Perspectives from Local or National Power Companies
Japan – Fumio Arakawa (Global Engineering Institute, Inc.)

Restructuring Needed for PGI

1. Introduction

1.1 Invitation by the Nautilus Institute

The concern of all as we enter the 21st century is global security, both political and economic, especially in Northeast Asia. The Nautilus Institute is thus very timely in inviting excellent specialists from all over the world to the closed Workshop under the auspices of the Northeast Asia Power Grid Interconnection Project. From the standpoint of a Japanese engineer, the importance of this Workshop is obvious. First, the issue is also critical to the security of Japan. Second, engineering is one of the most crucial infrastructure elements in securing the economic stability of a society. This is the fundamental reason this author appreciates the invitation to participate and work earnestly for the success of the Workshop.

1.2 Meeting in Beijing

The three-day meeting in Beijing in mid-May was successful for these three reasons:

① Four of the participants were from the Democratic People's Republic of Korea (DPRK). One made an impressive closing speech on the bright prospects for reunification of the Korean Peninsula.

② From an engineering perspective, the discussion was quite practical and focused on the objectives of political security and stability of regional power systems.

③ Because the Workshop discussions were specific, the role of each participant was clearly defined and each could come away with specific tasks.

1.3 Perspectives from Japan's Electric Power Companies

One objective of this paper is to provide a perspective on Japan's electric power companies, as summarized below, for participants in the Workshop. To pursue the objectives, the author will pursue the positive and effective participation of Japan, not only in political areas, but in economic and engineering roles. Unfortunately, it is a reality of the times that expectations for Japanese involvement in the Northeast Asia Power Grid Interconnection Project are poor, in part because of the less than positive response of Japanese to the solicitation. Despite the general situation in Japan, however, the author will endeavor to pursue the success of this project.

2. Technical Characteristics

2.1 Technical characteristics of Japan's Electric Power System

Technical characteristics of the Japanese electric power system are shown in Tables, **T-1** for the current electricity demand, **T-2** for the current sources of electricity supply and **T-3** for the demand forecasts and planned additional capacity in Japan.

As **T-1** illustrates, the current electricity demand in Japan is still slowly increasing, even though the economy is sluggish. Increase in peak load seems to have reached the saturation point, but a very hot summer in Japan in 2001 set a new record. Current sources of electricity to cope with the demand are shown **T-2.** Currently the sources are shared in capacity by 61% of thermal, 20% of Nuclear and 19% of Hydroelectric power. As shown in **T-3**, this generation capacity is expected to increase to a shared output distribution of 61% of thermal, 21% of Nuclear and 18% of Hydroelectric power in fiscal year 2009.

2.2 Status of Transmission Grid in Japan

The main transmission systems and power stations in Japan are shown in the figure. **(F-1)** Since Japan has four major islands, the power trunk line traverses these islands in a "fishbone" network, rather than the "mesh type" grid. Although the islands of Okinawa are still isolated from this system, the trunk power grid does include several marine cables linking islands, as well HVDC transmission lines and AC/DC converter stations. These are not necessarily for bulk power transmission but for the stable operation of interconnected power systems. Since there is a good balance of supply and demand in local power systems maintained and operated primarily by nine private electric power utility companies, all are loosely interconnected. This means there is little need for the interconnection of the Japanese transmission grid to be interconnected with such systems in the Eurasian mainland.

2.3 Major Issues in Japan's Power Systems

Two key issues affecting Japan's power grid are these:

i) Distributed small power sources, like MGT, PVC, FC, WP, etc, are a technical concern.
ii) Competition, which will have an effect on rates and therefore affect corporate performance.

Eventual interconnection of the Japanese power system with the Eurasian mainland will be achieved with restructuring of Japan's electric power market to be freely competitive. In addition, the relationship between Japan and Russia must be improved to a point that the neighboring nations will be able to cooperate, for example, in mutual development of Siberian natural resources. Apart from the political and economic concerns, no major technical difficulties in PGI are anticipated.

3. Institutional Characteristics

3.1 Electric Utility Authorities in Japanese Government

Current political and economic dynamics in Japan make it difficult to anticipate the role of the government. One clear reality is that the trend toward deregulation is a potent force for all in terms of keeping the authorities neutral in terms of global market operations. Another reality is the restructuring of government agencies and organizations. But as experts often point out, such restructuring in Japan will not necessarily result in a significant change in authority. As an example, the governing agency for energy and power policy that was formerly called the Ministry of International Trade and Industry (MITI) is now known as the Ministry of Economy, Trade and Industry (METI).

Elections were held in the first half of 2001 for the House of Councilors (Upper House) of the Diet, the nation's parliament, and for the Tokyo Metropolitan Assembly. The outcome of these elections was highly regarded by the general public in anticipation that the administration now led by Prime Minister Junichiro Koizumi will remain for some time. But we must realize that there are no small number of critics who note a lack of international strategic perspective in the Koizumi administration's policy development. If this is so, it is not very likely that Japan would be positively engaged in the Northeast Asia Power Grid Interconnection Project. At the same time, it should also be noted that a significant number of specialists continue their efforts to establish a Japanese global strategy on energy policy.

3.2 Electric Utility Companies and Their Organization

The utility companies and organization of them as shown in **F-1** and **T-2** illustrate their geographic location and their power generation capabilities. There is an organization of private resellers of electric power, organized as the Federation of Electric Power Companies (FEPC). There are also many wholesalers of electric power in Japan, of which two of the biggest are the Electric Power Development Company (EPDC) and the Japan Atomic Power Company (JAPC). EPDC has long been quite active as a government-backed utility, and is in the process of privatization and restructuring begun in 1986, nearly 35 years after it was established in 1952.

Wholesalers could be regarded as IPP, but recent and anticipated changes in Japan's electric power institutions identifies them as Power Producers and Suppliers (PPS), apart from EPDC and JAPC. Continuing reform of the power sector compels newcomers to be involved. Among them, for example, Diamond Power, Ennet, eREX, Summit Energy, etc. Enron Japan and its affiliate, E-Power, has been established but not registered as PPS yet, as of April 01.

According to the "Denki Shimbun"(Journal of Electric Industries), the contract awarded PPS's in Japan, since they began operation in August 2000, amounts 200MW in one year, sharing about 3% of Extra High Voltage Commercial Service. (EHV/CS; 20kV class, 2MW or over) 200MW includes 106MW for office building service, 61MW for sales and logistics, 26MW for public services, including the headquarters office of METI in Tokyo. There are two aspects to these numbers. One is serious, and the other less so.. As the EHV/CS shares now about 30% of total sales of the electricity supply companies in Japan, the former looks 3% is critical as a number shared in one category of sales in one year and the latter seems negligible, as the total share is less than 1%.

David Hayes, writing in the July 2001 issue of "Asian Power," entitled "Japanese deregulation—Making its mind up," rightly noted the "slow" process of deregulation but, the author of this paper feels, this does not address the reasons for the process. If it turns out to be a matter of corporate management and a lack of international strategic perspective on policy development, dynamic changes in the Japanese power utility sector could soon be reality, as corporate management is eager to have realistic and effective policy development in the face of global political and economic considerations.

3.3 Power Sector Reform

It is important to be realistic and diligent in developing the right path for our objectives, especially amid so much confusion. The power utility industry's goal is to provide the best service at a reasonable price for a reliable supply of electricity. The general approach in Japan is expected to follow this pattern:

i) To resolve stability of electric power supply while restructuring market mechanism, as well as corporate organization, for free competition, deregulation and corporate efficiency.

ii) To resolve environmental concerns, especially with regard to CO_2 emission and nuclear power development.

All of Japan's power utilities are making positive efforts to find and implement solutions that will enable them to attain the goals under the current dynamic circumstances that face the power utility industry worldwide. In the course of their efforts, it is obvious that these two objectives will not be attained independently, but are actually two elements of the same issue.

One of the highest national priorities in practical and specific terms is to resolve the global competitive threat to Japan's electric power utility companies. Although this is a little-recognized clash, there will be a dynamic change in the Japanese power utility industry as corporate executives recognize the challenge because they are willing to develop global strategies and energy policy

4. Financial Characteristics

4.1 Features and Technology for PGI

As defined by the author, "engineering" incorporates both technology and finance. Technologically, there is little difficulty in establishing PGI facilities anywhere on earth. In Japan and practically every other nation of Northeast Asia, there is the technological capability necessary for PGI. **(F-3)** As is well known, HVDC is one of these technologies featuring the high potential of implementing PGI projects. Every engineer is aware of super conductivity technology. **(F-4)** Experts always note the merit and demerit of power systems interconnection. Particularly in Japan the power systems interconnection has been introduced to improve the security and the stability of systems operation. Another merit of interconnection is, of course, the bulk power supply from natural energy resource area far away from the demand area. As seen in California in the summer of 2000, power grid interconnection could lead to wide area system failure, even if the failure involves only a small part of the system. To prevent a wider disaster, a very sophisticated control system and careful maintenance of facilities are required.

4.2 Promotion of PGI: Meetings and Ideas

Let us consider the financial considerations for promoting the PGI project Many PGI promotion ideas have been proposed in many important international meetings including ICEE and WESC, in which they discussed the matter mainly from technological point of view and talked about their dreams. Even with so many proposals, for instance in ASEAN region **(F-6)**, and sound bases of engineering for the promotion of PGI, the promoting thrust is not necessarily strong enough at this moment. One of the biggest reasons of course is that not enough attention has been paid to that other essential factor of engineering, i.e. finance.

4.3 Competitive Realities

It is the opinion of this author that the Japanese perspective on potential international power grid interconnection, especially the view of Japanese electric power utilities, is largely a matter of lack of interest in PGI. Institutional reasons are simply that they cannot find any financial interest, that is to say a favorable opportunity for capital gain, by investing in PGI. This reality prevails not only in Japan but in the rest of the world, where many powerful competitors are engaged in the field of energy supply. As seen in Irkutsk in September 2000, discussion was much more focused in the conference on the subject of gas pipelines, in part because of positive support from one of the oil companies, and for the fantastic proposals of a Japanese think tank.

4.4 Will DSS Be the Silk Road Model?

The author of this paper has developed a feasibility study model, "The Silk Road Model" (SRM), in cooperation with his colleague, Dr. Kato, Masakazu, as an approach to analysis of the realities and potential benefits and liabilities for Japan and the whole region in involvement in grid interconnection.. The core of SRM is a formula, or an objective function, to calculate annual capital and O/M cost of interconnected systems from Moscow to Tokyo under several constraints on generation plants, converter stations, transmission lines and demand/supply balance. (**F-8**) Several cases have been studied, one of which shows the feasibility of transmitting low cost solar and hydropower generated in Gobi Desert and the other on the Yen say River to Japan in some optimistic conditions. (**F-9**)

It is the personal view of the author that these factors apply:

i) There will be little financial merit in PGI between Japanese islands and Eurasian mainland, as there is little need for Japanese systems to have bulk energy supplied as electrical power.

ii) People in the Northeast Asia region could share in a considerable merit by fully utilizing Japanese facilities of technology and finance to promote PGI in the region. There would also be a meaningful contribution from Japan in global terms.

To pursue these elements, the author of this paper believes, SRM will provide people concerned with a tool for practical review and discussion to promote the project. As the computer model is a flexible decision support system (DSS) under the uncertainty, the model can be used in discussions between decision makers and specialists to study power systems interconnection. Participants in the discussion can exchange practical views and rational opinions on the data and scenarios shown on the computer view panel.

5. Conclusion and Perspective

5.1 Money Is the Solution, Not the Problem.

In addressing the key question of whether and under what conditions Japan would help finance a regional grid project, the author always refers to a remark from Anthony A. Churchill in the October 16th WEC, held in Tokyo. He said "Money is not the problem: it is the answer." It will be reasonable to understand it means that executives will be interested in the project, on the condition that specialists will be able to present the project as a technologically sound and financially feasible to provide investors with enough return. The development of DSS Model like SRM is expected from this point of view, too.

5.2 Restructuring PGI

With successful restructuring of government and corporate reorganization that is truly effective, the conditions would be right for Japan to secure financing for a regional power grid interconnection project to be promoted for a truly effective and freely competitive market mechanism from the engineering standpoint. The same kind of restructuring needed for PGI to be realized must be achieved in every other sector of society. This necessary restructuring applies to all sectors. For engineering, for instance, engineers must recognize that they are specialists with the responsibility to offer a technologically sound and financially feasible restructuring program to the public or private sector leadership.

5.3 Role of Japanese Engineers

In addition to the general role of engineers mentioned above, Japanese engineers are currently asked to be much more globally involved. Many, naturally, have been involved in important roles, especially in corporate activities. From now, however, they are expected to devote their full faculties for a more global perspective. At the same time, each can establish a personal identity by being involved in the program. For the promotion of PGI, for example, Japanese power systems engineers will have one of the best opportunities to fully apply their faculties.

The author has embraced for more than 40 years the dream of a ring of power transmission lines and cables that encircle the Sea of Japan. A part of this dream would become reality with the successful completion of the PGI Project. He shall never give up!

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LIST OF TABLES AND FIGURES

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(T-1)

Peak Capacity, Peak Load, Energy Requirement, Reserve Margin, and Load Factor

FY	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Peak Capacity (GW)	141.8	148.6	158.2	162.4	171.5	171.5	178.9	183.3	188.8	194.1	195.9
Peak Load (GW)	127.4	142.9	147.0	150.9	143.8	165.1	167.7	167.5	166.6	168.2	168.0
Energy Requirement (TWh)	669.8	718.9	741.4	747.7	751.9	803.5	822.1	842.2	858.9	866.3	884.2
Reserve (GW)	14.3	5.8	11.2	11.6	27.7	6.4	11.2	15.8	22.3	25.9	27.9
Reserve Margin (%)	11.3	4.0	7.6	7.7	19.3	3.9	6.7	9.4	13.4	15.4	16.6
Load Factor (%)	60.0	57.4	57.4	56.6	59.7	55.4	56.0	57.2	58.9	58.8	59.9

Notes: 1. Peak capacity and peak load are for all electric utilities in Japan. Peak capacity is the largest possible supply capacity; peak load is the average value of the three highest daily loads at the transmission end occurring during the month in which the annual peak is recorded.
2. Energy requirement is the total annual demand for electric utilities in Japan.
3. Reserve = Peak Capacity − Peak Load

$$\text{Reserve Margin} = \frac{\text{Reserve} \times 100}{\text{Peak Load}}$$

4. $$\text{Load Factor} = \frac{\text{Energy Requirement} \times 100}{\text{Peak Load} \times 365\ (366)\ \text{days} \times 24\ \text{hours}}$$

Source: Japan Electric Power Survey Committee

(T-3)

Forecast of Supply/Demand Balance for Electric Power (Electric Utilities)

FY	1998 (Actual)	1999 (Actual)	2000	2001	2004	2009
Electric Energy Requirement (TWh)						
At Transmission End	866	884	887	903	959	1,049
At Customer End	818	835	838	853	905	991
Annual Peak Balance (GW)						
Peak Capability						
Thermal Power Plants*	116.7	119.9	121.3	124.8	132.4	139.2
Nuclear Power Plants	39.4	38.6	37.5	36.7	37.3	46.1
Hydroelectric Power Plants	36.2	35.8	35.3	34.9	36.4	40.7
Total Peak Capacity	192.3	194.2	194.0	196.5	206.2	225.9
Peak Load	168.2	168.0	174.3	177.6	188.4	205.6
Reserve	25.9	27.8	21.4	20.5	18.6	21.0
Reserve Margin (%)	15.4	16.6	12.3	11.6	9.9	10.2
Total Generating Capacity (GW)						
Thermal Power Plants*	135.2	137.6	142.8	145.6	154.8	167.4
Nuclear Power Plants	44.9	44.9	44.9	45.7	47.1	57.5
Hydroelectric Power Plants	43.9	44.4	44.9	45.0	45.8	50.2
Total	224.1	226.9	232.6	236.3	247.7	275.1

*Includes geothermal power plants.
Source: Japan Electric Power Survey Committee

Forecast of Long-term Energy Supply and Demand (as of June 1998)

	FY 1996 (Actual)		FY 2010 Standard Case		FY 2010 Corrected Case	
Coal (million tons)	132	(16.4)%	145	(15.4)%	124	(14.9)%
Nuclear (TWh)	302	(12.3)	480	(15.4)	480	(17.4)
Natural Gas (million tons)	48	(11.4)	61	(12.3)	57	(13.0)
Hydroelectric Power (TWh)	82	(3.4)	105	(3.4)	105	(3.8)
Geothermal (million kl)	1	(0.2)	4	(0.5)	4	(0.6)
Oil (million kl)	329	(55.2)	358	(51.6)	291	(47.2)
New Energy (million kl)	7	(1.1)	9	(1.3)	19	(3.1)
Total (million kl)	597	(100.0)%	693	(100.0)%	616	(100.0)%

Notes: 1. "Standard case" is an estimate assuming a continuance of present user-side energy conservation policies.
2. "Corrected case" assumes maximum energy conservation from both providers and users.
3. One liter of crude has an energy value of 9,250 kcal.
4. "New energy" includes solar, compost, pulp liquid, and other non-traditional energy sources.
5. Figures for hydroelectric energy exclude pumped storage type.
6. One kiloliter of natural gas is 0.712 tons.
7. Figures in parentheses indicate the proportion of energy by source in terms of crude oil.

Source: MITI

(T-2)

Installed Generating Capacity (as of March 31)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Thermal	115,551	119,304	124,984	127,183	130,745	134,101	138,049	141,665	146,074	152,202	159,054	161,869
Electric Utilities	99,987	102,373	106,905	108,389	111,039	113,196	116,420	119,204	123,242	127,920	132,925	134,312
Industry-owned	15,564	16,930	18,079	18,793	19,706	20,905	21,629	22,461	22,832	24,282	26,129	27,557
Nuclear	28,866	29,445	31,645	33,404	34,584	38,541	40,531	41,356	42,712	45,248	45,248	45,248
Electric Utilities	28,701	29,280	31,480	33,239	34,419	38,376	40,366	41,191	42,547	44,917	44,917	45,083
Industry-owned	165	165	165	165	165	165	165	165	165	165	165	165
Hydroelectric	37,291	37,483	37,831	39,117	39,523	39,965	41,932	43,455	44,407	44,462	45,382	45,860
Electric Utilities	36,134	36,322	36,452	37,734	38,140	38,593	40,558	42,082	43,054	43,106	43,888	44,399
Industry-owned	1,157	1,160	1,378	1,382	1,384	1,372	1,374	1,374	1,353	1,356	1,494	1,461
Geothermal	215	215	269	269	270	299	379	504	530	530	533	533
Electric Utilities	180	180	235	235	235	263	343	468	494	494	497	497
Industry-owned	35	35	34	34	35	36	36	36	36	36	36	36
Fuel Cell				11	11	7	6	13	12	3	1	
Electric Utilities				0	0	0	0	0	0	0	0	
Industry-owned				11	11	7	6	13	12	3	1	
Solar Cell			1	1				1	1	1		
Electric Utilities			0	0				0	0	0		
Industry-owned			1	1				1	1	1		
Wind Power						1	1	1	1	1	6	34
Electric Utilities						0	0	0	0	0	0	1
Industry-owned						1	1	1	1	1	6	33
Total	181,708	186,231	194,730	199,985	205,133	212,914	220,898	226,994	233,737	242,447	250,124	253,544
Electric Utilities	164,822	167,976	175,072	179,598	183,832	190,427	197,687	202,944	209,337	216,603	222,227	224,291
Industry-owned	16,886	18,256	19,658	20,387	21,301	22,487	23,212	24,051	24,400	25,844	27,897	29,253

Source: FEPC

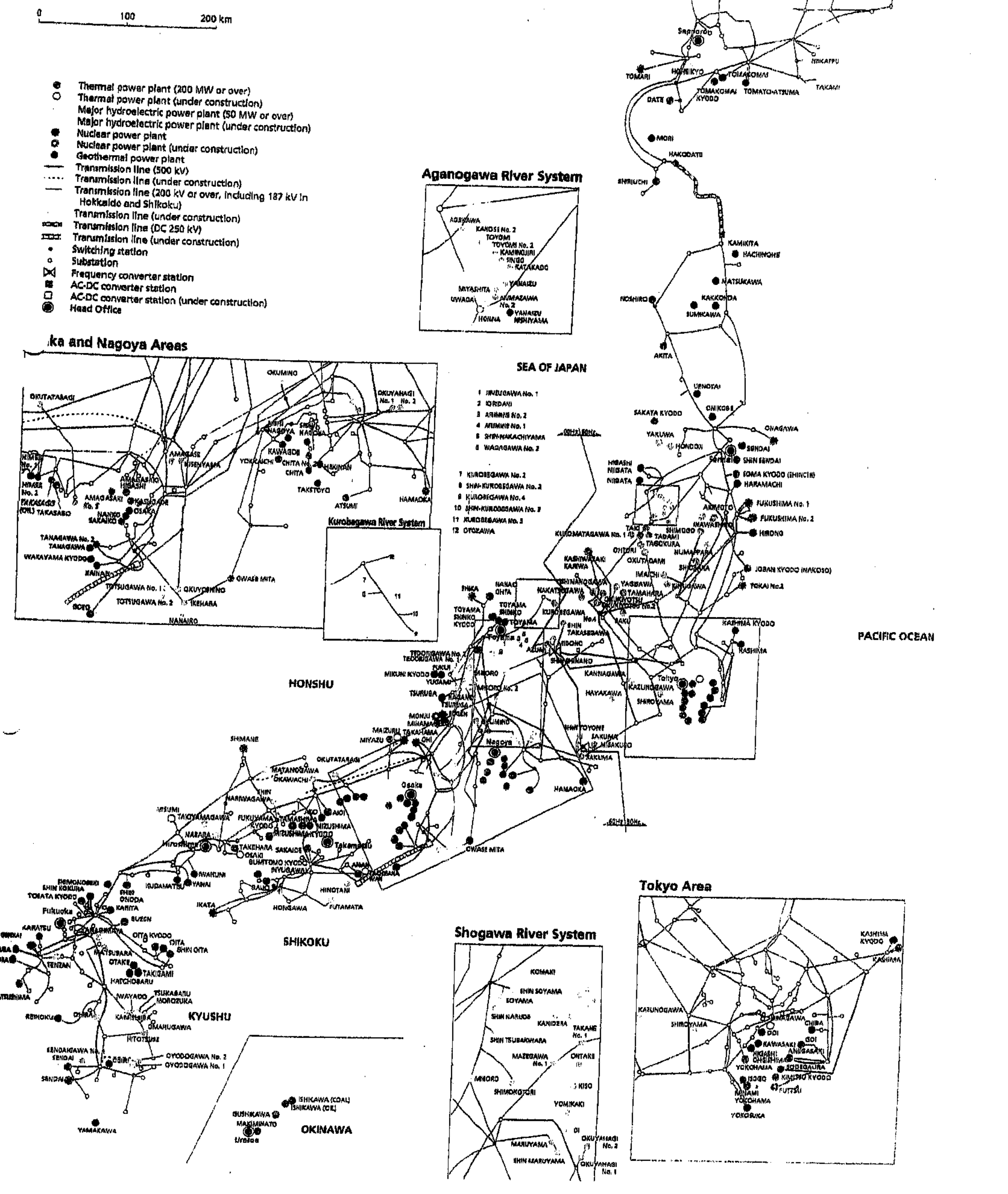
Installed Generating Capacity and Electric Power Generation by Electric Utilities (Fiscal Year 1999)

Company	Thermal*		Nuclear		Hydroelectric		Total		
	MW**	GWh	MW**	GWh	MW**	GWh	MW**	GWh	
Hokkaido EPCo	3,500	15,835	1,158	9,175	1,278	4,016	5,936	29,025	
Tohoku EPCo	11,430	56,271	1,349	9,880	2,431	9,093	15,209	75,243	
Tokyo EPCo	32,434	123,056	17,308	128,265	8,103	13,017	57,846	264,338	
Chubu EPCo	22,941	86,545	3,617	25,070	5,211	8,791	31,769	120,407	
Hokuriku EPCo	3,862	15,897	540	3,581	1,806	5,952	6,209	25,429	
Kansai EPCo	19,921	45,306	9,768	70,388	8,107	13,880	37,796	129,574	
Chugoku EPCo	7,765	35,241	1,280	10,059	2,893	3,506	11,938	48,806	
Shikoku EPCo	3,171	11,890	2,022	14,661	1,123	2,326	6,316	28,878	
Kyushu EPCo	11,327	28,688	5,258	38,774	2,370	4,559	18,955	72,021	
Okinawa EPCo	1,445	5,355	—	—	—	—	1,445	5,355	
Subtotal	117,796	424,083	42,300	309,852	33,321	65,141	193,418	799,077	87%
EPDC	5,655	32,407	—	—	8,261	12,596	13,915	45,003	
Others	11,358	60,379	2,617	6,061	2,817	10,542	16,958	76,982	
Total	134,809	516,869	44,917	315,914	44,399	88,279	224,291	921,062	100%

*Thermal includes geothermal.
**Figures are as of March 31, 2000.
Note: The "Others" category includes Japan Atomic Power Co., municipal power-generating enterprises, joint venture generating companies, and special electricity suppliers.
Source: FEPC

...AND POWER STATIONS IN JAPAN (As of April 1, 2000)

F-1

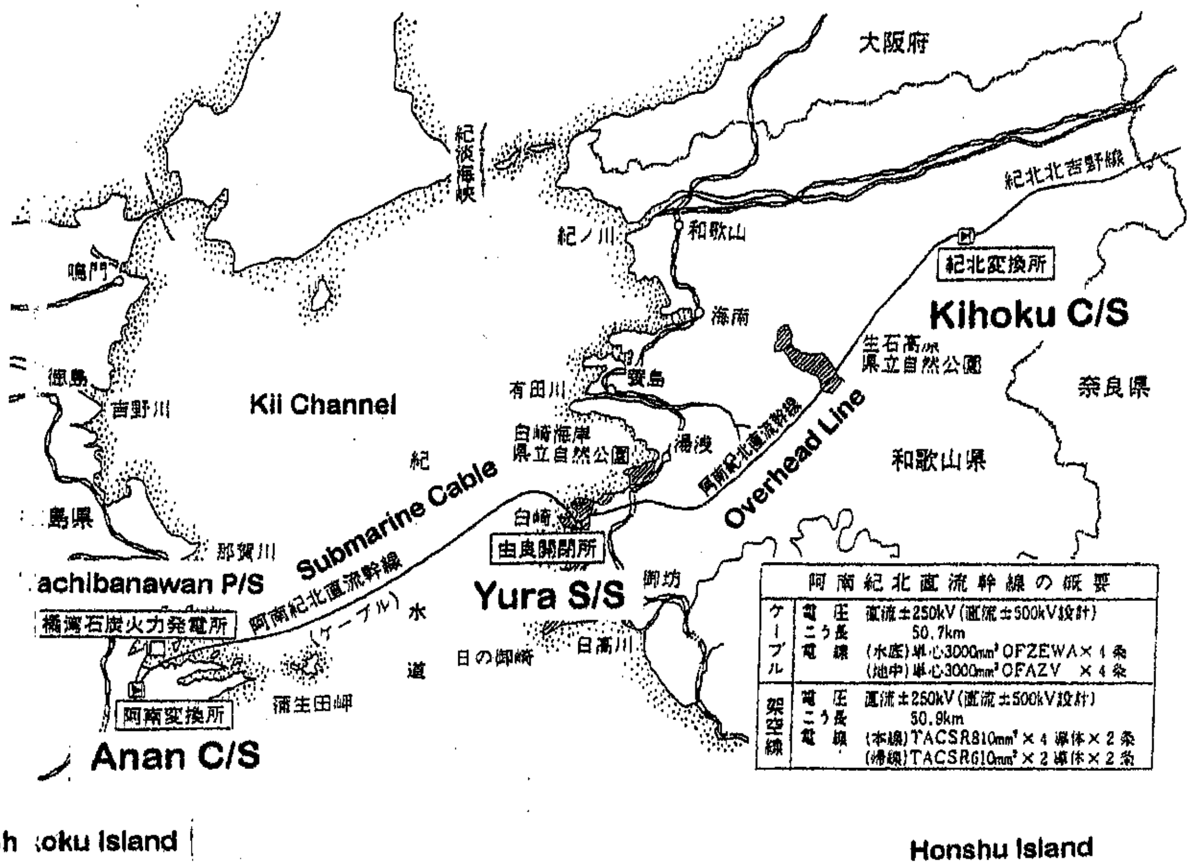


ト-2

紀伊水道直流連系設備

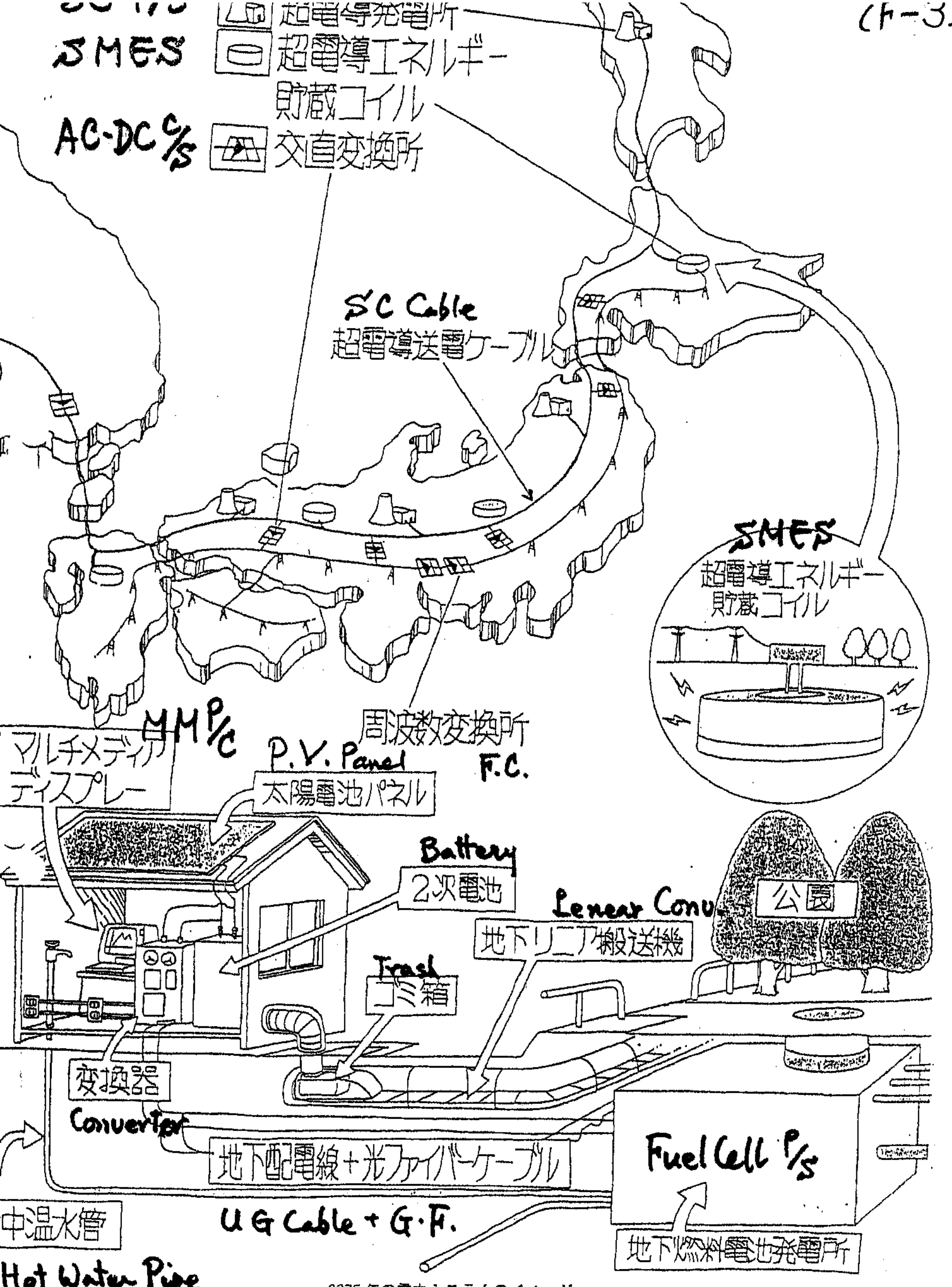
ルート概要

Kii Channel HVDC Link



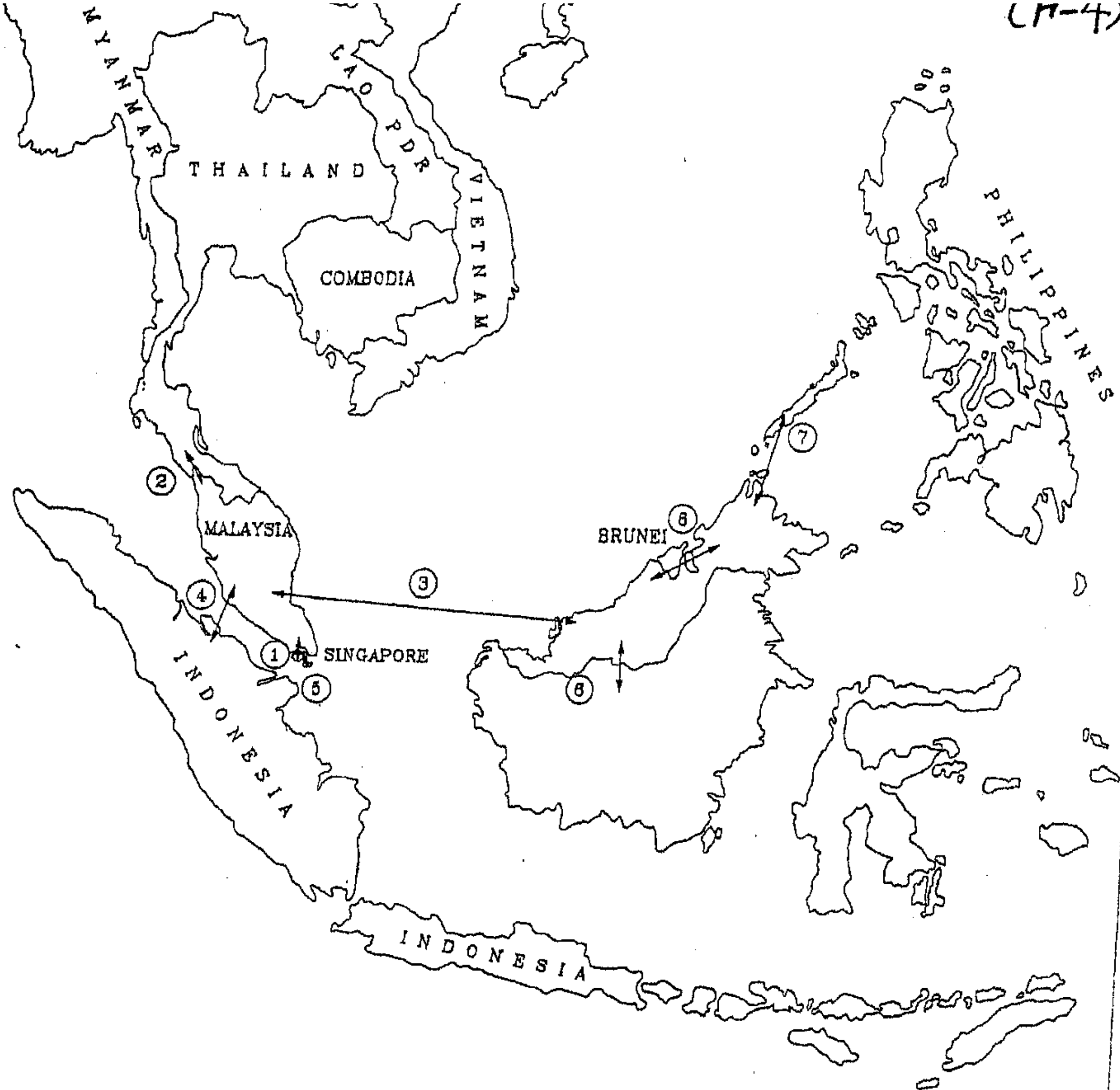
阿南紀北直流幹線の概要		
ケーブル	電圧	直流±250kV(直流±500kV設計)
	こう長	50.7km
	電線	(水底)単心3000mm² OFZEWA×1条
		(地中)単心3000mm² OFAZV ×4条
架空線	電圧	直流±250kV(直流±500kV設計)
	こう長	50.9km
	電線	(本線)TACSR810mm²×4導体×2条
		(帰線)TACSR610mm²×2導体×2条

7.



2075 年の電力システムのイメージ

(A-4)



ASEAN INTERCONNECTION PROJECT

1. PENINSULAR MALAYSIA - SINGAPORE
2. PENINSULAR MALAYSIA - THAILAND
3. PENINSULAR MALAYSIA - SARAWAK
4. PENINSULAR MALAYSIA - SUMATRA
5. SINGAPORE - BATAM
6. SARAWAK - WEST KALIMANTAN
7. SABAH - PHILIPPINES
8. SARAWAK - BRUNEI - SABAH

The Eight ASEAN Power Interconnection Project

Interstate Interconnections (F-5)

< Formulation >

Objective Function : *Total Annual Cost* =

$$\sum_{\substack{t \\ (Time)}} \sum_{\substack{i \\ (System)}} \sum_{\substack{j \\ (Unit Type)}} C_{ij} \times G_{ij}^{(t)} + \sum_{\substack{ij \\ (Transmission Line)}} \alpha_{ij} \times P_{ij\max} + \sum_{\substack{i \\ (System)}} \beta_i \times L_{i\max} \quad \rightarrow \min$$

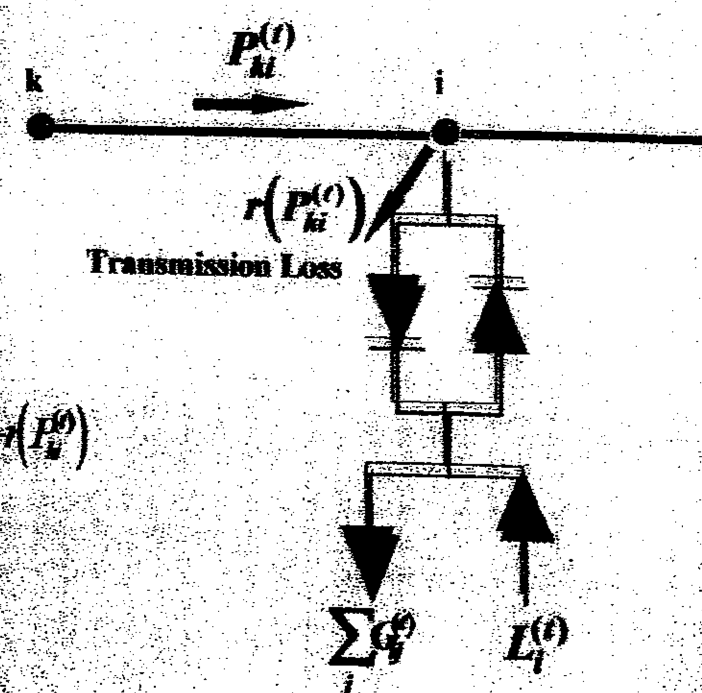
Constraints :

Generation Plant Capacity $\quad G_{ij}^{(t)} \leq G_{ij\max}$

Converter Station Capacity $\quad \left| \sum G_{ij}^{(t)} - L_i^{(t)} \right| \leq L_{i\max}$

Transmission Line Capacity $\quad \left| P_{ki}^{(t)} \right| \leq P_{ki\max}$

Demand Supply Balance $\quad \sum_j G_{ij}^{(t)} + \sum P_{ki}^{(t)} = L_i^{(t)} + r\left(P_{ki}^{(t)}\right)$

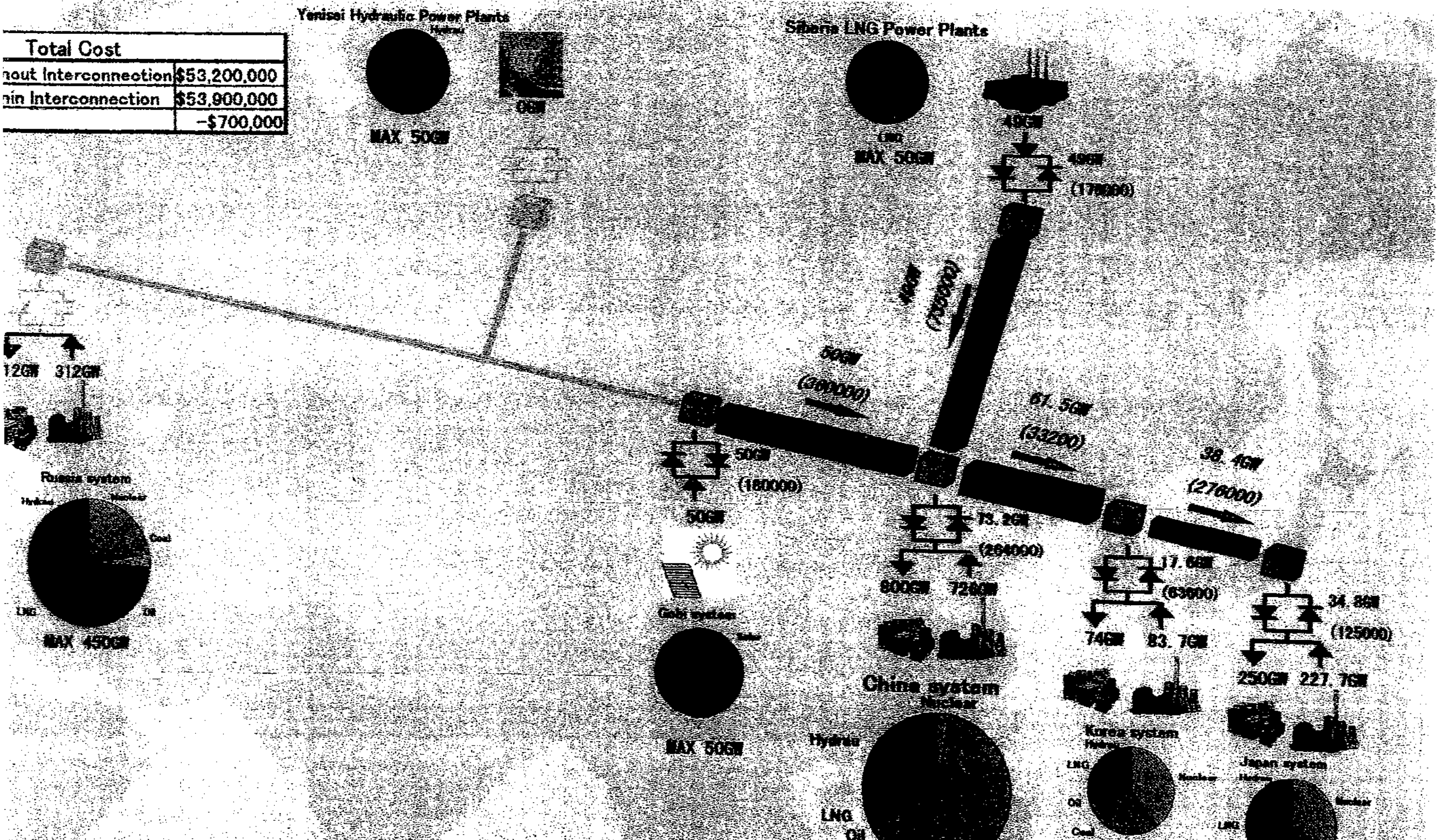


(F-6)

nterstate Interconnections <Case-2 -Droughtiness in Summer in China> Peak period in Summer

( ):Annual Cpaital Cost
unit:$10,000

Total Cost	
hout Interconnection	$53,200,000
hin Interconnection	$53,900,000
	-$700,000



ual Generation Cost

	Russia	Yenisei	Gobi	Siberia	China	Korea	Japan	Total
out Interconnection	$14,180,000	$0	$0	$	21,940,000	$3,740,000	$13,370,000	$53,230,000
n Interconnection	$14,180,000	$0	$219,000	$2,150,00	21,210,000	$3,080,000	$10,590,000	$51,429,000
	$0	$0	-$219,000	-$2,150,000	$730,000	$660,000	$2,780,000	$1,801,000