Asia International Grid Connection Study Group

Interim Report

APR 2017

ASG SG Interim Report: Members

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Table of Contents

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Chapter1: Basic Concept of an International Power Grid

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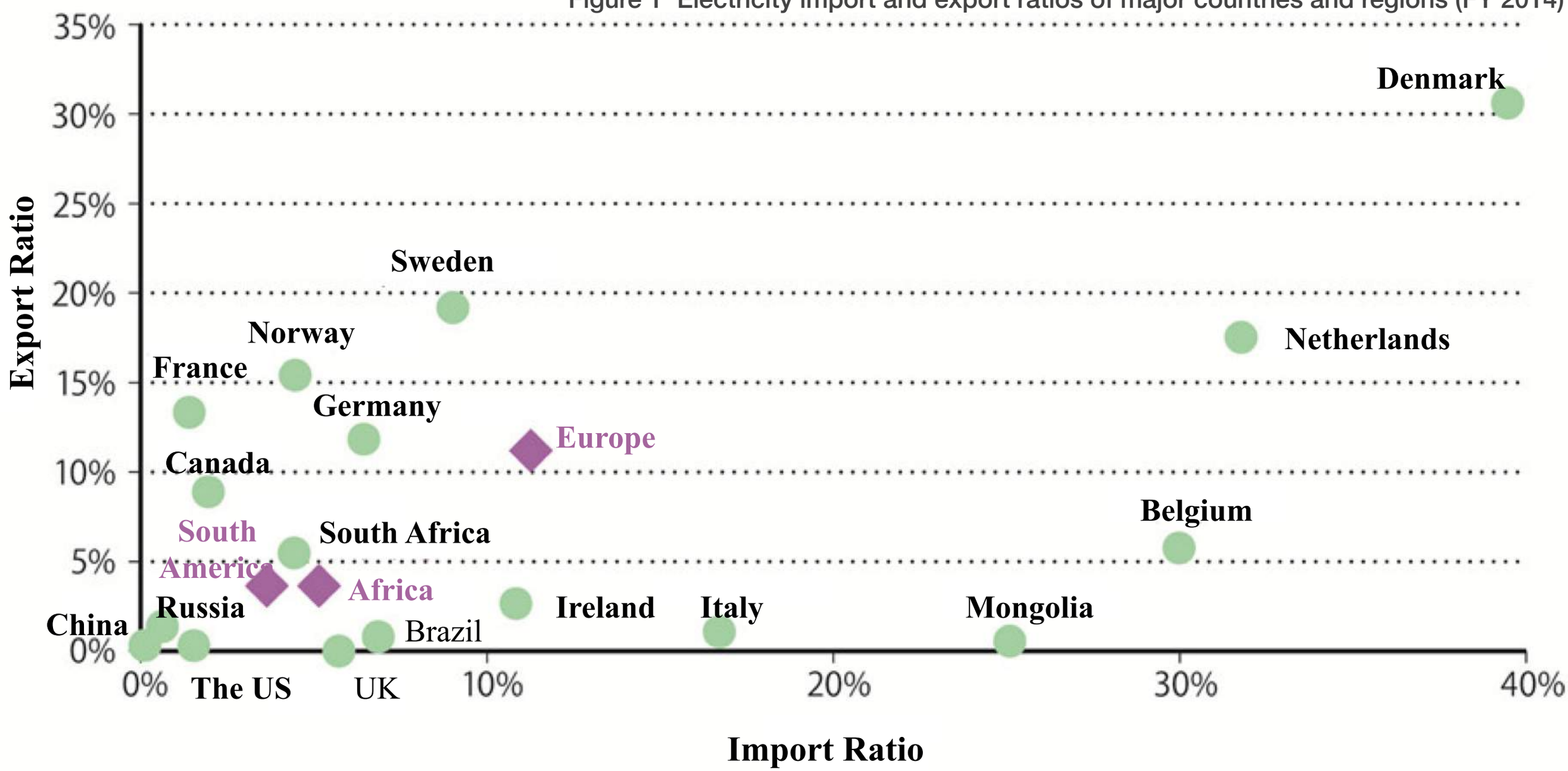
- Electricity trade via interconnections is common practice in many regions in the world, including Europe and North America.
- In Europe as a whole, import and export ratios are 11.3% and 11.2%, respectively
- Electricity is tradable, and can be reasonably imported and exported with economic benefits if there is a physical interconnection.

Figure 1 Electricity import and export ratios of major countries and regions (FY 2014)



Source: IEA, Electricity Information 2016

Purposes of the international power grid

1. Improvements in economic efficiency through international competition

・A country with a higher electricity price could import cheaper power from another country at lower price.

・ A country may supply electricity at a lower price in a time period and offer a higher price in another period.

・Two countries, when connecting their markets to trade electricity on a larger scale, competition between them drives down power prices in both. (win-win relationship)

2. Stable supply of electricity thanks to larger network.

・A larger network generally makes it easier to balance supply and demand by integrating large numbers of power plants and consumers.

・Great complementarity between countries with different power supply structures or supply-demand patterns .

3. An effective solution to output fluctuation, and helps integrate more renewables.

・ Helps secure stability of power supply, especially when much of the supply comes from variable power sources. (equalization effect)

Diplomatic concerns and benefits:

1. Diversification of risks contributes to energy security

・Japan imports a significant amount of oil and LNG from the Middle East.

Power interconnections with neighboring countries could be added as an option for energy source diversification.

2. Appropriate scale of interconnections and multiple routes should be secured.

・Usual interconnection has a capacity of around 1 GW. Several interconnection systems would not supply more than 2-3% of the maximum demand in Japan.

・Multiple transmission lines with several countries both for exporting and import would mitigate risks and enhance security.

3. Relations of reciprocity developed through such economic transactions

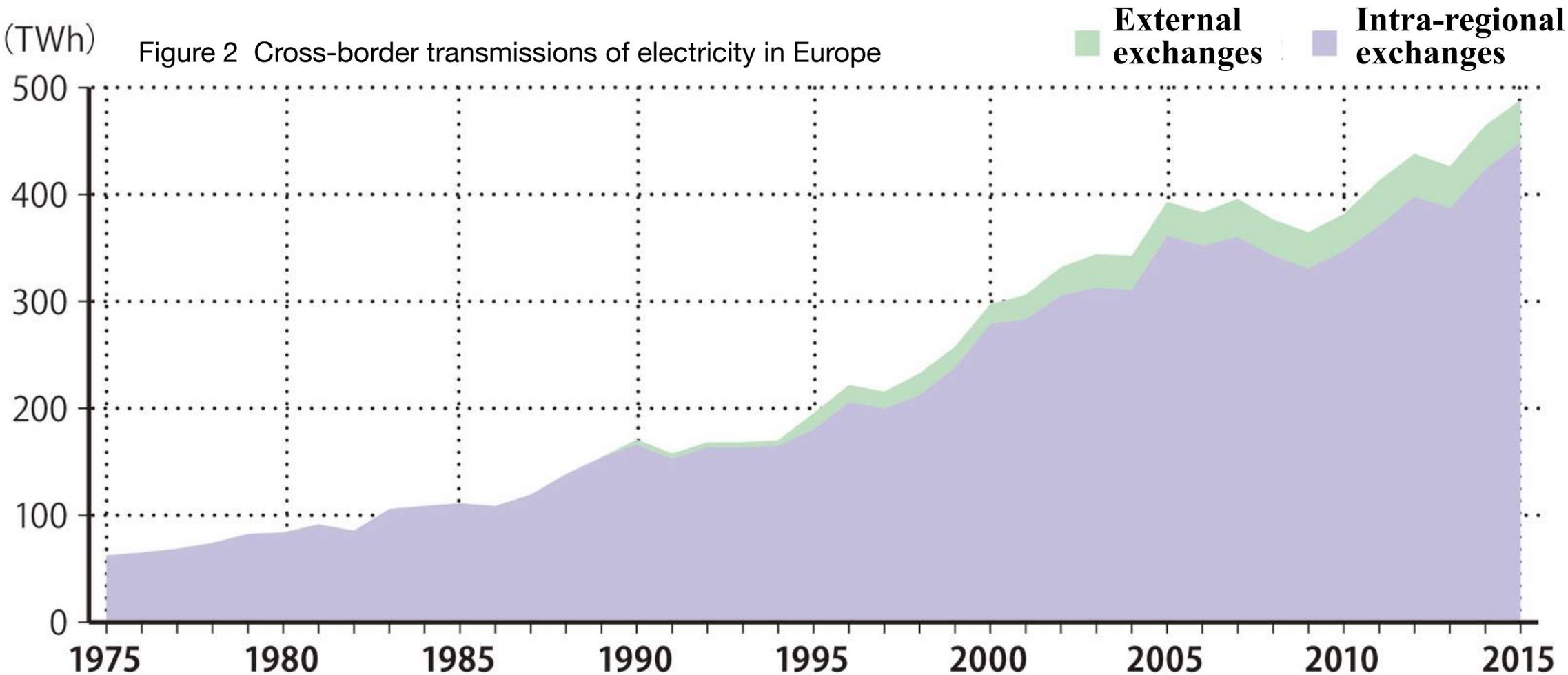
・In Europe, since the world war political support for market integration and interconnections has helped to maintain peace.

・Economic interdependence leads countries in a good diplomatic relationship for a long term.

Background of recent growth of the international power grid in Europe

1. Rapid advancement of electricity liberalization: liberalized market sought larger merged electricity market and accelerated cross-border electricity trade.
2. Renewables rapid expansion: wider-regional operation and interconnectors developed as the most efficient way to provide flexibilities to electricity systems.
3. Great technology development: Great advancement of HVDC technology, which enabled low cost and efficient long distance transport of electricity.

Figure 2 Cross-border transmissions of electricity in Europe



Source: by Renewable Energy Institute based on ENTSO-e, Statistical Yearbook 2011, Statistical Factsheet 2015

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【Since 1910s】

- 1915 Denmark-Sweden Interconnection
- 1920 Interconnection between France, Switzerland and Italia.

【After WWII】

- 1951 UCPTE among 8 countries. (West-Germany, France, Italy and others)
- 1963
  NORDEL in Northern Europe
  UFIPTE by France, Spain and Portugal

【Currently】

The region is divided into four synchronous grids, Continental Europe, Nordic, UK, and Baltic, and they are connected asynchronously through direct current transmission, so that electricity trade can be conducted among them.

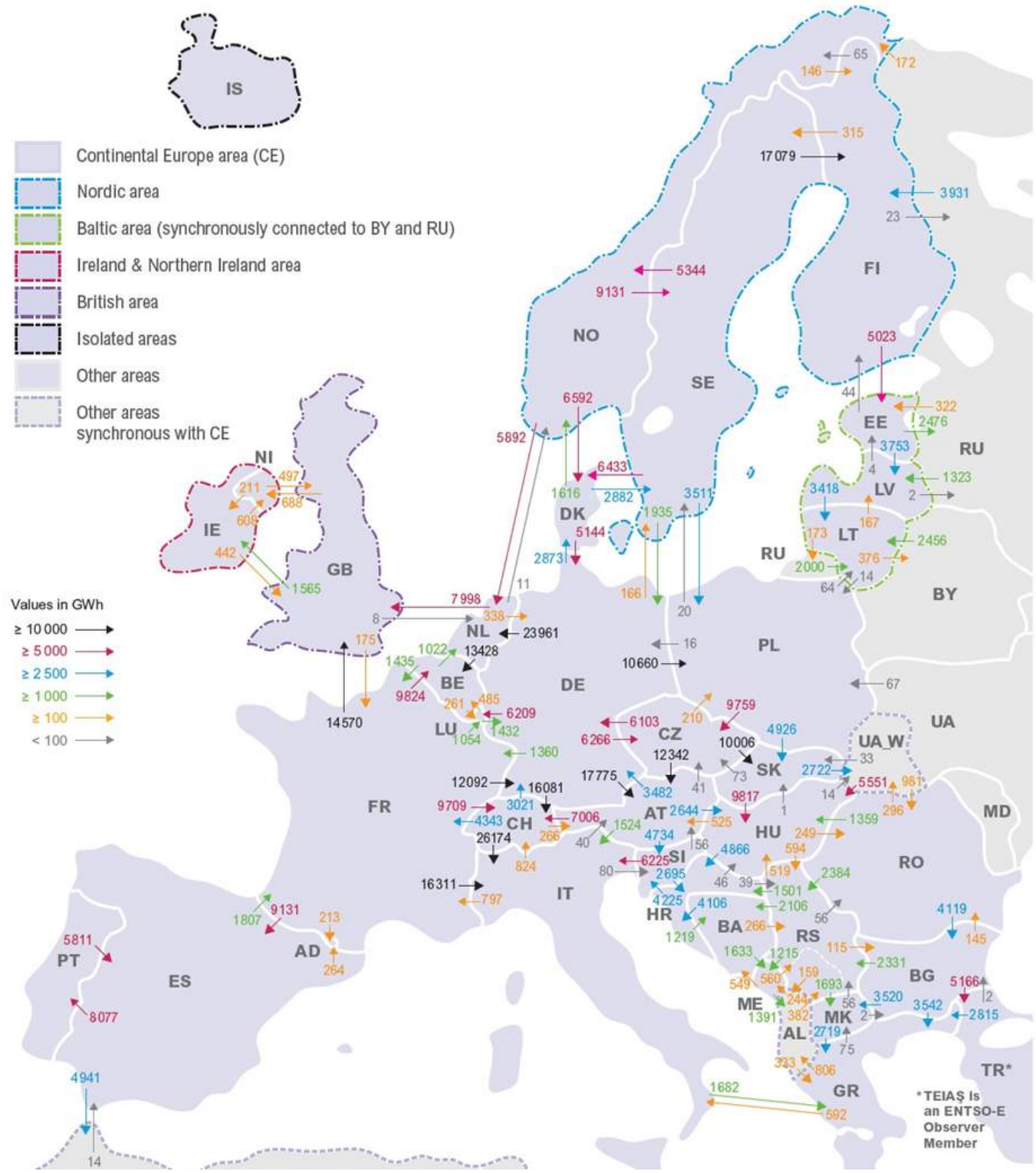

Figure 5 Power flows between countries in Europe (2015)
Source: ENTSO-e, Statistical Factsheet 2015

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Table 1: Major large-scale DC transmission projects overseas

No.	Project		Distance (km)	Under sea part (km)	Transmission method	Grid voltage (kV)	Transmission capacity (MW)						
1	SAPEI		435	420		400	±500	1,000	2011	$180m	€400m	€750m	20
2	BritNed		259	250		400 380	±450	1,000	2011	€220m	$350m	€600m	26
3	Nemo Link		141	130		400 380	±400	1,000	2019	—	—	€500m	40
4	Estlink 2		171	145		330 400	450	650	2014	€100m	$180m	€320m	32
5	NorNed		583	580		380 300	±450	700	2008	$270m	€51m	€600m	17
6	Fenno-Skan 2		196	194		400	±500	800	2011	$170m	€150m	€315m	23
7	Skagerak 4		243	140		400 300	±500	700	2014	$180m	€87m	—	17
8	Nord.Link		623	516		380 420	±525	1,400	2019	$900m	€500m	€1.5—2.0b	20～26

※114.0円/€、103.8円/$で換算（10/19日現在の為替レート）

Source: “On Preparation of Long-term Cross-regional Network Development Policy,” Material No. 1 for the 18th Meeting of the Cross-regional Network Development Committee, OCCTO (October 25, 2016, Committee Secretariat)

Table 2: Major benefits expected from interconnection for countries (Case of HVDC cables)

Country	Challenges	Major benefits expected by connected countries			
		UK	Norway	Denmark	Netherlands
UK	Higher shares of thermal and nuclear power. Replacing them in the future is a challenge. Higher wholesale electricity prices than in Nordic countries and the Continent.	–	Cheaper hydropower. NSL	Cheaper excess wind power. Viking Link	Cheaper power. BritNed
Norway	98% of electricity comes from hydropower. Hydropower is cheaper while securing capacities in drought is a challenge.	Supply capacities in drought. NSL	–	Supply capacities in drought. Cheaper excess wind power. Skagerrak	Supply capacities in drought. Supply of gas-fueled power at times when cheaper. NorNed
Denmark	Its wind power plants have a maximum capacity larger than demand at specific times. Optimizing wind power use is a challenge.	Higher adjustability. Viking Link	Cheaper hydropower. Higher adjustability. Skagerrak	–	Higher adjustability. COBRAcable
Netherlands	Electricity is supplied mainly by gas and coal-fired power plants. Higher wholesale electricity prices than in neighbors (Germany and France).	Enhanced supply capacities. BritNed	Cheaper hydropower. NorNed	Cheaper excess wind power. COBRAcable	–

*Shaded in light blue are projects in operation. The others are under construction or in the planning phase.

・Physically Short distance （Cape Soya–Sakhalin 43km, Fukuoka–Busan 200km）

・Multiple large-scale demand zones, centers of economic activity, adjoin each other.

・The four countries of Japan, China, South Korea, and Mongolia together account for 76% of Asia's power generation and 77% of its power consumption

	GDP (in billion dollars) Figures in parentheses are GDP per capita (in thousand dollars)	Population (in million people)	Electricity generated (in TWh)	CO_2 emissions (in million tons CO_2)
China	8,909 (6.5)	1,376	5,811	9,154
Japan	5,986 (47.2)	127	1,036	1,208
South Korea	1,267 (25.0)	50	522	649
Mongolia	12 (3.9)	3	5	18
Russia	1,616 (11.0)	143	1,063	1,483
Northeast Asia	17,790 (~10.5)	1,699	8,437	12,512
World	74,889 (10.2)	7,349	24,098	33,508
Share of Northeast Asia	20-25%	20-25%	30-35%	~37%
Source	World Bank *Constant 2010	United Nations	BP; For Mongolia, figure from IEA in 2014	BP; For Mongolia, figure from IEA in 2014

Source: by Renewable Energy Institute based on data released by national governments and international organizations.

Structures of electricity industries and markets in Northeast Asian countries

	Generation	Transmission	Distribution	Retail	Wholesale electricity trading market	Electricity trading
China	State-owned enterprise (5 major power companies: Owning more than 50% of total generation capacity) Local government-owned enterprise Private-sector companies	State-owned TSO (State Grid Corporation of China (SGCC): Operating transmission and distribution networks covering 88% of China's land) *Other operators in some areas. *Some plants and end-users trade directly between themselves.			No	State-owned TSO (SGCC) *Other operators in some areas.
Japan	Major power companies (Owing 80% of generation capacity) Independent power producers, etc.	In the process of legal unbundling, to be completed by 2020. * TEPCO Power Grid already set up as independent.		Electric retailers	Yes 2-3% of total demand	No experience
South Korea	State-owned enterprise (KEPCO Group: 75% of generation capacity) Private-sector companies	State-owned TSO (KEPCO)			Yes[18] Approx. 95%	No experience
Mongolia	State-owned enterprise Private-sector companies	State-owned TSO (The National Transmission Company)	State-owned distribution & retail company Private-sector distribution & retail companies		No[19]	State-owned TSO (The National Transmission Company)
Russia	State-owned enterprise (More than 60% of generation capacity) Private-sector companies	State-owned TSO[20] (Rosseti Group)	State-owned distribution company (Rosseti Group) Private-sector distribution companies	State-owned retail company (Rosseti Group) Private-sector retail companies	Yes[21] Approx. 97% (2015)	State-owned electricity trading company (Inter RAO)

Source: by Renewable Energy Institute based on data released by national governments and international organizations.

Current status of Power market structure in NEA countries.

1. Each of these countries permits private-sector participation in generation sector, including foreign investments

2. In each of these countries other than Japan, unbundling is introduced, with the grid operated by a state-run transmission company.

Japan is in the process of a legal unbundling planned for completion by 2020.

3. Japan, South Korea, and Russia each have their own wholesale electricity markets as part of initiatives they are pursuing for market liberalization.

4. Electricity trading is carried out by the state-owned transmission companies in China and Mongolia, and Inter RAO in Russia.

Chapter 3: The Current State and Feasibility of an International Power Grid in Northeast Asia

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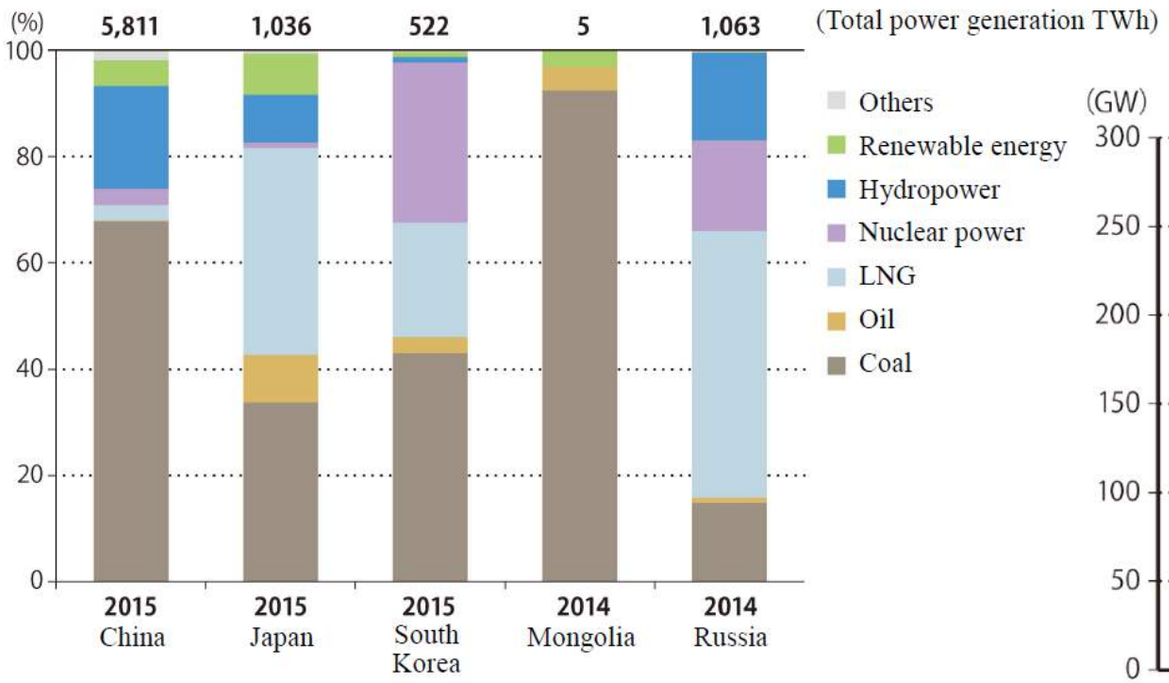
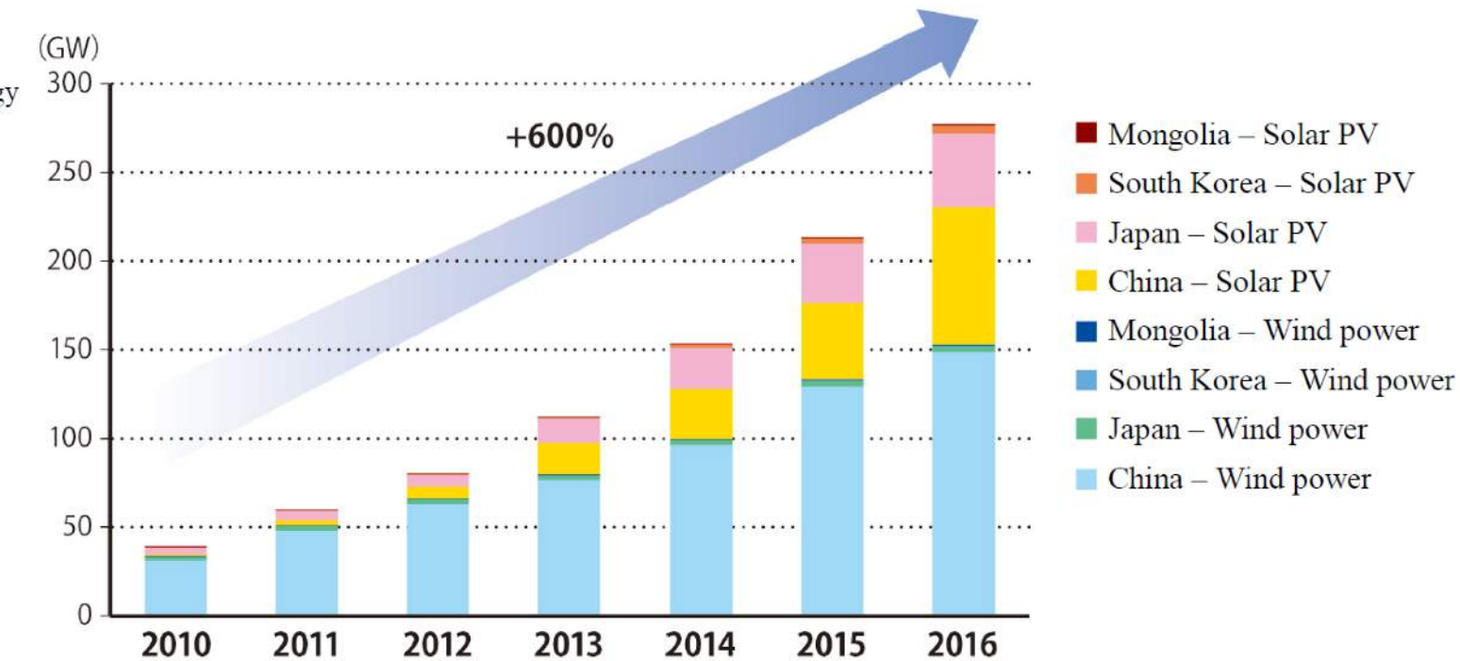
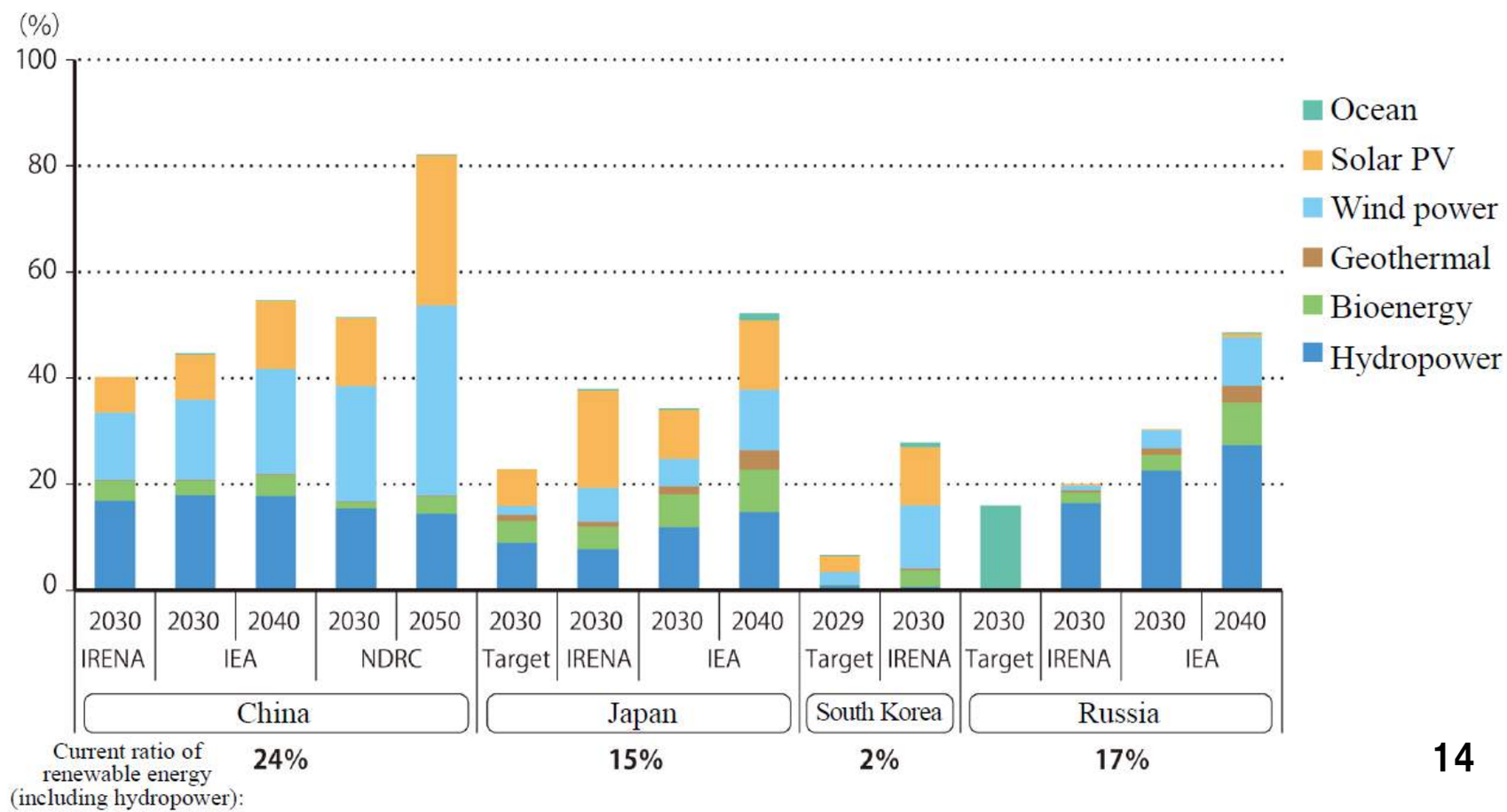
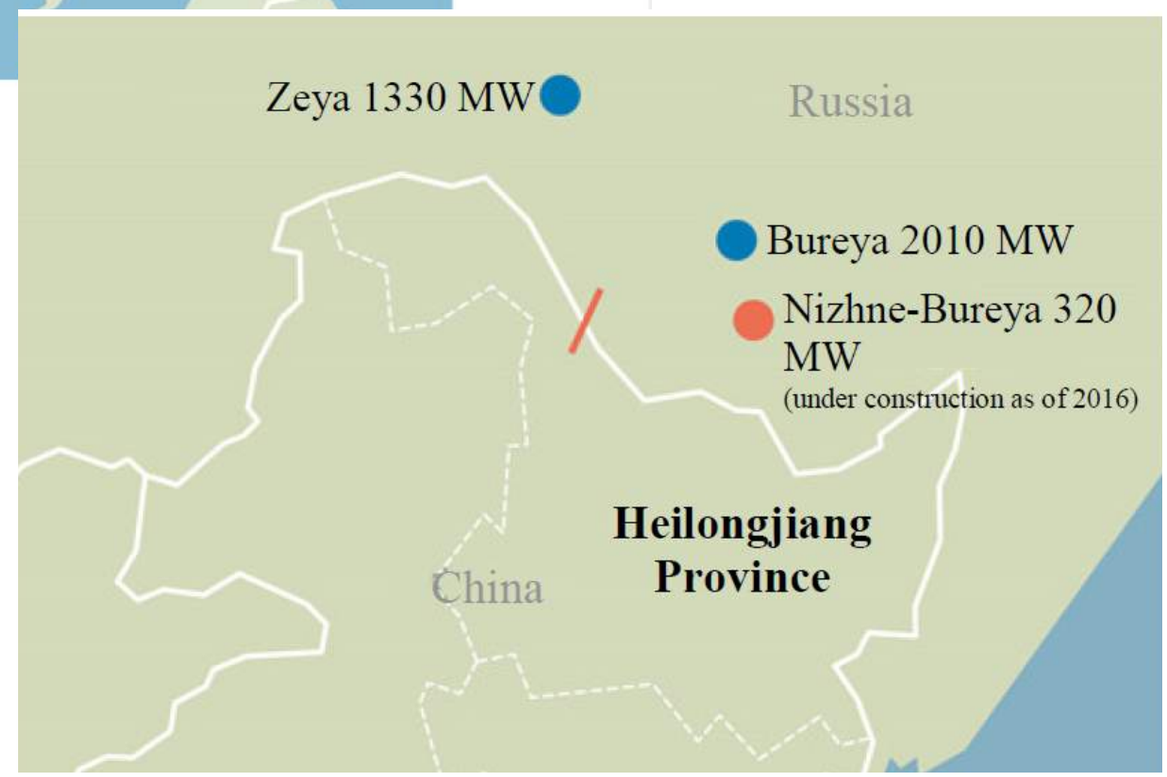




Currently, mutual complementarity of power supply structures among Northeast Asian countries is not so much expected. On the other hand, each country has been actively promoting investments in domestic renewable energy.




Existing interconnections
Russia
Russian Far East
500kV(1)
220kV(2)
110kV (1)
Amur Oblast
110 kV
transmission line
220 kV
transmission line
Heilongjiang
Province
Mongolia
Oyu Tolgoi
copper mine
220 kV
transmission line
China
Inner
Mongolia


Zeya 1330 MW
Russia
Bureya 2010 MW
Nizhne-Bureya 320
MW
(under construction as of 2016)
Heilongjiang
Province
China

Chapter 3: The Current State and Feasibility of an International Power Grid in Northeast Asia

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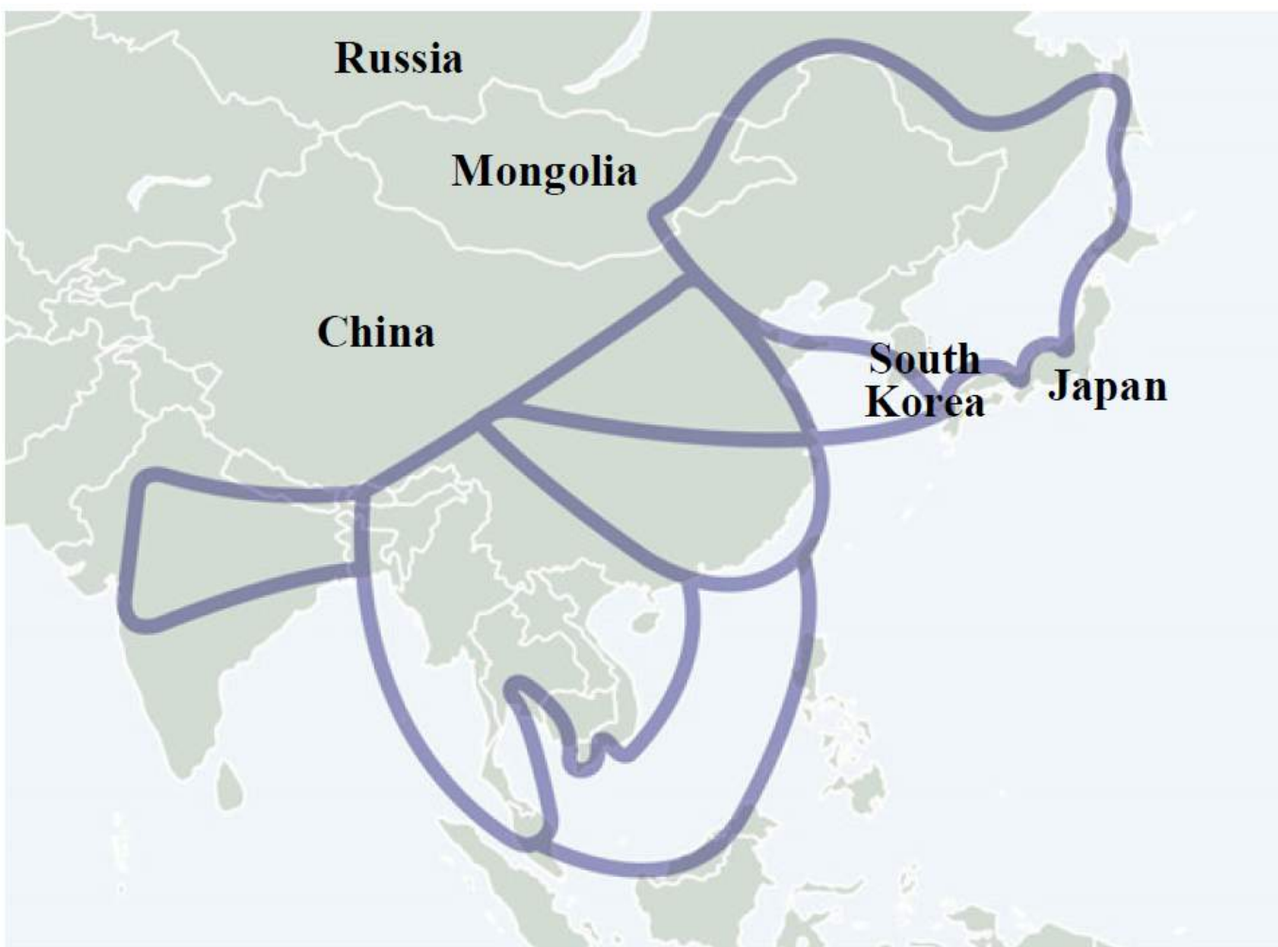
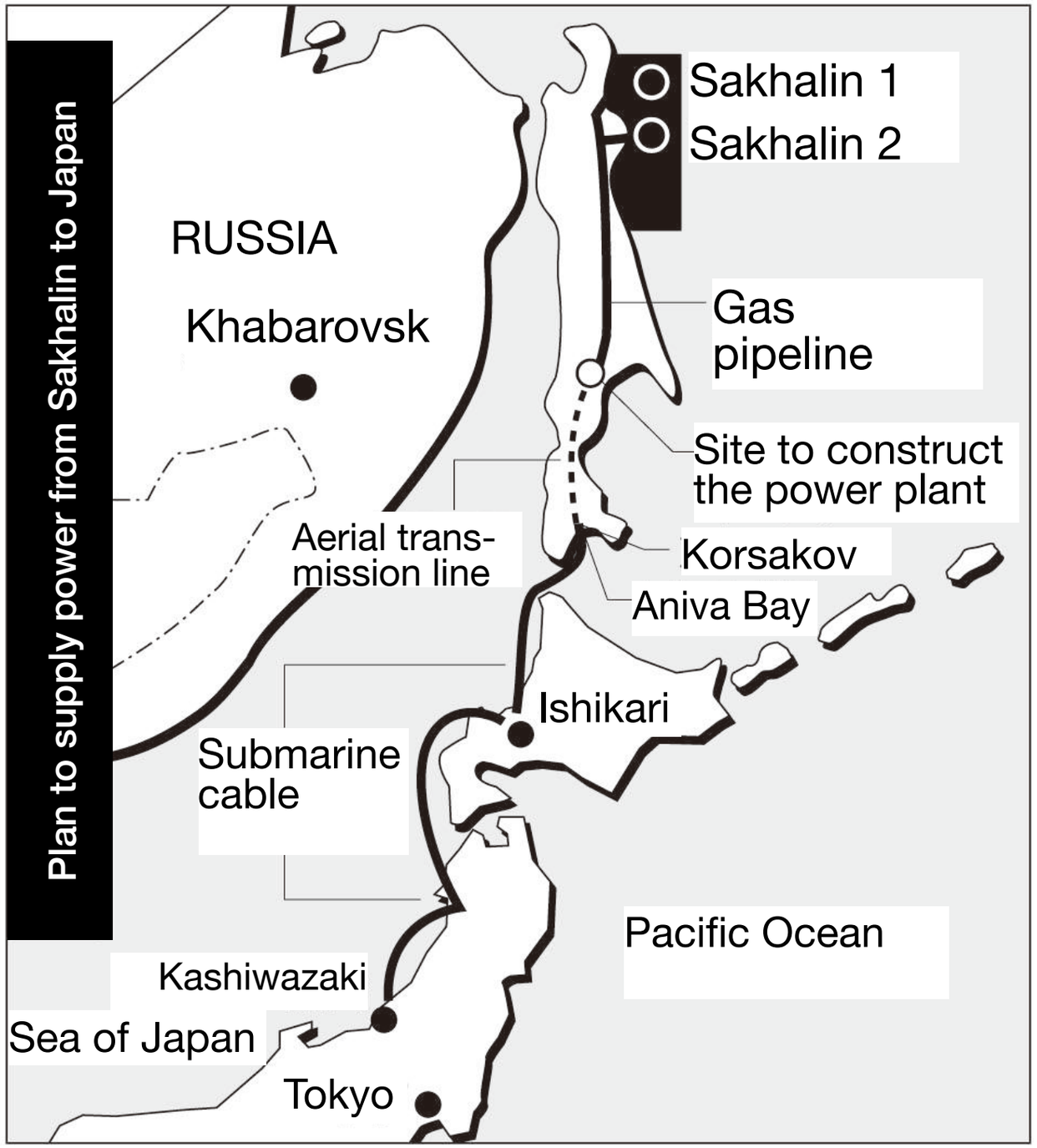
Scheme name	Scheme owner	Year of scheme proposal
North East Asian Electrical System Ties	Korea Electrotechnology Research Institute and ESI in Russia	2002
GOBITECH Initiative	Seoul Office of Hanns Seidel Foundation, etc.	2009
Asia Super Grid	Renewable Energy Institute	2011
Asia Pacific Power Grid	Japan Policy Council	2011



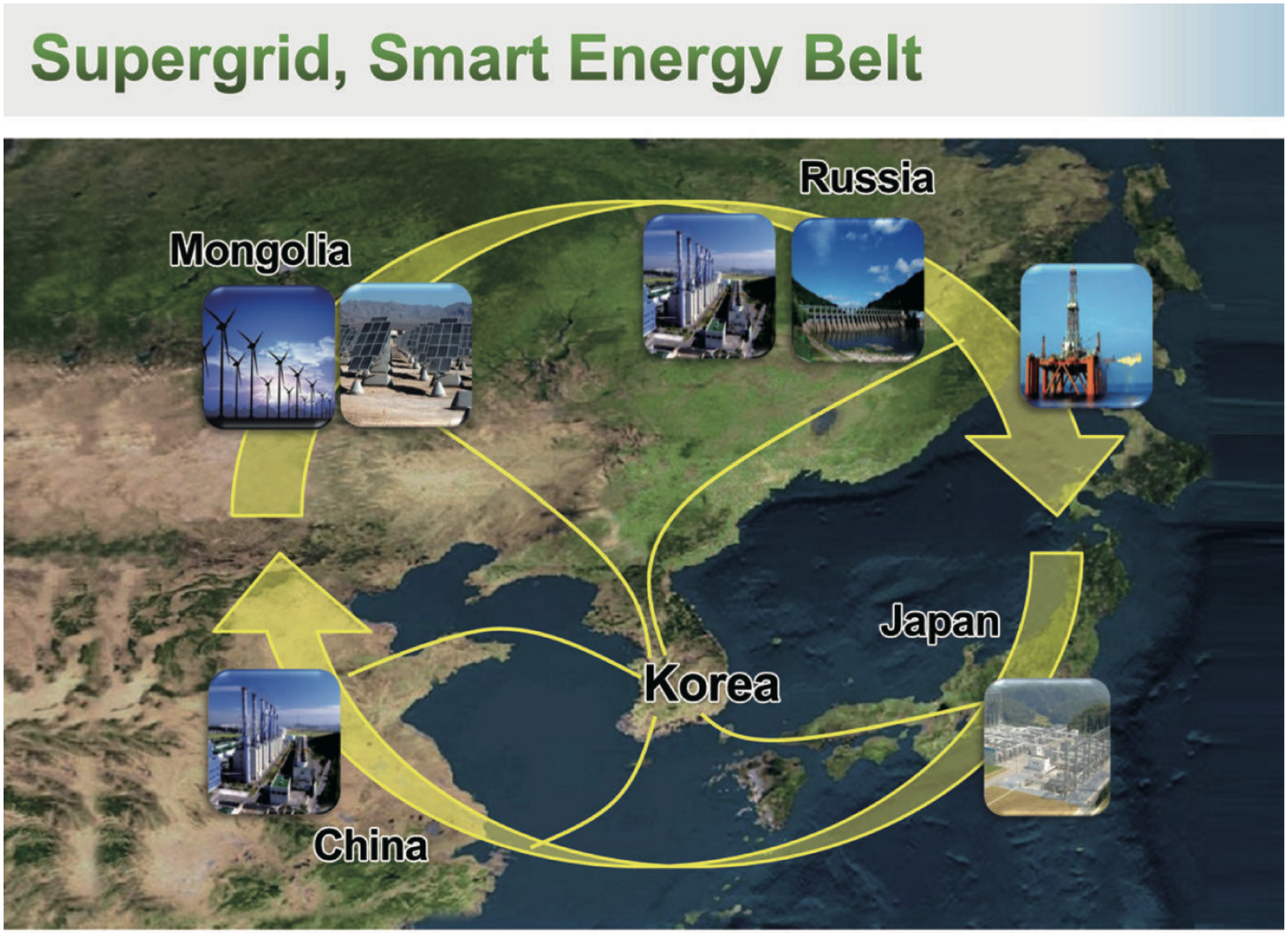
Renewable Energy Institute has proposed “Asia Super Grid” based on renewable energy.
The goal is to utilize renewable energy across Asia by connecting China, South Korea, Russia, and Japan via an international power grid using solar and wind power generated in Mongolia as the main power supply.



Japan-Russia
"Power Bridge Project"
that would link a thermal power plant on Russian Far East Sakhalin Island to Niigata via Hokkaido, using undersea transmission lines

A feasibility study conducted by Marubeni, Sumitomo Electric Industries, and RAO UES in early 2000s.

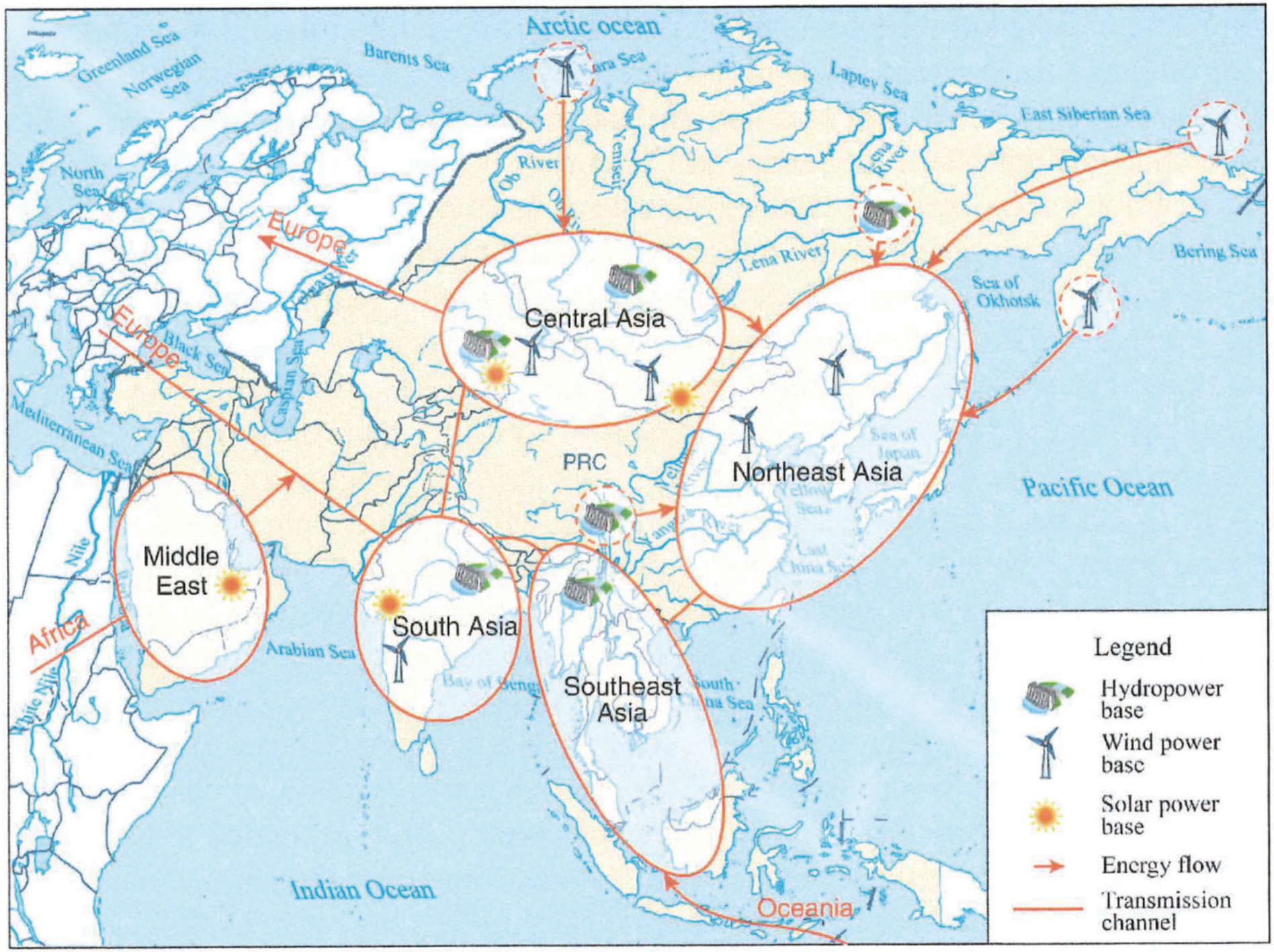
Source: "The Kyoto Protocol and the Northeast Asia Energy, Resource, Environmental and Economic Cooperation Region" by Ryosuke Hata, SEI TECHNICAL REVIEW, September 2005



Korea Electric Power Corporation “Northeast Asia Interconnection Vision”

Source: Hwan-Eik Cho, President of Korea Electric Power Corporation, lecture document September 9, 2016)

International power grid in Asia in the GEI vision



Source: Official website of the international non-profit organization "Global Energy Interconnection Development and Cooperation Organization (GEIDCO)"

From concept making phase to realization of the Interconnection concept

"Global Energy Interconnection Development and Cooperation Organization (GEIDCO)"：

In March 2016, the international nonprofit foundation Global Energy Interconnection Development and Cooperation Organization (GEIDCO) was established with the goal of realizing this GEI concept.

"Japan-Russia Power Bridge (Asia power ring)"：

In September 2016, the Eastern Economic Forum was held in Vladivostok in the Far East. At its plenary session, President Putin said, "we support the initiative of Russian, Japanese, South Korean, and Chinese companies to create an Energy Super Ring linking our countries." He also proposed setting up an intergovernmental working group for the initiative.

In this way, enterprise-driven movements towards the realization of the Asia international power grid scheme have been accelerated since 2016. Recent movements show that, as compared with the previous scheme, the main actors of interconnection are more directly involved with the project. Now, they are aiming for intergovernmental agreement and realization of the project, as well as setting the utilization of renewable energy as one of the main goals.

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Obstacles for interconnection in Japan and perspective to overcome them

1. Geographic condition (an archipelago) → • Development of Under sea cable technology

2. Deplomatic situation in NEA → • Improvement in diplomatic relationship and economic cooperation.

3. Delayed liberalization in Power Sector. (separate supply areas dominated by respective regional monopoly utilities) → • Progress in Power sector reform Globalization of Power business

4. Delay of RE Installation → • Expansion of RE capacity. Expansion of inter-regional transmission operation enables to absorb more RE.

Necessary Conditions for Interconnection are being put into place in Japan.

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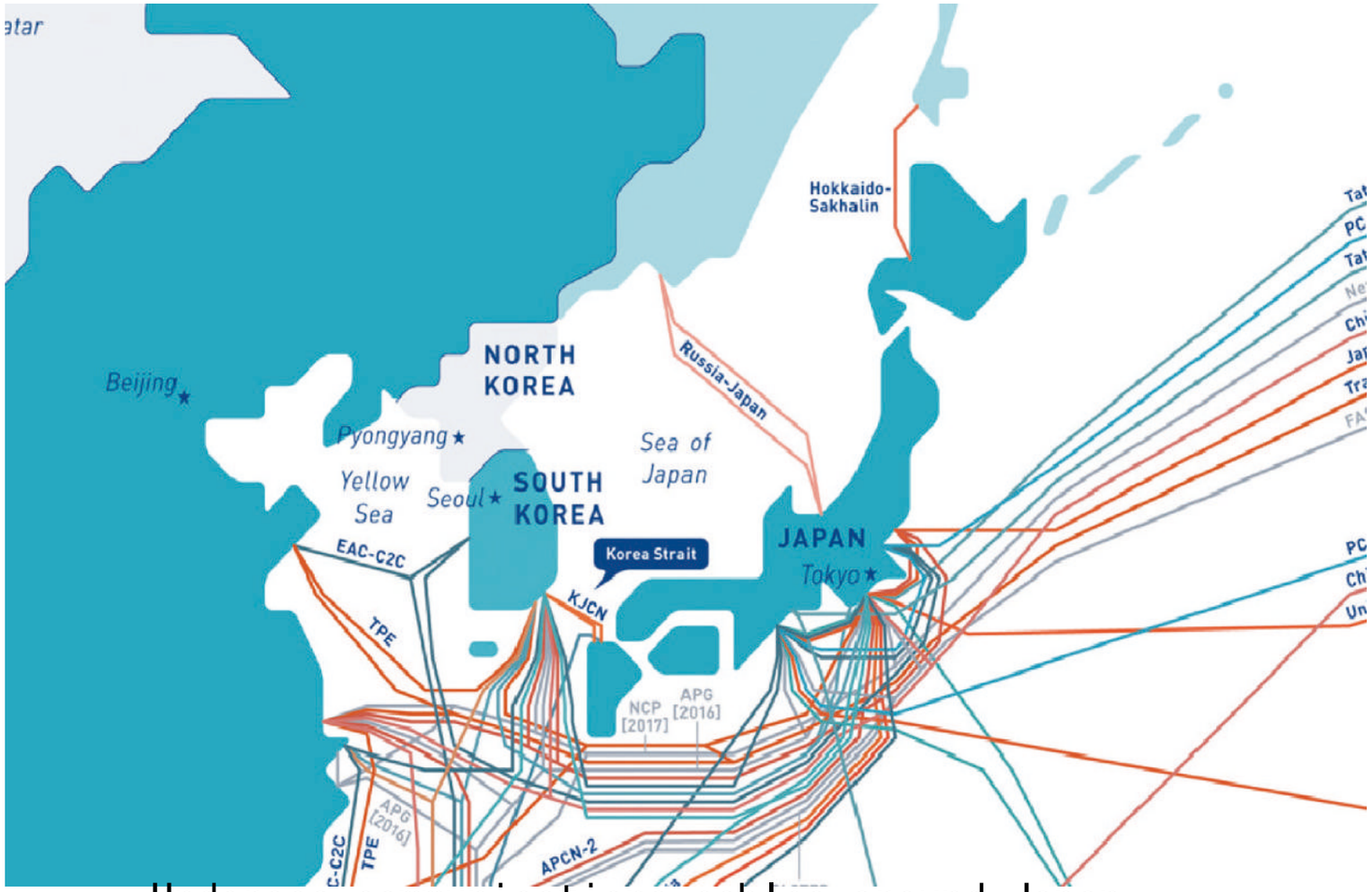
Legal issues for Interconnections in Japan: Construction of cross-border lines

・Each country may install undersea cables freely in extraterritorial waters (the United Nations Convention on the Law of the Sea). Many fiber-optic cables for telecommunication are installed in the seas around Japan

・No provision about under sea transmission lines in “Electric Utility Industry Law”, what doesn’t prohibit a construction of under sea lines (ex: lines between Hokkaido and Honshu)



Undersea communications cables around Japan

source:TeleGeography Submarine Cable Map 2016. http://submarine-cable-map-2016.telegeography.com/

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Legal issues for Interconnections in Japan: License for cross-border lines Operators

The current Japanese law does not have specific provisions on connection to overseas

Option -1:
To apply the Transmission Business license under current law to cross-border line operation too.
In this case it is necessary to create just a special permission system for transmission operators to conduct cross-border operation. (based on the model of The Telecommunications Business Act).

Option-2:
To establish new licenses especially for interconnections.
For example, we can add a new section titled “International transmission business” in Japanese “Electric Utility Industry Law” to specify the details of the license.

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Legal issues for Interconnections in Japan: Other issues

1. Construction of undersea cable

・The Fishery Act does have provisions concerning installation of underwater cables (Article 39(1))。

2. Participation in electricity markets from overseas.

・Membership is necessary to trade in JEPX. The only condition for an entity to obtain membership is to be “qualified” by JEPX. These provisions require conclusion of a connection service contract or a power generation adjustment contract with General Transmission and Distribution Utilities.

3. Provisions on tariffs

・As electricity is considered as a good, it can be subject to tariffs. However, as electricity is not listed in the current Customs Tariff Act in Japan, tariffs for electricity should be specified in the law. (Even if 0 % tariff)

CONCLUSION

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- An international power grid is economically reasonable in general. Compared with domestic grids, there is no particular technical difficulty in an international power grid.

- Interconnections are utilized not only in Europe but also in Asia.

- In light of global renewable energy expansion in the future, many interconnection construction projects are planned across the world.

- China has the largest installed capacity of renewable energy in the world and Russia and Mongolia have huge potential

- The 21st century should be the age of electricity trading not only in Northeast Asia or all over Asia, but also on a global basis.

- The fact that other countries of Northeast Asia, as well as their transmission and power companies, have made proposals for international power grids connecting this region should be given serious consideration.