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**IEEE POWER ENGINEERING SOCIETY
ENERGY DEVELOPMENT AND POWER GENERATION COMMITTEE**

**PANEL SESSION: ELECTRICITY INFRASTRUCTURE IN ASIAN REGION AND
ENERGY SECURITY PROBLEMS**

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INTRODUCTION

Sponsored by: International Practices for Energy Development

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Track 1 Understanding and Responding to System-Wide Events

Track 2 Securing New Sources of Energy...

On behalf of the Energy Development and Power Generation Committee, welcome to this Panel Session on Electricity Infrastructure in the Asian Region and Energy Security Problems.

The Asian region is a promising region for creation of a joint interstate electricity infrastructure. It embraces the industrially developed (Japan, Republic of Korea) and intensively developing (China, India, Vietnam) countries. The distribution of and demand for the fuel resources for electricity production do not coincide geographically. In the last years a number of bilateral studies (Russia-Japan, Russia-Republic of Korea, Russia-China) have been carried out. The studies have dealt with the potential options of interstate electric ties in East Asia. There are also a number of conceptual studies on potential interstate electricity infrastructure in East Asia (Russia, Japan, China, Republic of Korea, KPDR, Mongolia), South Asia and Oceania (Vietnam, Thailand, Myanmar, Indonesia, Philippines, Kampuchea), India with neighboring countries. All these studies form a basis for interstate cooperation in the sphere of the electric power industry and for the increase of interstate electricity exchanges, which is beneficial for all the participants.

At the same time each country encounters the problem of energy security. Energy security is the immunity of the country, its economy, society and citizens from the threats of impossibility to fully meet their energy demands by economically accessible energy resources of an admissible quality from the threats of energy supply interruption. An important aspect of energy security in any country is its energy independence that can be provided by diversified external sources of energy resources, including electric power.

In course of the discussion, answers to the following questions will be given:

- What are the views of different countries in the Asian region of interstate electricity infrastructure development?
- Is the problem of energy security a limiting factor for interstate electricity infrastructure development in the Asian region?

- What are the views of different countries in the region of the impact of this limitation?
- Do the growing interstate electricity exchanges in the Asian region play an important role for increasing energy independence of the countries in terms of other energy resources?

The Panelists and Titles of their Presentations are:

1. Nikolai Voropai, Director, N. I. Pyatkova, S. M. Senderov, G. B. Slavin, and M. B. Cheltsov, Energy Systems Institute, Russian Academy of Sciences, Irkutsk, Russia. Energy Security as a Factor of Energy Cooperation in East Asia (Paper 05GM0240)
2. Yasumasa FUJII, Associate Professor, The University of Tokyo, Japan. Assessment of Energy Supply Systems with an Energy Infrastructure Model for Asia. (Paper 05GM0435)
3. Ahmed F Zabaa, Cairo University, Giza, Egypt. Energy Security in the Asia-Pacific Region (Paper 05GM0063)
4. Wu Wei, Zhao He, and Quang Guo, Planning and Research Center, China Power, Engineering Consulting Corporation, Beijing, China. China Power Grid and its Future Development (Paper 05GM0177)
5. L.S. Belyaev, N.I. Voropai, L.Yu. Chudinova, S.V. Podkovalnikov, V.A. Savelyev, Energy Systems Institute, Russian Academy of Sciences, Irkutsk, Russia. Prospects of Electricity Infrastructure in East Asia (Paper 05GM0221)
6. Tae Kyoo Oh, Korea Electro-Technology Research Institute, Euiwang City, Geounggi Do, Korea. . (Invited Discusser)
7. YBhg Dato' Mohd. Zainal Azirun, Vice President (Transmission), TNB Transmission Network, Kuala Lumpa (Invited Discusser)

Each Panelist will speak for approximately 20 minutes. Each presentation will be discussed immediately following the respective presentation. There will be a further opportunity for discussion of the presentations following the final presentation.

The Panel Session has been organized by Nikolai Voropai (Energy System Institute, Russian Academy of Sciences, Russia) and Tom Hammons, (Chair of International Practices for Energy Development and Power Generation IEEE, University of Glasgow, UK).

Nikolai Voropai and Tom Hammons moderate the Panel Session.

The first presentation is on Energy Security as a Factor of Energy Cooperation in East Asia. Nikolai Voropai, Director, N. I. Pyatkova, S. M. Senderov, G. B. Slavin, and M. B. Cheltsov, Energy Systems Institute, Russian Academy of Sciences, Irkutsk, Russia has prepared it. Nikolai Voropai will present it.

The essence of energy security problem will be explained. The main threats to energy security of Russia in current conditions will be discussed. Positive and negative arguments concerning energy cooperation will be formulated in terms of energy security for Russia and East Asia countries and will also be discussed.

Nikolai I. Voropai is Director of the Energy Systems Institute (Siberian Energy System until 1997) of the Russian Academy of Science, Irkutsk, Russia. He was born in Belarus in 1943. He graduated from the Leningrad (St. Petersburg) Polytechnic Institute in 1966. Voropai received his degree of Candidate of Technical Sciences at the Leningrad Polytechnic Institute in 1974 and Doctor of Technical Sciences at the Siberian Energy System in 1990. His research interests include: modeling of power systems, operation and dynamics performance of large power grids;

reliability and security of power systems; development of national, international and intercontinental power grids; and liberalization of the power industry.

Natalya I. Pyatkova was born in 1952. In 1975 she graduated from Ufa Oil Institute as an economy engineer. She received the degree of Candidate of Technical Sciences in 1996. At present she works as Head of a Laboratory at the Energy Systems Institute. Her main fields of scientific interests are: elaboration and application economy-mathematical models on fuel and energy complex development, and research on energy security problems. She is the author and co-author of about 100 scientific papers and books.

Sergei M. Senderov was born in 1964. He graduated from Irkutsk Polytechnic Institute in 1986. He specialized in heat and gas supply. He received the degree of Candidate of Technical Sciences in 1996. At present he works as Head of Department at the Energy System Survivability and Security of Energy Systems Institute. His main fields of scientific interests are: research in gas supply systems, problems in developing gas reserves, and research in energy security problems. He is the author and co-author of almost 60 scientific papers and books.

Grigoriy B. Slavin was born in 1937. He graduated from Moscow Textile Institute in 1959 with a power engineer degree. He received the degree of Candidate of Technical Sciences in 1976. At present he works as a Chief Researcher at the Energy Systems Institute. His main fields of scientific interests are: development of fuel and energy complex, energy saving, energy security problems and energy monitoring. He is the author and co-author of more than 170 scientific papers and books.

Michael B. Cheltsov was born in 1928. He graduated from Tomsk Electric-Mechanic Institute in 1950 with an electrical engineer degree. He received the degree of Candidate of Technical Sciences in 1965. At present he works as a Chief Researcher at the Energy Systems Institute. His main fields of scientific interests are: adaptive development energy systems, fuel and energy complex, reliability assessment, and energy security problems. He is the author and co-author of more than 200 scientific papers and books.

The second presentation is entitled: Assessment of Energy Supply Systems with an Energy Infrastructure Model for Asia. Yasumasa FUJII, Associate Professor at the University of Tokyo, Japan has prepared it. He will present it.

The purpose of the study is to obtain insights into the optimal future configuration and operation of the Asian energy infrastructure. The author's research group has been developing a global energy system model that minimizes inter-temporally the sum of discounted total energy system costs up to the year 2050. The model explicitly involves international transportation networks of fuels and power as well as various energy conversion facilities, such as electric power plants. The model tries to illustrate concretely optimal geographical distributions of future demand and supply of various energy commodities in the world, and their international transportation flows. In the presentation, an outline of the current energy model and a summary of computational results for Northeast Asia will be presented.

Yasumasa Fujii graduated from the University of Tokyo in 1988. He received his master and doctor degrees in Engineering from the University of Tokyo in 1990 and 1993, respectively. He is Associate Professor with the Department of Electrical Engineering, Graduate School of

Engineering, University of Tokyo. He is a member of IEEE and the Institute of Electrical Engineers of Japan. His research interests are power system modeling and analysis.

The third presentation is on Energy Security in the Asia-Pacific Region. It has been prepared and will be presented by Ahmed F Zaba, Cairo University, Giza, Egypt.

The Asia Pacific region is undergoing fundamental changes affecting both the oil and gas sectors. Demand growth from China dominates regional growth and is now affecting global oil prices. Meanwhile the region is experiencing positive refining margins despite a fundamental capacity surplus. This is giving false signals to the refining sector and encouraging additional unneeded investments. The region has limited commercial or strategic storage and there are prospects now for the first time to encourage Middle East investments or commitment to usage for commercial storage in the region-particularly Singapore. On the LNG front, Singapore now has joined a growing list of LNG consumers in examining the options for LNG imports. The LNG business is also changing rapidly with new terms and conditions that were unheard of in the past. For Singapore there are many interesting opportunities available to both increase energy security and at the same time undertake projects, which make commercial sense in the storage and LNG sectors. But there is a clear need to plan the moves carefully and shepherd the process to a successful conclusion. This is discussed and analyzed in the presentation.

Ahmed Faheem Zaba received the B.Sc. (hons.), M.Sc. and Ph.D. degrees in Electrical Power & Machines from the Faculty of Engineering at Cairo University, Giza, Egypt, in 1992, 1997 and 2002, respectively.

Currently, he is with the Department of Electrical Power & Machines, Faculty of Engineering, Cairo University. He was an Instructor in the Department of Electrical Power & Machines, Cairo University from 1992 to 1997. He was a Teaching Assistant from 1997 to 2002. He regularly reviews papers for eight IEEE Transactions especially all IEEE/PES transactions and seven journals in his areas of interest. He is author or co-author of many refereed Journal and Conference papers. His areas of research include harmonics, compensation of reactive power, power quality, photovoltaics, wind energy, education and distance learning.

Dr. Zaba is a member of the IEEE Power Engineering / Industry Applications / Industrial Electronics / Power Electronics Societies, the Institution of Electrical Engineers and the International Solar Energy Society.

The fourth presentation is entitled: China Power Grid and its Future Development. It has been prepared by Wu Wei, Power System Planning and Research Center, China Power, Engineering Consulting Corporation, Beijing, China; Zhao He, Planning and Research Center, China Power, Engineering Consulting Corporation, Beijing, China; and Quang Guo, Planning and Research Center, China Power, Engineering Consulting Corporation, Beijing, China. Wu Wei will present it.

The uneven distribution of energy resources and power load centers, as an impetus, is driving China Power Grid to strengthen its nation-wide interconnections to achieve high utilization efficiency. The current situation and planning of China Power Grid is introduced in the presentation. Specific problems considered in planning nation-wide interconnections and their countermeasures are analyzed, such as low frequency oscillation, stability of the receiving-end system, and security of multi-in feed HVDC systems, etc.

Wei Wu was born in Hubei, China, in 1977. She received her BS and MS degrees in 2000 and 2003. She is working as a power system-consulting engineer with China Power Engineering Consulting.

The fifth presentation is on Prospects of Electricity Infrastructure in East Asia. L.S. Belyaev, N.I. Voropai, L.Yu. Chudinova, S.V. Podkovalnikov, and V.A. Savelyev, Energy Systems Institute, Russian Academy of Sciences, Irkutsk, Russia has prepared it. Lev. Belyaev and Nikolai Voropai will present it.

The major principles, required conditions, objectives and stages of creating common electric power space in East Asia are determined. Effects of interconnecting electric power systems with different seasonal load maxima are considered. Prospective electricity demand and free volumes of electric power markets in East Asian countries are estimated. Export power projects in Siberia and Russian Far East are also analyzed.

Lev S. Belyaev was born in 1928. He graduated from Moscow Energy Institute in 1950 with an electrical engineer degree. He is a Professor (1986) and Doctor of Technical Sciences (1969). At present he is a fellow of the Energy Systems Institute named after L.A. Melentyev - ISEM- (Siberian Energy Institute until 1997), Irkutsk, Russia. In 1975-1976 he was with the Energy Program at the International Institute for Applied Systems Analysis – IIASA (Luxenburg, Austria). His main fields of interest are: development, simulation and optimization of energy systems including global systems, energy technology assessment, interstate electric ties, and methodology of decision-making under uncertainty, He is the author and co-author of more than 200 scientific papers and books.

Nikolai I. Voropai is Director of the ISEM. He is also Head of the Electric Power Systems Department at the Institute and Professor at the Irkutsk Technical University. He was born in Belarus in 1943. He graduated from the Leningrad (St. Petersburg) Polytechnic Institute in 1966 and has been with the Siberian Energy Institute since that year. Voropai received his degree of Candidate of Technical Sciences at the Leningrad Polytechnic Institute in 1974 and Doctor of Technical Sciences at the Siberian Energy Institute in 1990. His research interests include: modeling of power systems, operation and dynamics performance of large interconnections; reliability and security of power systems; and development of national, international and intercontinental interconnections. He is the author and co-author of more than 200 scientific papers and books.

Lyudmila Yu. Chudinova was born in 1966. She graduated from Leningrad Polytechnic Institute as a hydropower engineer in 1960. At present she is a researcher at ISEM. Her fields of interest are: interstate electric ties and hydropower. She has published 10 scientific papers.

Sergey V. Podkovalnikov was born in 1958. He graduated from Irkutsk Polytechnic Institute as an electrical engineer in 1980. In 1993 he participated in the Young Scientists Summer Program of IIASA (Austria). In 1997–1998 he was with Pace University (USA) as a Fulbright Scholar. At present he is a principal researcher at ISEM. His research interests are: methods for decision-making in energy under uncertainty and multiple criteria, interstate electric ties and interconnected power systems, and development of restructuring the electric power industry. He is the author and co-author of more than 80 scientific papers and books.

Vladimir A. Savelyev was born in 1932. In 1955 he graduated from Moscow Energy Institute as a hydropower engineer. At present he is a senior researcher at ISEM. His research interests are: long term development, optimization and scheduling of power systems and cascades of hydropower plants, hydropower safety, and methods for electricity tariffs setting for power systems with substantial hydropower capacities. He is the author and co-author of more than 80 scientific papers and books.

The sixth and seventh presentations are invited discussions. They have been prepared by Tae Kyoo Oh, Korea Electro technology Research Institute, Euiwang City, Geounggi Do, Korea. and YBhg Dato' Mohd. Zainal Azirun, Vice President (Transmission), TNB Transmission Network, Kuala Lumpur, respectively.

PANEL SESSION SUMMARIES

1. ENERGY SECURITY AS A FACTOR OF THE COMMON ENERGY COOPERATION IN EAST ASIA (PAPER 05 GM 0240)

Nikolai Voropai, Director, Energy Systems Institute, Russian Academy of Sciences, Irkutsk, Russia

N. I. Pyatkova, Energy Systems Institute, Russian Academy of Sciences, Irkutsk, Russia

S. M. Senderov, Energy Systems Institute, Russian Academy of Sciences, Irkutsk, Russia

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Abstract – The essence of energy security problem is explained. The main threats to energy security of Russia in current conditions are discussed. Positive and negative arguments concerning energy cooperation are formulated in terms of energy security for Russia and East Asia countries.

Keywords – energy security, energy cooperation, East Asian countries, positive and negative arguments.

Energy Security (ES) implies here protect ability of a person, society, state, economy from threats of deficiency in meeting their energy demands by economically accessible fuel resources (FR) of an acceptable quality, from threats of disturbances of stable and uninterrupted power supply. The indicated state of protect ability corresponds to the full meeting of the reasonable demands under normal conditions and to the guaranteed meeting of the minimum required demands under extreme conditions. In so doing, the reliable and guaranteed external supply of energy carriers is the most important component of ES for the countries and regions with insignificant reserves of local FR (for instance, Japan, Central and Volgo-Vyatsky areas of Russia); energy independence: capability to manage with local resources at a loss/decrease of external supplies - for the countries and regions with a middle level of provision (the USA, Great Britain, Povolzhie and Ural areas of Russia, etc.); for relatively well provided territories (Russia, Canada, Turkmenistan, Iran, West Siberia, etc.) the following four factors which also play an important role for the mentioned above territories are decisive in the ES support:

a) Capability of the fuel and energy complex (FEC) to supply energy carriers continuously and in sufficient volume, creating energy prerequisites for stable operation and progressive development of the economy and maintenance of the adequate living level of citizens;

- b) Capability of consumers to efficiently consume energy, to limit energy demand, decreasing it, thus to prevent energy balance tension and deficiency;
- c) Balanced FR supply and demand with regard to economically feasible export and import of FR;
- d) Favorable socio-political, legal, economic and international conditions for realization of the above capabilities by FR producers and consumers.

It seems to be a common practice that ES is considered an important component of economic security being in its turn one of the basic constituents of the national security of each country.

Analysis of the up-to-date state and trends in the development of FEC and its industries as well as conditions of their development and functioning has allowed one to reveal a wide range of threats to energy security of Russia. These threats grouped in 6 classes are presented in Table 1 (in more detail about the subject-matter, problems of ES and threats to ES see [1-6, etc.]).

TABLE 1. MAIN THREATS TO ES OF RUSSIA

Group of threats	Threats
Economic	<ul style="list-style-type: none"> • Shortage of investments. • Uncontrolled energy use by the economy. • Monopolization of energy markets. • Price disproportions. • Low technical level of energy equipment. • Weak energy-transport ties with energy imbalances of regions. • Excessive concentration and centralization in energy. • Weak diversification of energy supply. • Insufficient amount of energy reserves and stocks. • Leading growth of FR demand.
Socio-political	<ul style="list-style-type: none"> • Labor conflicts, strikes. • Political, ethnic conflicts, terrorist acts. • Ecological extremism. • Limitation of free flows of energy goods between the regions. • Conflicts between different levels of authorities, separatism. • Low qualification, discipline of personnel, carelessness. • Criminalization in energy sphere.
External economic and external political	<ul style="list-style-type: none"> • High dependence of FEC on imported equipment and materials, disruption of delivery. • Dependence of energy supply to individual regions on external FR supplies. • Discrimination measures against the Russian FR. • Critical dependence of the Russian FR exports on conditions of their transport. •
Technogenic	<ul style="list-style-type: none"> • Ageing, wear of equipment. • Accidents, explosions, fires on the FEC objects. • Accidents, explosions, fires on the objects of other branches connected with the FEC objects.
Natural	<ul style="list-style-type: none"> • Natural disasters (earthquakes, storms, etc.) • Severe winters. • Long-term low waters, particularly multiyear ones, on the rivers with hydro power plants.

Managerial-legal	<ul style="list-style-type: none"> • Inefficient economic and social policies, mistakes in their realization. • Weak mechanisms of antimonopoly policy and regulation of natural monopolies. • Incompleteness and imperfection of energy legislation. • Weak state control. • Excessive state interference. • Inefficient energy saving policy. • Poor management quality of enterprises, companies, corporations.
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The most important economic threats are sharp shortage of investment resources, entailing insufficient volumes of new capacities put into operation (3-5 times less than the minimum required ones), reconstruction and reequipping in the FEC industries; non-compensated retirement of capacities; sharp decrease in prospecting and, hence, a delay between increase in explored reserves, in particular concerning oil, and production volumes; operation of inefficient and deeply worn equipment. Mitigation of these threats to ES is one of the basic incentives to activate strategic efforts of Russia for formation of the common energy spaces in Europe and East Asia and its integration in them.

Russia is still the major energy country (Table 2) and its FEC is the most important component of the economy (Table 3) [7,8].

TABLE 2. ROLE OF RUSSIA IN THE WORLD ENERGY (2003)

Fuel resource	Fraction in world explored reserves, %	Fraction in world production, %
Oil	13	11
Gas	33	24
Coal	20	6

TABLE 3. SHARE OF FEC IN THE STRUCTURE OF THE RUSSIAN ECONOMY IN 2002-2003, %

In industrial production	31-30
In receipts to federal budget	46-42
In export	54-60
In production investments	26-31
In number of production personnel	13-14

Russia can fully meet its demands for fuel resources and supply their considerable amount for export. Particularly it concerns oil and gas. Table 4 presents corresponding data for the pre-crisis 1990 year. Though the internal consumption, production of energy carriers and their export to some extent be considerably reduced due to the economic crisis, still the situation has not changed qualitatively. In 2003 Russia exported 224 million t of oil; 189 billion m³ of gas; about 78 million t of oil products; about 66 million t of coal and 12 billion kWh of electric power. However, this export (as well as the energy co-operation on the whole) is oriented mainly to the countries of West and Central Europe and the European countries of CIS (Ukraine, Belorussia, etc.).

There are two arguments in favor of diversification of the Russian external energy ties by their extension in the eastern direction. The first consists in the fact that the eastern territories of

Russia (East Siberia and Far East) possess a sufficient energy potential for development of FR export to the East Asia countries. Whereas West Siberia meets local oil and gas demands, the main demands of European Russia and also exports these energy resources to the West, the East-Siberian and Far-Eastern oil/gas complexes under formation as well as the electric utility industry of these regions based on hydro energy and coal can both meet the local needs (and transmit a part of electric power from Kansk-Achinsk Fuel and Energy Complex to the West) and develop the eastern direction of the Russian energy policy.

TABLE 4. SOME INDICES OF THE RUSSIAN FUEL BALANCE FOR 1990 [9, ETC.]

Energy carrier	Production	Import to Russia	Export from Russia	Net export
Oil, including gas condensate, million t	516.3	16.8	210.2	193.4
Natural gas, billion m ³	640.2	31.3	212.0	180.7
Coal, million t	396.3	43.2	53.6	10.4
million .c.e		28.3	35.2	6.9
Basic oil products (diesel fuel, motor and aviation gasoline, engine fuel, furnace and marine residual oil), million t	239.3	10.1	65.8	55.7
Electric power, billion kWh	1082.2	8.4

Two considered eastern regions of Russia (ERR) - East Siberia and Far East with a territory (10.3 million km²) making up 60% of the whole country and population of 16.7 million people that produced 13% of GDP of Russia in 1995 possess the major reserves of natural energy resources. The initial potential oil resources of ERR with the shelf of Far-Eastern and arctic seas are estimated approximately at 17.8 billion t, those of natural gas - about 56 trillion m³ [7], however these resources are mainly the forecast ones whose exploration extent is low. As for the reserves of commercial categories, the fraction of ERR in oil of categories A+B+C₁ is more than 4% of the whole Russia, that of category C₂ - 13.5% (basic reserves are in West Siberia); natural (free) gas - about 6% and more than 14%, respectively [10]. In magnitude the gas reserves of ERR of categories A+B+C₁+C₂ are about 5 trillion m³ according to [10], the oil reserves (only in East Siberia) [7] are about 1 billion t according to [7]. Based on these reserves potential oil production in ERR in 2010 is estimated at about 34-42 million t (with active participation of foreign investors) according to [7] and in more remote future it can reach 70-75 million t/year,

the export resources will be about 40 million t. Gas production in 2010 in ERR is estimated at 30-60 billion m³, including about 20 billion m³ on the Sakhalin shelf. Export potentialities of ERR in the more distant future are estimated at 50 billion m³/year [7].

Eastern regions of Russia possess the largest explored balance resources of hard and brown coals: about 115 billion t of categories A+B+C₁ and more than 55 billion t of category C₂. The economically efficient hydro power potential of ERR is 75% of the whole Russia, i.e. more than 640 billion kWh, more than 135 billion kWh (33% in East Siberia and 6% in Far East) including the hydro power plants under construction have been realized. Possible scales of electric power production in ERR at the level of 2010 reach 255-260 billion kWh/year at local consumption of up to 230 billion kWh (about 180 billion kWh in 1990) [7]. The difference forms an essential part of the export potential.

The second factor of changing the priorities in the external energy policy of Russia is a growing role of the Asia-Pacific region, in particular of the East Asia countries, deficient in energy resources. There is a stable tendency in the world economy to turn this region into the most important centre of the world economy.

Import of energy resources is crucial for Japan and South Korea, since these countries have practically no natural fuel resources of their own. However, during the recent years Japan has been intensively searching for alternative gas sources, which could at least partially reduce dependence of the country on foreign supplies. In particular, the program for prospecting and development of the gas hydrate shelf fields near the sea coast of Japan has been elaborated. By now 12 hydrate-bearing areas of the shelf, containing about 6 trillion m³ of methane [11] has been explored. But the commercial exploitation of the gas hydrate fields is a matter of the distant future. China can be an important importer of fuel and energy resources in nearest future.

Russia also pursues its economic interest in East Asia region. In this connection in different time joint discussions and work on a number of energy projects "Russia-East Asia countries", which are at different stages of realization, were started. Some characteristics of these projects are given in Table 5.

TABLE 5. PROSPECTIVE PROJECTS ON CONSTRUCTION OF MAIN OIL PIPELINES IN EASTSIBERIA AND THE FAR EAST WITH PENETRATION TO FOREIGN OIL MARKETS

№	Project	Capacity, million t/year	Length, km	Diameter, mm	Investment US\$ million	Supposed year of construction	Project participants
1	Angarsk-Peevoznaya bay	50	3885	1020-1220	5817	2004-2008	Transneft
	Including: Angarsk-Skovorodino	80	2047	1020-1220	3430	2004-2006	Transneft
2	Angarsk-Datsin	1 – 20 2 - 30	2290	820 1020	2912	2004-2006	Transneft YUKOS
3	Sakhalin-1 (De-Kastri - Komsomolsk-on- Amur)	12.5	207	500	500	2004-2005	Exxon Neftegaz Rosneft Rosneft-Sakhalinmorneftegaz ONGC SODECO
4	Sakhalin-2 (Yuzhnosakhalinsk - Prigorodny)	10	800	500	1000	2005	“Sakhalin Energy Investment Company, Ltd” “Marathon” “Mitsui” “Shell” “Mitsubishi”

Having considered the subject matter and main incentives of the Russia-East Asia energy export-import co-operation it is necessary to estimate it in terms of energy security (of Russia and its partners) and partially in terms of economic and ecological security.

Positive arguments for the East Asia countries consist in the following

:

1. Provision of economically beneficial balance of their energy supply.
2. Provision of diversification of sources of hydrocarbons supplies: Russia, objectively interested in stable East-Asia market for its oil and particularly natural gas joins the conventional sources - countries of Persian Gulf, Africa and partly Southeast Asia and Australia (gas). In so doing the Russian sources themselves are also diversified (Sakhalin, Irkutsk region, Yakutia).
3. Improvement of the structure of fuel balances of the East Asia countries by using environmentally clean fuel (gas) of higher quality and supplying “clean” (for these countries) electric power as an alternative to its production by the coal-fired thermal power plants of their own and on the whole as an alternative to development of coal technologies. Though this idea is formulated in terms of ecological security, it is important for energy security: firstly, the latter implies both the quantitative meeting of demand and acceptability of energy carrier quality (see above the ES definition); secondly, the considered improvement of the fuel balance structure reduces antienergy feelings and

movements in the society, ecological extremism - one of the major threats to ES (see Table1).

4. Extension of the possibilities for the East-Asian companies to penetrate into the Russian markets of investments, equipment, technologies and other goods and services. Generally speaking, this argument testifies to the advantages of the considered projects in terms of economic security of the East Asia countries. At the same time such penetration favors commercial success and development of energy machine building, R&D works in energy and associated spheres of activities of these countries, which is obviously important for strengthening of their ES.
5. Improvement of the EPS reliability of the East Asia countries, reliability of their power supply and achievement of the other known "system" effects due to interconnection of power system at implementation of electric power projects (Table 6). Realization of these projects will lead to replacement of some capacities of power plants, particularly thermal ones, in Japan, South Korea, China at the expense of construction of power plants in East Siberia and Far East, rich in hydro resources. Correspondingly the environmental situation in the East Asia countries is improved.

The considered projects of EPS interconnection allow the countries-importers of FR to diversify their import at the expense of electricity, since electric power supplies can replace the shortfalls in supplies of some fuels. It undoubtedly strengthens their energy security.

We believe that the objections to the considered projects and co-operation from the ES viewpoint of East Asia countries are the following:

1. There is a danger of either monopoly position of Russia in FR supplies to the market of any country or its extremely large fraction enabling one to use these supplies as an instrument of economic or political pressure. But as is seen, in particular from comparison of the data in Tables 5 and 6 this situation is hardly probable.
2. The interruptions of the continuous FR supplies due to insufficient political and social stability in Russia are possible. However, one can suppose with a high degree of certainty that by the beginning of the period of supplies under the considered projects the situation in Russia will become more stable. Besides, the regions of conventional FR supplies to the East Asia countries do not belong at all to the politically stable ones, taking into account growing fundamentalistic tendencies there, interstate and interethnic conflicts, etc.

Let us consider positive arguments in terms of ES of Russia and its East- Siberian and Far-Eastern regions.

1. The basic argument which has been already mentioned is overcoming (mitigation) of the threat (to ES) of deficient investments, possibility to get direct investments, credits for development of the Russian, first of all the East-Siberian and Far-Eastern energy resources in the amounts, sufficient for their export to East Asia, their supply to the internal market and for meeting the local demand for hydrocarbons, including creation of the appropriate transport and other infrastructures. Besides, the expected investments and revenues from the export should and can be used for updating and reequipping the FEC industries and enterprises, as well as other branches of the economy (especially in frames of energy saving programs), and for solving social problems in restructurisation of the energy sector in the eastern areas of the country.
2. The possibilities for introduction of efficient technologies and equipment for solution of the problems indicated in item 1, for updating and reconstruction of the production capacities

of FEC as a whole are extended and hence, the threat of its low technological level and deep wear is reduced (Table 1).

3. A new stable market of the Russian FR is being formed. This fact is directly connected with the financial and external economic security of Russia contributing indirectly to provision of its ES.
4. Electric power effect, i.e. mutual effect due to interconnection of power systems that is similar to the described one for the ES of the East Asia countries (item 5) is attained.
5. Development of the economic (energy) co-operation in the region, determined by performance of the considered export projects will promote implementation of more progressive forms of co-operation. Though this argument concerns first of all the economic security, support of the Russian energy machine building, design and construction organizations, associated with such projects is of great importance for ES of Russia.
6. Realization of export projects reduces the social tension in Russia, especially in its eastern regions which is an essential threat to ES, since it allows one to raise the level of employment for the population, particularly the skilled workers owing to construction of energy objects and creation of the corresponding infrastructure, their servicing, production of materials and equipment, etc.

Finally, the negative arguments (objections) in terms of ES of Russia can be formulated as follows.

1. The most frequently expressed objection consists in the fact that the currently considered gas projects take into account the local gas needs insufficiently. In particular similar remarks concern the Sakhalin projects, since they mainly solve energy problems of the countries-investors and on the territory of Russia meet local demands only and do not lead to a radical change to better in energy supply of the south of Far East.
2. The threat of premature depletion of highly efficient fields of non-renewable natural resources (oil and gas), a failure to preserve them for future generations, and, hence, potential weakening of ES of Russia and particularly of its eastern regions in the middle of the 21st century seems to be serious enough. In fact, it concerns commensuration of the today's effects (including those from the ES view point) and future losses.
3. An extreme influence of foreign owners of the Russian energy enterprises on the decisions made by Russia in the energy sphere and on utilization of the strategic resources on the whole can form a definite threat while realizing export projects. This and partially two previous threats can be overcome by the thoroughly developed legislation, comprehensive substantiation of the corresponding agreements, state participation or state control at the regional and municipal levels, in the process of preparation and realization of agreements, maximum possible publicity and public control in the given sphere.
4. Export of foreign technologies and equipment within the framework of energy co-operation leads to a great dependence of Russian Federation on supply of spare parts from abroad. Licensing and arrangement of production of extremely important spare parts and units by the Russian industry including joint ventures, which are envisaged in the corresponding agreements could contribute to elimination of this threat.

On the whole it should be pointed out that the enumerated aspects, particularly those of the negative influence on ES are taken into account insufficiently in the currently considered projects. Elimination of this drawback is still an urgent problem to be solved.

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BIOGRAPHIES



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2. ASSESSMENT OF ENERGY SUPPLY SYSTEMS WITH AN ENERGY INFRASTRUCTURE MODEL FOR ASIA (PAPER 05GM0435)

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Abstract-- The purpose of the study is to obtain insights into the optimal future configuration and operation of Asian energy infrastructure. The author's research group has been developing a global energy system model, which minimizes inter-temporally the sum of the discounted total energy system costs up until the year of 2050. The model explicitly involves international transportation networks of fuels and power as well as various energy conversion facilities, such as electric power plants. The model tries to illustrate concretely optimal geographical distributions of future demand and supply of various energy commodities in the world, and their international transportation flows. In this paper, the outline of the current version of the energy model and a summary of its computational results for Northeast Asia are presented.

Index Terms— Energy conversion, Energy resources, Linear programming, Power system economics.

1. Introduction

While energy demands in China, Southeast Asia and East Asia are projected to grow substantially over the coming decades, the development and exploitation of energy resources in Asia including East Siberia and the Russian Far East have attracted considerable attentions. It has become increasingly important to answer the question of what energy infrastructure, such as long distance natural gas pipelines and international electricity networks, should be constructed in the region, and the question of how their energy demands should be satisfied economically, securely and environmentally benignly.

Let us see briefly the outlook of primary energy supplies in Asia. Coal is an abundant and broadly distributed fossil fuel in Asia, and is expected to continue to be a major energy resource. Although the price of coal per unit calorific value has been relatively inexpensive, the growing demands of coal will not be met without the extensive development of its transportation infrastructures such as railroads and bulk carriers. In the case of crude oil, the amount of its resource in the region is not plentiful as that of coal, and is unevenly distributed. Oil supplies for Asia will continue to be increasingly dependent upon the Middle East, and such over-dependency of oil procurement on the single geopolitical region may potentially aggravate the energy securities of the countries in Asia. Natural gas is a clean and high quality fuel. It generates less CO₂ than any other fossil fuels on a per calorie basis. From the viewpoint of environmental protection, natural gas is the best substitute for oil and coal. However, enormous capital investment for its transportation infrastructure of liquefied natural gas tankers, liquefaction and re-gasification facilities, as well as, extensive pipeline networks in Asia will be required in order to increase its share in total primary energy supply.

In response to the above questions, the purpose of the study is to obtain insights into the optimal future configuration and operation of Asian energy infrastructure in a long run, and also potential roles of emerging energy related new technologies. For this purpose, the author's research group has been developing a large-scale global energy system model, which minimizes inter-temporally the sum of the discounted total energy system up until the year of 2100 with a dynamic linear-programming technique.

2. Global Energy Infrastructure Model

2.1 Geographical Coverage and Transportation Network

The geographical coverage of the energy model is the whole world. The world is geographically divided into 54 regions in order to express the detailed regional characteristics of socio-economic and geographical conditions.

As seen in Figure 1, the model assumes a transportation infrastructure network of 82 nodes.



Figure 1. World Division Framework and Transportation Network

The bright circle markers in the figure show the geographical location of 54 city nodes which represent energy consuming areas of the respective divided world regions. The dark rectangle markers indicate the location of 28 energy production nodes which were added to the network in order to express remote fuel production sites far from major cities.

The nodes are connected with plausible land and/or ocean transportation routes. The model takes account of transportations of coal, oil, natural gas, H₂, synthetic liquid fuels, captured CO₂ and electricity. As specific measures for transportation, the model assumes freight trains, on-shore and/or offshore pipelines, overhead power transmission lines, submarine power cables and various types of ships. The specific capacity and operation of each transportation route is determined as the result of minimization of the total energy system cost through linear programming.

2.2 System Structure of the Energy Model

Figure 2 indicates the assumed possible energy flow at each node in this energy model. Fossil fuels and biomass gasification, methane synthesis, DME synthesis, methanol synthesis, indirect coal liquefaction, H₂ production and electric power generation are considered as technological options for energy conversion. An elaborate integration of these conversion plants together with CO₂ capture facilities provides for a large of low carbon-intensive fuels with little additional CO₂ emissions from their conversion processes. Such an integrated energy system can be expected to contribute to remarkable reductions in CO₂ emissions from end-use sectors.

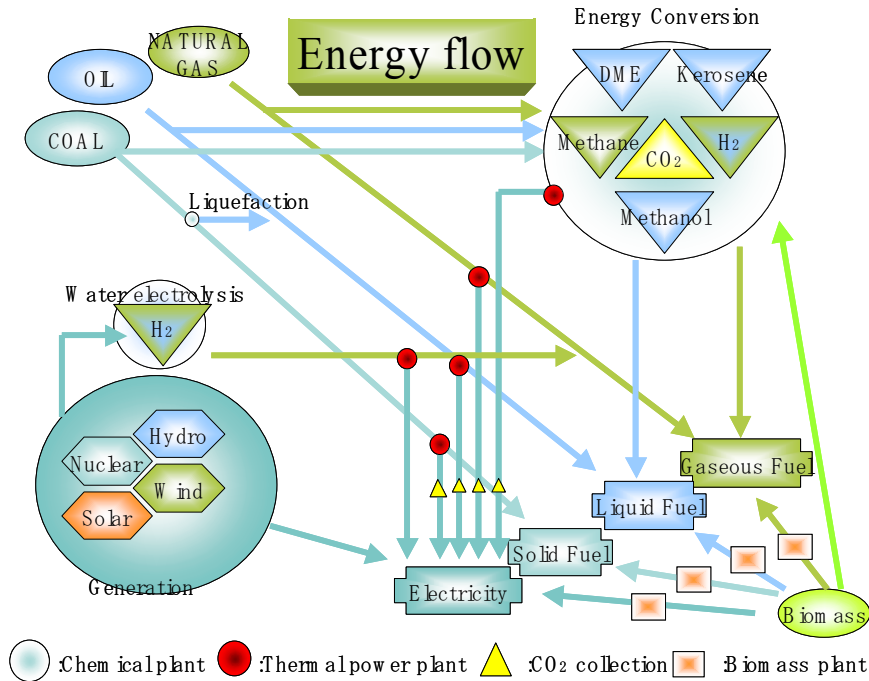


Figure 2. Configuration of the Energy System of Each Node of the Model

With respect to electricity generation sectors, the model explicitly takes into account daily load curves expressed simply with three time periods (morning, afternoon and evening) by season (summer, winter and intermediate), so as to determine how each type of power plant will be operated in accordance with diurnal and seasonal variation of electricity demands and renewable supplies. This is because the capacity factors of electric power plants are supposed to have a large influence on their economic characteristics.

One of the notable features of the model is that it can explicitly analyze the roles of processes of CO₂ capture and storage in the energy system. As specific measures for CO₂ capture, the model takes into account both chemical absorption from flue gas of thermal power plants and physical adsorption from the output gases of fossil fuel reforming processes. There are two major methods for CO₂ storage: geological storage and ocean storage. Geological storage is classified into three types: 1) injection of CO₂ into oil wells for enhanced oil recovery (EOR) operation; 2) storage of CO₂ in depleted natural gas wells; and 3) storage of CO₂ in aquifers. The model takes account of all the CO₂ capture and storage technologies, and can assess their future potentials by node in the model.

2.3 Mathematical Formulation

The model built here is mathematically formulated as a multi-period inter-temporal linear optimization problem with linear inequality and equality constraints. The constraints represent supply and demand balances of each type of energy carriers by node, energy and CO₂ balances in various energy conversion processes, and state equations for several inter-temporal dynamics, such as the depletions of fossil fuel resources and geological CO₂ storage reservoirs' capacities, the vintage structures of various facilities in the energy system and so forth. The objective function of the problem is defined as the sum of the discounted total energy system costs distributed over time, which include fuel production costs, amortized capital costs, maintenance and operation costs, energy transportation costs, CO₂ capture and storage costs, and energy

saving costs measured as the losses of consumer surpluses. The supply cost curves of fossil fuels by node are expressed as step-wise linear functions with respect to their amounts of cumulative productions.

The model seeks the optimal regional development paths of the energy-related infrastructure for the years from 2000 through 2100, at intervals of 10 years, using a linear-programming technique. The model, therefore, does not take into account any nonlinear effects, such as economies-of-scale with respect to unit construction costs of various facilities, especially those of pipelines. Furthermore, for simplicity, all the variables in the model are treated as continuous real numbers, although some of them, such as those expressing the number of tankers, should be indeed treated as discrete integer numbers in the real world.

The number of the variables of the model is about one million, and the problem is solved with an interior point method of linear programming. My research group uses commercial software of CPLEX.

2.4 Reference Energy Demand Scenario

The final consumption sector of the model is disaggregated into the following four types of secondary energy carriers: 1) gaseous fuel, 2) liquid fuel, 3) solid fuel, and 4) electricity. In the case of electricity consumption, as mentioned before, the model explicitly takes into account daily load duration curves by season. The future energy consumption in the model is exogenously given as reference scenarios by energy carrier type, by node of the network and by year.

The future energy demand scenarios in this model are based on SRES B2 scenario that was made by IPCC. The amounts of energy consumption by node were principally adjusted by demographic data on geographical distribution of national populations in the future.

3. Simulation Results of the Model

This section presents some of the simulation results of the energy infrastructure model. This study assumes two policy cases for simulation of the model, i.e., a reference case (REF case) and a controlled case (CON case). In CON case, the atmospheric CO₂ concentrations until the year 2100 are limited below 550 ppm, and additionally the annual CO₂ emissions of each Annex1 country of Kyoto Protocol are assumed to be reduced less than 20% of their respect emission levels of 1990 by 2050 and thereafter. No emission trades of greenhouse gases were assumed in the simulation of this paper.

3.1 Reference Case Results

The profile of the world primary energy production in REF Case is shown in Fig.3. When no CO₂ regulation exists, the share of coal in primary energy supply is very large because of its low price, and natural gas including unconventional gas is to become the second most important primary energy source. World electricity generation is shown in Figure 4. The share of coal-fired generation is substantially large. Photovoltaics will begin to be used practically after 2050, partly because in this model, the unit capital costs of solar cells are expected to be reduced by 3.6% per annum until 2050.

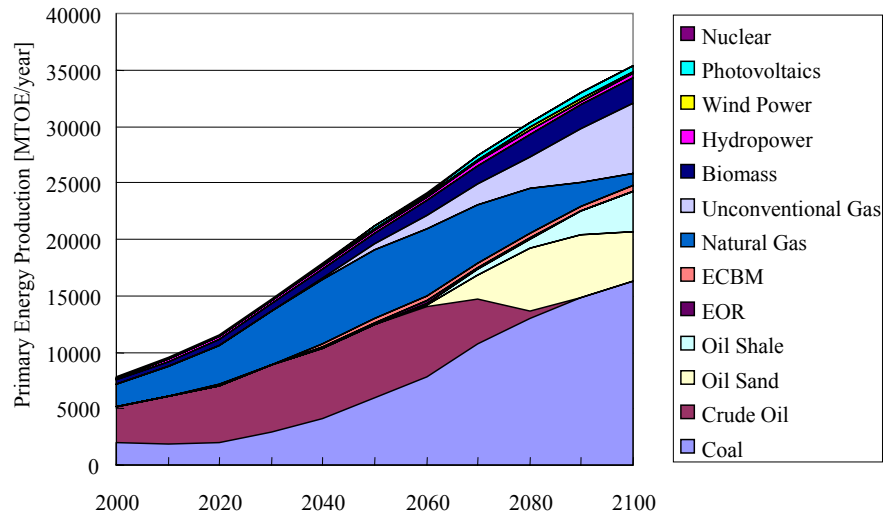


Figure 3. World Primary Energy Production in REF Case

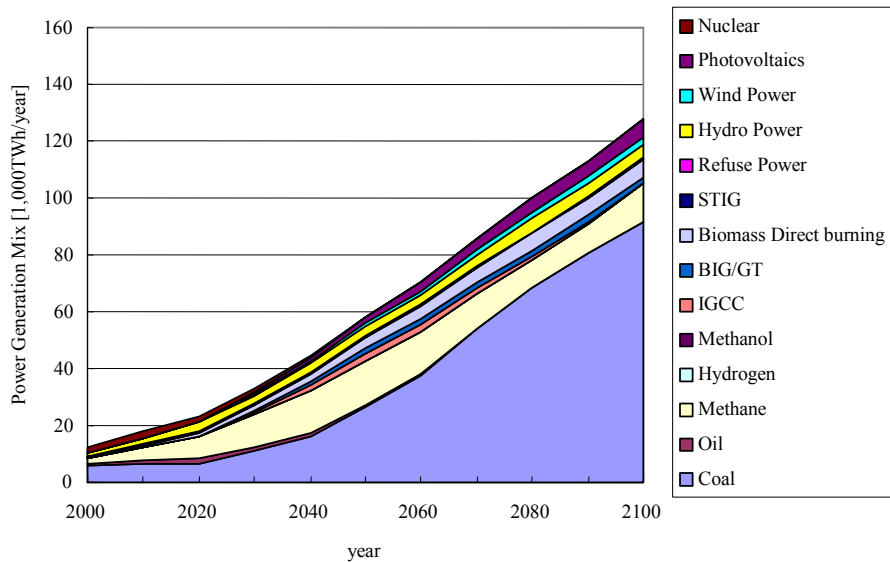


Figure 4. World Power Generation Mixes in REF Case

The calculated global patterns of coal, oil and natural gas productions and transportations for the year 2050 are shown in Figures 5, 6 and 7, respectively. The cost of coal land transport by rail is rather expensive, and most of coal for international market trades is therefore transported by ship. North America and South Africa are expected to be large coal producing regions. In the case of oil, its costs for both land and ocean transportations are relatively low. This means that one single world region can provide oil resources economically for the rest of the world via its international market trades. The Middle East is therefore expected to continue to be a major oil-exporting region over the century. As for natural gas, its transportation cost is relatively high, and its international markets are divided into several local markets by continent. An increased reliance on natural gas would provide countries with more geographically diversified energy supply structures, thus improving the securities for their energy procurement.

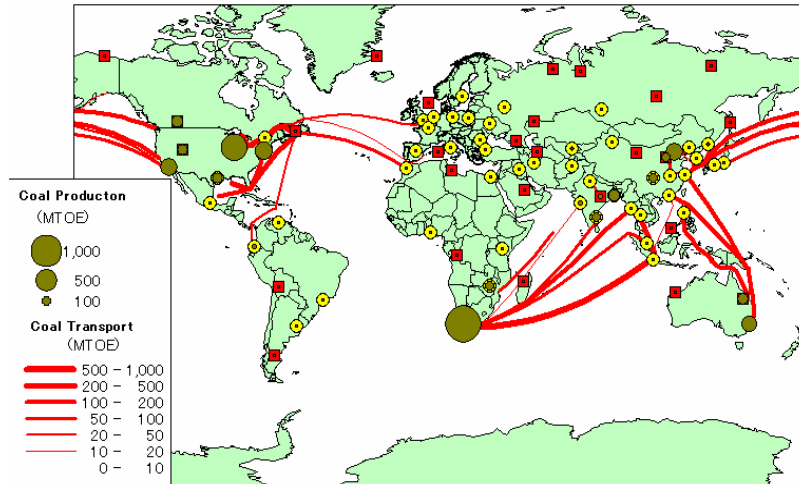


Figure 5. Coal Production and Transportation of 2050 in REF Case

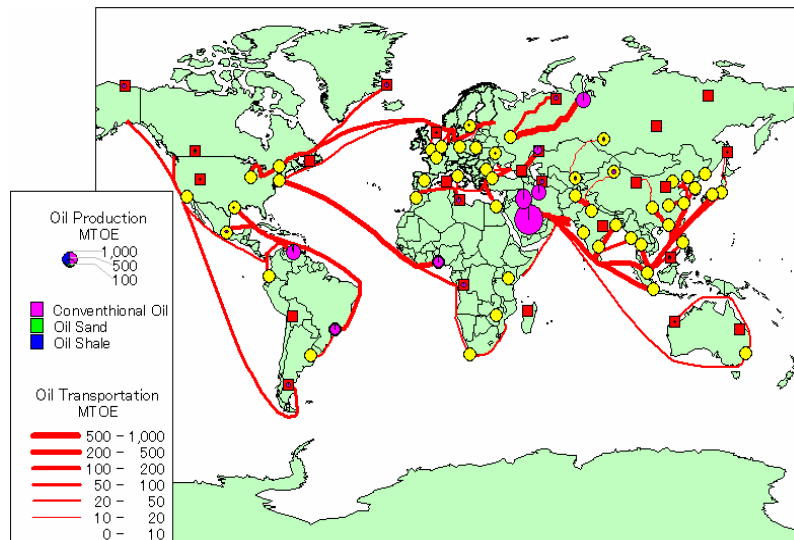


Figure 6. Oil Production and Transportation of 2050 in REF Case

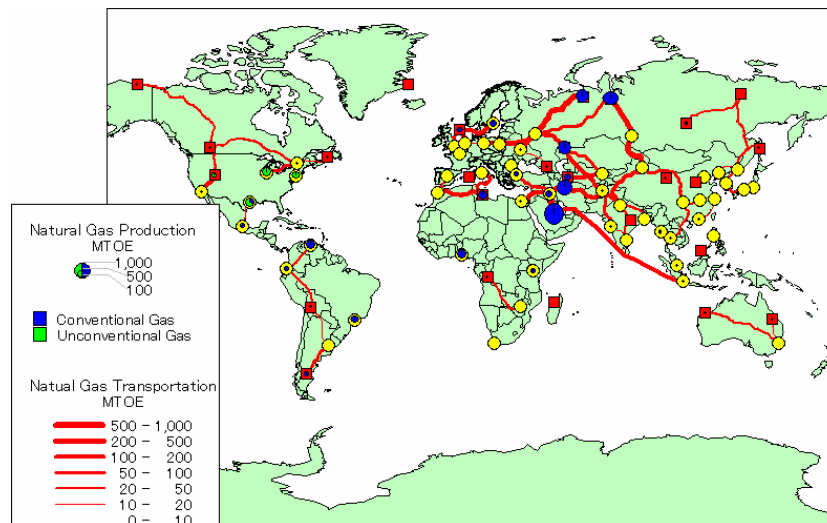


Figure 7. Natural Gas Production and Transportation of 2050 in REF Case

Figure 8 indicates the calculated long distance power transmission network in Northeast Asia. In REF case, the necessity of the development of region-wide electricity grids among Northeast Asian countries does not seem apparent in the model result. The model indicates that transporting those fuels by rail or pipeline and generating electricity close to the energy consuming cities seems to be more economical than generating electricity at mine mouth or wellhead and transmitting electricity for a long distance by power transmission line. Obviously, the results are highly dependent upon the assumption about the relative cost competitiveness of power transmission lines against other types of energy transporting measures.



Figure 8. Power Transmission in Northeast Asia in REF Case

3.2 Controlled Case Results

In CON case, energy conservation, fuel switching, and CO₂ capture and storage leads to significant CO₂ emission reduction. The fuel switching means changing high carbon content fuels, like coal, to less carbon-intensive fuels, like natural gas. World electric generation in Regulation Case is shown in Figure 9. The share of coal-fired generation is reduced and the share of natural gas-fired generation is increasing. Additionally coal-fired generation is changed to IGCC that enables us to conduct CO₂ capture more efficiently.

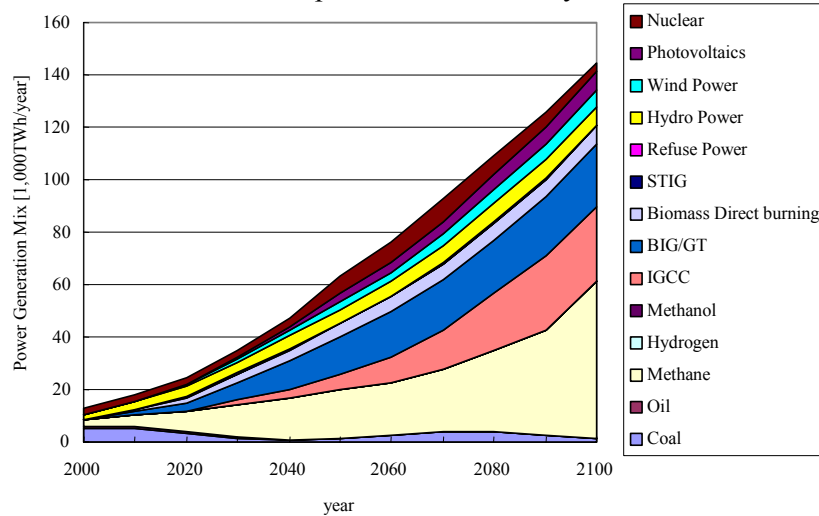


Figure 9. World Power Generation Mixes in CON Case

Figure 10 indicates the calculated power transmission network in Northeast Asia for the years of 2030 and 2050. In CON case, the extensive international power transmission network around

Japan can be seen in the figure for the year 2050. A very stringent CO₂ emission control policy may enhance significantly the economic viability of imported electricity from Sakhalin Island and the Korean Peninsula for Japanese power market.



Figure 10. Power Transmission in Northeast Asia in CON Case

5. Concluding Remarks

The purpose of the study was to obtain the insights into the possible future configuration and operation of energy infrastructure in Asia where energy demands are rapidly growing. This paper presented the outline of the energy system model built in the study, and showed a part of the results obtained. Bearing in mind the considerable uncertainties as to various assumptions made in the model, the simulation results indicate that the economic validity of the development of region-wide electricity grids among Northeast Asian countries does not necessarily seem obvious in REF case. The current energy model cannot take account of the influences of energy security issues explicitly. It is necessary to conduct extensive sensitivity analyses to derive a general conclusion to the topic.

This study has not yet been completed, and the following research topics are to be incorporated in future studies, i.e. further improvement of the accuracy of the data on fossil fuel resources and production costs, sensitivity analyses of future energy demand scenarios, and consideration of nonlinear effects of infrastructure, such as economies-of-scale.

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Biography



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3. ENERGY SECURITY IN THE ASIA-PACIFIC REGION (PAPER 05GM0063)

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Abstract— The Asia Pacific region is undergoing fundamental changes affecting both the oil and gas sectors: Demand growth from China dominates the regional growth and is now affecting global oil prices. Meanwhile the region is experiencing positive refining margins despite a fundamental capacity surplus, giving false signals to the refining sector and encouraging additional un-needed investments. The region has limited commercial or strategic storage and there are prospects now for the first time to encourage Middle East investments or commitment to usage for commercial storage in the region—particularly Singapore. On the LNG front, Singapore now has joined a growing list of LNG consumers in examining the options for LNG imports. The LNG business is also changing rapidly with new terms and conditions, which are unheard of in the past. For Singapore there are many interesting opportunities available to both increase energy security and at the same time undertake projects, which make commercial sense in storage and LNG sectors. But there is a clear need to plan the moves carefully and shepherd the process to the successful conclusions.

Index Terms— Asian electricity infrastructure, energy security, international electricity connections

I. INTRODUCTION

Energy security may be achieved when a state is able to minimize vulnerability to resource supply disruptions, access reliably energy at reasonable and/or market-driven prices, and consume resources that least damage the environment and/or promote sustainable development. By extension of this broad definition, energy becomes a security concern when states are denied access—whether it is the actual resource itself or by way of volatile and/or unfair pricing. There exists a vast literature on the history, politics, and economics of resource consumption in the world, and how states may act in an effort to secure their needs. Relatively little is written, however, on understanding how, why, and whether energy—as the unit of analysis—triggers competition or cooperation among states at the national security level.

By 2010, energy use in developing Asia (including China and India, but excluding Japan, Australia, and New Zealand) is projected to surpass consumption of all of North America; by 2020 it is expected to exceed North American consumption by more than 36%. The Asia-Pacific region will consume more than half of the world's energy supply, and will emerge as the dominant energy consumer by the early next century. Some scholars argue that the region's growing energy needs have led to new strategic relations with other parts of the world, especially the Middle East, and have raised new questions about the reliability of the international market system in providing predictable and affordable access to energy resources.

What are the pressing energy issues of the Asia-Pacific region? Do energy needs pose new challenges to Asia-Pacific security? How important is energy as a source of tension between states, or are energy security matters considered "low politics" which have a higher tendency toward resolution rather than conflict?

In an attempt to explore these and other questions, the Asia-Pacific Center for Security Studies held a one-day seminar on regional energy security on January 15, 1999. The specific purposes of the seminar were to assess the current and future energy outlook for the region, identify the salient factors that influence energy security, and evaluate whether new aspects of the energy scenario raise new security challenges. The seminar was organized into four sessions: "Outlook on Energy Supply and Demand in Asia," "Energy Constraints and International Politics on Key Asian States" (two case studies on China and India), "Comparative Perspectives on the Politics of Energy Resource Management in the Asia-Pacific Region," and "Concluding Discussions: Lessons Learned." This seminar report draws on the papers, presentations, and subsequent discussions held during the one-day

proceedings. It also incorporates the broader literature on the subject as it relates to matters discussed at the seminar.

In short, discussions led to a general conclusion that the energy security debate of the nineties is less about energy, per se. Unlike the energy security debates of the 1970s and 1980s, which focused on supply shortages as a source of conflict and competition, *rivalry and competition over energy itself is a non-issue in today's debate*. In fact, some would go so far as to argue that the common challenge of greater external reliance on energy supplies among Asian states would create incentives to cooperate, not compete. The security concerns, rather, arise from issues related to the access, transportation, and reasonable prices and distribution of energy, specifically, the changing patterns in trade, a greater reliance on the Middle East for oil and thus a greater reliance on open access to sea-lanes, and shifting strategic relationships.

Overall, discussions were not pessimistic about the future of Asia's energy security. The general sentiment seemed to be that the identified problems were not entirely unavoidable if countries applied a constructive use of diplomacy during tensions; shaped national policies based on facts—not *perceptions*—regarding resource potential in certain parts of the region; and made commitments to utilize relationships already in place, such as bilateral alliances, to explore energy security questions.

This paper presents an overview [1]-[9] of the energy security in the Asia-Pacific.

II. WHY ENERGY SECURITY IN ASIA

The view that increasing competition for energy resources, a consequence of increasing Asian economic growth, is producing growing insecurity in the Asia-Pacific region is best proffered by Kent Calder in *Pacific Defense*, his 1996 analysis of the U.S. role in the future of Asia.

Calder argues that economic growth gives Asian nations the resources to strengthen their military might, but that it also results in rising energy demands, and the resulting need to secure stable energy supplies in competition with one's neighbors increases global insecurity and a region-wide arms buildup.

Petroleum, coal, and natural gas continue to be in insufficient supply in Asia, which provides only 11 percent of global oil production and 4.5 percent of reserves. Japan, with half the region's economic output, remains 95 percent dependent on oil imports. The growing Chinese economy's hunger for energy will soon make that country a net oil importer despite its status as the top supplier (with Indonesia) of energy in Asia. And increasing demand among other countries in the region will intensify competition for oil supplies and raise insecurity about neighbors' plans to ensure a supply of energy.

More important than rising Asian dependence upon Middle East oil-producing nations per se (an East-West center study estimates that Asia's share of oil imports from the Middle East will rise from 70 percent in 1993 to 95 percent in 2010) is the tension surrounding reliability of access to shipping lanes from the Middle East.

Asia Pacific region use increased with the strongest growth (6.3 percent) in 2003. Among fossil fuels, coal grew fastest in 2003, with an increase of 6.9 percent, largely due to a reported increase of more than 15 percent in China. Chinese oil demand has also doubled over the past 10 years, leading BP's chief executive, Lord Browne of Madingley, to conclude in his foreword that China "will be a major influence on the world energy scene from now on."

The approaches to the Strait of Malacca (for smaller tankers) and the Lombok and Makassar Straits in Indonesia (for larger tankers) are surrounded by Southeast Asian nations (Malaysia, Indonesia, and Singapore), which control those straits, and adjacent waters with increasing naval might. Calder maintains that China's strengthening naval presence and territorial claims to waters of the South China Seas, reflecting its own desire to secure shipping lanes for its energy supply and trading routes, will likely further heighten tension in the waters of Southeast Asia.

One solution to the energy demand crisis in Northeast Asia is nuclear energy. However, growing civilian nuclear power programs raise the risk of diversion of nuclear materials for military purposes, as is widely feared in North Korea. Northeast Asia includes three nuclear weapons states (the U.S., Russia, and China), and Japan and South Korea maintain large and growing civilian nuclear programs, which further contribute to anxieties in the region.

III. A REGION AT RISK: THE ASIA-PACIFIC

The dramatic geopolitical shifts stemming from the end of the Cold War and the global war on terrorism in the wake of September 11th have resulted in an abrupt restructuring of the traditionally bipolar system of global governance that has served as the norm for 20th century. Of all the regions subject to the repercussions of this new geopolitical landscape, the Asia Pacific region has emerged as one of the key arenas. A convergence of new factors, ranging from the threats posed by Al Qaeda to the sweeping engagement of the U.S. military throughout the region, has endowed the region with a significantly enhanced strategic importance.

The implications for the Asia-Pacific region from within this new prism of global geopolitics and a greater reliance on military security have also been deepened by several underlying characteristics. Specifically, the Asia-Pacific has seen a pattern of increasing insecurity in recent years that has exposed the absence of any regional institution capable of forging common and cooperative security. This pattern of mounting threats has been marked by three escalating crises: the Taiwan Straits crisis in 1996, the Asian financial crisis of 1997-1999 and the recent North Korean nuclear crisis. There is also a danger of a fourth crisis, involving Chinese frustration with the intricacies of Taiwan's political ambitions.

This absence of a governing regional structure has only exacerbated the region's vulnerability within a new post-Cold War/post-September 11th threat matrix. Although there has been some attempt to address this regional insecurity through existing regional organizations such as the Association of Southeast Asian Nations (ASEAN), the regional states still lack the political will, military capability and experience to adequately enforce security in any significant multilateral approach. And as the only substantive security architecture in the region is limited to the web of bilateral security treaties centered on the United States, there is a serious need for a new security regionalism. Such an effort can link Asian-Pacific economic cooperation to a regional security process and also build on the regional powers of Australia, Japan and South Korea, each of which have been recently "deputized" by the United States. Therefore, energy security may offer the most effective avenue toward this "securitized regionalism," especially given the genuine level of cooperation and shared interests in seeking adequate and secure supplies of energy.

Such a need for regionalized security is also reflected in the less visible security challenges facing the Asia-Pacific region. These security problems are concentrated in the core of the region, in the very foundations of the still incomplete state- and nation-building process, and stem from the fragility and weakness of these states. Coupled with the economic, social and environmental issues in the region, the complexity of these threats requires a multilateral, yet regionally based approach.

IV. THE ECONOMICS OF ENERGY SECURITY

In terms of pure economics, the outlook for energy security in the Asia-Pacific looks particularly troubling, with rising levels of oil consumption and an even stronger rise in demand, Figure 1. Some experts, such as Ji Guoxing of the Shanghai Institute of International Strategy Studies, contend that the Asia-Pacific region's dependence on Middle Eastern oil may exceed 90% by 2010. While oil fields in Russian Siberia and Central Asia do offer some short-term energy relief, the lack of existing

infrastructure to facilitate the transport of this oil poses costly political and economic challenges of their own.



Figure 1. Asia Pacific Oil Consumption and Share in the World

Aside from the dependence on imports from the Middle East, there is also a danger of tension stemming from such an oil shortage within the Asia-Pacific region itself. The growing demand for energy may strain relations between such important regional actors as China and Japan, for example, which may then engender a set of new destabilizing regional or international conflicts. But an even more immediate problem is the effect of oil market volatility on the region, with the sharp rise in oil prices putting particular pressure on the currencies of some crude importing emerging market countries and the dangers of soaring current account deficits and weaker economic growth. This also threatens to impact the record of growth that has served as the driving force for Asian stability and development since the end of World War II. And while Asia is seen as the most affected region, the surge in oil prices, an increase of 48% over the last two years, also threatens other struggling oil importers.

V. REGIONAL ENERGY SECURITY IN THE ASIA-PACIFIC

Energy security in the Asia-Pacific remains a complex and multifaceted challenge, with four main strategic issues mandating coordinated action:

- 1) Measures are needed to reduce Asian dependence on fossil fuel or to secure an adequate alternative supply to meet rising demand,
- 2) The need to address the environmental impact of the region's energy structure, as seen by the environmental repercussions from the heavy coal use in Chinese industries, for example,
- 3) The necessity for ensuring nuclear security in the face of regional ambitions to expand nuclear power, and
- 4) Specific policies to improve the vulnerable regional energy infrastructure and transportation networks, as well as safeguarding vital sea-lanes and "chokepoints."

As demonstrated by the set of four strategic priorities areas listed above, regional energy security in the Asia-Pacific requires a multilateral approach. There is a potential for regional cooperation, stemming from the convergence of national interests in the face of recent transnational threats. Much of these shared interests and threats have only been revealed in the aftermath of September 11 and the ensuing global “war on terrorism.”

To date, the regional approach to Asia-Pacific energy security has been focused on petroleum security, conservation and the search for alternative fuels. Specific examples of regional cooperation are largely through the Association of Southeast Asian Nations (ASEAN), and include a Petroleum Security Agreement, requiring ASEAN member states to provide crude oil and/or petroleum products for countries in short supply. Studies for a Trans-ASEAN Gas Transmission System and an ASEAN Power Grid have also been initiated aimed at ensuring a reliable supply of energy to the region, with some notable progress to date related to cooperation in natural gas use and energy management.

Regional energy security was formalized as a priority issue at an Asia-Pacific Economic Cooperation (APEC) Energy Security Initiative Workshop on “Elements of Energy Security Policy in the Context of Petroleum,” held in Bangkok, Thailand in September 2001. Dr. Piyasvasti Amranand, the Secretary General of Thailand’s National Energy Policy Office (NEPO), reported to the APEC workshop that the current imbalance between reserves, production, and consumption of oil within the region has elevated oil security as a major concern for APEC officials. Amranand stated that the total reserves in the APEC region are far less than regional demand, exacerbating the regional dependence on oil imports, especially from the Middle East, therefore, made energy security a key element in establishing economic development policies.

Thailand has long been sharing information with the Asia-Pacific Energy Research Center (APERC) and other research centers, such as the ASEAN Center for Energy (ACE), and has also implemented other measures that have substantially enhanced the energy security of the country. Strategic oil stockpiling by the Thai private sector is one of the measures, but there is an inadequate government role in developing a state-owned stockpile.

The 2001 APEC workshop also recognized the security of tanker traffic as a main concern. In an address to the workshop, APERC President Tatsuo Masuda explained that the combination of vulnerable transport from the Middle East and West Africa with the fact that tankers are getting smaller, while the number of tankers crossing the Indian Ocean to Asia triples or quadruples, necessitates a reduction of the risks posed by tanker traffic. Masuda specifically pointed to the need for pipeline infrastructure projects connecting Russia, China, Korea, and Japan, as a means by which to reduce this risk.

VI. BUILDING ENERGY-STRATEGIC RELATIONSHIPS

CHINA

China’s interest in expanding its resource linkages with Central Asia, Russia, and the Middle East will be better integrated. The government plans to promote market penetration into these areas in an effort to secure oil supplies. Given the political environment of the Persian Gulf, China plans to choose and develop better relations with "niche markets" such as Iran and Iraq while maintaining traditional relationships with other markets such as Sudan and Nigeria. The Chinese government has also enhanced its relations with Arab producers in the Gulf and North Africa, where approximately 36% of the world’s oil reserves are located. In order to gain access to the Arab market, Chinese oil construction services and technical support units have been expanded in Kuwait, Iraq and several other Arab countries. At the same time, Arab producers are encouraged to enter Chinese offshore upstream and downstream projects. In the future, China plans to establish new linkages with Arab producers, which comprise sea shipments, land pipelines, and other investments.

China's past reluctance to see Russian resource development in Eastern Siberia has changed with its growing interest in the resources of Eastern Siberia and the Russian Far East region. Beijing expects gas imports from Eastern Siberia to double by 2010. Efforts toward building a strategic partnership between China and Russia have led to signed commitments in 1996 for major oil and gas pipelines projects with over US\$20 billion in investment requirements. Sino-Russian relations remain complicated, however, by political and diplomatic uncertainties. It is expressed concern that a Sino-Russian confrontation could emerge in the long-term as pipeline projects routed east-west from Central Asia to China may undermine Russia's historical authority and control over resources in the region. Others raised the specter of possible competition among the United States, EU interests, China, and Russia over control of resources in the Central Asia/Caspian Basin area.

INDIA

Coal and oil constitute India's primary energy sources. Figures for 1997 indicate that the share of coal in total primary energy consumption was about 56.2% and the share of oil was about 32%, making up almost 90% of India's total energy needs. Energy consumption has kept up with the pace of economic growth of about 6% since the post-reform period beginning in 1991. After the oil shocks of 1973, India's energy sector became heavily controlled by the state. A number of foreign companies were nationalized, and a number of public sector undertakings started in the coal, oil, and electricity sectors. However, rapidly growing energy demand outpaced the public sector's ability to provide adequate supplies. In an effort to attract foreign investment in the energy sector, the Indian government in 1991 began loosening state control over the energy sector by implementing phased programs for deregulating coal, oil and gas prices by 2002-2003. Progress in India's liberalization of its energy sector has been mixed, however. Multinational corporations still consider the transaction costs in India's energy sector to be too high.

Coal and oil remain India's primary energy source. Coal consumption has steadily increased in the last decade; India used 283 million metric tons (MMT) of coal in 1997/1998, or 6.5% of the world's total consumption of coal. India's coal usage is expected to double from 405 MMT per year in 2001 to over 800 MMT by 2010. While India will continue to rely heavily on coal, its consumption of oil will steadily rise. India's oil demand currently exceeds 1.75 million b/d, and is the fourth largest oil consumer in the region after Japan (5.78 million b/d), China (4.01 million b/d), and South Korea (2.25 million b/d). Similar to energy patterns in the rest of Asia, India will consume a predominant amount of oil in the medium to long term. India imports about 700,000 barrels of the 1.7 million barrels it currently consumes per day. Imports are likely to increase to 1.5 million b/d by 2010, most from Russia, Iran, Saudi Arabia, Iraq, and the United Arab Emirates (UAE). The bulk of its oil imports will continue to come from the Middle East.

Natural gas is a distant third in terms of India's current energy use, accounting for only an 8.5% share of the country's primary energy needs. Natural gas, however, could become a potentially important resource in the future. For instance, it is estimated that India faces a shortfall of 50,000 megawatts in power generation by 2000, but the country will continue to turn to traditional options to fuel its power stations, namely coal, oil, and hydroelectric power. LNG is not more amply used in India for two reasons: it is a scarce domestic commodity and its transportation methods over the mainland are poor. Forecasts of growth in demand suggest that 20-25 million tons per year of LNG could be imported into India by 2010, limited mainly by the lack of import terminals to receive LNG shipments. A large factor in predicting growing future consumption of LNG, however, is India's close proximity to some of the world's largest gas reserves, namely in Yemen, Qatar, Oman, Yemen, Indonesia, and Malaysia. Any growth in India's share of LNG consumption will depend on the coordination of various agencies in India such as the state maritime boards, the Finance Ministry, port

authorities, the Ministry of Petroleum, the Ministry of Power, the state electricity boards, national and state grids and India's financial institutions.

Given India's energy interests in the Middle East, India has often taken positions contrary to the United States on Middle East issues. For instance, U.S. sanctions have delayed initiatives to import gas and oil from Iran and Iraq; but it is in India's interest to support the lifting of sanctions. Longstanding difficult relations with its neighbors also complicate India's energy security. For instance, the Oman-India deep-sea pipeline project, which needed to avoid the territorial waters of Pakistan, required the pipeline to be laid out at technologically infeasible depths. Another gas project, which would deliver gas from Iran through Pakistan to India, was cancelled because Pakistan would not permit pipelines to be laid on its territory or through the EEZ. Improvement in India-Pakistan relations is critical if huge gas reserves in the Middle East and Central Asia are to reach either country. However, persistent problems in this bilateral relationship have led India to adopt more costly alternatives for importing natural gas.

India expects no major or sudden changes in its energy needs in the near future, assuming steady economic growth and successful completion of its liberalization program in its energy sector. However, given India's increasing dependence on foreign sources for energy resources such as oil and gas, the government is concerned about several potential developments that could affect India's access to resources. Political instability in the Middle East, possible conflict between India and Pakistan, or potential tensions with China are all liable to negatively impact India's access to foreign supplies. Given the political uncertainties, India seeks an adequate emergency response capability to possible disruptions in energy supplies, a well-functioning international oil market, and a regional forum for cooperation on energy matters. India supports the creation of a regional version of the International Energy Agency (IEA) with the specific goal of improving states' emergency response capabilities to possible future disruptions in supply. Views were mixed about whether an energy-specific regional organization would be feasible; it is argued that such cooperation seemed ambitious given that more immediate inter-state security issues remained unresolved between India and its neighbors. Situated adjacent to the world's largest oil reserves in West Asia and along the route of the bulk of international oil trade moving from the Persian Gulf to East Asia and the Pacific, however, India is well-placed to play a key leadership role in enhancing the "collective energy security" of the Indian Ocean Rim (IOR).

JAPAN

Japan, the world's second largest—and Asia's most powerful—economy, remains highly dependent on foreign suppliers for its energy resources. Japan's primary energy sources today are oil, coal, and gas. Although Japan was heavily dependent on oil during the 1970s—its share of oil consumption exceeded 70% at times during this decade—it pioneered trade in liquefied natural gas (LNG), sharply increasing the share of natural gas in the country's primary energy supply from 5% in 1980 to 12% in 1998. Today, Japan is the world's largest importer of LNG, accounting for 61.2% of total global LNG imports in 1996. Despite the rise in LNG consumption, Japan's primary energy source is oil, which accounts for about 53% of its total energy needs, followed by coal (18%), nuclear energy (16%), natural gas (12%), and hydroelectric fuel (2%). Japan's energy mix remains heavily oil-dependent because it possesses only incidental indigenous fossil fuel reserves and production. Its heavy reliance on oil is due to direct burning of crude for power generation. In terms of the outlook for Japan's resource needs, the share of oil is expected to decrease while that of natural gas will increase, with the role of nuclear power remaining uncertain. Although electricity generation will be increasingly met by LNG imports, Japan's consumption of oil is predicted to rise significantly, and a much greater amount of the resource will travel by sea, primarily from the Middle East. While still heavily reliant on oil,

Japan in recent years has dramatically reduced its dependency from 77.4% in 1973 to 55.8% in 1995. Nevertheless, Japan remains concerned about the safety of shipping lanes.

VII. TRADITIONAL AND NEWLY EMERGING REGIONAL SECURITY CONCERNS

Access to energy sources is a critical security issue for the Asia-Pacific region given the structure of its energy needs and expected future consumption patterns. Governments and security professionals continue to wrestle with traditional energy security concerns such as safe access to sea-lanes, reliable transportation, territorial conflicts, and attendant environmental security issues such as pollution. New sources of energy, such as natural gas, a more sophisticated and integrated energy market, and newly emerging strategic relationships have introduced new energy security considerations in the Asia-Pacific.

VIII. GENERAL NOTES

- 1) Reducing dependency on oil has been a top priority in Japan's energy policy since the first oil shock in 1973. As a result, the amount of imported oil as a percentage of Japan's energy supply dropped from 78% in 1973, to 51% in 2001. However, the percentage of oil imports from the Middle East as a percentage of total oil imports has recently been on the rise and reached 86% in 2001.
- 2) According to the IEA's *World Energy Outlook 2002*, oil imports for developing countries in Asia are expected to increase dramatically from 4.9 Mbd (42% of demand) in 2000, to 24 Mbd (83% of demand) in 2030. In particular, net oil imports for China alone are expected to jump from 1.7 Mbd (35% of demand) in 2000, to 10 Mbd (83% of demand) in 2030.
- 3) The Japanese government has formulated a comprehensive policy, called the Hiranuma Initiative, which is aimed at maintaining energy stability in the Asian region. This policy was presented at a meeting of energy ministers from Japan, Korea, China, and the ASEAN nations at the IEF forum in Osaka, and was approved by all participants. The main points of this policy are (1) to promote cooperation in the development of natural gas resources in the Asia region, (2) to exchange information in emergencies, and (3) to cooperate with Asian countries in price negotiations with oil-producing nations.
- 4) KEDO is an international organization which was founded in 1995 based on the Agreed Framework between the US and North Korea. Since North Korea's admission that it had continued its nuclear weapons development program, the effectiveness of the framework itself has been called into question.
- 5) Japan's petroleum product tax per kiloliter is ¥1200 for gasoline, ¥570 for kerosene, ¥1270 for light oil, ¥2400 for low-sulfur crude oil, and ¥3410 for high-sulfur crude oil. Naphtha is tax-exempt. In tandem with a 1972 policy of deregulation of fuel oil imports, a proportional tax was introduced to support refining near areas of consumption, and this high secondary tax is still in effect today. On imported fuel oil priced at ¥20,000 per kiloliter, the tax amounts to between 12% and 17%. In contrast, Korea imposes a uniform tax on all petroleum products of 7% of the import price—except on naphtha, for which the taxation rate is 1%.

IX. COCLUSIONS

Therefore, the imperative for energy security in such vulnerable strategic regions as the Asia-Pacific is paramount for global stability and development. The priority of this challenge for the Asia-Pacific region is also no accident, as it is the world's fastest growing energy consumer, with projected demand to steadily surpass other regions for some time. But it remains to be seen whether this troubled region

will be able to forge a collective and cooperative approach in the wake of the daunting challenges and demands posed by the global “war on terrorism” and an increasingly destabilizing unipolar world.

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XI. BIOGRAPHY

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4. CHINA POWER GRID AND ITS FUTURE DEVELOPMENT (PAPER 05 GM 05GM0177)

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Abstract-- The uneven distribution of energy resources and power load center, as an impetus, is driving China power grid to strengthen its national-wide interconnection to achieve high utilization efficiency. The current situation and planning of China power grid is introduced in this paper. Specific problems considered in planning of national-wide interconnection and their countermeasures are analyzed, such as low frequency oscillation, stability of receiving-end system, and security of multi-in feed HVDC systems etc.

1. Introduction

Decades of years, China power grid experienced a long developing process, from individual-provincial network to across provincial power network and to the current regional-interconnected power grid. This general develop process of electrical system is driven by the pursuit of optimal utilization of energy resources in a national-wide scale, which is also an impetus to the future development of China power grid. Feasible power network configuration is the basic for secure and stable system operation, and the power network planning has always emphasized the overall sense and combination of short and long term considerations. In the planning of national-wide power grid, principles are stuck to, which are high security of power grid, unification and entirety of planning, combination of short term and long term plan, moderately advance construction, and advanced technology appliance. In this paper, from the point of power system planning, the future development of China power grid is introduced; the planning of national-wide power grid and related problems are discussed based on the current power grid structures.

2. The current situation of China power grid

Up to the year 2003, the total installed capacity of China is about 391400MW with yearly generation of 1.9×10^{12} kWh. Six regional power grids are established, as shown in Fig. 1, they are East-North China power grid with an installed capacity of 4132 MW, North China power grid with an installed capacity of 7517 MW, West-North China power grid with an installed capacity of 2903 MW, East China power grid with an installed capacity of 8130 MW, Central China power grid with an installed capacity of 8349 MW and South China power grid with an installed capacity of 7147 MW. The main frame of the power network in East-North China, North China, Central China, East China and South China power grid is 500kV and 220kV transmission lines except that in West-North China power grid is 750kV and 330kV transmission lines. Up to the year 2003, total length of transmission lines above 220kV is about 2.1×10^5 km and the total capacity of transformers above 220kV is about 5.88×10^8 kVA.

Currently, the East-North China and North China power grid are interconnected by two 500kV AC lines, forming a large synchronous interconnected grid, and there are two ± 500 kV HVDC transmission lines that have total transmission capacity of 4200MW from Central China power grid to East China power grid.

Recent years, unexpectedly rapid economic developments caused a power supply crisis in China. The crisis was exacerbated by the coal supply shortages and drought and high summer temperature, the crisis induced extended rolling brownouts or blackouts with expectations in most provinces in year 2003. Under this situation, the constructions of new generation capacity and transmission utilities are urgent and necessary to resolve the power supply crisis within two or three years. With respect to the planning of future power grid, the optimal and maximum utilization of energy resources are paid great attentions.



Figure 1. Diagram of China Power Grid and Energy Resources Distributions

3. Planning of national-wide interconnected power grid

China is abundant in coal and hydro resources, but 80% of the coal reserve is in the north and northwest China, and over 80% of hydro resources are in the west region. The power consumption of the east and coast region is over 60% while the coal resources there is only a share of 10% and hydro resources is only a share of 14%. The uneven distribution of energy resources and economic location has formed the basic pattern of transmitting power from the west to east, which is called “West-to-East Electricity Transmitting”. A briefed indication of hydro and coal distribution in China is also shown in Fig. 1.

The national-wide interconnected power grid mainly composes three west-to-east electricity-transmitting channels, which are North Channel, central channel and south channel. The North Channel consists two parts, one is to exploit coal power in west Inner Mongolia and Shanxi and build AC lines to transmit power to Beijing, Tianjin, Hebei and Shangdong. Another one is to exploit coal power in north Shanxi, hydropower and thermal power in west-north china and transmit power to Beijing, Tianjin, Hebei and Shangdong by AC lines or DC lines. The central channel is to develop large hydropower stations along Jinsha River, Yalong River and Dadu River and build AC and DC lines to transmit power to East China, Central China and South China. The south channel is to exploit hydro and coal power in Yunnan and Guizhou, and transmit them to Guangdong and Guangxi through AC or DC lines. From the electricity demand forecast and analysis, the total amount of power transmitted from west to east will be about 58000MW, and reach about 130000MW in year 2020.

In regard to power transmission between different regional power grids, a national-wide interconnected power grid would take into shape within year 2010, and within year 2020, the interconnection between regional power grids would be strengthened, and higher voltage power grid will start to be built. Comprehensive planning and researching in the structure of national-wide power grid are made in the past few years. On deciding the number and scale of synchronous grid, following technical problems are considered: influences to the transfer ability

of the key transmitting paths, the ability of the system to bare severe faults, transient stability of the whole system and the adaptability to the future development. Besides, another consideration of the scale of synchronous grid is to avoid “strong DC and week AC interconnection”, which means the amount of transmitted power through HVDC interconnection lines is larger than that through AC interconnection lines between two regional power grids, and large scale loop structure, because in emergency cases, the lost of the HVDC lines in “strong DC and weak AC interconnection” structure or main AC interconnection lines in loop structure will cause large amount of power transfer, which would threaten the receiving system, in worst case, would induce blackout in large area. So that, regional power grid with large amount power sent out to other areas by HVDC lines is suggested to form independent synchronous system.

Considering the feasibility of technology and economy, it is approved that the structure with 4 to 5 synchronous power grids in China is acceptable. By the year 2010, the East-North China, North China and East China power grids are interconnected by AC lines and formed a large synchronous power grid. Central China, West-North China and South China power grid are independent synchronous power grid, and connected with other synchronous power grids with HVDC lines. By the year 2020, the basic structure of national-wide power grid is similar; the large synchronous power grid including East-North China, North China and East China may be divided into two synchronous grids or not changed, which is decided by the development of the inner network in each region. The possibility of changing AC interconnections into Back-to-Back DC connection exists between East-North China and North China power grid or North China and East China power grid. Under this basic structure of national-wide power grid, the transient stability, power transfer ability, and power supply reliability of the whole system is improved.

4. Specific problems concerned in national-wide power grid

As introduced above, in the near future, the relationship between different regional grids will become more complex and tight. A change in one area may have influence the system stability in a large-scale area. System simulations are made comprehensively to study the stability of national-wide power grid under year 2010 and year 2020. The simulation results show that for the power grid structure of year 2010, system may keep stable under “n-1” contingencies and by applying measures like cutting machines under “n-2” contingencies, i.e. bipole converter blocking on HVDC lines or lost of two main AC transmission lines. In year 2020, the inner structure of each regional grid and the connection between synchronous grids will be strengthened, which leads to a result that the stability level of whole system increases a lot. For the power grid structure of year 2020, system may keep stable almost under all “n-2” contingencies.

Besides the stability ability of the system, during the study of national-wide power grid planning, several specific problems are paid more attentions.

4.1 Low frequency oscillation

Low frequency oscillation is one of the important stability problems in weak-connected power systems. If the oscillation is strong, the transient transmission ability of the transmission lines or generators will be decreased, in worst case, the reliability of the whole system will be affected. From the calculations, some modes of low frequency oscillations are found. In the large synchronous power grid, East-North China and North China and East China power grid, East-North China region and part of North China region have low frequency oscillation at about 0.19Hz relative to East China region, and inner part of East China regional system and North

China regional system; there are low frequency oscillations between different parts of systems. In Central China power grid, the oscillation is at about 0.23 to 0.25HZ between west and east part of the system. Because the damping capacity is acceptable and enough to restrain the oscillation, the problem is not very severe, but for the reliability and stability of the system operating, PSS of generators is emphasized to be applied, which is currently installed in most of the generators but not enabled.

4.2 Stability of receiving systems

Pear River Delta, Yangtze River Delta and Beijing-Tianjin-Hebei area are economical-developed districts, and hence, they are load centers, the “East” in the “West to East Electricity Transmitting” project. The proportion of imported power to the maximum load is relatively high. Take Beijing-Tianjin-Hebei load center for example, in year 2010, the proportion of imported power to the maximum load is about 36%, and that in year 2020 is near 50%. With such a large amount of imported power, influences to the stability of the receiving systems become complex and hard to control. Specific researches on this topic are taken and some guidelines are drawn for the planning of receiving systems.

(a) Optimizing of receiving-end network structure. Most load centers in China have circle network structure to ensure the reliability of power supply. With the increase of imported power, the requirements for a feasible and rational receiving-end system become higher. In the planning stage, the length of the circle and the layout of substations should be considered from a longer-point of view to have good adaptability to the long-term development. The network structure should be simple and clear, and optimizing adjustments should be kept on with the whole power grid development.

(b) The transmission paths to the receiving system should be independent and dispersed, if the conditions allowed, and the amount transmitted power to the load center in each transmission path should be limited to a certain percent, which is 10~15% in China. So that, in the most severe case that losing the whole transmission path, the lost of transmitted power would not cause instable problems in the receiving system.

(c) Receiving systems should have enough reacting power support, including static reactive power and dynamic reactive power. As known, the lack of reactive power support is one of the most important reasons for voltage instability; it is paid more and more attention in recent years. Since reactive power is not allowed to be transmission during normal operating, the receiving systems have to supply enough reactive power to correspond to its imported active power. Capacitors and generators are traditional means for static and dynamic reactive power support. It is required that newly added generators must follow the so called “Layered and zoned” principle in China, which is to ensure local dynamic power in receiving systems, and the power factor of new generator should be 0.85. Besides, FACTS devices, as an advanced technology for power system stability, are highly recommended in the future power system.

4.3 Security of multi-in feed HVDC systems

HVDC technology is applying widely in the “West-to-East Electricity Transmitting” project, mainly for large hydro power stations to transfer power to load centers. As planning, in year 2020, there would be about 22 HVDC transmission projects ($\pm 500\text{kV}$ and $\pm 600\text{kV}$) in China. For the receiving-end, there would be several HVDC converter stations in relatively small areas. The high density of DC converter stations will influence the operating reliability in converter. For example, 8 DC converter stations are planned in east China area, mainly around Shanghai.

Because the interrelationships between multiple converters may induce failure in commutating and sub synchronous oscillation, which have appeared in some HVDC systems in the world, the security of multi-in feed HVDC systems are paid great attentions and under study, and detailed electromagnetic transient simulations are required.

5. Future development of China power grid

Currently, the study of ultra high voltage AC transmission system (1000kV or 1150kV) and DC transmission line (± 750 kV or ± 800 kV) are initiated for future power grid development. The higher voltage class power grid based on the 500kV national-wide power grid will be tentatively built near year 2020 as a long-term plan.

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Biography

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5. PROSPECTS OF ELECTRICITY INFRASTRUCTURE IN EAST ASIA (PAPER 05GM0221)

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Abstract: Major principles, required conditions, objectives and stages of creating common electric power space (CEPS) in East Asia (EA) are determined. Effects of interconnecting electric power systems (EPSs) with different seasonal load maxima are considered. Prospective electricity demand and free volumes of electric power markets in EA countries are estimated. Export power projects in Siberia and Russian Far East (RFE) are analyzed.

Key words: common electric power space, electricity demand, power plant capacities, interstate electric ties.

INTRODUCTION

The problem of forming interstate electric ties and interconnecting electric power systems of countries and regions of East Asia, including Siberia and Far East of Russia, China, Mongolia, Democratic People's Republic of Korea (DPRK), Republic of Korea (ROK) and Japan has attracted ever-greater attention in recent years. There are favorable preconditions for electric power cooperation and creation of power interconnection in EA. First of all these are: a) uneven distribution of fuel and energy resources (in particular hydro energy) on the territory; b) substantial difference in tariffs for electricity in various power systems; c) different seasons and hours of annual load maxima in power systems.

Taking into account these factors economic effectiveness and prospects of forming interstate electric ties (ISETs) and interconnection of power systems in East Asia have been studied. The results of the studies are presented below.

CREATION AND DEVELOPMENT OF COMMON ELECTRIC POWER SPACE OF EA COUNTRIES

The concept of common electric power space is the basic one for studying interstate electric ties and interconnection of electric power systems in EA. The following definition is suggested. *CEPS is a territory interconnected by electric ties and contract agreements for mutually beneficial exchange (trade) of electric power (and fuel for power plants).* It is kept in mind that ISETs and transmission lines in each country create technical infrastructure of CEPS and interstate agreements and internal legal acts are economic, financial and legal components of CEPS. Figure 1 presents block diagram of potential ties, forming CEPS.

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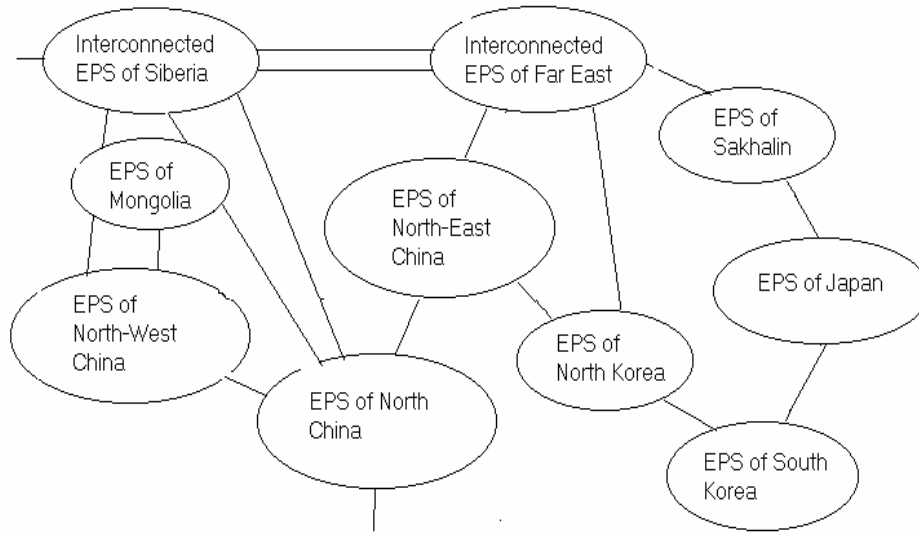


Figure 1. Scheme of ISETs in CEPS of EA Countries

Formation of common electric power space in East Asia is aimed at creation of favorable conditions for:

1. Free and mutually beneficial export-import of electricity and power;
2. Use of effects of interconnecting national and regional electric power systems.

In this connection CEPS formation is reasonable, on the one hand, owing to different natural-climatic and economic conditions of EA countries and, on the other hand, owing to substantial energy and economic effects that can be achieved by interconnecting power systems of different countries.

Thus, Japan and ROK are insufficiently provided with fuel and energy resources and the cost of fuel and energy is high in these countries. Russia, China and DPRK are provided with resources much better but are far behind in capabilities to finance energy development. Besides, China has high rates of economy development and growth of electricity demand, which causes power supply problems. All this makes export-import of electric power potentially expedient, first of all, export from Russia to the other countries of the region.

As for the effect of interconnecting power systems, it can be particularly great in the considered region owing to different seasons (and hours of day) of annual load maxima of consumers (based on these maxima the total required installed capacities of power plants and their commissioning are determined). In Russia, North EPSs of China, DPRK and Mongolia annual load maximum is in winter in the evening hours, and in Japan and ROK - in summer in the daytime. A detailed description of effects of interconnecting EPSs with different seasons of load maxima is presented in [1]. Their brief description is presented below.

In summer period of electric load decrease, thermal power plants (TPPs) of EPS with winter maximum of consumer electric load can be additionally loaded. This additional generation can be transmitted to power systems with summer consumer load maximum replacing semi-peak TPPs from the balance of capacities there. In winter period, to the contrary, TPPs of power system with summer load maximum can be additionally loaded and their generation will be transmitted to EPS with winter maximum of consumer load. Thus, installed capacity of power plants in power systems with different season maxima can be decreased only by commissioning

interstate electric ties connecting them. Thus, this decrease in each EPS will be approximately equal to an ISET transfer capability.

The effect of interconnecting EPSs with different seasons of load maxima can be used when commissioning new capacities. Capacity of a new power plant, commissioned in the interconnection of power systems with different seasons of load maxima can be used in balances of capacities of both power systems (in one - in summer, in the other - in winter). Here each kW of capacity of this plant will substitute up to 2 kW of installed capacities of other power plants. This effect can be used when constructing any types of power plants - hydraulic, thermal burning fossil fuel, nuclear, tidal (if their power supply is regulated).

Common electric power space should be created based on the following (so far preliminarily formulated) principles and required conditions:

1. Attaining energy-economic and environmental efficiency of ISETs, to be constructed within CEPS, for all countries-participants.
2. Maintenance of energy security and accepted levels of power supply reliability of all the countries, comprising CEPS.
3. Joint elaboration by countries-participants of legal, prescriptive and methodological grounds for creation, operation and development of CEPS.
4. Formation of bilateral and multilateral commissions (or other bodies) to consider and solve the problems of coordinated development and operation of CEPS.
5. Conclusion of bilateral and multilateral agreements on conditions and guaranties of power supply and exchange between the countries.

Since the interstate electric ties existing in the region are weak, formation of EA CEPS will start from the scratch, in fact. Obviously it will proceed by stages, which can be set presumably only.

At the first stage, as one can suppose the ties within Russia, Korea, China, Mongolia and Japan will be getting stronger. Then, ISETs connecting East Russia with other EA countries are expected to be in place.

On the whole the first stage of CEPS formation will be characterized by the bilateral solving the problems of construction and control of power flows for each individual ISET. In fact, at the given stage one cannot speak of electric power space in EA countries in the full sense of this concept.

The second stage of CEPS formation will start after the constructed ISETs begin to noticeably affect energy balances and operating conditions of the interconnected EPSs. Here the power flows on individual ISETs can affect operating conditions of several EPSs, shown in Fig.1. There can be transit flows via some countries (for instance, via DPRK from Russia or China to Republic of Korea), etc. This will require ISETs construction, effects given by them and regimes of power flows to be coordinated at the level of several countries, and later, probably at the level of the whole interconnection.

ESTIMATION OF PROSPECTIVE ELECTRICITY DEMANDS OF NEA COUNTRIES AND FREE VOLUMES OF THEIR ELECTRICITY MARKETS.

Electricity demand of NEA countries was estimated for a time span to 2010-2020. The calculations were done based on the information on levels and rates of power consumption in the countries of the region, presented in [2-5, etc.]. Taking into account a substantial uncertainty of the information the electricity consumption estimates were set by a range.

Free volume of electricity market is considered to mean the part of prospective electricity consumption that is not covered by generation of existing and predetermined power plants. Predetermined plants are those being constructed or whose construction is decided.

Electricity demand and market volume for China and Japan were so far determined for the "Northern" territories only. The "Northern" territories of China include the provinces served by power systems of Northeast, North, North-West (including Xinjiang autonomous region) and power systems of Shandong province. The "Northern" territories of Japan include prefectures served by power systems of Hokkaido, Tohoku and Tokyo, i.e. the whole 50 Hz zone of Japanese national electric power system. Electricity demand for Russia was determined for its East territories only, including East part of Interconnected EPS (IEPS) of Siberia, IEPS of Russian Far East (RFE) and EPS of Sakhalin. The volume of East-Russian electricity market was not calculated since, due to available and predetermined power plants, Siberia and RFE have surplus capacities for a time span to 2010-2020.

Calculations were done based on annual rates of electricity consumption growth assumed from [2-5, etc.] and presented in Table 1. The presented values were rounded off with a precision of 0.5%.

TABLE 1. ANNUAL RATES OF ELECTRICITY DEMAND GROWTH OF NEA COUNTRIES, %

Countries	2000-2010	2010-2020
China	6.5-7.0	5.0-6.5
Japan	1.5-3.0	1.0-1.5
Republic of Korea	3.5-4.5	2.0
DPRK	2.5	2.5-3.5
Mongolia	2.5	2.5-3.5
Eastern Russia	2.5-3.5	3.5-4.5

In Table 2 numerator presents obtained estimates of prospective electricity demand and denominator - estimates of free volume of electricity markets through EA countries. The largest fraction of electricity demand falls on China. In 2000 its fraction is about 40% and by 2020 it may reach nearly 60%. Electricity demand of Japan, Republic of Korea and East Russia is also substantial. The fraction of DPRK and Mongolia is much smaller.

**TABLE 2. ELECTRICITY DEMAND AND FREE VOLUME OF ELECTRICITY
MARKETS IN THE EA COUNTRIES, TWh/year**

Countries	2010	2020
North China	$\frac{910 - 1050}{280 - 400}$	$\frac{1550 - 1950}{920 - 1300}$
North Japan	$\frac{455 - 560}{10 - 105}$	$\frac{495 - 660}{50 - 205}$
Republic of Korea	$\frac{310 - 345}{0 - 35}$	$\frac{370 - 415}{60 - 105}$
DPRK	$\frac{35}{5 - 10}$	$\frac{40}{10 - 15}$
Mongolia	$\frac{3.5}{1}$	$\frac{4}{1.5}$
East Russia	150-160	180-200
TOTAL	$\frac{1865 - 2155}{295 - 550}$	$\frac{2640 - 3270}{1040 - 1625}$

As is seen from Table 2, by 2010 free volume of the electric power markets in the region increases reaching 300-550 TWh/year and by 2020 it increases several times more. Like the case with electricity demand, the main fraction of market volume belongs to China. However it is much greater, being about 80-90%. Role of Japan and ROK is less significant. Though these countries may as well have free volumes of electricity market, reaching several hundreds of TWh/year in 2020.

EXPORT ELECTRIC POWER PROJECTS OF EAST RUSSIA

At the expected rates of electricity demand growth on the territory served by IEPs of Siberia and RFE there will be underused electric power generation even at a limited number of new generating capacities to be commissioned in the nearest future. The magnitude of the generation determines minimum potentialities of electric power export to EA countries, which requires construction of interstate transmission lines only. At the same time export potential of Eastern IEPs of Russia can be substantially increased by development and implementation of special export projects envisaging construction of electric power sources jointly with transmission lines.

Russian research and design organizations have studied the prospects of developing interstate electric ties between EPSs of East Russia and EA countries [6,7, etc.]. As a result potential directions of such ties were revealed and pre-feasibility studies of individual ISETs were made. Such export electric power projects are given below.

1. ISET “Bratsk-Beijing”, length – 2600 km, voltage ± 600 kV, transfer capability – 3 GW, transmitting electricity – 18 TWh/year, cost – \$ 1.5 Bln.
2. “Bureysk Hydro – Kharbin”, 700 km, ± 400 kV, 1 GW, 3 TWh/year, \$ 2 Bln. Cost for the transmission itself is about \$ 250 Mln. The rest cost is for completing the hydropower plant construction.
3. “RFE – DPRK – ROK”, 1100 km (additionally, transfer capability of 700 km of bulk power transmission lines of RFE power systems are needed to be enlarged), ± 500 kV, 4 GW on the section “RFE – DPRK” and 8 GW on the section “DPRK– ROK”, 7 TWh/year, \$ 2 Bln. – cost for ISET and additionally \$ 2.8 Bln. – cost for Primorye Nuclear power plant.

4. “Sakhalin – Japan”, 470 km, \pm 500 kV, 4 GW, 23 TWh/year, \$ 6.7 Bln (including \$ 2.6 Bln. – cost of transmission and \$ 4.1 Bln. – cost of export gas fired power plant on Sakhalin).
5. “ RFE Nuclear – China – ROK”, 2300 km, \pm 500 kV, 2.5 GW, 18 TWh/year, \$ 3 Bln. – cost of transmission and additionally \$ 4 Bln. – cost of the nuclear power plant.
6. “Uchursk Hydro – China – ROK”, 3500 km, \pm 500 kV, 3.5 GW, 17 TWh/year, \$ 4.5 Bln. – cost of transmission and additionally \$ 6 Bln. – cost of the hydropower plant.

CONCLUSION

- 1) Power cooperation of EA countries with formation of common electric power space and power interconnection will give substantial energy-economic effects to the countries-participants.
- 2) Creation of interstate power interconnection in EA opens a great market of new electric power technologies, in particular, on DC power transmission.
- 3) Development of methodology for assessment of ISETs economic effectiveness is required, in particular from the viewpoint of investors and potential owners.
- 4) Cooperation of efforts of research, design and other concerned power and financial organizations and state bodies is required to carry out further studies of interconnecting power systems of EA countries.

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