

# **ASSESSMENT OF ENERGY SUPPLY SYSTEMS WITH AN ENERGY INFRASTRUCTURE MODEL FOR ASIA/EURASIA**

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It has become important to answer the question of what energy related infrastructure, such as transcontinental natural gas pipelines and international electricity grids, should be constructed in Asia/Eurasia, and the question of how energy demand should be satisfied there securely, and economically as well as environmentally benignly over the next several decades. The purpose of this study is to investigate the possible future configuration of energy and CO<sub>2</sub> related infrastructure in Asia/Eurasia that is a neighboring region of Japan.

We have been developing a large-scale energy related infrastructure model, which minimizes inter-temporally the sum of the discounted total energy system up until the year of 2050 with linear programming technique. The model explicitly involves intra-regional transportation networks of fuels, electricity and recovered CO<sub>2</sub> among about 90 nodes in Asia/Eurasia. The model illustrates concrete geographical distributions of demand and supply of various primary energy, CO<sub>2</sub> recovery and disposal, and transportation flows of the fuels, electricity and recovered CO<sub>2</sub> among the nodes. The nodes are connected with plausible land and/or ocean transportation routes. Coal freight trains, oil pipelines, natural gas pipelines, DC power transmission lines and CO<sub>2</sub> pipelines are considered as the specific measures for land transportation. We assume ocean transportation routes for coal, oil and natural gas between each pair of the coastal nodes in the model. Coal bulk carriers, oil tankers and LNG (Liquefied Natural Gas) tankers are considered as the specific measures for ocean transportation. The specific capacity of each transportation route is determined as the result of minimization of the total energy system cost.

With respect to the electricity generation sector, the model explicitly takes into account daily load duration curves expressed simply with three time periods (peak period, intermediate period and off-peak period), so as to determine how each type of power plant will be operated in accordance with diurnal variation of electricity demands. This is because the capacity factors of electric power plants are supposed to have a great influence on their economic characteristics. The future contributions of nuclear and hydraulic power plants in the model are exogenously determined prior to the cost minimization in this study.

In order to assess the energy supply systems in Asia/Eurasia with the model, three simulation cases were assumed, that is, Business as Usual case, Investment constraint case and CO<sub>2</sub> constraint case. The preliminary computational results of the model can be summarized as follows.

- (1) In BAU case, coal is to be the dominant primary energy source, especially for power generation in most Asian countries, and natural gas is to become the second most important primary energy.
- (2) The results indicate that transporting those fuels by rail or pipeline and generating electricity close to the energy consuming cities is generally more economical than generating electricity at mine mouth or wellhead and transmitting electricity by power transmission line.
- (3) The development of gas production and transportation infrastructures appears as a robust energy supply option for Asian countries. An increased reliance on natural gas would provide Asian countries with more geographically diversified energy supply structures, thus improving the securities for their energy procurement.

- (4) The necessity of the development of region-wide electricity grids among Asian countries is not obvious. However, in some cases, we can find a few of inter-city routes of power transmission lines as an optimal solution of the model.
- (5) Investment constraints on energy transportation infrastructure in Asian countries may lower the use of domestic coal, and raise the degree of dependence to oil and natural gas, as well as imported coal.
- (6) In CO<sub>2</sub> constraint case, the model estimated that an extensive network of natural gas pipelines is developed in China and East Asia. Neither the investment constraint nor the CO<sub>2</sub> constraint seems to have a significant influence on the optimal configuration of region-wide electricity grids.
- (7) It seems to be unlikely that the electric power systems of Japan will be linked with those of neighboring countries, mainly because of its poor economical meaning. When it comes to regional energy grids, it may have to give priority to international natural gas pipelines.