ERIA Research Project Report 2018, No. 25

Study on the Formation of the ASEAN Power Grid Generation and Transmission System Planning Institution

A deliverable in the project Study on the Formation of the ASEAN Power Grid Generation and Transmission System Planning (AGTP) Institution

Tokyo Electric Power Company Holdings, Inc.

Study on the Formation of the ASEAN Power Grid Generation and Transmission System Planning Institution

Published by
Economic Research Institute for ASEAN and East Asia (ERIA)
Sentral Senayan 2, 6th floor,
Jalan Asia Afrika no.8,
Central Jakarta 10270
Indonesia

ERIA Research Project FY2018 No.25
Finished in April 2019, approved to be publish June 2022

Contents

List of Project Members

Mr Noboru Seki: System Planning Expert, Power System Planning Office, TEPCO Power Grid, Inc.

Mr Masafumi Shinozaki: System Operation and Planning Expert, Power System Operation Department, TEPCO Power Grid, Inc.

Mr Yu Furudate: System Operation Expert, Power System Operation Department, TEPCO Power Grid, Inc.

Mr Hirokazu Miyazaki: System Planning Expert, Power System Planning Office, TEPCO Power Grid, Inc.

Mr Hokuto Tsunoyama: System Planning Expert, Power System Planning Office, TEPCO Power Grid, Inc.

Mr Fumiya Inoue: System Planning Expert, Power System Planning Office, TEPCO Power Grid, Inc.

Mr Wilhelm Söderström (Technical adviser): Nord Pool Consulting AS.

Mr Hans-Randen (Project owner): Chairman of Nord Pool Consulting and head of Business Development at Nord Pool AS.

Mr Hans-Arild Bredesen (Project manager): CEO Nord Pool Consulting AS.

Mr Matias Pelotniemi (Technical advisor): Nord Pool Consulting AS.

Mr Jonathan Hedgecock (Technical advisor): Ricardo Energy & Environment.

Dr Graeme Chown (Technical advisor): Ricardo Energy & Environment.

Dr Yanfei Li (Organizer): Energy Economist, Energy Unit, Research Department, Economic Research Institute for ASEAN and East Asia

Mr Junichi Wada (Organizer): Senior Policy Adviser, Energy Unit, Research Department, Economic Research Institute for ASEAN and East Asia

List of Abbreviations

AGTP	ASEAN Power Grid Generation and Transmission System Planning Institution
AIMS	ASEAN Interconnection Masterplan Study
AMEM	ASEAN Ministers on Energy Meeting
AMS	ASEAN member state
AMEM	ASEAN Ministers on Energy Meeting
APG	ASEAN Power Grid
APGCC	ASEAN Power Grid Consultative Committee
APP	ASEAN Power Pool
ATSO	ASEAN Power Grid Transmission System Operators Institution
CBA	cost–benefit analysis
COP	Convention on Climate Change
EGEAS	the Electric Generation Expansion Analysis System
ENTSO-E	European Network of Transmission System Operators for Electricity
EPRI	Electric Power Research Institute, Inc.
EU	European Union
GDP	Gross Domestic Product
HAPUA	Heads of ASEAN Power Utilities/Authorities
IT	information technology
IPP	Independent Power Producer
LOLE	Loss of Load Expectation
MISO	Midcontinent Independent System Operator
MOU	Memorandum Of Understanding
PDP	power development plan
PSS/E	power system simulator for engineering
OCCTO	Organization for Cross-regional Coordination of Transmission Operators
SAIDI	system average interruption duration index
SAIFI	system average interruption frequency index
SAPP	Southern African Power Pool
SCADA	supervisory control and data acquisition
SPP	Small Power Producers
TDP	transmission development plan
TPA	Third Party Access
TSO	transmission system operator
TYNDP	ten-year network development plan

vRE	variable renewable energy
WASP	Wien Automatic System Planning

Executive Summary

Literature Report is one of the main deliverables for the project, “Study on the Formation of the ASEAN Power Grid Generation and Transmission System Planning Institution (AGTP)” by TEPCO and provides case examples about this field in Japan, Europe and Southern African region to refer and learn.

Another coupled project “Study on the Formation of the ASEAN Power Grid Transmission System Operator Institution (ATSO)” is performed by Nord Pool Consulting and two deliverables are coordinated and harmonized supported by ERIA, the implementation agency for both projects.

The other two main deliverables are the AGTP guideline and the AGTP implementation plan. The former contains the principles, framework, and other technical arrangements for the establishment of APP and the latter deals with the roadmap of actions for the establishment of the APP.

In this document, last two chapter is the summary of above two deliverables:

- Summary of the AGTP guideline
- Summary of the AGTP implementation plan

This document includes various key examples especially about system planning and its organization as follows:

- How they define their mission and vision.
- Functions and basic procedures of system planning part
- Current grids with many interconnections and how to develop their interconnections.
- Proposed regulations for APP based on Japanese case example

According to technical analysis and global trend, followings are main points about the development of interconnections:

- In general, security, economy and grid stability are key reasons to connect the grids with neighbouring countries.
- It’s very important to respect such as current electrical mechanism, development stage, philosophy of each countries.
- As seen in many regions, it’s possible to connect the grids under agreed regulation and leave different systems, schemes and methodology.
- It’s necessary to discuss agreed documents including establishment of APP and share their clear goals of short-term, mid-term and long-term.

Three deliverables surely contribute for AMS policy makers, experts and all stakeholders to understand international case examples, how to proceed these complex and tough steps and start to discuss to build connected grids, effective markets and harmonized corporation of AMS.

Chapter 1

Introduction

1. High-level contents of this report

The AGTP report is one of the main deliverables for the project “Study on the Formation of the ASEAN Power Grid Generation and Transmission System Planning Institution (AGTP)”. It provides the related information and background for the AGTP guideline and implementation plan.

The literature report has 6 chapters and each chapter describes as follows.

- Chapter 2 Benefit of the APG

  This chapter provides the vision and mission for each institution, like APP, from international experiences of Japan, Europe, and Southern Africa.

- Chapter 3 Case examples about planning process and current situation of Japan, Europe, and SAPP

  This chapter describes case examples about functions of system planning and development of current interconnections.

- Chapter 4 Proposed regulations for APP based on Japanese case example

  This chapter explains the necessary regulations and manuals for APP to keep its quality and consistency of functions.

- Chapter 5 Summary of the AGTP guideline

  This chapter explains the high-level contents of the AGTP guideline.

- Chapter 6 Summary of the AGTP implementation plan

  This chapter explains the high-level contents of the AGTP implementation plan.

2. Remarkable Development of ASEAN Power Grid

ASEAN is one of the most dynamic and fastest growing economic regions in the world. It recognizes the critical role of an efficient, reliable, and resilient electricity infrastructure in stimulating regional economic growth and development. To meet the growing electricity demand, huge investments in power generation capacity and power system expansion are required.

In addition, the ASEAN region has an abundance and diversity of not only fossil energy resources such as natural gas, coal, and oil but also renewable energy potential such as hydropower, solar power, wind power, and biomass. Members of ASEAN Power Utilities/Authorities (HAPUA) recognized such circumstance, so, they established a plan of ASEAN Power Grid (APG) in 1997 as a flagship program under ASEAN Vision 2020 to enhance

cross-border electricity trade. This will provide benefits to meet the rising electricity demand and improve access to energy services in the ASEAN region. HAPUA have vitally promoted the ASEAN Interconnection Masterplan Study (AIMS) to formulate the strategy to accelerate the realization of APG.

The study consists of two phases – AIMS I and AIMS II – successfully completed in 2003 and 2010. The strategy, established based on these studies, is to firstly encourage participation on a cross-border bilateral basis, then gradually expand to a sub-regional basis (northern subsystem, southern subsystem, and eastern subsystem), and finally move to a totally integrated APG system. The APG undertaking had planned 16 power interconnection projects. By end of 2014, six of the 16 projects were implemented with a total of 3,489 megawatts (MW) in power exchanges and purchases achieved. It is expected that power exchanges and purchases will triple the capacity during the period between 2014 and 2020, and further increase to 16,000MW post 2020.

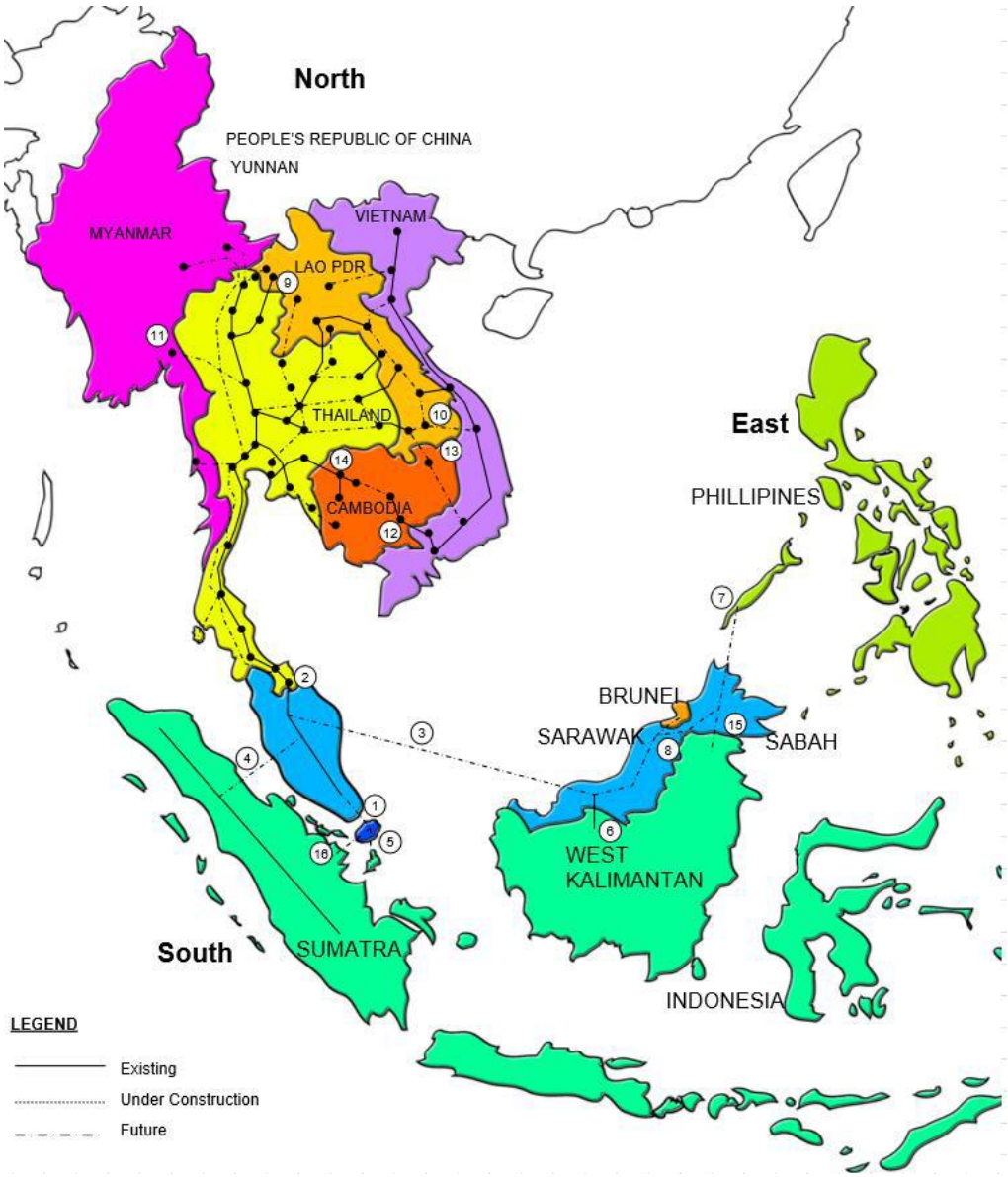
Since then, however, the energy landscape in the region has changed. ASEAN member states (AMSs) have been facing challenges in fulfilling the energy demand since demand has been growing significantly and will continue to grow at a rate of 5% to 6% per year in the coming decades. In addition, AIMS II was not able to explore the utilization of the renewable energy source as ASEAN indigenous resource at maximum level, as a response to the direction from the ASEAN Plan of Action for Energy Cooperation 2016–2025 that the 33rd ASEAN Ministers on Energy Meeting endorsed in September 2015 in Kuala Lumpur, Malaysia.

Since the conclusion of the agreement at the 21st Conference of the Parties to the UN Framework Convention on Climate Change held in 2015, governments around the world have been promoting policies on the use of renewable energy. In some countries where the potential of solar and wind power energy is high, it is becoming prominent that too much amount of installation plan precedes the expected electricity demand.

As recognized by many, to stably integrate a variable renewable energy power source such as solar power generation and wind power generation into a power system, it is necessary to absorb the fluctuation and maintain the balance between supply and demand. This requires the synchronous generators to respond more sensitively to the system frequency fluctuation and be prepared to cover the cost. If the APG is properly developed, reserves for supply–demand adjustment and frequency regulation provided from synchronous generators can be widely shared or exchanged throughout the ASEAN region. Thereby, it is possible to maximize economic benefits through effective utilization of renewable energy sources and reduce comprehensive generation cost. In addition, the whole AMSs can enjoy the benefits such as prevention of environmental pollution and global warming.

AIMS III will be planned to be implemented in April, 2018. The crucial point in its development is to propose optimal allocation of power sources including variable renewable energy and the reasonable reinforcement plan of interconnection lines. The aim is to reduce the cost of electricity supply while enhancing the economic integration of the whole ASEAN region through the completion of APG, taking into account the rapidly growing power demand and the ambitious promotion of deploying renewable energy sources.

Figure 0: Interconnection Projects of ASEAN Power Grid



Source: Heads of ASEAN Power Utilities/Authorities (HAPUA), 2017.

1) P.Malaysia – Singapore	
Plentong – Woodlands	Existing
P.Malaysia – Singapore (2nd link Plentong – Woodlands)	post 2020
2) Thailand – P.Malaysia	
Sadao – Chuping	Existing
Khlong Ngae – Gurun	Existing
Su Ngai Golok – Rantau Panjang	TBC

Khlong Ngae – Gurun (2ndPhase, 300MW)	TBC
3) Sarawak – P. Malaysia	TBC
4) P.Malaysia – Sumatra	TBC
5) Batam – Singapore	TBC
6) Sarawak – West Kalimantan	Existing
7) Philippines – Sabah	TBC
8) Sarawak – Sabah – Brunei	2021
Sarawak – Sabah	2021
Sarawak – Brunei	TBC
9) Thailand – Lao PDR	
Nakhon Phanom – Thakhek – TheunHinboun	Existing
UbonRatchathani2 – HouayHo	Existing
RoiEt 2 – Suvannakhet – Nam Theun2	Existing
Udon Thani 3 – Na Bong – Nam Ngum 2	Existing
NakhonPhanom2 – Thakhek – Then Hinboun (Exp.)	Existing
Mae Moh3 – Nan2 – Hong Sa (3Units)	Existing
UdonThani3 – Nabong – Nam Ngiep (converted to 500KV)	2019
UbonRatchathani3 – Pakse – XePianXeNamnoi	2019
KhonKaen4 – Loei2 – Xayaburi	2019
Nakhon Phanom –Thakhek (Suggested by AIMs–II)	TBC
Thailand – Lao PDR (New)	TBC
10) Lao PDR –Vietnam	2016 – 2020
Xekaman3 – Tranhmy	Existing
Xekaman1 – Pleiku2	Existing
11) Thailand – Myanmar	TBC
12) Vietnam – Cambodia (New)	
Chau Doc – Takeo – Phnom Penh	Existing
Tay Ninh – Stung Treng	TBC
13) Lao PDR – Cambodia	
Ban Hat – Kampong Sralao	Existing
Ban Hat – Stung Trengpost	Post 2018

14) Thailand – Cambodia (New)	Post 2020
WatthanaNakhon – Aranyaprathet – BanteayMeanchey	Existing
Thailand – Cambodiapost	Post 2020
15) East Sabah – East Kalimantan	TBC
16) Singapore – Sumatra	TBC

Chapter 2

Benefit of ASEAN Power Grid

1. Mission of each institution

Below is the mission of each institution according to each website. And considering their mission and current situation of ASEAN, one draft for the mission of APP is suggested. This should be discussed deeply from now on.

Some common points are found in the current mission of OCCTO, ENTSO-E and SAPP. Then Security and Economy are key factors. And Sustainability is also one of them. Then according to the current situation of ASEAN, Electrification could be one important factor to be achieved. These 4 points are chosen for the draft missions.

Figure 1: Overview of the Missions of OCCTO, ENTO-E and SAPP[1]

	Mission
OCCTO	●**Security** ・Securing Stable Electricity Supply ●**Economy** ・Suppressing Electricity Rates to the Maximum Extent Possible ・Expanding Choices for Consumers and Business Opportunities
ENTSO-E	●**Security** ・Pursuing coordinated, reliable and secure operations of the interconnected electricity transmission network ・Promoting the adequate development of the interconnected European grid and investments for a reliable,efficient and sustainable power system. ●**Economy** ・Providing a platform for the market by proposing and implementing standardised market integration and transparency frameworks ●**Sustainability** ・Facilitating secure integration of new generation sources, particularly renewable energy
SAPP	●**Economy and Sustainability** ・Aim to provide the least cost, environmentally friendly and affordable energy ・Facilitate the development of a competitive electricity market ・Give the end user a choice of electricity supplier ・Ensure sustainable energy developments through sound economic, environmental and social practices ●**Security and Electrification** ・Provide a forum for the development of a world class, robust, safe, efficient, reliable and stable interconnected electrical system ・Increase accessibility to rural communities

Source: website of OCCTO, ENTSO-E and SAPP as follows:

[1] https://www.occto.or.jp/en/about_occto/about_occto.html
https://www.entsoe.eu/about/
http://www.sapp.co.zw/

	Security	Economy	Sustainability	Electrification
OCCTO	◯	◯		
ENTSO-E	◯	◯	◯	
SAPP	◯	◯	◯	◯

	Security	Economy	Sustainability	Electrification
APP	◯	◯	◯	◯

ATSO = ASEAN Power Grid Transmission System Operators Institution.
ENTSO-E = European Network of Transmission System Operators for Electricity.
OCCTO = Organization for Cross-regional Coordination of Transmission Operators.
SAPP = Southern African Power Pool.

Draft Mission of APP

- Securing stable electricity supply
- Facilitating economical and sustainable energy development
- Increase accessibility to rural communities

And in the future

- Providing a platform for the market by proposing and implementing standardized market integration and transparency frameworks

Source: Overview compiled by Nord Pool Consulting.

2. Japan

For keeping 'Life with Electricity' in Japan by securing stable electricity supply even in an emergency, the Organization for Cross-regional Coordination of Transmission Operators (OCCTO) plays as a control tower. It has three goals: (i) securing stable electricity supply; (ii) suppressing electricity rates to the maximum extent possible; and (iii) expanding choices for consumers and business opportunities.

OCCTO plays a major role in the promotion of cross-regional management of electrical businesses by[2]:

[2] https://www.occto.or.jp/en/about_occto/about_occto.html

(1) Strengthening supply–demand control function in both normal and emergency situations on a nationwide basis

i) Instructing for improvement of supply instability situation to members

ii) Monitoring conditions of supply–demand and system operation 24 hours a day, 365 days a year

iii) Grasping situation of nationwide supply–demand balance by plan management

(2) Securing mid-term and long-term stable electricity supply

i) Securing stable electricity supply by plan aggregation and generator bidding

ii) Formulating long-term development plan of cross-regional network and cross-regional network development plan and taking a lead in reinforcing necessary facilities

(3) Developing fair utilization environment for power system

i) Formulating rules to be observed by system operators and users

ii) Accepting system impact studies for power generation facilities

iii) Managing use of interconnection lines

iv) Settling troubles amongst electric power companies

(4) Operating a system to support procedures related to switching

3. ENTSO-E[3]

a. Mission

The European Network of Transmission System Operators for Electricity (ENTSO-E) is the legally mandated body of electricity transmission system operators (TSOs) at the European level. Its mission is to fulfil its various legal mandates for the benefit of electricity customers, and to leverage its mandated work products to shape future energy policy for the benefit of society in the face of significant challenges in the following areas:

(1) Security – pursuing coordinated, reliable, and secure operations of the interconnected electricity transmission network, while anticipating the decision to cope with upcoming system evolutions.

(2) Market – providing a platform for the market by proposing and implementing standardized market integration and transparency frameworks that facilitate competitive and integrated continental wholesale and retail markets.

(3) Sustainability – facilitating secure integration of new generation sources, particularly renewable energy, as well as significantly contributing to the European Union's (EU) greenhouse gases reduction and renewable energy supply goals. These challenges also imply addressing network adequacy – promoting the adequate development of the interconnected European grid and investments for a reliable, efficient, and sustainable power system.

[3] https://www.entsoe.eu/about-entso-e/inside-entso-e/mission-and-vision/Pages/default.aspx

b. Vision

ENTSO-E is the association of European electricity transmission system operators (TSOs) with key legal mandates from the EU institutions. It aspires to become the professional body to which European and national policy makers, regulators, and market participants turn for competent guidance. It prepares proactive proposals and objective assessments for technical, market, and policy issues related to the European electricity systems. ENTSO-E will take the TSO perspective at the European level and will create value for society.

4. SAPP[4]

a. Mission

Southern African Power Pool (SAPP) aims to provide the least cost, environmentally friendly, and affordable energy and increase accessibility to rural communities.

b. Our Strategy

SAPP's strategy is to be the most preferred region for investment for value for money by energy intensive users.

c. Vision

The following are SAPP's vision:

(1) Facilitate the development of a competitive electricity market in the Southern African region

(2) Give the end user a choice of electricity supplier

(3) Ensure that the Southern African region is the region of choice for investment by energy intensive users

(4) Ensure sustainable energy developments through sound economic, environmental, and social practices

The following are SAPP's objectives:

(1) Provide a forum for the development of a world class, robust, safe, efficient, reliable, and stable interconnected electrical system in the Southern African region

(2) Coordinate and enforce common regional standards of quality of supply, measurement, and monitoring of systems performance

(3) Harmonize relationships between member utilities

(4) Facilitate the development of regional expertise through training programmers and research

(5) Increase power accessibility in rural communities

(6) Implement strategies in support of sustainable development priorities

[4] http://www.sapp.co.zw/

Chapter 3

Case example of Japan, Europe, and SAPP

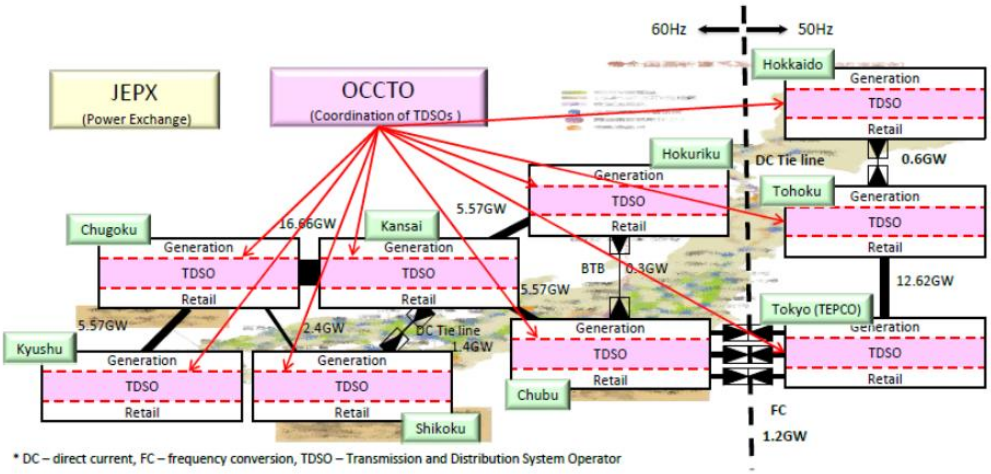
1. Function of system planning for the interconnections

1.1. Japan

Establishment of Nationwide Organization to Coordinate System Planning and System Operation of Interconnections.

Following the transition of organization for nationwide coordination of system planning and system operation, the Organization for Cross-regional Coordination of Transmission Operators (OCCTO) was established in April 205 as an organization with a strong authority to administrate the following tasks: (i) construction or reinforcement of interconnections; (ii) operation of interconnections; and (iii) operation of cross-regional power trading[5].

Figure 2. Conceptual Diagram of OCCTO



JEPX = Japan Electrical Power Exchange.
OCCTO = Organization for Cross-regional Coordination of Transmission Operators.
TEPCO = Tokyo Electric Power Company.
Source: Yamazaki, 2015.

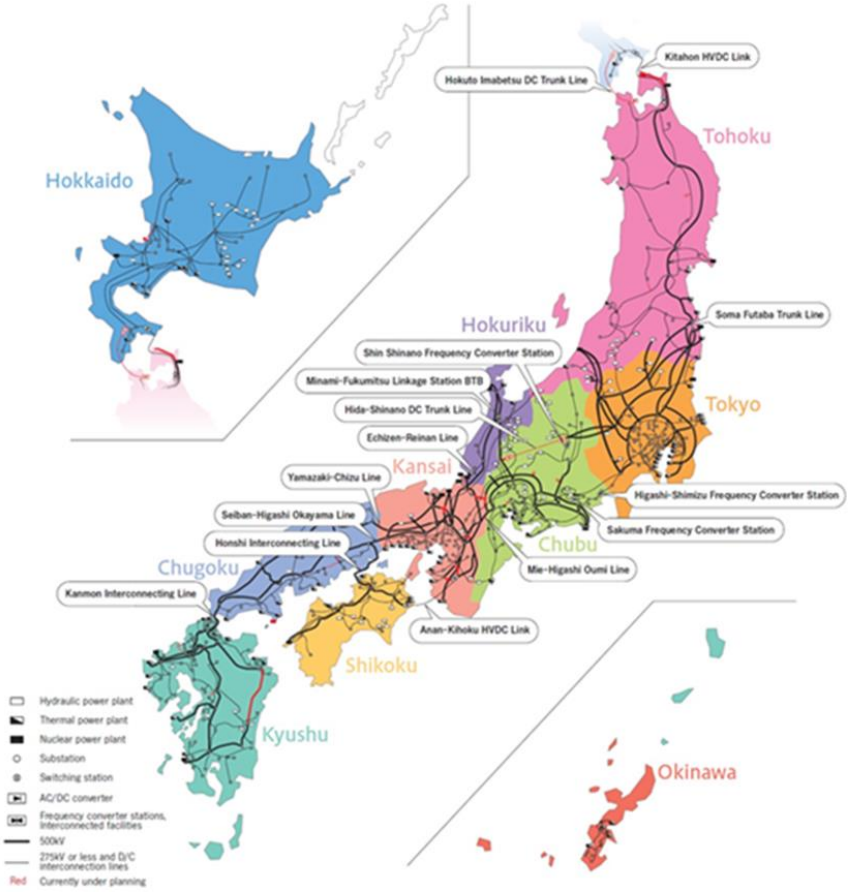
[5] https://www.occto.or.jp/en/about_occto/about_occto.html

Below is a summary of the major roles of OCCTO:

(1) Securing mid-term and long-term stable electricity supply
    (i) Securing stable electricity supply by plan aggregation and generator bidding
    (ii) Formulating long-term development plan of cross-regional network and cross-regional network development plan and taking a lead in reinforcing necessary facilities
(2) Strengthening supply–demand control function in both normal and emergency situations on a nationwide basis
    (i) Instructing for improvement of supply instability situation to members
    (ii) Monitoring conditions of supply–demand and system operation 24 hours a day, 365 days a year
    (iii) Grasping situation of nationwide supply–demand balance by plan management
(3) Developing fair utilization environment for power system
    (i) Formulating rules to be observed by system operators and users
    (ii) Accepting system impact studies for power generation facilities
    (iii) Managing use of interconnection lines
    (iv) Settling troubles between electric power companies
(4) Operating a system to support procedures related to switching

One of the most important functions of OCCTO relates to system planning of interconnections. OCCTO aggregates, reviews, and evaluates supply and demand balance based on the data from all related stakeholders such as TSOs, generating companies, and retail companies. After evaluating these data, it conducts a study on the planning of grid system interconnections with the support from TSOs and develops a plan of interconnections as shown in Figure 4.

Figure 3. Cross-regional Interconnections Enhancement Plan



Source: Organization for Cross-regional Coordination of Transmission Operators (OCCTO), n.d.

Plan of electricity system reform and market design

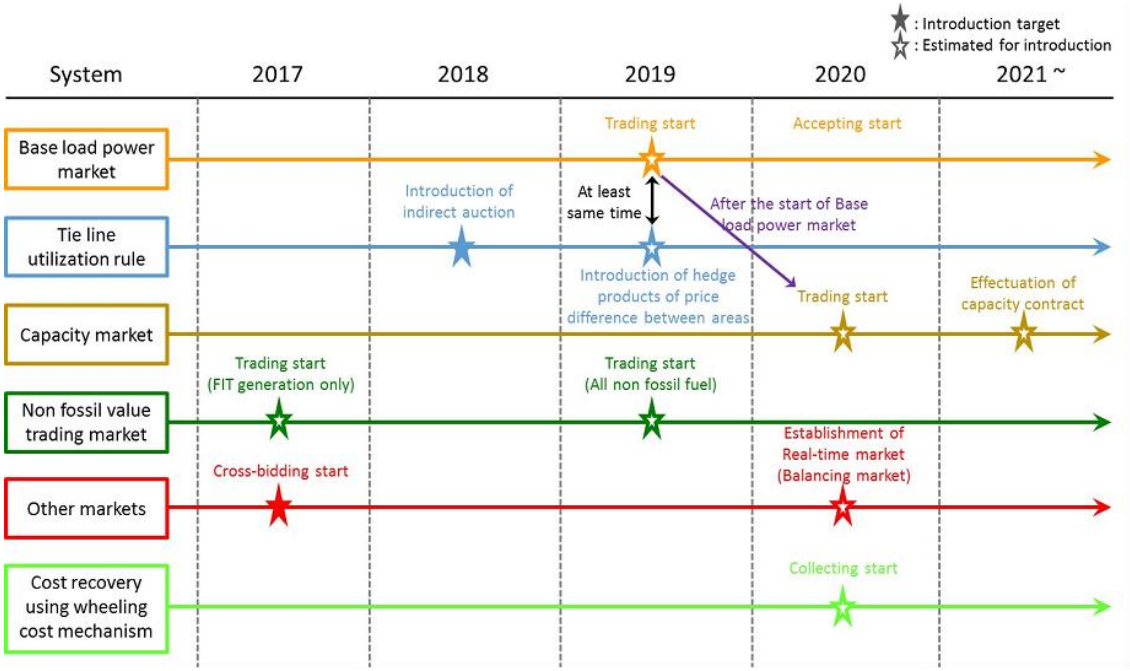
In Japan, electricity retail for small low-voltage (under 50 kilowatts) customers was liberalized in 2016 to complete the full liberalization of electricity retail market. Ten power utilities that were regional monopoly before are obliged to publish the standard tariff table for these small customers as the transition from regulated to tariff to market price, but this is expected to be removed after 2020.

Another milestone expected to occur in a series of power sector reforms is the unbundling of transmission and distribution of 10 utilities from other divisions (generation and electricity retail), which will be in force by 2020 to enhance the neutrality and transparency of the transmission and distribution sector and activation of cross-regional power trade.

In accordance with the electricity system reform cited above, reform of electricity market is also underway. To achieve the power sector reforms, it is important to maximize the use of market mechanisms while achieving 3E + S (Energy, Economy, Environmental conservation and Security). To meet this trend, establishing new markets to trade various values of electric power such as ‘capacity market’ and ‘non-fossil value trading market’ is underway, in addition to the existing energy spot market (Japan Electronic Power eXchange). Figure 5

shows the tentative timeline of establishing these new markets. Details about the commencement of these markets are under discussion.

Figure 4. Tentative Roadmap of Establishing New Market in Power Sector

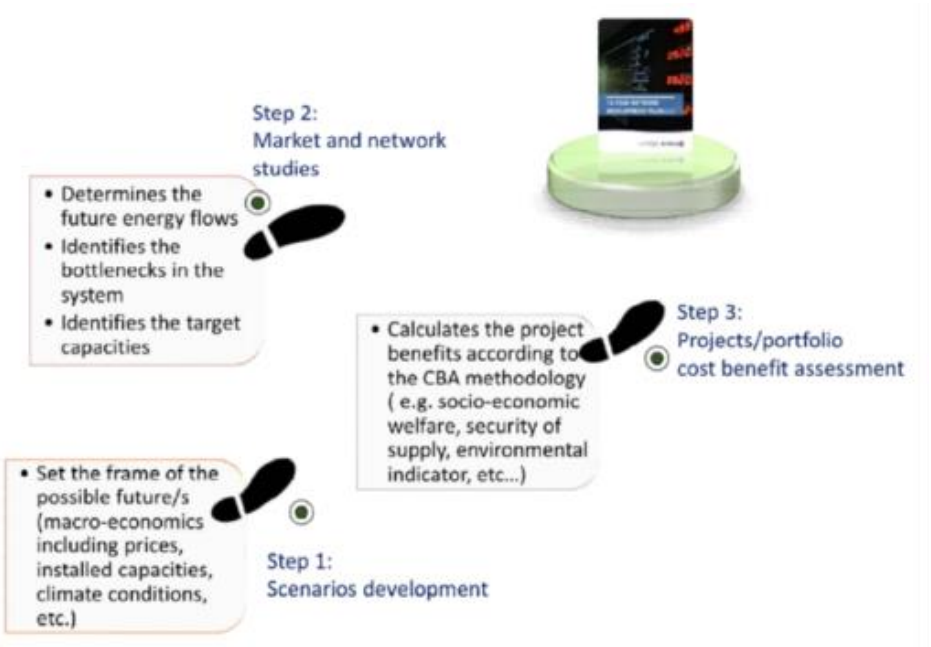


Source: Advisory Committee for Natural Resources and Energy, 'Interim report of subcommittee to achieve the Electricity System Reform' by Ministry of Energy, Trade and Industry (METI), Japan.

1.2. Europe

Since 2009, the European legislature has tasked ENTSO-E with the delivery of a European network development plan that builds on national plans and includes specific regional investment plans. Each ten-year network development plan (TYNDP) takes two years to complete. The first edition was issued in 2010. TYNDP 2016 is the latest available, and TYNDP 2018 is ongoing development. Figure 6 shows how ENTSO-E implements the planning studies.

Figure 5. The Planning Process in a Nutshell



Source: ENTSO Europe's Network Development Plan to 2025, 2030 and 2040 (2018).

The following are the details of each process:

(1) Step 1. Development of scenarios

To identify what Europe needs in terms of electricity transmission infrastructure, one needs to first analyse how the energy landscape will evolve. Some political objectives are set until 2030, but uncertainties about generation investments, demand evolution, market developments, etc. abound. The TYNDP scenario development is about framing uncertainties and not about predicting the future. Stakeholders are formally invited to participate actively in scenario building.

(2) Step 2. Planning studies

The TYNDP has four scenarios for the development of the power system. Some have high objectives in terms of renewables; some envisage a more decentralized power system; and some envisage a strong European framework. Based on these scenarios, 200 experts of 41 TSOs in 34 European countries carry out common planning studies.

Using common methodologies and tools, the experts look at how power will flow in Europe in 2030, taking into account the different scenarios. This allows them to see the location of bottlenecks and determine the amount of transmission capacity needed at borders to manage the flows.

The results of the planning studies are a series of infrastructure projects. These are only part of the whole TYNDP projects. The other part consists of projects that do

not come from ENTSO-E members but meet the criteria for inclusion in the TYNDP set by the European Commission.

The projects resulting from the planning studies take into account the constraints identified in the six regional investment plans published together with the list of projects. As regards scenarios, the list of projects and regional investment plans are open to public consultation before finalization.

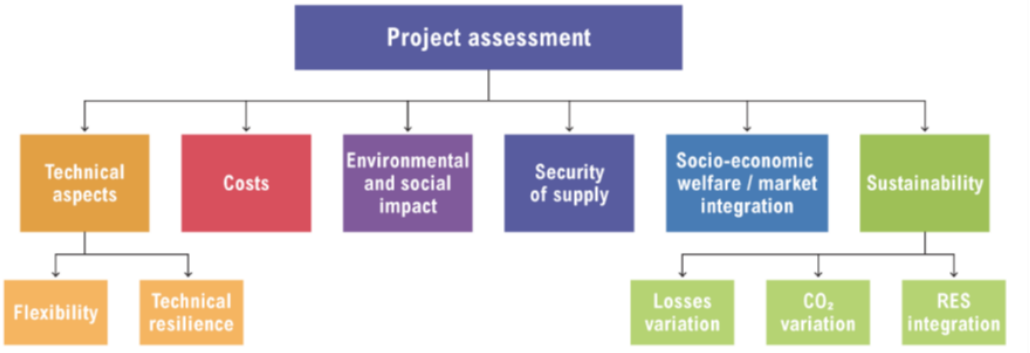
(3) Step 3. Projects assessment

The last phase of the planning process in the TYNDP is the assessment of projects. It is done using a European-approved methodology to assess the costs and benefits of projects. The assessment is not just a purely economic assessment. It takes into account also how projects support the environment, the welfare in Europe, the security of supply, among others. The results of this cost–benefit assessment of projects form the core of the TYNDP report.

By reading the TYNDP report, one can see the value of each infrastructure project. The TYNDP provides decision makers with a robust and detailed analysis of transmission infrastructure projects on which to base their decisions. One illustration is the TYNDP projects and their assessment are used in a European Commission-led process, the Projects of Common Interest.

Figure 7 shows the Cost–Benefit analysis (CBA) methodology for TYNDP project assessment.

Figure 6. Cost–Benefit Analysis (CBA) Methodology for TYNDP Project Assessment



Source: ENTSO (n.d.).

ENTSO-E drafted the cost–benefit analysis (CBA) after consultation with stakeholders. Thereafter, the CBA was sent to Agency for the Cooperation of Energy Regulators and the European Commission for opinion and to member states for information. Following the opinions received, the CBA methodology was revised and the commission adopted it in 2015.

Each project included in the TYNDP is assessed using the pan-European CBA methodology. As such, its benefit is evaluated against nine indicators ranging from socio-economic welfare to environmental impact.

1.3. SAPP

The activities and functions of the planning sub-committee are contained in the SAPP Inter-Utility Memorandum of Understanding. Some of the issues include but are not limited to the following[6]:

(1) Establishing and updating common planning and reliability standards, which have an impact on the SAPP.

(2) Based on individual member's plans, reviewing, every two years, an overall integrated generation and transmission plan to highlight the benefits and opportunities for cost savings that can be derived by the members from the coordination of activities. The integrated generation and transmission plan shall:

   (a) Take into account the forecasted demand and energy consumption in each member's system, including demand side management.

   (b) Indicate the anticipated sales and purchases by each member.

   (c) Contain the characteristics, location, and commissioning dates of new generating units and new transmission facilities, which are planned in each member's system, when such facilities have a significant impact on the interconnected system.

   (d) Contain the characteristics, location, and commissioning dates of new telecommunication, tele control, and supervisory facilities, which are planned in each member's system, when such facilities have a significant impact on the operation of the interconnected system.

   (e) Identify and record new generation, transmission, telecommunication, or tele control facilities to be installed in the systems of members and endeavour to identify and record new generation, transmission, telecommunication, or tele control facilities to be installed in the systems of non-members.

   (f) Be purely indicative and shall not create an obligation upon the members to comply.

(3) Evaluating software and other tools, which will enhance the value of planning activities such as load forecasting, determination of planning or reliability standards, cost–benefit analysis, or system studies, and submitting proposals to the management committee.

(4) Submitting proposals to the management committee regarding new service schedules, revising as necessary existing service schedules.

[6] http://www.sapp.co.zw/coordination-centre/planning-sub-committee

(5) Specifying the reliability standards that shall be used to determine the accredited capacity obligation of each operating member.

(6) Specifying compliance criteria, which will enable each operating member to comply with its accredited capacity obligation.

(7) Assessing the benefits attributable to each operating member resulting from the installation of protection relays, control equipment, or any system study.

(8) Improving facility required for the satisfactory operation of the interconnected system. Recommending to the management committee regarding the financial contribution of each operating member to the costs of such improvements.

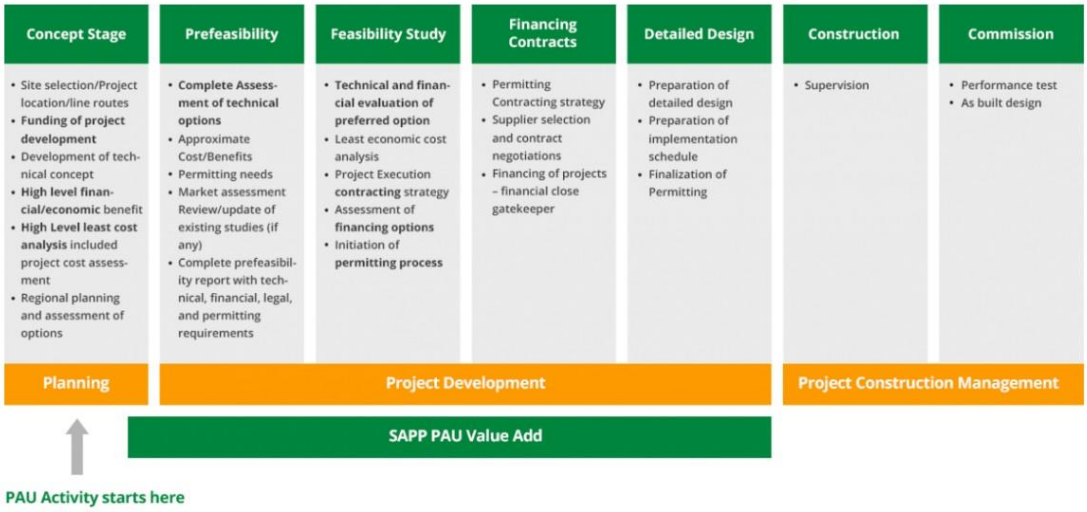
(9) Determining the transfer capability limits between systems on an annual basis or as and when required to enable the operating sub-committee to prepare detailed operating procedures.

(10) Identifying specific reliability problems and recommending the generation or transmission additions or changes required to eliminate them.

(11) Assessing the capacities of transmission plant in the system of operating members for the purpose of calculating wheeling rates and reviewing these on an annual basis.

Figure 7 shows the project development roadmap.

Figure 7: Project Development Roadmap



Source: Southern African Power Pool (n.d.) http://www.sapp.co.zw/project-development-road-map

2. Interconnections in 2018

2.1. Japan

Development of cross-regional operation and power trade through grid interconnection in Japan

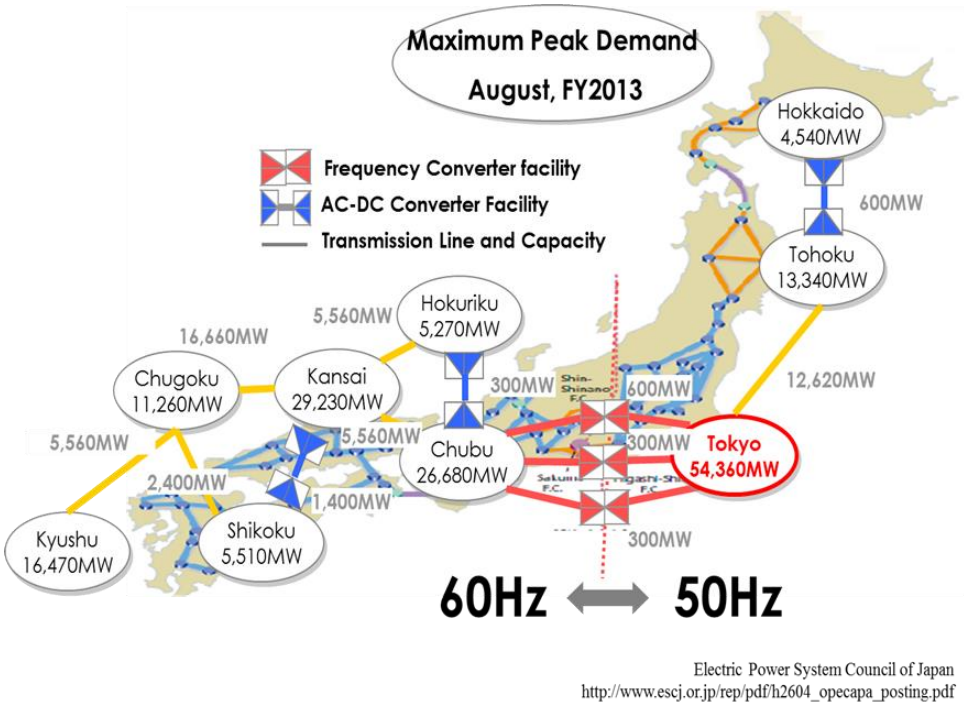
In this section, we present the history, current practices, and future prospects of electric power industry in Japan, focusing on the cross-regional grid system operation and power trade. The electric power industry in Japan has been developed under the coordination of regional power utility companies (grid system operators) that are mutually independent. We consider that lessons learned from Japan's experiences are worth it in considering the development of grid interconnection and power trade in the ASEAN region.

Overview of electric power in Japan

In Japan, there are 10 electric power utility companies with individual regional franchise. Figure 8 illustrates the peak demand of each utility and the interconnection system. The grid system of these power utilities, except for Okinawa that is the region of remote islands, is interconnected through multiple modes of interconnection system.

Since the beginning of electric power industry, two different frequency systems have been adopted in Japan – i.e. 50 hertz (Hz) in eastern region and 60Hz in western region – because the first generator installed in each region was imported from Germany and the United States. Three frequency converter stations (back-to-back) are installed to connect between the two frequency systems. Alternating current–direct current (AC-DC) converters interconnect remote islands via submarine cable.

Figure 8: Grid System of Electric Power Utilities and Interconnection, Japan



Source: Authors.

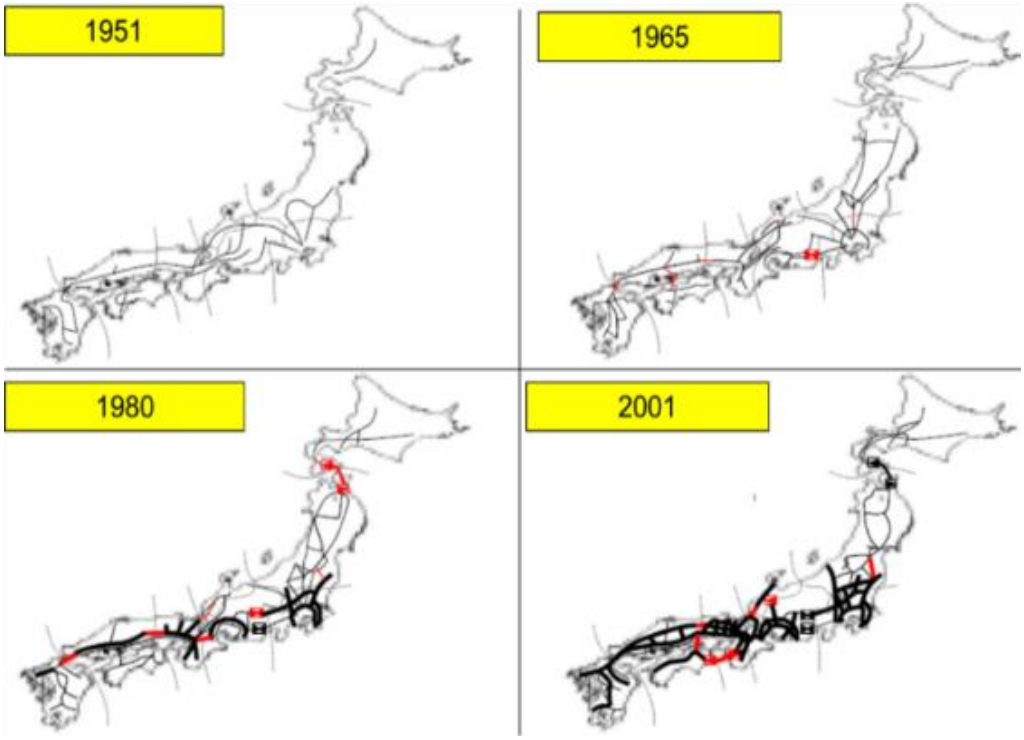
Enhancing power supply stability through the promotion of interconnection

Each Japanese utility had been developed to be vertically integrated with individual regional franchise. It is independent in the business of power generation and retail. Since about 1960s,

there has been a cross-regional cooperation of utility companies to develop power generation utilization through interconnections. Following this movement, utility companies' coordination in wider-area system planning has been strengthened to achieve cost-effectiveness.

Japan had been hit by several natural disasters such as big earthquake, heavy snow, and typhoons, which triggered the establishment of high-standard resilience of power supply. The wider-area power trade through grid interconnection has prevented a disaster-hit utility company from catastrophic system collapse caused by power shortage. After a number of years and with its rapid economic growth, Japan has addressed the renovation of old transmission system, including interconnections as shown in Figure 10. In addition, to enhance further the reliability and efficiency of power supply, plans to strengthen the interconnections are underway.

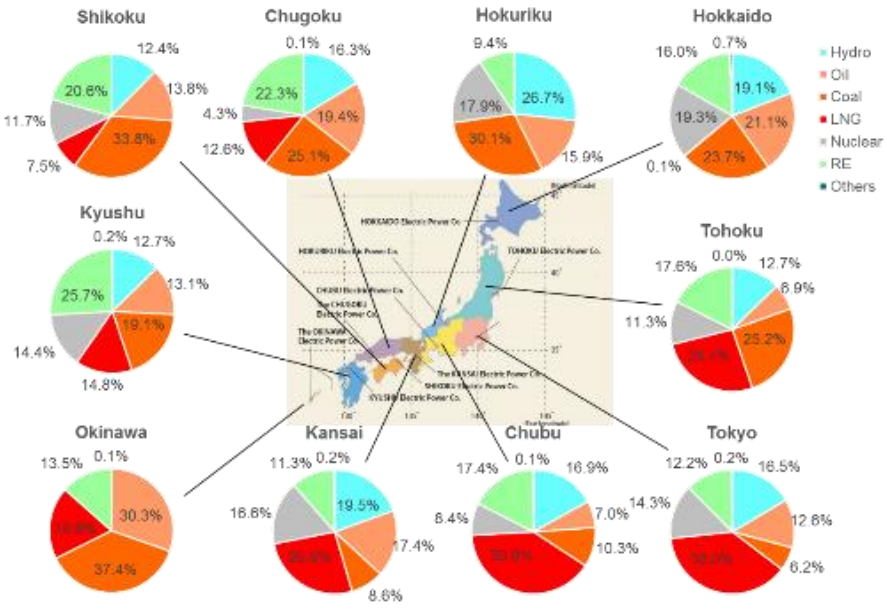
Figure 9: Development of Interconnection Lines, Japan



Source: Authors.

Considerable difference in the composition of energy sources exits amongst 10 utility companies as shown in Figure 11. Each type of energy sources has its pros and cons, thus power trade through interconnections is expected to contribute to the reliability and stability of supply for the mutual benefit of all utilities.

Figure 10: Power Source Capacity Portfolio of Each Service Area



Source: Authors.

Statistics show the high reliability of Japan's power grid systems. Table 1 shows record of Tokyo Electric Power Company (TEPCO) on frequency deviation and outage. The data clearly show the very low outage occurrence and the very stable frequency and voltage level. Figure 10 indicates that the frequency deviation stays within 0.1Hz in 99.8% and within 0.2Hz in almost 100% of total duration. Strong grid, including many interconnections, is one of the major reasons for the reliability.

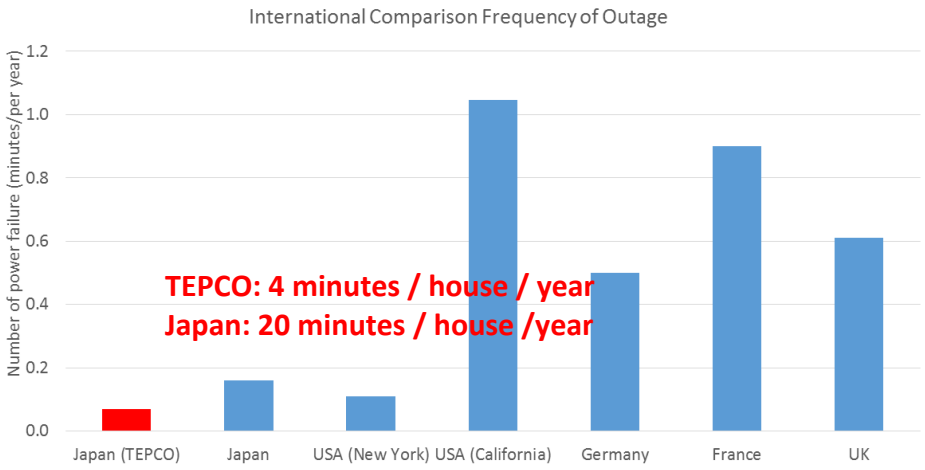
Table 1: Frequency Record of TEPCO

	50±0.1Hz	50±0.2Hz
FY2015	99.8540% (12h49m32s)	99.9999% (4s)
FY2016	99.7755% (19h39m44s)	99.9997% (1m50s)

FY = fiscal year.
TEPCO = Tokyo Electric Power Company.
Source: Authors.

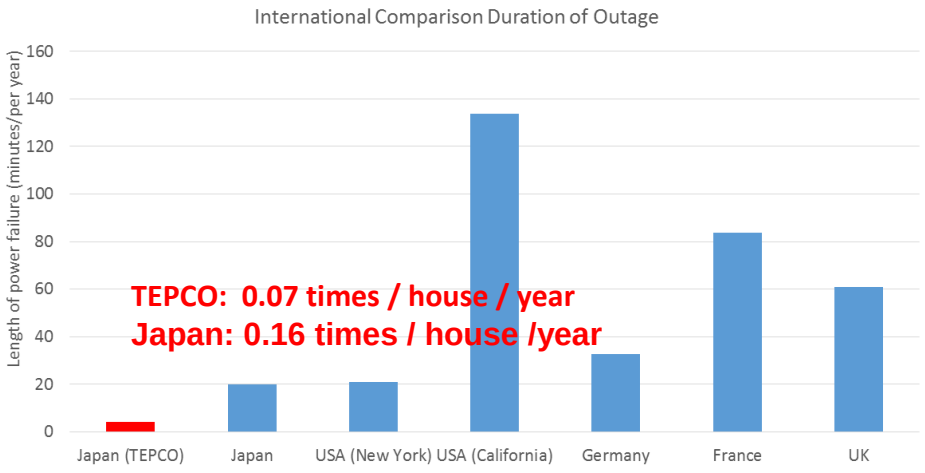
Figure 12 and Figure 13 show the international comparison of SAIDI and SAIFI in 2012.

Figure 11: International Comparison of SAIDI in Year 2012



SAIDI = system average interruption duration index.
TEPCO = Tokyo Electric Power Company.
Source: Authors.

Figure 12: International Comparison of SAIFI in Year 2012

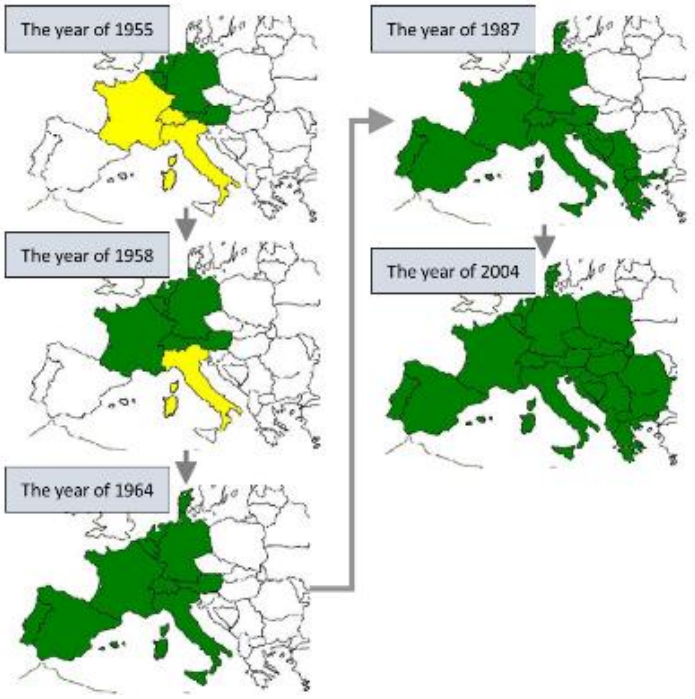


SAIFI = system average interruption frequency index.
TEPCO = Tokyo Electric Power Company.
Source: Authors.

2.2. Europe

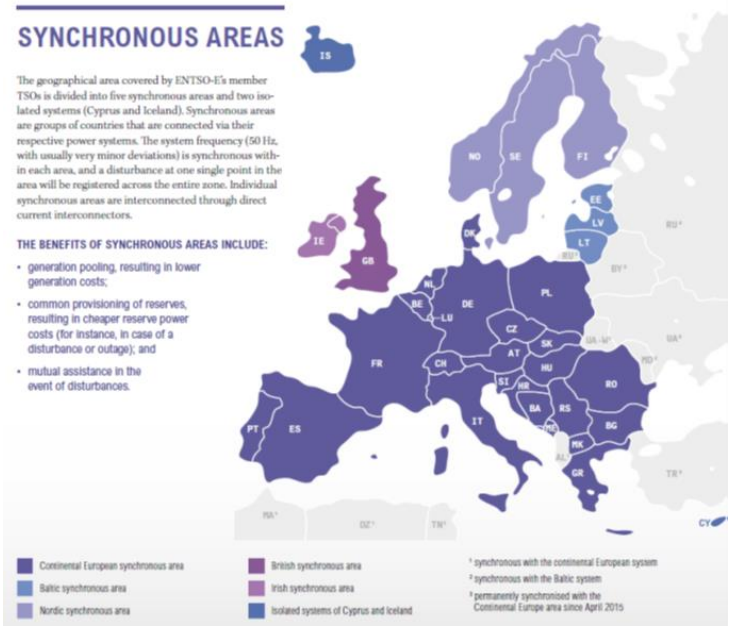
The next figures show the synchronous grids in Europe. The figures below show the synchronous grids in Europe.

Figure 13. Synchronous Grid Development in Europe



Source: authors based on the information from the website below Japan Electric Power Information Center (n.d.) https://www.jepic.or.jp/JEPICDB/index.html

Figure 14. Current Synchronous Grid in Europe



Source: ENTSO-E (2015), https://docstore.entsoe.eu/Documents/Publications/ENTSO-E%20general%20publications/entsoe_at_a_glance_2015_web.pdf

European Commission – Fact Sheet Brussels, 25 February 2015

Connecting power markets to deliver security of supply, market integration, and the large-scale uptake of renewables

(1) What is the 'electricity interconnection target'?

The European Council of October 2014 called for all Member States to achieve interconnection of at least 10% of their installed electricity production capacity by 2020. This means that each Member State should have in place electricity cables that allow at least 10% of the electricity that is produced by its power plants to be transported across its borders to its neighbouring countries.

(2) Will reaching the target make a difference on our energy bills?

Yes. Well-connected European energy grids will translate into direct savings for the consumer. According to a recent study EU consumers could, each year, save €12–40 billion if energy markets are fully integrated.

(3) Will the 10% target be enough?

This target sets a required minimum interconnectivity level, which should be achieved by all Member States by 2020. Depending on the geographical position of a country and its energy mix, for example the weight of renewables in it, achieving just the required 10% minimum may not be enough. The EU is therefore looking into raising the target to 15% by 2030. However, as in some Member States, the 15% target might require investments which would not anymore be economically justifiable, it is important to assess the bottlenecks and the higher targets will be established on a case-by-case basis.

(4) How much money will be needed to reach the 10% interconnection target?

The European Commission estimates that up to 2020 about €40 billion will be needed to reach the 10% target across the EU.

(5) Where will the money come from?

First of all, most of the PCIs present a solid business case and can be financed under normal market conditions, mostly through the tariffs. Some projects, when they meet strict conditions and help enhance security of supply, can benefit from a grant from the Connecting Europe Facility (CEF). €5.35 billion has been earmarked for energy infrastructure projects in the CEF between 2014 and 2020. While the CEF funding represents only around 3% of all the investment needed up to 2020 in electricity, but also in gas infrastructure, it can leverage other funds through using financial instruments, such as project bonds.

To have the expected impact the CEF grants have to be combined with the efforts of regulators and governments to finance projects through network tariffs and by making use of the new European Structural and Investment Funds (ESIF), where possible.

One of the main obstacles to building new infrastructure is lengthy permit granting procedures. Is there a solution?

Indeed, today, on average obtaining the necessary permits can take between 10 and 13 years. The TEN-E Regulation introduces a binding overall time limit of 3.5 years for permit granting. It foresees that a single national competent authority has to act as a one-stop-shop for all permit granting procedures. Such one-stop-shops should be in place in all Member States by spring 2015.

2.3. SAPP

The following table 2 and Figure 16 show the grid map of SAPP and the demand and supply of each country. Figure 17 shows the interconnections of SAPP.

Table 2. Demand and Supply of Each Country

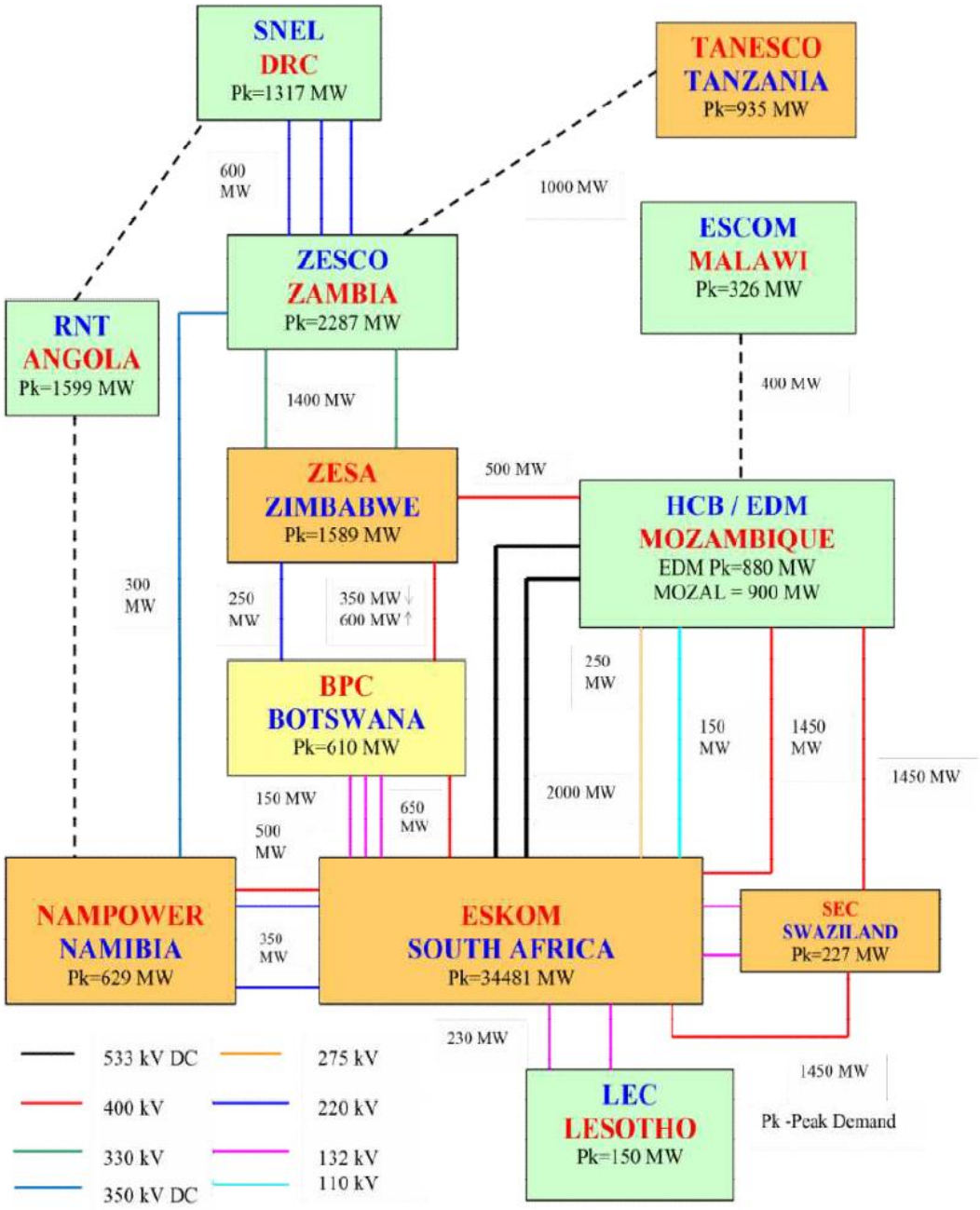
No. Country	Utility	Installed Capacity (MW)	Operating Capacity (MW)	Current Peak Demand (MW)	Peak Demand Plus Reserves	Capacity excess / shortfall including Reserves
Angola	RNT	3,129	2,500	1,869	2,138	362
Botswana	BPC	927	459	610	698	-239
BRC	SNEL	2,457	1,076	1,376	1,574	-498
Lesotho	LEC	74	70	150	172	-102
Malawi	ESCOM	352	351	326	373	-22
Mozambique	EDM/HCB/MOTRACO	2,724	2,279	1,850	2,116	163
Namibia	Mampower	538	354	647	740	-386
South Africa	Escom	50,774	48,463	38,897	41,374	7,089
Swaziland	SEC	70	55	232	265	-210
Tanzania	TANESCO	1,366	823	1,051	1,202	-379
Zambia	SESCO/CEC/LHPC	2,734	2,734	2,194	2,510	224
Zimbabwe	ZESA	2,045	1,555	1,615	1,847	-292
Total		67,190	60,719	50,817	55,009	5,710

Source: SAPP (n.d.) http://www.sapp.co.zw/demand-and-supply

Figure 15. Grid Map of SAPP

Source: Southern African Power Pool (n.d.) http://www.sapp.co.zw/

Figure 16. Interconnections of SAPP



Source: Southern African Power Pool (n.d.) http://www.sapp.co.zw/interconnectors

Chapter 4

Proposed regulations for APP based on Japanese case example

1. Regulations for APP and respective relations

It is essential for APP to decide systematic regulations about organizations, business, procedures, etc. to secure fairness, transparency, and accuracy. Examples for reference are presented in this chapter according to the case of Japan. Regulations consist of three hierarchy levels such as articles of incorporation, business rules, and business guideline (Table 3). Articles of incorporation regulates fundamental items like establishment, authority, scope, and functions. Business rules provide methods and procedures for business operation. Business guideline deals with substantial and concrete rules for each business such as demand and supply plan, system operation, and information disclosure of grid information.

Table 3. Proposed Regulation Hierarchy for APP

Regulations	Contents
Articles of incorporation	Governance policy
Business rules	Outline of each business operation and basic procedures
Business guideline	Substantial and concrete rules for each business including implementation period, data submission deadline, etc.

Source: Authors.

These three documents should follow and are positioned under relevant governing agreements equivalent to treaty or law such as intergovernmental agreement on regional power trading and memorandum of understanding for the establishment of the APP organization. The main objective of the documents is for the APP to keep quality of work.

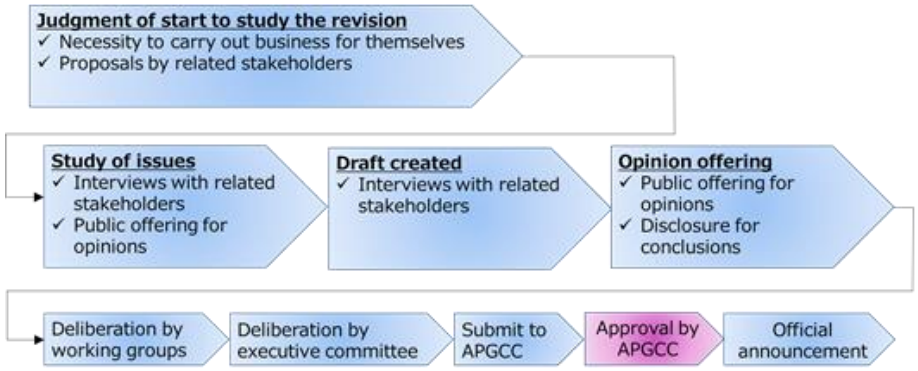
2. Process of regulation revision

The following is the process of regulation revision:

(2) APP publishes the draft revision and collects opinions.

(3) Draft is submitted for deliberation by executive committee and approval by The ASEAN Power Grid Consultative Committee.

Figure 17. Process of Regulation Revision



APGCC = ASEAN Power Grid Consultative Committee.
Source: Authors.

3. Articles Process of regulation revision

General outlines are described in articles of incorporation and details are followed in business rules and business guideline. The following are included:

(1) Items

i) Objectives of establishment

ii) Scope of business

iii) Name

iv) Office location

v) Related stakeholders

vi) Executive committee

vii) Officers

viii) Fund

ix) Financial affairs and accounting

x) Revision of articles of incorporation

xi) Public announcement

(2) The following are examples of two items listed above:

Scope of business

i) Monitor of the supply and demand balance by each ASEAN country

ii) In case there is deterioration of supply and demand balance or necessary improvement, AGTP department of APP provide guidance to improve the situation.

iii) Development of business guideline

iv) Evaluation of supply reliability by checking demand and supply plan

v) Public offering for new power supply

vi) Handling of complaints by related stakeholders and settling disputes

vii) Disclosure of grid information

viii) Other business that matches the objective of establishment

Executive committee

APP shall appoint one president, four or less board members, and two or less auditors as its executives. The president and board member shall perform full-time.

Duties and authority of executives

i) The board member shall assist the president in handling the operations of

APP and perform the duties of the president when the president is unable to carry out the duties.

ii) The auditors shall audit the operations of APP.

Appointment and term of office of executives, etc.

i) The executive committee shall be appointed based on a resolution of general meeting. They shall hold their office for two years and be appointed twice.

ii) The executive committee shall not engage in commercial enterprises.

iii) The auditor shall not concurrently hold a post of president, a board member and a member of APP.

iv) After leaving the executive committee, the executive shall not be appointed in an executive committee involved in making decisions on the electric power business and businesses closely related thereto at a corporation that operates electricity business.

Fees

Membership fee

i) Members of APP shall pay an annual membership fee within one month after receiving notice of membership.

ii) Membership fee is non-refundable.

Special membership fee

i) A member of APP from a general electricity utility shall pay a special membership fee separate from membership fee annually.

ii) Special membership fee is set by the board of directors based on the demand of each supply area.

iii) Special membership fee is non-refundable.

4. Business rules

Business decided in articles of incorporation and business operation are described in business rules.

(1) Items

a) Functions of system planning

(i) Demand forecast

(ii) Development of operation guide for demand forecast, development of demand forecast

(iii) Aggregation of the supply plan

(iv) Public offering for new power supply

(v) System planning

(vi) Development of long-term enhancement policy, development of interconnection reinforcement plan

b) Functions of system planning

(i) Monitor of demand and supply balance

(ii) Provide guidance in case of deterioration of demand and supply balance

(iii) Monitor and manage of interconnections operation capacity, margin setting

(iv) Short-term and long-term frequency control

(v) Plan of utilization for interconnections

(vi) Adjustment of planned outage for interconnections

c) Functions of others

(i) Disclosure of grid information

(ii) Available capacity for interconnections, information about demand and supply, information about interconnections including planned outage plans and records

(iii) Disaster management

(iv) Settling disputes and handling complaints for issues between TSOs

(2) Examples of described contents

a) Allocation of activities of organization

(i) General Affairs Department, Secretary, finance, HR, public relations

(ii) APG codes, Guidelines and Research Department common transmission capacity mechanism design, technical standards, environmental

(iii) Power System Planning Department system planning, system planning for interconnections, aggregation of supply plan

(iv) Power System Operation and Coordination Department

(v) Monitoring and metering of APG, system operation

(vi) Information technology (IT) and supervisory control and data acquisition (SCADA) department System operation centre IT tools, market operation centre IT tools

(vii) ASEAN Market and Multilateral Trading Department

Market design, market operation

(viii) Legal and regulatory group

b) Development of operation guide for demand forecast

To perform the business of demand forecast properly and smoothly, APP shall develop the operation guide for demand forecast and announce it to related stakeholders.

(i) Basic items: forecast period (by which year, interval, etc.), responsible organization, forecast target, demand classification, etc.

(ii) Correction method of demand record: Concrete correction method considering temperature, leap year, etc.

(iii) Demand forecast method in the service area

(iv) Form of submit

(v) Other necessary items related to development of suitable demand forecast.

c) Power system development

Formulating long-term development policy of cross-regional power system

APP formulates a long-term policy that shows the action plans regarding development and renewal of cross-regional network in APG and the ideal situation of interconnection forecasting a period exceeding 10 years and the view to realize it.

d) Supervision

Supervising the demand and supply condition

APP conducts the following as a supervising task of demand and supply condition:

(i) Matters regarding demand and supply conditions of service area

- The condition regarding demand, supply and securing reserve in service area of APP member from general electricity utility
- The condition regarding demand and supply in service area of APP member from specific transmission and distribution system operator

(ii) Conditions regarding demand and supply in each ASEAN country

(iii) Conditions regarding utilization of interconnections

5. Business guideline

Business guideline constitutes substantial and concrete rules about each business and about demand and supply plans, system operation, disclosure of grid information, etc.

Items are the same as those in business rules. However, business guideline includes period, deadlines, contents, granularity, etc. in detail for proper and smooth business operation.

Development of operation guide for demand forecast

All TSOs shall develop demand forecast of the service area based on the operation guide for demand forecast and instructions. They shall submit to APP on 20 January the forecast covering the whole year from April to March.

(1) Forecast period

   a) In principle, successive 10 years from the year starting from next April to March

   b) Monthly value of energy at using end, energy at supplying end, and peak demand for the first year

(2) Forecast target

   a) Net system energy demand, energy at using end, energy at receiving end, energy at supplying end

   b) Peak demand, yearly top three average of day peak

(3) All TSOs shall consider economic outlook, related information, recent demand trend, past demand record, etc. to develop demand forecast of the service area.

(4) All TSOs shall submit by required form and include calculation basis.

Network development

The following are matters to be stated in long-term development of cross-regional network:

(1) Basic concept on development of cross-regional network

   a) Matters regarding the future demand in AMS

   b) Matters regarding the ideal situation of future cross-regional network in AMS

Points of attention regarding basic concept on development of cross-regional network

(1) Demand and supply conditions up to previous year

(2) Outlook for demand and supply based on changes in economic circumstances

(3) Characteristics of supply area in each AMS

(4) Outlook for improving environment of cross-regional power electricity trade

(5) Service reliability at the occurrence of a large-scale outage or disaster

(6) Ageing, deterioration information of power equipment, progress in technology development, and other technical information

Requirements for starting consideration of interconnection reinforcement

(1) In the annual plan of interconnection, a case in which the number of hours, during which the available transfer capability for operational capability is 5% or less, exceeds 20% of the target period of annual plan.

(2) In the utilization record of interconnection, a case in which the number of hours, during which the available transfer capability for the operational capability was 5% or less in the past year, exceeded 20% of the total number of hours in the past year.

(3) The record of generation output limitation due to the constraints of transmission line of upper two voltage levels in each AMS.

(4) Frequency of market split according to interconnections capacity.

Collection of supply plan

Submission of draft supply plan

Each business operator shall submit the draft supply planning in prescribed form to APP on the deadline specified below to confirm the point reviewed based on checks and advice from APP.

(1) Transmission System Operator, Specific Transmission and Distribution System Operator

Every 10 February

(2) General Electricity Utility

Every 10 March

The deadline cited above is an example based on a fiscal year beginning in April.

Submission of supply planning

Business operators shall submit the draft supply planning in prescribed form to APP on the deadline specified below.

(1) Transmission System Operator, Specific Transmission and Distribution

System Operator, Retailer and Power producer

Every 1 March

(2) General Electricity Utility

Every 25 March

The deadline cited above is an example based on a fiscal year beginning in April.

Supervision

Supervising the power system

General electricity utility shall supervise the following matters regarding the power system in its own service area:

(1) Conditions of frequency and voltage

(2) Demand and supply condition in each service area

(3) Operating condition of power equipment

(4) Power flow condition

(5) Other necessary matters for stable power system operation

Preliminary measure when an abnormality is expected in the electric power system

When the general electricity utility judges that there is a possibility of abnormality such as power outage in the power system of the service area due to typhoon, snowstorm, etc., it shall take countermeasures and prepare a system for the occurrence of abnormality.

Instruction from APP to improve demand and supply condition

When business operators receive the instruction or request from APP, unless there is a justifiable reason, they shall promptly respond to it and cooperate in improving the demand and supply condition.

Chapter 5
Summary of AGTP guideline

1. Introduction

AGTP guideline contains the principles, framework, and other technical arrangements for the establishment of AGTP. It is one of the main deliverables for the project 'Study on the Formation of the ASEAN Power Grid Generation and Transmission System Planning Institution (AGTP)' by TEPCO.

Another coupled project, 'Study on the Formation of the ASEAN Power Grid Transmission System Operators Institution (ATSO)', is performed by Nord Pool Consulting. ERIA is the implementation agency for both projects.

This document proposed that AGTP and ATSO functions be put under one umbrella, APP, eto keep a close relationship. ATSO and AGTP guidelines are developed without overlapping with same contents, unless necessary. The overall organizational structure of APP, which incorporates AGTP functions, is discussed in detail in ATSO guideline. AGTP guideline mainly deals with system planning and the corresponding proposal of regulations for APP.

The following are four of the five chapters of the guideline:

Chapter 2 Summary for current practices of system planning

This chapter explains main items of the current functions of AMS regarding the necessary interconnections study based on the answers to the questionnaire.

Chapter 3 Function of system planning department

This chapter elaborates the function of system planning department. Evaluation of supply reliability by checking demand and supply plan, and proposal for reinforcement of interconnections are the two main business.

Chapter 4 Roles and responsibility for system planning department

This chapter describes the responsibility of working group and subunits belonging to system planning department and proposes staffing at the initial stage and the advanced stage.

Chapter 5 Appendix, Current practices of system planning according to answers to the questionnaire

This chapter describes current practices about system planning amongst AMSs such as demand forecast, power development plan (PDP), transmission development plan (TDP), and interconnections development plans. All answers to AGTP questionnaire are shared in this chapter.

2. Summary of current practices of system planning

Main items of the current functions of AMS as regards necessary interconnections study are shown below based on the answers to the questionnaire.

(1) Procedures, criteria, and software

a) There are some difference in procedures and criteria amongst AMSs for developing demand forecast, power development plan, and transmission development plan.

b) As the software of transmission planning, power system simulator for engineering (PSS/E) is used in many countries.

c) As the software of generation planning, there are no de facto standard at present.

(2) Corporation process with other countries

a) To study necessary interconnections, there are some cases of corporation process between only two countries. However, there are no cases of it amongst more than three countries.

b) To develop PDP and TDP, there are no cases of corporation process with neighbouring countries.

(3) Others

a) Issues about environment to affect interconnections are under control in all AMSs.

b) All AMSs have organization to check or monitor PDP and TDP in national levels.

3. Business o system planning department

3.1. Working group

System planning department discuss, propose, and decide rules, criteria, and procedures to implement study and business for system planning as shown below.

(1) Evaluation of supply reliability by checking demand and supply plan

a) How to develop demand forecast

b) Evaluation method of supply capacity

(2) Proposal for reinforcement of interconnections

a) Procedures for long-term reinforcement policy

b) Criteria and procedures for the necessity of interconnections

(3) Basic concepts for beneficiary and cost allocation

3.2. Subunit for aggregation of supply plan

This subunit is for aggregation of supply plan that implements evaluation of supply reliability by checking demand and supply plan based on rules, criteria, etc. developed by working group.

3.3. Subunit for system planning for interconnections

This subunit is for system planning for interconnections that implements proposal for reinforcement of interconnections.

This interconnection study is divided into two parts:

(1) High-level study, which is implemented on an annual basis by staff in this subunit.

(2) Detailed study, which is implemented on the specified period by staff in this subunit and related AMS experts who live in connecting grid points or are beneficiaries.

4. Roles and responsibility for system planning department

4.1. In the initial stage

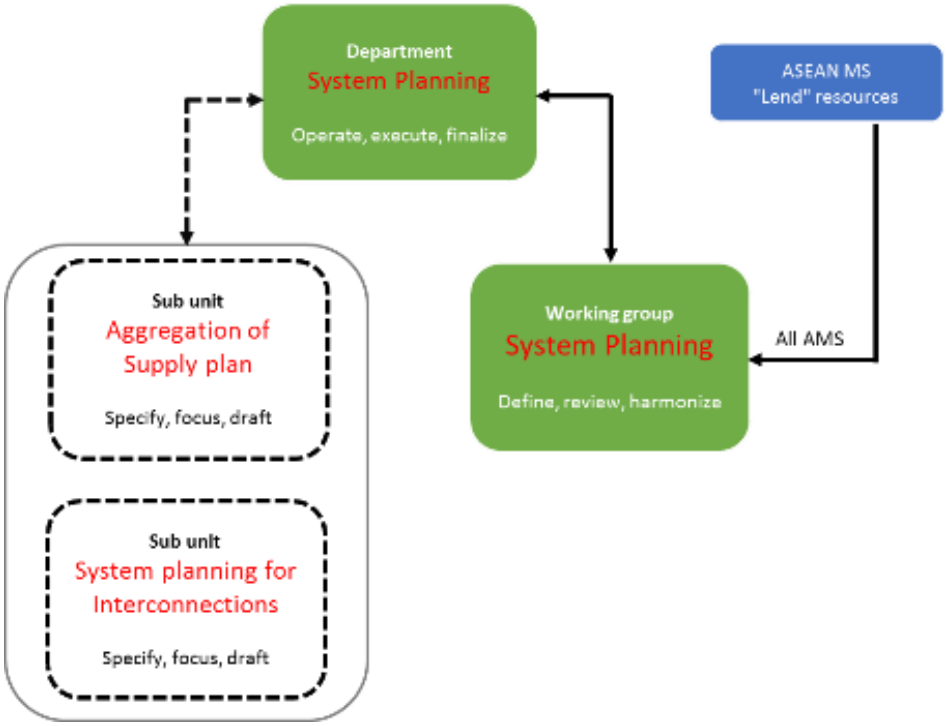
APP is expected to be started as a small organization in the initial stage. System planning department study and discuss at the beginning system planning department starts to study and discuss the business, like the articles of incorporation, amongst themselves and establish regulations in working group (Figure 18). The following are the personnel who belong to this department and numbering less than five:

(1) One department head

(2) One or two staff to study and discuss the business of the system planning department like the articles of incorporation

(3) One or two staff to establish the standards and regulation in working group

Figure 18: Organizational Relations within System Planning Department in the Initial Stage

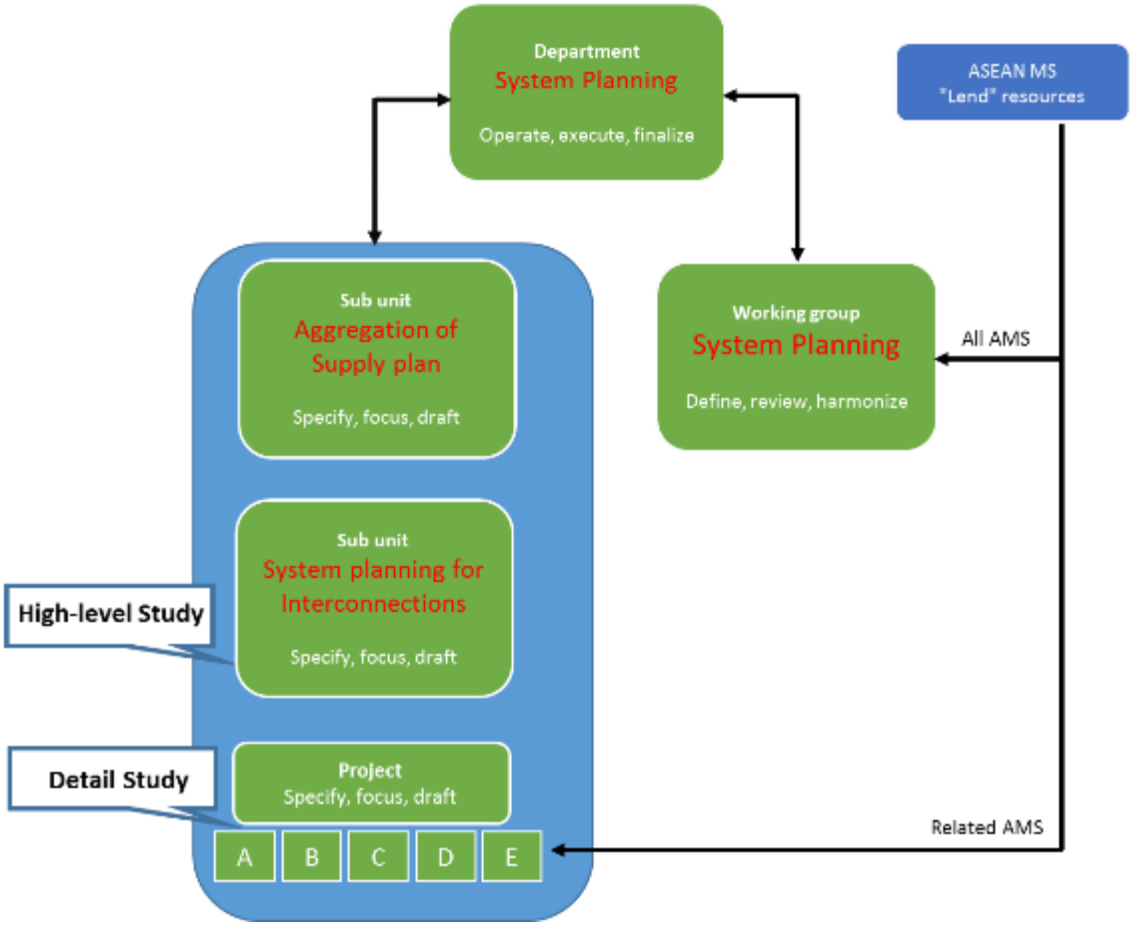


AMS = ASEAN member state.
Source: Authors.

4.2. In the advanced stage

Figure 20 shows organizational relations in system planning department. Appropriate number of staff will be hired, and working group, including 10 AMSs, set the rules and criteria. Two subunits implement annual base business mainly for evaluation of 10 AMSs' supply plan and selection for necessary interconnections. When a subunit of system planning reaches the necessity of interconnections, it is studied in the project including related countries.

Figure 19: Organizational Relations within System Planning Department in the Advanced Stage



AMS = ASEAN member state.
Source: Authors.

Chapter 6

Summary of AGTP implementation plan

1. Introduction

The implementation plan is one of the main deliverables for the project 'Study on the Formation of the ASEAN Power Grid Generation and Transmission System Planning Institution (AGTP)'. The plan contains the roadmap of actions for the establishment of the APP institution.

Importantly, AGTP implementation plan is developed in a way as not to overlap with the ATSO implementation plan made by Nord Pool Consulting on the same contents, unless necessary. The overall implementation plan and roadmap for a whole organization are elaborated in the ATSO implementation plan. The AGTP implementation plan deals mainly with those concerning system planning.

The following are five of the six chapters of the implementation plan:

Chapter 2 Roadmap

This chapter summarizes the ATSO implementation plan that especially relates to system planning. Thereafter, it elaborates the roadmap for system planning.

Chapter 3 Function design of system planning

This chapter describes detail contents such as annual schedule, data to be submitted, and how to implement each step of functions of system planning.

Chapter 4 Criteria and methods to be standardized for system planning

This chapter elaborates that in implementing the functions of system planning, APP should standardize some technical criteria and methods for developing necessary data to be submitted based on thorough discussion and approval by all AMS experts.

Chapter 5 Review for the current functions of system planning

This chapter elaborates current functions of AMS, functions to be updated or standardized, and capacity building for fulfilling the gaps.

Chapter 6 Barriers and solutions

This chapter shows the barriers and the solutions thereto. To realize the roadmap of APP, some barriers need to be solved.

2. Roadmap

2.1. Linking to the ATSO implementation plan

The guideline proposed that the AGTP and the ATSO functions be put under one umbrella called the APP organization to keep a close relationship, which was agreed upon at the first workshop. The implementation plan of the organization is elaborated in the ATSO implementation plan. The AGTP implementation plan details the system planning. This section describes the summary of the ATSO implementation plan especially on the contents related with system planning. Table 4 illustrates four high-level milestones and their respective stages.

Table 4. Milestones for ATSO Development

Milestone	Stage description and main activity to be finalized for the milestone
Milestone 1	Enabling agreements
Milestone 2	Organizational establishment
Milestone 3	Initial stage of ASEAN Power Pool (APP) operation
Milestone 4	Advanced stage of APP operation

ATSO = ASEAN Power Grid Transmission System Operators Institution.
Source: ATSO Implementation Plan and Roadmap by Nord Pool Consulting.

Table 5 and Table 6 show the key activities and steps needed, as well as the responsible institution or stakeholder for each step related to system planning.

Table 5. Activities and Responsible Organizational Units in the Initial Stage.

Task No.	Key activities needed in the initial stage	Responsible body/entity
3.2	Establish APG-agreed technical standards and performance grid code	Technical standard working group
3.3	Develop the data requirement, procedures, and criteria for APG system planning	System planning working group
3.4	Develop APG third-party access (TPA) agreement	Common transmission capacity mechanism design working group
3.5	Develop APG wheeling and losses methodology	Common transmission capacity mechanism design working group

APG = ASEAN Power Grid.
Source: ATSO Implementation plan and Roadmap by Nord Pool Consulting.

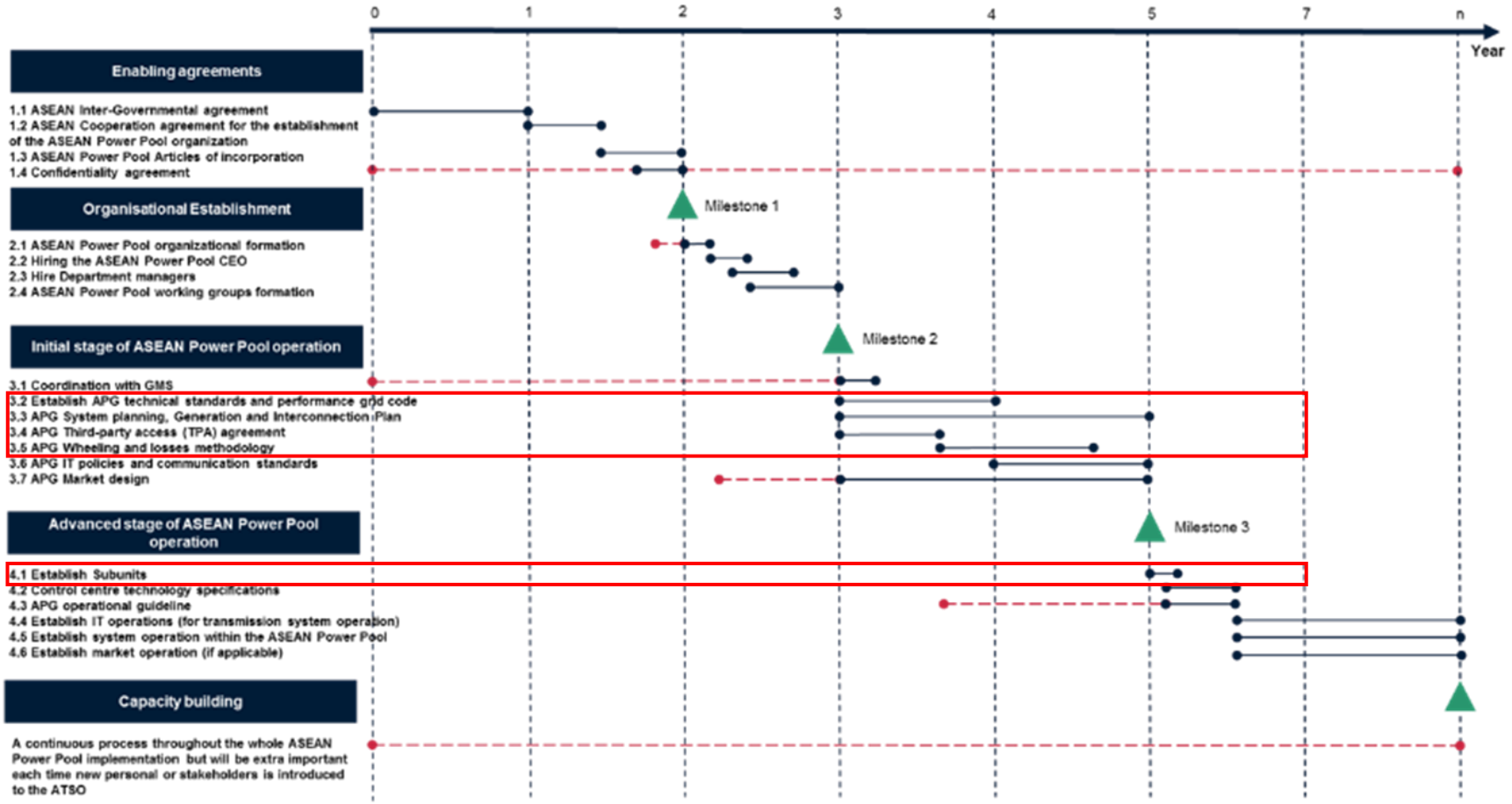
Table 6. Activities and Responsible Organizational Units in the Advanced Stage

Task No.	Key activities needed in the advanced stage	Responsible body/entity
4.1	Establish subunits: System planning for interconnections Aggregation of supply plan Monitoring and metering of APG System operation centre	System planning department manager System operation and coordination department manager

APG = ASEAN Power Grid.
Source: ATSO Implementation plan and Roadmap by Nord Pool Consulting.

Figure 21 shows the high-level roadmap of APP. The order of all steps based on four milestones is clarified in this figure, and related items with system planning is highlighted in red frame.

Figure 20: High-level Road Map of APP

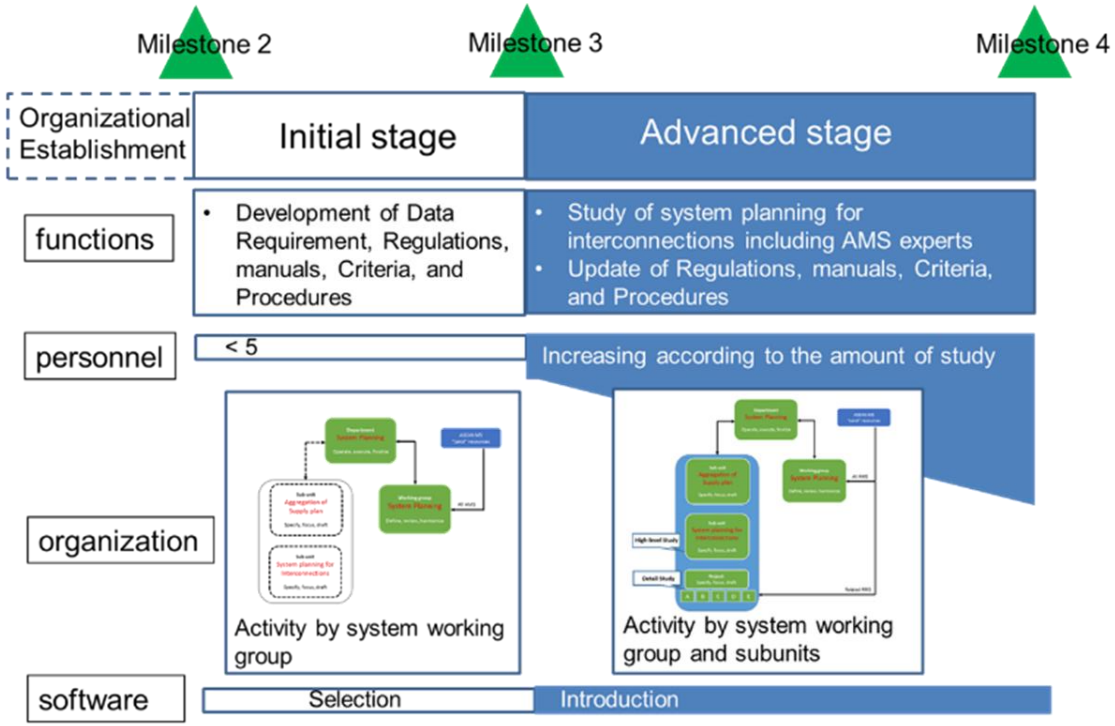


Source: Authors.

2.2. Roadmap for system planning

Figure 21 shows the high-level roadmap for system planning department. Functions of system planning start after the establishment of APP at the point of milestone 2. Figure 20.

Figure 21: High-level Road Map for System Planning Department



Source: Authors.

3. Implementing the function design of system planning

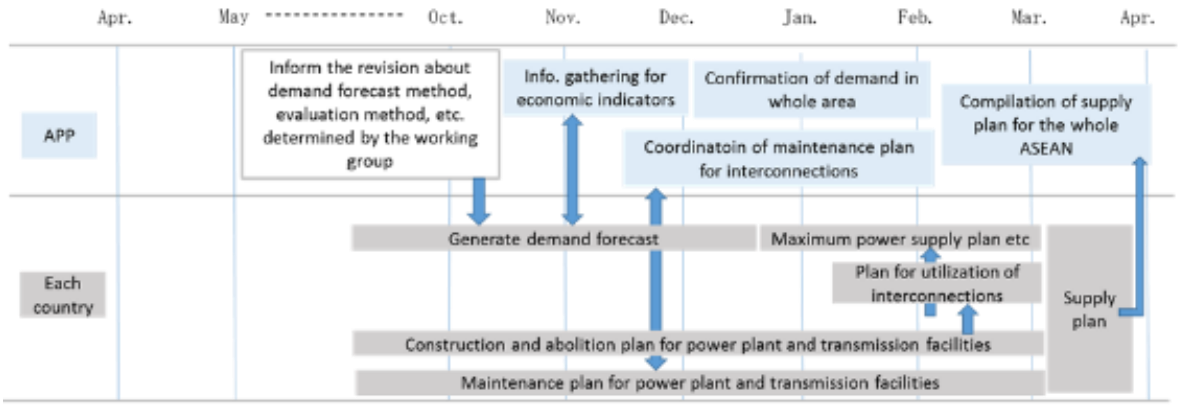
3.1. Aggregation and evaluation of power supply plan

To prepare power supply plan, AMSs have to submit data according to a standardized format based on a unified annual schedule.

(1) Annual schedule

Figure 22 shows a Japanese case example of annual schedule. April is the beginning of the fiscal year, and the power supply plan and the interconnection line plan need to be prepared by end of March. For this purpose, the annual schedule is desirable as shown in the figure.

Figure 22. A Japanese Case Example of Schedule for System Planning



Source: Authors.

(2) Data to be submitted to APP for system planning

Purpose

It is necessary to evaluate each country's supply plan for APP to realize the following:

a) To judge whether to build the new interconnection lines

b) To make a future reinforcement plan of interconnection lines

Types of data

It takes a long time, about 10 years, to construct interconnection lines. To quantify this long-term plan, each country needs to submit annually to APP the following 10-year data.

Demand or supply capability

a) Plan to construct/deprecation power supply and distribution facilities

b) Plan to utilize interconnection line

Utilization

APP knows that such data and information are prohibited in principle to be leaked to not only countries other than ASEAN but also other ASEAN countries. In case APP needs to disclose information for ASEAN or countries other than ASEAN to realize the above object, it has to obtain permission of the country related to information.

Submission form

The system planning working group creates and revises the format of demand forecast method, supply capability, and each evaluation method, and presents the submission form to each country in October.

(3) Evaluation method of the supply plan

APP evaluates the supply plan submitted by each country focusing on the following points: (i) whether each country has supply capability for 10 years of demand and (ii) if interconnection lines are incorporated as supply power, whether cooperation is aligned with the utilization plans of interconnection lines amongst countries.

3.2. Development of interconnection plan

(1) Individual project

Decision of members

In case the system planning working group decides that it is necessary to establish the new interconnection lines, APP orders the launch of an individual project and the dispatch of representatives to the countries related to establish the new interconnection lines.

Related countries means not only two countries physically connected by the interconnection but also beneficial or affected countries when the interconnections are completed. The working group also discuss the rules on how to select such countries.

Principally, APP is an advisory organization, and the countries related to establish the new interconnection lines decide whether to establish the line.

The development of construction plan

Members of individual project engage in specific tasks to establish the new interconnection line. In case expertise is required, it is desirable to proceed with the work while utilizing consulting companies to support the discussion and prepare necessary documents.

(2) Planning of repair and augmentation of interconnection lines

APP creates a repair and augmentation plan for interconnection lines based on the plan for future use of interconnection lines submitted by each country.

4. Criteria and methods to be standardized for system planning

In preparing the supply plan and the new interconnection lines plan, it is necessary to apply standardized criteria, consideration method, and software to improve efficiency of the system operation and planning.

4.1. Criteria

There are five criteria. However, the specific criteria need to be carefully set based on the policies of each country's electric power business: (i) voltage, (ii) frequency, (iii) power stability, (iv) regulation power, and (v) spinning reserve.

4.2. Standard method

The system planning working group standardize the evaluation methods such as demand forecast, supply planning, and interconnections construction plan.

4.3. Software to be used for generation planning

Table 7 shows the software to be used for PDP based on the answers to the questionnaire. There are no de facto standards at present for generation planning software.

Table 7. Software to Be Used for PDP

Country	Software
Indonesia	Power development plan: WASP-IV Energy production/dispatch: jROS
Lao PDR	-
Malaysia (TNB)	• PLEXOS
Malaysia (Sarawak)	• EGEAS • Forecast Pro XE version6 • PSS/E version32 • Digsilent
Myanmar	• WASP • PSS/E
Philippines	• PSS/E
Singapore	• P-Plus • PLEXOS
Thailand	• Strategist

EGEAS = Electric Generation Expansion Analysis System.
Lao PDR = Lao People's Democratic Republic.
PDP = power development plan.
PSS/E = Power System Simulator for Engineering.
TNB = Tenaga Nasional Berhad.
WASP = Wien Automatic System Planning.
Source: Authors

Table 8 shows the features of and remarks for each software.

Table 8. Features of the Generation Planning Software

Software	Developer	Released	Note
EGEAS (Electric Generation Expansion Analysis System)	EPRI (Electric Power Research Institute, Inc.) USA	1983	The forerunner and funded by MISO (Midcontinent Independent Transmission System Operator)
PLEXOS® Integrated Energy Model	Energy Exemplar (Australia)	2000	Used in 43 countries, including PJM (Pennsylvania, New Jersey, Maryland), AEMO (Australian Energy Market Operator).
Strategist	ABB (ASEA Brown Boveri)	1980	The industry standard for nearly 30 years.
WASP (Wien Automatic System Planning)	IAEA	1972	Developed in 1970s to meet the needs of IAEA (International Atomic Energy Agency)

Source: Authors.

4.4. Software to be used for transmission planning

Table 9 shows the software to be used for TDP based on the answers to the questionnaire. PSS/E is currently used in many countries for transmission planning software.

Table 9. Software to Be Used for TDP

Country	Answer
Indonesia	PSS/E DigSILENT
Lao PDR	PSS/E Version 32 DigSILENT Version 15.0
Malaysia (TNB)	PSS/E
Malaysia (Sarawak)	PSSE Version 32
Myanmar	PSS/E NEPLAN
Philippines	PSS/E
Singapore	PSS/E
Thailand	DIgSILENT GmbH

Lao PDR = Lao People's Democratic Republic.
PSS/E = power system simulator for engineering.
TDP = Transmission Development Plan.
TNB = Tenaga Nasional Berhad.
Source: Authors.

Figure 10 shows the features of and remarks for each software.

Table 10. Features of the Transmission Planning Software

Software	Developer	Released	Note
PSS/E (Power System Simulator for Engineering)	Siemens (Germany)	1976	Leading global market share (>40%) Used in over 140 countries
PowerFactory	DigSILENT (Germany)	1990s	
NEPLAN	NEPLAN (Switzerland)		

Source: Authors.

4.5. Functions to be updated

To compare the current functions with function design and standardized criteria and procedures described, the following are some important points to be updated:

(1) Procedures, criteria, and software

a) AMS should develop and submit data and information to APP for the study of necessary interconnections on agreed schedule and format according to conclusions of the working group.

(2) Corporation process with other countries

a) AMS should support or involve the working group to study, discuss, and decide criteria, rules, and procedures about system planning.

b) AMS should support or involve the individual project to study, discuss, and decide necessary interconnections proposed by APP.

4.6. Capacity building for next steps

Basic idea and methodology about capacity building is consistent with ATSO implementation plan. The following are the key points from the ATSO implementation plan made by Nord Pool Consulting:

(1) The introduction of the APP organization will create a need for training and capacity building for both the APP organization and relevant shareholders in the AMS.

(2) The capacity building is most likely needed throughout the whole APP establishment and organizational building phase from initial stage to advanced stage.

(3) The capacity building should be applied whenever and wherever a new function or field of work is added to the APP where the employees require additional knowledge and expertise to run the new tasks and operation duties.

(4) The training of AMS TSO controllers is key to ensuring operational security and reliability of the interconnection.

(5) The high-level training plan for the APP organization should consist of three parts:

a) Administrate APP, business transparency and business execution

b) Manage APP, business improvement and development

c) Operate APP, system planning, operation and coordination, IT and SCADA, trading

In capacity building for system planning, the system planning department starts activity after the establishment of APP. At the initial stage, the working group discuss the rules, regulations, procedures, and criteria on how to implement system planning study in APP supported by AMS experts. To prepare for the discussion, capacity building to APP staff and AMS experts to participate in the working group is essential. Capacity building is implemented at the first stage of the working group activities. At the advanced stage, after decision on rules, capacity building to inform new standard to the AMS experts and all related shareholders in the AMS is necessary. A summary of the two stages is shown below.

(1) Initial stage

a) Contents

To prepare for the discussion in the working group to decide the rules, regulations, procedures, and criteria on how to implement system planning study in APP supported by AMS experts

(b) To whom

(i) APP staff in charge of system planning

(ii) AMS experts of system planning

(iii) Relevant shareholders in the AMS

(2) Advanced stage

b) Contents

To inform new standard

c) To whom

(i) APP staff in charge of system planning

(ii) AMS experts of system planning

5. Barriers and solutions

For next steps, the key point is discussion in the working group at the initial stage after APP establishment. Table 11 summarizes the discussion points.

Table 11. Discussion Points in the System Planning Working Group

No.	Barriers	Solutions
1	Error! Reference source not found. To set the annual schedule and decide date of submission	All items should be discussed in the working group with AMS experts, and minimum parts should be standardized.
2	Error! Reference source not found. **for system planning** To decide the necessary and minimum data to submit to APP (i) Demand/supply capability (ii) Plan to construct/deprecation power supply and distribution facilities (iii) Plan to utilize of interconnections	
3	Error! Reference source not found. To decide the evaluation method of the supply plan to judge the necessary interconnections	
4	Regarding individual project, to decide who participates, how to proceed, what to be discussed	
5	Error! Reference source not found. Regarding planning of repair and augmentation of interconnections, to decide the criteria, how to study, what to be proposed by APP	
6	Error! Reference source not found. **and s**Error! Reference source not found. To standardize criteria and procedures to develop demand forecast, PDP, TDP, etc.	
7	**Software for system analysis** Each software for generation and transmission planning should be discussed whether to set the standard	

AMS = ASEAN member state.
APP = ASEAN Power Pool.
PDP = power development plan.
TDP = transmission development plan.
Source: Authors.

References

ATSO Implementation Plan and Roadmap by Nord Pool Consulting (unpublished document)

ENTSO (n.d.), 'Cost Benefit Analysis Methodology CBA 1.0 for TYNDP Project Assessment', https://docstore.entsoe.eu/major-projects/ten-year-network-development-plan/CBA-Methodology/Pages/default.aspx (accessed 31 December 2018)

ENTSO Europe's Network Development Plan to 2025, 2030 and 2040 (2018), 'Stakeholder Engagement', https://tyndp.entsoe.eu/Documents/TYNDP%20documents/TYNDP2018/consultation/Communication/ENTSO_TYNDP_2018_StakeholderEngagement.pdf (accessed 31 December 2018)

ENTSO-E (2015), *ENTSO_E at A Glance.* https://docstore.entsoe.eu/Documents/Publications/ENTSO-E%20general%20publications/entsoe_at_a_glance_2015_web.pdf (accessed 20 December 2018).

Heads of ASEAN Power Utilities/Authorities (HAPUA), http://www.aseanenergy.org/blog/the-evolution-of-electricity-trades-in-asean/ (accessed 31 December 2018)

Japan Electric Power Information Center (n.d.), 'Synchornous Grid Development in Europe', https://www.jepic.or.jp/JEPICDB/index.html (accessed 20 December 2018).

Ministry of Energy, Trade and Industry (METI), Japan, Advisory Committee for Natural Resources and Energy, 'Report of the Electricity System Reform Expert Subcommittee' (2013),https://www.meti.go.jp/english/policy/energy_environment/electricity_system_reform/pdf/201302Report_of_Expert_Subcommittee.pdf (accessed 31 December 2018)

Organization for Cross-regional Coordination of Transmission Operators (OCCTO) (n.d.), 'Securing Mid-term and Long-term Stable Electricity Supply'. https://www.occto.or.jp/en/about_occto/securing.html (accessed 20 December 2018).

Organization for Cross-regional Coordination of Transmission Operators (OCCTO) (n.d.), 'About' https://www.occto.or.jp/en/about_occto/about_occto.html

SAPP (n.d.) 'SAPP demand and supply', http://www.sapp.co.zw/demand-and-supply (accessed 31 December 2018)

Southern African Power Pool (n.d.), 'Interconnectors', http://www.sapp.co.zw/interconnectors (accessed 20 December 2018).

Southern African Power Pool (n.d.), 'Planning Sub-committee'. http://www.sapp.co.zw/coordination-centre/planning-sub-committee (accessed 20 December 2018).

Southern African Power Pool (n.d.), 'Project Development Road Map'.

http://www.sapp.co.zw/project-development-road-map (accessed 31 December 2018).)

Southern African Power Pool (n.d.), http://www.sapp.co.zw/ (accessed 20 December 2018).

Yamazaki, T. (2015), *Japan's Electricity Market Reform and Beyond.*, 'Japan's Electricity Market Reform and Beyond'. Ministry of Economy, Trade and Industry (METI). https://studylib.net/doc/18302969/japan-s-electricity-market-reform-and-beyond (accessed 20 December 2018).