# ENVIRONMENTAL ASPECTS OF ELECTRICITY GRID INTERCONNECTION IN NORTHEAST ASIA

**David Streets**
**Argonne National Laboratory**

Environmental degradation is widespread in Northeast Asia, particularly atmospheric pollution. Enhanced grid interconnections in Northeast Asia offer two distinct kinds of benefits: (a) the spatial separation of source and point of end-use, and (b) the substitution of cleaner fuels for coal. The first of these factors offers real potential. In most of the region, the pollution sources, i.e., power plants, are geographically co-located with the points of electricity end-use, i.e., population centers. Transmission lines are short. Thus, there is maximum exposure of populations to elevated pollution concentrations, and damage to human health is the result. Second, coal is the cheapest and most readily available fuel for electricity generation in China, and its combustion leads to high emissions of airborne pollutants. If the electricity generation can occur in places where cleaner fuels are more plentiful (whether natural gas, hydroelectricity, nuclear, or other renewables), then additional benefits can accrue.

It is presumed that there are three major cross-border interconnections that are feasible: (A) from the Irkutsk/Lake Baikal region of Siberia through Mongolia to the Beijing area; (B) extensions from north-eastern China to the DPRK and perhaps ROK and Japan; and (C) from far-eastern Russia via Sakhalin to Hokkaido by submarine cable and thence to the rest of Japan. The ready availability of natural gas and hydropower, and the possibility of nuclear power, make energy supply for additional electricity generation in eastern Siberia a real possibility. In all cases, the construction and operation of new coal-fired power plants would be avoided.

The air quality benefits can be realized at three spatial scales: local (both urban and rural), regional, and global.

The cities of Northeast Asia (Japan largely excepted) all battle air quality problems because of the extensive use of coal to fuel economic development. Interconnection option A would supply electricity to Beijing and Tianjin and other industrialized cities in the region, such as Shijiazhuang. It could also help to alleviate Mongolia's electricity deficiency along the way. By extending further to the west, it would be possible to connect some of the most polluted cities in northern China: Taiyuan, Lanzhou, and Yinchuan. Option B would supply electricity to the industrialized Northeast Plains, where, again, are some of China's most polluted cities: Shenyang, Changchun, and Harbin. All these cities regularly figure at the top of the list of cities with an air quality index of Class III and IV. Pyongyang would be an additional beneficiary. Ambient concentrations of sulfur dioxide, nitrogen oxides, and particulate matter would all be reduced in these cities. If the interconnection could stretch to the ROK, then the large industrialized area around Seoul would undoubtedly benefit, because rapid electricity demand growth is anticipated with few attractive generation options.

Throughout northern China and the DPRK the ability to increase rural electrification would greatly benefit air pollution and human health. Coal and biofuels (wood, agricultural residues, and dried animal waste—in the west) are all burned in domestic stoves for cooking and, in the winter, heating. These combustors are notoriously inefficient. They generate large quantities of the products of incomplete combustion: carbon monoxide, methane, volatile organic compounds, and fine carbonaceous particles. These emissions are a threat at all spatial scales: from the inhalation by women and children in kitchens, through the regional problems of reduced visibility

and lowered insolation, to the global warming potentials of the direct greenhouse gases, methane and black carbon. The gaseous species are also indirect greenhouse gases in that they participate in the formation of regional tropospheric ozone. All these aspects of rural energy use in Asia are currently receiving great attention. So the import and distribution of additional electricity throughout these rural areas would bring with them a variety of largely unappreciated benefits.

At regional scale, the issues revolve around acid deposition and regional ozone formation. Sulfur dioxide emissions and acid deposition have received the most attention. The regional sulfur source-receptor relationships for Northeast Asia are in some dispute for political reasons. Thus China asserts that its contribution to sulfur deposition in Japan is much less than Japan believes. Nevertheless, certain relationships are incontrovertibly true. The Northeast Plains of China (the provinces of Heilongjiang, Jilin, and Liaoning) are most strongly linked to sulfur deposition in ROK, DPRK, and Japan. According to the RAINS-Asia model, sources in the Northeast Plains are responsible for about 17% of sulfur deposition in DPRK and 22% of sulfur deposition in Japan. In the ROK, the contribution is only 9% because local emissions are considerably higher there. From the point of view of alleviating long-range transport of pollution, it is clearly in these three provinces that the greatest benefits of emission reduction would occur. Of course, China itself is the recipient of the majority of the sulfur, nitrogen, acid deposition from its own sources.

Estimates of the potential for regional emission reductions show that the benefits would be modest. For a typically proposed annual supply of 15 TWh of electricity from Siberia to northern China, about 7 million tonnes of coal use and 140 Gg of $SO_2$ emissions would be avoided. However, this represents only about 8.5% of the $SO_2$ emissions from power plants in the region (including Nei Monggol, Ningxia, Heilongjiang, Jilin, Liaoning, Beijing, and Tianjin) and 4.3% of total $SO_2$ emissions in the region. This reminds us of the fact that much of the coal in China (about 50% in this region) is used in the industrial sector. So, unless industrial electrification can be enhanced, there is a limit to the extent to which imported electricity can displace coal. Nevertheless, if this imported electricity could be carefully targeted, say to a city like Beijing or Shenyang, it could accrue substantial local benefits.

At global scale, any substitution of hydroelectricity, nuclear power, or other renewables for coal will essentially eliminate emissions of carbon dioxide. Even substitution of natural gas for coal will reduce such emissions. This could be important to Japan, say under the interconnection option C. Japan is presently the only country in Northeast Asia required to reduce greenhouse-gas emissions under the Kyoto Protocol (6% from 1990 levels by 2008-2012). This is a real challenge for Japan, which already has a low energy-consuming economy that makes further reductions from domestic sources expensive. The advantages of imported electricity are thus clear. An energy “bridge” from Yakutia through Sakhalin to Japan could supply as much as 60 TWh/yr from natural-gas, coal, and hydroelectric power plants. This would help meet Japan’s joint electricity and greenhouse-gas targets.

Balanced against the clear benefits at the point of electricity use, must be weighed the environmental pollution created at the point of fuel extraction and use for electricity generation. If natural gas is the fuel of choice, then the pollution generated at the point of gas extraction, including methane emissions, must be added to the leakages from processing and distribution, and the emissions—though low—from combustion. Nuclear power and hydroelectricity are associated with their own well-known sets of pollution and risks. In addition, undersea cables and offshore gas extraction pose an additional set of marine ecosystem threats. But, overall, because of the sparsely populated nature of much of the Siberian resource regions, it is likely that the damage or risk of damage would be to natural ecosystems rather than to human health. The only additional possible threat to human health would be the still-controversial hazard from high-

voltage transmission lines, due to magnetic fields or electrostatic induction. Prudent practice would suggest routing transmission lines away from populated areas.

The achievement of regional environmental benefits, such as the ones that would accrue from enhanced grid interconnections, pose a challenge to present regulatory regimes. Though there are precedents for cross-border environmental compacts elsewhere in the world (such as the LRTAP Convention in Europe), in Asia the concept is in its infancy. Only recently has the Tripartite Environment Ministers Meeting (TEMM) among China, Japan, and Korea, taken the first steps to foster regional environmental cooperation and sustainable development. There is a long way to go before national policies can be harmonized and international agreements implemented.