North-East Asia Energy Interconnection and Regional Development

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Global Energy Interconnection Development and Cooperation Organization

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1. New Opportunities for Cooperation

2. Outlook of Energy and Electricity

3. Grid Interconnection Planning Schemes

4. Comprehensive Benefits
1.1 Potential for Regional Cooperation

**Large Economy, and Great Prospects for Regional Economic Cooperation**

- In 2017, the total GDP in Northeast Asia accounted for 25% of the world total.
- In 2017, the foreign exchange reserve was 5.3 trillion USD; the total foreign investment was 352.8 billion USD, accounting for 25% of the world total (exclude the DPRK).
- The foreign trade of China, Japan and Korea keeps increasing. In 2017, the total foreign trade of the three countries was 5.8 billion USD, accounting for 20% of the world total. In particular, the trade among the three countries was 1.5 billion USD, accounting for 25% of the total foreign trade of the three countries.

Sources: World Bank, UN

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**GDP and foreign exchange reserve of Northeast Asian countries/areas in 2017**

- China
- Russian
- Japan
- ROK
- DPRK
- Mongolia

**Trade within Northeast Asian countries/areas in 2017**

- China
- Japan
- ROK
- Russia
- Mongolia

Total volume of trade (US$billion)

Proportion of the intra-regional trade of a country to its total volume (%)
1.1 Potential for Regional Cooperation

- Complementary Economic Structure, Broad Cooperation Field

- Complementarity of industrial structure. The Northeast Asian countries can leverage their own strengths and then cooperate in the fields such as energy, intelligent manufacturing, energy saving & environmental protection, IT and producer services. An industrial division system can ensure the complementary and coordinated development of the industry.

- Complementarity of supply and demand. Northeast Asia has a tremendous consumer market. For example, Japan and the ROK export high-end manufacturing products and import raw materials; Mongolia and the DPRK mainly export raw materials and import manufacturing equipment. The market within the region can satisfy the needs of raw materials such as energy and mineral products, and meanwhile, support the industrial development in Mongolia and the DPRK.

- Aiming at mutual benefits, Northeast Asia will embrace new opportunities in regional cooperation
1.2 Energy and Electricity, the Key of Cooperation

- Energy and Electricity Demand is High and the Growth is Rapid
  - The key to promote regional development. Energy and electricity is not only the basic industries of the national economy but also the driving force of the social development.
  - The consumption accounts for a high proportion in the world. In 2015, the energy consumption in Northeast Asia was 2.6 billion tons of coal equivalent, accounting for 14% of the global total; the total electricity consumption was 3.3 PWh, accounting for 16% of the global total.
  - Demand is growing rapidly. From 2005 to 2015, the total primary energy consumption in Northeast Asia increased by 21%; the power consumption increased by 43%.
1.3 Challenges in Energy Development

- **High Dependence on Fossil Fuel**
  - Causes severe problems in environment and climate
  - Fossil fuels account for 90% of the total energy consumption.
  - In 2016, the total CO2 emissions in China, Japan and the ROK reached 12.3 billion tons, 3.3 times the amount in 1990 and accounting for 34.4% of the global total. The average annual concentration of PM2.5 is 2~4 times higher than the WHO standard.

- **High Dependence on Imports**
  - Causes risks in energy security
  - Fossil fuel import takes a high proportion in consumption. In 2017, the coal/oil/gas imports in Japan and the ROK were 550 and 350 million tons of coal equivalent, accounting for 84% and 83% of their total energy consumptions. 95% of oil and 94% of natural gas were imported from outside of Northeast Asia.
  - Energy import is easily affected by the global situation

Sources: IEA, NASA
1.4 Advantages in Clean Energy

Abundant Clean Energy Resources

- **Hydro energy**: mainly stored in the Russian Far East, and the technical potential is 100 GW.
- **Wind energy**: the technical potential is 2.3 TW in the Russian Far East, 1.1 TW in Southeast Mongolia Gobi, and 2.1 TW in North and Northeast China.
- **Solar energy**: mainly distributed in Mongolia and the technical potential is about 1.9 TW.

Complementarity of Clean Energies

- **Hydro resources are complementary in different basins**. The peak runoff occurs in May - June in the Lena River, while occurs in August - September in the Amur River.
- **Hydro and wind resources are complementary**. The hydro resource in the Russian Far East is plentiful in summer while exhausted in winter; on the contrary, the wind in the Russian Far East and Mongolia is strong in winter while weak in summer.
1.4 Advantages in Clean Energy

■ Complementarity of Resource and Market

- **Japan, the ROK and the DPRK** have high electricity demand but are short of energy resources and dependent on imports.
- **The Russian Far East and Mongolia** are both rich in clean energy resources but low in electricity demand.
- Supply and demand of energy and electricity are complementary. A bright future in resource exploiting and utilization is expected.

■ Complementarity of Technology and Capital

- **China, Japan and the ROK** have technical advantages in smart grid and clean energy generation. China is in the leading position in the UHV technology.
- **Japan and the ROK** are developed in economy and strong in capital.
- **The DPRK and Mongolia** require technologies and investments, which provides opportunities for the technology cooperation and project investments within Northeast Asia.
- **The Russian Far East** is in economic restructuring period, and thus has great potential and requires technologies and investments.
1.5 Clean Development, the Common Vision

**Energy Transition & Sustainable Development.** The key is to accelerate the utilization of clean energy. The countries have issued policies to promote the clean development:

- **Russia**
  - Released the State *Program Energy Efficiency and Energy Development*, and proposed construction of seven large-scale energy and electricity projects in the Russian Far East.

- **China**
  - Released the *Renewable Energy Law* to promote the development and utilization of renewable energy, optimize energy structure, ensure energy supply security, protect the environment, and reduce carbon emissions.

- **DPRK**
  - Released the *Renewable Energy Law* to encourage the development and utilization of renewable energy; formulated the *five-year economic plan* to develop renewable energy and solve power problems.

- **Japan**
  - Released the *Feed-in Tariff* to optimize the energy structure and increase the proportion of renewable energy. Released the *Strategic Energy Plan* and increases investment in renewable energy.

- **Mongolia**
  - Released the *Renewable Energy Law* and approves the "National Renewable Energy Program" and the "Mongolian Integrated Power System Program" to promote clean energy development.

- **ROK**
  - Released the *Basic Plan for New and Renewable Energies and 2030 New Energy Industry Diffusion Strategy* to enhance the promotion of clean energy and gradually transform into a low-carbon economy.
1.6 Regional Energy Cooperation, the Key Trend

- The supply and demand of energy and the distribution of clean energy resources are unbalanced
  - Clean energies are mainly distributed in the Russian Far East, Mongolia, North and Northeast China. Load centers are mainly in Japan, North China, the ROK and the DPRK.
  - Wide-area energy allocation is essential for the energy production and consumption.

- Clean energy needs to be locally converted into electricity
  - Because the wind and solar energies are intermittent and volatile, the large-scale development should rely on an interconnected, long-coverage and large-capacity electricity allocation network.

Accelerating clean energy utilization, strengthening international energy cooperation and ensuring regional energy security are the key trends of the energy development in Northeast Asia. To achieve the large-scale development, wide-area allocation and efficient utilization of clean energy, the Northeast Asia Energy Interconnection (NEAEI) should be established. The NEAEI is a platform aiming at clean development and energy/power cooperation, it will be a milestone of the sustainable energy development in Northeast Asia.
1. New Opportunities for Cooperation

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2.1 Outlook of Energy Demand

**Sustained Growth in Energy Demand with a Stable Speed**

- By 2050, the total primary energy demand will increase by more than 25%. 2015~2050, the demand will increase from 2.6 billion to 3.3 billion tons of coal equivalent with an average growth rate of 0.7%. The growth rate is 1.3%, 0.7% and 0.3% from 2015~2025, 2025~2035 and 2035~2050. North China, Japan and the ROK lead in the amount of energy demand growth; the DPRK, Mongolia and the Far East have high growth rates.

**Clean and Low-Carbon Energy Goes Mainstream**

- The clean energy will become the dominant energy source by 2040. 2015~2050, the clean energy demand is predicted to increase by 1.8 billion tons of coal equivalent, with an average annual growth rate of 6.9%. The proportion of the clean energy increases from 7.3% to 60% and the carbon emissions will be halved.
2.1 Outlook of Energy Demand

Electricity Dominates in Final Energy Consumption

In around 2030, electricity will replace oil and become the largest energy source in the final energy consumption. 2015~2050, the proportion of electricity in the final energy consumption will increase from 21.5% to 49%. The electricity in North and Northeast China, Japan, and the ROK will contribute 53%, 41%, 48%, and 41% of their final energy consumptions, respectively.

End use energy demand and electrification rate in Northeast Asia
2.2 Outlook of Electricity Demand

Relatively Fast Increase in Electricity Demand, Per Capital Consumption Differs Among Countries

✓ In 2050, the electricity consumption and the peak load will double. 2015~2050, the electricity consumption will increase from 3.3 to 6.1 PWh, with an average annual growth rate of 1.8%. The peak load will increase from 520 to 1,040 GW, with an growth rate of 2.0%.

✓ In 2050, per capita electricity consumption will double the number in 2015. In 2050, per capita electricity consumption will be 12 MWh, equivalent to the current level of the developed countries. The number in Far East and the ROK will exceed 14 MWh; the number in North and Northeast China and Japan will exceed 10 MWh; the number will be 6.8 and 7.8 MWh in the DPRK and Mongolia.
2.2 Outlook of Electricity Demand

- Demand is Concentrated

- **China, Japan and the ROK will continue to be the load centers.** In 2050, the electricity consumption in North and Northeast China, Japan and the ROK will be 3.8, 1.3 and 0.73 PWh, respectively; the combined consumption accounts for 95% of the total number in Northeast Asia. 2015~2050, the annual growth rate of the electricity consumption in the DPRK and Mongolia exceeds 5%, the growth rate is higher than 2% in the Far East and North and Northeast China, and is around 1% in Japan and the ROK.
### 2.3 Outlook of Electricity Supply

#### Rapid Development of Clean Energy Generation

- **The competitiveness of clean energy in electricity generation is rapidly improving.** 2010~2017, the PV cost in China and Japan decreases 70%, and the onshore wind power cost decreases 20% and 10%, respectively. In 2017, the costs of utility-scale PV and onshore wind power are close to fossil fueled generation, globally. The bid price for some PV projects in China is lower than 5 US cents/kWh. Before 2025, it is predicted PV and wind power will have stronger competitiveness than fossil fuels. The large-scale energy storage technology and the grid operation control technology will develop rapidly, making clean energy the dominant electricity supply.

- **Around 2030, clean energy will replace fossil fuels and become the dominant energy in electricity generation.** By 2050, the installed capacity and electricity generation of clean energy will increase to 80% and 70% of the totals.

![Trend of cost variation of Global clean energy (cent/kWh)](chart.png)
2.3 Outlook of Electricity Supply

- Clean Energy is Mainly Developed in Utility-Scale

- Development of clean energy bases according to exploiting conditions. It is suggested to develop hydro and wind power bases in the Russian Far East, wind and solar power bases in Mongolia, and wind power bases in North and Northeast China. Japan, the ROK and the DPRK is advised to develop domestic clean energy and also increase the clean electricity import.

Electricity generation from clean energy in Northeast Asian countries/areas in 2050

- Proportion of power generated from fossil fuel
- Proportion of power generated from clean energy
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3.1 GEI Leads to Clean Development

- The essence of sustainable development is clean development, the direction is “Two Replacements”
  - “Clean Replacement” on production: replace fossil fuels with the clean alternatives, such as solar, wind.
  - “Electricity Replacement” on consumption: use clean electricity to eliminate the dependence on fossil fuels.

- Global Energy Interconnection (GEI) is the carrier of clean development and also a modern energy system aiming at global production, allocation and utilization of clean energy. The essence is “Smart grid + UHV grid + Clean energy”.

- The sustainable development and energy cooperation in Northeast Asia require us to follow the concept of GEI, accelerate the construction of the NEAEI, and support the regional energy and electricity demands in a clean and green way.
3.2 Blueprint of NEAEI

Development Strategy of the NEAEI:

Because the imbalance between energy supply and demand and the imbalance of clean energy distribution exist simultaneously, the optimal wide-area energy allocation is required in Northeast Asia. Under this circumstance, it is important to build large clean energy bases and a high capacity, high efficiency and interconnected clean electricity allocation network to ensure a safe and reliable energy supply. In addition, the joint participation, cooperative construction and coordinated development of all countries are also necessary before the clean, low-carbon and efficient NEAEI can be built. The NEAEI will then ensure the multi-energy complementarity and regional co-construction in Northeast Asia. Finally, the NEAEI will guarantee the peace, stability, development and prosperity in the region, and achieve the coordinated and sustainable development between economy and society, resource and environment, humans and nature.

- **Accelerating the clean energy utilization, and ensuring the regional energy security based on green development**
- **Improving the electrification, and realizing the low-carbon and efficient development relying on electricity**
- **Enhancing the optimal allocation of clean energy, and building a win-win cooperation via grid interconnection**
3.3 Distribution of Clean Energy Bases

- Based on the characteristics, distribution and exploiting conditions of clean energy, the proposed key projects include: 2 hydropower, 19 wind power and 5 solar energy bases.
- Total technical potential: 990GW.
3.3 Distribution of Clean Energy Bases

- **Hydropower Bases:** mainly distributed along the Lena and the Heilongjiang-Amur Rivers, with the technical potential of 40GW and 14.5GW, respectively.
- 10% of the potential has been utilized.
### 3.3 Distribution of Clean Energy Bases

- **Wind Power Bases:** mainly distributed over the Sea of Okhotsk, the Sakhalin Island, Southeast Mongolia, and North and Northeast China.

- Total 19 bases are planned with a technical potential of 430GW.

<table>
<thead>
<tr>
<th>No.</th>
<th>Site Location</th>
<th>Country</th>
<th>Potential (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Coast of the Sea of Okhotsk</td>
<td>Russia</td>
<td>66,000</td>
</tr>
<tr>
<td>2</td>
<td>Sovetskaya Gavan</td>
<td>Russia</td>
<td>31,200</td>
</tr>
<tr>
<td>3</td>
<td>Alexandrovsk</td>
<td>Russia</td>
<td>30,000</td>
</tr>
<tr>
<td>4</td>
<td>Makarov</td>
<td>Russia</td>
<td>9,600</td>
</tr>
<tr>
<td>5</td>
<td>South Sakhalinsk</td>
<td>Russia</td>
<td>13,200</td>
</tr>
<tr>
<td>6</td>
<td>Choybalsan</td>
<td>Mongolia</td>
<td>21,000</td>
</tr>
<tr>
<td>7</td>
<td>Erdenetsagaan</td>
<td>Mongolia</td>
<td>27,000</td>
</tr>
<tr>
<td>8</td>
<td>Sainshand</td>
<td>Mongolia</td>
<td>10,500</td>
</tr>
<tr>
<td>9</td>
<td>Choir</td>
<td>Mongolia</td>
<td>13,500</td>
</tr>
<tr>
<td>10</td>
<td>Neidegler</td>
<td>Mongolia</td>
<td>9,900</td>
</tr>
<tr>
<td>11</td>
<td>Hinggan League</td>
<td>China</td>
<td>36,000</td>
</tr>
<tr>
<td>12</td>
<td>Jilin</td>
<td>China</td>
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</tr>
<tr>
<td>13</td>
<td>Chifeng</td>
<td>China</td>
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</tr>
<tr>
<td>14</td>
<td>Xilinhot</td>
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</tr>
<tr>
<td>15</td>
<td>Zhangbei</td>
<td>China</td>
<td>19,500</td>
</tr>
<tr>
<td>16</td>
<td>Wakkanae</td>
<td>Japan</td>
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</tr>
<tr>
<td>17</td>
<td>Suzu</td>
<td>Japan</td>
<td>10,500</td>
</tr>
<tr>
<td>18</td>
<td>Gangneung</td>
<td>ROK</td>
<td>18,000</td>
</tr>
<tr>
<td>19</td>
<td>Kilju</td>
<td>DPRK</td>
<td>16,500</td>
</tr>
</tbody>
</table>
3.3 Distribution of Clean Energy Bases

- **Solar Energy Bases**: mainly distributed at the Gobi area in the south of Mongolia.
- Total 5 bases are planned with a technical potential of 510GW.

<table>
<thead>
<tr>
<th>No.</th>
<th>Site location</th>
<th>Country</th>
<th>Technical potential (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Begell</td>
<td>Mongolia</td>
<td>100,000</td>
</tr>
<tr>
<td>2</td>
<td>Bogdo</td>
<td>Mongolia</td>
<td>120,000</td>
</tr>
<tr>
<td>3</td>
<td>Bulgan</td>
<td>Mongolia</td>
<td>100,000</td>
</tr>
<tr>
<td>4</td>
<td>Mandal-Ovoo</td>
<td>Mongolia</td>
<td>92,000</td>
</tr>
<tr>
<td>5</td>
<td>Tavan Tolgoi</td>
<td>Mongolia</td>
<td>93,000</td>
</tr>
</tbody>
</table>

Main Solar Energy Bases in Northeast Asia
3.4 Plan of Installed Capacity

**Low-Carbon Scenario:**
- The countries are accelerating the transition towards a clean energy system and a low-carbon power industry. Clean energy resources are fully utilized to reduce fossil fuels to the minimum. The electricity exchange within the region will be significantly developed.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Thermal</th>
<th>Nuclear</th>
<th>Clean Energy</th>
<th>Electricity Exchange</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-Carbon Scenario</td>
<td>Significantly reduced</td>
<td>Steadily shutdown</td>
<td>Large scale of development</td>
<td>High</td>
</tr>
</tbody>
</table>

- In **Low-Carbon** Scenario, the total installed capacity is expected to reach **2.44 TW** by 2025, and the clean energy capacity accounts for **80%**.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Clean energy installed capacity ( % )</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>30%</td>
</tr>
<tr>
<td>2025</td>
<td>46%</td>
</tr>
<tr>
<td>2035</td>
<td>65%</td>
</tr>
<tr>
<td>2050</td>
<td>80%</td>
</tr>
<tr>
<td>Low-carbon</td>
<td></td>
</tr>
</tbody>
</table>
3.4 Plan of Installed Capacity

- In around 2030, the capacity of clean energy is expected to exceed the capacity of fossil fuel in Northeast Asia.
- In 2050, the proportion of thermal plants will reduce to 20.3% with a total number of 490 GW. The nuclear power capacity will reduced to 38.55 GW, accounting for 1.6% of the total. The wind and solar capacity will significantly increase to 920 GW and 670 GW, respectively, accounting for 37.6% and 27.5% of the total. The 250 GW hydropower plants will mainly locate in North and Northeast China, and the Russian Far East, accounting for 10.1% of the total.
3.4 Plan of Installed Capacity

- **Russian Far East and Mongolia**: will be the clean energy bases in Northeast Asia. By 2050, the capacities are expected to reach 140 and 56 GW, respectively, accounting for 5.8% and 2.3% of the total capacity in Northeast Asia.

- **North and Northeast China**: The clean energy bases in China are located in the Northeast, inner Mongolia and Shanxi, and the load centers include Beijing, Tianjin, Hebei and Shandong. The total capacity in 2050 is expected to be 1.5 TW, accounting for 61.5% of the total.

- **Japan, ROK and DPRK**: will be the load centers and require domestic clean energy development and increased electricity import. The thermal and nuclear power plants in Japan and ROK will be gradually shut. In 2050, the capacities will be 460, 210 and 70 GW, respectively, accounting for 18.7%, 8.7% and 3.0% of the total.
**International Electricity Exchange is Expanding.** The electricity exchange within the region in 2025, 2035 and 2050 is expected to reach 11.75 GW, 59.75 GW and 107.75 GW, respectively.
3.5 Potential for Regional Interconnection

- In 2050, the electricity export in Mongolia and Russia will reach 20 GW and 42 GW, respectively. The Russian Far East will not only export electricity to the neighboring countries but also deliver clean electricity to the western grid of Russia.

- North and Northeast China is outstanding in location and resources, exporting 9.75GW in 2050.

- In 2050, electricity import in Japan, the ROK and the DPRK will reach 40 GW, 23.5 GW and 8.25 GW.

Power Flow in Northeast Asia in 2050
3.6 Interconnection Structure

- The “Three-ring and one-line” grid interconnection pattern: By 2015, five corridors will be commissioned, namely, Mongolia-China-ROK-Japan, China-Russia, Russia-Japan, China-DPRK-ROK and Russia-DPRK-ROK. In the north, the corridors receive hydropower from the Russian Far East and wind power from the Sea of Okhotsk and Sakhalin; in the west, they receive the wind power in North and Northwest China, and the solar and wind power in Southeastern Gobi of Mongolia; in the south, they deliver electricity to the load centers in North China, the ROK and Japan.
2025


<table>
<thead>
<tr>
<th>Project</th>
<th>Countries passed</th>
<th>Length of route (km)</th>
<th>Voltage level (kV)</th>
<th>Transmission capacity (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mongolia-Tianjin DC Transmission Project</td>
<td>Mongolia, China</td>
<td>1,500</td>
<td>±660</td>
<td>4</td>
</tr>
<tr>
<td>Weihai-Incheon, Goseung-Matsue Transmission Project</td>
<td>China, ROK, Japan</td>
<td>830</td>
<td>±500</td>
<td>2</td>
</tr>
<tr>
<td>Liaoning-Pyongyang-Seoul Three-terminal Flexible DC Project</td>
<td>China, DPRK, ROK</td>
<td>500</td>
<td>±500</td>
<td>3</td>
</tr>
<tr>
<td>Yunfeng Back-to-back Project</td>
<td>China, DPRK</td>
<td>0</td>
<td>500</td>
<td>0.75</td>
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<tr>
<td>Sakhalin-Hokkaido DC Transmission Project</td>
<td>Russia, Japan</td>
<td>300</td>
<td>±500</td>
<td>2</td>
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</tbody>
</table>
3.7 NEAEI Schematic

- **2035**

### New Interconnection Project during 2025-2035

<table>
<thead>
<tr>
<th>Project</th>
<th>Countries passed</th>
<th>Length of route (km)</th>
<th>Voltage level (kV)</th>
<th>Transmission capacity (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mongolia-Shandong DC Transmission Project I</td>
<td>Mongolia, China</td>
<td>1,700</td>
<td>±800</td>
<td>8</td>
</tr>
<tr>
<td>Shandong-Busan-Kyoto Three-terminal Flexible DC Project</td>
<td>China, ROK, Japan</td>
<td>2,000</td>
<td>±800</td>
<td>8</td>
</tr>
<tr>
<td>Liaoning-Seoul DC Transmission Project I/II</td>
<td>China, DPRK, ROK</td>
<td>750/750</td>
<td>±660</td>
<td>8</td>
</tr>
<tr>
<td>Lena River-Hebei DC Transmission Project</td>
<td>Russia, China</td>
<td>2,700</td>
<td>±800</td>
<td>8</td>
</tr>
<tr>
<td>Khabarovsk-Chongjin-Daegu Three-terminal Flexible DC Project</td>
<td>Russia, DPRK, ROK</td>
<td>2,300</td>
<td>±800</td>
<td>8</td>
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<tr>
<td>Sakhalin-Tokyo DC Transmission Project</td>
<td>Russia, Japan</td>
<td>2,000</td>
<td>±800</td>
<td>8</td>
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</tbody>
</table>
3.7 NEAEI Schematic

■ 2050


New Interconnection Project during 2035-2050

<table>
<thead>
<tr>
<th>Project</th>
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<th>Length of route (km)</th>
<th>Voltage level (kV)</th>
<th>Transmission capacity (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mongolia-Shandong DC Transmission Project II</td>
<td>Mongolia, China</td>
<td>1,900</td>
<td>±800</td>
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<tr>
<td>Shandong-Fukuoka DC Transmission Project</td>
<td>China, Japan</td>
<td>1,600</td>
<td>±800</td>
<td>8</td>
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<tr>
<td>EIM-Kaesong-Gwangju Three-terminal Flexible DC Project</td>
<td>China, DPRK, ROK</td>
<td>1,600</td>
<td>±800</td>
<td>8</td>
</tr>
<tr>
<td>Jilin-Osaka DC Transmission Project</td>
<td>China, DPRK, ROK, Japan</td>
<td>2,000</td>
<td>±800</td>
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<tr>
<td>Lena-Shandong DC Transmission Project</td>
<td>Russia, China</td>
<td>2,700</td>
<td>±800</td>
<td>8</td>
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<td>Okhotsk-Nagano DC Transmission Project</td>
<td>Russia, Japan</td>
<td>2,700</td>
<td>±800</td>
<td>8</td>
</tr>
</tbody>
</table>
3.8 Key Projects

- Yunfeng 500 kV Back-to-back Project
  - Deliver the electricity from Northeast China to the DPRK, solving the short-term electricity shortage issue in the DPRK.
  - Total investment: 330 million USD.
3.8 Key Projects

- **Mongolia-Tianjin ±660 kV DC Transmission Project**
  - Deliver the electricity from Mongolia to North China, transforming the resources into economic benefits in Mongolia.
  - Total investment: 1.7 billion USD, transmission cost: 1.2 US cents/kWh.
3.8 Key Projects

- Liaoning-Pyongyang-Seoul ±500 kV Three-terminal Flexible DC Project
  - Support the demand growth in the ROK and DPRK and mitigate the electricity shortage.
  - Total investment: 900 million USD, transmission cost: 0.85 US cents/kWh.
3.8 Key Projects

- **Weihai-Incheon, Goseung-Matsue ±500 kV DC Transmission Project**
  - Deliver clean energy to Japan to meet the short-term demand and increase the diversity of energy supply.
  - Weihai-Inchoen part: investment 1.4 billion USD, transmission price 1.7 US cents/kWh;
    - Goseung-Matsue part: investment 1.63 billion USD, transmission price 1.9 US cents/kWh.
3.8 Key Projects

- **Sakhalin-Hokkaido ±500 kV DC Transmission Project**
  - Develop the clean energy in the Russian Far East, transforming the resources into economic benefits. Meet the demand in Japan and ensure the diversity of electricity supply.
  - Total investment: 670 million USD, transmission cost: 0.96 US cents/kWh.
1. New Opportunities for Cooperation

2. Outlook of Energy and Electricity

3. Grid Interconnection Planning Schemes

4. Comprehensive Benefits
4.1 Cooperation and Political Trust

- **Mechanism for Cooperation**
  - Promote the cooperation among the Northeast Asian countries/areas in clean energy utilization, technical innovation, construction, investing and financing, and eventually, achieve the collaborative development and share common benefits.

- **Enhance Mutual Political Trust**
  - Enhance the bilateral/multilateral partnership, providing guarantees for the regional cooperation.
4.2 Unified Market and Energy Security

- **Guarantee Energy Security**
  - Achieve clean replacement, increase energy supply diversity, and reduce the dependence on energy import.
  - In 2050, clean energy will contribute 60% of the total installed capacity, and the rate of energy self-sufficiency in the region will reach 82%.

- **Expand Energy and Electricity Market in Northeast Asia**
  - Based on the grid interconnection, an unified energy and electricity market in Northeast Asia can be formed.
  - Expand the scale of energy export within Northeast Asia, such as the energy export from the Russian Far East and Mongolia.
4.3 Infrastructure and Investment

■ Attract Investments

- By 2050, the total investment in the NEAEI will reach 2.7 trillion USD.
- Stimulate the upstream and downstream industries, such as new energy, new materials, equipment manufacturing, electric vehicle, etc.

■ Accelerate Regional Economic Development

- The clean-energy-related investments in Russia and Mongolia will reach 175.2 and 40 billion USD, respectively. The electricity export will bring additional revenue of 10.5 and 5 billion USD for the two countries.

<table>
<thead>
<tr>
<th>Investment</th>
<th>Revenue from electricity export</th>
</tr>
</thead>
<tbody>
<tr>
<td>in electricity generation</td>
<td>Mongolia</td>
</tr>
<tr>
<td>2.1 Trillion USD</td>
<td>5 Billion USD</td>
</tr>
<tr>
<td>in power network</td>
<td>Russia</td>
</tr>
<tr>
<td>600 Billion USD</td>
<td>10.5 Billion USD</td>
</tr>
</tbody>
</table>
4.4 Environmental Benefits

Solution to Climate Change

✓ By 2050, the clean energy generation in Northeast Asia is expected to reach 4.2 PWh equivalent to a replacement of 1.76 billion tons of coal, reducing the greenhouse gas emission of about 3.9 billion tons of CO₂ equivalent.

Ameliorated Environmental Pollution

✓ By 2050, the emission reduction achieved in Northeast Asia includes: 1.23 million tons of sulfur dioxide, 1.38 million tons of nitrogen oxides and 0.26 million tons of tiny particles.

Reduce Greenhouse Gas Emission

2025 1.7 billion tons CO₂ eq./yr
2035 2.7 billion tons CO₂ eq./yr
2050 3.9 billion tons CO₂ eq./yr

Reduce NO₂ Emission

2025

560 thousand tons/yr

2035

890 thousand tons/yr

2050

1230 thousand tons/yr
4.5 Social Benefits

- **Improve Accessibility to Electricity**
  ✓ In 2050, electrification rate will exceed 49% and accessibility to electricity reach 100%.

- **Reduce Generating Cost**
  ✓ In 2050, generation cost will reduce 2 US cents/kWh (compared to 2015) and the total save in electricity using will be 130 billion USD.

- **Create Jobs**
  ✓ By 2050, the construction of the NEAEI will create in total 24 million new jobs.

![Chart showing new jobs created due to NEAEI (unit: 10 thousand)]
Conclusions

Energy and electricity cooperation is the core for the regional cooperation and clean development in Northeast Asia. Due to the economic globalization, the key of cooperation is to establish the NEAEI. In specific, the first emphasize should be laid on replacing the traditional energy development mode relying on fossil fuel and local balance by a new mode focusing on clean energy and wide-area optimal allocation. Other important contents to ensure the energy security and sustainable development in Northeast Asia include the construction of large-scale clean energy bases, the establishment of a strong interconnected grid, and the energy transition in the countries.

The NEAEI is of great value and prospect, and its implementation is necessary for the region. To achieve that, the consensus must be reached among the stakeholders and their efforts must be concentrated on enhancing the policy-making coordination and improving the mechanism for bilateral and multilateral cooperation. To be specific, a regional electricity market should be built in Northeast Asia, innovations should be made in investing and financing aspects, and the pilot projects of clean energy utilization and grid interconnection should be implemented in the near future.

Though the “green” and low-carbon development of energy and the regional cooperation, a bright future with shared benefits is foreseen in Northeast Asia.
Thank you!