Chapter 3

Case Example of Japan, Europe, and SAPP

This chapter should be cited as
Study team (2019), 'Case Example of Japan, Europe, and SAPP', in Tokyo Electric Power Company Holdings (eds.), *Study on the Formation of the ASEAN Power Grid Generation and Transmission System Planning Institution.* ERIA Research Project Report FY2018 No. 25, Jakarta: ERIA, pp.10-26.

Chapter 3

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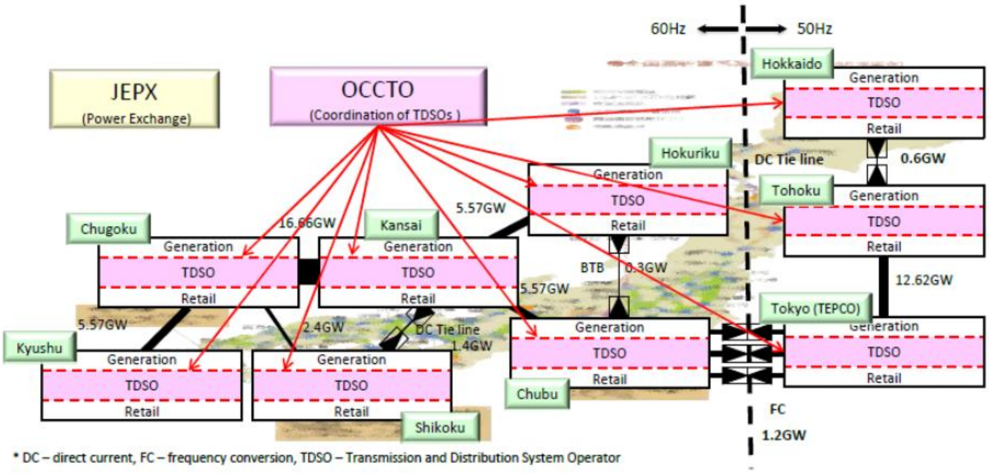
1. Function of system planning for the interconnections

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

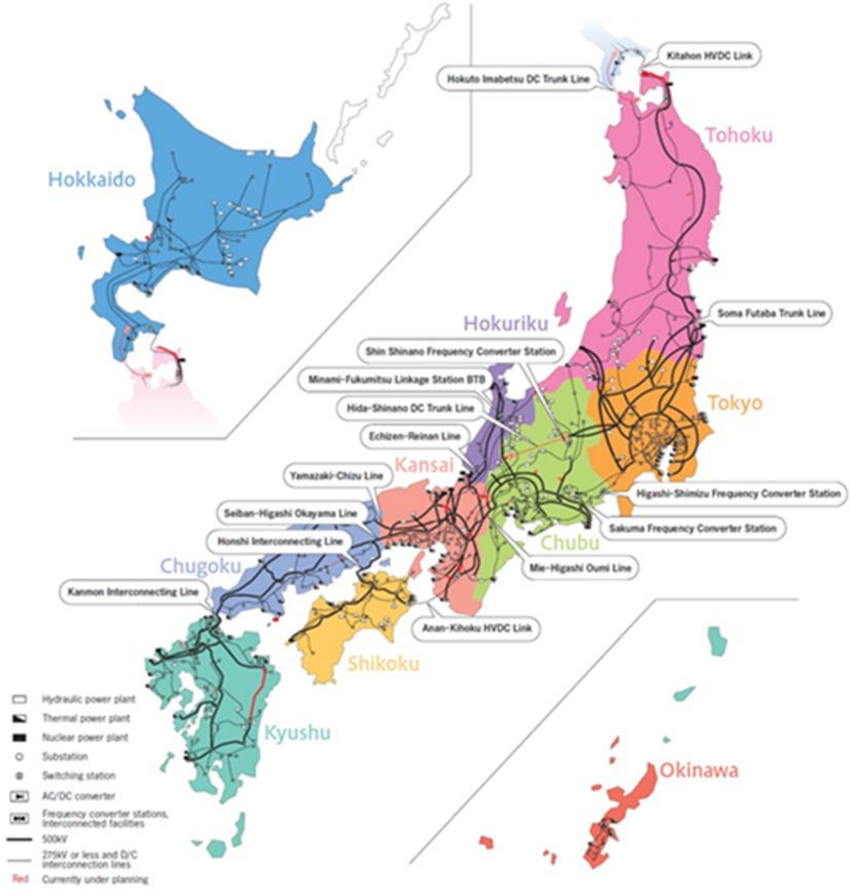
  (iii) Managing use of interconnection lines

  (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.

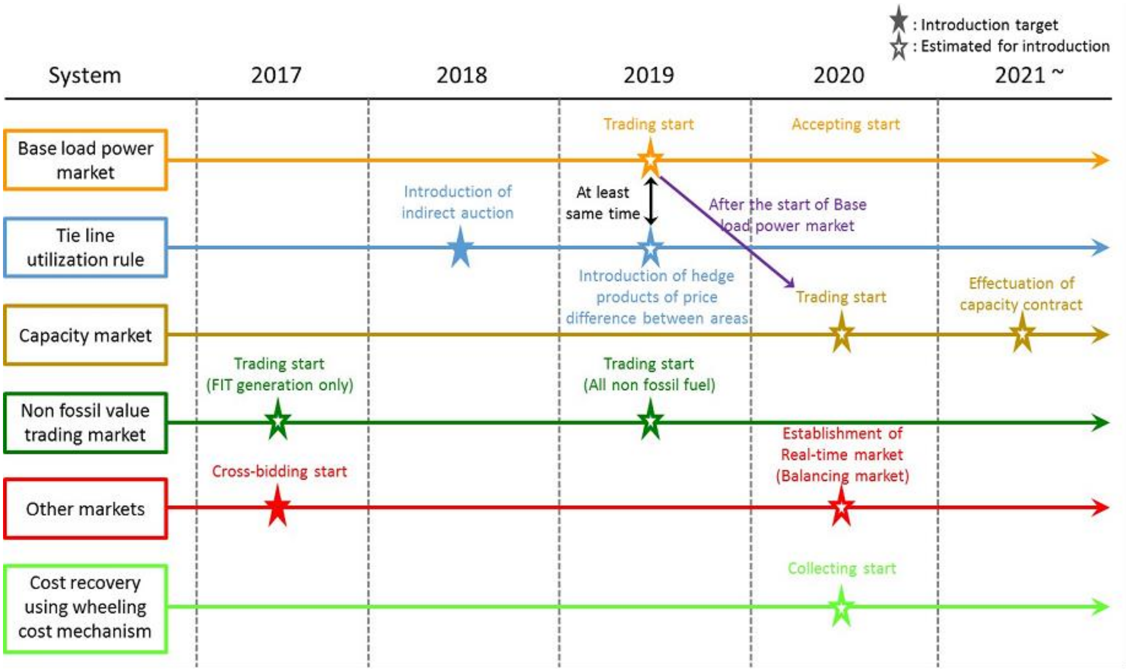
Plan of electricity system reform and market design

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

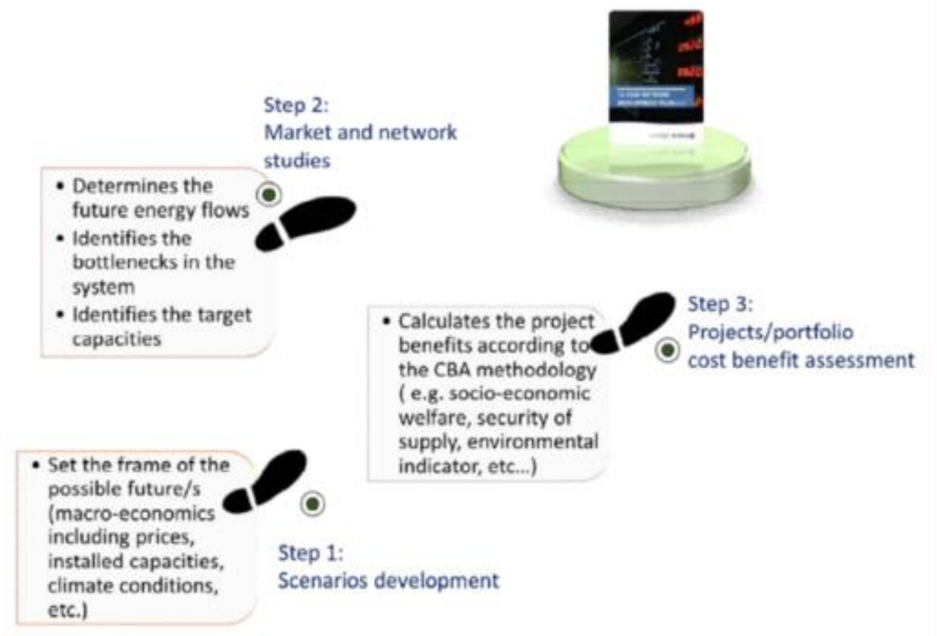


Source: Advisory Committee for Natural Resources and Energy, 'Interim report of subcommittee to achieve the Electricity System Reform' by Ministry of Energy, Trade and Industry (METI), Japan.

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.

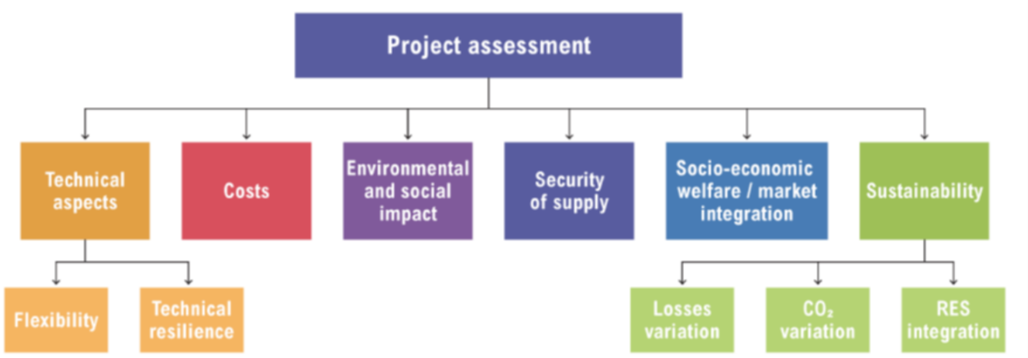
(3) Step 3. Projects assessment

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.

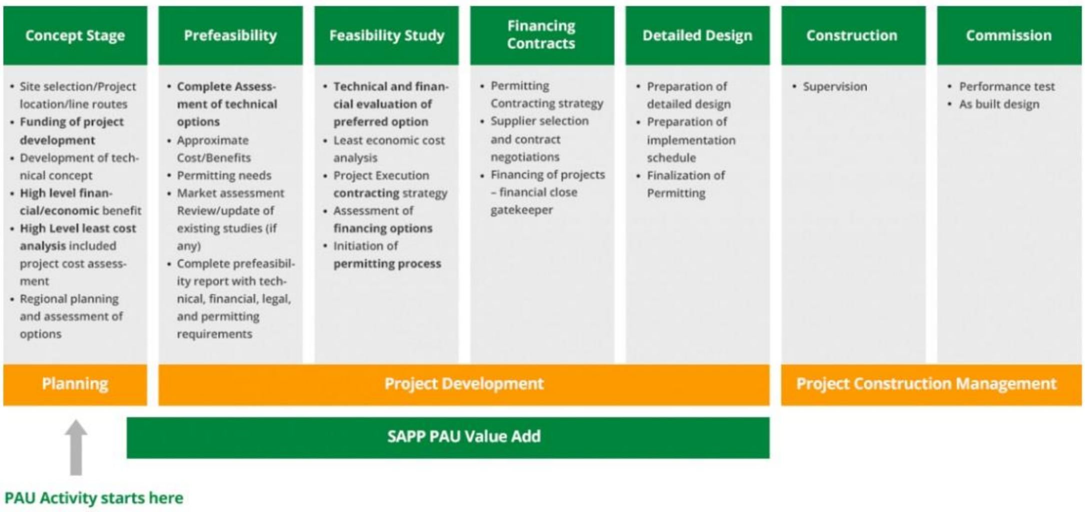
(9) Determining the transfer capability limits between systems on an annual basis or as and when required to enable the operating sub-committee to prepare detailed operating procedures.

(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

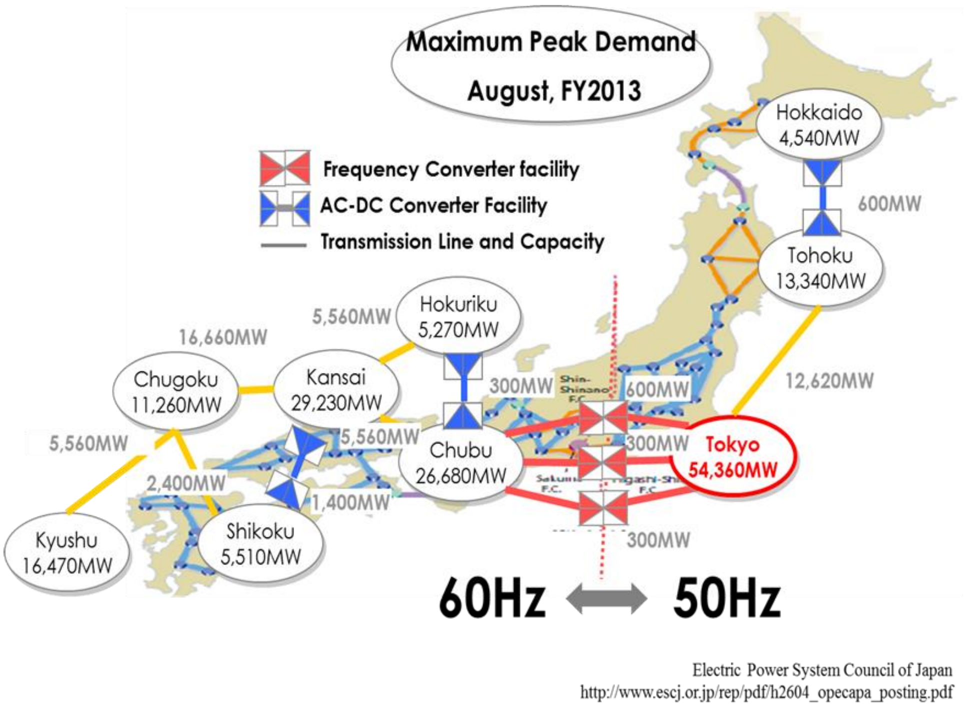
In this section, we present the history, current practices, and future prospects of electric power industry in Japan, focusing on the cross-regional grid system operation and power trade. The electric power industry in Japan has been developed under the coordination of regional power utility companies (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



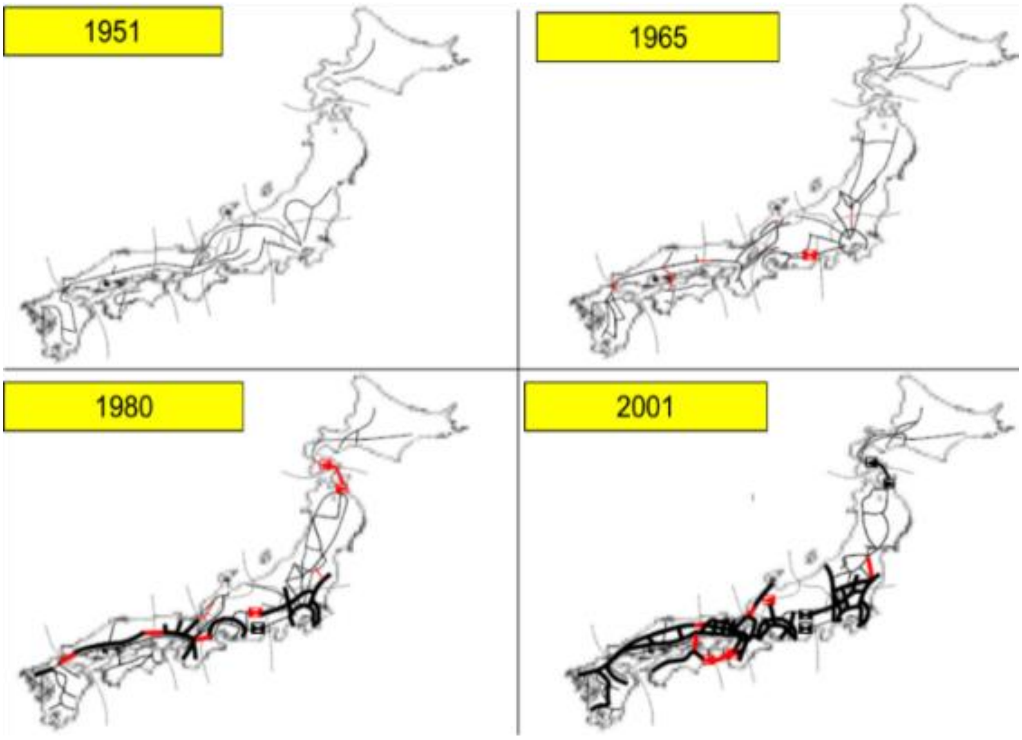
Source: Authors.

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.

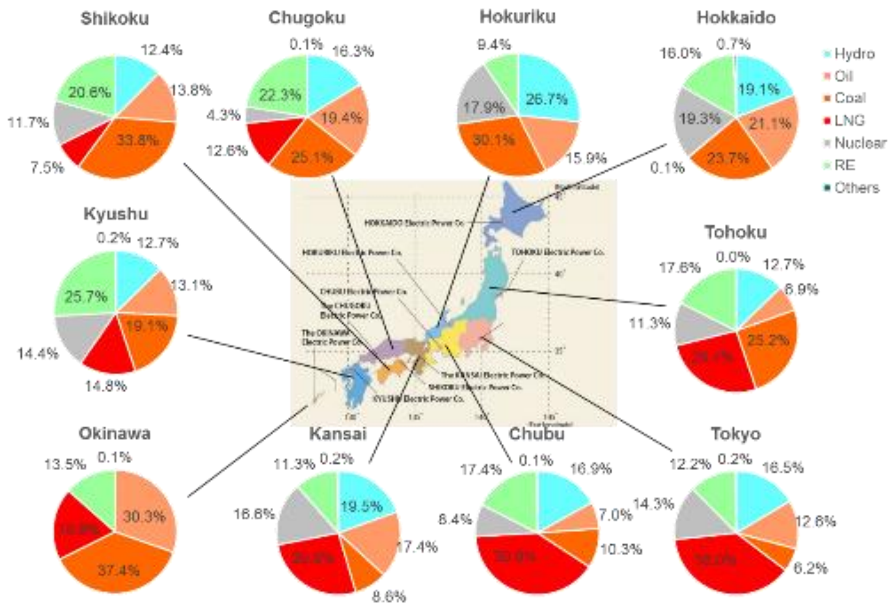
Figure 9: Development of Interconnection Lines, Japan



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.

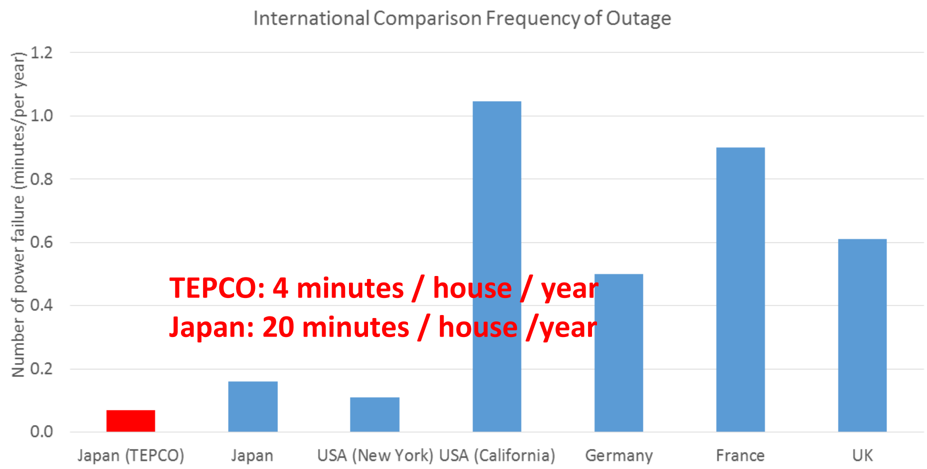
Table 1: Frequency Record of TEPCO

	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.

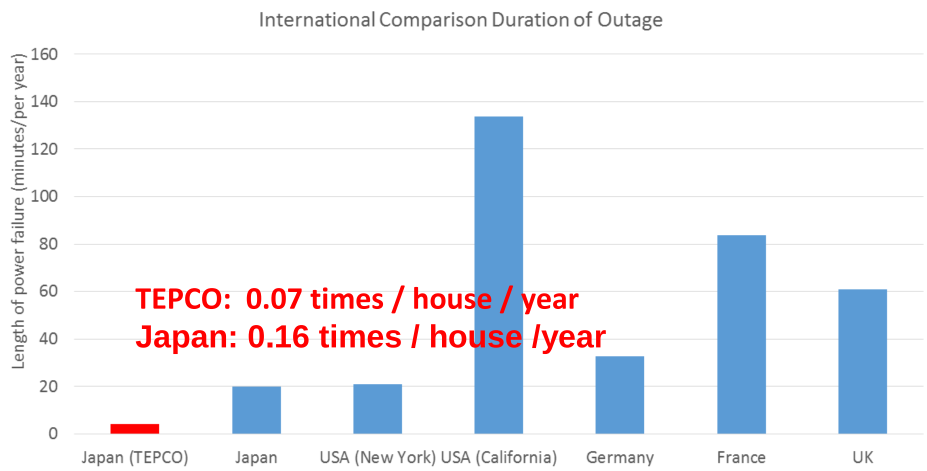
Figure 12 and Figure 13 show the international comparison of SAIDI and SAIFI in 2012.

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

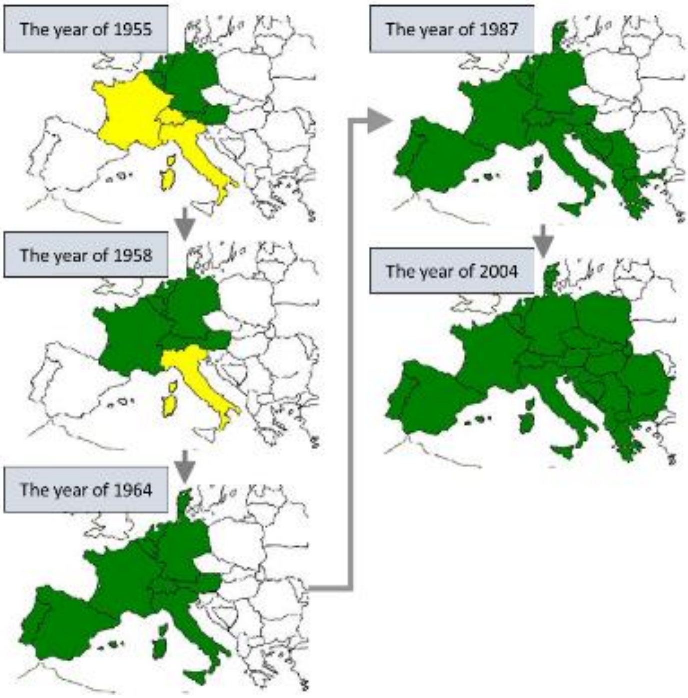


SAIFI = system average interruption frequency index.
TEPCO = Tokyo Electric Power Company.
Source: Authors.

2.2. Europe

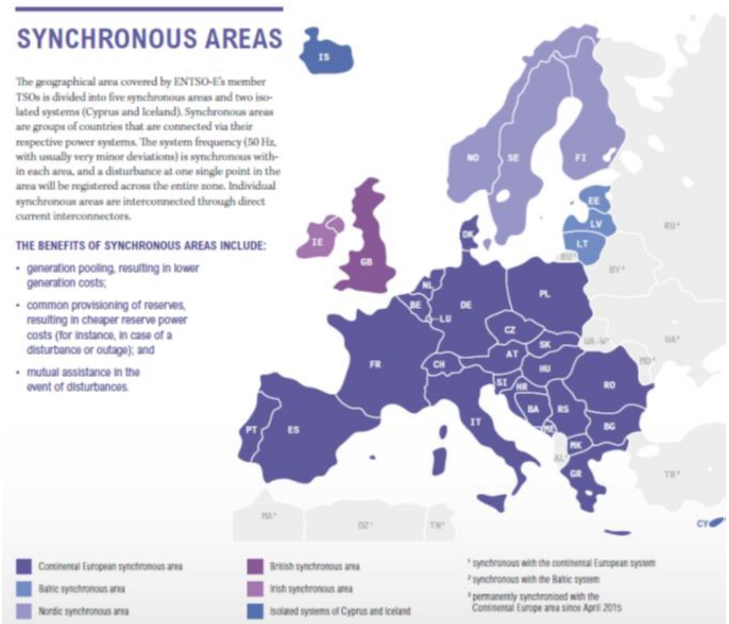
The next figures show the synchronous grids in Europe. The figures below show the synchronous grids in Europe.

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

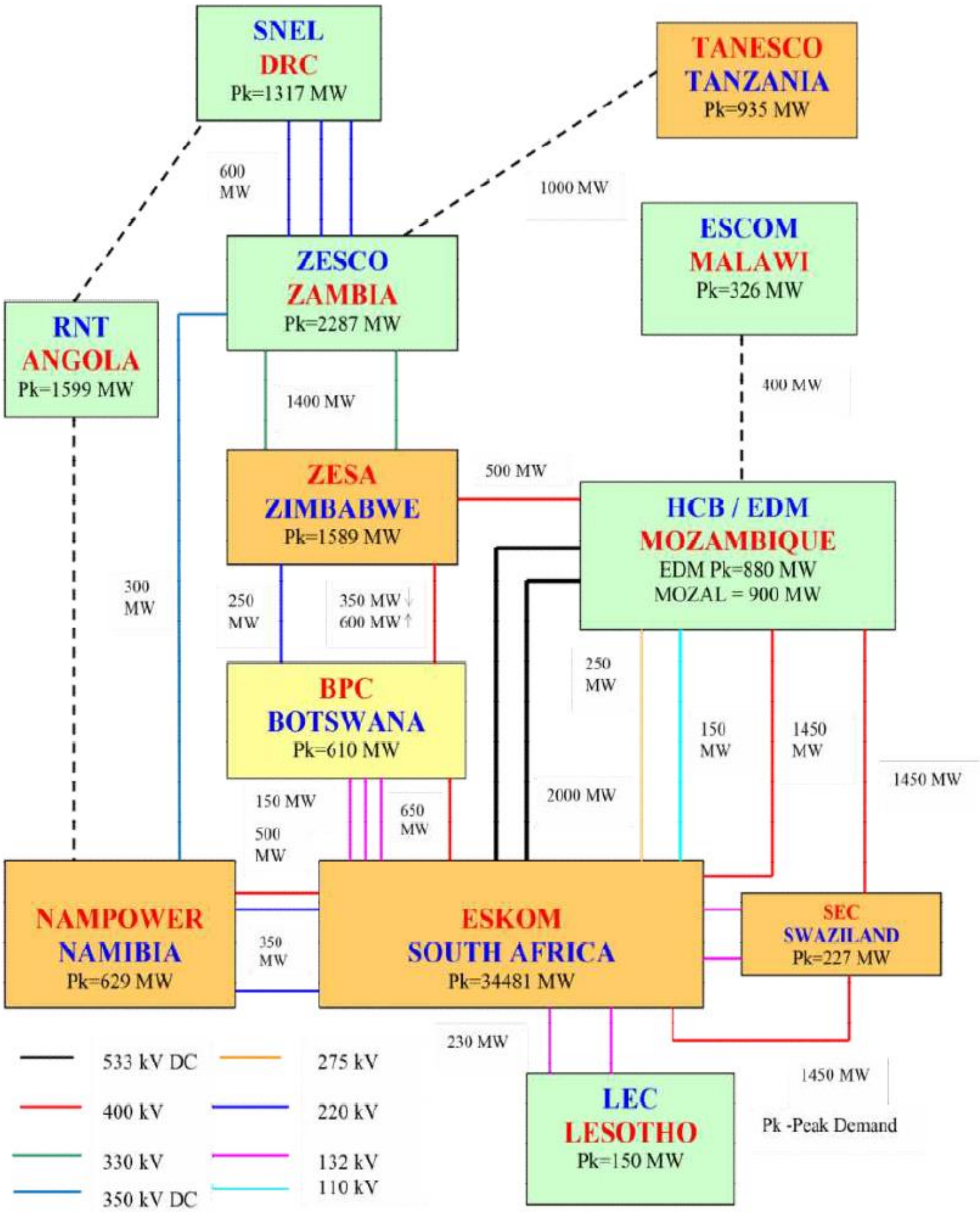
No. Country	Utility	Installed Capacity (MW)	Operating Capacity (MW)	Current Peak Demand (MW)	Peak Demand Plus Reserves	Capacity excess / shortfall including Reserves
Angola	RNT	3,129	2,500	1,869	2,138	362
Botswana	BPC	927	459	610	698	-239
BRC	SNEL	2,457	1,076	1,376	1,574	-498
Lesotho	LEC	74	70	150	172	-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