Status Quo & Concept of Interconnection

[ASG WORKSHOP TOKYO]

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<Keyword & Notice>

- Meaning of PSI in NEA Regions: Roadmap for Sustainable Peace
- Status Quo: Only Weak Interconnection in NEA Reason
- Many Interconnection Scenarios, Multilateral & Bilateral in NEA
- Business Issues & Requirements for ASG-CBT
- Energy Security & Sustainability & To be determined Topics
- Need Feasibility Assessment: Technical/Economic/Marketability
- Promotion & Suggestion for Realizing ASG in NEA Region
<Meaning of PSI & CBT in NEA Region>

“Power System Interconnection & Cross-Border Trade between ...”

- Enhancement the sustainable Regional Peace parade
- Economic Win-Win game & Technical Reserve Supporting System,
- Having Positive & Negative Points in CBT & Energy Security
<Benefits of Electricity Market Integration>

- Diversity of Generation Plants
- Harmonize & Optimization of Power Mix

- Development of Renewable Energy, GOBITEC Solar & Wind
- CDM(Clean Development Mechanism) Project

- Asian Super Grid, Transfer of Bulk Energy, Trunk Line
- Global Electricity Trade Market using Ultra-HVDC System

- Stimulate of Energy Resources Development, Coal & Gas ...
- Decrease of Middle-East Energy Dependency
<Purpose of Deregulation & Interconnection>

- To promote competition and economic efficiency
- To regulate monopolies (both intra and inter-country)
- To organize efficient markets without distortions
- To ensure the security of supply and the existence of infrastructures
- To incentive the quality of service
- To ensure the accomplishment of the public service obligations
- To promote consumer interests
- To contribute to a better environment
- To contribute to the efficient and sustainable use of energy
- To enhance the peaceful cooperation between interconnected countries
<PSI/CBT & Relation Factors>

Deregulation:
- Regulation and Incentive (ex: Green power)
- Competition, Market
- Enhancement deregulation
- Transmission Right
- Free Market
- Economic viewpoint
- Enhancement interconnection

GHG/Environ:
- Cheap Fuel cost
- Refuse NRE, DSM, IRP
- Negative for Environment
- Enhancement interconnection
- Positive for NRE
- Trade of GHG Diffusion
- Positive for environment

Interconnection:

Reliability/PQ:

Economics:
<Complementary of interconnect. & Deregulation>

Deregulation

Interconnection

Public
Economic
Environment
Power Quality
Competition

Positive

Negative

Energy Security
Most of NEA Countries

- have mutual complementary characteristics
  - Natural resources, Power mix ratio, Electricity tariff ...
  - Need to build more power plants & Resource Development

- PSI can be alternatives to ...
  - Overcome these difficulties in NEA power sector
  - Utilize the complementary characteristics between them

Northeast Asian Bulk Energy Network, Supergrid is a Key Issue

- Many Scenarios have been discussed, but not realized until now
- Need to cooperation activities to realize the Asian Supergrid, should initiate feasibility study at first
<The Rational for deregulation & interconnection>

◆ Globalisation in general
  ■ Increase of economic efficiency
  ■ Traditional wisdom of government owned monopolies (utilities) was wiped away!

◆ OECD countries
  ■ Seek to more efficient Power Sector and lower prices to customers

◆ Developing countries: Funding (ex WB) policy is important
  ■ Lack of capital and skills to meet future goals
  ■ Experiences following of developed countries
<Ex) Power Market & Interconnection Parties>

- Market structures of interconnection parties (ex: FR-UK)
  - Monopoly utility vs Monopoly utility (before 1990, both regulated)
  - Monopoly utility & Liberalized market (before 1998, only UK deregulation)
  - Liberalized market vs Liberalized market (after 1998)

- Power Trading Rule between interconnection parties (ex: FR-UK)
  - Under agreements (before 1990, EDF-CEGB)
  - Under agreements (before 1998, EDF-NGC)
  - Under auctions (after 1998, competitions between private investors)
<Economic Gains of Power Interconnection>

- Welfare gain is the total social welfare by power supply
- Welfare gain (WG) = Producer surplus (PS) + Consumer surplus (CS)

If power interconnection is realized,
- MCP (Market Clearing Price) or SMP (System Marginal Price) is increased in exporting country, but decreased in importing country when compared with before interconnection
- The resulting MCP by interconnection will be an average value of MCPs of two interconnection parties
- Net WG summing two parties increase ↑ (PS increase, CS decrease)
- Exporting country: WG decrease ↓ (P increase, C decrease)
- Importing country: WG increase ↑ (P decrease, C increase)

If no interconnection,
- Each MCP will be applied to separate system
<Ex) Welfare gain calculation>

- (Ex.) Increase of welfare gain by power interconnection
<Present status>

◆ No PSIs on NEA with the exception of ...
  - Weak 220kV ties b/t Siberia and RFE
  - Weak 220kV ties b/t Siberia and Central Mongolia
  - Weak 110/220kV & future HVDC ties b/t RFE and China

◆ Potentials interconnecting power system in NEA region
  - RF – CH
  - RF – JP
  - ASG PROJECT : RF(Hydro) - MO(GOBITEC) - (CH) – KOR – JP
  - ROK – DPRK
  - ROK – CH
  - ROK – JP
<Major Existing CBT in NEA>

- Only weak tie lines exist at now, but in near future
  - Strong PSI will be commercially will commissioning b/t RU and CH
  - Long-term stable & reliable contract base power trade rule is needed

<table>
<thead>
<tr>
<th>Transmission Line Component</th>
<th>Voltage [kV]</th>
<th>Capacity [MW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gusinozerskaya GRES (Russia) – Darkhan (Mongolia)</td>
<td>220</td>
<td>150</td>
</tr>
<tr>
<td>Kharanorskay GRES (Russia) – Choibalsan (Mongolia)</td>
<td>110</td>
<td>90</td>
</tr>
<tr>
<td>Chadan (Russia) – Khandagaity – Ulanngom (Mongolia)</td>
<td>110</td>
<td>90</td>
</tr>
<tr>
<td>Blagoveshensk (Russia) – Heihe (China)</td>
<td>220/110</td>
<td>95</td>
</tr>
<tr>
<td>Sivaki (Russia) – Sirius /Aigun (China)</td>
<td>110</td>
<td>90</td>
</tr>
<tr>
<td>Blagoveshensk (Russia) – Sirius /Aigun (China)</td>
<td>2 * 220</td>
<td>300</td>
</tr>
<tr>
<td>Amurskay (Russia) – Heihe (China)</td>
<td>500</td>
<td>750</td>
</tr>
<tr>
<td>Lyaonin (China) – DPRK</td>
<td>2 * 220</td>
<td>300</td>
</tr>
</tbody>
</table>

*) ELECTRIC POWER GRID INTERCONNECTIONS IN NORTHEAST ASIA, APERC, 2015
There are so many projects performed on NEA-CBT since 2000 …

- NEAREST (KERI, ESI 2003)
- GRENETEC (HRENATEC 2010)
- Asian Super Grid (JREF 2011)
- Asia Pacific Power Grid (Japan Policy Council 2011)
- GOBITEC and Asian Super Grid (ECS 2014)
- NEA Supergrid (KEPCO 2014)
- Northeast Asia Supergrid (Skoltech in cooperation with KEPCO & KEEI 2014)
- And so on .........
<Future Plan for NEA-Supergrid>

- Weak Tie Line (110/220kV) + Future HVDC
- Undersea cable (DC)
- Under discussion

Existing

Future Plan
<CBT Projects & Scenarios in NEA>

- Many Studies performed on NEA-CBT since 2000 (Multilateral PSI)
  - NEAREST (KERI, ESI 2003)
  - Asian Super Grid (JREF 2011)
  - GOBITEC and Asian Super Grid (ECS 2014)
  - Northeast Asia Supergrid (KEPCO, KEEI with Skoltech, 2014)
  - GRENA TE C (HRENATE C 2010)
  - Asia Pacific Power Grid (Japan Policy Council 2011)
  - And so on

- Bilateral PSI Scenarios
  - KO-CH, KO-JP, KO-RU
  - CH-RU, RU-JP ...
<So many Projects Studied, But only Plans ...>
<Common Issues for PSI & Deregulation>

- **[Technical/Economic] Transmission planning & pricing**
  - Planning: Capacity, Voltage, AC/DC, System design
  - Pricing: Fixed or Negotiated pricing
  - Institutional considerations

- **[Economic/Environmental] Generation tracking and electricity market**
  - Creation of international electricity market
  - Electricity and CO2 trading (Green market)

- **[Only Technical Issue] Reliability standards**
  - Analysis the interconnected system security (short-term)
  - Evaluation the generation/load adequacy (short and long-term)

- **[Marketable Issue] Market power & International negotiation**

  - Intra political & financial factor (Deregulation)
  - Inter political & financial factor (Interconnection) & Energy Security
# Economic & Market & Political Issues

<table>
<thead>
<tr>
<th>Category</th>
<th>Opinions</th>
</tr>
</thead>
</table>
| Power exchange model            | ★ Simple power exchange model  
★ Develop guidelines for power exchange.                                                                                                                                                                    |
| Overseas benchmarking model     | ★ Review NORDEL, SAPP, and England - France power exchanges.  
★ Introduction of a new trade market due to market restructuring.  
★ Organize a derivative product market in preparation of unstable pricing.                                                                                                                                   |
| Financing                       | ★ directly related to economic feasibility, political and diplomatic relationship, law/regulation and policies support. DPRK uncertainty requires participants’ government guarantee and international financial institutions’ participation.  
★ Consider long term contract, project collateral, and risk management for sound finance enhancement.                                                                                                      |
| Politics and energy security    | ★ DPRK nuclear is the main issue. Necessity to forecast DPRK’s political change by phase.                                                                                                                  |
| Obstacles and solutions         | ★ No issue is raised in legal aspect, but DPRK laws should be examined if power system interconnection passes through DPRK. Establish a NEA Energy Charter Treaty as a long term perspective.                       |
<Future Prospects : Interconnection Scenario>

- Many scenarios for ASG have been published ...
  - ESI, KERI, NI, SOFTBAK report/paper etc.
  - Have rough concept/contents and similarities with each other
  - Among these scenarios, ASG is the key point

- ASG Scenario
  - Integrating with GOBITEC ....
  - RU(Hydro) – MO(GOBITEC) – CH – KOR – JP

- Need some detail Feasibility Study for ASG Project
  - On the Technical & Economic & Marketability Points
  - Should proceed the Governmental Base Co-operational F/S
<CBT Scenarios: Korea’s Perspectives>

- **KOREA**: Geographical Center of Northeast Asia Region
- Private Sector Discussion with neighboring countries since 2000 ...
  - RU – NK – SK with Overhead line
  - SK – CH with submarine cable
  - SK – JP with submarine cable
  - GOBITEC includes all of NEA ...

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KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE
<CBT Scenarios : Korea’s Perspectives>

◆ Energy Security & Financing Problem
  - Politically, DPRK Variants due to Trans NK CBT Line ...
  - Technical Deterioration of Power Supply Reliability ...
  - Operation & Data Exchange & /Maintenance ...
  - Investment Recovery ...
<Cooperation Plan b/t Korea and Japan>

◆ (Mr. Son’s Initiative) JREF’s ASG Plan
- ASIA LNG HUB CO Plan
- Only private sector, No Public ...

◆ (Unified Infra Plan)
- Submarine Tunnel Plan
- Road, Train, Gas & Electricity Net.
- (Ex) UK-FR CROSS-CHANNEL

Project by Political Leadership!

Transmission Route Selection Process
- Transmission Route to be finalized based on: Construction Cost Review, Seabed Survey, and Environmental Impact Assessment
- Exact Converter Location to be decided through Electricity Current Flow Analysis

Korea-Japan HVDC 210-270km

Fukuoka City

Pohang Area

Busan-Jinhae/Masan Area

AC/DC Converter
<HVDC Submarine Cable Installing>

◆ Undersea Cable Installing: HVDC Submarine Cable (500/800kV)
<Potential Route of ASG Project (Ex)>
<Process of Energy Highway in NEA Region>

*Academic & Engineering Study for Specific Interconnection Project

Adjust the Long Term Electricity Demand & Supply Plan of NEA Countries

Site Survey & Plan on Interconnection Points (C/S & Submarine Cable)

Governmental & Power Utility Level Dialogue → SPC Establishment

Construction → Commissioning → Operation & Maintenance (Trading)
<What we do for PSI in NEA Regions>

- Sincere participation of DPRK on NEAREST (ASG) project?
  - Power industry and system data offering
  - DPRK, is it possible to join this peaceful meeting?
- Continuous discussion for realization of PSI, NEAREST
  - Joint Research for feasibility assessment of NEAREST
  - Presentations of Power trade experiences by UCTE, ASEAN ...
- Energy Security problem should be solved ....
  - How can we guarantee this important issue in terms of technical, business and political points ...
<What should do we for PSI in NEA>

◆ Step by Step Cooperation, from Private to Governmental Level
  ■ Firstly, Suggestion for Organizing NAPCI Energy Forum, both private and governmental level …
  ■ Cooperation Joint Study for Energy Network sponsored by each government …
  ■ For the Enhancement of Energy Security

◆ Joint research and Exchange of data for NEAREST(ASG)
  ■ Participation of experts on Technical, Economic and Marketability assessment …

◆ Hold the Annual International Symposium or Forum in turn
  ■ For the Realization and Joint Study on NAPCI Energy Network
  ■ (Non) Official meeting & Presentations & Publications
Beyond NEA, Toward Worldwide ...

Trans Northeast Asian Network
“RU-MO-CH-NK-SK-JP”
<Power Industry Deregulation in KOREA>

- [CBP Market] KEPCO+6 GENCO+IPPs → Future TWBP Market
  KEPCO shares of 80% or more in Power MARKET
- Maybe, Retail Market will open in near future ...

Year 2001

KEPCO

Generation

Transmission
Distribution
Sales

Customer

6 generation companies

KOMIPD
KOSPO
WP
KOSER
KHDN
IPPs

KPX

Transmission (KEPCO)
Distribution (KEPCO)
Sales (KEPCO)
<Korean Power System>

- [GEN] East Coast TP, West NP(24) transmits to Seoul Load Center
- [Transmission] 765 & 345 & 154kV TLs & 2-HVDCs
- [Future] HVDCs will be constructed to increase Power Stability & decrease Fault Current Problem
- Quite high load density, but will face saturated load demand in near future
7th Long Term Power Demand & Supply Plan

- Saturated demand increasing rate, sufficient reserves
  → CBT (Import/Export) is possible with neighboring countries

<table>
<thead>
<tr>
<th>Year</th>
<th>Peak Load (MW)</th>
<th>Installed Capacity (MW)</th>
<th>Reserves (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>82,478</td>
<td>92,438</td>
<td>121%</td>
</tr>
<tr>
<td>2016</td>
<td>84,612</td>
<td>102,722</td>
<td>214%</td>
</tr>
<tr>
<td>2017</td>
<td>88,206</td>
<td>111,954</td>
<td>269%</td>
</tr>
<tr>
<td>2018</td>
<td>91,795</td>
<td>115,211</td>
<td>255%</td>
</tr>
<tr>
<td>2019</td>
<td>94,840</td>
<td>117,870</td>
<td>243%</td>
</tr>
<tr>
<td>2020</td>
<td>97,261</td>
<td>120,396</td>
<td>238%</td>
</tr>
<tr>
<td>2021</td>
<td>99,792</td>
<td>127,089</td>
<td>274%</td>
</tr>
<tr>
<td>2022</td>
<td>101,849</td>
<td>130,679</td>
<td>283%</td>
</tr>
<tr>
<td>2023</td>
<td>103,694</td>
<td>130,477</td>
<td>258%</td>
</tr>
<tr>
<td>2024</td>
<td>105,200</td>
<td>129,306</td>
<td>229%</td>
</tr>
<tr>
<td>2025</td>
<td>106,644</td>
<td>129,879</td>
<td>218%</td>
</tr>
<tr>
<td>2026</td>
<td>107,974</td>
<td>131,588</td>
<td>219%</td>
</tr>
<tr>
<td>2027</td>
<td>109,284</td>
<td>133,289</td>
<td>220%</td>
</tr>
<tr>
<td>2028</td>
<td>110,605</td>
<td>134,981</td>
<td>220%</td>
</tr>
<tr>
<td>2029</td>
<td>111,929</td>
<td>136,684</td>
<td>221%</td>
</tr>
</tbody>
</table>
<Conclusions & Suggestions>

It should be promoted ...

① Future Peaceful Energy Network in NEA Region
② Free volume of NEA Power Interconnection and Trade Market

However, we have some barriers & should be solved ...

So, I would like to suggest strongly to organize the periodic experts group forum and governmental meeting including Private Business Sectors ...