OVERVIEW OF THE SOUTH KOREA TRANSMISSION NETWORK

(with particular emphasis on the recently commissioned 765kV Network)

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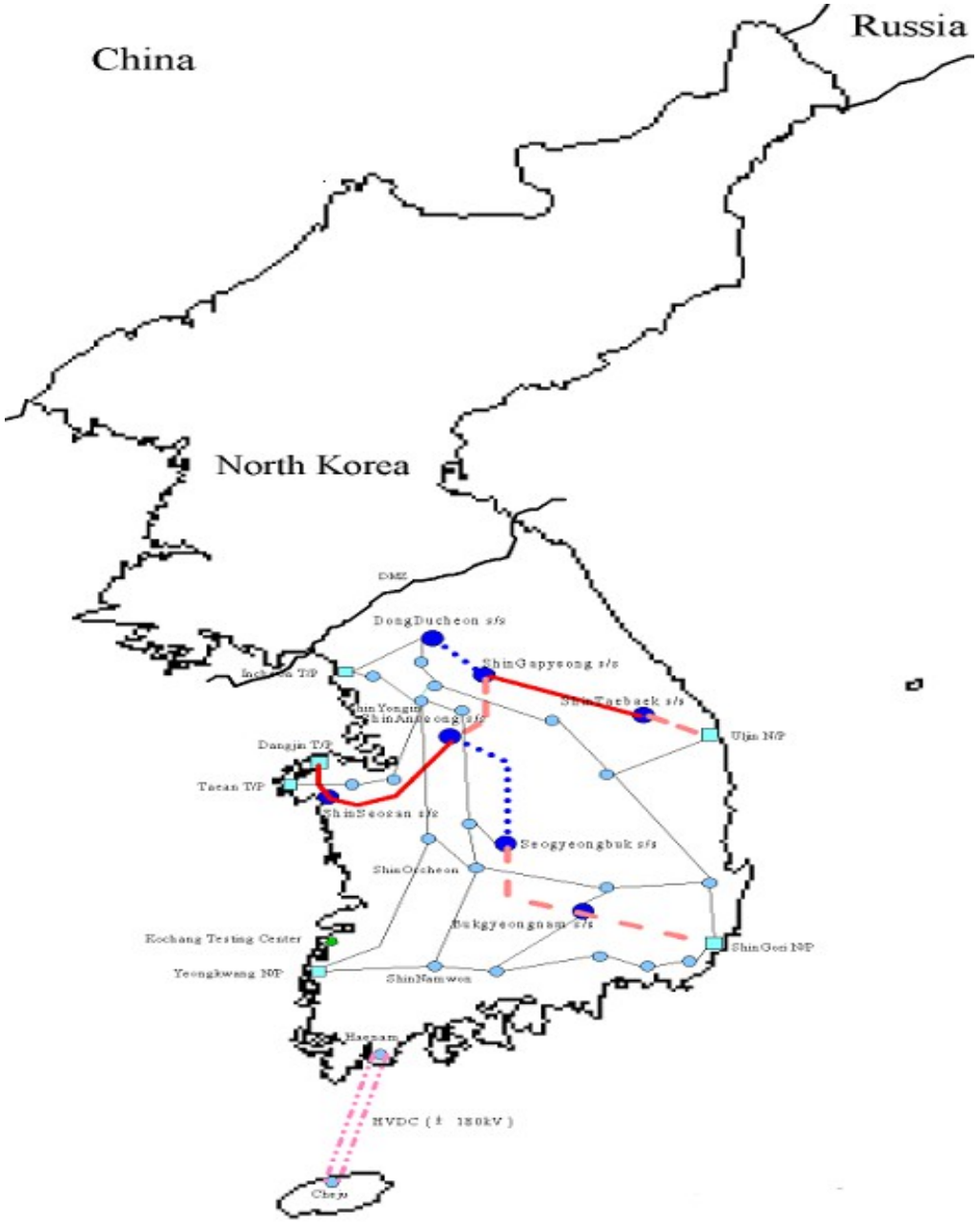
345 & 765kV Transmission Lines of Korea



1st Project

2nd Project

3rd Project

345kV T/L

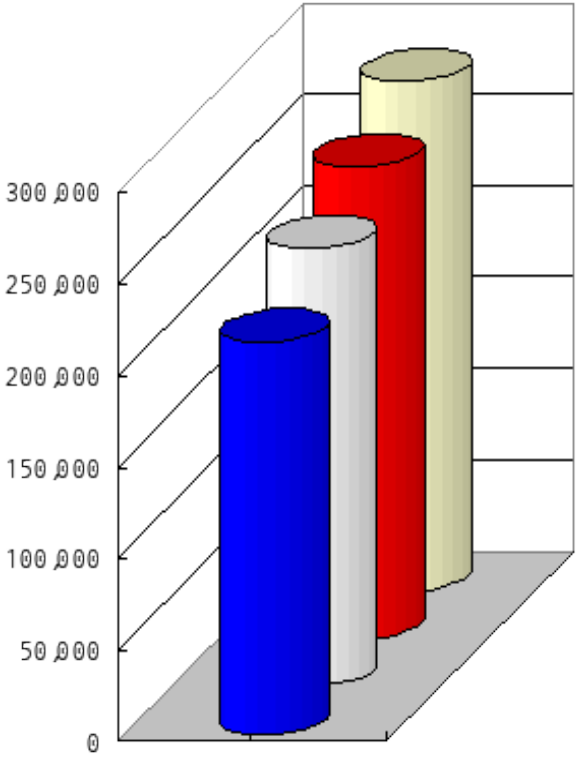
AGENDA

- **Overview of Korea Power Statistics**
  - Load
  - Generation
  - Transmission Lines
  - Substation
- **Introduction of Korea 765 kV System**
  - Transmission Lines
  - Substation

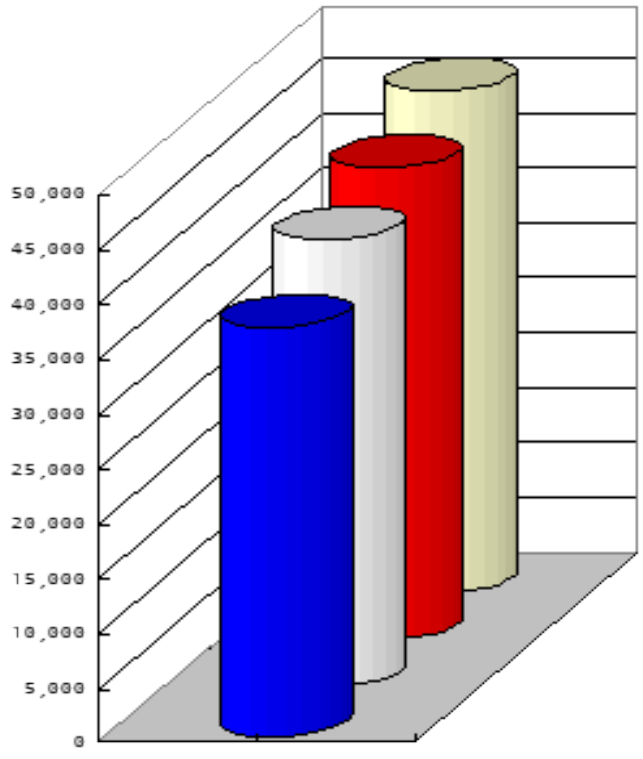
Load Trends of Korea

Item / Year	1999	2000	2001	2002
Energy Sales [GWh]	214,215	239,535	257,731	278,451
Increase per annum [%]	10.7	11.8	7.6	8.0
Peak Load [MW]	37,293	41,007	43,125	45,773
Increase per annum [%]	13.0	9.9	5.2	6.1
Consumption per capita [kWh]	4,572	5,067	5,444	5,845
Increase per annum [%]	9.7	10.8	7.4	7.4

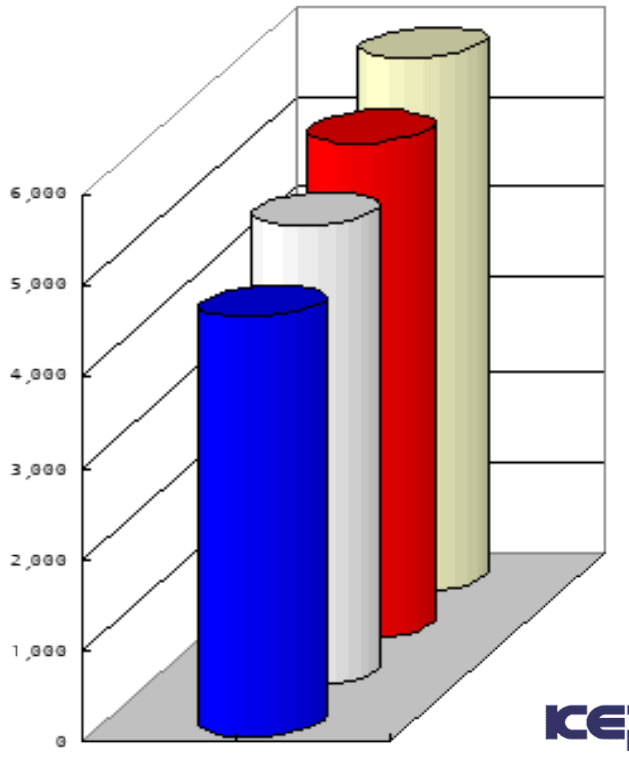
Energy Sales [GWh]



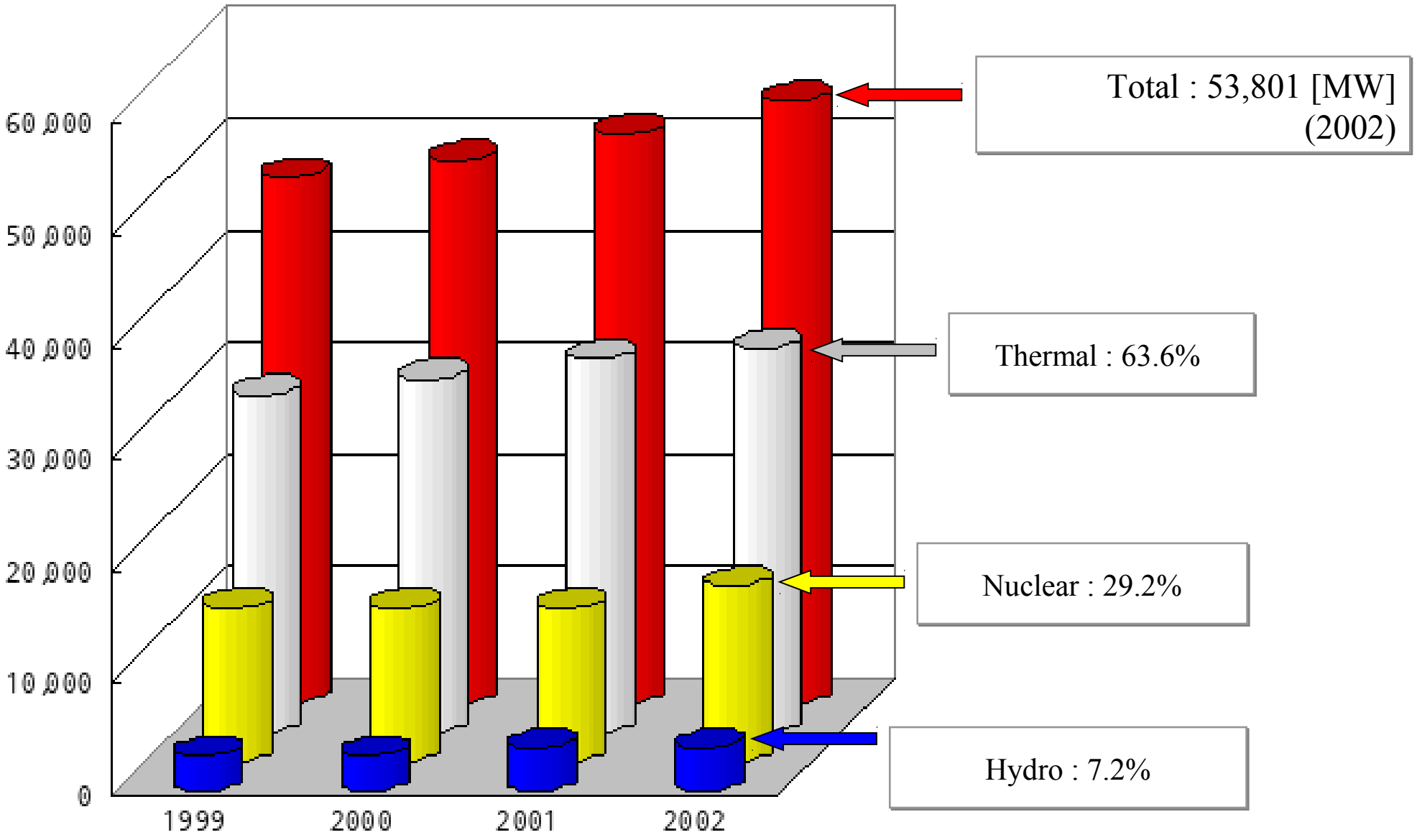
Peak Load [MW]



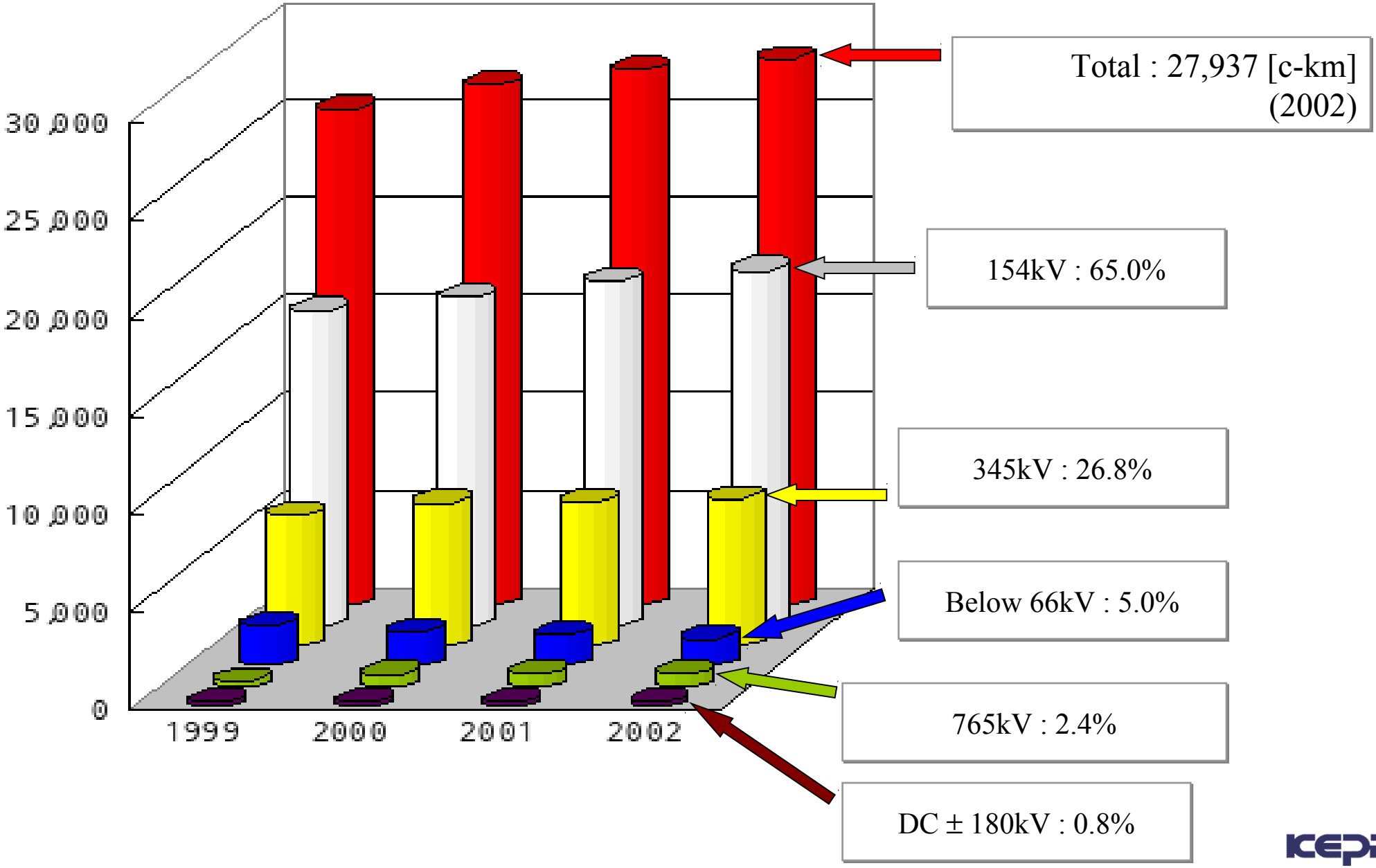
Comsumption per capita [kMh]



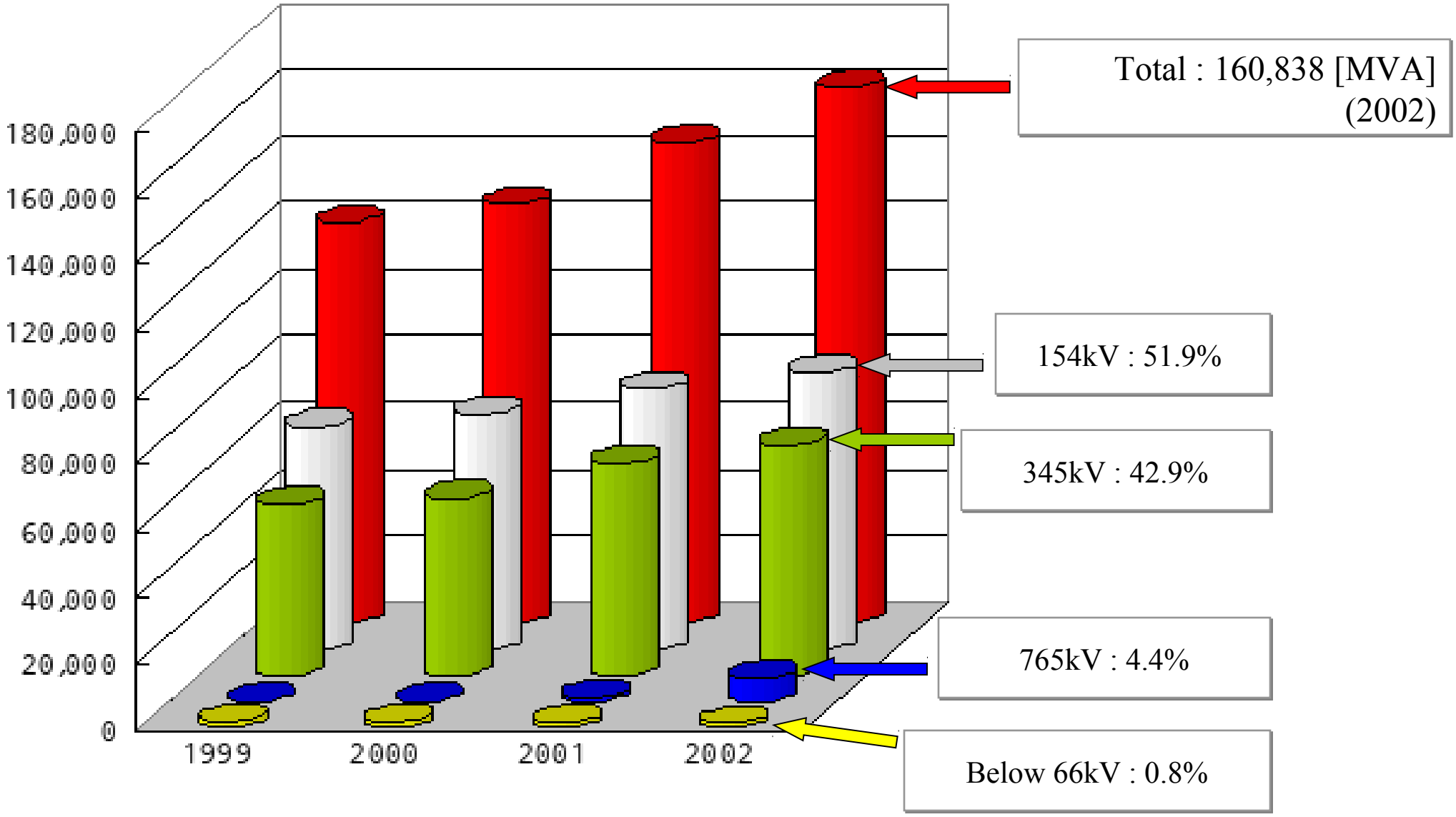
Trend of Generating Facility



Trend of Transmission Line Length



Trend of Capacity of Transformer



Overview of 765kV Facilities

Transmission Lines: 330 km (1st Project)

- Conductor : ACSR 480 mm^2 × 6 Bundles
- Ground Wire : AW 200 mm^2, OPGW 200 mm^2
- Switching Surge : 1.9 p.u. & TOV : 1.2 p.u.
- Tower Foundation : pad & chimney, pier etc.
- Tower Design
  - Type: Pipe
  - Span: 500~600 m
  - Height: 80~100 m
  - Weight: 70~100 tons
- Insulator String : 300 kN, 400 kN, 530 kN

Substation: 4 substations (1st Project)

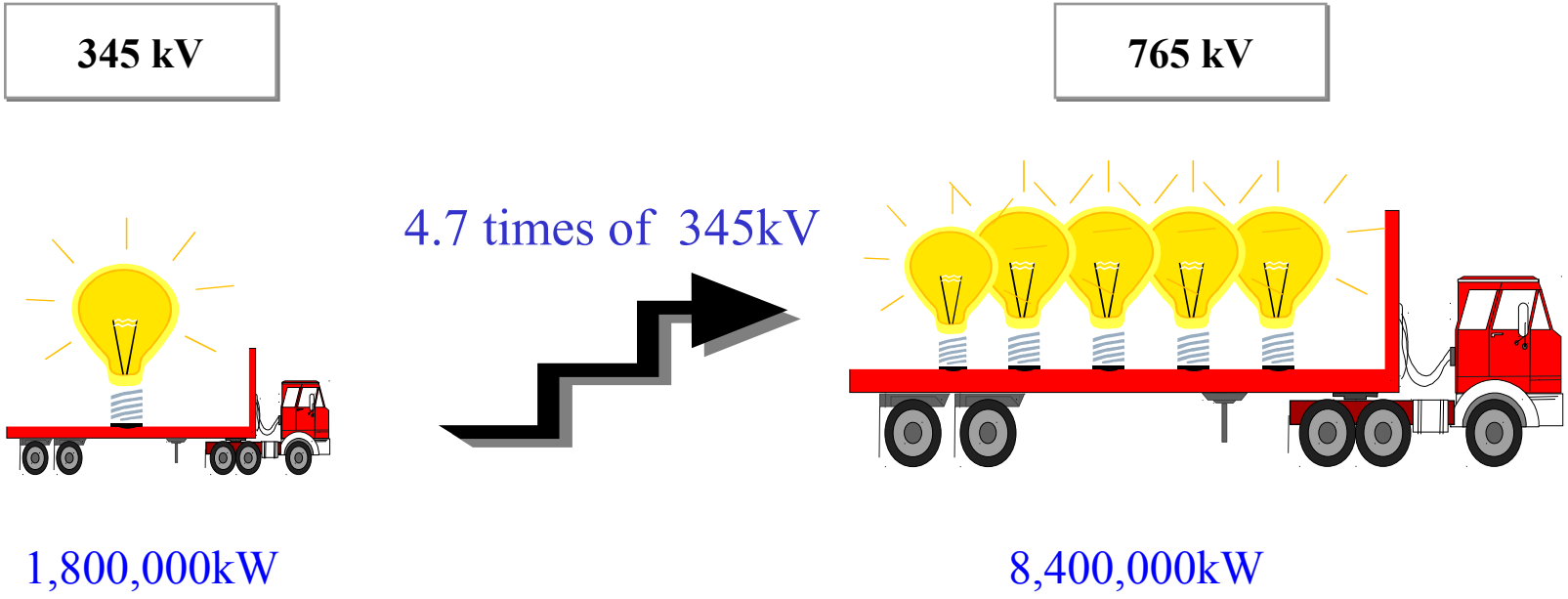
- Type: outdoor GIS
- BUS Scheme: 2 BUS 1.5 CB
- 765 kV 8 T/L, 4 Transformer Bank (or 5 Bank)
- Site Area: approximately 235,000 m^2
- Transformer: 1 Ph, 666 MVA × 3 (765/345/23 kV)
  - BIL: 2,050 kV
  - Weight: 150 tons
- Circuit Breaker: rated current ➔ 8 kA
  - BIL: 2,250 kV
  - Short Circuit Cap.: 50 kA

Necessities

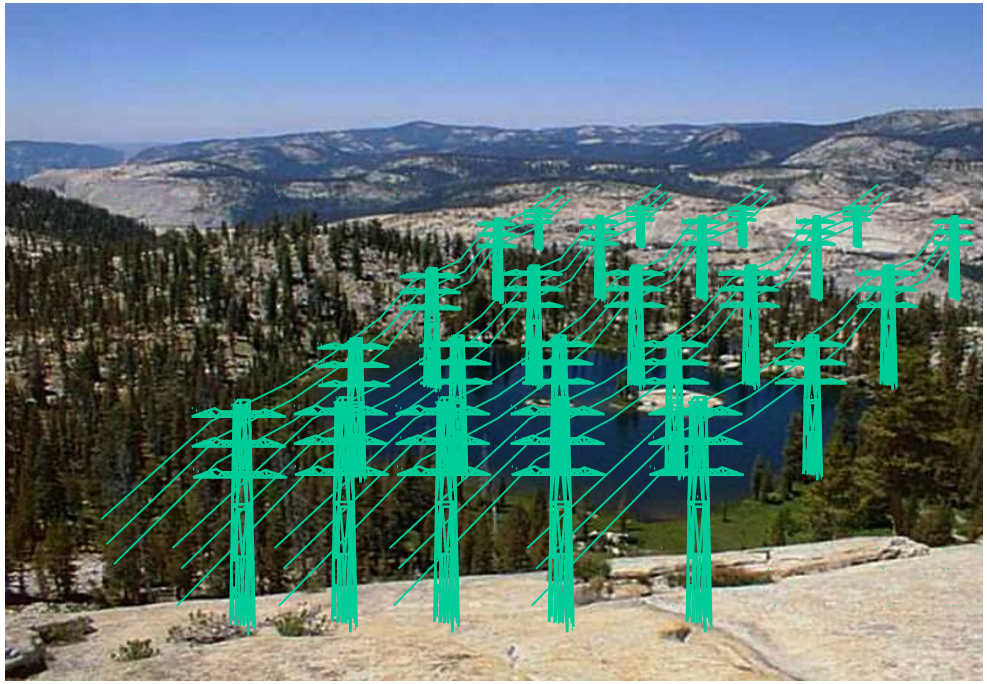
- Increasing Rate of Peak Demand : average 10 % / year
- Difficulty of Obtaining on Rights-of-way

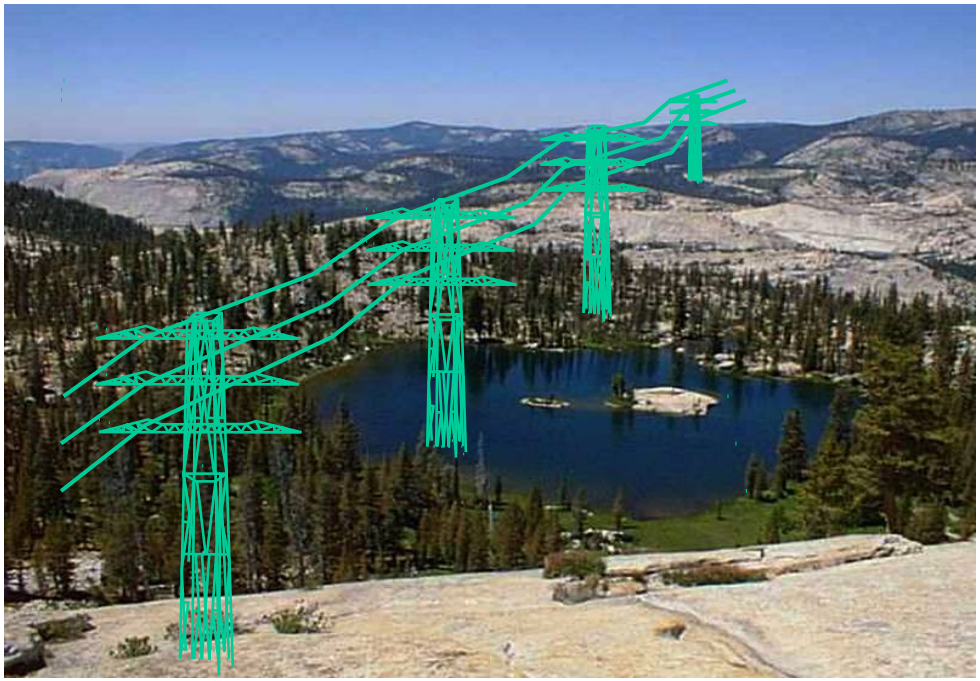
Upgrading Advantage (765kV : 345kV)

- Increasing of Transmission Capacity



- Decreasing of Transmission Loss : 20 % of 345 kV
- Decreasing of Tower Area : 50%
- Decreasing of Transmission Line Route Area : 30 %



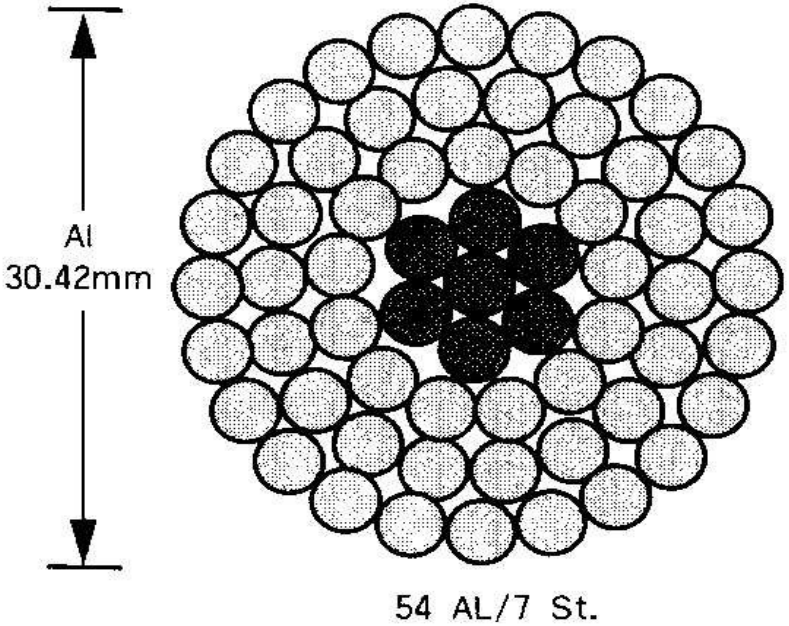


53% of 345kV

Conductor

Kind of Conductor	Stranded wire composition	Calculated sectional (mm^2)	Tensile strength (kg)	Outer diameter (mm)	Weight (kg/km)	Coefficient of elasticity	Coefficient of linear expansion (106 / °C)
ACSR 480mm^2 (Cardinal)	Al 54/3.38 St 7/3.38	Al 484.53 St 62.81	15,300	30.42	1,836	7,987	19.53

Cross sectional view of wires

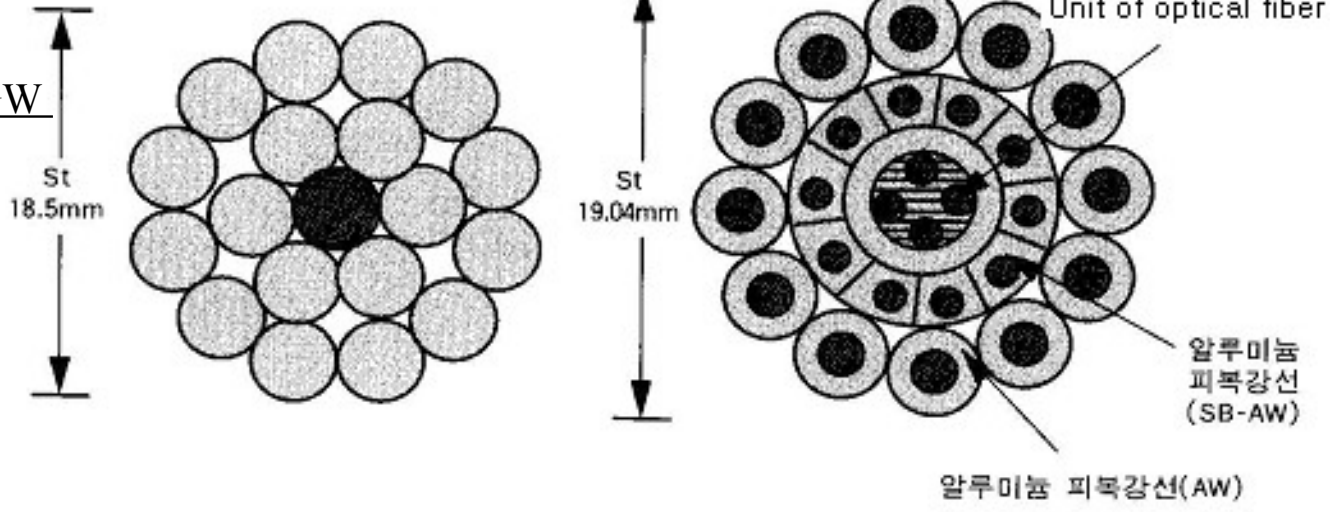


6 bundle conductor and spacer

Ground Wire & Jumper of Tension Tower

Ground Wire

AW 200mm² and OPGW 200mm²

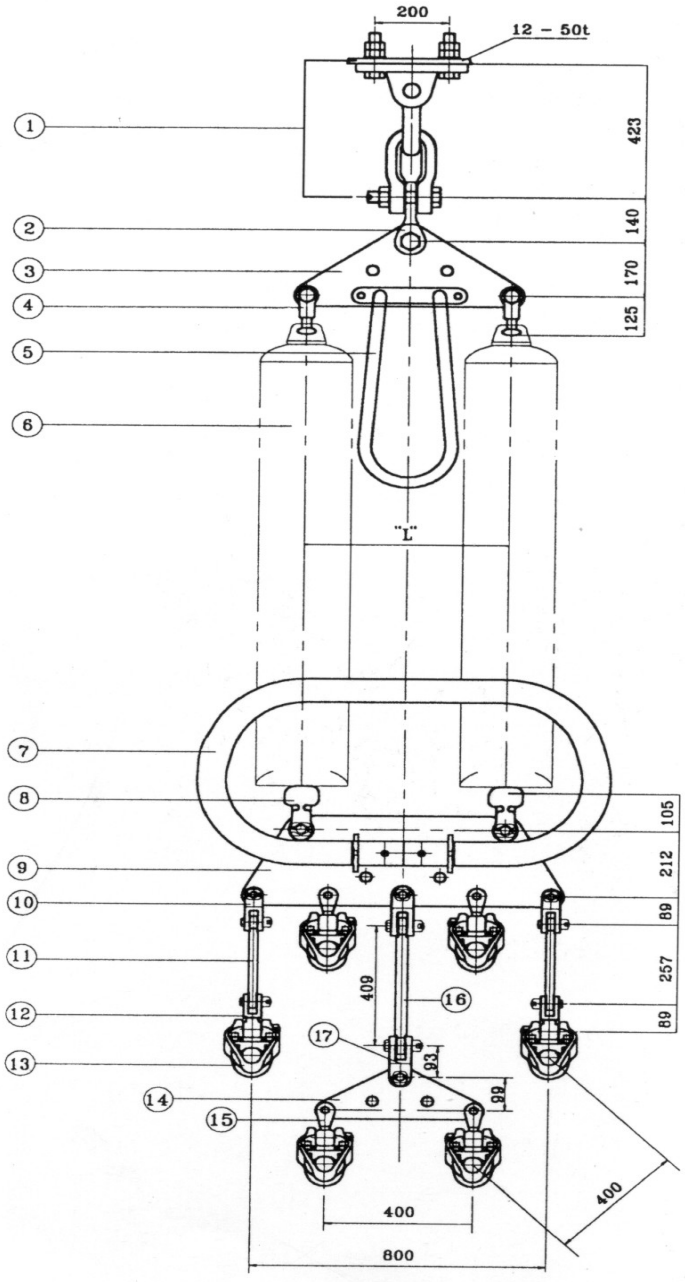


Jumper

Suspension rod type pre-fab Jumper

Insulator Strings and Fittings

No.	Name of Parts
1	Tower Fitting
2	90° Clevis Eye
3	Yoke
4	Ball Clevis
5	Arcing Horn
6	Insulators
7	Arcing Ring
8	Socket Clevis
9	Yoke
10	90° Clevis Eye
11	Eye Link
12	Clevis Eye
13	Suspension Clamp
14	Yoke
15	90° Clevis Eye
16	Eye Link
17	90° Clevis Clevis



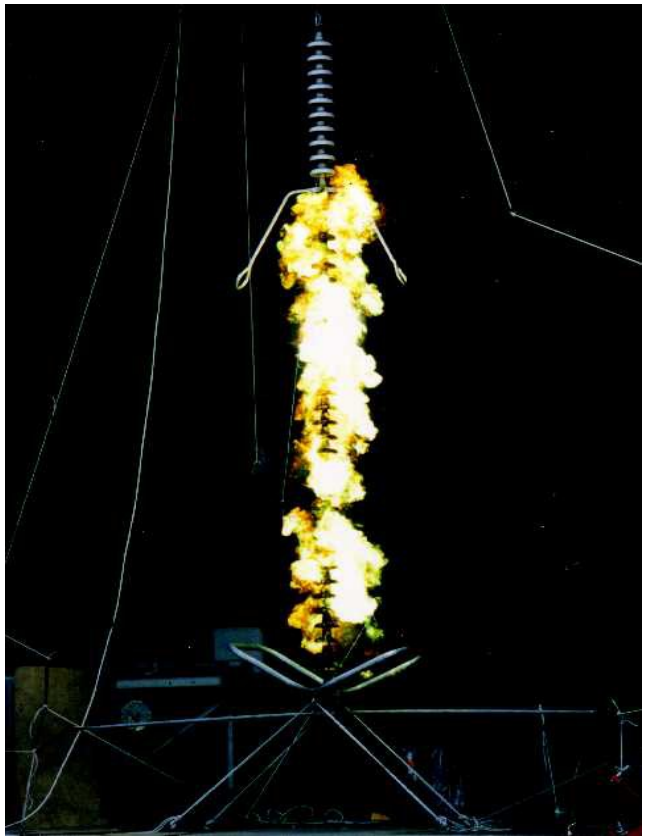
The Number of Insulators of KEPCO 765 kV Transmission Line

Sea Level	Pollution Level		Clean		Polluted Area				
			Clean I	Clean II	A	B	C	D	
	ESDD (mg/cm^2)		~ 0.01	~ 0.03	~ 0.063	~ 0.125	~ 0.25	~ 0.5	
	Type		Normal type			Fog type			
Below 1,000m	SUS	300kN	30	37	44	34	39	45	50
		400kN	29	36	41	33	38	45	50
	TEN	400kN	28	36	41	33	38	45	50
		530kN	24	30	35	-	-	-	-

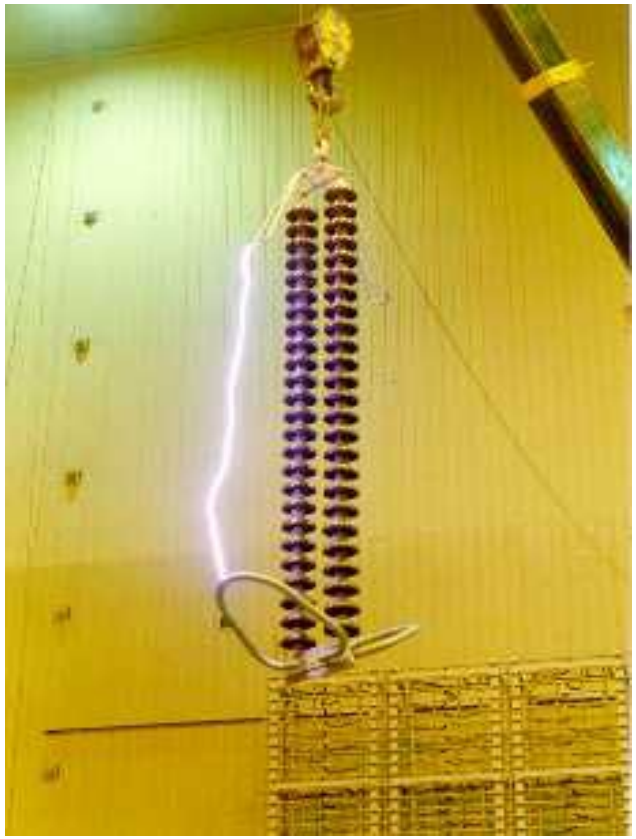
Kinds of Insulator String

- Suspension String : 300 kN × 2, 400 kN × 2
- V Suspension String for Jumper : 210 kN × 2
- Tension String : 400 kN × 3

Impulse test of suspension insulator

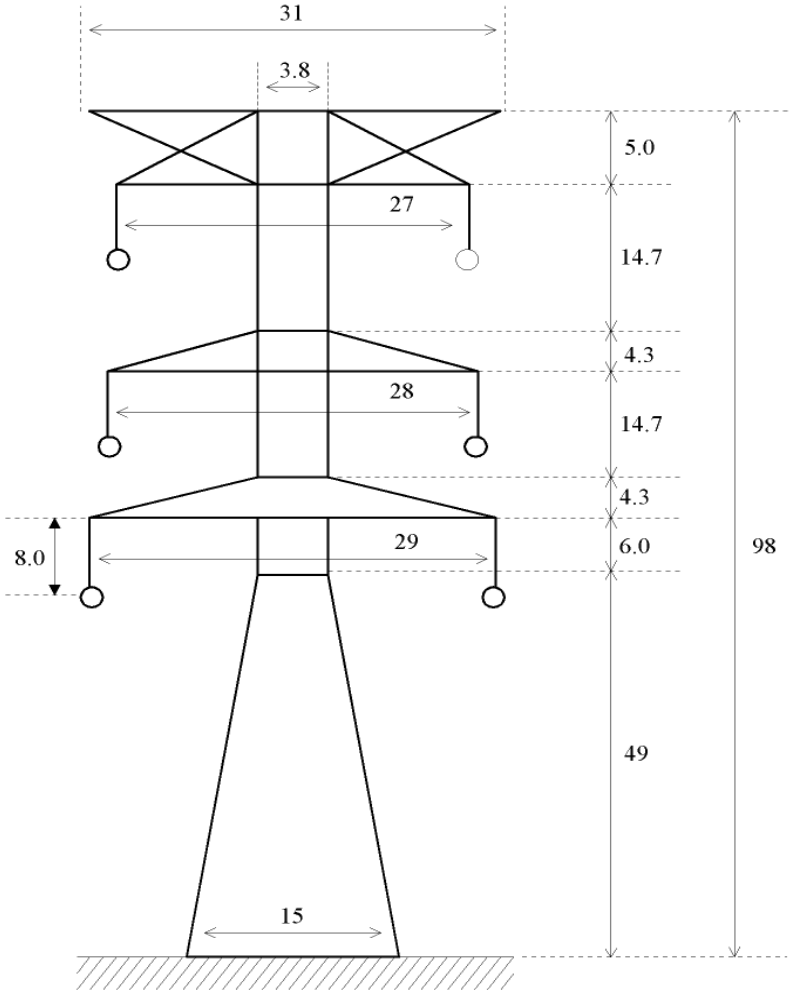


Arc-resistivity test of arcing horn

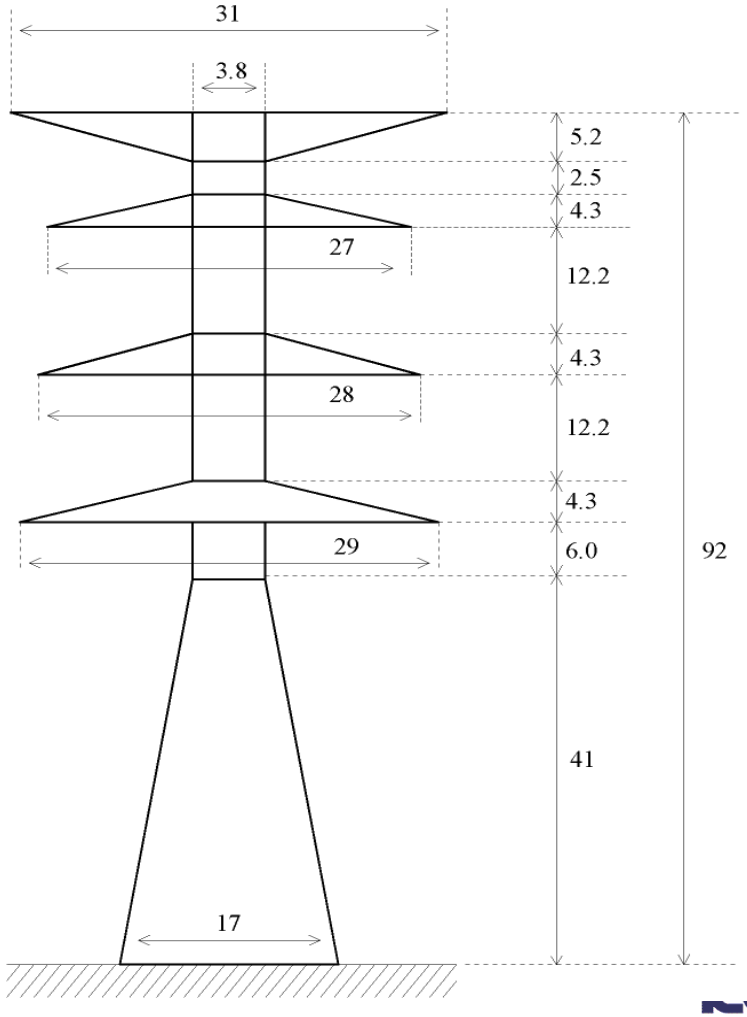


Typical 765 kV Transmission Tower

Suspension Type



Tension Type



Tower Design

- Kind of members : pipe (arm part is angle)
- Tower Type
  - Type: A, LA, B, C, D, D_0, X (dead end tower)
  - C type and above (heavy angle tower): asymmetric arm
    - Inside arm is shorter than the outside arm
- Accessories : Ladder, Rail for Lift, Resting places etc.

Manufacturing of 765 kV tubular tower

Lift for tower and its rail

Foundation Design

Ordinary foundation

- pier & pad foundation, pier foundation, rock anchor foundation

Special foundation

- pile foundation, well foundation

Pier foundation

Excavation of pier foundation using Telescopic

Setting the stub

Design of Ground Clearance

• Electric Field on ground level = 3.5 kV/m (resident area)
7.0 kV/m (mountain area)

Division	Facility standard (m)	Added value (m)	Designed value	Remarks
Flat ground area	13.68	-	28	Region frequented by people
Mountainous area	12.68	-	19	Region seldom visited by people and with no tree
Railway (Including electric railway)	14.18	-	28	
Road	13.68	-	28	Express highway, national road and other
Other trees	10.88	16.2	27	
Larches	10.88	21.2	32	Collective afforestation area
Rigid Pine trees, Big cone pines	10.88	21.2	32	Collective afforestation area
Farm land	13.68	-	28	
Scheduled residential area (3 stories)	10.88	-	28	
Other structures crossing separating	10.88	4	15	Overhead electric wires, Overhead low voltage line

Electrical Environment Design

Test Results from long term tests for 28 months

ITEM	Test Results	Criteria
AN	• Rainy weather: 48.4 dB(A) • Fair weather: 40.9 dB(A)	50 dB(A)
RI	• Fair weather: 43.5 (dBμV/m) = SNR 25.7 dB	SNR 24 dB
TVI	• Rainy weather: 14.2 (dBμV/m) ≈ SNR 40 dB	SNR 40 dB

Cardinal Conductor (480mm^2 x 6 Bundle / Phase) satisfies the KEPCO design Criteria

Overvoltage Analysis Results

- Power Frequency Temporary Overvoltage is below 1.2 p.u.
  - 1.2 p.u. (analysis results) + margin = 1.2 p.u.

- Line-to-Ground Fault Initiation is below 1.8 p.u.
  - No Reduction Method

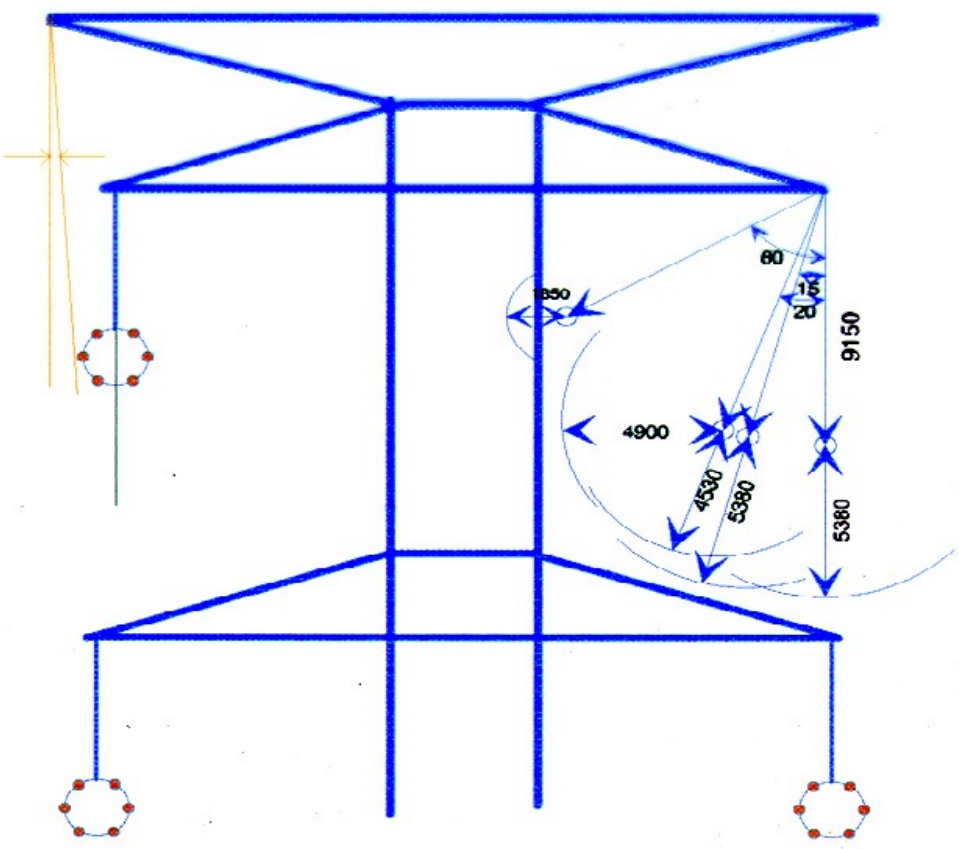
- Energization & Re-energization with one step per-insertion resistor is below 1.9 p.u.
  - Maximum Resistor Value 800 Ohms (Optimum = 400 Ohms)

- Simultaneous Single Line-to-Ground Fault Clearing at each circuit is below 1.9 p.u.
  - Without Opening Resistor

Lighting Flashover Rate

- Calculated Condition
  - IKL : 20
  - Shielding Angle : -8 degree
  - Hill Side Angle : 10 degree (average)
  - Tower Foot Resistance : 15 ohms
  - Horn Gap Length : 4.6 m, 4.8 m (765 kV)
    2.34 m (345 kV)

Shielding Angle



➔ Ground wire arm is longer than lower arm by 1 m and shielding angle of upper conductor is approximately –8 degrees.

Type of substation

Type : Outdoor Full GIS Type

- With no exposure of hot-line parts, except for the bushing at the front end of incoming T/L
- Most equipment is installed inside a metal enclosure which is insulated with SF6 gas
- GIS and Transformer are connected with a SF6 Gas Insulated Bus (GIB)

BUS Scheme : Double Bus 1.5CBs Type

- Highly reliable (in case of bus failure), flexible (in power flows) and economical
- Enough operational experience with this type:
  - The standard bus scheme in the 345 kV S/S

View of 765 kV Substation

765kV Sin Ansung S/S

KEPRI

Completed 765kV Commercial T/L

Completed 765kV Commercial T/L

Insulation Design

Basic Concept

- External over voltage: Suitable arrangement of high performance surge arrester
- Internal over voltage: No flash over

Internal over voltage criteria

Division		Overvoltage Ratio (p.u.)	p.u. Ratio
Power Frequency Overvoltage	Phase conductor	1.2	$1\ \text{p.u.} = \frac{800}{\sqrt{3}}\ \text{kV}$
	Neutral	0.3	
Switching Overvoltage	Phase to ground	1.8	$1\ \text{p.u.} = 800 \times \frac{\sqrt{2}}{\sqrt{3}}\ \text{kV}$
	Phase to phase	3.5	

Standard Insulation Distance

Insulation Clearance	Standard	Minimum
Phase to Phase	11 m	8.5 m
Phase to Ground	7 m	5 m

Main Power Transformer

- 2 tanks for each phase: possibility of transportation
- It is possible to operate 1 tank for each phase

Classification	Rating
Type	Auto transformer (2 tanks per each phase)
Rated voltage	765 /$\sqrt{3}$ kV, 345 /$\sqrt{3}$ kV, 23 kV
Capacity (1, 2)	2,000 / 3 MVA
Capacity (3)	60 / 3 MVA
Tap range	± 7 % (23 tap)
% Impedance	18 % (1st-2nd wire)
Cooling	3 steps FOA (ANSI)
Audible noise	85 dB

Setting the Main Transformer in Sin Ansung S/S

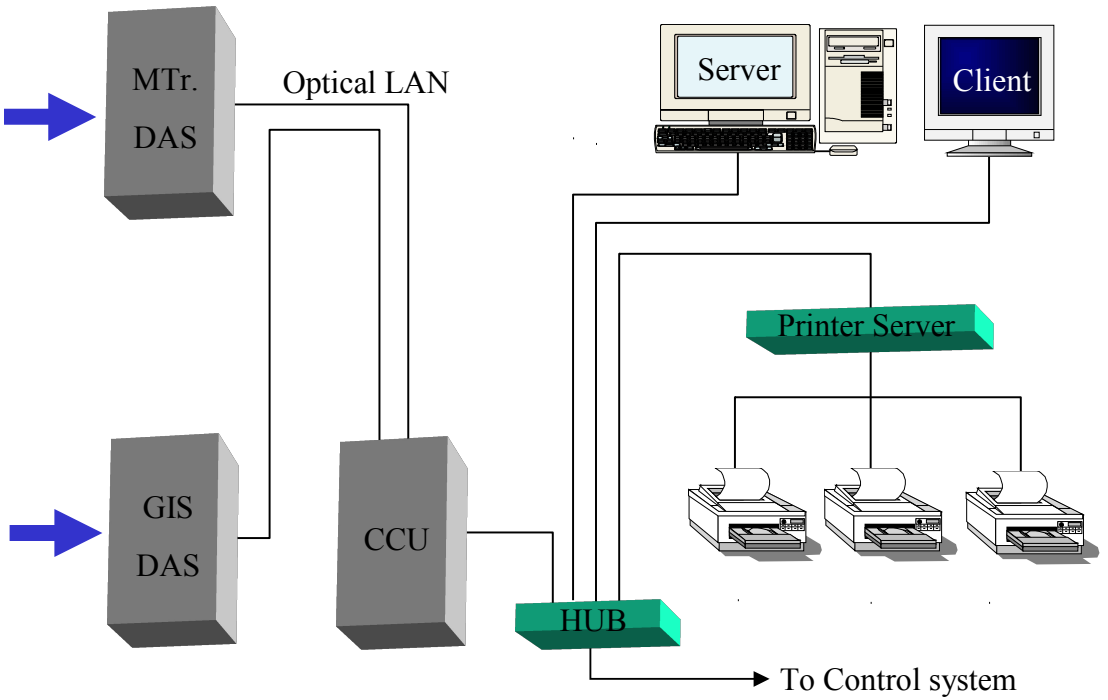
800 kV GIS at Sinseosan S/S

Preventive Diagnostic System

- On-line diagnosis of the operating status of apparatuses
- Use accumulated data to prepare an optimal maintenance and repair plan according to the condition of devices

Class	Diagnose Item
MTr.	• Gas in oil • Temperature • Oil level • particle Discharge • OLTC • Fan, pump current • Current and voltage • Ambient temperature
GIS	• UHF Coupler • CB, HSGS operation • Gas pressure • LA current

765 kV Predictive diagnostic system configuration

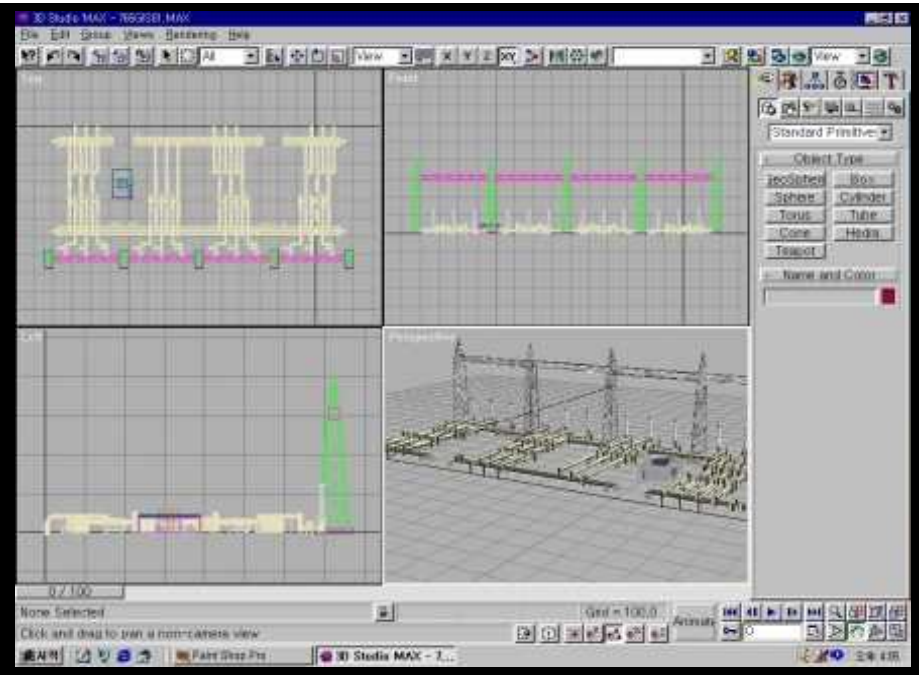


Environmental Countermeasures

- Full GIS type
- Colored water-permeable concrete at the switch yard surface
- A barrier of trees on the outside
- Application of 3D graphic simulation

Bird's eye view

3D graphic simulation



Conclusions

- **765kV Transmission Line of Korea is the first 765kV double circuit AC T/L in the world**

- **Characteristics of 765kV Transmission Lines**

  • Bulk Carrying Capacity (8,400 MW): 5 times of 345 kV

  • Efficient Utilization for Land (529 m^2): 53% of 345 kV

  • Cost Reduction in Construction (3,900 million Won/km): 74% of 345 kV per kW

  • Decrease in Transmission Loss (0.05%): 20% of 345 kV

  • Environment Affinity 765 kV Transmission Line: EMF, Corona

- **Exporting of Technology**

  • Vietnam, Myanmar, Libya, China, etc.