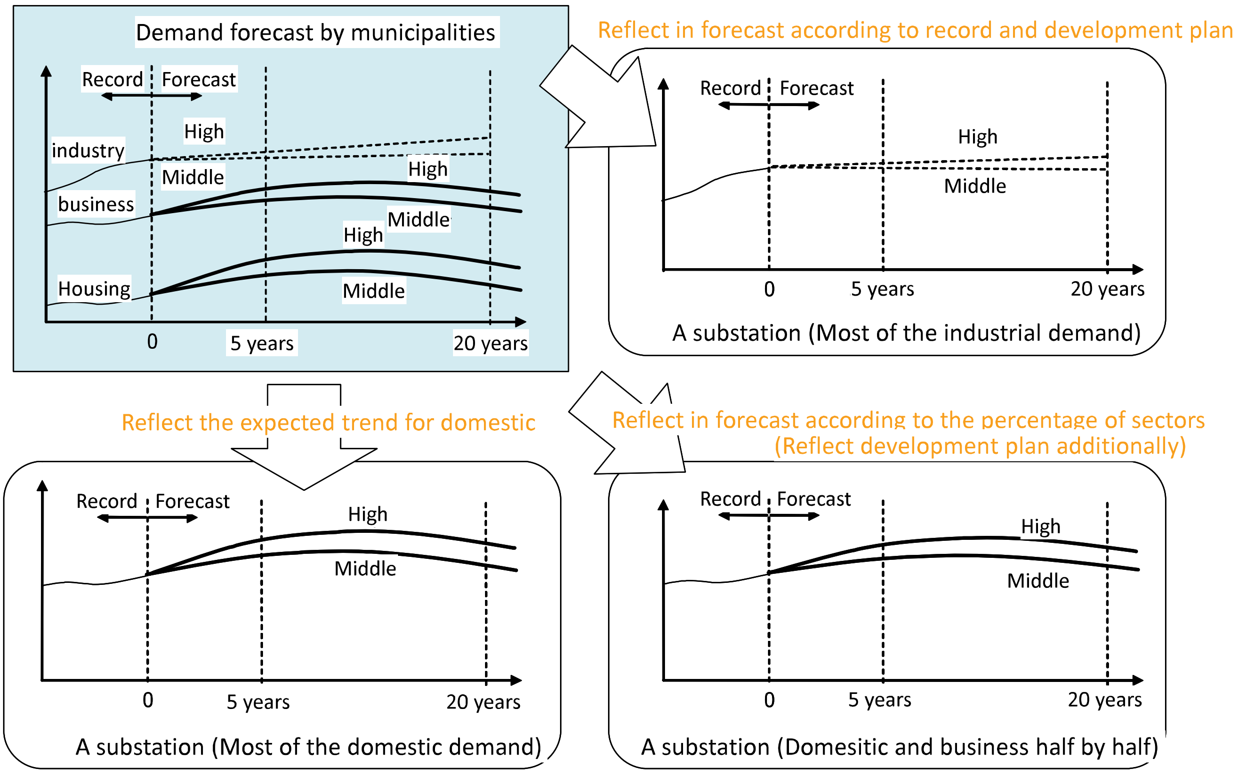
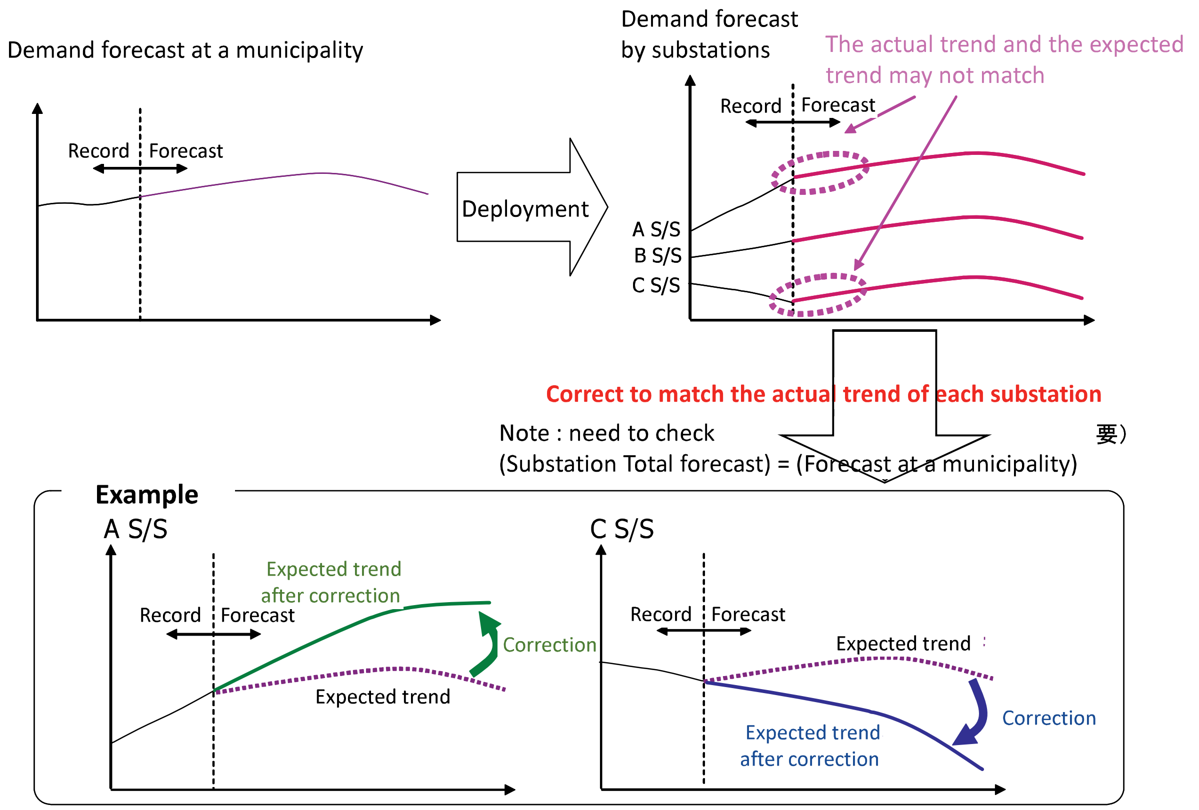
Deployments from municipality to substation



Deployments from municipality to substation



Temperature correction of demand records

Temperature correction of demand records

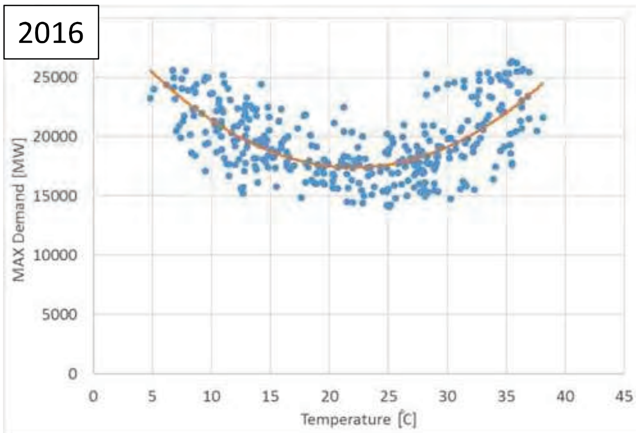
The peak demand and the max. / min. temperature have a strong correlation.

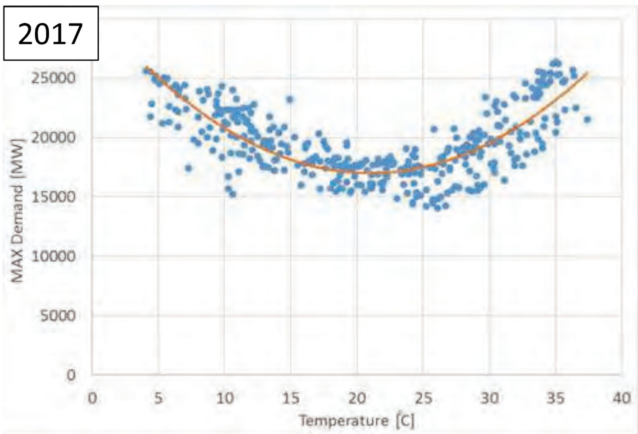
The temperature	Hot condition	Cold condition
Increasing electricity demand	The air conditioning The fan	The heating

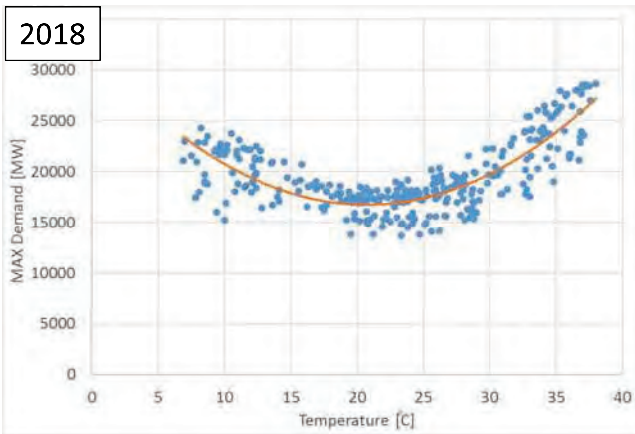
Eliminate the effects of temperature

Peak demand record → Corrected peak demand record

Used for forecast







Flow of temperature correction

Step	Detail
Tracking record of Peak Demand	Calculate total max demand below - Distributing substations - Direct distributions from small hydro generators - 6kV generator outputs - Pillar boxes, area inter-charges - Offices of extra-high voltage consumer
Temperature correction for demand record	Calculate the correlation equation by the multiple correlation of dew point and 5-days cumulative max temp.. Correct the following differences to total max demand: - Peak demand at average dew point and temperature in normal year on correlation equation - Resultant max demand in this summer
Assumption of base demand at substations	As explained in Japanese demand forecasting procedure, assume 10 years of demand using corrected total max demand

Temperature correction of demand records

5-days cumulative max temperature

(Reason) If the hot day continues, the cooling operation rate will increase.
Ex. Humans endure the heating for a while.

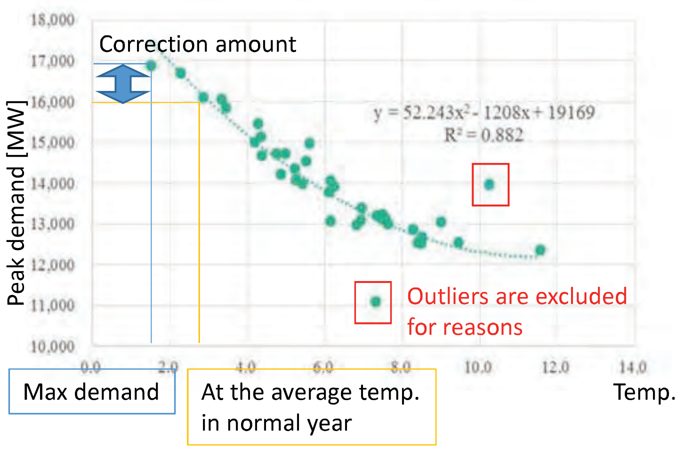
5-days cumulative max temp. = **Max temp. (the day)** ×0.6+ **Max temp. (the day before)** ×0.2+ **Max temp. (the 2-4 day before)** ×0.2

Day	4 day before	3 day before	2 day before	1 day before	That day
Temp.	30	31	32	33	34

(30+31+32)/3 x 0.2+33 x 0.2+34*0.6

Correlation coefficient

Correlation with max temp. for 1 day	0.8443
Correlation with 5-days cumulative max temp.	0.8721

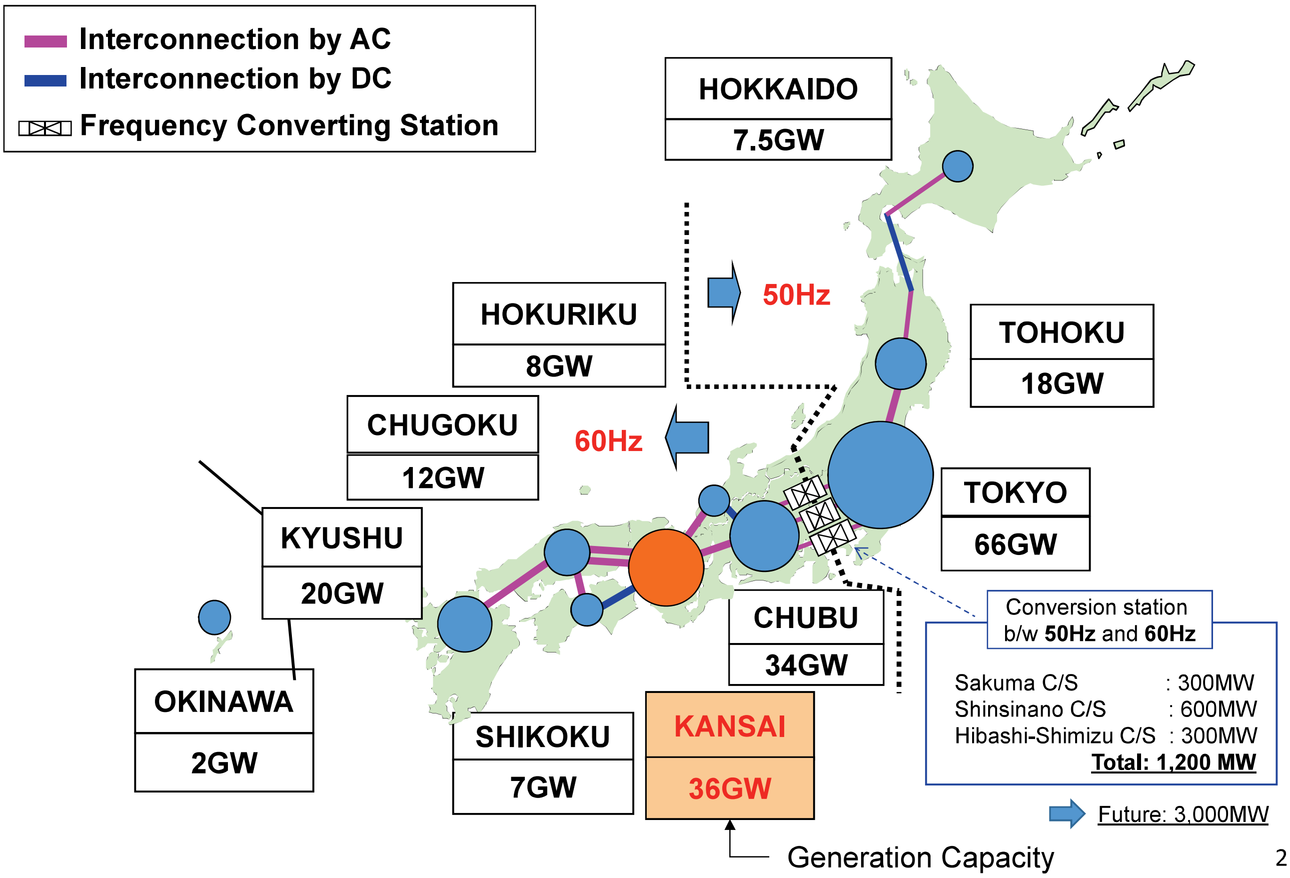


Introduction of long-term power system planning experience in Japan

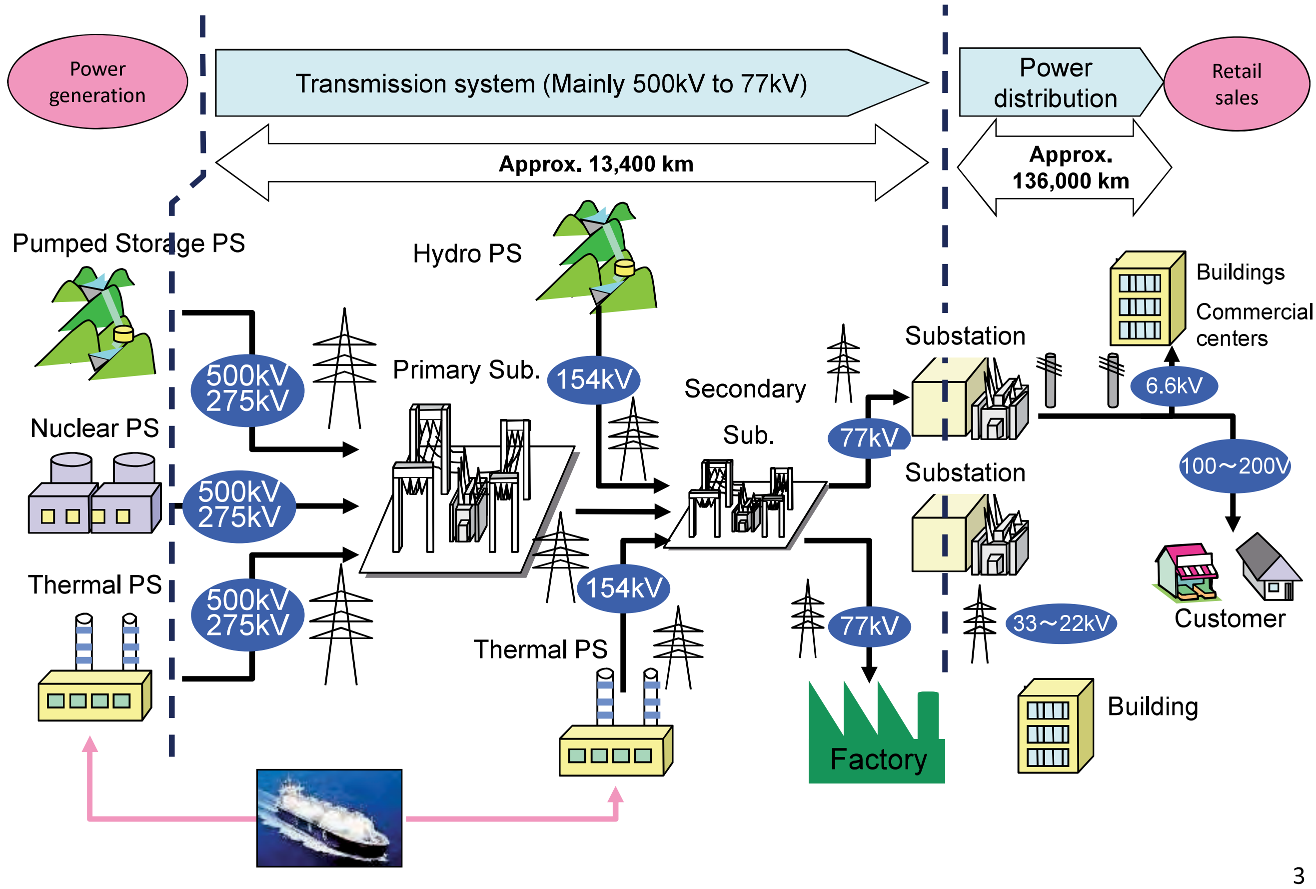
April 2019

JICA Expert Team

Present Electric Power Companies and interconnections in Japan



Power system voltage configuration of KANSAI



Basic Concepts of Bulk Power System Planning in Kansai Electric PC

Basic Concepts

1. To maintain supply reliability

-Prevention of large-scale blackouts
-Criteria of system security are mainteined for normal and abnormal conditions. (N-1 criteria)

2. Pursuit of economical efficiency

-Cost of constructing transmission facilities
-Cost of operation / maintenance
-Transmission loss

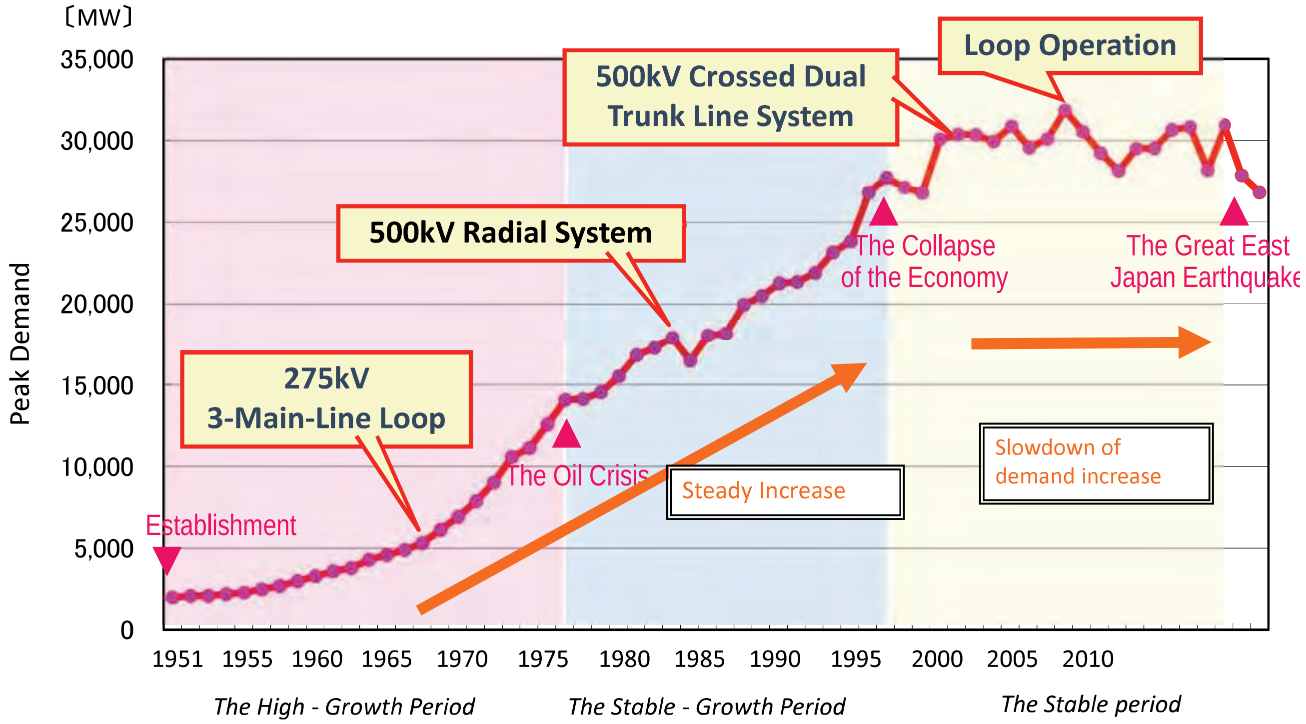
3. Correspondence to future system expansion

-To take into account demand forecast by area and power resource distribution

History of Power System Development in Kansai EP

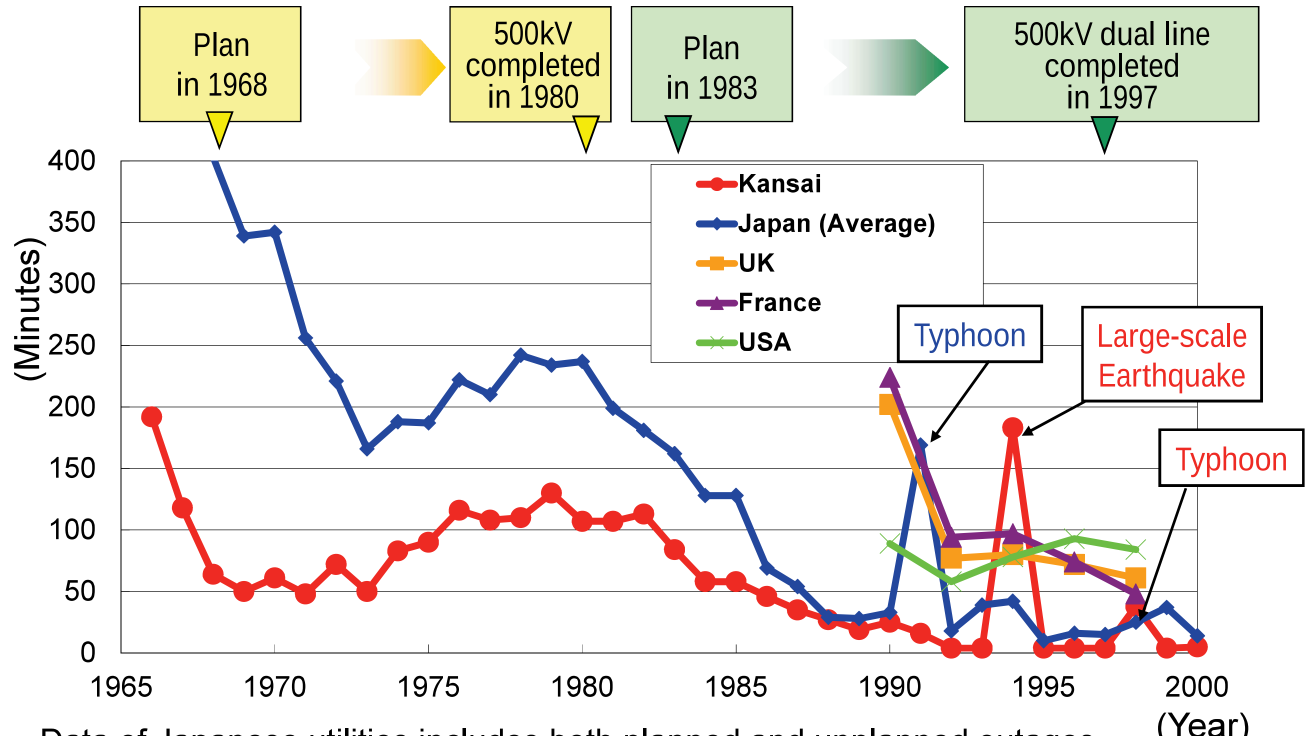
Transition of Peak Demand and System Configuration

- The power system of Kansai Electric PC has been expanded in accordance with the increase in power demand.



Supply Reliability (result of the action to enhance the system)

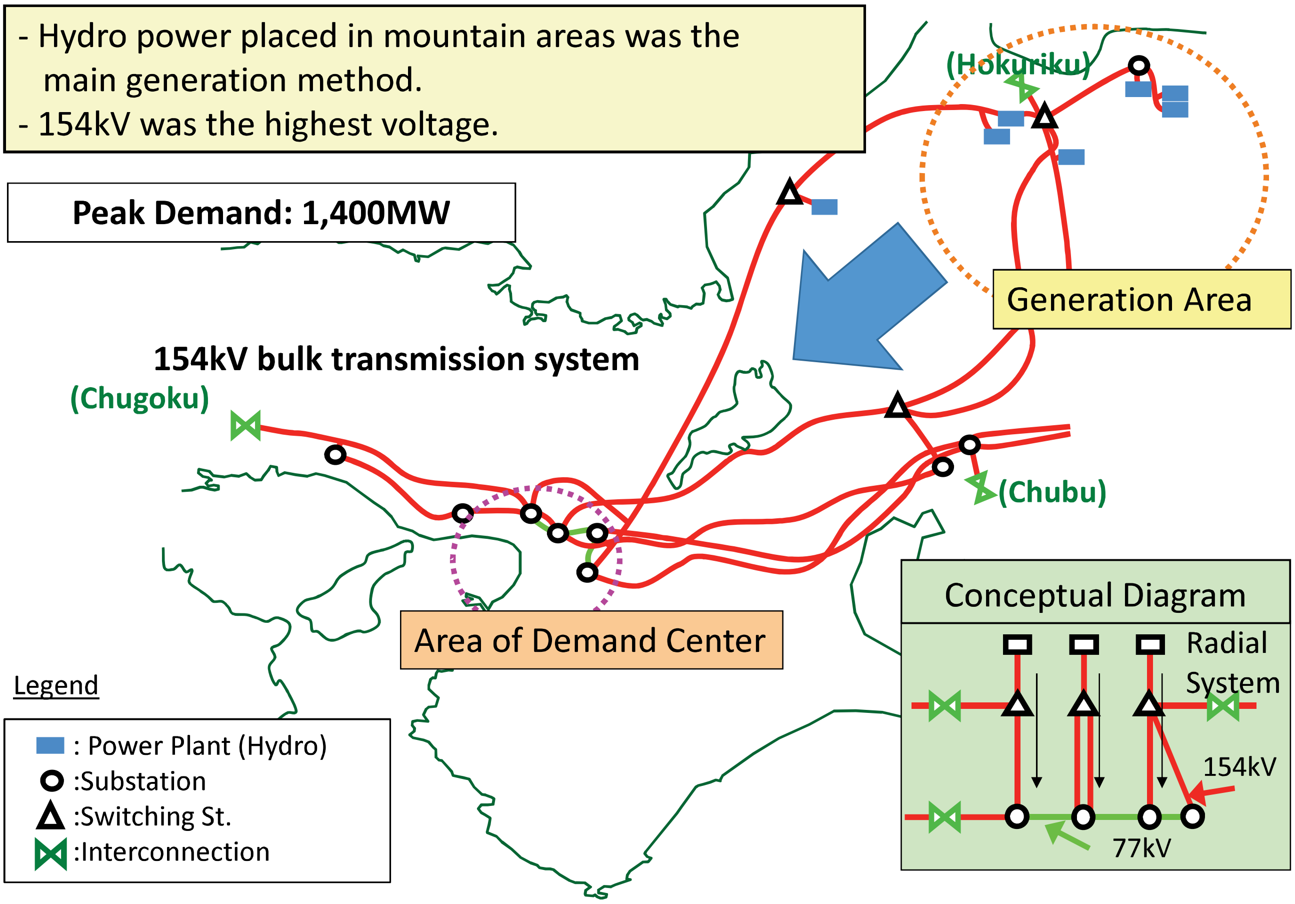
- Average unplanned outage duration per customer declines accordingly, with enhancing the system



Data of Japanese utilities includes both planned and unplanned outages.
(Source: The federation of Electric Power Companies of Japan, Kansai's internal record)

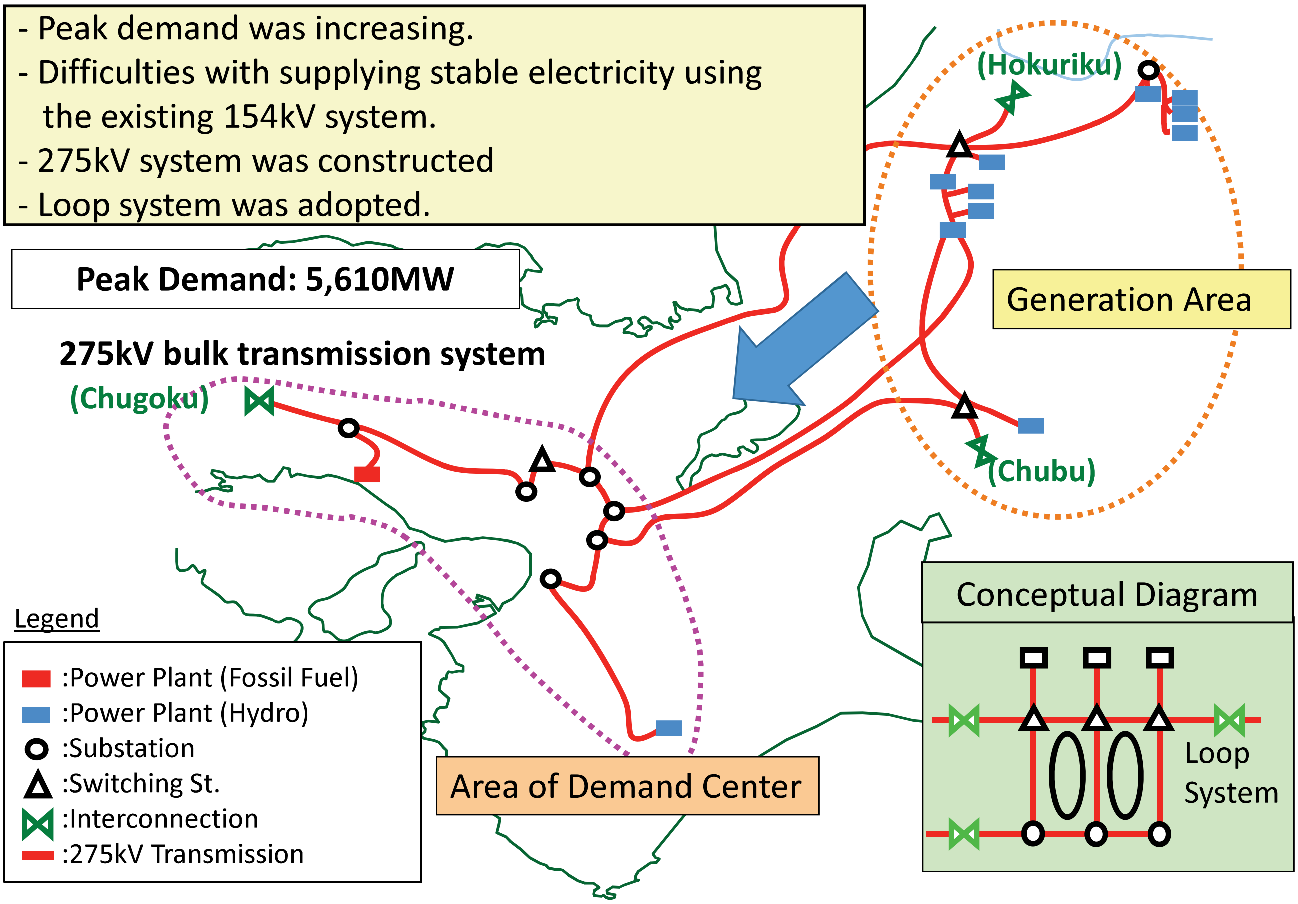
Power System in 1951

- Hydro power placed in mountain areas was the main generation method.
- 154kV was the highest voltage.



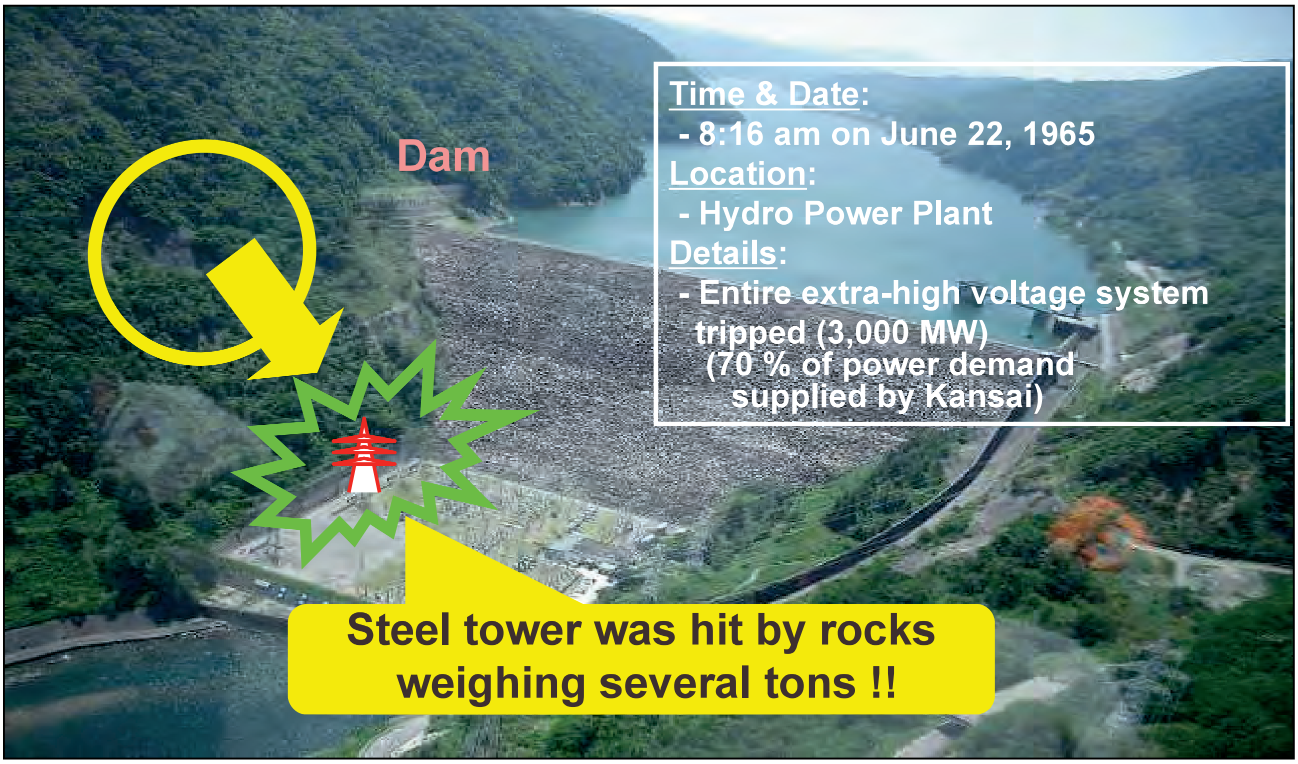
Power System in 1965 (3-Main-Line Loop Operation Period)

- Peak demand was increasing.
- Difficulties with supplying stable electricity using the existing 154kV system.
- 275kV system was constructed
- Loop system was adopted.



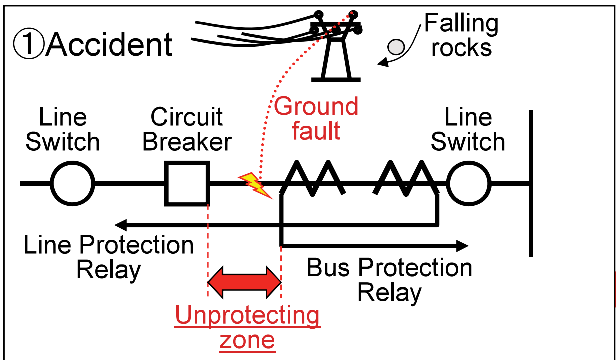
Experience of Cascading Fault in 1965

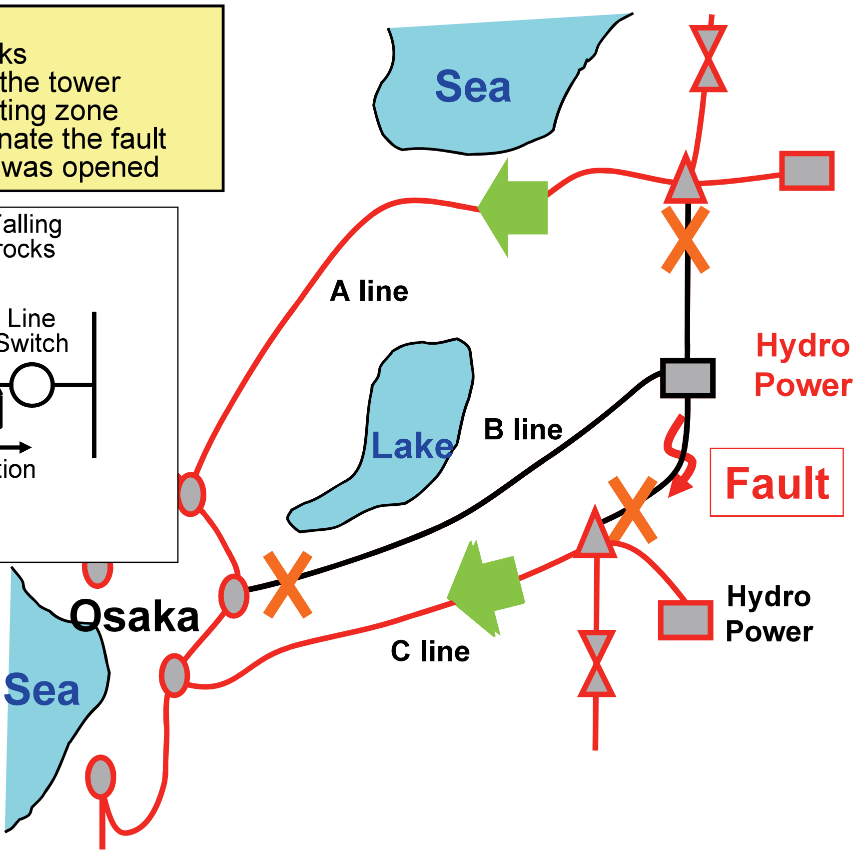
- At Hydro Power Plant, a steel tower was hit by several tons of rocks.
-The entire 275kV system stopped operation. (3000MW of electricity)



Mechanism for cascading fault (1)

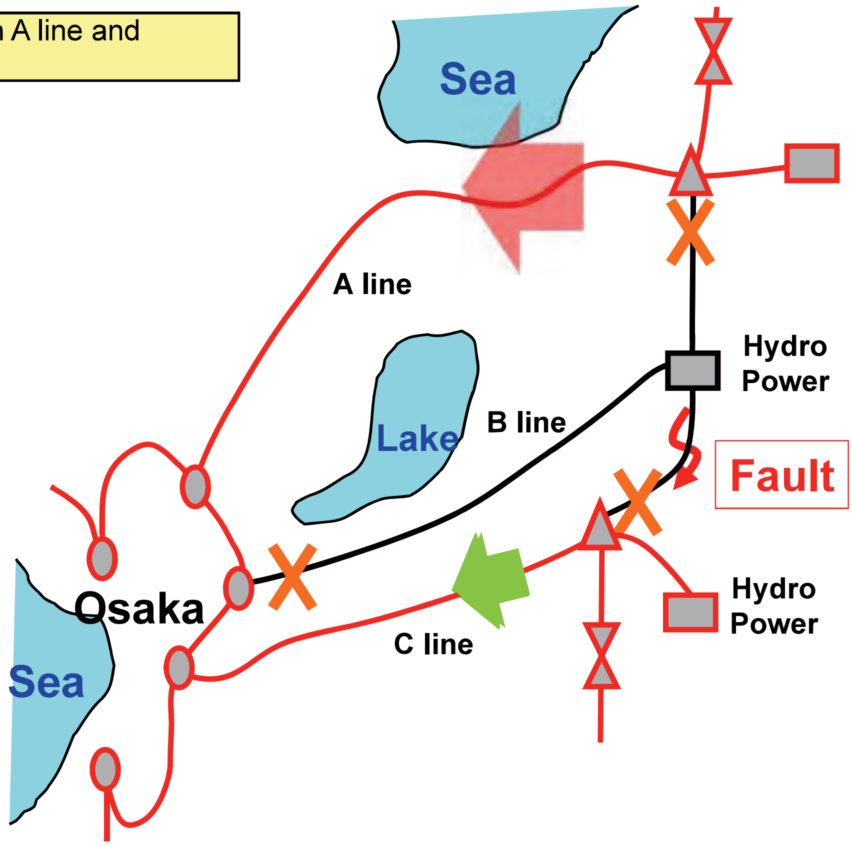
① Accident occurred
⇒ Steel tower was hit by rocks
⇒ Ground wire was off from the tower
⇒ Wire touched on unprotecting zone
⇒ It took a long time to eliminate the fault
② The line tripped and the loop was opened





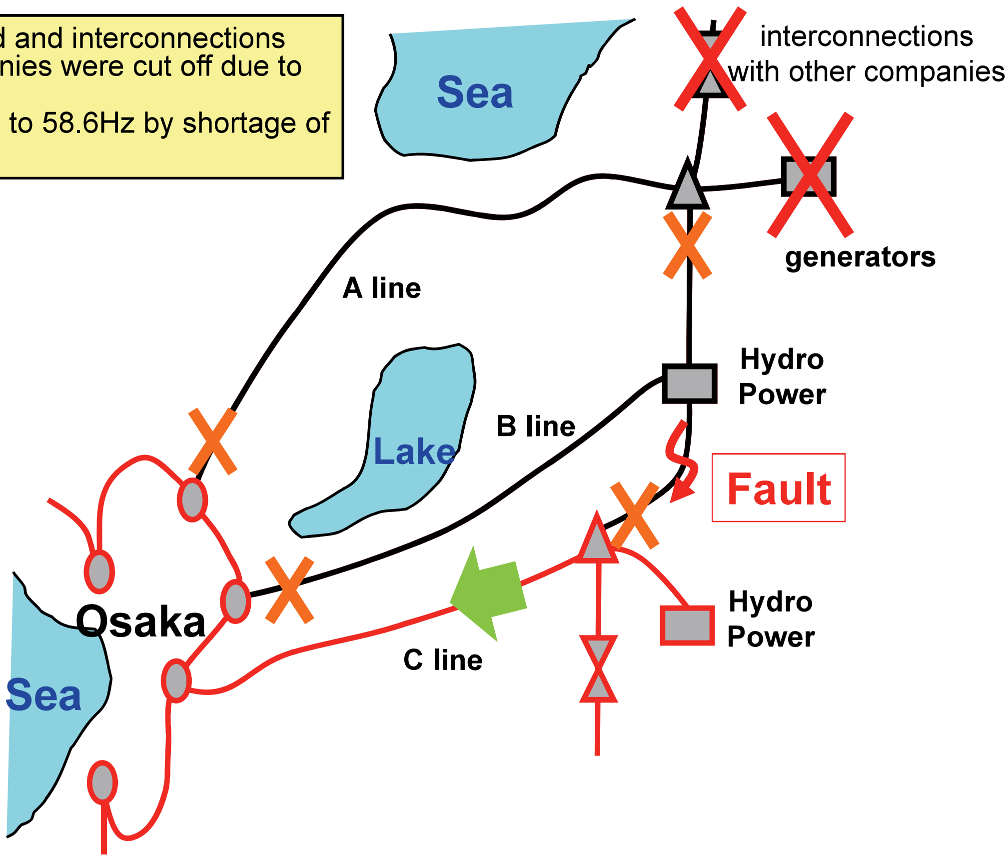
Mechanism for cascading fault (2)

③ Power flow concentrated on A line and exceeded the capacity.



Mechanism for cascading fault (3)

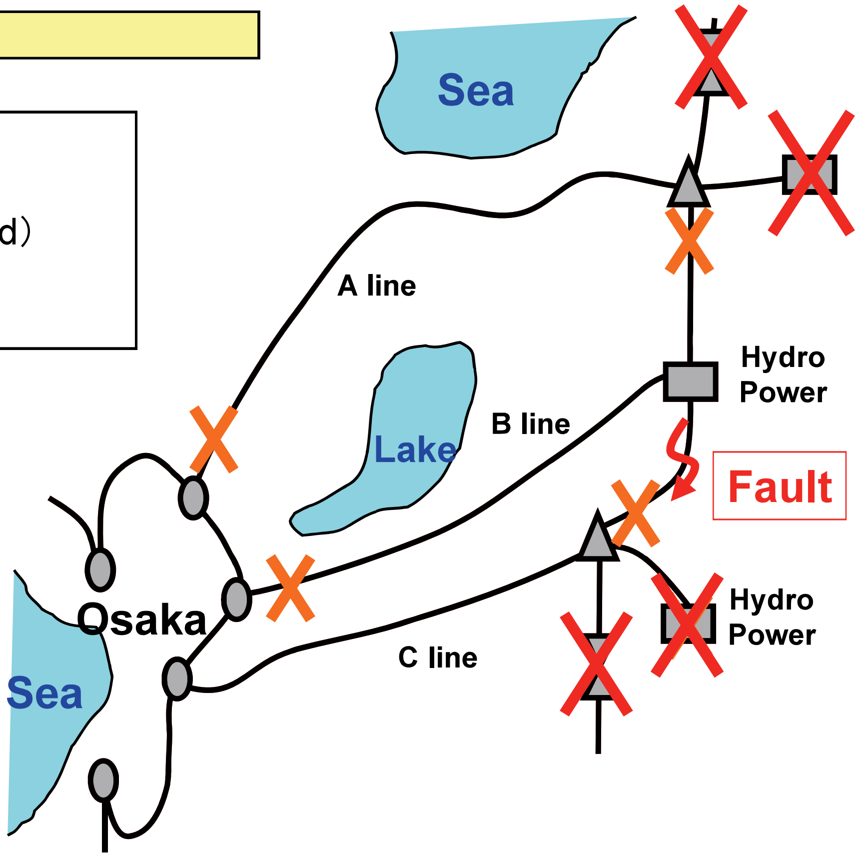
④ Generators stopped and interconnections with other companies were cut off due to frequency drop
⑤ Frequency dropped to 58.6Hz by shortage of power supply



Mechanism for cascading fault (4)

⑥ Large-scale blackouts

Outage of system
⇒**Approx. 3GW**
（70% of all demand）
Recovery time
⇒**Approx. 3hours**

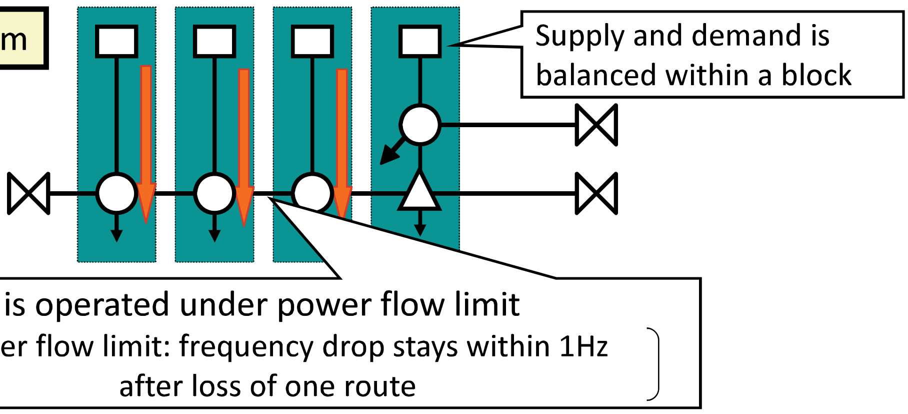


Lesson learned from the accident

- Radial system has an advantage to prevent large scale blackout.
- Bulk power system concepts in 1968 followed this idea.

	Radial system	Loop system
Merit	-Simple structure -Less chance of large scale blackouts	-No outage in N-2 faults
Demerit	-N-2 faults may cause outage	-Local fault may affect whole system -Possibility of large scale blackouts

Concept of Radial System



Expansion of Power System Plan (500kV Radial System)

Background

1. Steady demand increase.
   (Peak demand: 10% increase per year)
2. Increase of short-circuit current in 275kV system
3. Location of Large power plant in the distance.
4. Technical development of high-voltage, high-capacity and compact equipment.

There was a need adopting 500kV Radial System

Basic Policy of 500kV Radial System

1. To maintain supply reliability

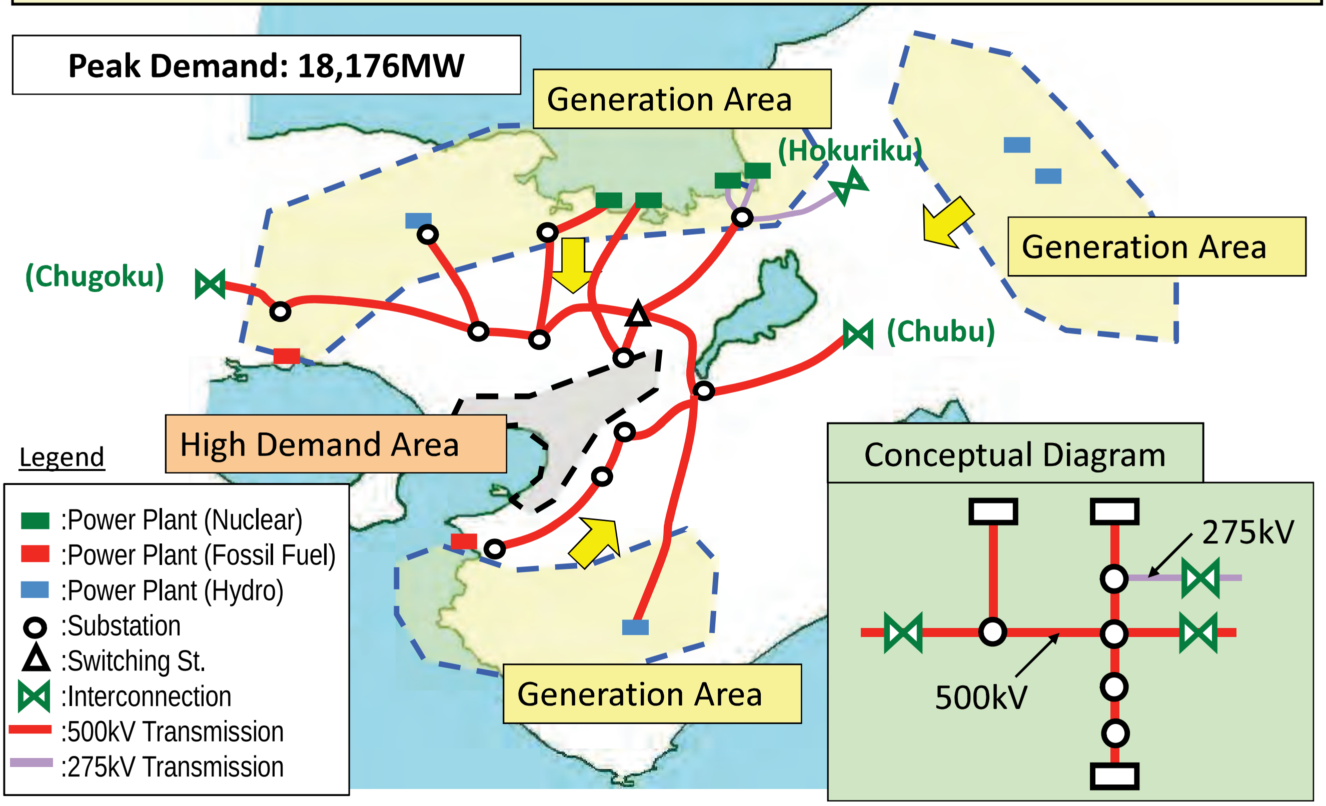
- Aiming for simple system which has less probability of large scale blackouts and has simple protection measures.
- Balancing supply and demand at 500kV substation
- Preventing system-wide collapse even when one route (two circuits) is lost.

2. To pursue the economical efficiency

- Adopting economical system considering future technical innovation.

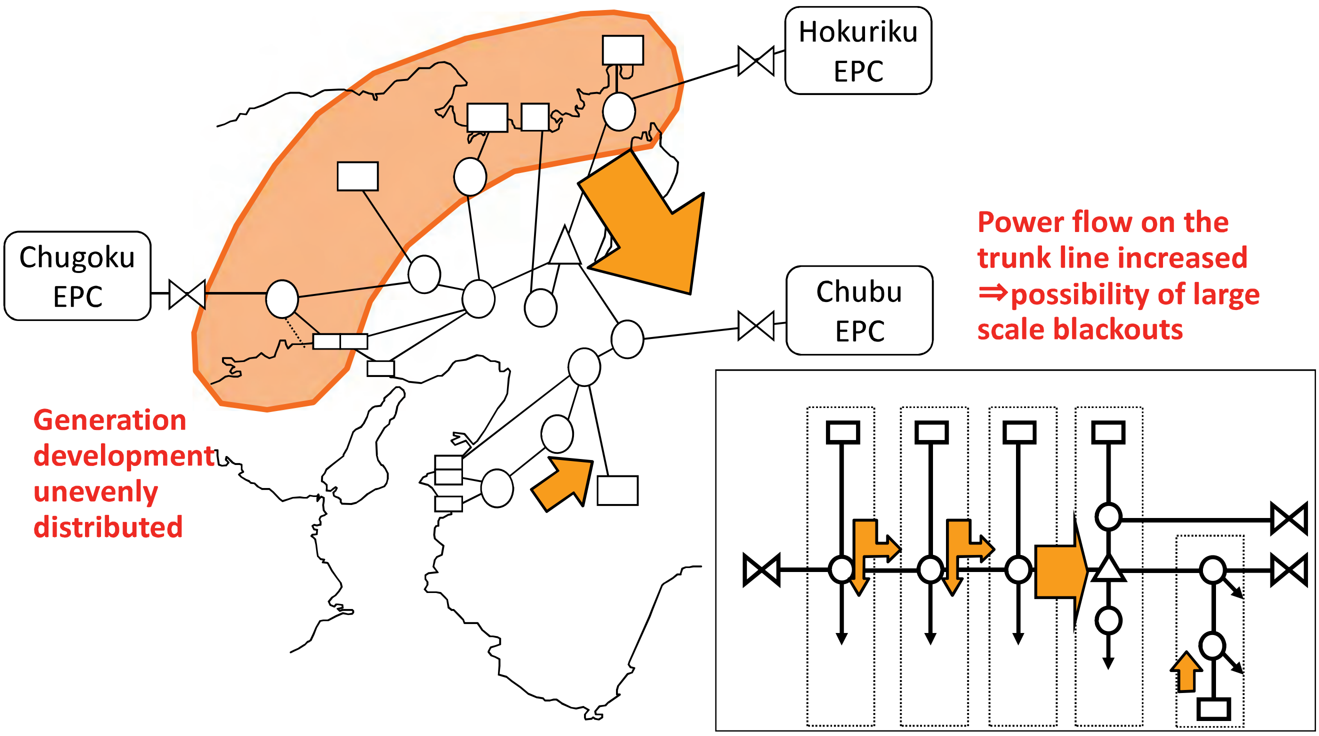
Power System in 1980 (500kV Radial System)

- According to the basic policy, 500kV radial system was completed.
- Kansai Electric PC was interconnected with other Electric PC at 500kV.



New issues after Completion 500kV System

- Increase of power flow on the trunk line due to changes in generation development locations
- Which caused the possibility of large scale blackouts



Basic Policy of 500kV crossed dual trunk line system

1. To maintain supply reliability

-The system has less probability of large scale blackouts

2. To pursue economy

-Restraining the cost of constructing transmission facilities

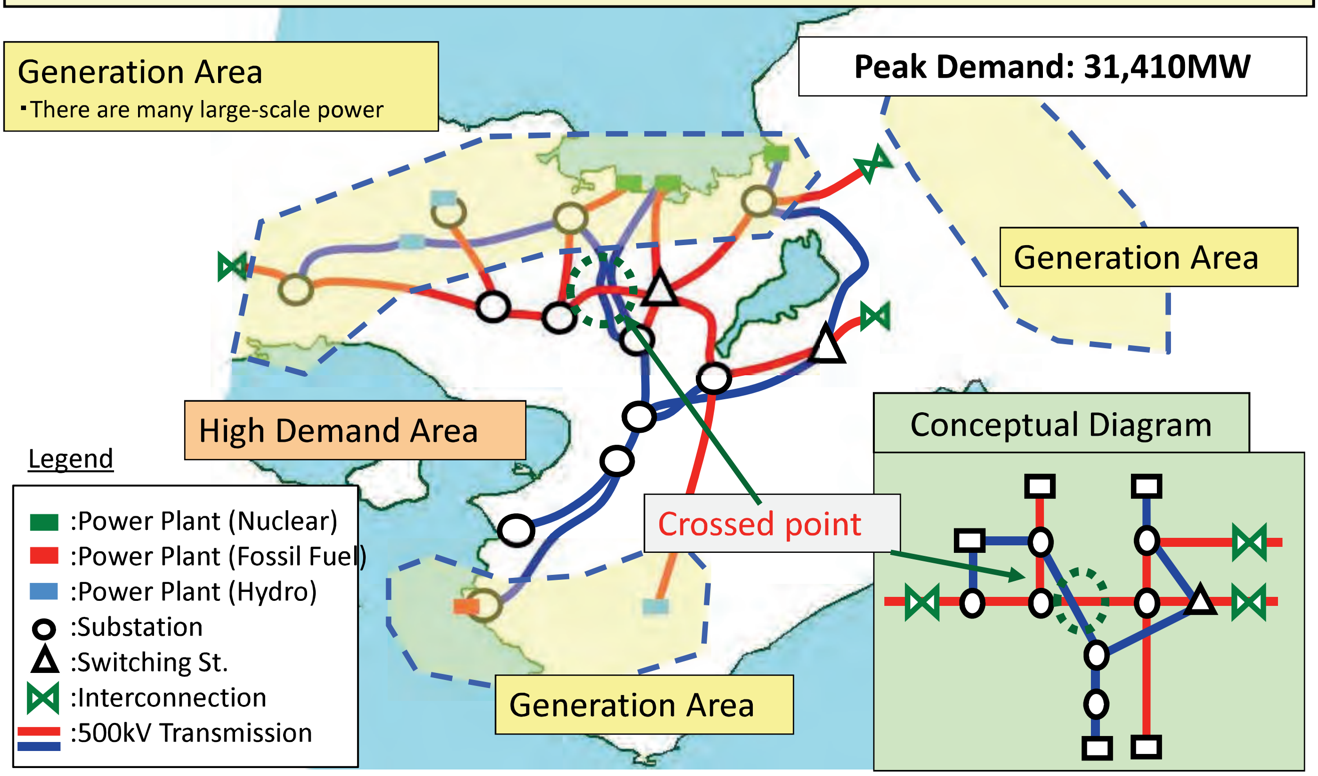
3. To make power system flexible

-The trunk lines have enough capacity to react to the change of planned location of power plants.

Installation of 500kV crossed dual trunk line system

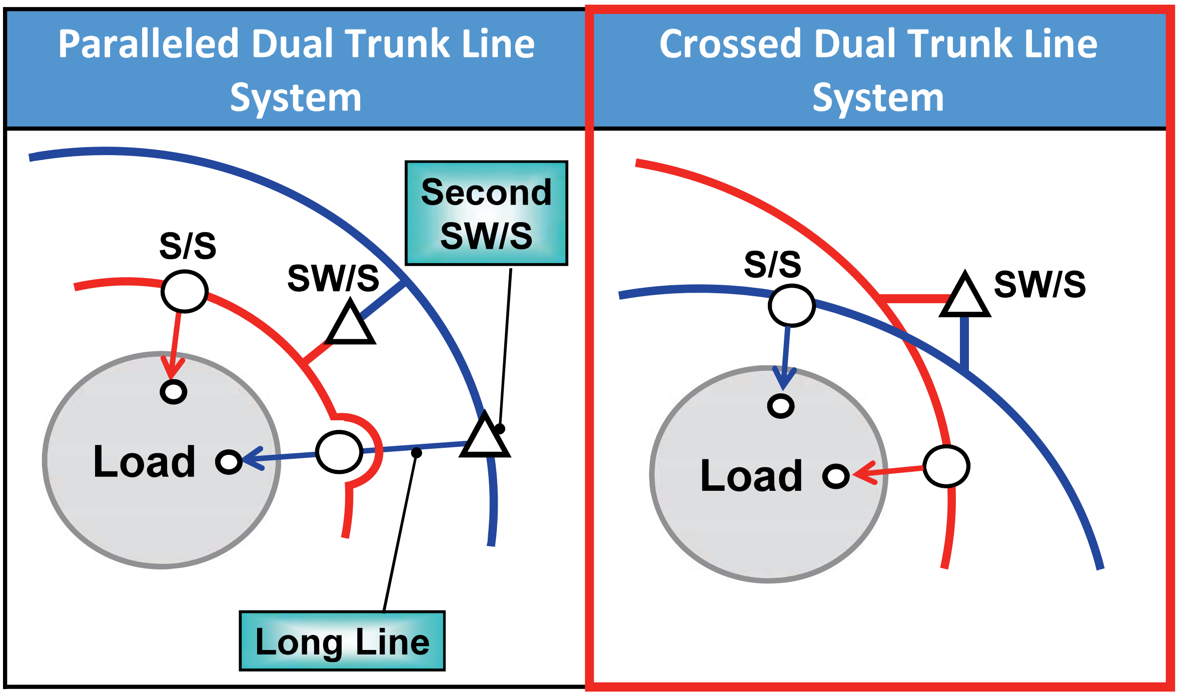
Power System in 1997 (500kV Crossed Dual Trunk Line System)

- 500kV Crossed Dual Trunk Line System completed in 1997.
- The power system was duplicated and crossed.



Merit of Crossed Dual Trunk Line System

- Necessary for Crossed Dual Trunk Line
  ⇒To adjust the balance of supply and demand of each trunk lines
  ⇒To cope with the change of the location of power plant flexibly

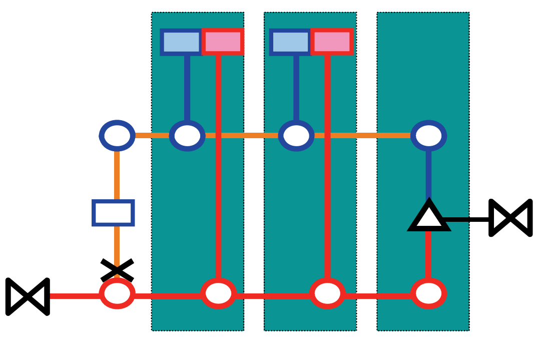
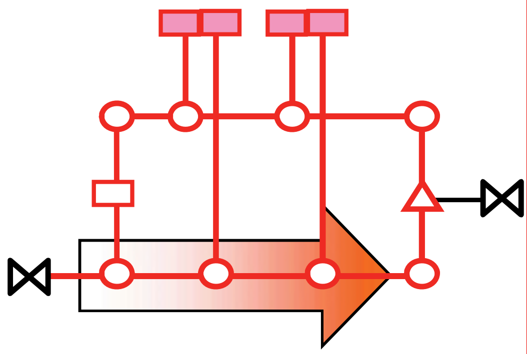


Change the concept from Radial to Loop in 2001

Background

-Requirement to increase interconnection capacity among utilities.

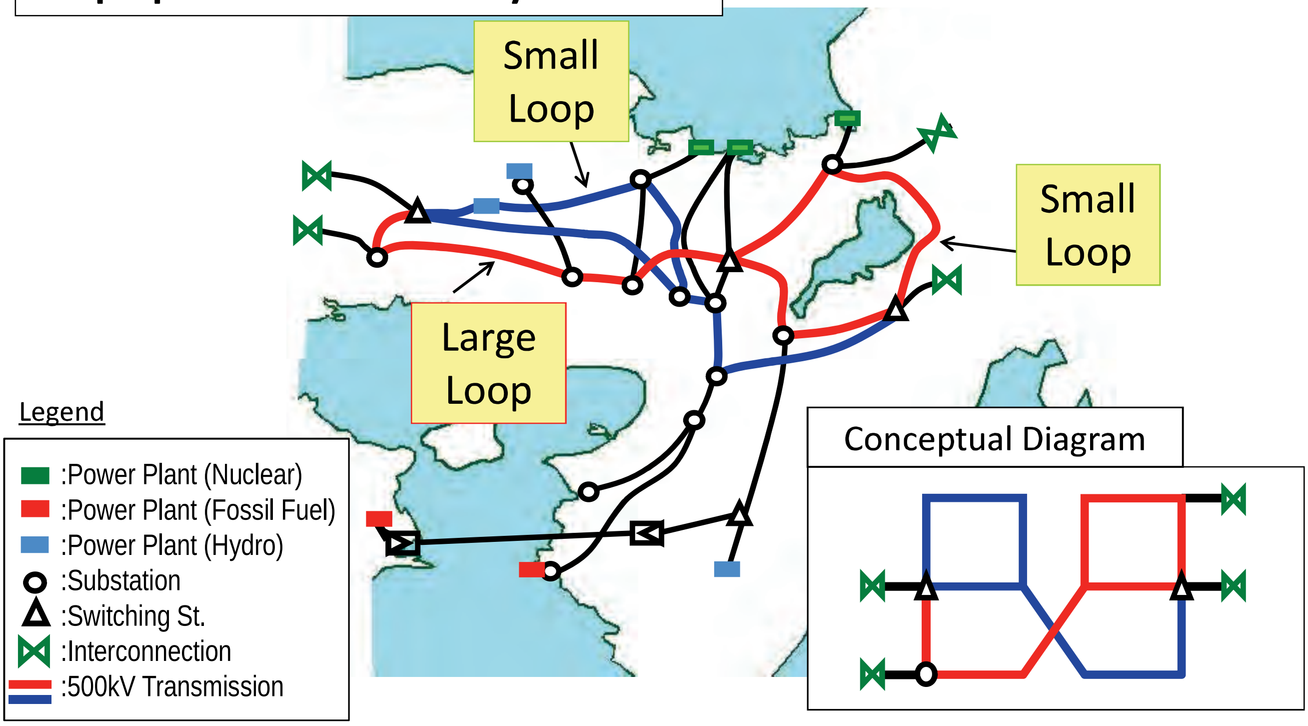
-Technology development to prevent large scale blackouts

	Radial Operation	Loop Operation
System		
Remarks	Supply and Demand should be balanced in a block ⇒Minimizing flow on trunk line	Supply and Demand is balanced in a whole system ⇒Utilizing trunk line capacity effectively

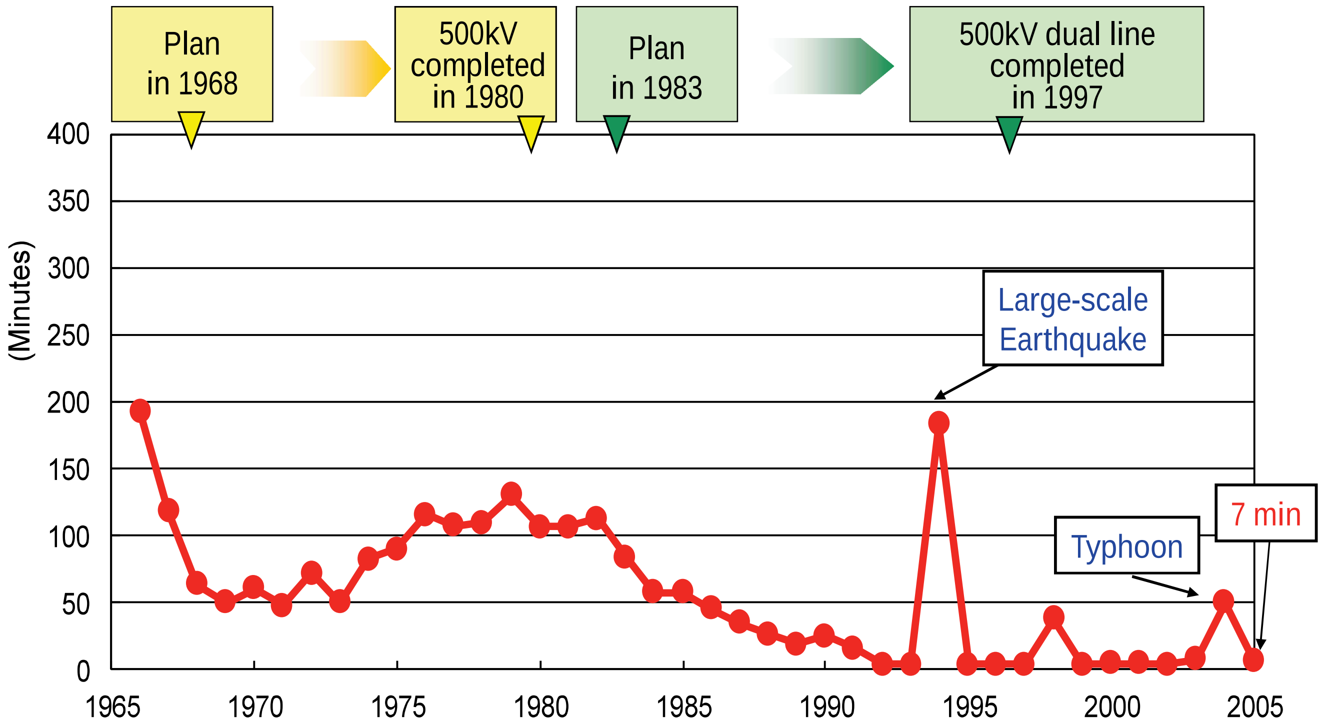
Present Bulk Power System（2001～）

- Present bulk power system

Loop operation of 500kV system



Service Reliability
(power interruption duration per customer)



FACTS Technology

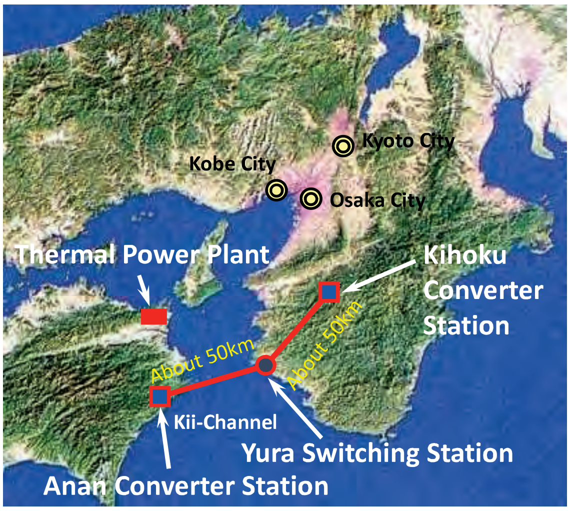
1.HVDC system
2.STATCOM for system stability

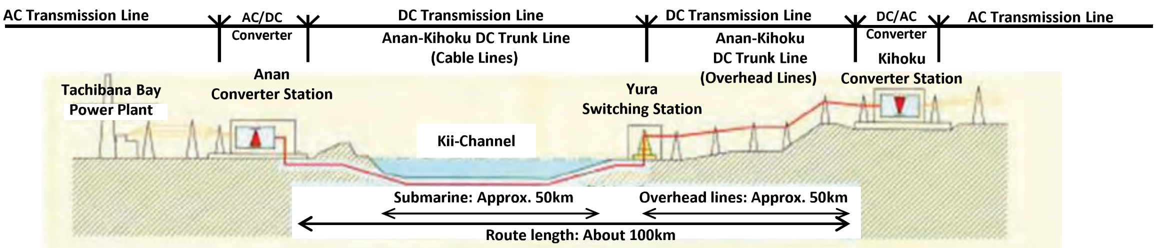
1. HVDC Trunk Line Installation Project

- High voltage direct current (HVDC) transmission was adopted for operation and economy of the electric power system.

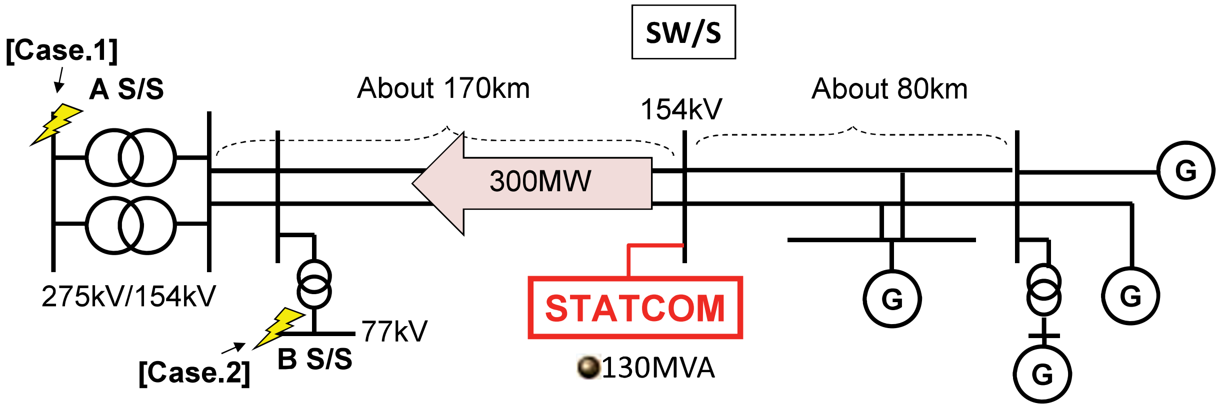
Outline of project

System voltage ±500kV
(±250kV at first stage)
Nominal capacity 2800MW
(1400MW at first stage)
Power transmission method
DC
Route length Approx. 100km
(Submarine: Approx. 50km
Overhead lines: Approx. 50km)
Start of operation June 2000





2. STATCOM Installation Project



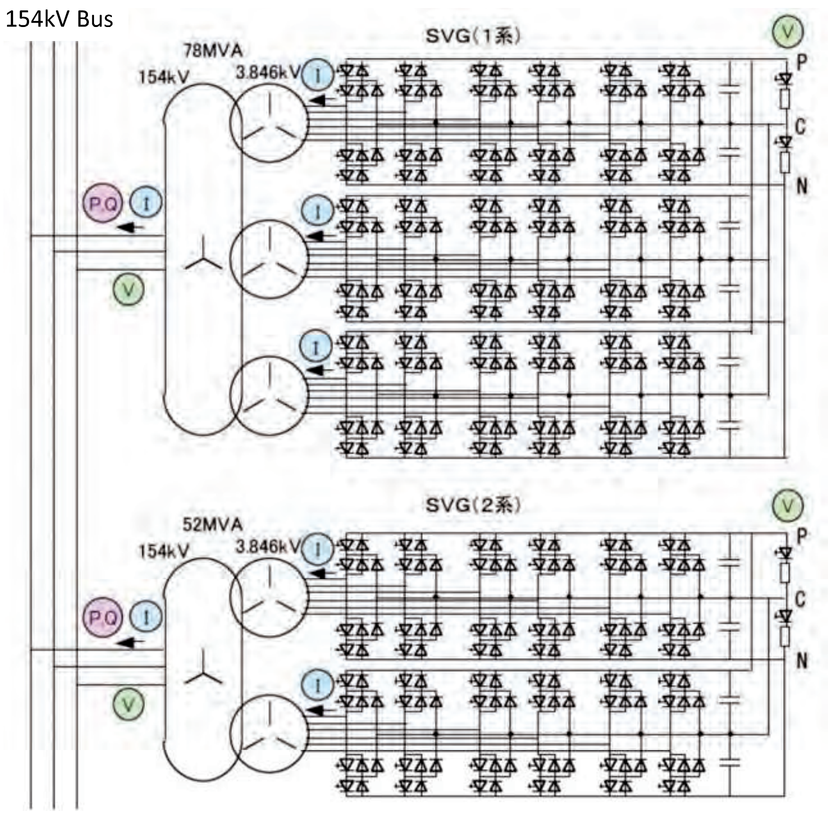
Improvement of transient stability, considering two fault cases as severe faults.

Case.1: three phase fault on one of the double buses at A substation

Case.2: three phase fault on 77kV bus at B substation

2. STATCOM Installation Project

- Rated capacity: 130MVA
- Number of multiple transformer
  78MVA: Three-stage
  52MVA: two-stage
- Configuration: Two STATCOMs in parallel



17th April

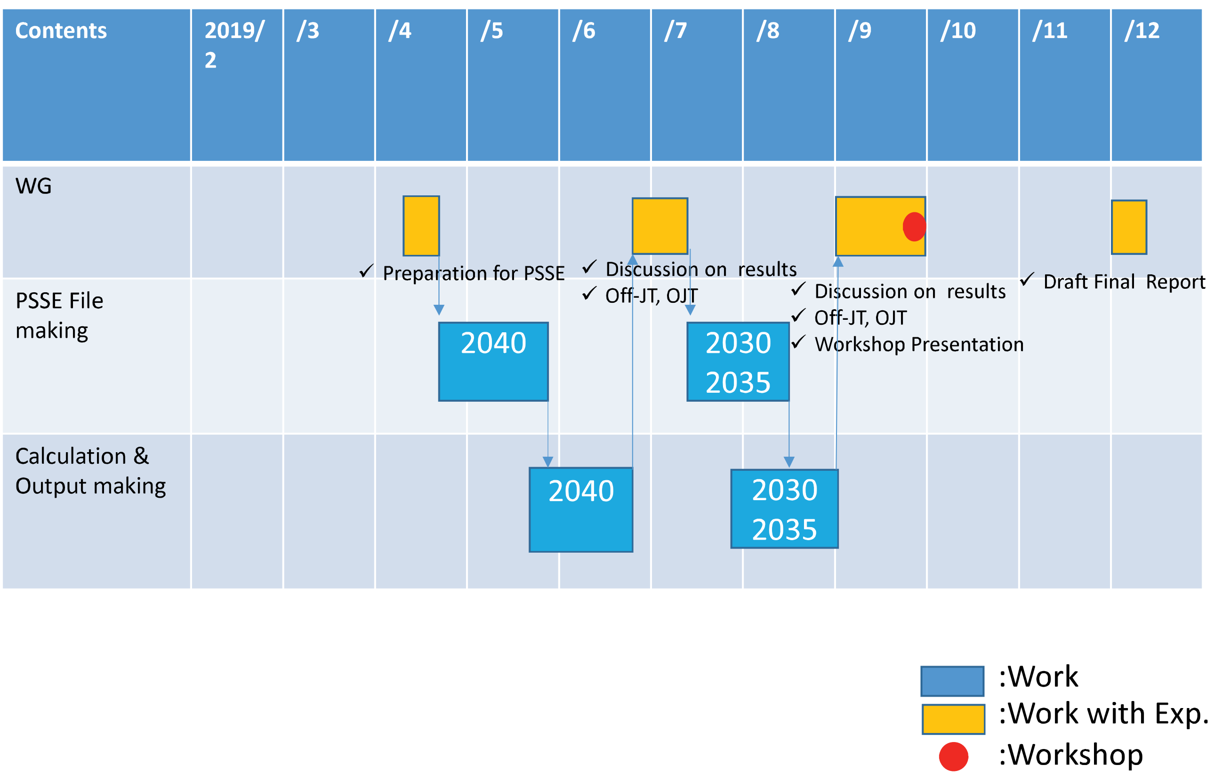
Power System Analysis

PSS/E model making & running
for transmission master plan in Pakistan

April 2019 (2nd Trip)
NEWJEC / JICA team
K.UENO

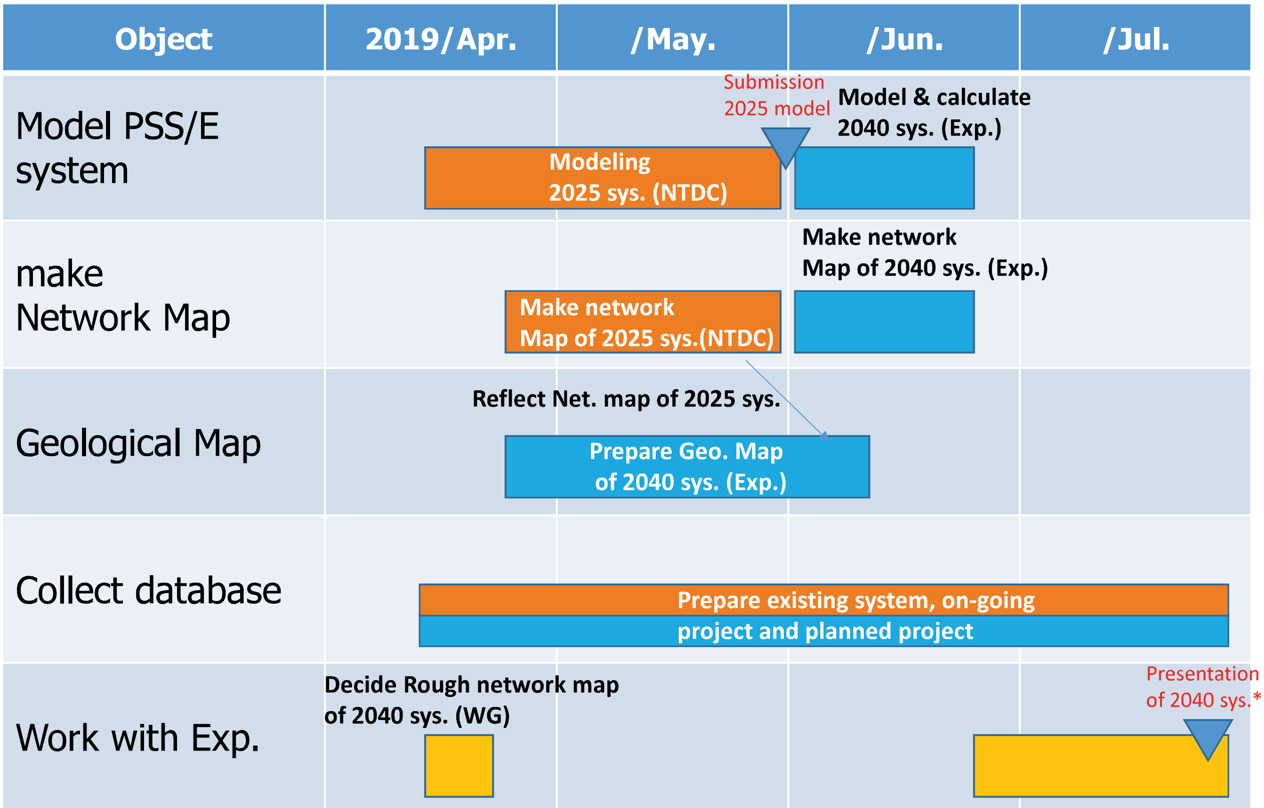
1

Total work schedule



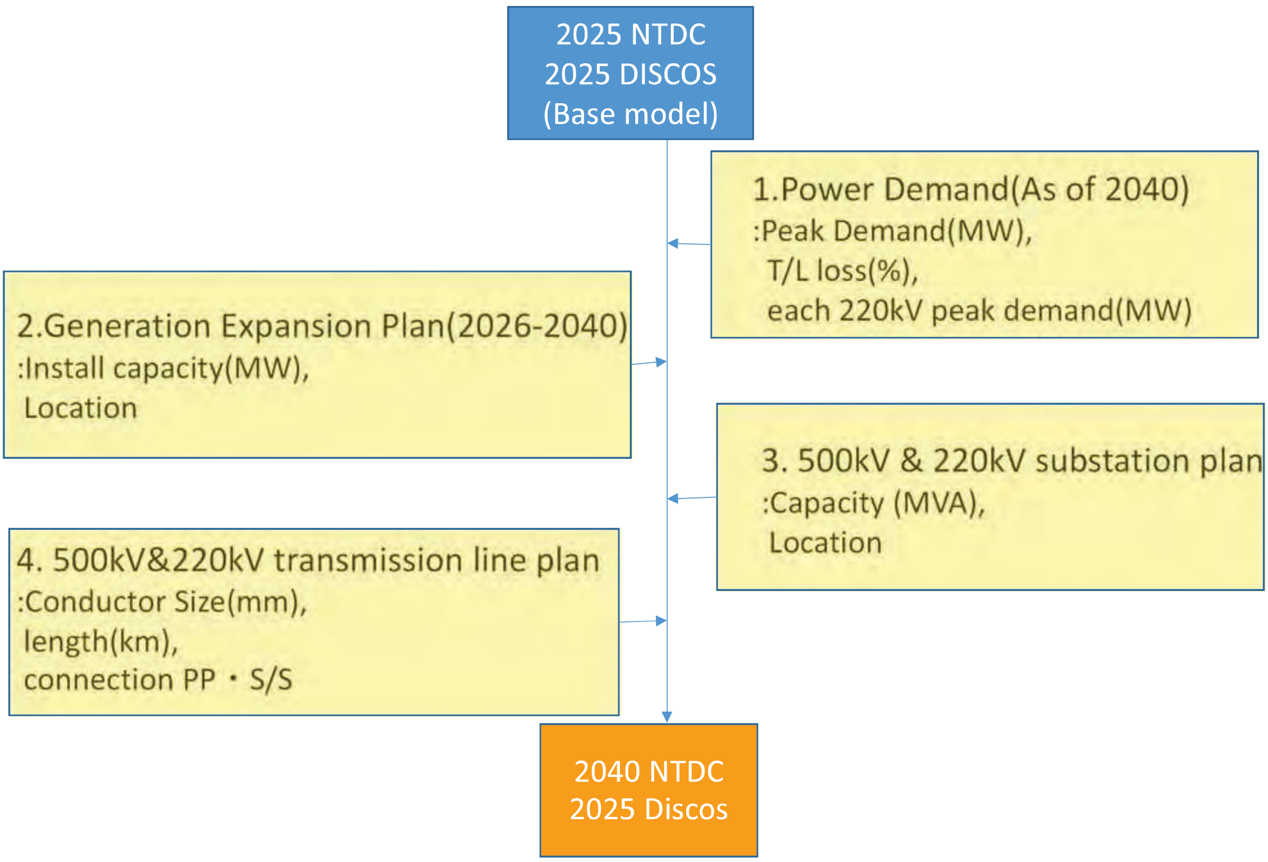
2

Work Schedule up to next July



*Power Flow& Short Circuit Current

Working Flow for 2040 PSSE model making



Study Case

	2025	2030	2035	2040
Rainy	500kV 220kV 132kV	500kV 220kV 132kV (Y2025)	500kV 220kV 132kV (Y2025)	500kV 220kV 132kV (Y2025)
Dry	500kV 220kV 132kV	500kV 220kV 132kV (Y2025)	500kV 220kV132 kV (Y2025)	500kV 220kV 132kV (Y2025)

✓Total 6 study cases

✓For each case,

-Power Flow Calculation

-Short Circuit Calculation

-Dynamic Stability Simulation

第 3 次現地調査

The Project for the Study of Upgrading National Power System Expansion Plan in The Islamic Republic of Pakistan

Interim Report

July, 2019

Japan International Cooperation Agency
NEWJEC Inc.

CONTENTS

1.1 Progress of the Project

Dis-patch	Period	Actions
1st	FEB 2019	✓ Holding 1st Joint Coordination Committee ✓ WG organization (demand forecast, power system plan, E&F analysis) ✓ Baseline survey for capacity development
2nd	APR 2019	✓ Review of present IGCEP ✓ Discussion of the work process of power system plan ✓ Information and data collection ✓ SEA team organization
3rd	JUN 2019	✓ Interim report (explanation & discussion) ✓ SEA stake holder meeting ✓ Information and data collection ✓ Site survey (transmission line and substation facility)

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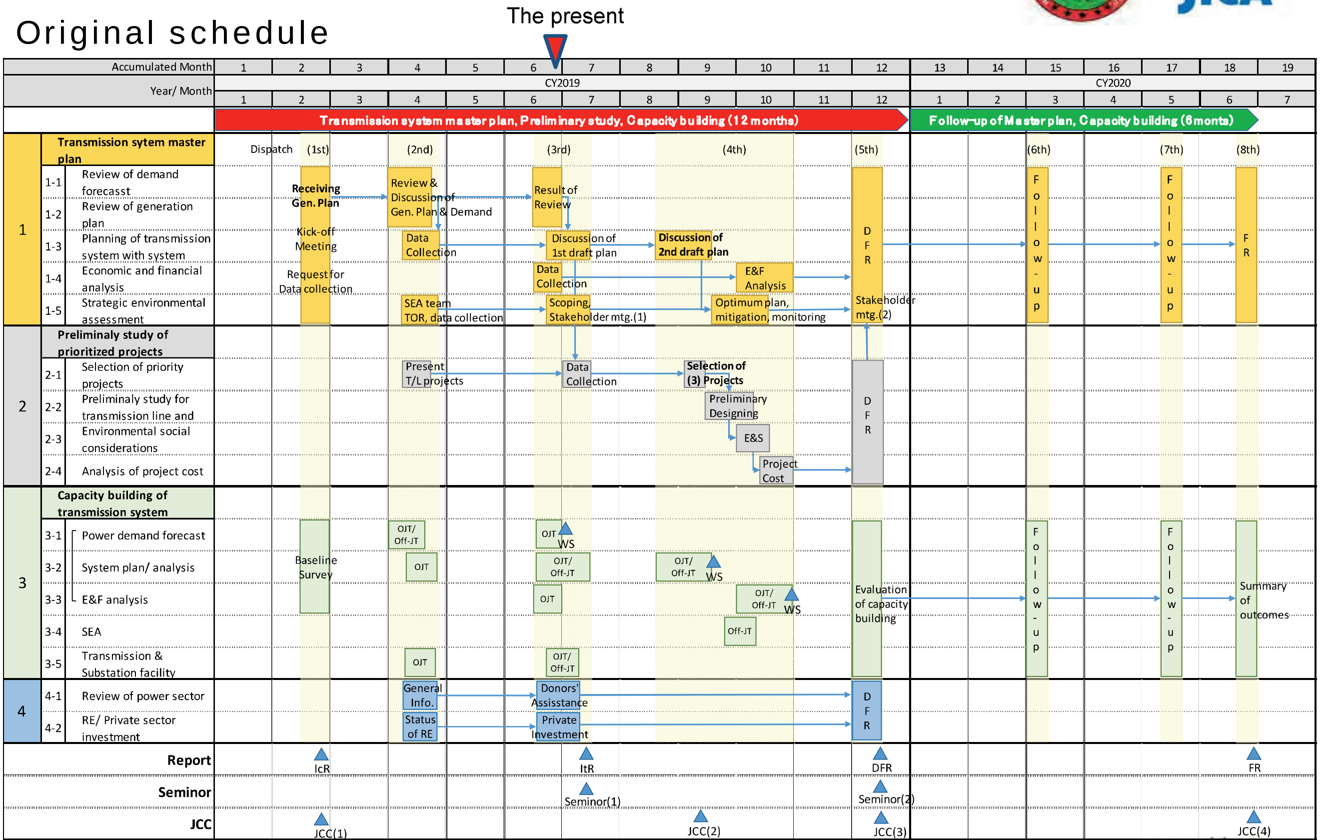
1.2 Progress of the Project

Original schedule



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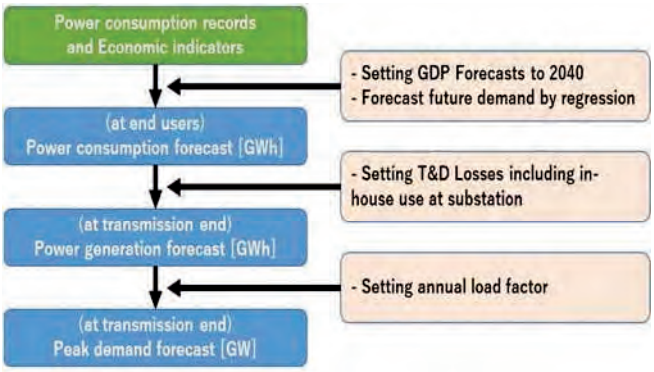
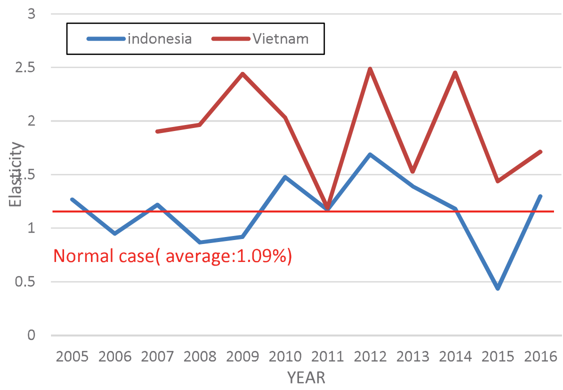
2.1 Summary of IGCEP Review - Demand Forecast

Title	Substance	Evaluation
Methodology	Regression based on historical data (E-views)	✓ Good
Procedure	According to the flow diagram Note:1	✓ Good
Result	Continuity between records and forecasts	✓ Good
	Validity compared with other countries Note:2	✓ Good
	Consistency of records and past forecasts	✓ Good

Note:1



Note:2



Forecast result in IGCEP is sufficient to apply for our project.

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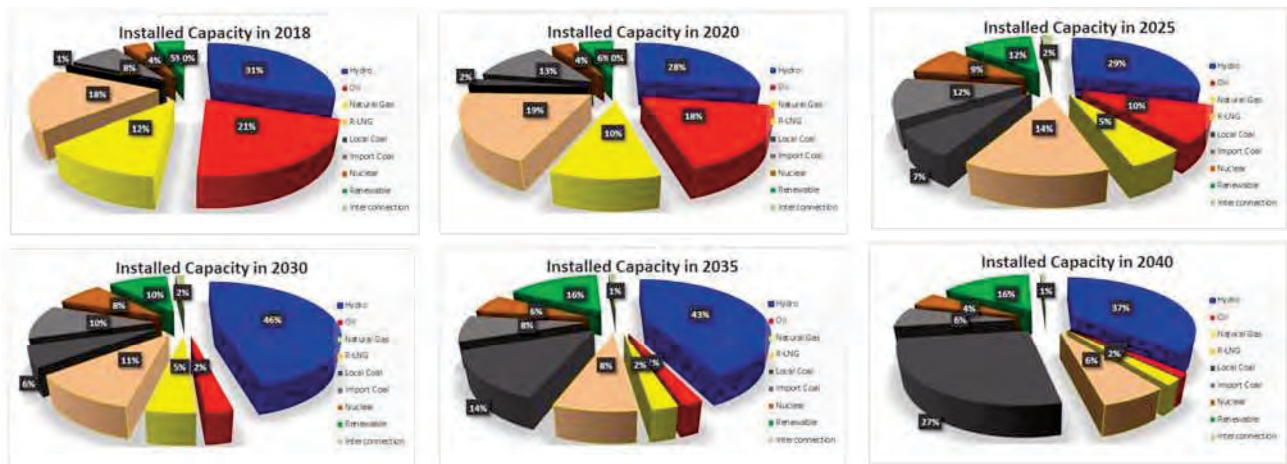
2.2 Summary of IGCEP Review - Generation Development Plan



Sources	2018		2020		2025		2030		2035		2040	
Hydro	9,635.0	30.4%	10,002.0	27.5%	15,166.3	41.6%	27,901.3	53.7%	34,251.3	43.2%	37,801.3	36.7%
Oil	6,657.7	21.0%	6,657.7	18.3%	5,167.7	14.2%	1,533.3	2.9%	1,533.3	1.9%	1,151.1	1.1%
Natural Gas	3,794.0	12.0%	3,794.0	10.4%	2,820.0	7.7%	2,820.0	5.4%	2,009.0	2.5%	2,009.0	2.0%
R-LNG	5,801.0	18.3%	7,044.0	19.3%	7,044.0	19.3%	6,454.0	12.4%	6,251.0	7.9%	6,651.0	6.5%
Local Coal	150.0	0.5%	810.0	2.2%	3,780.0	10.4%	3,630.0	7.0%	10,890.0	13.7%	27,390.0	26.6%
Import Coal	2,640.0	8.3%	4,620.0	12.7%	6,240.0	17.1%	6,240.0	12.0%	6,240.0	7.9%	6,240.0	6.1%
Nuclear	1,330.0	4.2%	1,330.0	3.7%	4,630.0	12.7%	4,630.0	8.9%	4,630.0	5.8%	4,630.0	4.5%
Renewable	1,690.5	5.3%	2,169.5	6.0%	6,139.5	16.9%	6,139.5	11.8%	12,439.5	15.7%	16,039.5	15.6%
Interconnection	0.0	0.0%	0.0	0.0%	1,000.0	2.7%	1,000.0	1.9%	1,000.0	1.3%	1,000.0	1.0%
Total	*31,698.2*		*36,427.2*		*36,427.2*		*51,987.5*		*79,244.1*		*102,911.9*	

Installed Capacity of Power Plants

Calculated by JICA Team based on IGCEP

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2.3 Summary of IGCEP Review - Conclusions

(Energy Security)

- Domestic energy is well utilized in IGCEP and energy security in the future is expected to be good conditions. However, introduction in long term is heavily depended on coal and divesification of input is expected.
- After the commencement of new energy policy, some alternative scenarios studies for the generation mix are recommended.

(Financial Burden)

- As hydropower, local coal and renewable is utilized in IGCEP, generation cost will be expected to be cheap and stable for the inflation of fuel. However, generation cost (cents/kWh) is not estimated. It is strongly recommended to calculate it.

(Environmental and Social Considerations)

- Analysis is not executed in IGCEP. It is also recommended to be included.

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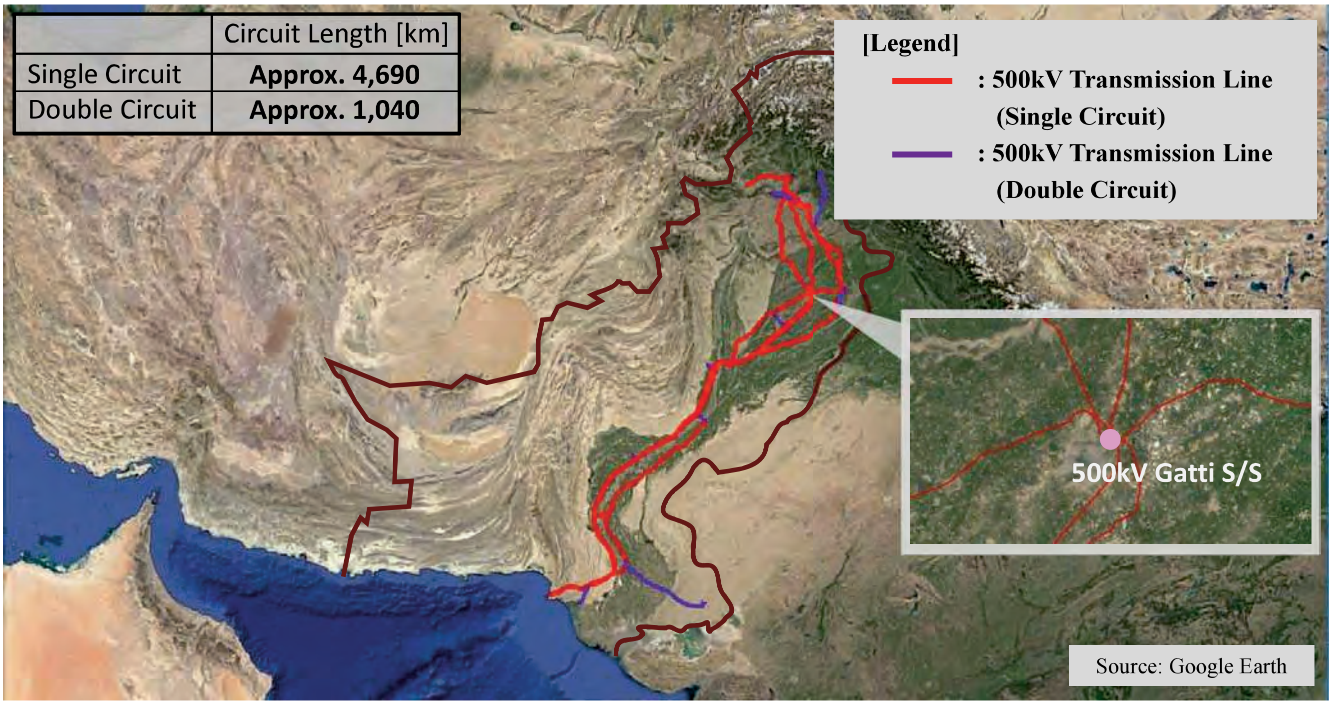
3.1 Outline of 500kV Existing T/L's

	Circuit Length [km]
Single Circuit	**Approx. 4,690**
Double Circuit	**Approx. 1,040**



- **Single circuit towers are almost applied in 500kV existing T/L's.**

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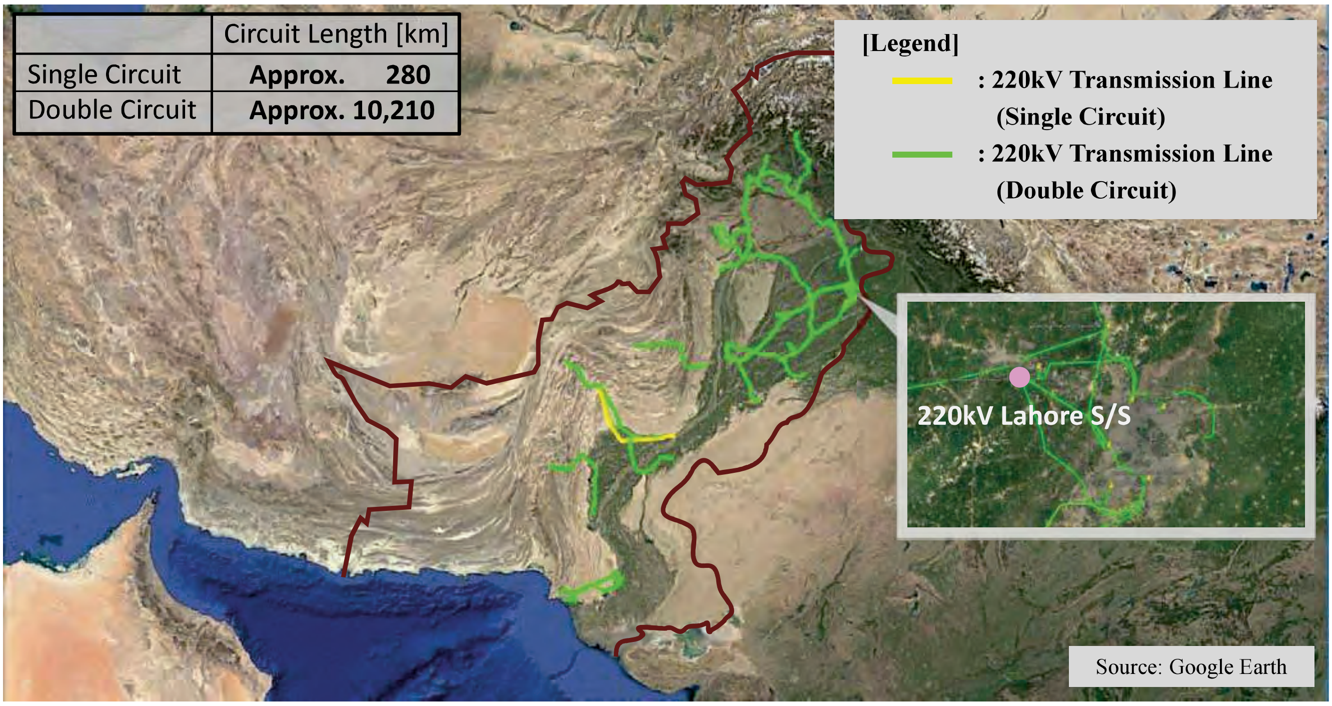
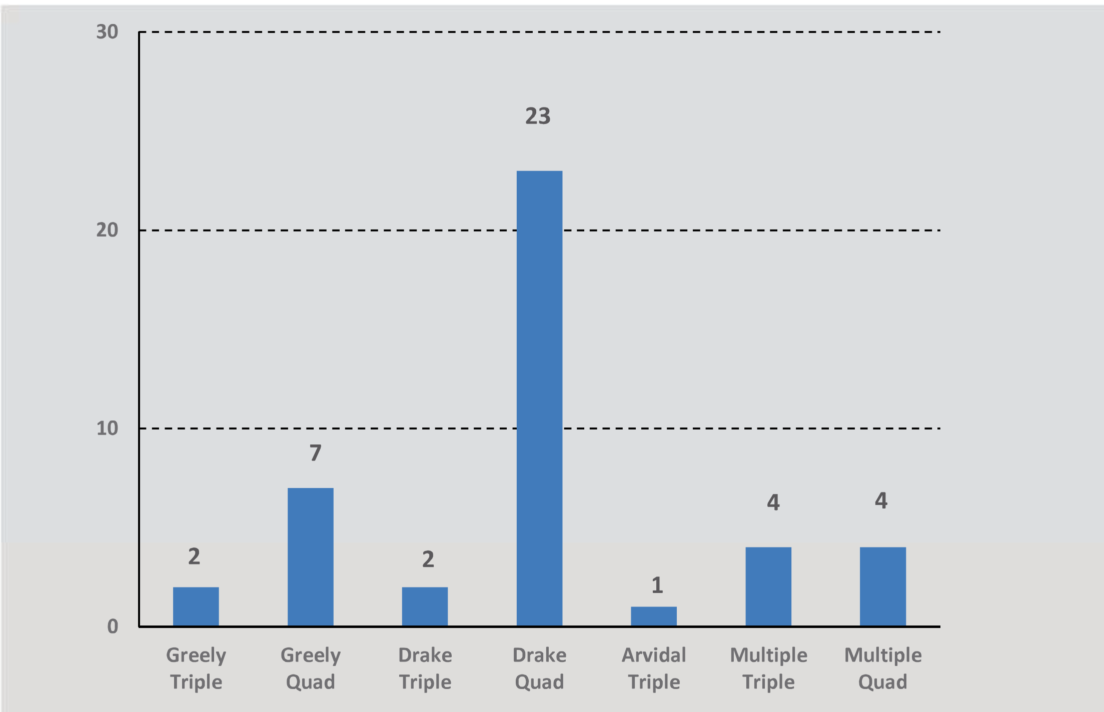
3.2 Outline of 220kV Existing T/L's

	Circuit Length [km]
Single Circuit	Approx. 280
Double Circuit	Approx. 10,210



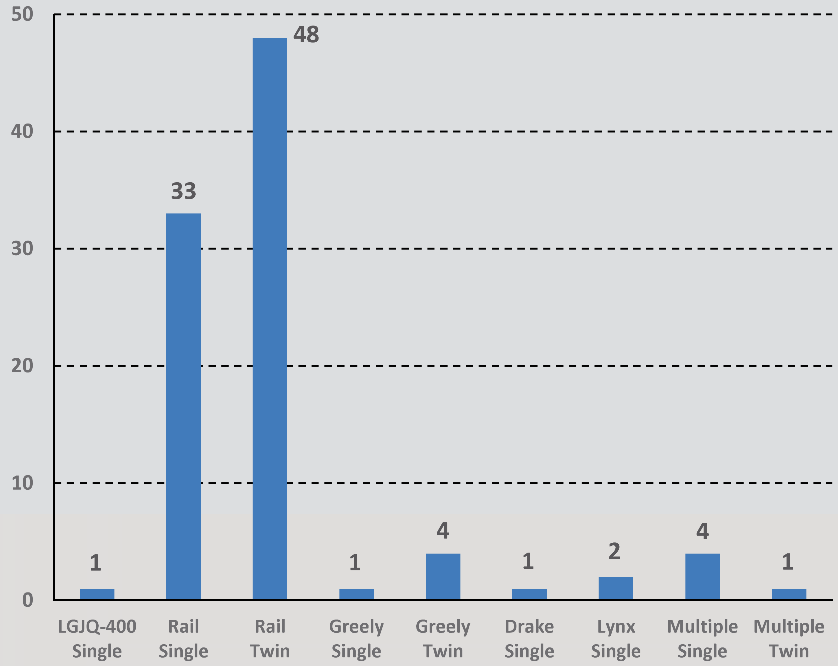
- Double circuit towers are almost applied in 220kV existing T/L's.

3.3 Spec of Conductors of 500kV Existing T/L's



- "Drake (Quad)" is almost applied in 500kV existing T/L's.

3.4 Spec of Conductors of 220kV Existing T/L's



- "Rail (Single & Twin)" is almost applied in 220kV existing T/L's.

3.5 Standard Specification of Conductors

[500kV]

In case that the current carrying capacity is 2,700 MW, the standard specification of conductors is as below in consideration of (n-1) criteria.

Type	Nos of Bundle	Nos of Circuit	Current Carrying Capacity
Drake 795MCM	Quad (4 Bundled)	Double	2,731 [MW/cct]

[220kV]

In case that the current carrying capacity is 1,200 MW, the standard specification of conductors is as below in consideration of (n-1) criteria.

Type	Nos of Bundle	Nos of Circuit	Current Carrying Capacity
Rail 954MCM	Quad (4 Bundled)	Double	1,302 [MW/cct]

Type	Nos of Bundle	Nos of Circuit	Current Carrying Capacity
TACSR 810mm^2	Twin (2 Bundled)	Double	1,484 [MW/cct]

3.6 Outline of Existing 500kV Substations

- Class of existing Transformer

Voltage (kV)	Capacity (MVA)	Qty (unit)	ratio (%)
500/220 (1 ph x 3)	750 600 450	4 18 18	10 45 45
Total	≒29,000	40	-

- Class of existing Circuit Breaker

Voltage (kV)	Rated Breaking Current (kA)	Insu lation	Operation
500	50/63	Air SF6 Gas	Air Hydraulic

- Typical Configulations of Existing 500kV Substations

Voltage (kV)	Nos of site	Type	Typical Configuration	Main Bus Configuration
500/220	16	Outdoor, Conventional (AIS : Air Insulated Substation)	Transformer:3-4unit Circuit Breaker:12-15unit	1-1/2

3.7 Outline of Existing 220kV Substations

ng Transformer

Voltage (kV)	Capacity (MVA)	Qty (unit)	ratio (%)
220/132	250 160	53 68	42 54
23/220	400&370	5	4
Total	≒25,800	126	-

- Class of existing Circuit Breaker

Voltage (kV)	Rated Breaking Current (kA)	Insu lation	Operation
220	40/50	Air SF6 Gas	Air Hydraulic or Spring

- Typical Configurations of existing 220kVsubstations

Voltage (kV)	Nos. of site	type	Typical Configuration	Main Bus Configuration
220/132	32 (68%)	Outdoor, Conventional (AIS)	Transformer : 2-3 units Circuit Breaker : 8-12 units	1-1/2
	15 (32%)	Outdoor, Conventional (AIS) and Indoor, Gas Insulated (GIS : Gas Insulated Substation)	Transformer : 3-4 units Circuit Breaker : 8-9 units	Double Bus

3.8 Standard Specification of Substation Equipment

- Transformer's brief specification

Voltage (kV)	Capacity (MVA)	%Iz
500/220	750 (250/ph)	12
220/132	250 (83.3/ph)	Under Investigation

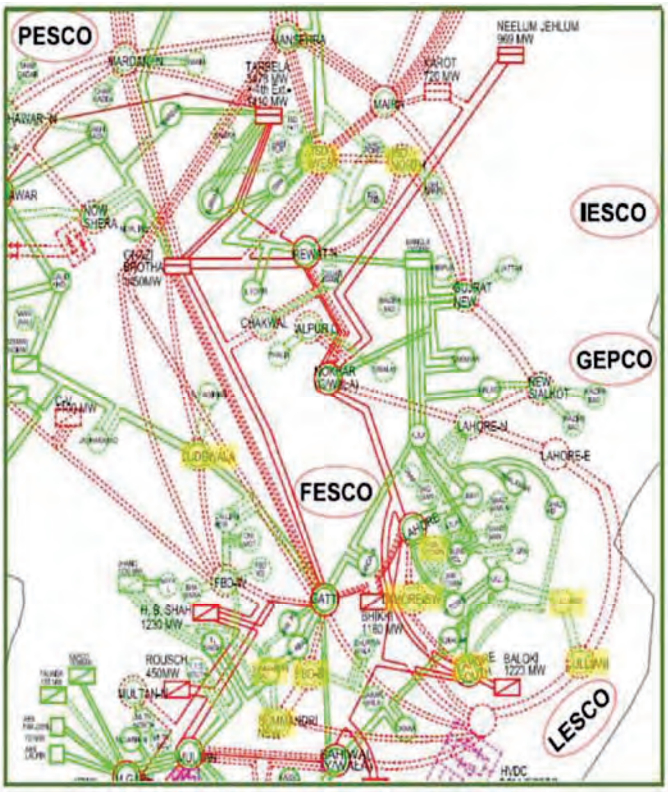
- Circuit Breaker's brief specification

Voltage (kV)	Rated Interrupt Current (kA)	Operation
500	50/63	Hydraulic, Spring
220	40/50	Spring

- Basic Configurations of Substations

Voltage (kV)	type	Main bus configuration	Main Equipment
500	Air Insulated Outdoor	1-1/2	Transformer : 4 units (750MVA) Circuit Breaker : 12 units
220	Air / Gas Insulated Outdoor/Indoor	1-1/2 Double Bus	Transformer : 4units (250MVA) Circuit Breaker : 10units

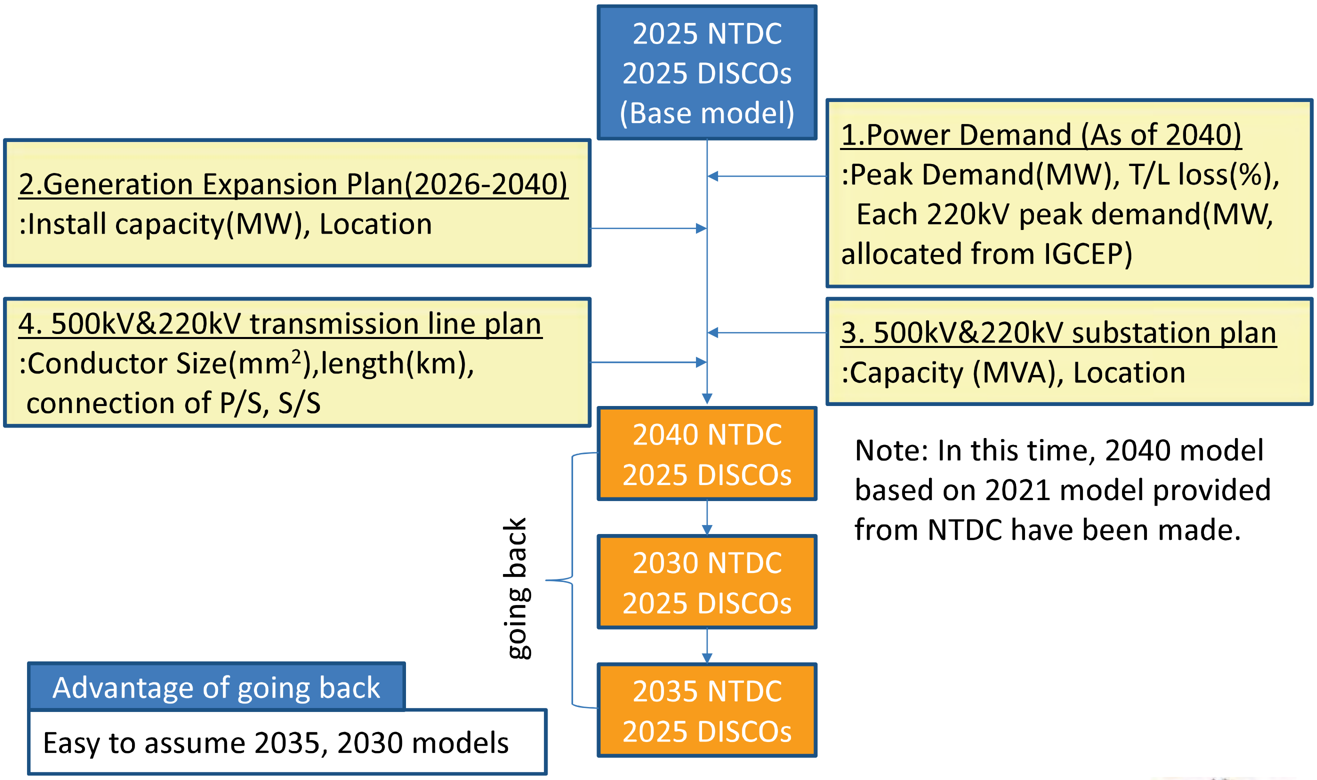
3.9 Candidate for Preliminary F/S & M/P



- Candidate for Preliminary F/S & M/P

Province	Type	Voltage	Capacity	Site
IESCO	New	500/220	750x4	Islamabad North
	New	500/220	750x4	Islamabad West
LESCO	New	500/220	750x4	Lahore East
	New	500/220	750x4	Lahore South West
	New	500/220	750x4	Lulliani
	New	220/132	250x4	Lulliani 2
	New	220/132	250x4	IQBL town
	Ext	500/220	750	Lahore South
	Ext	500/220	750	Lahore North
FESCO	New	500/220	750x4	Summandri
	New	500/220	750x4	Faisalabad South
	New	220/132	250x4	Jaranwala South
	Ext.	220/132	250	Ludewala
	Ext.	220/132	250	Summandri RD

4. Procedure for Power System Planning



NEWJEC

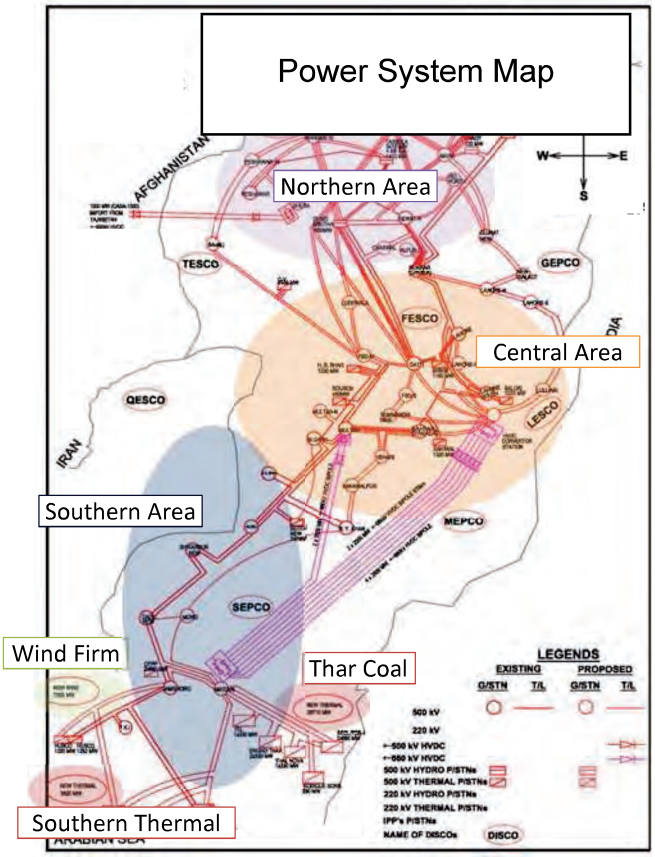
5. Criteria of Power System Planning

Conditions	Substance
Normal	1) All transmission lines and transformers shall be loaded below their Normal Continuous Maximum Ratings (Grid Code PC 2.2.1) 2) All bus voltages shall be within the bandwidth of (+5%) to (5%) of Nominal System Voltage (Grid Code PC 2.2.3)
Contingency	1) All transmission lines and transformers shall be loaded below their Emergency Ratings. (Grid Code PC 2.2.1) 2) All bus voltages shall be within the bandwidth of +-10% of Nominal System Voltage (Grid Code PC 2.2.3) 3) Short Circuit Current 500kV: 50-63kA 220kV: 40-63kA 132kV: 31.5-50kA

Procedure	Model year	Study case	Content of simulation
1	2040	Dry / Rainy Peak / Off-Peak (4 case)	-Power Flow Calculation -Short Circuit Calculation -Dynamic Stability Simulation
2	2030		
3	2035		

NEWJEC

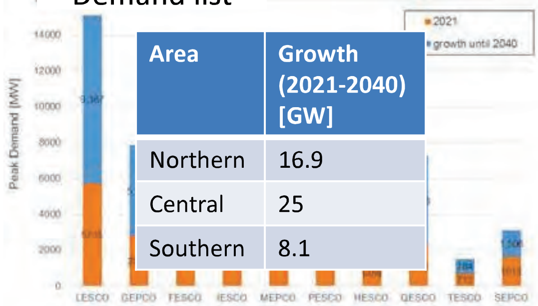
6.1 Outline of 2040 System Model



Generator list

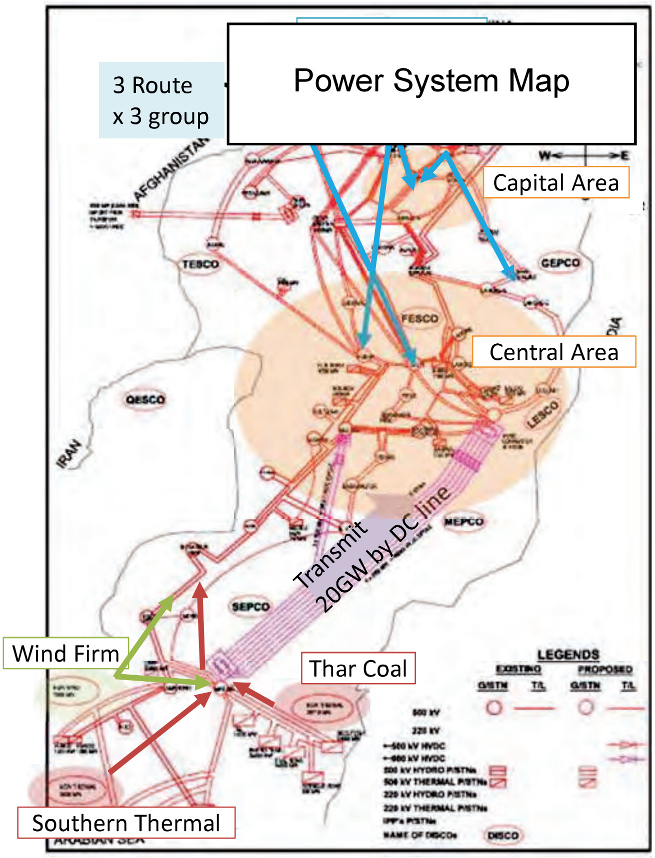
Type	Detail	Output [GW]
Hydro	Northwest	9.3
	Northern	8
	Northeast	10
Thermal	Southern	32.5
	Retirement	-8.2
Renewable Energy	PV	6
	Wind	7
Other	C/V(Nuclear)	1.1
	CASA 1000	1

Demand list



Area	Growth (2021-2040) [GW]
Northern	16.9
Central	25
Southern	8.1

6.2 Outline of 2040 System Model



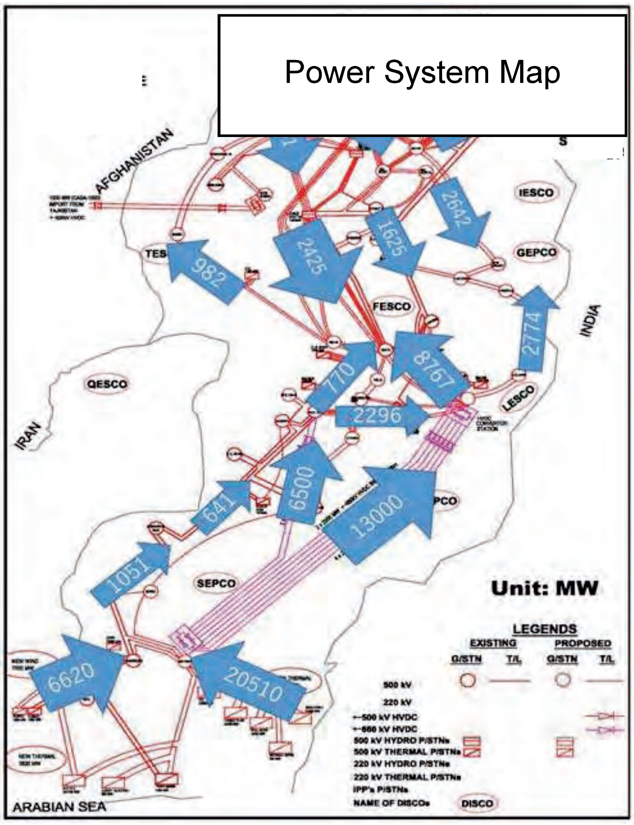
Main route list

Place	Route	Nos.
Hydro	Northwest - Mardan	3 Route (6cct)
	Northern - Mansehra	3 Route (6cct)
	Northeast - Maira	3 Route (6cct)
North - Central	Mardan - (G Brotha) - Gatti	2 Route (4cct)
	Mansehra - ISD West	2 Route (4cct)
	Mansehra - FBD West	1 Route (2cct)
	Mansehra - Gatti	1 Route (2cct)
	Maira - ISD West	2 Route (4cct)
	Maira - Gujrat	1 Route (2cct)
Thermal	Under process	
Southern - Central	Matiari - Lahore (DC)	3 Route (6cct)
	Matiari – Multan (DC)	1 Route (2cct)

Additional number of grid stations

Voltage class [kV]	Northern & Central [Nos.]	Southern [Nos.] (under process)
500	26	4
220	58	10

7. Draft Result of Power System Analysis



Calculated case: Rainy(Summer) / Peak time

Criteria	Simulation result
Bus voltage	500kV: Within +- 5% of reference voltage 220kV: Within +- 5% of reference voltage
Short circuit current	Under process

Northern Power
Transmitted to the central area while consuming in the northern area.

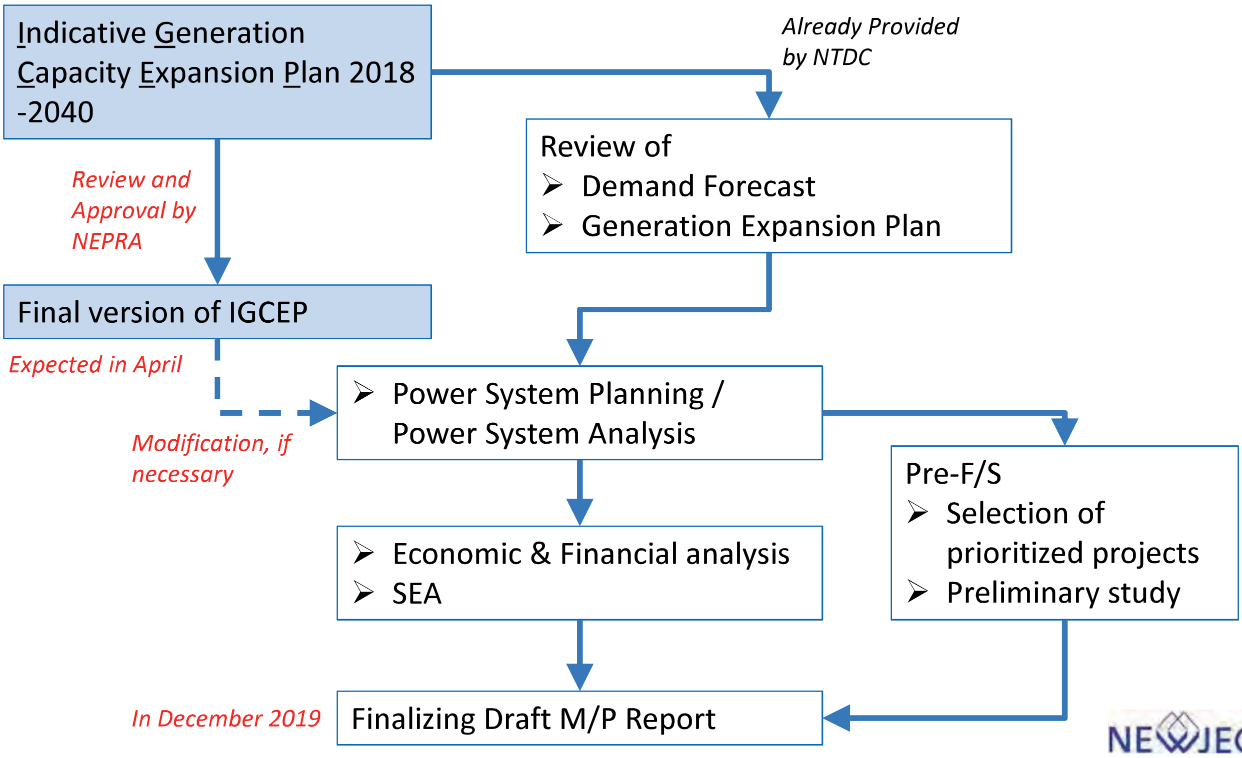
Southern Power
Transmitted by DC to the central area. Some power is supplied to SEPCO and QESCO areas.

8. Schedule of the Project

This topic will be discussed in the Project schedule meeting.

8.1 Workflow of the Project (original)

This slide is extracted from the presentation of 1st JCC



8.2 Current status of the IGCEP

The present IGCEP

- Generation development plan 2018 – 2040
- Progress of approval process by NEPRA ?

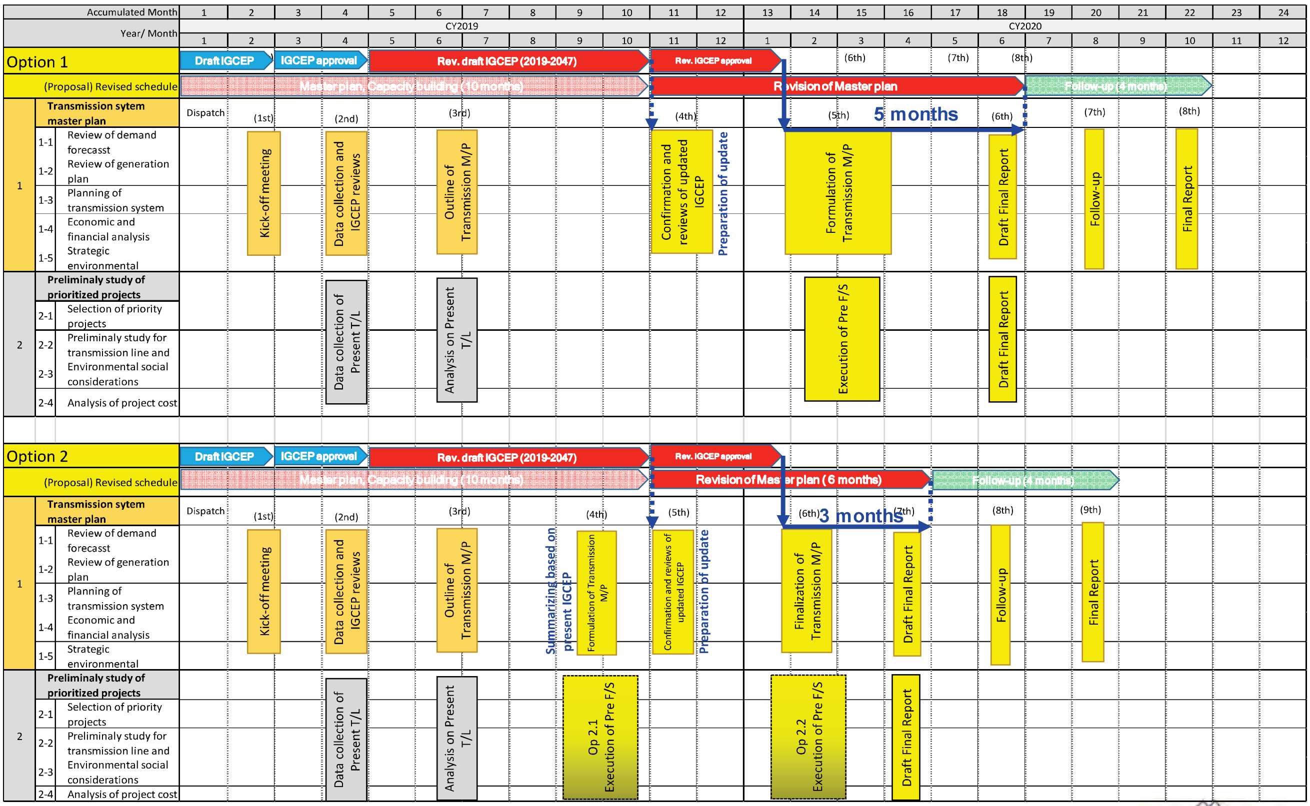
The revised IGCEP

- Generation development plan 2019 – 2047
- Points to be revised ? (share of renewable energy, etc)
- When draft report released ?
- When approved report released ?

National power system expansion plan is to be upgraded based on the revised IGCEP

8.3 Alternative schedule

Possible option (Option 1, Option 2)



8.4 Explanations of options

Option 1

- 4th dispatch is carried out after release of draft IGCEP report
- 5th dispatch is carried out after release of approved report
- DFR will be submitted after **5 months** after IGCEP approval
- Pre F/S is implemented in the 5th dispatch

Option 2

- 4th is carried out next September according to the original schedule
- 5th is carried out after release of draft IGCEP report
- 6th is carried out after release of approved report
- Duplication of work would occur, but
- DFR will be submitted after **3 months** after IGCEP approval
- Pre F/S is implemented in the 4th dispatch, or 6th dispatch

1. A clear timeline of revised IGCEP is necessary in both options and should carefully monitor its progress
2. A clear timeline of submission of Transmission expansion plan is necessary.

Japanese Demand Forecast Method

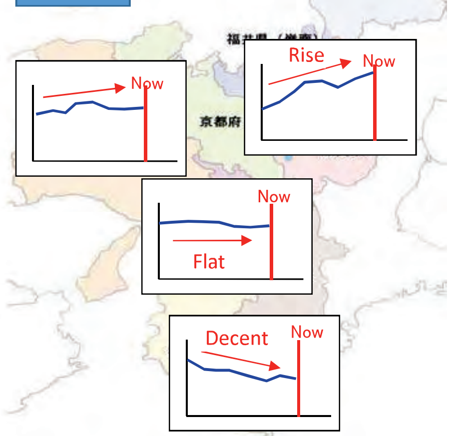
July 2019
JICA team
M.Ohara

Circumstance surrounding Japanese power system

Kansai's current status

All Kansai

By region



Former

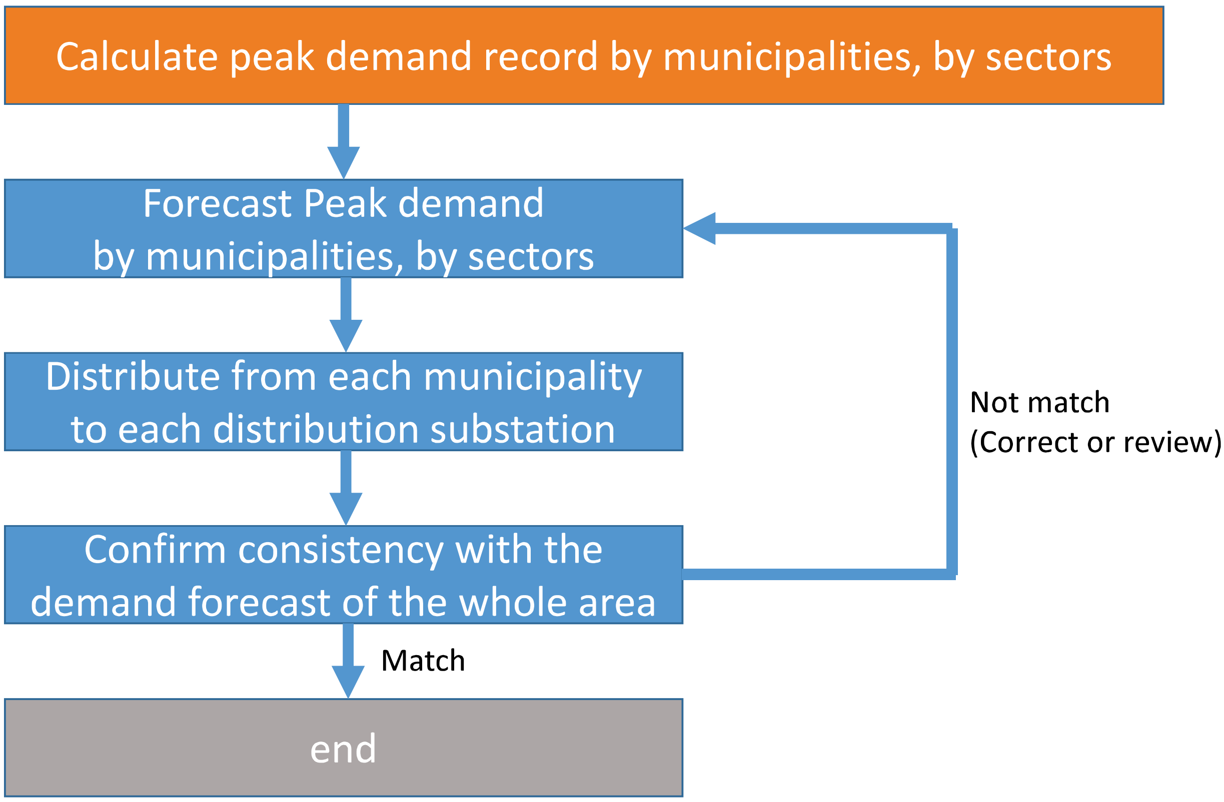
It was not wasted to expand according to the growth of demand.

Recent years

Dividing forecast by regional gaps, power company plan facilities to eliminate waste of electric power capacity.

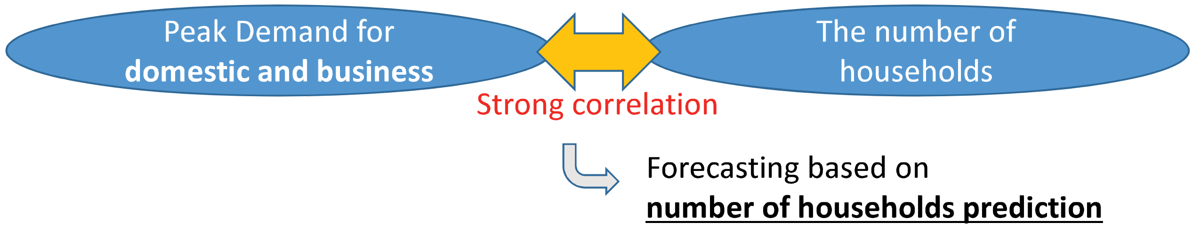
The day may come when demand is saturated in Pakistan, useful methods for demand forecasting will be introduced.

Procedure for Japanese demand forecast

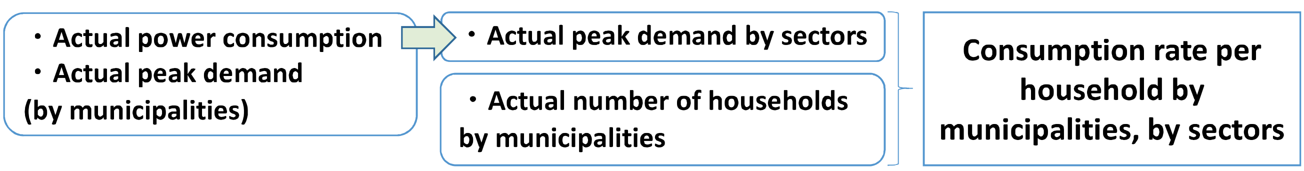


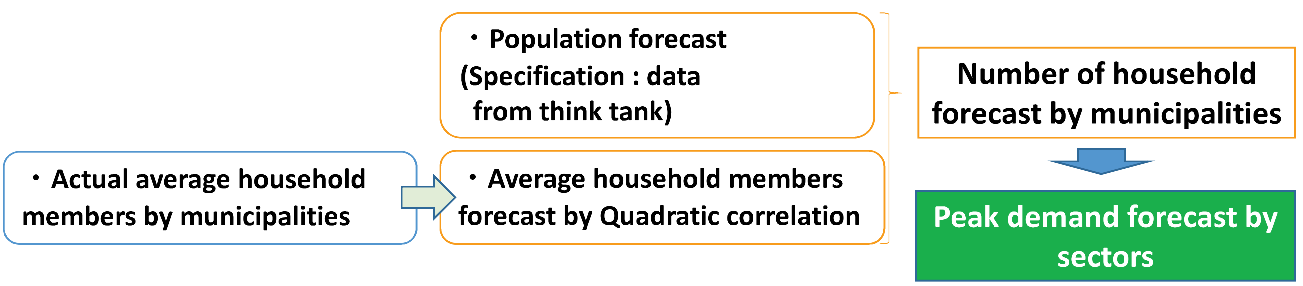
3

Domestic, Business demand forecast



- Procedure





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Domestic, Business demand forecast

- Calculation

Actual peak demand by sectors (MW) = **Actual peak demand at a municipality (MW)** × **Sector ratio (%)**

Consumption rate per household(kW/Nos.) = **Actual peak demand by sectors (MW)** / **Actual number of households (Nos.)**

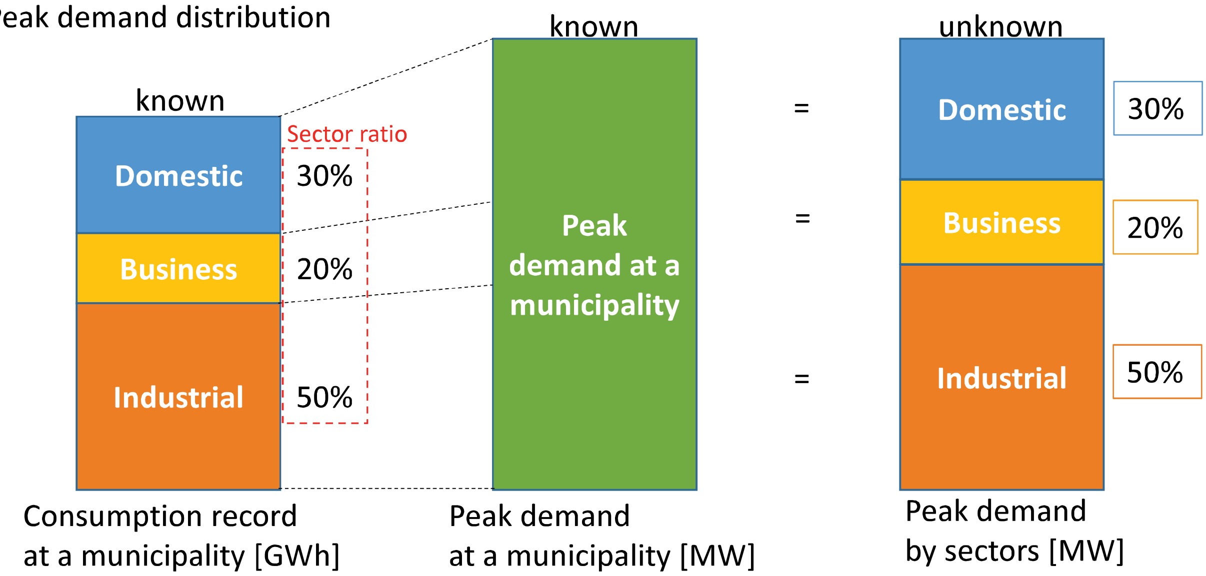
Peak demand forecast (MW) = **Consumption rate per household(kW/Nos.)** × **Number of households forecast (Nos.)**

Industry demand forecast

Peak Demand for **industry** sector has <u>no correlation</u> with all index.
Calculate adding the development planned area demand of the new development plan.

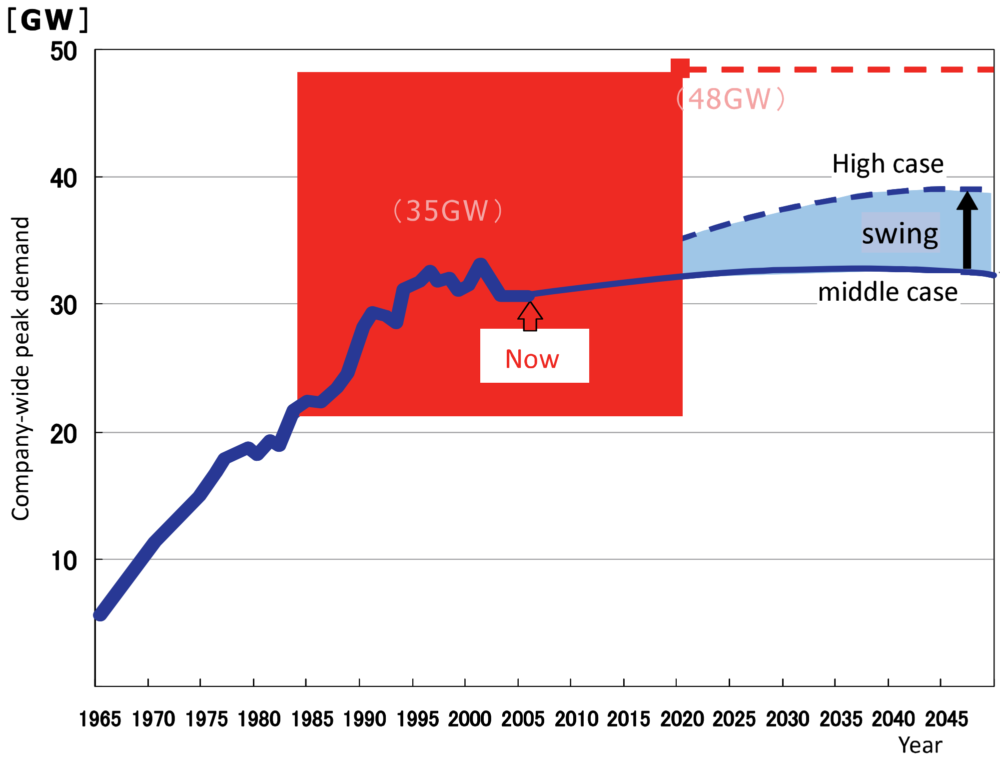
Industrial peak demand forecast [MW] = **Industrial peak demand at a municipality (Previous year) [MW]** + **Consumption rate from past record [W/m²]** × **Consumption area for planned development area [m²]**

Peak demand distribution



Forecast condition setting

From comparing population record and past forecast,
upside swing is possibility of max 3%. So middle and high case(+3%) are set.



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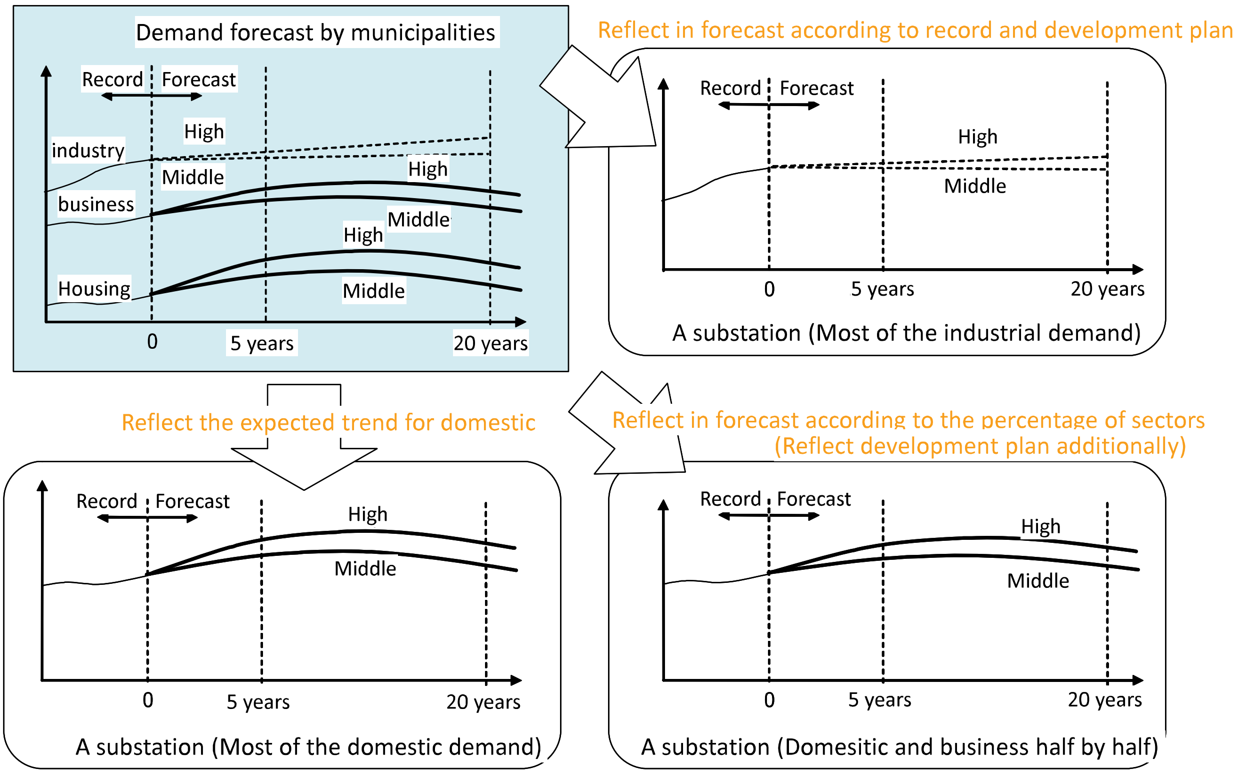
Forecast condition setting

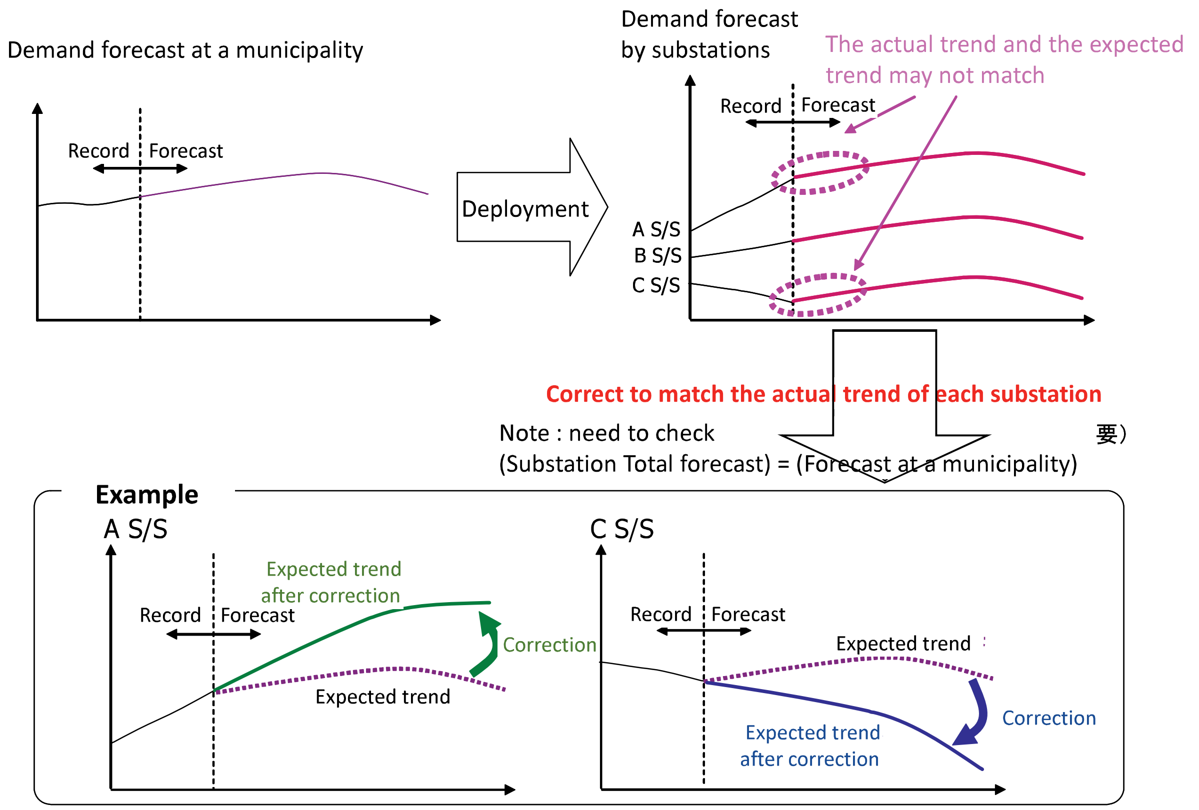
Items		Forecast scenario	
		High case	Middle case
Domestic	Number of household	Base +3%	Expected value from think tank (Base)
Business	Number of household	Base +3%	Expected value from think tank (Base)
	New development plan	Base + Undecided development area	Previous year record + Development plan area (Base
	Installation of in-house generator	-10 MW annually	0MW annually
Industry	Record and new development plan	Base + Undecided development area	Previous year record + Development plan area (Base)
	Installation of in-house generator	-10 MW annually	0MW annually

8

Deployments from municipality to substation



Deployments from municipality to substation



Temperature correction of demand records

Temperature correction of demand records

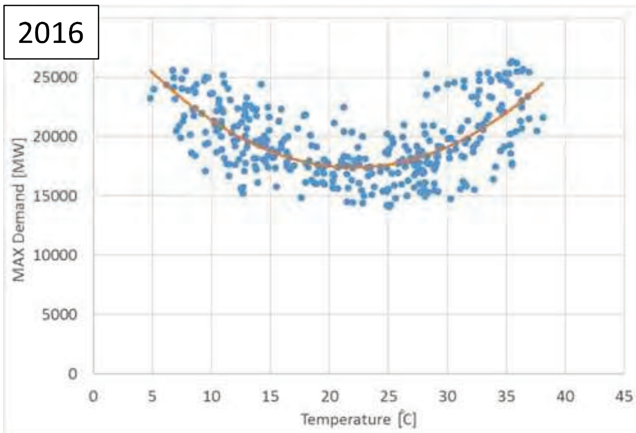
The peak demand and the max. / min. temperature have a strong correlation.

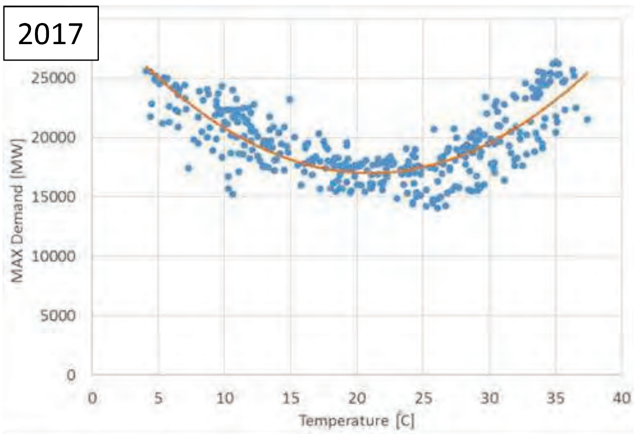
The temperature	Hot condition	Cold condition
Increasing electricity demand	The air conditioning The fan	The heating

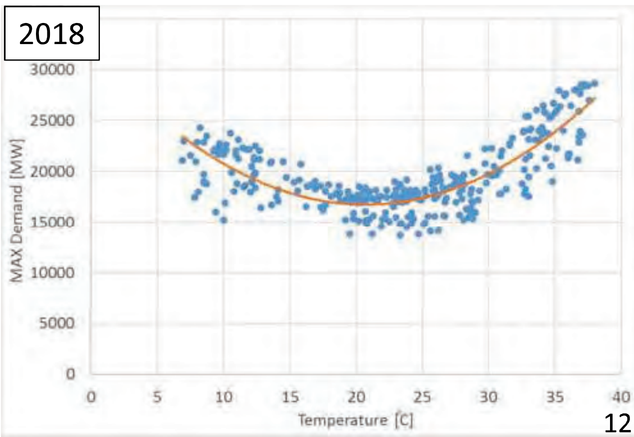
Eliminate the effects of temperature

Peak demand record → Corrected peak demand record

Used for forecast







Flow of the demand forecast

Step	Detail
Tracking record of peak demand	Calculate total max demand below - Distributing substations - Direct distributions from small hydro generators - 6kV generator outputs - Pillar boxes, area inter-charges - Offices of extra-high voltage consumer
Temperature correction for demand record	Calculate the multiple correlation equation by dew point and 5-days cumulative max temperature. Correct last total max demand by the following differences: - Resultant peak demand at average dew point and temperature in normal year on correlation equation - Resultant peak demand in last summer
Assumption of base demand at substations	As explained in Japanese demand forecasting procedure, assume 10 years of demand using corrected total max demand

Temperature correction of demand records

5-days cumulative max temperature

(Reason) If the hot day continues, the cooling operation rate will increase.
Ex. Humans endure the heating for a while.

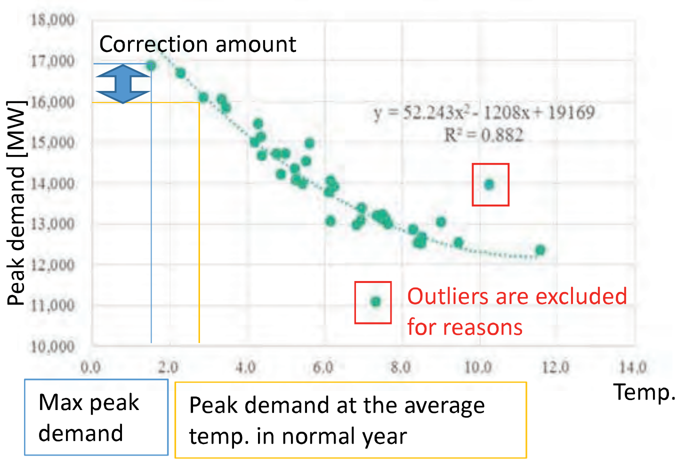
5-days cumulative max temp. = **Max temp. (the day)** ×0.6+ **Max temp. (the day before)** ×0.2+ **Max temp. (the 2-4 day before)** ×0.2

Day	4 day before	3 day before	2 day before	1 day before	That day
Temp.	30	31	31	33	34

(30+31+31)/3 x 0.2+33 x 0.2+34*0.6

Correlation coefficient

Correlation with max temp. for 1 day	0.8443
Correlation with 5-days cumulative max temp.	0.8721



Important things in demand forecast

1. The reason why it is appropriate for the predicted result.
   - The future is unknown to anyone, but it is important to show the ground.
   - Remove external factors such as temperature and unusual days after considering the reason.

2. The fragmented statistical data
   - Developing countries often have detailed statistical data under development. In most cases, the demand is forecasted from statistics of the whole country.

Thank you for your attention

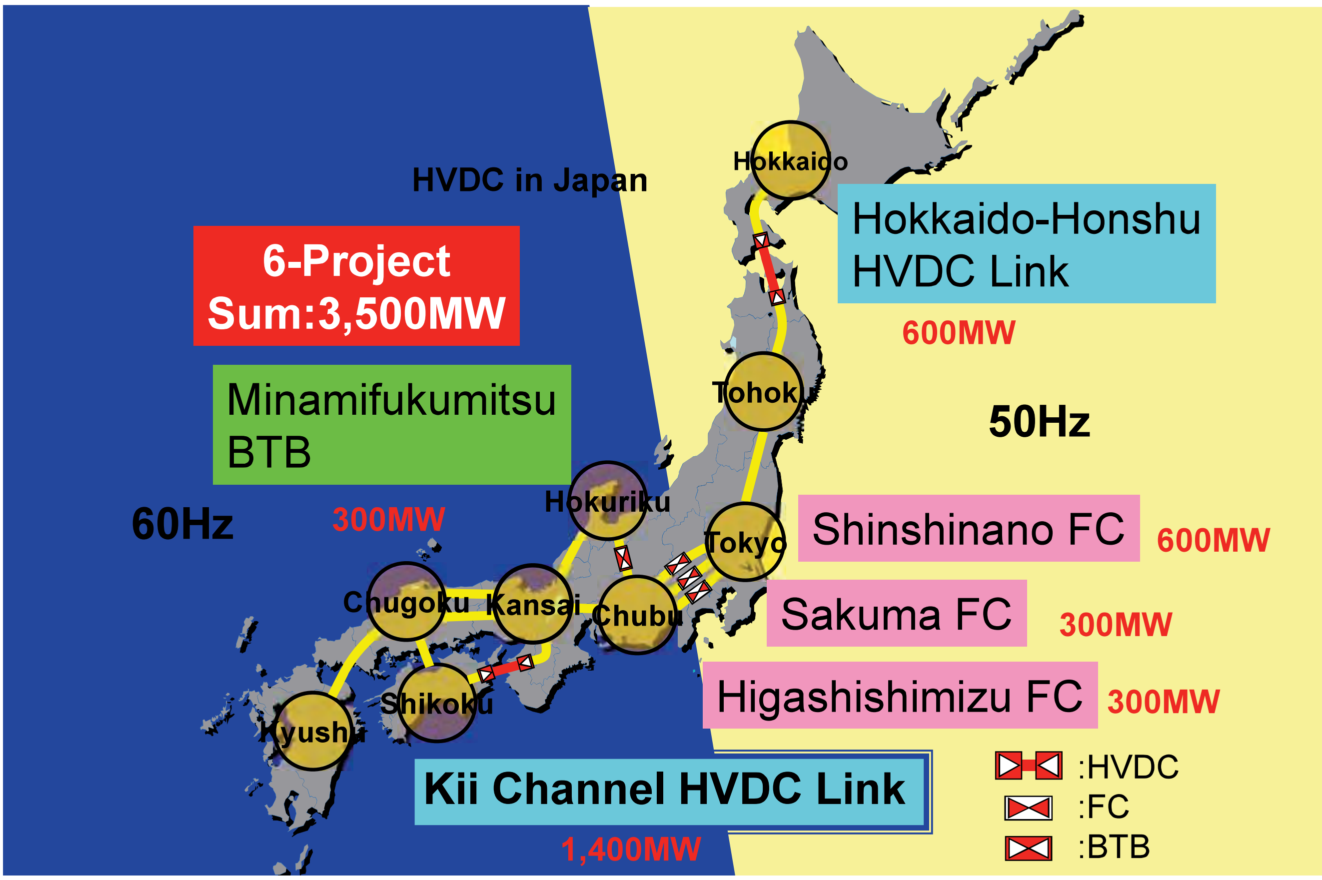
شكريه

ご清聴ありがとうございました

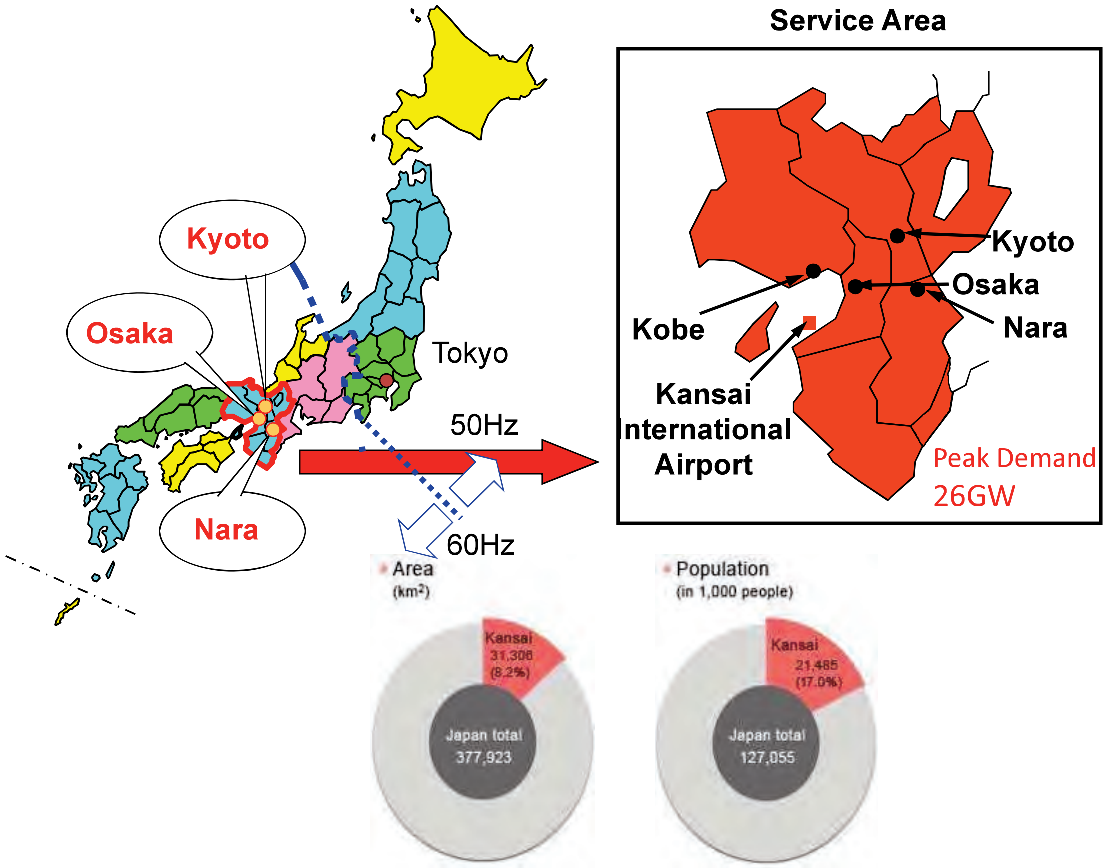
Introduction of HVDC SYSTEM in JAPAN

July 2019 (3rd Trip)
NEWJEC / JICA team
K.UENO

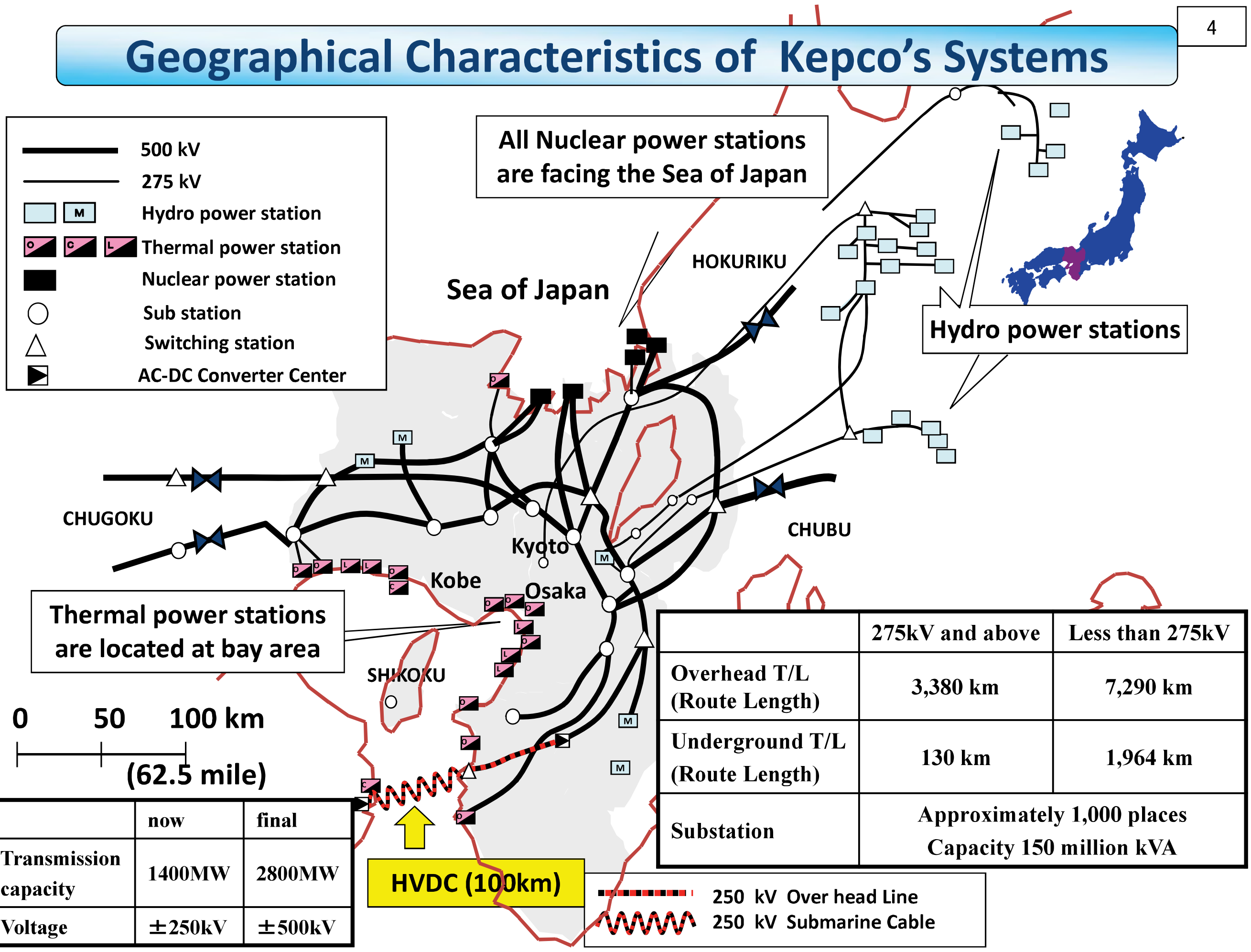
HVDC in Japan



Profile of KEPCO's Service Area



Geographical Characteristics of Kepco's Systems



	275kV and above	Less than 275kV
Overhead T/L (Route Length)	3,380 km	7,290 km
Underground T/L (Route Length)	130 km	1,964 km
Substation	Approximately 1,000 places Capacity 150 million kVA	

	now	final
Transmission capacity	1400MW	2800MW
Voltage	±250kV	±500kV

Features of DC Power Transmission

＜Merits＞

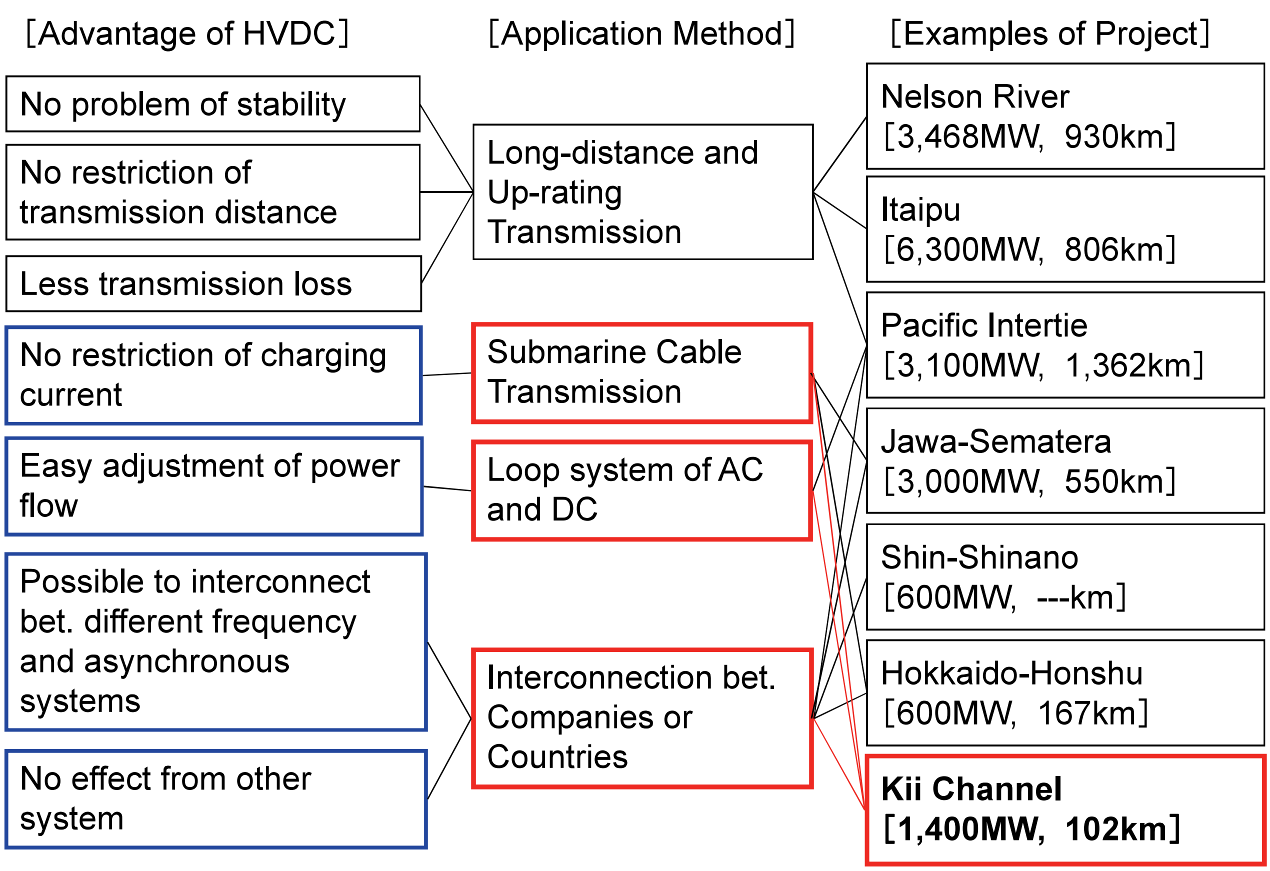
1. Low construction cost of transmission lines
2. Small transmission loss and no Ferranti effect
3. There is no stability problem at both sending and receiving ends, making asynchronous interconnection possible
4. Prevention of increase in short-circuit capacity increase of the system
5. Easy and fast load flow control

＜ Demerits ＞

1. Much reactive power is needed for converter
2. Costly prevention measures against problems caused by production of harmonics and high frequency
3. High cost of converter construction

Generally more advantageous for long-distance transmission

Application of HVDC (Kii Channel)

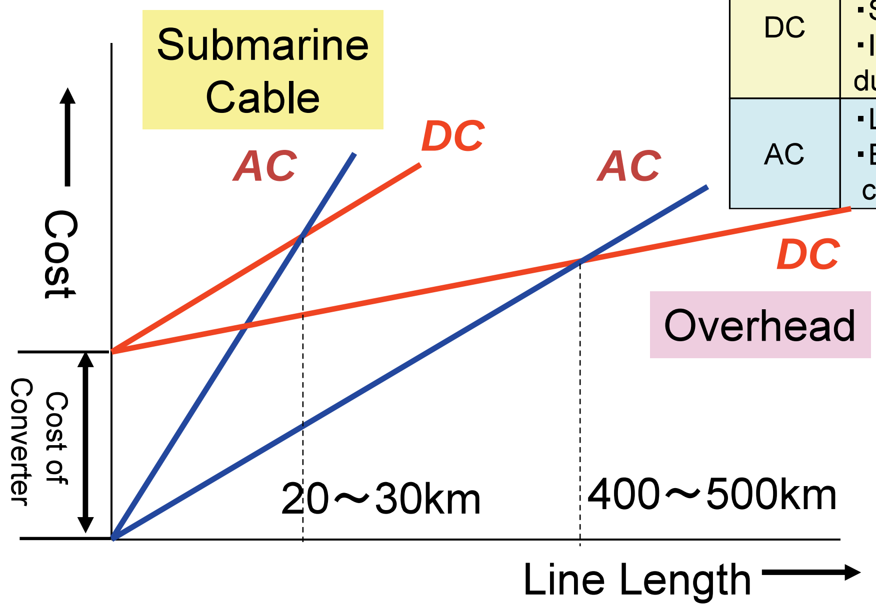


Reasons of adoption of HVDC in the world (1)

1. Cost

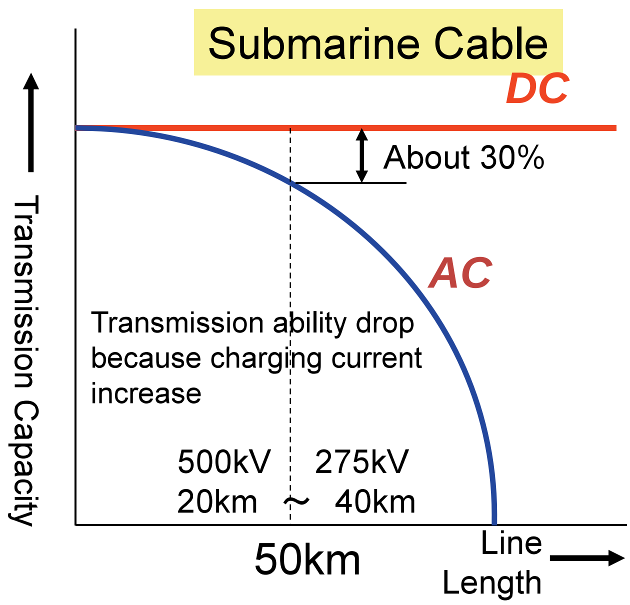
DC has advantages
•with submarine cable in case of more than 20-30km
•with overhead line in case of more than 400-500km

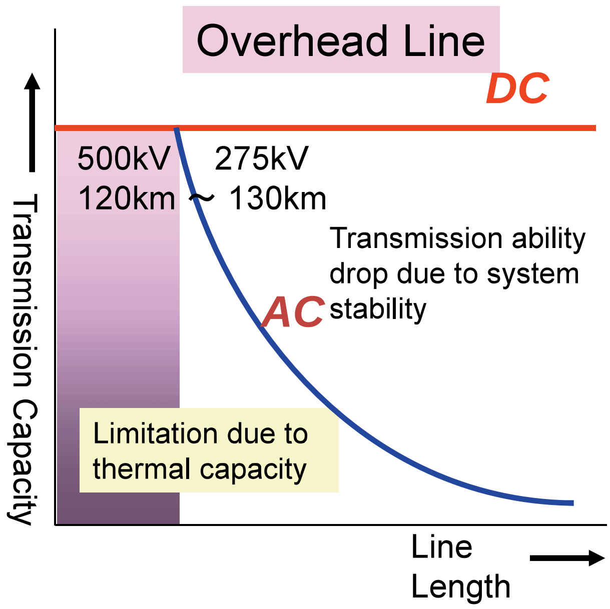
DC	･Expensive converter cost ･Small number of cable ･In expensive cost of overhead due to simple tower
AC	･Large number of cable ･Expensive cost of overhead line compared to DC



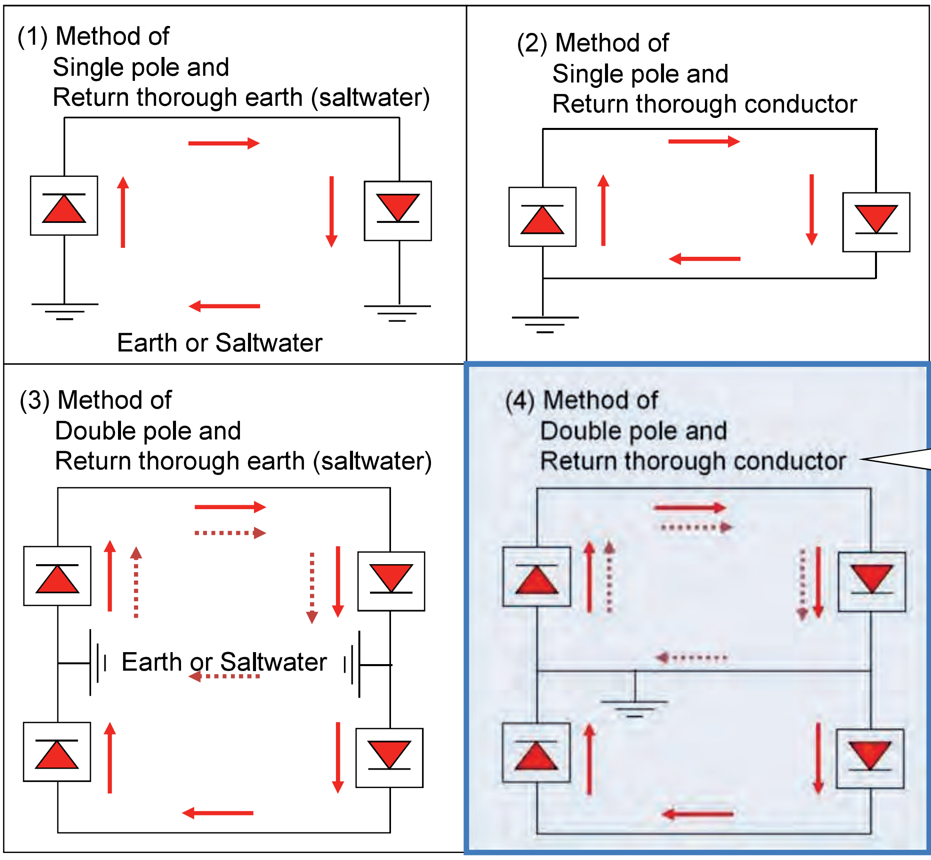
Reasons of adoption of HVDC in the world (2)

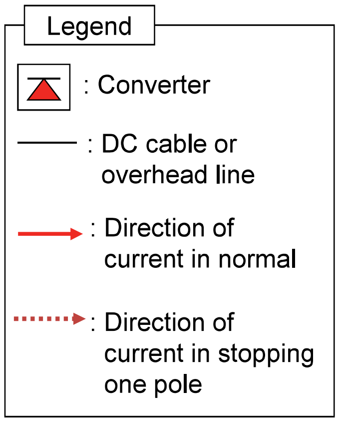
2. Possible to interconnect between different frequency systems
3. Possible to interconnect between asynchronous systems
4. Having advantage with long distance transmission due to no problem of system stability
5.Possible to contribute to system stabilization because high speed control of power flow





HVDC Transmission Method

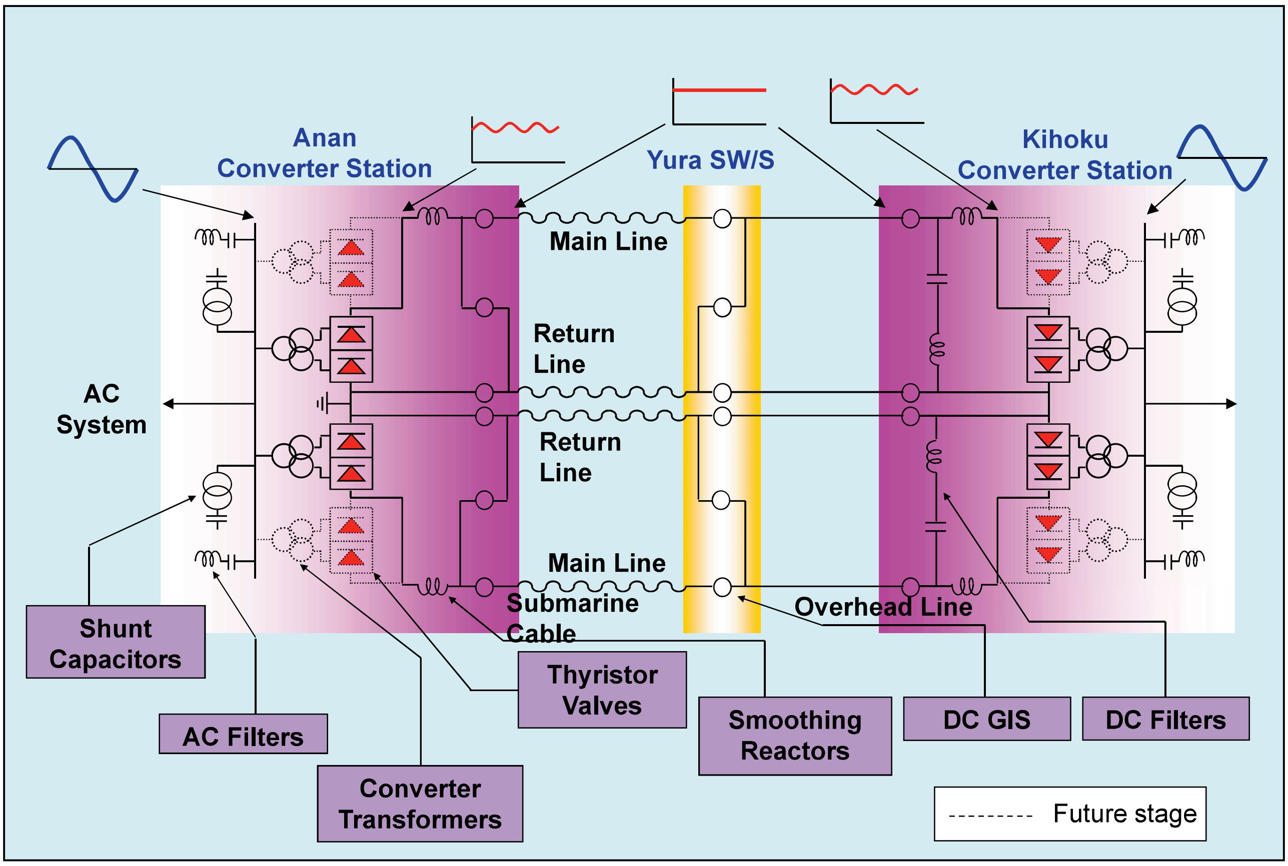




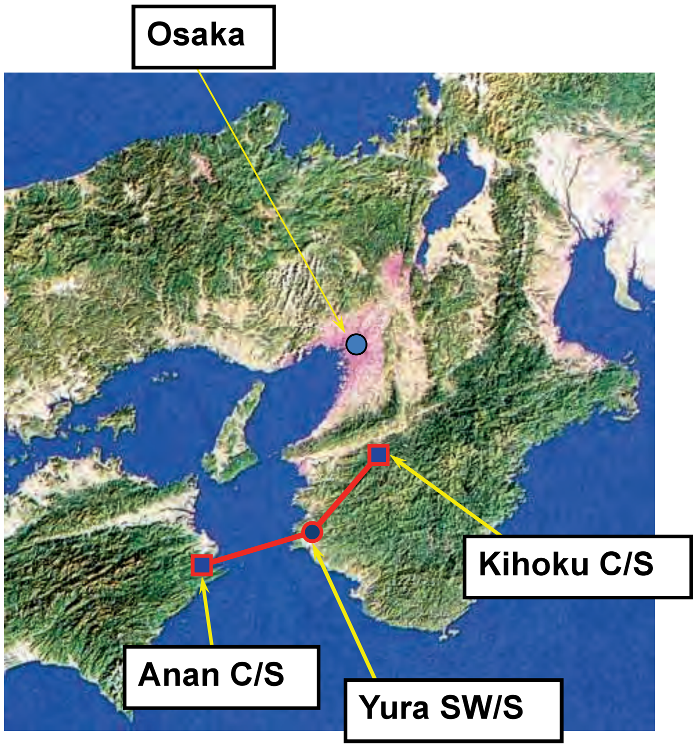
Applied at Kii Channel HVDC

Due to not affect to other objects or magnetic compass in an environmental point of view

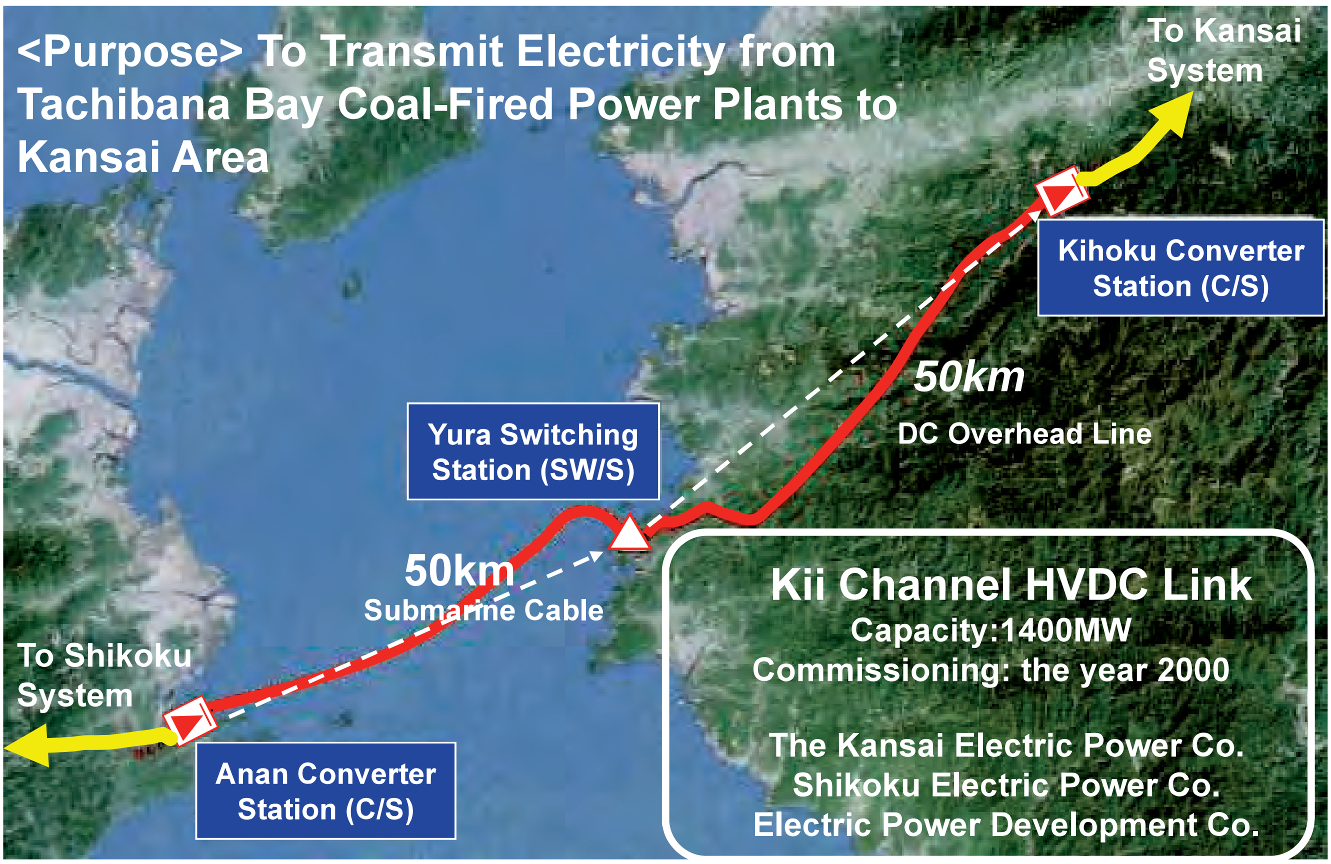
Outline of HVDC System Diagram



Position of DC Transmission in Kii Channel



Outline of Kii Channel HVDC



Overall Outline of the Line

Name of the line	Kii Channel HVDC (Anan-Kihoku DC Trunk Line)*
Line length	About 102km Overhead line: 50.9km Submarine cable:50.7km
Power transmission system	DC bipolar system with metalic return
Neutral Point Grounding System	One End Grounding System at Anan Converter Station
Voltage	±250kV (Fixed max. voltage±500kV)
Number of circuit	One
Transmission Capacity	1,400MW(Designed for 2,800MW)
Section of overhead line	From Yura Switching Station to Kihoku Converter Station

*In this presentation, Overhead Transmission Line in Kii Channel HVDC is called "Kii channel DC Trunk Line".

Thank you !

1st Stakeholders Meeting on Strategic Environmental Assessment for the Study of Upgrading National Power System Expansion Plan in the Islamic Republic of Pakistan

09-July-2019

Coral Hall, Park Lane Hotel 107 MM Alam Rd, Block B3, Gulberg III, Lahore

AGENDA

09:30-10:00 - Registration

10:00-10:05 - Recitation of Holy Quran

10:05-10:10 - Welcome Speech

10:10-10:40 - Presentation Session I
Project for the Study of Upgrading National Power System Expansion Plan
Mr. UEOK, Team Leader, JICA Expert Team

10:40-11:00 - Presentation Session II-1
Strategic Environmental Assessment (SEA) and the Project
Mr. USUI, JICA Expert Team

11:00-11:30 - Tea/coffee Break

11:30-12:00 - Presentation Session II-2
SEA and the Project
Mr. USUI, JICA Expert Team

12:00-12:55 - Discussions and Q & A

12:55-13:00 - Vote of Thanks

13:00 - Lunch

The Project for the Study of Upgrading National Power System Expansion Plan in The Islamic Republic of Pakistan

1st Stakeholders Meeting

9 July 2019

JICA Expert Team
NEWJEC Inc.

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Session I

Project for the Study of Upgrading National Power System Expansion Plan

UEOKA Seiji

JICA Expert Team
NEWJEC Inc.

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1. Target facility of the project

2. The project outline

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1. Target facility of the project

In the power network system, electrical facility is categorized by voltage.

In the Pakistan, 220kV and above voltage system is owned by NTDC, and lower voltage system is owned by Discos in each region.

(Transmission line network: 220kV and above voltage)

(Distribution line network: 132kV and lower voltage)

Target facility of the project is transmission line network

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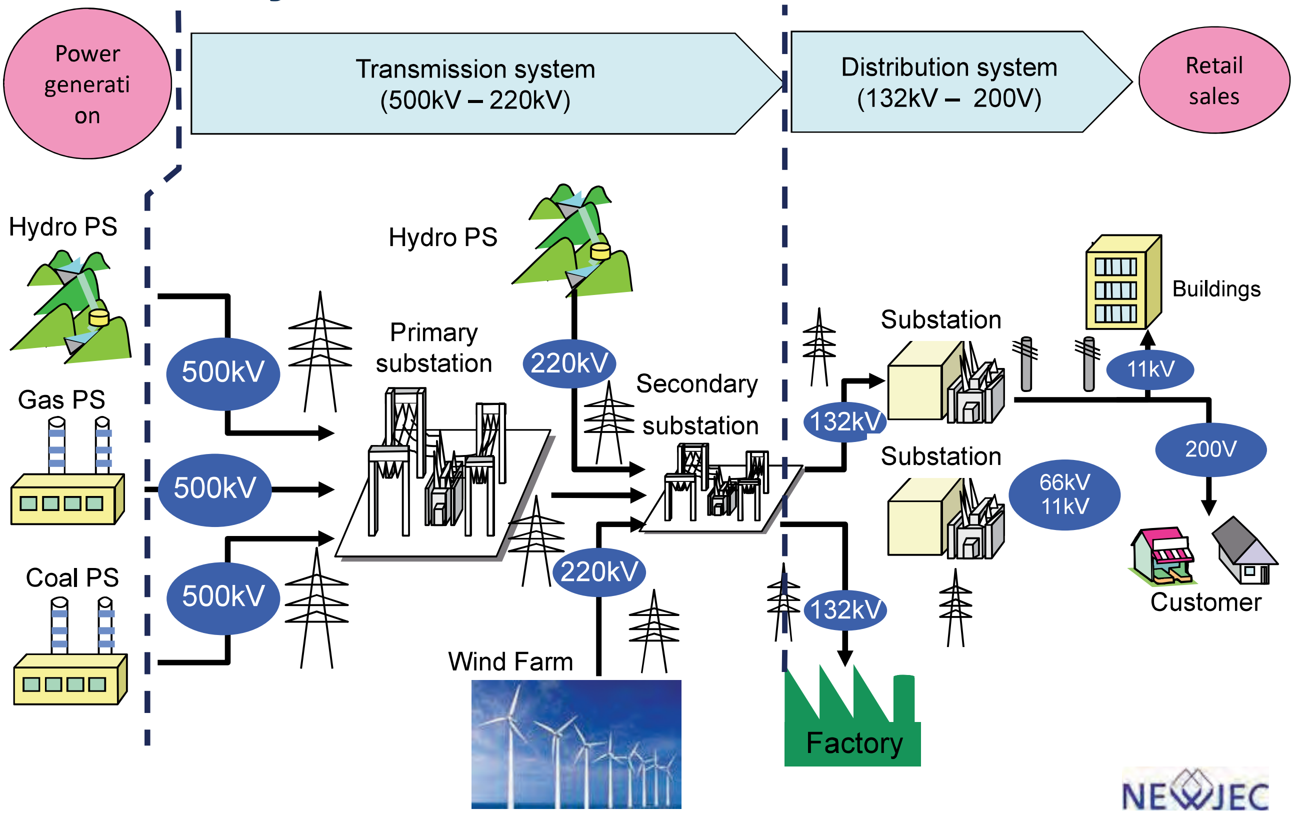
1.1 Transmission and distribution network system



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1.2 Transmission and distribution network system (cont'd)

- ✓ **Transmission and distribution network are constructed in order to connect power plants and consumers.**
- ✓ **EHV (Extra High Voltage: 220 – 500kV) is applied to the transmission network in order to transmit power on a large scale, and it contributes to reduce transmission loss drastically.**
- ✓ **However, voltage on distribution network is stepped down to lower to approach the end users.**

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1.3 Transmission towers and lines

500kV Steel tower

220kV Steel tower

132kV Steel tower

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1.4 Distribution poles and lines

11kV distribution lines and poles

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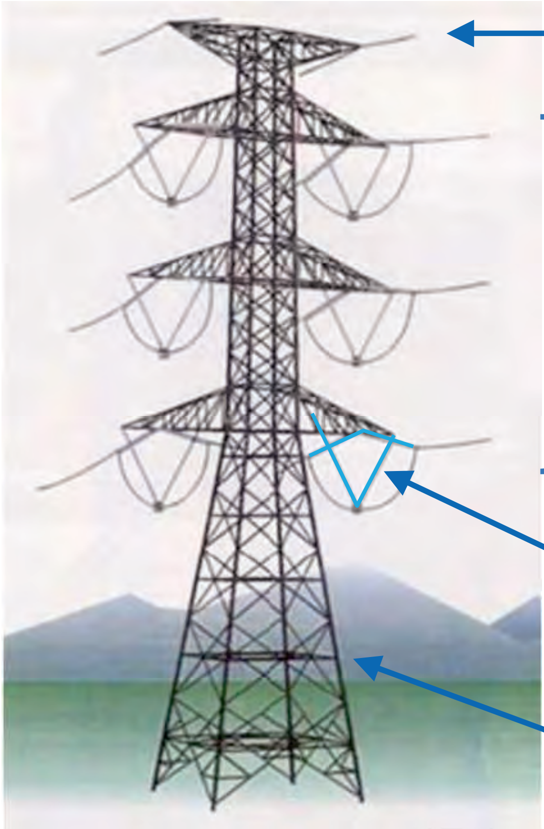
1.5 Structure of transmission tower



Ground wire
- ✓ For protection of conductors from lightning
- ✓ For communication

Conductor
- ✓ For transmission of electricity
- ✓ Material: Aluminum alloy
- ✓ 1 circuit is composed of three (3) separated lines

Insulator
- ✓ For electrical insulation of conductor from the earth

Tower
- ✓ Material: Steel
- ✓ Height: 30 – 80m

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2. The Project outline

Item	Substance
Purpose	This project is implemented for the purpose of formulating power system expansion plan (M/P) up to Y2040 and capacity building for the staff of NTDC.
Implementation area	Throughout the country
Implementation agency	1) Competent authority: Ministry of Energy (MOE) 2) Agency: National Transmission and Despatch Company Limited
Scope of works	1) Support for formulation of M/P up to Y2040 2) Implementation of pre-feasibility study (Pre F/S) of prioritized projects 3) Capacity building of NTDC engineers for transmission system planning

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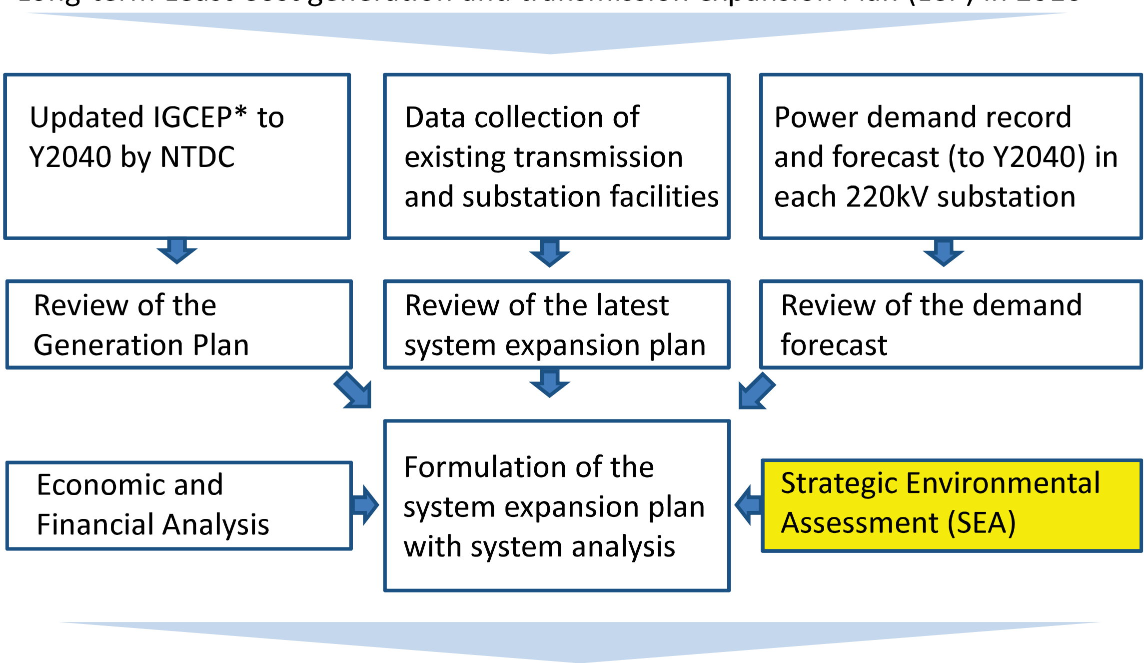
2. The project outline (cont'd)

Item	Conditions
Target	Transmission system of 220kV and above voltage level throughout country
Period of plan	Short term (present - 2025) Middle term (2026 - 2030) Long term (2031 - 2040)

2.1 Procedure of the project

National Power System Expansion Plan in 2011
Long-term Least Cost generation and transmission expansion Plan (LCP) in 2016



Updated National Power System Expansion Plan

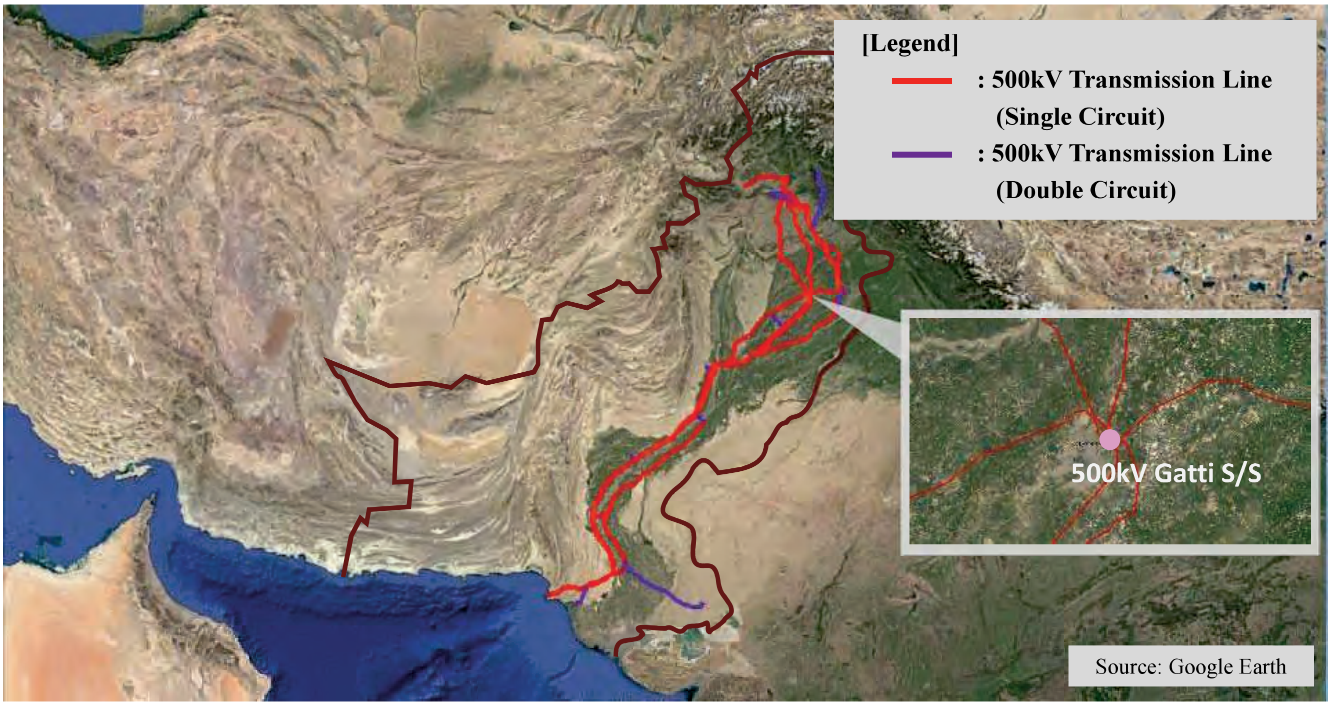
* Indicative Generation Capacity Expansion Plan

2.2 Demand forecast/ Power generation development plan

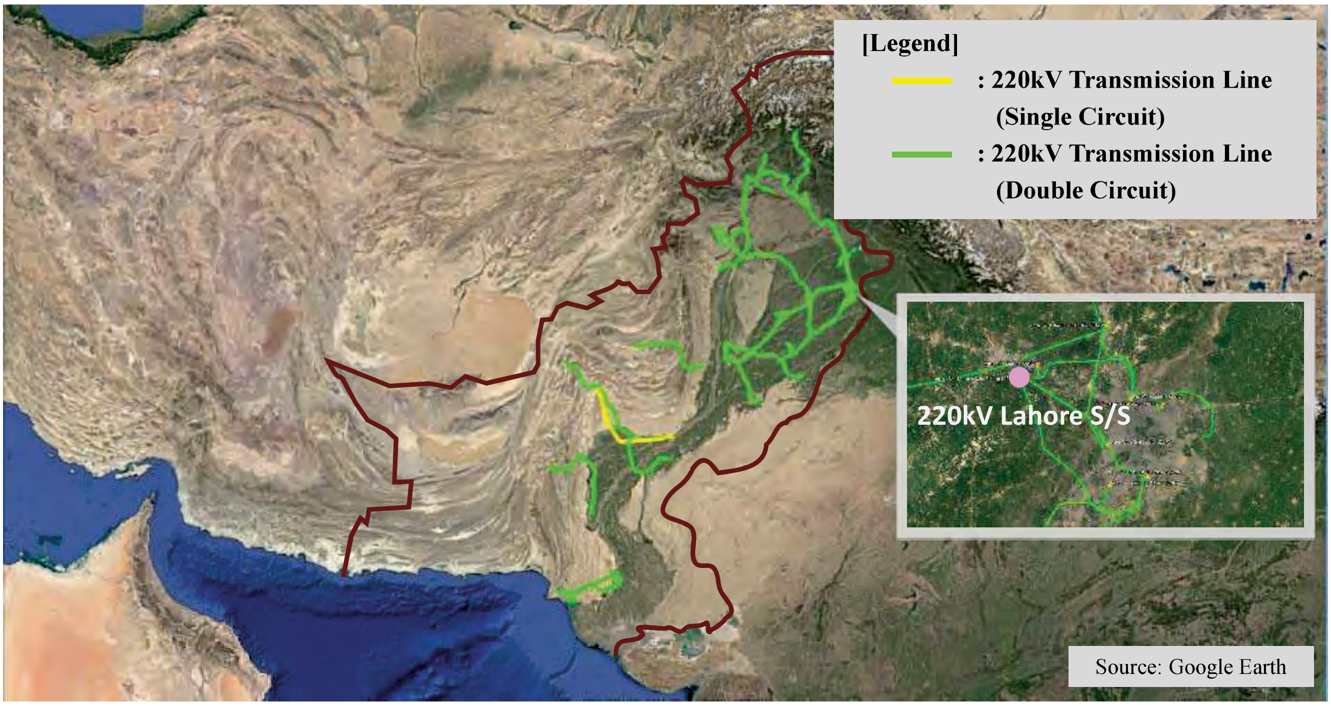
	Power Demand Forecast	Power Generation Development Planning
Review Items	• Forecasting Policy • Methodology • Power Demand Record • Key Index for forecasting • Analysis Results	• Basic Policy for Generation Mix • Basic Information of Existing and New Power Plants • Design Criteria • Design Conditions • Analysis Model • Input Data • Analysis Results

- **Power demand forecast and power generation development planning are updated by NTDC.**
- **JICA Expert Team shall review them from the viewpoint of LCP prepared in 2016 considering the latest situation of power sector.**

2.3 Outline of existing 500kV T/Ls



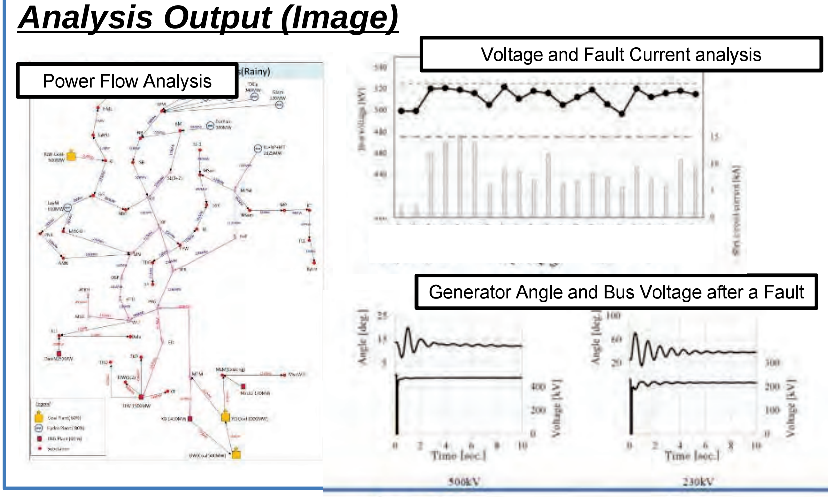
2.3 Outline of existing 220kV T/Ls



These (500kV, 220kV) diagram will be revised based on the updated national power system expansion plan up to 2040

2.4 Power system analysis

Analysis Output (Image)



Criteria for Planning

Status	Criteria (example)
Normal	- Maintain the frequency and voltage within the normal range
Accident	- No outage with a single fault - Maintain the frequency and voltage within the emergency range

Item	Contents	Conditions
Power flow Voltage	To analyze the power flow in the normal operation state and output power flow of the transmission line and the voltage of the substation bus bar.	- Peak load time of wet/ dry season
Fault current	To simulate a 3 phase short circuit accident and analyze the short circuit current of substation bus bar.	- 3 phase fault at each substation's bus bar - All generators in operation - Reactance Xd' is used for generator
Transient stability	Simulate a single fault and analyze the synchronous stability of the generator.	- Fault of 3 phase short circuit on line near end of substation - Reclosing function isn't operation - Peak load time of summer/ winter