.1	
71	Architectural and engineering activities; technical testing and analysis	2	0.03	9.2	39.3	24.3	15.0	543.0	Y
72	Scientific research and development	0	0.00	0.6	1.6	0.9	0.7	374.9	Y
73	Advertising and market research	5	0.03	5.8	63.9	48.7	15.2	519.7	Y
74	Other professional, scientific and technical activities	8	0.03	4.6	26.1	15.3	10.8	349.4	Y
77	Rental and leasing activities	15	0.05	3.9	26.3	15.2	11.1	217.0	
78	Employment activities	1	0.05	8.2	16.4	6.3	10.1	202.3	
79	Travel agency, tour operator, reservation service and related activities	6	0.03	5.9	73.8	59.8	14.0	416.6	
80	Security and investigation activities	1	0.10	16.1	29.4	10.2	19.2	183.5	
81	Services to buildings and landscape activities	1	0.03	4.0	8.5	3.0	5.5	170.5	
82	Office administrative, office support and other business support activities	14	0.04	4.0	69.6	18.1	51.5	1,144.8	
90	Creative, arts and entertainment activities	10	0.06	2.0	5.7	1.7	4.0	61.5	
92	Gambling and betting activities	1	0.00	0.0	1.4	1.2	0.2	144.7	
93	Sports activities and amusement and recreation activities	19	0.06	4.5	22.4	11.1	11.3	191.3	

Source: National Statistical Office of Thailand.

Setting for Input-Output Analysis

Input-Output Analysis is an analysis method with which spillover effect is estimated. It utilizes Input-Output table, in which investment and production for each industry, as well as transaction of goods, services in the region (country, prefecture, city, town, or village, etc.) is recorded. The transactions cover sales or purchase of raw materials or goods/ services between industries. The transactions also include salary payment for employees, commodity or service sales to consumers, export and import with other countries, as well as trade within the country. In this study, input-output analysis is conducted with the input-output table for Thailand. Through the analysis, the process of economic spillover and benefit for the entire industry, from Bang Sue Area, could be quantified.

For this analysis, input-output table for Thailand (data released in 2011 by the OECD) is used.

The open economy model is adopted to incorporate exports and imports. In this model, matrix M in which import coefficient is diagonalized, export vector E , and domestic final demand vector $F_{(D)}$, is follows the equation shown below:

$$X = AX + F_{(D)} - M(AX + F_{(D)})$$

As a result, the model formula is as below:

$$X = [I - (I - M)A]^{-1}[(I - M)F_{(D)} + E]$$

The closed economy model assumes that the economic spillover effect would be enclosed within the country, while the open economy model assumes that spillover effect would be extended to the country from which the goods are procured. In this study, the open economy model is adopted to reflect the real economy.

The table below shows set values for respective coefficients related to the calculation of economic spillover effects.

Table 5.88 Settings for Input-Output Analysis

Item	Settings
Target analysis	Consumption and production activities in Bang Sue
Consumption ratio in disposable income	48.2% (Source: World Bank)
Employee salary payment ratio in company added value	29.9% (National Statistical Office of Thailand)
Average annual salary (nationwide)	166,500 Thai Baht (National Statistical Office of Thailand)

Source: JICA Study Team

5.6.3 Results of Economic Benefit Analysis

Economic benefits derived from consumption activity

The total annual economic benefit which derive from consumption activity is 23.99 billion Thai Baht. The table below shows its detail.

Table 5.89 Annual economic benefit from consumption activity (Mil. THB)

Consumption Item	Residing Population	Visiting Population		Working Population
		Commercial facility visitor	Hotel Stay	
Packaged Foods	775.4	6,242.3	133.7	367.6
Percentage of survey respondents Beverages	241.8	1,946.4	41.7	114.6
Tobacco	51.1	411.1	8.8	24.2
Clothing and Footwear	293.6	2,363.4	50.6	
Personal Hygiene Products	177.9			
Household Cleaning Products	102.1	822.2		
Audio and Video Electronics Products	177.1	1,426.1		
Digital Cameras and Other Gadgets	280.0	2,254.2		
Major Household Appliances	139.6	1,124.2		
Small Household Appliances	115.0	925.5		
Communications and Media	228.9			
Housing and Utilities	743.1		85.4	
Transportation	536.2			
Credit Card Instalments	243.5			
Leisure and Holidays	503.7		86.9	
Welfare and Savings	948.0			
TOTAL	5,557.1	17,515.3	407.2	506.4

Source: JICA Study Team

Economic benefits derived from production activity

The total annual economic benefit which derives from production activity is 18.27 billion Thai Baht on a gross value added basis and 57.86 billion Thai Baht on a gross sales basis. The table below shows its detail.

Table 5.90 Annual economic benefit from production activity (Mil. THB)

Industry	Gross Value Added	Gross Sales
Motion picture, video and television programme production, sound recording	2,594	8,916
Programming and broadcasting activities	1,567	3,568
Computer programming, consultancy and related activities	2,152	7,359
Information service activities	494	2,074
Architectural and engineering activities; technical testing and analysis	4,117	10,791
Scientific research and development	204	448
Advertising and market research	4,174	17,537
Other professional, scientific and technical activities	2,965	7,171
TOTAL	18,269	57,864

Source: JICA Study Team

Spillover effects analysis by Input-Output Analysis

The spillover effects, brought to Thailand by the above consumption and production activities in Bang Sue Area, are calculated through Input-Output analysis. For this, consumption expenditures are categorized into respective industry groups in the Input-Output table. Likewise, the total sales amount for production activities are also categorized into the respective industry groups. The following table shows the results.

Table 5.91 Total consumption and I-O table classification by consumption items (Mil. THB)

Consumption Item	Classification in Input-Output Table	Total Consumption Expenditure
Packaged Foods	Food products, beverages and tobacco	7,519
Percentage of survey respondents Beverages	Food products, beverages and tobacco	2,344
Tobacco	Food products, beverages and tobacco	495
Clothing and Footwear	Textiles, textile products, leather and footwear	2,708
Personal Hygiene Products	Chemicals and chemical products	178
Household Cleaning Products	Chemicals and chemical products	924
Audio and Video Electronics Products	Electrical machinery and apparatus, nec	1,603
Digital Cameras and Other Gadgets	Electrical machinery and apparatus, nec	2,534
Major Household Appliances	Electrical machinery and apparatus, nec	1,264
Small Household Appliances	Electrical machinery and apparatus, nec	1,040
Communications and Media	Post and telecommunications	229
Housing and Utilities	Electricity, gas and water supply	829
Transportation	Transport and storage	536
Credit Card Instalments	Financial intermediation	243
Leisure and Holidays	Other community, social and personal services	591
Welfare and Savings	Public administration and defense; compulsory social security	948

Source: JICA Study Team

Table 5.92 Total sales and I-O table classification by production activities (Mil. THB)

Production activities	Classification in Input-Output Table	Total Sales
Motion picture, video and television programme production, sound recording	Computer and related activities	8,916
Programming and broadcasting activities	Computer and related activities	3,568
Computer programming, consultancy and related activities	Computer and related activities	7,359
Information service activities	Computer and related activities	2,074
Architectural and engineering activities; technical testing and analysis	R&D and other business activities	10,791
Scientific research and development	R&D and other business activities	448
Advertising and market research	R&D and other business activities	17,537
Other professional, scientific and technical activities	R&D and other business activities	7,171

Source: JICA Study Team

The following table shows the results of Input-Output Analysis. The total annual direct economic benefit is approximately 84.7 billion Thai Baht, which brings approximately 230.6 billion Thai Baht as an annual spillover effect. The following table shows the economic effect values in detail.

Table 5.93 Summary of economic benefit (Mil. THB)

Industry Classification in Input-Output Table	Direct Effect	Spillover Effect
TTL_C01T05: Agriculture, hunting, forestry and fishing	0	14,241
TTL_C10T14: Mining and quarrying	0	2,852
TTL_C15T16: Food products, beverages and tobacco	10,359	22,369
TTL_C17T19: Textiles, textile products, leather and footwear	2,708	12,877
TTL_C20: Wood and products of wood and cork	0	962
TTL_C21T22: Pulp, paper, paper products, printing and publishing	0	3,051
TTL_C23: Coke, refined petroleum products and nuclear fuel	0	7,341
TTL_C24: Chemicals and chemical products	1,102	3,502
TTL_C25: Rubber and plastics products	0	1,800
TTL_C26: Other non-metallic mineral products	0	1,147
TTL_C27: Basic metals	0	1,124
TTL_C28: Fabricated metal products	0	1,118
TTL_C29: Machinery and equipment, nec	0	2,014
TTL_C30T33X: Computer, Electronic and optical equipment	0	772
TTL_C31: Electrical machinery and apparatus, nec	6,442	6,858
TTL_C34: Motor vehicles, trailers and semi-trailers	0	1,457
TTL_C35: Other transport equipment	0	46
TTL_C36T37: Manufacturing nec; recycling	0	3,347
TTL_C40T41: Electricity, gas and water supply	829	6,066
TTL_C45: Construction	0	797
TTL_C50T52: Wholesale and retail trade; repairs	2,460	11,564
TTL_C55: Hotels and restaurants	457	5,343
TTL_C60T63: Transport and storage	536	9,845
TTL_C64: Post and telecommunications	229	3,695
TTL_C65T67: Financial intermediation	243	8,679
TTL_C70: Real estate activities	0	6,961
TTL_C71: Renting of machinery and equipment	0	477
TTL_C72: Computer and related activities	21,916	28,440
TTL_C73T74: R&D and other business activities	35,948	40,413
TTL_C75: Public administration and defense; compulsory social security	948	2,131
TTL_C80: Education	0	1,364
TTL_C85: Health and social work	0	325
TTL_C90T93: Other community, social and personal services	591	17,519
TTL_C95: Private households with employed persons	0	89
TOTAL	84,767	230,586

Source: JICA Study Team

6. Interest of Japanese Companies in the Bang Sue Area Development

6.1 Survey on Japanese Companies' interest

6.1.1 Method of Implementation of the questionnaire and content of the questions

(1) Method of Implementation of the questionnaire survey

A questionnaire survey was conducted with the purpose of understanding the level of awareness and potential interest by Japanese companies on the smart city development project in Bang Sue Area.

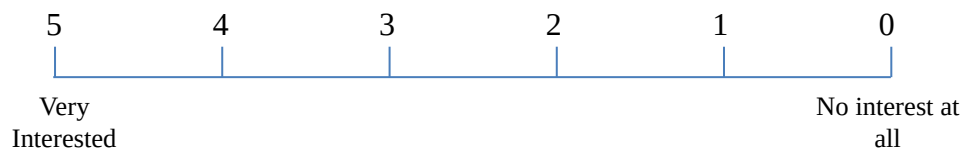
The questionnaire was handed in paper to participants of the “Thailand Smart City Development Seminar focusing on Bang Sue Area Development”, which was held in Tokyo (Thurs., 16th of May, 2019) and in Bangkok (Thurs., 7th of November, 2019). Participants were mostly Japanese Businesses.

(2) Items of the Questionnaire

The questions included in the questionnaire are shown below

- Question 1: Level of interest in the Bang Sue Area Development.

Please circle the number that appropriately expresses your level of interest in the Smart City Development Project in Thailand as introduced today



- Question 2: Development Potential for the Bang Sue Area

How would you rate the development potential in the Bang Sue Area Smart City Project in Thailand? Please circle the most appropriate number



- Question 3: Possibility of participation in Smart City Businesses

In what kinds of businesses to be developed in the Bang Sue Smart City Area do you think you could become involved? Please circle the numbers corresponding to as many options as appropriate.

- | | |
|-------------------------------------|---|
| 1. Real Estate (Condominium) | 9. Infrastructure Investment (Energy) |
| 2. Real Estate (Office) | 10. Infrastructure Investment (Transport) |
| 3. Real Estate (Commercial Rooms) | 11. Infrastructure Investment (Telecom) |
| 4. Real Estate (MICE) | 12. Infrastructure Investment (Others) |
| 5. Real Estate (Joint Developments) | 13. Technology Provider |
| 6. Real Estate (Others) | 14. Construction |
| 7. Tenant Branch (Office) | 15. Master Developers |
| 8. Tenant Branch (Commercial) | 16. Others (_____) |

• Question 4: Opinions and suggestions about Bang Sue Area Smart City Development

Please feel free to share your comments and suggestions regarding the Bang Sue Area Smart City Development Project

(3) Distribution and collection of questionnaires

The number of questionnaires handed out and the collection is as follows:

- Tokyo: 135 participants, where 83 valid responses were obtained (61.5%).
- Bangkok: 80 participants, where 56 valid responses were obtained (70%).

6.1.2 Results of the Survey

(1) Level of interest in the Bang Sue Area Development.

When asked about “Question 1: Level of interest in the Bang Sue Area Development, 32 respondents in Tokyo (39%) answered “5: Very Interested” and 31 people (37%), answered “4: Interested”.

On the other hand, with regards to respondents in Bangkok, 21 people (38%) answered “5: Very Interested” and 28 people (48%), answered “4: Interested” to Question 1. In total, 63 people (76%) in Tokyo and 48 people (86%) in Bangkok expressed interest, which suggests a high interest by companies in the development of the Bang Sue Area.

Table 6.1 Level of Interest in the in Bang Sue Area Development (Tokyo)

Level of Interest	No. of Respondents	
5 Very Interested	32	
4 Interested	31	
3 Moderately Interested	16	
2 Mostly Not Interested	1	
1 Not Interested	1	
0: No interest at all	0	
No response	2	
Total	83	

Source: JICA Study Team.

Table 6.2 Level of Interest in the in Bang Sue Area Development (Bangkok)

Level of Interest	No. of Respondents	
5 Very Interested	21	
4 Interested	27	
3 Moderately Interested	8	
2 Mostly Not Interested	0	
1 Not Interested	0	
0: No interest at all	0	
No response	0	
Total	56	

Source: JICA Study Team.

(2) Development Potential for the Bang Sue Area

When asked about “Question 2: Development Potential for the Bang Sue Area, in Tokyo, 38 people (46%) answered “5: Very High” and 28 people (34%), answered “4: High”.

With regards to respondents in Bangkok, 12 people (21%) answered “5: Very High” and 24 people (43%), answered “4: High” to Question 2. In total, 66 people (80%) in Tokyo and 36 people (63%) in Bangkok expressed the perception that there is a high potential in the Bang Sue Area., which suggests that many companies evaluate the potential as high.

Table 6.3 Evaluation of the Development Potential for the Bang Sue Area (Tokyo)

Evaluation of Potential	No. of Respondents	
5 Very High	38	
4 High	28	
3 Moderately High	14	
2 Moderately Low	1	
1 Low	0	
0 Inexistent	0	
No Response	2	
Total	83	

Source: JICA Study Team.

Table 6.4 Evaluation of the Development Potential for the Bang Sue Area (Bangkok)

Evaluation of Potential	No. of Respondents	
5 Very High	12	
4 High	24	
3 Moderately High	19	
2 Moderately Low	0	
1 Low	1	
0 Inexistent	0	
No Response	0	
Total	56	

Source: JICA Study Team.

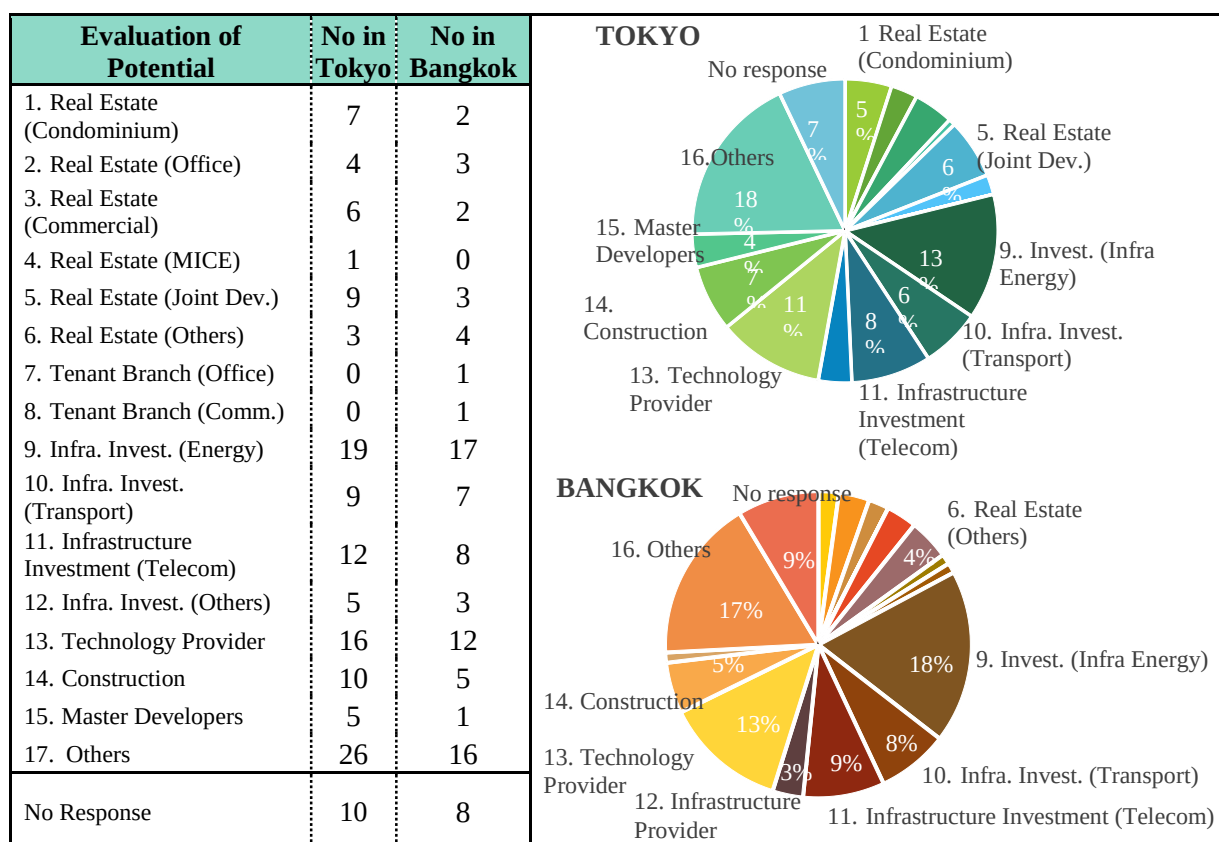
(3) Possibility of participation in Smart City Businesses

For Question 3, responses have been spread across the options given. With regards to respondents in Tokyo, the most frequent responses have been: “Other”, with 26 respondents (18%), “Infrastructure investment (energy)”, with 19 respondents (13%), “Technology Provider”, with 16 respondents (11%), “Infrastructure investment (Telecom)”, with 12 respondents (8%), “Construction”, with 10 respondents (7%), “Real Estate Investment (Joint Developments), and “Infrastructure investment (transportation)”, with 9 respondents (6%). Some of the freely input responses have been “Advisory to Developers”, “Research and data collection”, “Architectural design”, “Data Businesses” and “Other infrastructure development”.

On the other hand, with regards to respondents in Bangkok, the most frequent responses have been “Infrastructure investment (Energy)” with 17 respondents (18%), “Other” with 16 respondents (17%), “Technology Provider” with 12 respondents (13%), “Infrastructure investment (Telecommunication) with 8 respondents (9%), and “Infrastructure investment (transport) with 7 respondents (8%). Some of the freely input responses includes “finance”, “consulting”, and “Smart Grid”.

With responses covering the full range of possible answers and particularly with the high number of responses falling into “Others” and “Technology Provider”, it seems that smart cities create opportunities in diverse fields.

Table 6.5 Possibility of participation in Smart City Businesses



Source: JICA Study Team.

(4) Opinions and suggestions about the Bang Sue Area Smart City Project

Regarding question 4, a number of comments were raised by questionnaire respondents and summarized below

1) Opinions about the possibilities related with the smart city development

- “Possibilities for Japanese small and medium enterprises to contribute with their technology and skills is are high, so how could we match them with the needs?”
- “Innovation could be promoted by including elements of all seven smart city fields, instead of making separate proposals for each field”

2) Opinions about challenges related with the smart city development

- “It may be difficult to secure business potential for a lease period of 30 years”
- “Urban infrastructure such as water, gas, electricity and drainage may be fragile, so strong urban infrastructure development is necessary”
- “It seems that incentives for Japanese companies are low”
- “Support for smart infrastructure and public infrastructure seems to be essential”

3) Opinions and suggestions about smart city technologies that can be applied to Bang Sue Area

- “It may be possible to promote energy saving schemes such as power exchange between homes and electricity companies using block chain technologies”
- “Proposals about smart houses in residential facilities can be put in place”
- “Surveying technologies through satellite can be introduced”
- “Possible to introduce information integration and city surveillance services for EV”
- “Cooperate with Japanese and local companies, general contractors and developers to introduce cooling systems and cogeneration”
- “Contribute to smart city data collection and communication regarding radar and optical fiber technologies”

6.2 Understanding the Japanese Companies' Intentions through Interview Surveys

6.2.1 Outline of the Interview Survey

(1) Objective

Interview surveys have been conducted individually with Japanese companies engaged in real estate and infrastructure development projects. The interview aimed at identifying concerns about urban development and smart city development in the Bang Sue Area, issues to be carried out in the project, as well as expectations and requests, in order to use them as the basic data for the examination of Bang Sue district's development.

(2) Targets

The study team has surveyed eight Japanese companies doing real estate development and infrastructure development projects in cities overseas such as in Thailand and the ASEAN region. Of the eight companies, seven targeted local corporations and local offices promoting business based in Bangkok.

(3) Topics

The survey has been mainly conducted with the following topics.

- 1) Real estate market and business environment in Bangkok
- 2) Interests in the Bang Sue area development
- 3) Opinions and concerns for the urban development in Bang Sue
- 4) Opinions on smart city development and smart service in Bang Sue
- 5) Other topics

6.2.2 Interview Results

The interview results are as shown in the table below.

Table 6.6 The Opinions from the Interview Survey

Topic	The Opinions
1) Real estate market and business environment in Bangkok	• Compared to its neighboring countries, Bangkok is rather progressive in developing its transportation infrastructure within Southeast Asia, and real estate development has been observed accordingly. • For the younger generations, users can be expected in places with good train service, and solid demand can be expected. • The disadvantage is that the quality of buildings is low, and because the level of consumerism and needs is low, developers do not aim for much good quality. • In April 2019, a new mortgage loan regulation has been promulgated, and movements to suppress condominium purchases for investment purposes have become active.

Topic	The Opinions
	• In Bangkok, the condominium market seems to have peaked, where people have been buying smaller apartments for investment purposes until recently, but a decline has been seen in the trend suggesting a time of real demand. • We cannot be optimistic about the future demand for offices. However, there are only few high-grade offices even in the CBD, and high-grade offices such as One Bangkok are considered to be in demand in the future. • It is in the past 2 to 3 years that the Japanese developers have advanced into Bangkok. • We have the impression that Japanese developers still lack in know-hows for real estate development in Bangkok, and that they lack experience in promoting business development between independent developers and Japanese developers. • As an impression of Bangkok, urban planning seems to be weak overall, and there is merely any system for bonuses when city planning methods are adopted. • In Bangkok, land prices rising significantly high that it is difficult to purchase and develop land. • Bangkok is considered to be somewhat far from the city centre because traffic is relatively convenient. • Developers have been buying land around the station.
2) Interests in the Bang Sue area development	• Bang Sue has a bright prospect as it is close to Ladprao and is considered as a residential area for Thais. There are existing commercial facilities and parks, making the area attractive for daily life. • Involvement into Bang Sue development would be seriously considered if there would be a good business model. • It is difficult to consider housing development on a land with a 30-year lease, but there may be a loophole if it will be developed as offices. • Bang Sue is not considered as a suburb – we recognize it as the traditional CBD as there are big companies like SCG and PTT, which have been in the area. • Bang Sue is close to Don Muang and is accessible to the central area – from the perspective of real estate development, it is definitely considered a good area. • While office developments such as the CBD and One Bangkok is taking place, Thais prefer offices to the north of Siam which makes the area very popular, giving Bang Sue a high potential from the Thais' demands. • As of now, Bang Sue's development seems advantageous for Thai companies, including the cost aspect. • We are considering to join for the infrastructure development, but we have not found the opportunity for it yet. • If there is anything necessary for crime prevention in Bang Sue, we may consider its development in the form of a pilot-business. • Although we believe that we cannot participate in the business without partnering with local companies, we are considering whether there is any room for individual businesses. • We are interested in combined development, and from that perspective, we are also interested in the Bang Sue development.
3) Opinions and	• We believe the Bang Sue development will not be so successful unless the SRT or the government develops a good plan and provides incentives.

Topic	The Opinions
concerns for the urban development in Bang Sue	• A good city cannot be developed unless the SRT or the government funds and keeps the minimum infrastructure to cover the whole area. • It seems difficult to me especially with the possibility that the government will not fund for the development of the basic infrastructure. • We are concerned that if the government leaves this development to the private sector, it will become an ordinary development project without Smart City aspect. • Business scheme must be carefully structured by the public side so that it would be attractive for the investor, but currently, there is an impression that most of the vital aspect is left for the investor. • It is good that there are different usages depending on the block, but on the other hand, we get the impression that it is difficult to have a clear concept of the city as a whole, unless there is a clear concept to follow in the requirement of each block. • One must first consider the separation of pedestrians and vehicles as well as the maintenance of green spaces – we feel, at a stage, that the development plan is not sufficient as a Smart City. • The location is not bad and that there are development demands, but do not see the solid plan of the entire development. • It will be more easy for one to participate if there are certain conditions that one has to meet (buildings cannot be built unless they meet some certain criteria, etc.). Without this, the competition becomes irrelevant of quality, making it impractical. • It will be better to build an integrated system and to then consider the rules, instead of having separate systems. • We think that development requirements should include the traffic environment, setback requirements, etc. which should be satisfied. • The Zone A bidding will be hard for foreign companies to participate, if the bidding proceeded under Thai business customs and Thai language. • Infrastructure development should be implemented under a big picture, but looking at the way in which it is handled, the project looks likely to be implemented in a disjoint manner. • Participating in the market sounding of Zone A, it felt like the infrastructure development was left to the developer. • The bidding documents written in Thai only makes it difficult for foreign companies to participate. • Even setting aside the Thai-tendering procedure, given the risk profile and profitability, there may not be a high competition for bidding. • Even the highway projects had their tender documents in English – the Bang Sue development on the other hand has theirs in Thai. This would be a major hindering factor for foreign companies. • It would be unrealistic to realize the smart city with the private sector alone. • The 30-year land lease would likely be unprofitable, so there is a need to extend it to 50 years. • From the prospective of a foreign firm, the project seems more inclined towards Thai local companies rather than the foreign firm, which is understandable to some extent. • The area may provide opportunity for conducting pilot projects at a small and closed area. It would be desirable if it could be a place where ideas and technologies could be

Topic	The Opinions
	incorporated in a business environment closer to real society. • It would be difficult for foreign companies to participate unless the process is made clear. • If the development proceeds individually by zones, rather than integrally, it would be less attractive for Japanese companies to participate. • If the urban development in Bang Sue is to be promoted with Japanese companies, it would be preferable if a council or a conference is developed, in which the stakeholders participate to promote the development together. • The big picture for this development has to be decided first – it will be troublesome were it to change in the future • Although the leasehold has the advantage of having little initial investment, it is difficult to decide how much money to spend as it will not be one's own land. • The biggest obstacle is that foreign capital restrictions are heavy when considering the possibility of bidding for zone development. Thai companies can hold up to 51% of the stake and have the right to make decisions. If this part of foreign capital regulation is overturned, the possibility of participation in development projects will be completely different.
4) Opinions on smart city development and smart service in Bang Sue	• Whether one participates in the real estate development may be decided by examining the profits and losses. However, there is the necessity to judge who will be responsible for the additional cost for Smart City development, as well as to decide how to evaluate the value added from the view point of real estate. • I am interested in smart cities as it is likely that this business will be widely spread in the future. However, it feels that we are still at the stage where we are trying to develop the right business model. • It is likely that bidding will be easier once the prospect for profit from business technologies such as the big data becomes clear. On the other hand, a business model for big data utilization without subsidies has yet to be found. It seems that private companies need some verification of the business model in prior to engaging into such business. Bang Sue could be one of the pilot project to verify such kind of business. • Since smart infrastructure cannot be realized without revenues, it seems difficult unless the government supports the business. • Development concept seems intriguing. Real estate could be more attractive when Smart City concept would be fully realized. • Deregulation for the floor-area ratio would be preferable along with the Smart City development process. • Having cheap electricity would be appealing as a developer. • As for mobility, having autonomous driving busses and public transportation would be intriguing. • The road transport condition is not adequate as there are traffic jams even in the cities. Building an all-inclusive environment, such as the one being planned here, would be captivating. • Having the Smart City elements from the very first stage is attractive to developers as well. • The safety, clean air, and basic functions such as anti-flooding measures and drainage/disposal systems would make it suitable to call this area a Smart City. • Smart mobility to connect different areas is essential, and the proposed services seem

Topic	The Opinions
	desirable. - Realizing barrier free walking space, roads and pedestrian paths that connects each zone, and mitigating traffic jam would be attractive. - If Zone A and Zone E would proceed with a normal bidding process, which is how it is currently being proceeded, it would make it hard for Japanese Government or Thai Government to support the project. With support of the Government, the Smart City project could become a more attractive business.
5) Other topics	- It would be preferable if the traffic condition in the nearby area improves as well. Especially, improving the connectivity to Don Mueang International Airport, as well as improving accessibility to the nearby stations could have big impact. - Thailand would be entering an aging society, so this should be an issue that should be taken into account. Important aspect would be to enable people of various generations – from children to the elderlies – to live a healthy and satisfying lifestyle.

Source: JICA Study Team

The interview survey revealed that many of the Japanese companies are keenly interested in the Bang Sue area development. With regard to real estate development in Bangkok, the condominium market is expected to decrease gradually while the demand for high class offices may stay high. It is also worth noting that the demands are expected to rise especially around the railway station. The Bang Sue development would be centered on the Grand Station, while comprised of parks, commercial facilities, and large businesses. This would present the area with a bright prospect. Consequently, Japanese companies which run real estate development projects in Bangkok find the Bang Sue Area development attractive.

On the other hand, many concerns were raised regarding the involvement with the Bang Sue area development. Real estate development companies have pointed out the stumbling blocks in the structure and system, such as: bidding rules and processes are not made to welcome foreign real estate development companies (bidding documents are only written in Thai and are written by Thai consultants, etc.); incentives are limited; and development projects have to ensure 51% share to Thai companies. Many interviewees mentioned that 50-year lease tenures are preferable over 30-year, and that residential development would be not profitable under a 30-year lease. Although the bidding structure will be left to the Thai side's consideration, the above mentioned issues need to be addressed in order to promote foreign companies' participation.

Furthermore, several opinions were raised concerning in the way the Bang Sue development are promoted – the basic infrastructure in the area should be funded and developed by the government, the concept image of the whole city should be clarified, and the rules for the city's development should be clearly defined. As these issues relates with the proposals of this study, it is vital to build up the image of the future town, while formulating the rules for the urban development, and implementing the project with appropriate assignments for different roles.

Many of the companies have high expectations for the smart city development, and raised many opinions including the demand for a mobility service in which people can move around safely and smoothly within the area. In contrast, some mentioned that the private sector alone has

limitations such as infrastructure development, and that there needs to be incentives for adopting smart services such as the deregulation of floor area ratios. Based on these opinions, under support of the government and related organizations, it is vital that a functional system for Bang Sue development is set up, in which the division of the roles would be coordinated and clarified, and the development would be implemented in an integrated manner. The rulemaking for the city based on the city development guideline, as well as the Smart Service Company that are proposed in this study would play a key role in realizing the Smart City.

6.2.3 Implications from Questionnaire and Interview Surveys

Many companies have evaluated highly of the potential in Bang Sue Area based on property development perspectives such as geographical conditions or access to public transportation. Meanwhile, it could be pointed out that the potential for the area is confined when evaluated from the perspective of foreign investment attraction, with regards to bidding conditions and others.

In the context of “Smart City Development”, despite the business model is yet to be clarified, the theme has attracted considerable attention with the recent trend. The term “Smart City Development” is regarded as a keyword for considering urban development or infrastructure service projects.

Among the many topics, the major interest of the Japanese companies lies in whether they have opportunities for participation in the project. Japanese companies will recognize the project as business opportunities if the bidding specifications include contents to which Japanese companies could contribute. Specifically, the areas in which Japanese companies seek business opportunities include high quality building and building-related applications for property development, or provision of infrastructure services for Smart City development.

From the perspective of the development for Bang Sue, integrated development is desired for the enhancement of property values. It is important to take substantial steps towards realizing this goal.

6.3 Applicability of Japanese Urban Infrastructure Technology

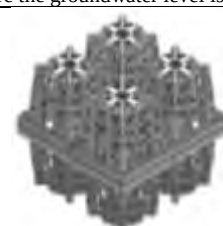
The applicability of Japanese technology in Bang Sue are examined and outlined below.

6.3.1 Measures against inundation utilizing rainwater storage facilities

Thailand suffered large-scale flooding, as characterised by the 2011 flood. In areas where sewerage is not established or where drainage is poor, flooding occurs everywhere even during medium rainfall. In addition, because sewage such as dishwashing water is running down the road, the water quality during flooding is assumed to be poor. Infectious diseases are considered dangerous, and water shortages due to ground subsidence due to excessive drawing of groundwater and an increase in water demand due to an increase in population have also been cited as issues.

Chichibu Chemical's plastic rainwater storage structure can be used for various purposes, such as flood control, groundwater replenishment, securing of alternative water sources by using rainwater and it is effective. It also believed that outsourcing construction to local workers will ensure local employment opportunities and revitalize the local economy. A project investigation was completed in August 2018, and demonstration activities are currently being carried out using the "SME and SDGs business support project-diffusion, demonstration, and business conversion project (SME support type)". Although the Bang Sue area is not affected by flooding, it is considered that the introduction of this technology is effective because drainage measures are indispensable for redevelopment.

Table 6.7 Summary of Proposed Products and Technologies (Main Purpose: Reduction of Inundation Damage)

Products name	New trench-kun	Puradamu-kun	New Pura-kun
Photo			
Pricing	23,200 yen/m (Components only)	23,000 yen/m3 (Components only)	24,000 yen/m3 (Components only)
Sales result	Total of 1,750 or more (Main customers: general contractors, trading companies)	1,100 or more in total (Main customers: general contractors, trading companies)	Total of five (Main customers: general contractors, trading companies)
Feature	Since it is specialized for installation in a trench shape, it is suitable for installation in a narrow space such as the side of a building.	It is suitable for constructing a large facility in a wide area in plan, such as under a parking lot.	It is suitable for constructing a large facility in a wide area in plan, such as under a parking lot. In addition, since the minimum facility height is 0.35m, it is highly applicable to the field where the groundwater level is high.
Specification	 Width 0.5m× Height 1.0m× Length 0.25m Approximately 6kg (porosity >95%) Encapsulated with a permeable sheet	 0.75m in length x 0.75m in width x 0.6m in height Approximately 7kg (porosity >95%) [Storage type] Encapsulated with protective sheet and water-proof sheet [Permeation type] Encapsulated with a permeable sheet	 Vertical 0.7m× horizontal 0.7m× minimum height 0.35m Approximately 3kg (porosity >95%)

Source: JICA, Chichibu Chemical Co., Ltd., Project Study on Rainwater Storage Structures from Plastics in Thailand, 2018.8.

Image of roads and development sites in Bangkok, represented by Soi39



Image of inundation during rainfall



Image of measures to suppress outflow by plastic rainwater storage structure



Source: JICA, Chichibu Chemical Co., Ltd., Project Study on Rainwater Storage Structures from Plastics in Thailand, 2018.8.

Figure 6.1 Image of measures to control the outflow of plastic-made rainwater storage structures in 1 Sukhumvit area Soi39, etc.

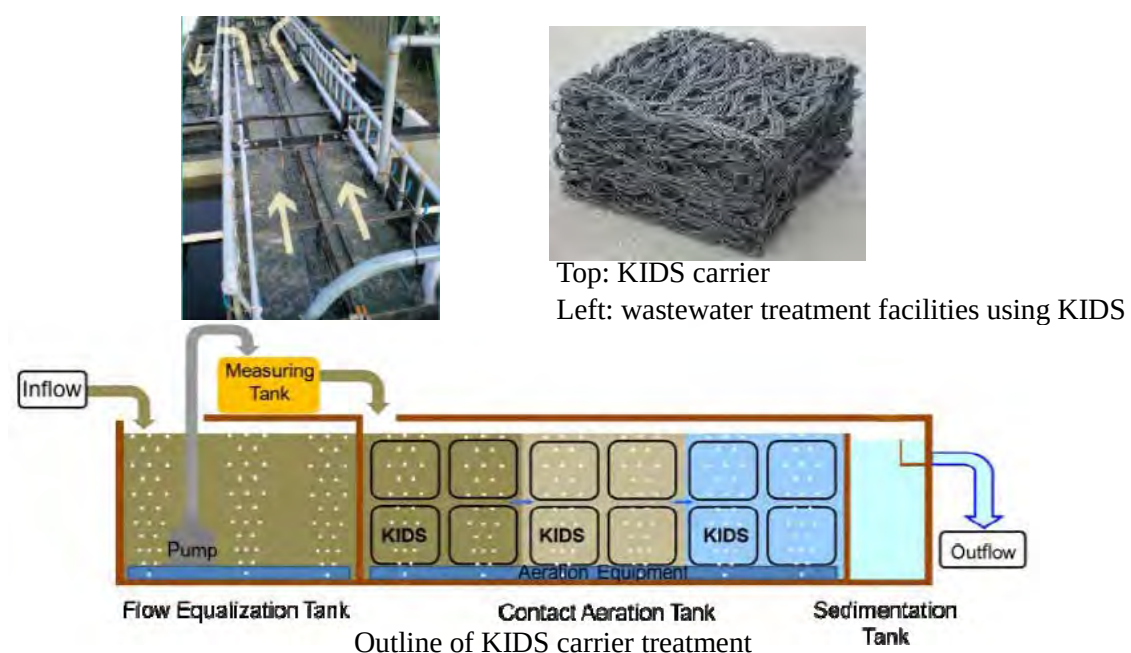
6.3.2 Water quality improvement technology along with improved drainage performance

In order to maintain the water quality properly in the Bang Sue area, it is essential to install drainage equipment. The wastewater treatment technology using the recycle carrier (KIDS: Kind Integrated Digestion Strand) owned by Acrete Co., Ltd. can reduce the maintenance and management costs compared with other treatment methods, and can also facilitate the operation and management.

This treatment technique is characterized by the fact that the amount of generated sludge can be significantly reduced compared to other methods (treatment cost is cheaper). By laying a KIDS as a filter bed carrier in a reactor and repeating the "aerobic" and "anaerobic" treatments, the operation and control are easier compared to other biological treatment methods such as the activated sludge method, because the treatment is a filter bed method. Note that the carrier used is a recycled product, has a large void due to its shape and material, and can be used stably for a long period of time. The field of application of the present technology is organic wastewater, which can treat wastewater in factories, restaurants, hotels and households etc. Features of the present processing technique are as follows.

- The amount of sludge generated can be reduced (reduced by half compared to the standard activated sludge method).
- The carrier is an environmentally recycled product made from plastic waste.
- The KIDS carrier does not need to be replaced and is easy to maintain.
- The equipment can be easily installed, and the equipment can be adjusted according to the situation of the installation space.
- Since the input of chemicals and the like is unnecessary in the treatment process and the sludge throughput can be reduced, the operation and maintenance costs are lower than those of other treatment technologies.
- Compared to a general wastewater treatment system, the number of devices is extremely small.

Currently, in Lao PDR, the business model formulation survey of JICA was completed in August 2018, and the company is currently working on a dissemination/demonstration/business project.



Source: JICA, Feasibility Survey for Wastewater Treatment System Utilizing Recycled Media (KIDS), 2018.4.

Figure 6.2 Image of the use of wastewater treatment facilities using KIDS carriers

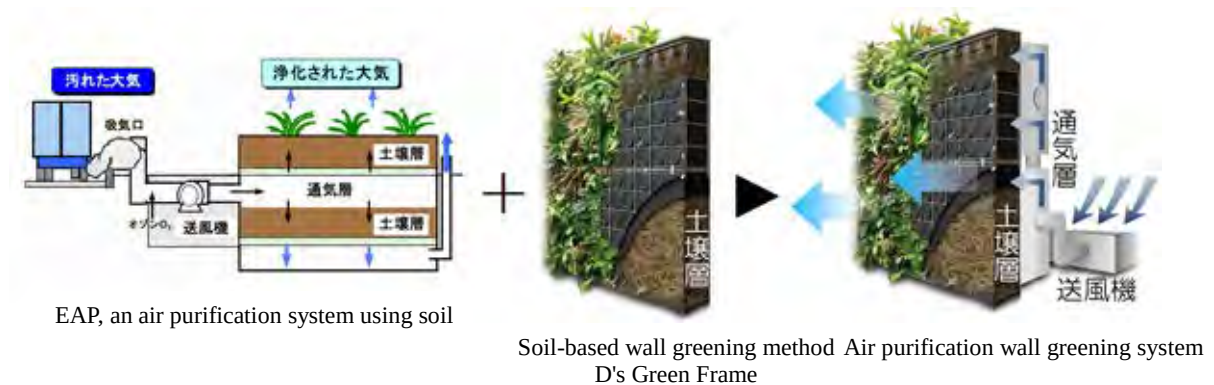
6.3.3 PM2.5 reduction technology using wall greening technology

As mentioned above, the problem of air pollution is also a problem in Bangkok, and dealing with them is an urgent matter.

The `Air Purifying Wall Greening System` jointly developed by Daiwa house Industry Co. Ltd. And Daiwa Lease Co. Ltd. Sucks polluted air with a fan, absorbs the pollutants by microorganisms in plants and soils. Nitrogen and PM2.5 can be decomposed and purified, and it is said that PM2.5 can be reduced by about 65% and nitrogen dioxide can be reduced by about 90%.

In addition, while a purification system using a general soil layer grounded on the ground requires a large site, the system can provide a soil layer on the wall surface, saving space on the required site area. Compared with the system in which the soil layer is horizontally installed, this product enables the required building area to be reduced to about 1/5, and it is easy to install even in urban areas. In addition, since soil microorganisms continue to decompose, a sustained effect can be expected.

By introducing such greening technologies into the Bang Sue area, it is possible to contribute to the purification of air pollutants in the area and realize a Smart Environment.

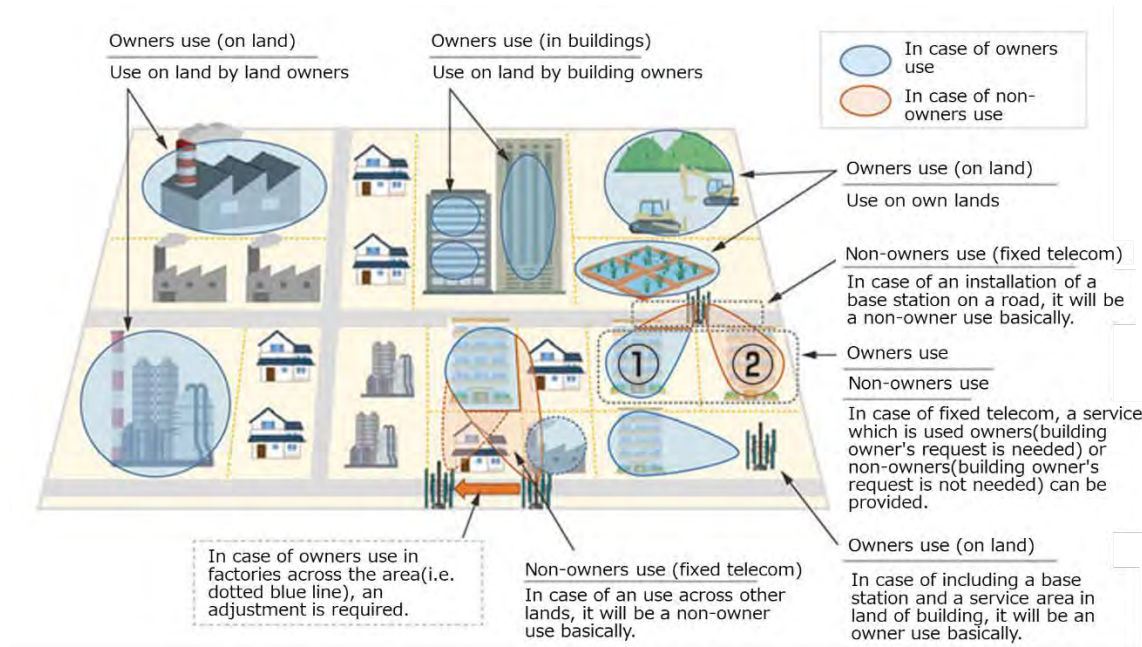


Source: Daiwa House Press Release, <https://www.daiwahouse.co.jp/release/20150805121413.html>

Figure 6.3 An image of the use of the greening system for air purification walls of the Daiwa House

6.3.4 Local 5G technologies

In Japan, the Ministry of Internal Affairs and Communications is working on "local 5G" in which 5G networks can be used in district areas like the Wi-Fi networks. If the local 5G is realized, 5G networks can be constructed with self-employed equipment, and various services using the 5G can be developed in these environments.

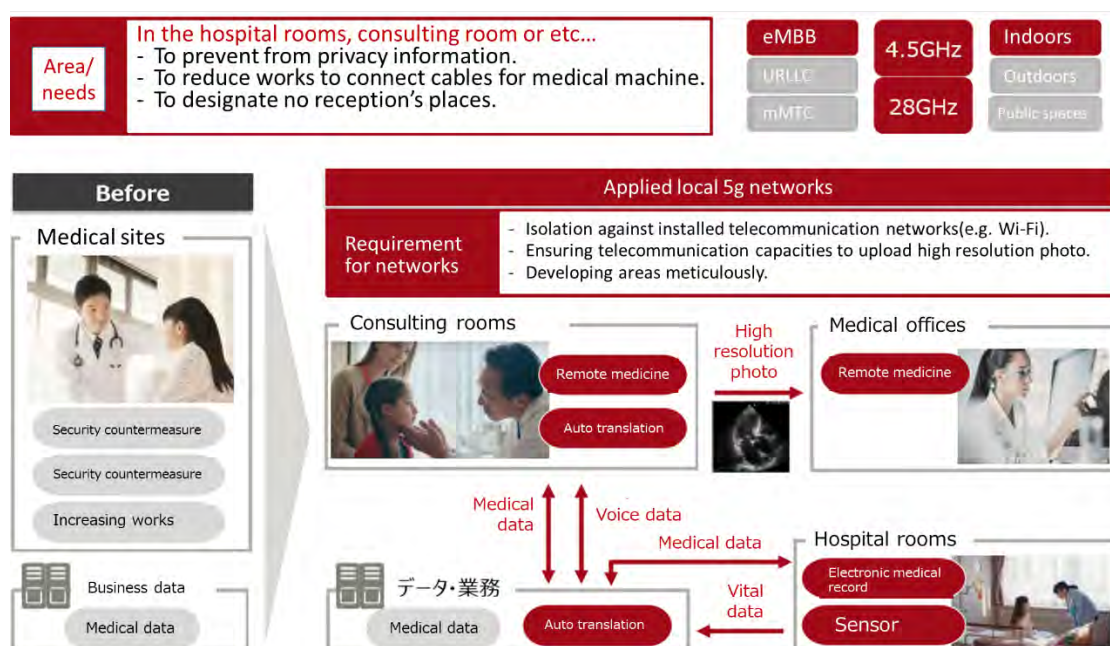


Source: General Report (draft) of the New Generation Mobile Communications System Committee, Information and Communications Technology Subcommittee, 2019.3.

Figure 6.4 Image of Local 5G Use in Japan

In order to realize the local 5G, a frequency band dedicated to the local 5G needs to be secured as in the case of the Wi-Fi. In Japan, there are two frequency bands that are considered to be allocated as frequency bands exclusively for local 5G (4.6 to 4.8GHz in the 4.5GHz band and 28.2G to 29.1GHz in the 28 GHz band), and the institutionalization work for the summer of 2020 is proceeding.

Telecommunications carriers and IT service providers are considering building next-generation networks of large facilities such as factories, research facilities, airports, business parks, and stadiums that are supposed to be allocated. For example, Fujitsu Corporation is developing local 5G construction solutions for factories, hospitals, and plants as typical application areas of local 5G. In hospitals, services such as telemedicine and diagnosis support by high-resolution images are assumed.



Source: Recited from the material submitted by Fujitsu (3rd) Working Group on Local 5G of the New-Generation Mobile Communications Systems Commission, Ministry of Internal Affairs and Communications

Figure 6.5 Examples of local 5G application scenarios (for Fujitsu Co., Ltd.)

These use cases are also very crucial in the Bang Sue area. However, in order to realize local 5G services in the Bang Sue area, it is essential to coordinate between the Japanese and Thai governments so that Japanese companies can easily develop local 5G networks.

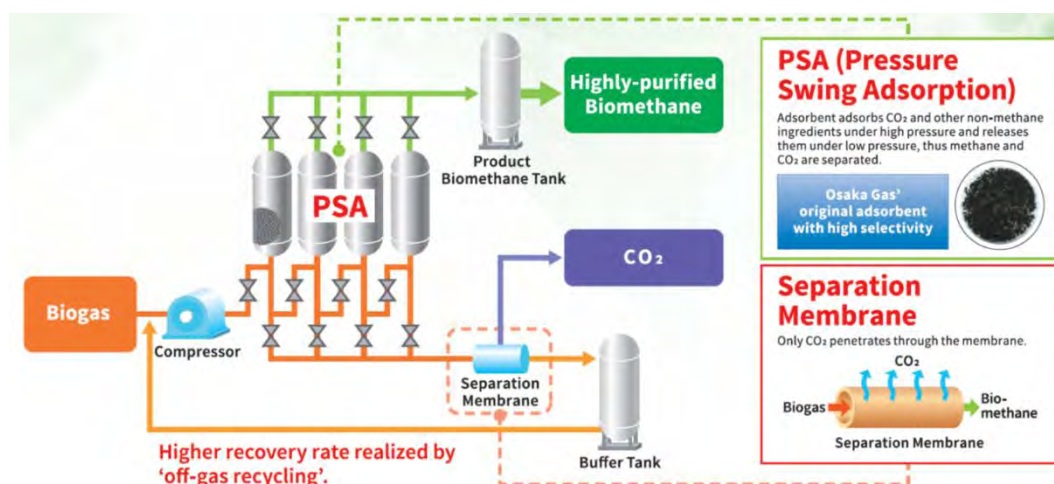
6.3.5 Reduction of Greenhouse Gas Emissions through Highly Efficient Biogas Purification Technology

Agriculture is one of the key industries in Thailand, which boasts of abundant biomass resources including strained sugarcane lees, palm oil residues and waste water from food factories and popularizing natural gas vehicles.

Osaka Gas Co., Ltd. has collaborated with Agriculture of Basin Company Limited (hereinafter referred to as “ABC”) based in Thailand to distribute hybrid-type biogas purification system. In the hybrid-type biogas purification system carbon dioxide and others are removed from biogas generated from agricultural residues and others to produce high-purity methane gas.

This unique system adopts PSA (Pressure Swing Adsorption) to absorb and remove CO₂ selectively with CO₂ separating film to achieve 99% or higher methane collection efficiency, recognized at a world-class level.

As natural gas-based cogeneration system has been considered as an energy system in the Bang Sue area, the combined use of natural gas and biogas generated from the hybrid-type biogas purification system can bring synergy effects with reduction of greenhouse gas emissions.



Source: Material documents supplied by Osaka Gas Co., Ltd.

Figure 6.6 Hybrid-type Biogas Purification System Developed Uniquely by Osaka Gas Co., Ltd.



Source: Material documents supplied by Osaka Gas Co., Ltd.

Figure 6.7 Case of High-efficient Biogas Purification Technology Used for ABC's Natural Gas Vehicle

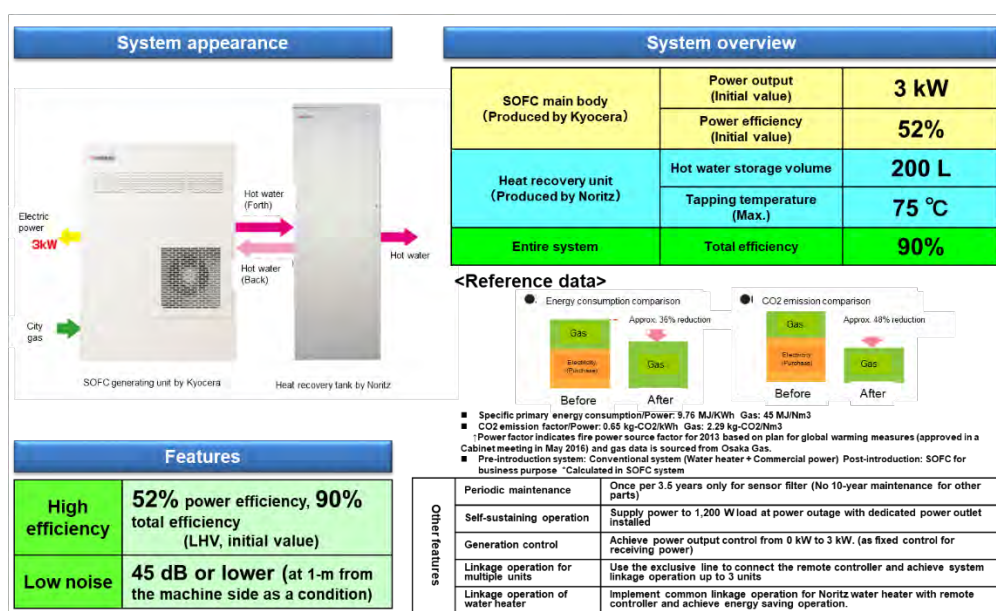
6.3.6 Reduction of Greenhouse Gas Emissions through Highest Efficiency Fuel Cell System for Business Purpose

Out of approximately 1.34 million users for business use in Japan, about 100,000 users are expected to make effective use of waste heat for business-use fuel cell market. Therefore, contributions are expected to energy conservation and CO₂ reduction in the business sector.

Power output for solid oxide fuel cell (SOFC) is 3 kW for business purpose with the industry's highest 52% as power generation efficiency, achieving 90% as the comprehensive efficiency including waste heat utilization (hot water supply). The system adopts four units of small-scale, high-efficient and high-resistant cell stacks, as the central part of power generation, which have been mass-produced for household fuel cell enefarm type S (700 W). And also, it achieves a high-efficient system designed to effectively use high-temperature exhaust heat at power generation.

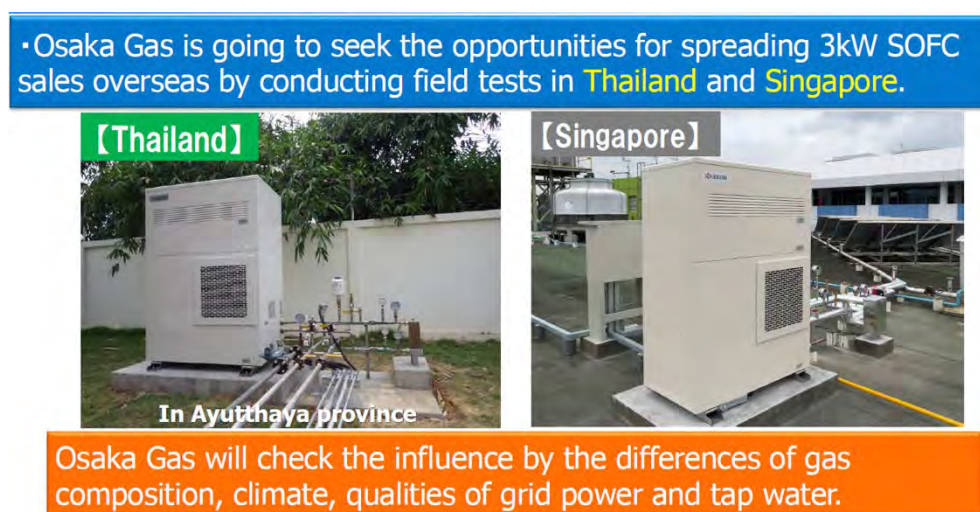
In the system production process, Kyocera Corporation developed the main body of power generation system and Noritz Corporation developed heat recovery unit. Tokyo Gas Co., Ltd., Osaka Gas Co., Ltd., Toho Gas Co., Ltd. and Saibu Gas Co., Ltd. considered specifications to meet customers' needs, conducted demonstration tests for developed model and evaluated performance and durability for system completion. They aim to distribute the system chiefly to small-scale restaurants or welfare facilities.

In addition, Osaka Gas Co., Ltd. aims to distribute the system to the business sector in Thailand and Singapore. As Osaka Gas conducted field tests with two cases of power system interconnection, together with Singaporean systems, in cooperation with the Petroleum Authority of Thailand (PTT), the urban gas market is expected to expand in the future in the country.



Source: Material documents supplied by Osaka Gas Co., Ltd.

Figure 6.8 3kW-SOFC System Produced by Kyocera Corporation



Source: Material documents supplied by Osaka Gas Co., Ltd.

Figure 6.9 Introduction Case of Overseas Demonstration

6.3.7 Contribution to Urban Solution through Smart House

As many residential buildings are to be constructed in the Bang Sue area, contribution can be made to low carbon performance across the area with energy efficiency efforts in each household.

If residential buildings incorporate the concept for Smart Home or Home Energy Management System (HEMS) into the facility design, they can make the energy management efficient and reduce energy costs and CO₂ emissions in each household or the entire building structure.

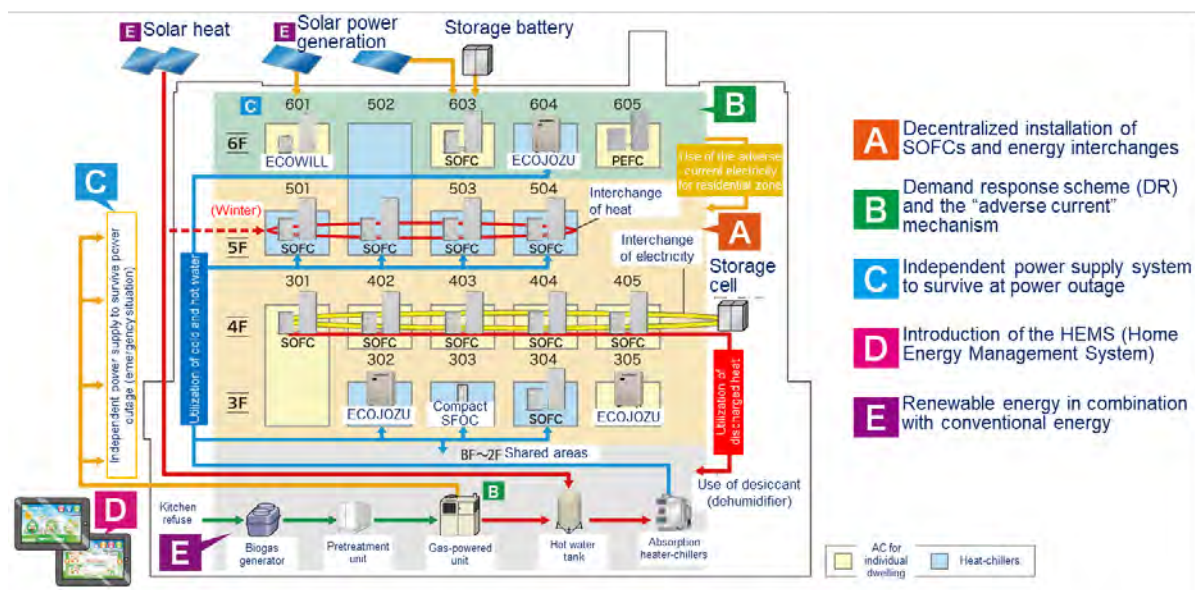
In NEXT21, as a typical example for this smart home, supplied in Japan by Osaka Gas, high, efficient fuel cell or gas engine-type gas cogeneration system has been effectively used in accordance with features for multi-family apartment building, and furthermore demonstration tests for smart system and technology have been implemented to respond to the additional pursue of energy conservation and CO₂ reduction and explicit energy supply issues after disasters (energy independence, power conservation, peak-cutting, etc.).

This demonstration test aims not just to pursue rationality, but also to review the relationship between energy and people/nature/residence/city, and tackle urban challenges with high, flexible energy system for dwelling life or residence and city with the objective of achieving “ecofriendly, comfortable day-to-day life”. In order for the Bang Sue area to fulfill Smart Environment or Smart Living, the technological deployment is expected with these concepts and design thought packaged.



Source: Material documents supplied by Osaka Gas Co., Ltd.

Figure 6.10 NEXT21 Concept



Source: Material documents supplied by Osaka Gas Co., Ltd.

Figure 6.11 Energy System Overview for NEXT21 (Posted previously)



Source: Material documents supplied by Osaka Gas Co., Ltd.

Figure 6.12 Actual Example of "Green Corridors" for NEXT21

6.3.8 Reduction of Greenhouse Gas Emissions through Optimal Operation Support Technology for Air-Conditioning System

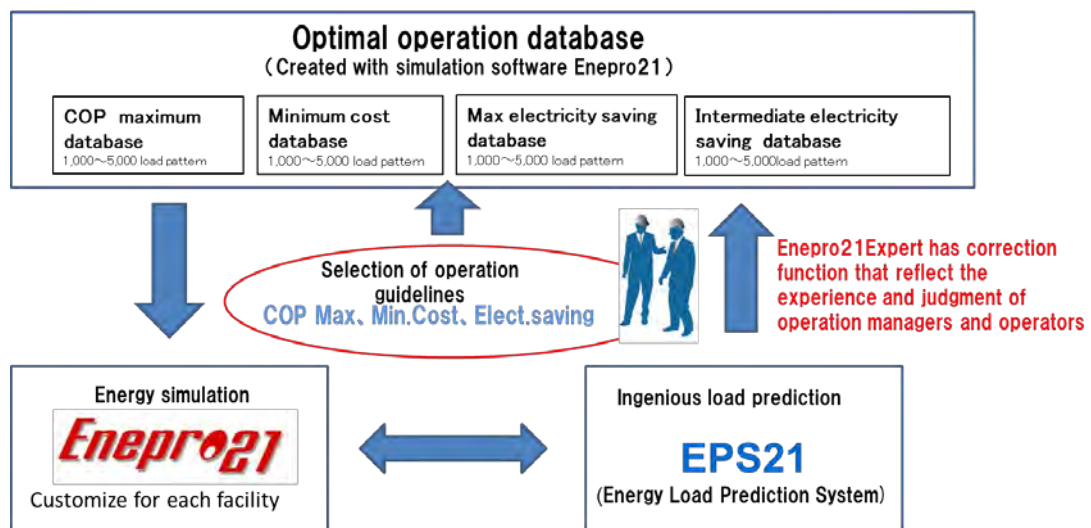
As many business facilities (office, commercial facility, hotel and public facility, etc.) are planned to be built in the area, the introduction of building energy management system (BEMS) has been actively promoted to boost efficiency of operation management for ventilation and others in each facility or achieve energy saving.

As the Japanese government has set a goal of reducing the final energy demand by 50.3 million kL (approx. 35%) per crude oil equivalent by FY2030 under COP21 Paris Agreement, the government needs to achieve improvement at 35% consumption efficiency (final energy consumption volume/real GDP) equivalent to the energy saving standard recorded after the oil shock.

In addition, as business challenges have become apparent in the operation management for regional cooling plant or building air-conditioning equipment due to fewer population or soaring labor costs in Japan, the introduction needs in operation support technology have been growing for optimal efficiency operation and profitability due to sophisticated equipment structure or complicated charge system brought by liberalized power and gas markets.

Based on these backgrounds, the development of optimal operation support system has been promoted in Japan by incorporating AI or other advanced technologies into energy simulation technology or energy demand prediction technology, and many performance results have been accumulated in Japan. Therefore, it is expected that this reliable operation management support system will be distributed in the Bang Sue area.

The optimal operation support software “Enepro21Expert” has many performance results on domestic regional cooling plant or individual concentrated heat source. The overview of the software is introduced in the following description. This Enepro21Expert adopts energy simulation software (Enepro21) and energy demand prediction system (EPS21) as basic software to achieve “energy conservation”, “minimum CO₂ emission”, and “minimum cost generation” with optimal operation in line with operation guidelines.



Source: Material documents supplied by E.I.Engineering Co., Ltd.

Figure 6.13 Function Overview for Optimal Operation Support Software “Enepro21Expert”

7. Roadmap towards Realization of the Vision

7.1 Progress and Challenges on Development Plans in Bang Sue

(1) Situation regarding Bang Sue Area development

Construction work for Bang Sue Grand Station has been steadily carried out and the station is planned to be opened in early 2021 along with the Red Line. In the meantime, selection process for developers is being prepared for some of the zones, for example the selection process for Zone A has been started with the bidding deadline at the end of July 2019. However, as there was no company applying for the Zone A bidding process, the selection needs to be prepared again. In Zone E, a construction plan for the new SRT head office is being considered along with the developer selection. In Zone D-1, a land leasing process has been initiated with the Ministry of Public Health where they plan to construct a medical complex under a PPP arrangement. Similarly, in Zone G (KM11 area), considerations are being made to implement the developer selection process by 2020.

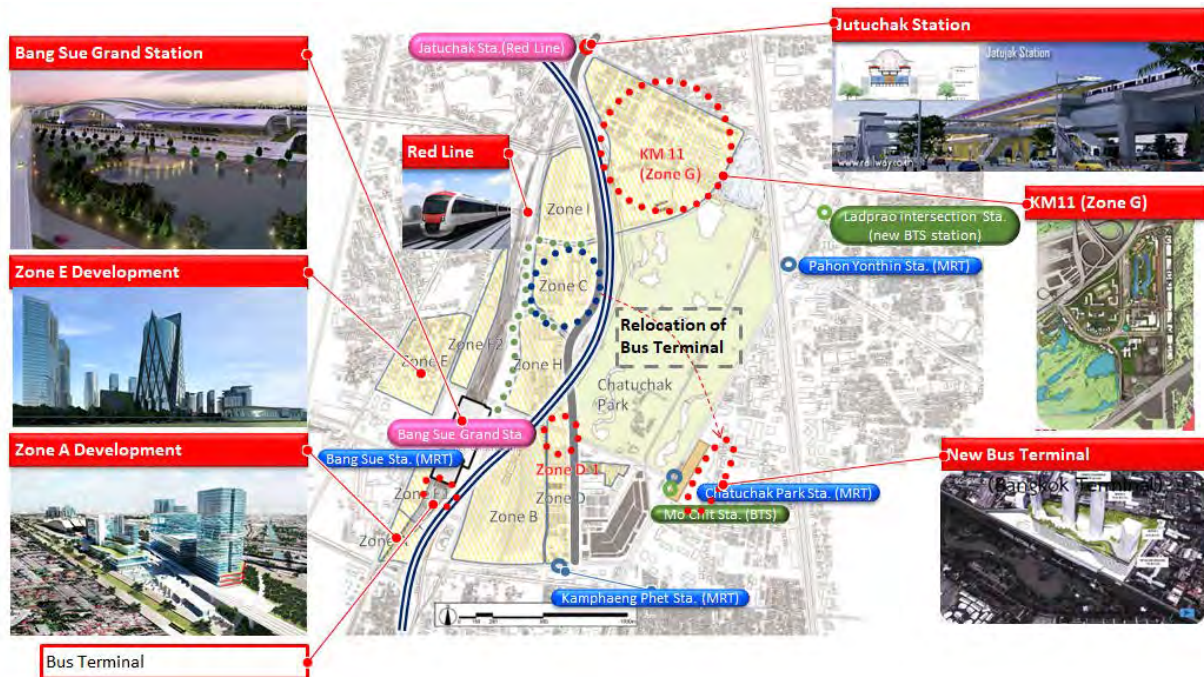
Furthermore, the bus terminal currently located in Zone C is to be relocated to the east side of BTS Mo Chit Station, while on-and-off ramps and U-turn roads for expressways are to be constructed in the Bang Sue Area.

These development projects are implemented independently, without a comprehensive plan that dictates the whole Bang Sue Area development. Also, the measures to develop the Area into a Smart City to enhance its value-added have not yet been considered in detail. Therefore, an integrated development approach is proposed in this study where the value-added can be enhanced through area-wide infrastructure services, mainly on Smart Mobility and Smart Energy. The proposed approach and the idea need to be harmonized with respective development plans.

Table 7.1 Progress regarding development for each zone

Zone	Area	Function	Current Situation	Note
Bang Sue Grand Station	-	Grand station Surrounding roads and infrastructure.	Under construction Open in 2021	
Zone A	32 Rais (5.1 ha)	“Smart Business Complex” shops, hotels, and offices, corridors within the Project to the Bang Sue Central Station	Under tender (2019 7/30 Due date of proposal submission) >No Bidder	PPP, 30 years concession
Zone E	140 Rais (22.4ha) S1~2 (15.6 Rais, 2.5ha) A1~3 (20.4 Rais, 3.3ha) B1~3 (55.8 Rais, 8.9ha) C1~4 (28.3 Rais, 4.5ha)	SRT Headquarters area Office/Commercial area Residential area SRT staff residence	Under F/S	
Zone D-1	15 Rais (2.4ha)	DMS(Department of Medical Science) Medical Complex	Lease to DMS	PPP, 30 years concession
Zone G (KM11)	325 Rais (52ha)	Mixed use	F/S in FY2015	

Source: Compiled by JICA Study Team, based on documents provided by the Thai government and other materials.



Source: Compiled by JICA Study Team, based on documents provided by the Thai government and other materials.

Figure 7.1 Situation in Bang Sue Area

(2) Challenges for Bang Sue Area development

Under the current situations as mentioned above, the following points can be raised as challenges in the Bang Sue Area development.

1) Delay in preparations for the integrated development

As of now, infrastructure development plans for the entire Bang Sue Area have not been fully formed. Taking this situation into account, this study examines and proposes measures to promote infrastructure development in an integrated manner under Smart City development. Such approaches would contribute to enhancing the overall value of Bang Sue Area development.

With the upcoming opening of Bang Sue Grand Station in 2021, accompanied by the early development surrounding zones, it is crucial to speed up the preparations and actions towards the implementation.

2) Coordination with existing facilities

The existing railway on the west of Bang Sue station is to be kept in the opening of Bang Sue station in 2021 and during the development of Zone A and E in Phase 1. There are also many existing facilities near the development area such as the railway overpass, highways, and underground oil pipes. It is therefore crucial that the plan adequately addresses these situations and the details are coordinated. Furthermore, as Zone A and E is the adjacent zones to Bang Sue Grand Station, guaranteeing connectivity to the station and appropriate landscape formation that symbolizes Bang Sue are essential requirements that needs to be in place in the tender documents for the developers.

3) Coordination with Smart City plan and Zone development

In this study, specific Smart City contents are suggested for the entire Bang Sue Area. To realize these ideas, coordination with the development plan would be necessary, while accelerating the

process towards its realization.

As the sky deck network connecting Bang Sue Grand Station and Mo Chit station is to pass through Zone D-1, the detail sky deck development plan and its project structure needs to be decided in prior to the bidding for Zone D-1.

7.2 Conditions for Success of Integrated Development in Bang Sue

The following table summarizes specific benefits and conditions for “integrated development for the Bang Sue area.”

Table 7.2 Benefits and conditions for integrated development

Benefits by integrated development	Conditions for integrated development
• Improve efficiency for area development/management. • Achieve preferable cityscape through guided design. • Enhancement of area values and achieve sustained attractiveness. • Introduction of new technology in area-basis. • Applying the model to other cities as a package. • Branding of the city under integrated concept or design.	• Implement area-wide infrastructure operation and management (energy supply, etc.) under one system. • Establish integrated area traffic system. • Harmonize the area landscape, building outer surface colors and shapes, based on consistent design codes. • Build systematic approach with area infrastructure development standards. • Consolidate area information. • Implement area-wide urban development and operation under one organization (or system).

Source: JICA Study Team

Based on these considerations, the following basic conditions for successful implementation of integrated development in the Bang Sue Area are identified as follows:

1. Set up a management entity to coordinate and manage development plans for the entire Bang Sue Area and sufficiently strengthen their capabilities.
2. Set up an entity to provide infrastructure services (smart services) which help promote integrated development and improve added values. Also, establish a measure to provide financial and institutional support for the entity.
3. Formulate guidelines which clarify basic policies on the entire Bang Sue Area development and ensure the guidelines are properly executed.
4. Encourage private companies to proactively engage in the project so as to provide quality infrastructure service (smart service).
5. Clarify roles and responsibilities of main stakeholders and establish cooperative relationship.
6. Secure connectivity across the entire Bang Sue Area by connecting neighboring stations to respective zones.
7. Set up an attractive business scheme to motivate investment by private companies.

If these actions are sufficiently taken under the “Smart City” initiative in line with the zone development plans, the development would lead to enhancement of the value of the land which in turn improves SRT’s financial status.

In Bang Sue, the smart service business operator and zone developer are considered to be different entities. Accordingly, the smart service would be judged by the potential zone developers on the basis of whether the service would have positive impact on their business. In this perspective, the smart service suggested in this study could be considered positive for the potential zone developers, as the service contributes to enhancing accessibility to the zones with the public transport system, while ensuring reliable and sustainable energy sources with the Smart

Energy network. The service also could benefit the zone developers by enhancing the possibility of attaining the Smart City certificate by the Government.

In addition, from the perspective of private investments in smart service businesses, once Thailand's first smart service supplier is established, more services may follow to provide a broader range of services. Although the capital is likely to be procured under state owned enterprises in the initial stage, it is expected that capital investment could be induced from the private sector or the financial market in the long run once Smart Service Company's business reaches its take off.

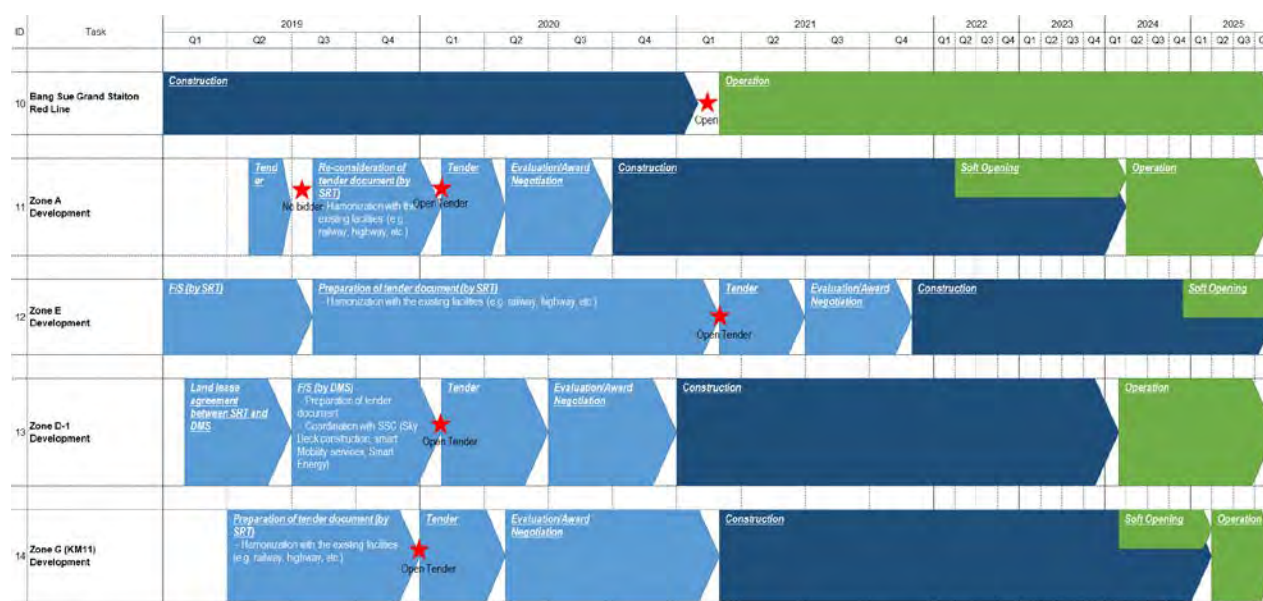
7.3 Roadmap towards Realization of the Vision

7.3.1 Development Schedule for Respective Zones

In this section the latest development schedule is summarized for Zones A, E, D-1 and G (KM11 area). These are the zones in which specific considerations are currently made. (The development schedules are outlined based on information attained on early August 2019).

Note that the considerations and analysis mentioned in the previous sections, including the financial analysis, are based on the development schedules specified in the previous JICA Study, and thus that the following revised schedule is not fully reflected.

- Zone A** The development schedule will be reconsidered as the tender process for developers, which closed at the end of July 2019, had been unsuccessful. Here, the development schedule is estimated to be delayed by about 6 months compared to the initial plan. The schedule is revised to select developers in early 2020, start construction towards the end of 2020, implement pre-opening in early 2022, and have its grand opening in early 2024.
- Zone E** The development schedule is revised to select developers in the first half of 2021, start construction towards the end of 2021, implement pre-opening in the latter half of 2024, and begin operation in the latter half of 2025. (Zone E would be developed in phase.)
- Zone D-1** The development schedule is revised to select developers in 2020, start construction in 2021 and start operation in early 2024.
- Zone G (KM11)** The development schedule is revised to select developers in early 2020, start construction in the first half of 2021, implement pre-opening in the first half of 2024, and begin operation in the first half of 2025. (Zone G would be developed in phase.)



Source: Compiled by JICA Study Team, based on SRT's information.

Figure 7.2 Expected development schedule for respective zones

7.3.2 Action Plan for Realizing the Smart City Development

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

	Challenge 1: <u>High-level decision making and coordination</u>
✓ Implement necessary deregulation measures ✓ Approval and authorization of plans and actions	
	Challenge 2: <u>Fulfil financial gaps and technical capabilities</u>
✓ Finance for initial investment ✓ Technical capability to lead Smart City project	
	Challenge 3: <u>Mechanism for integrated development</u>
✓ Phased infrastructure development ✓ Interface coordination among stakeholders ✓ Incorporation of private sector skills and expertise	

With regards to the mentioned challenges, the proposed measures and key points to consider are as follows.

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

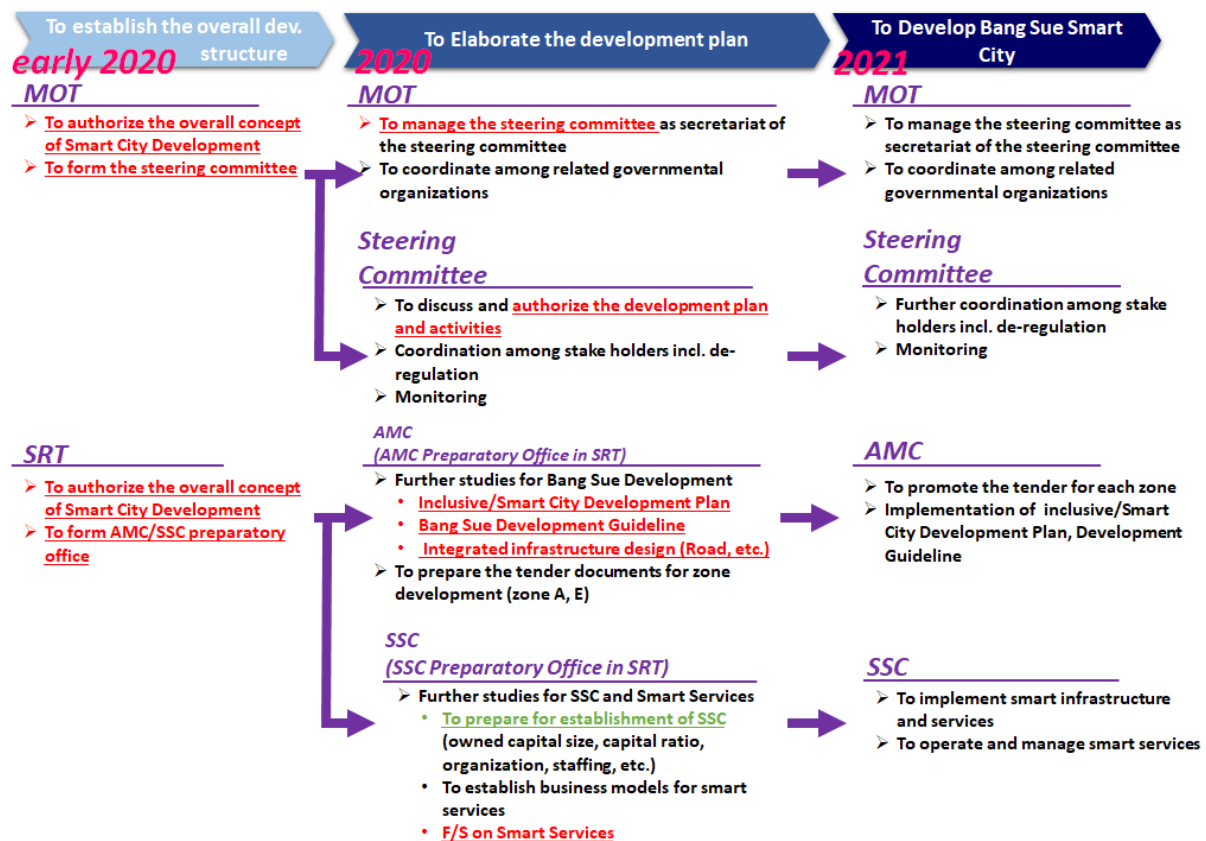
- ✓ Ensure a transparent governance structure and independence
- ✓ Address demand risk mitigation and arrange incentive schemes
- ✓ Recruitment and capacity building

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 the development
- ✓ Ensure coordination of plans at various levels – integrated infrastructure design, Master Plan, District Plan, Zone plan, Smart Service F/S

Taking into account the actions mentioned above, Figure 7.3 summarizes the proposed action plan for the Smart City development and the integrated development for the Bang Sue Area by 2021.



Source: Compiled by JICA Study Team.

Figure 7.3 Action plan for stakeholders

Descriptions of respective efforts to be made by each entity are outlined as follows.

(1) 1st stage (~ early 2020): To establish the overall development structure

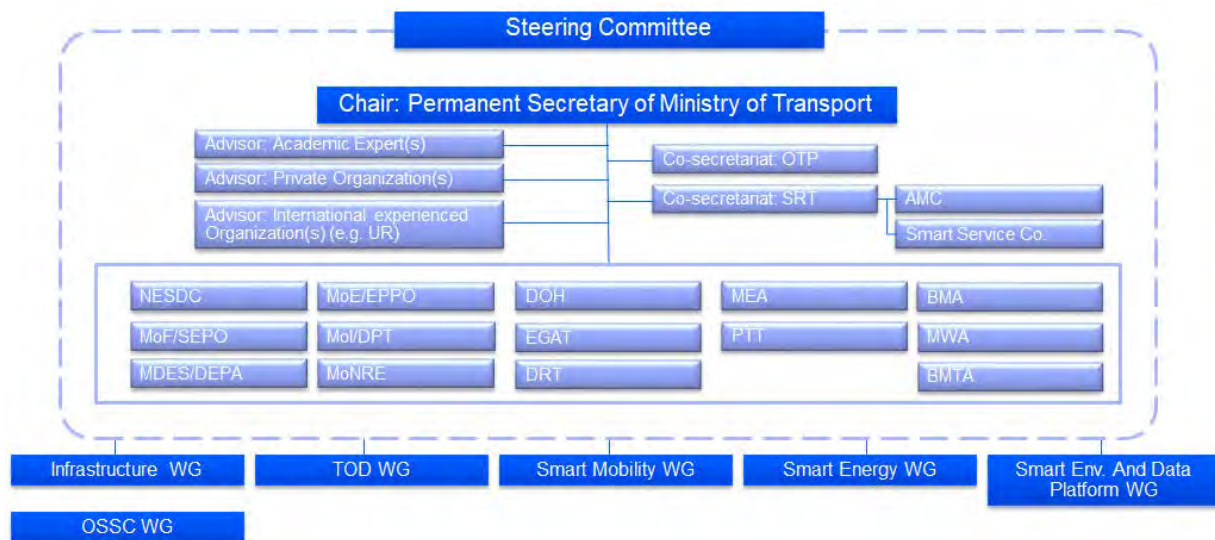
1) Authorization of the overall development concept of Bang Sue Smart City (MOT and SRT)

- MOT and SRT shall authorize the Smart City development concept and its contents, overall development structure including the establishment of Steering Committee and Smart Service Company, basic concept of business model, etc. which are mainly proposed in this study.

2) Establishment of Steering Committee (MOT)

- Steering Committee shall be formed as a promotion entity for the overall Bang Sue Area development. It is proposed to be chaired by the Permanent Secretary of Ministry of Transport. In the establishment of this Committee, MOT/OTP has the initiative in selecting the committee members, producing the committee prospectus, securing agreement with related organizations and arranging schedules.
- If necessary, working groups (WGs) will be set up under the Steering Committee in order to coordinate and consult in detail the infrastructure development or smart service business execution for the smooth development in Bang Sue area. The Steering Committee will consider setting up individual WGs when necessary, and designate the members.

The following figure shows the proposed structure for Steering Committee (as is also shown in the previous section).



Source: JICA Study Team.

Figure 7.4 Proposed structure for Steering Committee

3) Establishment of AMC and SSC preparatory office in SRT (SRT)

- Since it might take time to officially establish AMC and SSC, SRT shall form preparatory office for both AMC and SSC respectively in SRT.
- SRT shall assign capable staff for both preparatory offices.
- The preparatory offices will represent the roles and functions assigned to AMC and SSC respectively.

(2) 2nd stage (~ end of 2020): To elaborate the Bang Sue Smart City development plan

1) Steering Committee (from the 1st quarter of 2020)

- The Steering Committee shall approve key issues while facilitating coordination with several institutions for the Bang Sue Area development. Specific tasks include: the approval of basic policies for integrated development and Smart City development in the Bang Sue Area, supplemented by this Study; approval for City Development Guideline; coordination on zone development details and schedules; and monitoring progress.
- The Steering Committee shall facilitate necessary legal adjustment and deregulation, while securing budgets for the realization of the Smart City under the coordination with related organizations.

2) MOT (OTP): Secretariat of Steering Committee and coordination among related governmental organizations (from the 1st quarter of 2020)

- MOT shall manage the operation of the Steering Committee as the secretariat, and shall coordinate necessary arrangement among related governmental organizations.

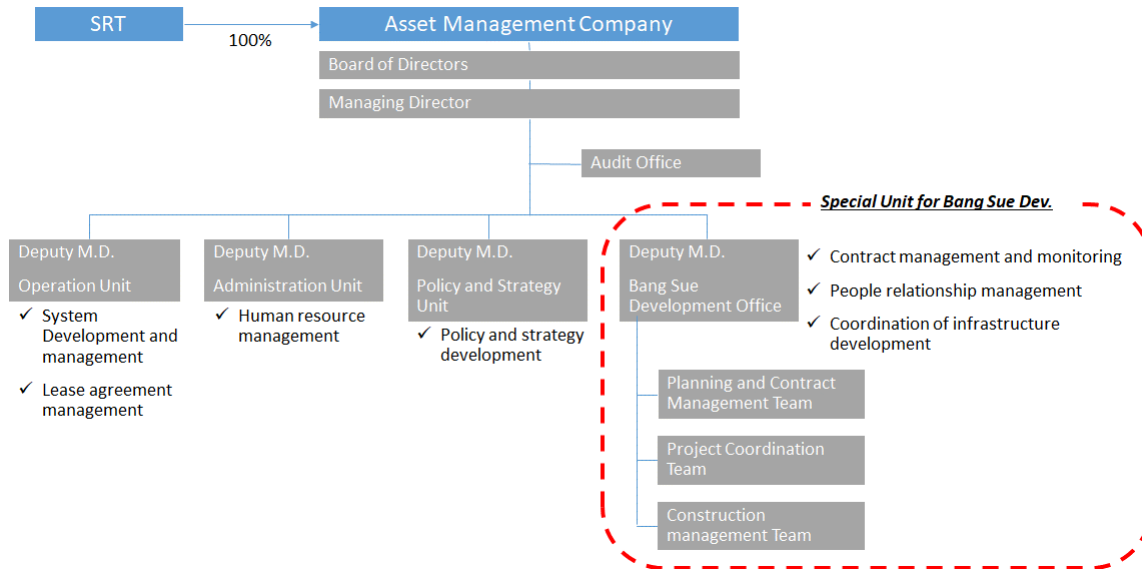
3) AMC (AMC preparatory office): Establishment of AMC

- Officially establish AMC after approval from the cabinet.
- Form a department dedicated to area development in Bang Sue, employ/ deploy dedicated staff (staff with expertise of urban/property development and finance/accounting would be preferable), and execute the following tasks in close cooperation with SRT and SSC (SSC preparatory office).
 - ✓ Manage and monitor land lease agreements or service supply contracts between SRT and zone developers, and between SRT and Smart Service Company.
 - ✓ Communicate with local community, consult with residents that need relocation, coordinate with related organizations, and conduct promotion and advertising

activities.

- ✓ Coordinate and manage development progress with public infrastructure developers; implement asset or contract management; and support the implementation of the plan.

The following figure shows the proposed structure for Steering Committee (as is also shown in the previous section).



Source: JICA Study Team.

Figure 7.5 Proposed Structure for AMC

4) AMC (AMC preparatory office): Formulation of development plans, Bang Sue development guidelines, integrated infrastructure design (by the 4th quarter of 2020)

- AMC shall formulate the Bang Sue Smart City development plan, based on consultations with respective stakeholders and this Study.
- AMC shall also formulate the Bang Sue development guideline which establishes guidelines for: area connectivity through the sky deck network; designs and functions of road, roadside space, public space, and green space; plan for transportation and mobility through pedestrian network and intraregional public transport network; design for landscape; and energy supply systems.
- The Smart City development plan and Bang Sue development guidelines will be reviewed, approved, and shared to relevant organizations by the Steering Committee.
- These materials shall serve as attachment documents in the developer selection process in each zone and would be used as a guideline for zone developers.
- The preconditions that relates to the developer selection in each zone (especially the requirements and conditions for connection of the sky deck in Zone D-1, obligations of using the Smart Energy service in each zone, and rules for landscape formation, etc.) should be examined prior to the other tasks in order to gain its approval from the Steering Committee before the developer selection.
- Integrated infrastructure planning and designing with consideration of the current condition shall also be formulated, consulting with BMA and other public agencies. The infrastructure plan should coordinate and specify infrastructures which would be developed by the public sector, while taking into consideration the Bang Sue development guideline.

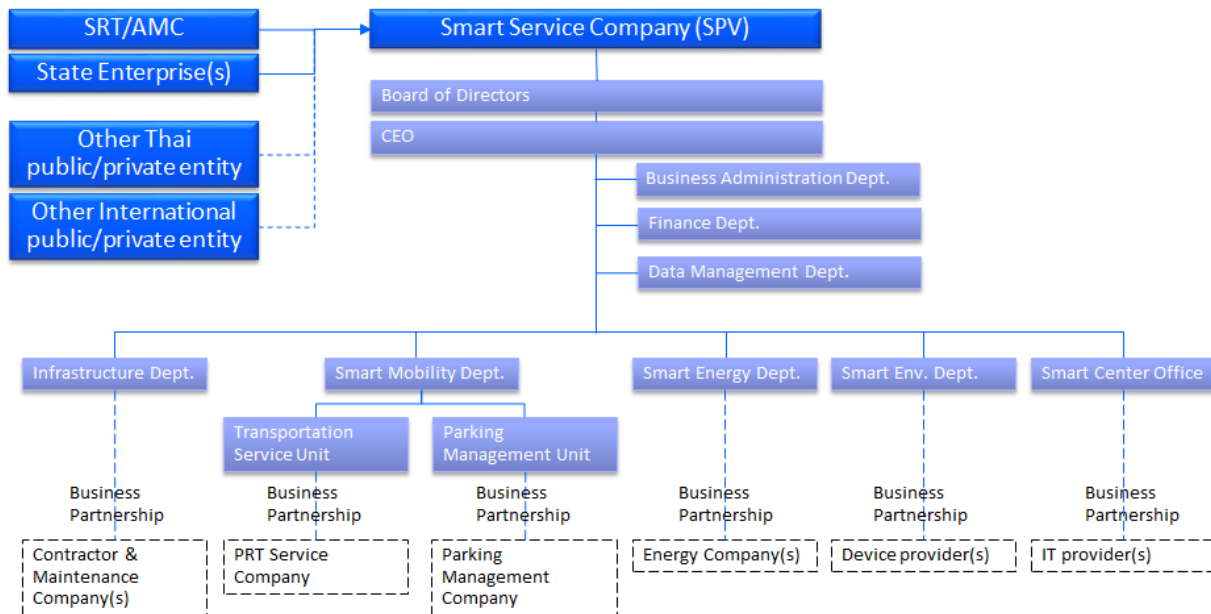
5) AMC (AMC preparatory office): Preparation for zone developer selection and implementation of the process (by the 4th quarter of 2020)

- The developer selection for each zone shall be prepared and implemented based on the Bang Sue Smart City development plans and the Bang Sue development guideline.

6) SSC (SSC preparatory office): prepare for establishment of Smart Service Company (the 4th quarter of 2020)

- SSC preparatory office under SRT shall take the initiative in establishing the implementation entity for the Smart City development in the Bang Sue Area, and study further about organizational arrangement, owned capital size, capital ratio, staffing, etc.
- The Smart Service Company shall closely coordinate with the relevant organizations such as SRT and interested entity to develop a business model for smart service.
- Utilization of private sector's know-hows shall be taken into consideration

The following figure shows the proposed structure for the Smart Service Company (as is also shown in the previous section).



Source: JICA Study Team.

Figure 7.6 Proposed Structure for Smart Service Company

7) SSC (SSC preparatory office): Conducting Feasibility Studies for Smart Service (by the end of 2020)

Feasibility studies shall be conducted at an early stage, especially for the businesses described below which require detailed considerations prior to the development of each zone.

Feasibility Study on Smart Mobility

- Implement basic design work for the sky deck; connectivity with Zones E, D-1 and G (KM11); and establish the business model.
- Coordination with D-1 zone (including coordination with the Ministry of Public Health), considering intersect with the elevated expressways, and connections with existing facilities need to be proceeded with urgency, as the sky deck between Bang Sue Grand Station and Mo Chit Station shall be implemented in the early stage. Financing of investment cost needs to be fully coordinated as well.
- Provide recommendations for necessary legal adjustments and deregulations for business.
- Consider pilot projects for field demonstration towards the launch of Bang Sue Grand Station in 2021.

Feasibility Study on Smart Energy

- Consider basic design on energy-related infrastructure and examine business feasibility in detail, and establish energy supply system with regards to Smart Energy.
- Provide recommendations for necessary legal adjustments and deregulations for business.

Feasibility Study on Smart Environment and Smart City Center (establishment of Data Platform)

- Consider in detail on the establishment of data platform, devise basic plans for Smart City Center, implement basic design and consider specific operation systems.
- Provide recommendations for necessary legal adjustments and deregulations for business.

(3) 3rd stage (2021~): To develop the Bang Sue Smart City

1) Steering Committee

- The Steering Committee shall monitor the progress and facilitate necessary legal adjustment and deregulation, while securing budgets for the realization of the Smart City under the coordination with related organizations.

2) MOT(OTP): Secretariat of Steering Committee and coordination among related governmental organizations

- MOT(OTP) shall manage the operation of the Steering Committee as the secretariat, and shall coordinate necessary arrangement among related governmental organizations.

3) AMC: Implementation of development plans, Bang Sue development guidelines, and integrated infrastructure design

- AMC will implement development plans, Bang Sue development guidelines, and integrated infrastructure design to the Bang Sue Development.

4) AMC: Starting the tender for each zone development

- AMC will prepare the tender documents for each zone development applying Bang Sue development guidelines.
- AMC will manage the tender process and select developers for each zone.

5) SSC: Implementation and Operation of smart services

- Implement and operate various smart service businesses in the Bang Sue Area.

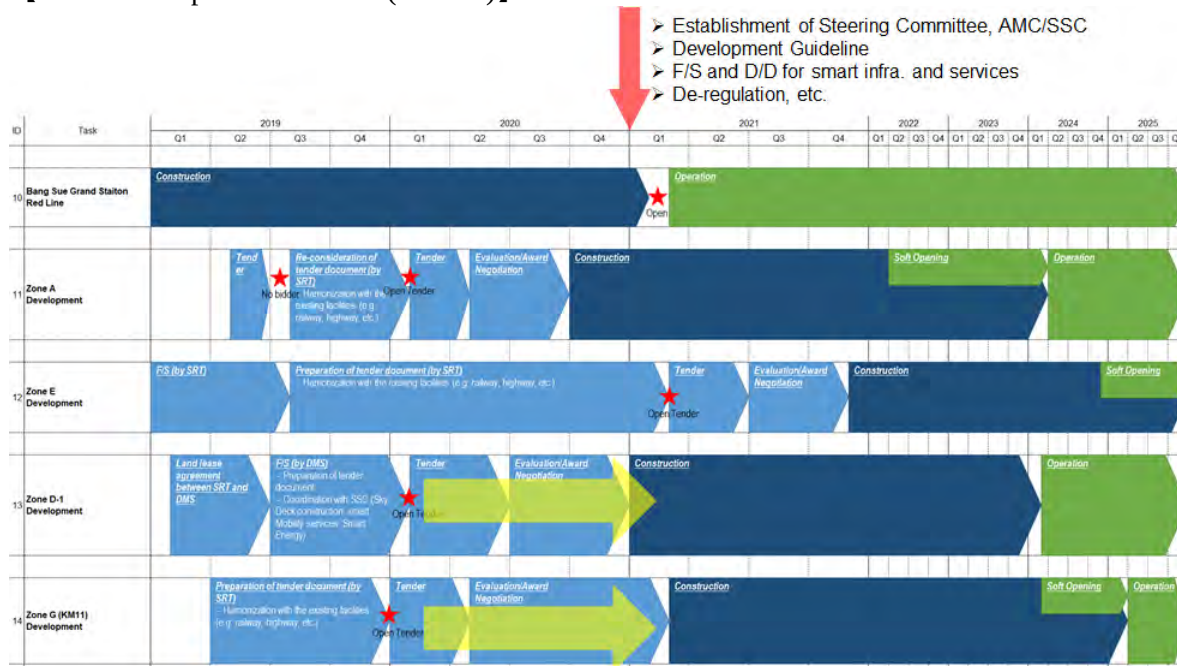
(4) Readjustment of the Zone development schedule

It will be desirable that the zone development schedule will be readjusted since all the necessary preparation work for smart city development will take at least one year as described above.

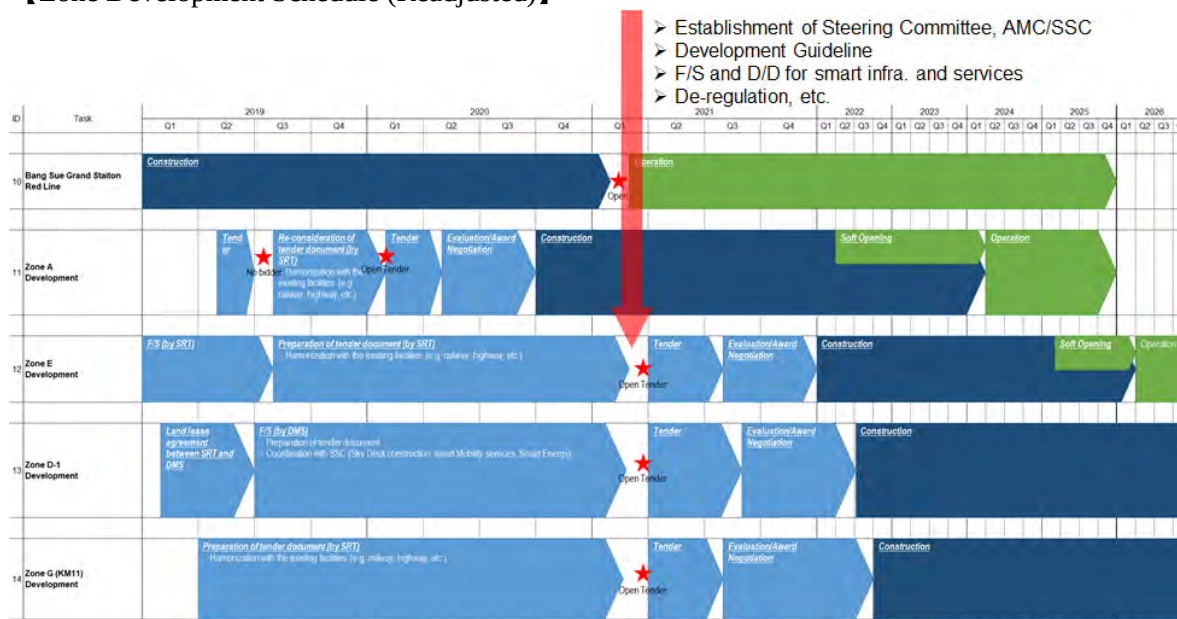
If the tender process to select a zone developer will be started before all the necessary preparation work mentioned above will be ready, necessary input for tender document shall be considered.

The figure below is an idea to re-schedule for zone E, G, and D-1 tender which will start after all the necessary preparation work will be done in 2020.

【Zone Development Schedule (Current)】



【Zone Development Schedule (Readjusted)】



Source: Compiled by JICA Study Team.

Figure 7.7 Readjustment of the Zone development schedule (proposed)

(5) Issues to be considered in consultation between SRT and related organizations by zones

1) Zone A (issues to be considered in consultation between SRT and related organizations)

Coordination with Smart Service Company's smart service

- Specify usage of SSC's Smart Energy service as a condition for the selection of developers.
- Ensure opportunity for sky deck development plan that allows introduction of Smart Mobility services.

Coordination with the existing facilities

- Ensure that the plan for Zone A development would adequately address issues regarding existing facilities around the development area, such as: the existing railway in the west side of Bang Sue Grand Station; the existing elevated railroad tracks and expressway; and the underground oil feed tubes. The plan needs to be closely coordinated with the relevant entities.
- Ensure that the tender document takes into account the connectivity to the Station and the landscape design, as Zone A is adjacent to Bang Sue Grand Station. It is important to ensure that Zone A facility would be equipped with appropriate feature to be the symbol of Bang Sue Area, as the zone would be the first zone to be developed and one of the nearest from the Grand Station.

Land lease period

- Although the land lease period was set at 30 years in the bidding process that finished at the end of July 2019, the period needs to be adjusted to 50-years or longer in order to attract investment for private operators.

2) Zone D-1 (issues to be considered in consultation between SRT and Ministry of Public Health)

Coordination with Smart Service Company's smart service

- Specify usage of SSC's Smart Energy service as a condition for the selection of developers.

Coordination with regards to sky deck development

- Ensure opportunity for sky deck development plan that allows introduction of Smart Mobility services. The detail of the alignments and the design of the sky deck needs to be studied urgently, as the sky deck connecting Bang Sue Grand Station and Mo Chit Station, which is proposed to be developed in the early stage, could pass through Zone D-1.
- Validate the plan approval flow for the sky deck construction to promote commercialization at an early stage.

Coordination with regards to main road construction

- Coordinate the road development plan with the Ministry of Public Health, upon sharing the plan set forth in the previous JICA Study. Consultation would be also needed to decide whether the road development would be implemented under a PPP structure with the Ministry of Health or under the SRT.
- Decide the entity responsible for managing the newly constructed road.
- Prepare the TOR for developer selection, which addresses conditions for road development such as the standard design.

3) Zone E

Coordination with Smart Service Company's smart service

- Specify usage of SSC's Smart Energy service as a condition for the selection of developers.
- Ensure opportunity for sky deck development plan that allows introduction of Smart Mobility services.
- Consider and coordinate the location for the Smart City Center.

Coordination with the existing facilities

- Consider measures to mitigate traffic congestion in the surrounding roads.
- Ensure that the tender document takes into account the connectivity to the Station and the landscape design, as Zone E is adjacent to Bang Sue Grand Station.

Land lease period

- Need to set the land lease period at 50-years or longer in order to motivate investment for private operators.

4) Zone G (KM11)

Coordination with Smart Service Company's smart service

- Specify usage of SSC's Smart Energy service as a condition for the selection of developers.
- Ensure opportunity for sky deck development plan that allows introduction of Smart Mobility services.

Land lease period

- Need to set the land lease period at 50-years or longer in order to motivate investment for private operators.

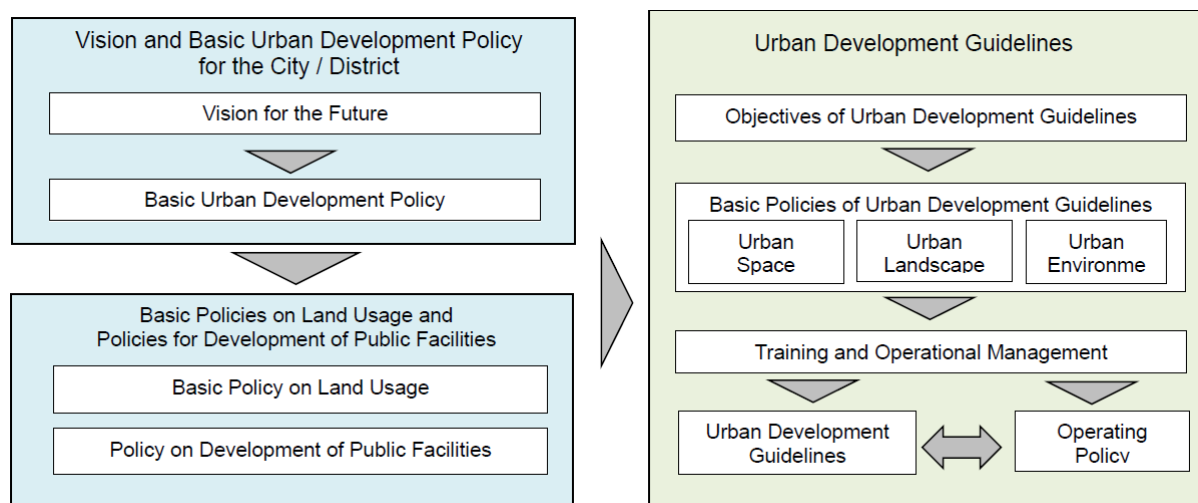
(Reference) What is a City Development Guideline?

(What is a City Development Guideline?)

A City Development Guideline is a guiding principle stipulated for implementing urban development in a certain area. This guideline would be formed based on the future visions, basic policies for the land use and public facilities, while also reflecting the intent of the relevant entities such as developers and local governments.

The guideline outlines the concepts and the general directions on urban planning aspects such as: urban space, landscape and environment. In addition, the guideline would also outline approaches for fostering and managing the city development.

The following figure shows the conceptual image of City Development Guideline.



Source: Previous JICA Study

Figure 7.8 Concept on City Development Guideline

(Benefits of the introduction of City Development Guideline)

City Development Guideline stipulate basic policies or guiding principles to be complied by developers and business operators that are responsible for land use or facility development in the area. Introduction of such guidelines would contribute to sharing the vision which the project is aiming to realize, while facilitating coordination among various related entities for a long period through the duration of the project.

This would contribute to realizing an integrated urban development in which the entire landscape, urban space, landscape, and environment is formed in a harmonized fashion.

These efforts are also expected to make the entire project attractive with increased property values and attraction of investors.

(Essential components for City Development Guideline)

Proposed contents for City Development Guideline and essential components for Bang Sue Area

■ Introduction

1. City Development Guideline

(1) Strategic positioning of the City Development Guideline

(2) Objective of the City Development Guideline

▶ Description of the goals through formulation and implementation of the guideline.

(3) Target area

▶ Description of the expected areas for the guideline.

2. Urban development in the Bang Sue Area

(1) Spatial and social positioning of Bang Sue

▶ Description of the positioning of the Bang Sue Area in upper-level plans, development visions, and other related plans.

▶ Description of the potential with regards to neighboring environments and strategic locational attributes.

(2) Future vision

▶ Description of the future vision for the Bang Sue Area, based on the above mentioned attributes.

(3) Basic policies for urban development

▶ Description of urban development policies and approaches towards future vision.

(4) Basic policies for land use

• Land use plan

▶ Description of the proposed land use with regards to basic policies.

(5) Development policies for public facilities

• Development plan for public facilities

• Plan for upgraded facilities

▶ Description of basic approaches on the development of public facilities (road, park, open space, supply treatment facility, etc.) in the Bang Sue Area.

▶ Description of basic approaches on upgrading of facilities to enhance development impact.

3. Basic policies on City Development Guideline

(1) Basic policies for urban space formation

• Transport network (public transport, vehicle, people, bus terminal, transit mall, parking lot, etc.)

• Green network (green corridor, wind passage plan, park and green space, etc.)

▶ Description on basic development policies and keynotes on intraregional transport network and green network for comfortable urban space formation in the Bang Sue area.

(2) Basic policies for urban landscape design

• Landscape design (open space, height, design, color, greenery, etc.)

▶ Description on basic policies and keynotes on urban infrastructures and landscape design in order to create attractive urban landscape in Bang Sue Area.

(3) Basic policies for urban environment

• Environmental friendliness (energy efficiency, energy-saving, water permeability, underground

storage, etc.)

- Disaster prevention approach

► Description on basic policies and keynotes on environmental friendliness such as energy efficiency or energy-saving and disaster prevention efforts in the Bang Sue Area.

4. Approaches for fostering and managing the city

(1) System and structures for sustainable development

► Description on basic policies and structures for city management in order to achieve sustained development of the city and creation of lively atmosphere in the Area.

(2) Approaches for establishment of system and structure

► Description on institutional system for city management, for example, management and operation scheme for public facilities like road

5. Guiding principles for city development

(1) Planning guiding principles for urban infrastructure and facilities

(2) Guiding principles for buildings, etc.

(3) Guiding principles for low-carbon city development

(4) Guiding principles for safe and secure city development

► Description on the specific plans and designs with regards to the basic policies specified in (3).

► Description on the specific rules and standards for construction with regards to the basic policies specified in (3).

6. Operation of City Development Guideline

(1) Operation system and structure

(2) Operation method

► Description on the institutional system (including permission and approval procedure) that ensure appropriate application of the guideline, in order to achieve the future vision.

Source: Compiled based on previous JICA Study Team

The Guideline shall be compiled based on this Study, the previous studies, as well as the development plans considered for each zone. Accordingly, consultations and coordination with respective stakeholders would be needed, which requires a certain time and effort.

It would be preferable if an agreement on introducing the City Development Guideline is made at Steering Committee first. Subsequently, the guideline shall be elaborated under the initiative of the Steering Committee.

7.4 Conclusion: Towards Smart City Development in Bang Sue

In this study, Smart City development concept are proposed with a focus on mobility and energy. The proposals are contemplated citing urban development and smart city development experiences in Thailand and other countries. The proposed concept aims to contribute to achieving integrated development and sustainable Smart City development, based on the current situation for the Bang Sue Area and Smart City development initiatives in Thailand. To this end, the project implementation structure, business scheme, and action plan are devised, building on the actual situation regarding the zone development in Bang Sue Area. The study and the proposals shall serve as a platform that catalyze Smart City development and innovative urban development in the Bang Sue Area.

Building upon this study, it is expected that the concept for Smart City development in Bang Sue Area would be shared among all related organizations in Thailand, and subsequently taken forward under the initiative of the implementation agencies such as OTP and SRT. As the development project would be a long term project extending over 10 years, it is also expected that the proposals set forth in this study would be implemented at an early stage, while at the same time, flexibly accommodating the rapidly evolving technology. Commitment from the Thailand Government and associated organizations would be a key factor in developing the Bang Sue Area as a cutting-edge Smart City which would not only be a model for Thailand, but also for the ASEAN region.