Local Perspective on Power Grid Interconnection in Northeast Asia: Background and Perspectives from Liaoning Province, China

Ge Weichun

Liaoning Electric Power Co., Ltd.

Abstract: **This paper presents simply an overview of electricity supply and demand in Liaoning province, China, including major demand centers and major power plants and their capacities. The current and future status of the electricity transmission network is presented, including an overview of the transmission layout, the interconnection status of the Liaoning Province grid with other grids in China, and the physical condition of the transmission infrastructure. Institutional responsibility for power sector operation in Liaoning Province is presented. Potential grid interconnection with Russia and/or the DPRK through Liaoning Province is introduced. Energy planning objectives and priorities are introduced, specifically advanced technology research and applications. The benefits of grid interconnection are mainly presented, including accident reserve,**

complementarity of the electric price, raising electric power grid operating stability, and meteorological complementarity.

1 Overview of electricity supply and demand in Liaoning province

1.1 Major demand centers

- **Shenyang is the largest load demand center. It has about 20 220kV substations, some 66kV substation is only single supply. The peak load demand is about 2500MW in the winter; winter load demand is much larger than summer.**
- **Dalian is the second largest city in Liaoning province. Its peak load demand is about 2000MW in the summer, and summer load demand is much larger than winter.**
- **Peak load demands at Ansan, Liangjin, and Fusun are about 800MW.**
- **Peak load demands at Dandong, Yingkou, Liaoyang, and Benxi are about 400MW.**
- **Peak load demands at Caoyang, Fuxin, Tieling, and Panjin are about 200MW.**

1.2 Recent trends in electricity demand in the province

- **Air-conditioning and light loads in the cities are increasing rapidly.**
- **Heating load is also increasing in the winter.**

- **Industrial load has stopped decreasing, and has begun to rise slowly.**
- **Power consumption by agriculture is slowly increasing.**
- **Therefore, electricity demand in the province is expected to increase and growth is forecast at a rate of about 5-8%.**

1.3 Different levels of service to manage rural and urban electric power networks

The power supplying company manages the urban electric power network, and the rural power company mainly manages the rural electric power network. The tariffs in rural and urban areas are different, and the quality of service is also different in both areas. The tariffs for different users in rural areas are also different; for example, light load is much cheaper than industrial load, and lighting for roads and highways is much cheaper than common lighting. Tariffs in rural areas were more expensive than in urban areas in the past, and now they are same.

1.4 Recent forecasts of future population, and economic growth, and of electricity demand

The future population cannot grow, but the urban population can grow. The economic growth rate can is expected to reach about 8%. Growth rate in electricity demand can is expected to reach 5%.

1.5 Major power plants

- **The capacity of the thermal power plant at Shuizhong is 1600MW. It includes two 800MW thermal generators that were made in Russia last year.**
- **The capacity of the thermal power plant at Dalianwan is 1400MW, which includes four 350MW Japanese thermal generators. This plant was built in ten years ago.**
- **The capacity of the thermal power plant at Tieling is 1200MW. It was built eight years ago and includes four 300MW thermal generators made in China.**
- **The capacity of the thermal power plant at Jinzhou is 1200MW, which includes six 200MW Chinese thermal generators. This plant was built in fifteen years ago.**
- **The capacity of the thermal power plant at Qinghe is 1200MW, and includes eight thermal generators. There are four Russian 210MW units and four Chinese 100MW units. This plant was built twenty years ago.**
- **The capacity of the thermal power plant at Dandong is 700MW and includes two Japanese 350MW thermal generators. This plant was built in four years ago.**
- **The capacity of the thermal power plant at Yingkou is 700MW and includes two Russian 300MW thermal generators. This plant was**

built in six years ago.

- **The capacity of the thermal power plant at Chaoyang is 400MW and includes two Chinese 200MW thermal generators, which were the first and third 200MW generators made in China. This facility was built in twenty years ago.**
- **The capacity of the thermal power plant at Nenggang is 400MW and includes two Chinese 200MW thermal generators. It was built ten years ago.**
- **The capacity of the thermal power plant at Shenhai is 400MW and includes two thermal Chinese 200MW generators. It was built ten years ago.**
- **The capacity of the thermal power plant at Fuxin is 500MW and includes four thermal generators that were made in China. The capacities of the single units are 200MW and 100MW. The 200MW unit is the only one that was built four years ago, and the three 100MW units are three sets that were built twenty years ago.**
- **The capacity of the thermal power plant at Fushun is 200MW. It was built three years ago and includes one Chinese 200MW thermal generator.**
- **The capacity of a cascade hydroelectric power plant is about 400MW. It includes three steps: the first step has three 75MW units, the**

second step has two 40MW units, and the third step has four 36MW units. They were all made in China.

- **There are many wind generators of small capacity, the number of which is rapidly increasing.**
- **Pollution control equipment includes:**
  - **Soot blowers or ash disposal systems**
  - **Sweetener or desulphurization equipment**
  - **Denitrators**
  - **Dust precipitators**

1.6 Near- and medium-term capacity changes planned (additions, retirement)

Near-term capacity will be increased. Some 200MW, 300MW, and 350MW generators will be built to satisfy the load demand. Medium-term capacity will be increased much more in planning. Some 50MW and under-50MW units have been retired in recent years, and others will be retired soon.

2 Current and future status of the electricity transmission network

2.1 Overview of transmission layout

- **Voltage grade in the transmission network includes:**

- **500kV**
- **220kV**

- **Transmission system at 500kV only has one loop network; there are fifteen lines and seven substations.**
- **Reactors at 500kV lines are installed to compensate line reactive power.**
- **There are two power plants through two 500kV parallel lines connected with the grid.**
- **Seven transformers at 500kV are installed; the capacity of each transformer is 750MVA.**
- **The transmission system at 500kV does not have other equipment to control the voltage.**
- **Transmission system equipment at 500kV is mainly made in China. Specifically, all of the equipment in the Dongjia substation was the first made in China.**
- **Transmission system at 220kV is the main network frame; the structure is much stronger, and is able to operate stably when one line faults and trips.**
- **Transmission system equipment at 220kV is made mainly in China.**
- **Transmission system at 220kV has about 130 substations, and capacity is enough to satisfy the load demand.**

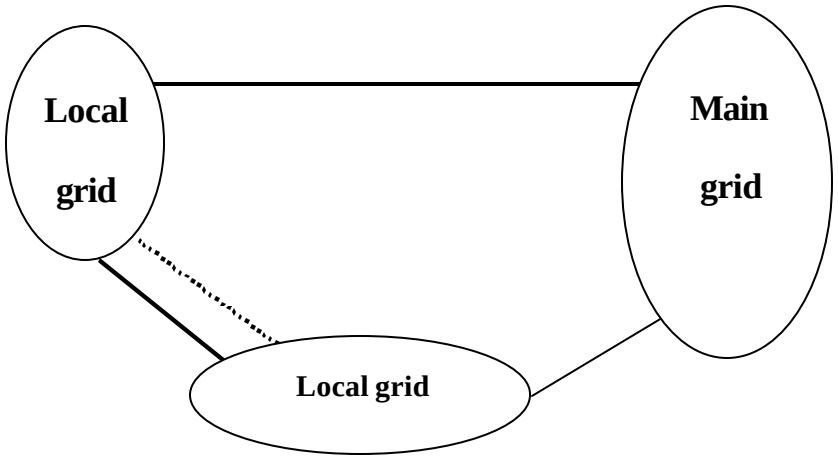
2.2 Interconnections of Liaoning Province grid with other grids in China

- **The Liaoning Province grid has been connected with the Jilin Province grid, the Northeast Electric Power Company grid, and the North China grid.**
  - **The Liaoning Province grid has been connected with the Jilin Province grid through two 500kV lines and four 220kV lines. Security and stability in tie lines can be ensured.**
  - **The Liaoning Province grid has been connected with the North China grid through one 500kV AC line. It is only with difficulty that security and stability in tie line be ensured.**
  - **The Liaoning Province grid has been connected with the Northeast grid; connection is through a lot of lines, including many 500kV lines and 220kV lines.**

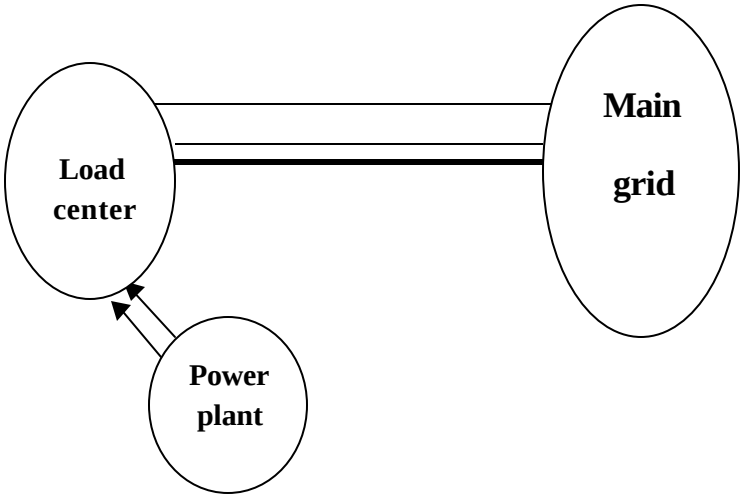
2.3 The physical condition of transmission infrastructure

The Liaoning grid is a much larger grid, which frequently has above 10,000MW active power load, and has the following characteristics:

- **The structure is not reasonable in some areas, for example:**
  - **One loop is connected between local networks:**



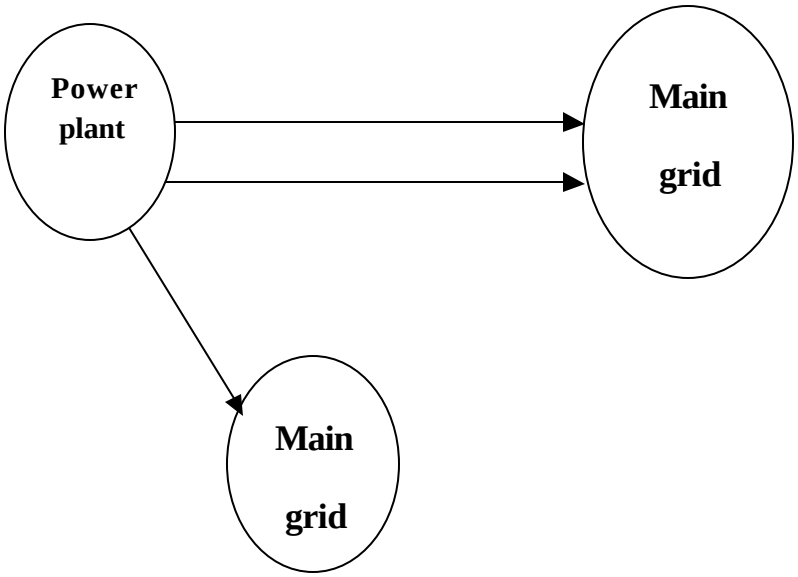
  - **Load center is only weakly connected with the main grid:**



Load center is connected with the main grid through one 500kV line and three 220kV lines. When the 500kV line faults or needs repairs,

the active power at one 220kV line will be beyond its limit.

- **Power plants of larger capacity are connected with the main grid through one or two 500kV lines.**



The Tieling power plant has two 300MW generators connected with the main grid through one 500kV line. The Shuizhong power plant has two 800MW generators connected with the main grid through one 500kV line to the North China grid and two 500kV lines to the Northeast grid.

- **Active power control is difficult for tie lines when some operating model appears.**

- **There is no advanced method to solve the swing problem for 500kV lines.**
- **There is no better technology to monitor operating states for transformers, breakers, and lines online.**
- **Technology for preventing pollution flashover is not useful.**
- **Supply power recently has been much larger than load demand.**

2.4 Near- and medium-term capacity changes planned

- **Second loop network of 500kV will be installed soon.**
- **Many 220kV lines will be installed to satisfy rapid additional demand for load.**
- **It is important to work to install many more transformers to raise operation reliability.**
- **New kind of transformers will be installed.**
- **New kind of breakers will be installed.**
- **New kind of switchers will be installed.**
- **New kind of substations will be installed.**

3 The institutional responsibility for power sector operation in Liaoning Province

3.1 How have or how will national power sector reforms affect the institutional organization and/or technical capability of local electricity sectors?

It is possible that the national power sector reforms the institutional organization, which can make the institutional organizations much more reasonably satisfy the demands of the electric power market. The technical capability of the local electricity sector can be increased by national power sector reforms, and more advanced technologies for the interconnection grid can be researched deeply and applied. Control technology and stability operation technology must be studied and applied. The technology support system has been operating for national power sector reforms.

3.2 Is there inter-regional cooperation and communication between Liaoning Province and other regions of China in terms of planning electricity interconnections? What are the major institutions involved in this process?

Liaoning grid has been interconnected with North China grid and Jilin Province grid, and one 500kV tie line that is connected with

North China grid has operated recently. Another one loop network of 500kV will be built soon in middle areas. The main institutions are the electric power companies.

4 Potential grid interconnection with Russia and/or the DPRK through Liaoning Province

4.1 Technology challenges and constraints to grid interconnection with DPRK and Russian power systems

- **There are many technology problems to grid interconnection:**
  - **The frequency control technology.**

    Automatic Generation Control (AGC) is needed to control frequency, especially when the grid is interconnected with AC.
  - **Power flow (active power and reactive power) control technology.**

    The active power must be controlled, otherwise frequency control is very difficult.
  - **Stability control technology**

    The transient stability of tie lines will be controlled by the controllable series compensators.
  - **How to define the price**
  - **If the active power for the tie lines is large enough when one or all**

faults, the electric power network of Liaoning is not able to support this power difference.

- **Automatic Generation Control (AGC) is repaired to control the active power of tie lines to be connected with Jilin grid, North China, and Northeast grid. If the Liaoning grid is connected with other foreign grids, how does Automatic Generation Control (AGC) control the active power of the tie lines?**
- **Information management is very difficult.**

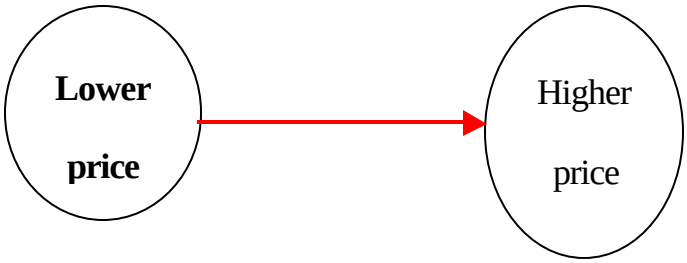
4.2 What do you see as the potential benefits and liabilities of grid interconnection for Liaoning province?

- **Accident reserve**

  When some regional power grid accident happens (for example, a larger capacity generator faults) other grids can supply the support of generation through tie lines.

- **Complementarity of the electric price.**

  Frequently, the electric price is different in both regional power grids so that one regional power grid (at the higher electric price) may buy electricity from other one. The price is very important for interconnection grid!



- **To raise stability**

  For regional power grid interconnection, the stability of each grid is raised, but the stability of the tie lines must also be controlled well.

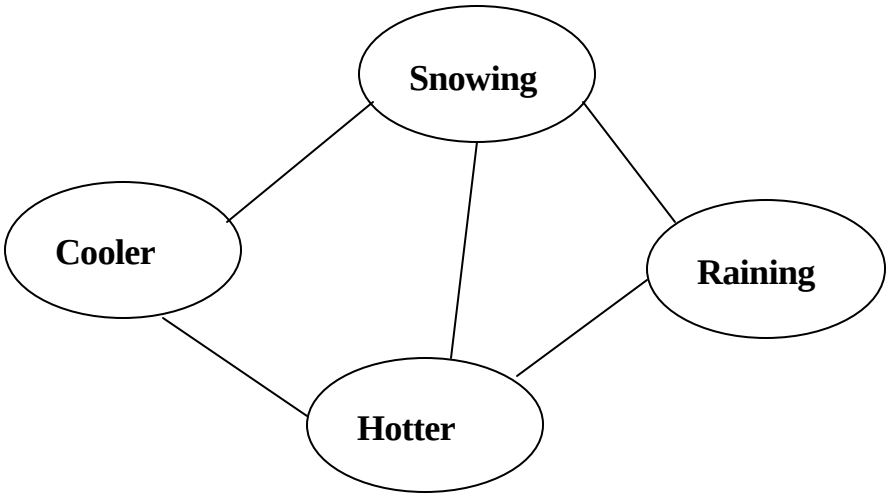
- **Both peak and valley load are complementary**

  The time at which the peak and valley loads both appear within the regional power grid is different, so that errors between peak and valley loads in each regional power grid can be decreased.

  The error between peak and valley load is one very important index and exerts a tremendous influence on economic benefits.

- **Meteorological complementarity**

  Some regional power grids have to deal with rain or snow while other do not, so the difference in load is great. If larger space is included after regional power grid interconnection, the benefits are also huge for dealing with meteorological issues.



5. Energy planning objectives and priorities

5.1 Energy planning objectives

- **It must satisfy the demand for the economic development of society.**
- **It must satisfy the increasing load demand.**
- **It must satisfy the demand for security of the electric power system.**
- **It must satisfy the demand for stability of the electric power system.**
- **It must satisfy the demand for economic operation of the electric power system.**
- **It must satisfy the demand for reliability of the electric power system.**
- **It must satisfy the demand for environmental protection by the electric**

power system.

- **It must satisfy the demands of the electric power market.**
- **It must satisfy the customers' demands.**

5.2 Energy planning priorities

- **Supply building**
  - **Priority builds the 300MW and 350MW generating units.**
  - **Supply building must satisfy the demand of increasing load.**
  - **Old units must be reformed in ways that satisfy the demands of the economy and environmental protection.**
  - **Units whose capacity is too small will be stopped.**
- **Electric power network building**
  - **Another 500kV loop network will be built.**
  - **Priority will be given to building the 220kV electric power network .**
  - **Priority will be given to building the city electric power network at 220kV and 66kV.**
  - **Priority will be given to building the rural electric power network at 66kV and 10.5kV.**
  - **Transformer capacity will be increased.**
  - **New kinds of transmission equipment will be installed.**

5.3 Advanced technology research and applications

- **Stability and economic analysis and control of electric power network operation**
  - **Frequency control technology.**

    Automation levels on units will be raised, dispatching automation system application technology will be raised.
  - **Peak-low load control technology.**
  - **Tie lines power flow control technology.**
  - **Network losing analysis and control technology.**
  - **Generation cost analysis.**
  - **Voltage regulation and control technology.**
  - **On-load changer control technology.**
  - **Generator stability control technology.**
  - **Region grid stability control technology.**
  - **Voltage stability control technology.**
  - **Tie line between region power grid stability control technology.**
  - **Automatic generation control.**
  - **Load transmission ability control technology.**
  - **Reliability analysis and control technology.**
  - **Quality of electric energy control technology.**
- **Dispatching automation system.**
  - **Advanced supporting system application to satisfy operating and**

electric power market demand.

- **Advanced application software, including:**
  - **Network topology.**
  - **State estimation.**
  - **Power flow analysis.**
  - **Optimal power flow.**
  - **Economic dispatching.**
  - **Static security analysis.**
  - **Load forecasting.**
  - **Unit scheduling.**
  - **Automatic generation control**
  - **Voltage stability analysis**
  - **Transient stability analysis**
  - **Security constraint dispatching**
  - **Dispatcher train and simulating system.**
- **Automatic measurement system of electric energy.**
  - **Advanced measuring device design for electric energy.**
  - **Overall error analysis technology of electric energy measuring in electric power network.**
  - **Processing technology of electric quantity.**
  - **Storage technology of electric quantity.**

- **Interface technology with other information systems.**
- **Fault diagnosing technology for electric quantity measuring system.**

➢ **Dispatching operating information management system.**

- **Dispatcher daily information management technology.**
- **Frequency testing system.**
- **Dispatcher operation order management technology.**
- **Real time operating information management technology.**
- **Tie line active power testing system.**

- **Distribution automation system.**

➢ **Advanced supporting system application**

➢ **Advanced application software, including:**

- **Network topology.**
- **State estimation.**
- **Power flow analysis.**
- **Reactive optimization and control.**
- **Load forecasting.**
- **Dispatcher train and simulating system.**
- **Advanced measuring device design for electric energy.**
- **Processing technology of electric quantity.**

➢ **Security technology for the system.**

- **Cost analysis system.**
- **Price analysis system.**
- **RTU network technology**

- **Advanced technology research and application for power plants**
  - **Coal quantity test technology.**
  - **DCS technology**
- **Advanced technology research and application for transmission system**
  - **New kind of wires application.**
  - **New kind of towers application.**
- **Advanced technology research and application for substation.**
  - **Insulation measurement and protection technology.**
  - **Transformer on-line measurement.**
  - **Breaker on-line measurement.**
  - **Switcher measurement technology.**
  - **New kind of substations building.**
- **Information management technology.**
  - **1000M ether network technology application.**
  - **ATM technology application.**
  - **Application software study.**
  - **Video frequency meeting system application.**

- **Database research and application.**

- **New energy generation technology.**
  - **Wind generation technology.**
    - **Operation technology.**
    - **Wind measurement technology.**
    - **Wind generator manufacture technology.**
  - **Solar energy generation technology.**
- **Electric power market technique support system.**
  - **Advanced hardware platform.**
  - **Advanced software platform.**
  - **Advanced database platform.**
  - **Price management system.**
  - **Cost management system.**
  - **Trade management system.**
  - **Contract management system.**
  - **Open information management system.**

6 Conclusion

- **The Liaoning grid is a part of the Northeast grid, and is difficult to connect with other countries.**
- **Regulation of the peak ability of the Liaoning grid is not strong enough.**

It is difficult to accommodate large disturbances in active power.

- **The Liaoning grid knows that grid interconnection has many benefits, and will cooperate with other grids.**
- **The technology level in the Liaoning grid will be raised to satisfy the demands of grid interconnection and the electric power market.**