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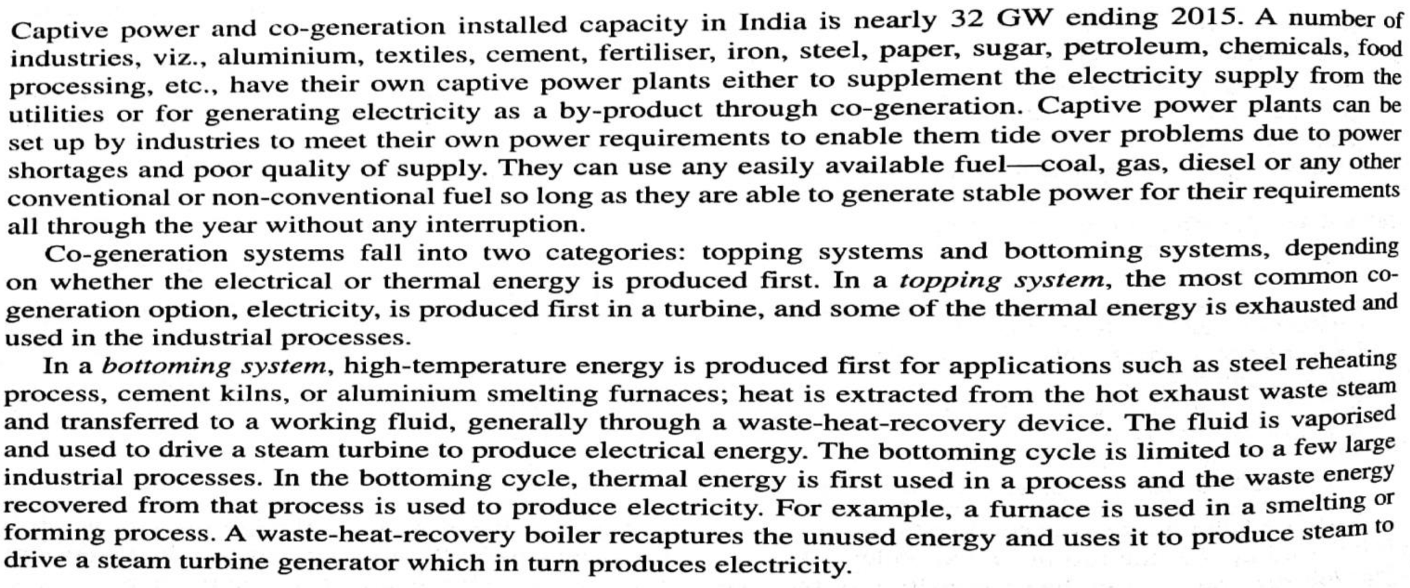
Internal Assesment Test –II

Sub:	Power System Planning							Code:	15EE744
Date:	15/10/2018	Duration:	90 mins	Max Marks:	50	Sem:	7	Branch:	EEE
Answer Any FIVE Questions									

		Marks	OBE	
			CO	RBT
1.	What is cogeneration? Describe two cogeneration tecniques	[10]	CO3	L1
2.	Explain clean coal technologies, also explain advantages of CFBC	[10]	CO2	L4
3.	Explain Renovation and Modernizations of Power Plants.	[10]	CO3	L4
4.	Write a note on high voltage transmission	[10]	CO3	L1
5.	Write a note on substation planning also explain the busbar schemes	[10]	CO3	L1
6.	a. Write a note on reactive power planning b. Write a note on energy storage	[05+05]	CO3	L1
7.	a. Write a note on types of conductors used in transmission b. Write a note on power grid	[05+05]	CO3	L1

Solution:

1.

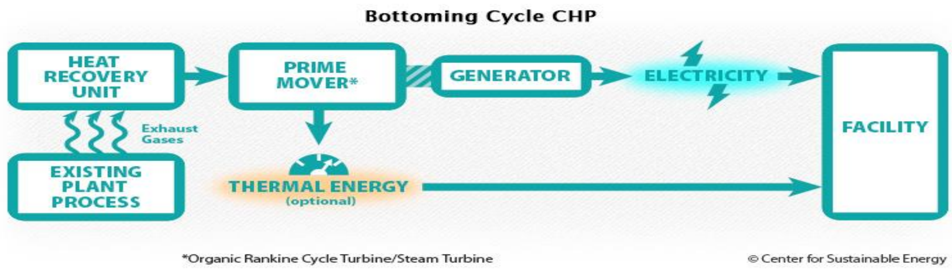


Captive power and co-generation installed capacity in India is nearly 32 GW ending 2015. A number of industries, viz., aluminium, textiles, cement, fertiliser, iron, steel, paper, sugar, petroleum, chemicals, food processing, etc., have their own captive power plants either to supplement the electricity supply from the utilities or for generating electricity as a by-product through co-generation. Captive power plants can be set up by industries to meet their own power requirements to enable them tide over problems due to power shortages and poor quality of supply. They can use any easily available fuel—coal, gas, diesel or any other conventional or non-conventional fuel so long as they are able to generate stable power for their requirements all through the year without any interruption.

Co-generation systems fall into two categories: topping systems and bottoming systems, depending on whether the electrical or thermal energy is produced first. In a *topping system*, the most common co-generation option, electricity, is produced first in a turbine, and some of the thermal energy is exhausted and used in the industrial processes.

In a *bottoming system*, high-temperature energy is produced first for applications such as steel reheating process, cement kilns, or aluminium smelting furnaces; heat is extracted from the hot exhaust waste steam and transferred to a working fluid, generally through a waste-heat-recovery device. The fluid is vaporised and used to drive a steam turbine to produce electrical energy. The bottoming cycle is limited to a few large industrial processes. In the bottoming cycle, thermal energy is first used in a process and the waste energy recovered from that process is used to produce electricity. For example, a furnace is used in a smelting or forming process. A waste-heat-recovery boiler recaptures the unused energy and uses it to produce steam to drive a steam turbine generator which in turn produces electricity.

2.


Bottoming Cycle CHP

*Organic Rankine Cycle Turbine/Steam Turbine

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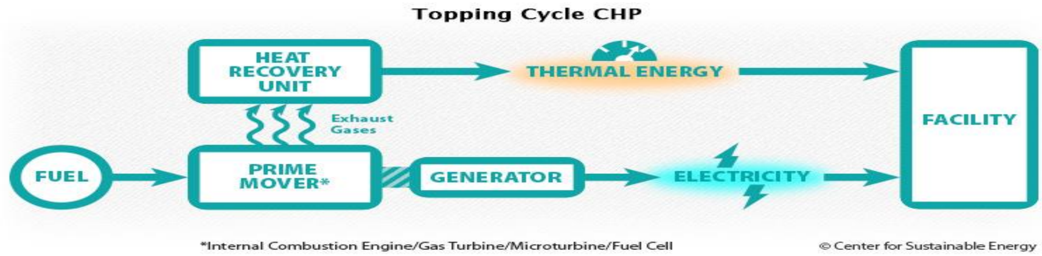
Topping Cycle CHP

*Internal Combustion Engine/Gas Turbine/Microturbine/Fuel Cell

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1. Gas turbine topping system : gas turbo gen→ power + heat(450-550^0c)

2. Steam turbine topping system(80% of co-generation power) :

fossil fuel fired boiler →

high pressure stem→ electricity (using steam turbine-generator)

Low –pressure process steam

3. Combined cycle system : gas turbine + steam turbine generator Process (recovered steam)
(waste heat boiler)

Choice of co-generation → site specific factors (fuel availability , environment constraints)

Preferred is topping cycle → first electricity

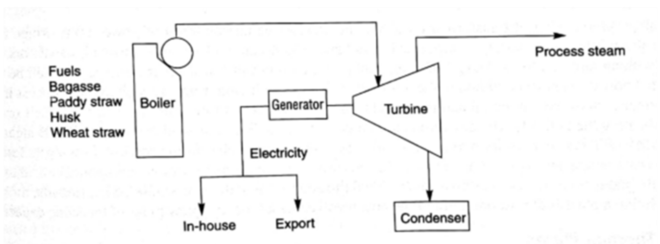
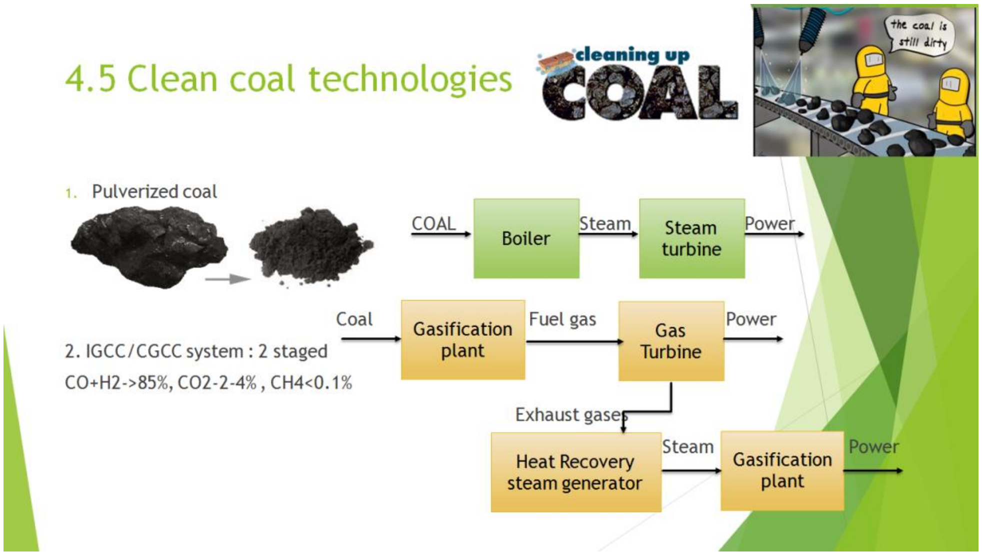


Fig. 4.11 *General scheme of captive generation*

2.



4.5 Clean coal technologies

1. Pulverized coal

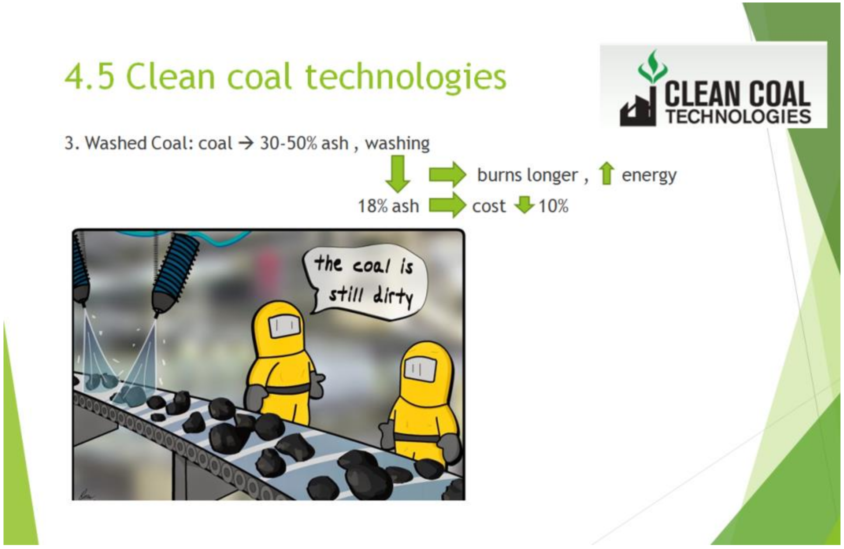
COAL → Boiler → Steam → Steam turbine → Power

2. IGCC/CGCC system : 2 staged

CO+H2->85%, CO2-2-4% , CH4<0.1%

Coal → Gasification plant → Fuel gas → Gas Turbine → Power

Exhaust gases → Heat Recovery steam generator → Steam → Gasification plant → Power



4.5 Clean coal technologies

3. Washed Coal: coal → 30-50% ash , washing

↓ 18% ash → burns longer , ↑ energy

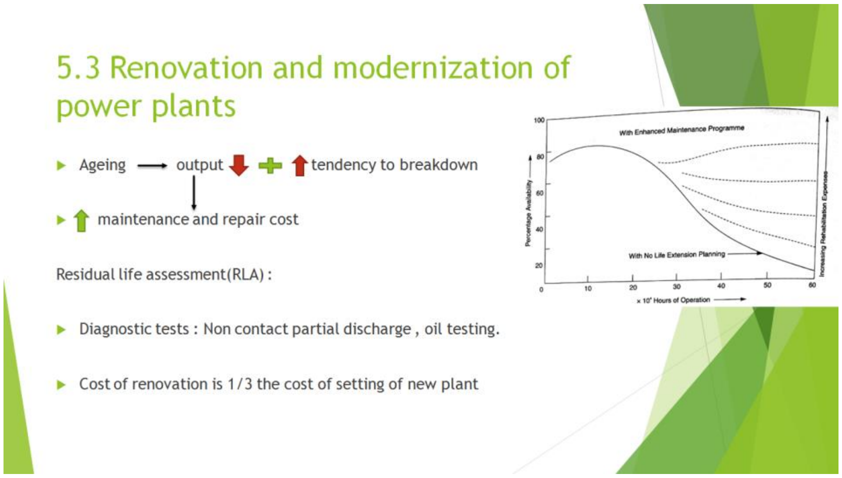
→ cost ↓ 10%

★. CFBC: Clean filtering technology boiler(400 MWe) burn low grade fuels

- Developed by BHEL
- Advantages

1. High combustion efficiency : turbulence and residence time
2. Low NOx emission: low combustion temp. and air staging
3. Low SO2 emissions: due to use of limestone low combustion temp.
4. Ability to burn low grade fuel: high thermal inertia of bed
5. Fuel flexibility : combustion temperatures(800-850 ℃)

3.



5.3 Renovation and modernization of power plants

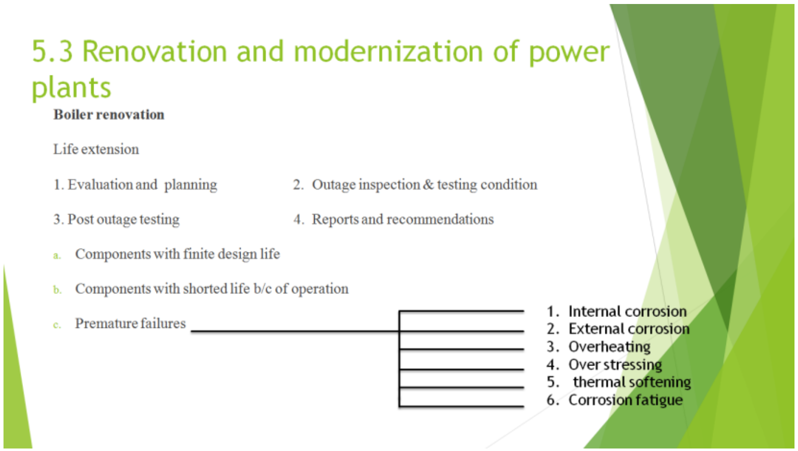
- Ageing → output ⬇ ➕ ⬆ tendency to breakdown
- ⬆ maintenance and repair cost

Residual life assessment(RLA) :

- Diagnostic tests : Non contact partial discharge , oil testing.
- Cost of renovation is 1/3 the cost of setting of new plant

Steam turbine rehabilitation:

1. Life of turbine 21-25 years , RLA after 10 Years of operating time
2. Critical components : entry nozzle steam piping etc
3. Material life consumption: As per BHEL norms $H_{OP} = H_{AO} + n_s * 25$
4. High-cycle fatigue : leads to blade failures
5. Data book of all the parts has be available



5.3 Renovation and modernization of power plants

Boiler renovation

Life extension

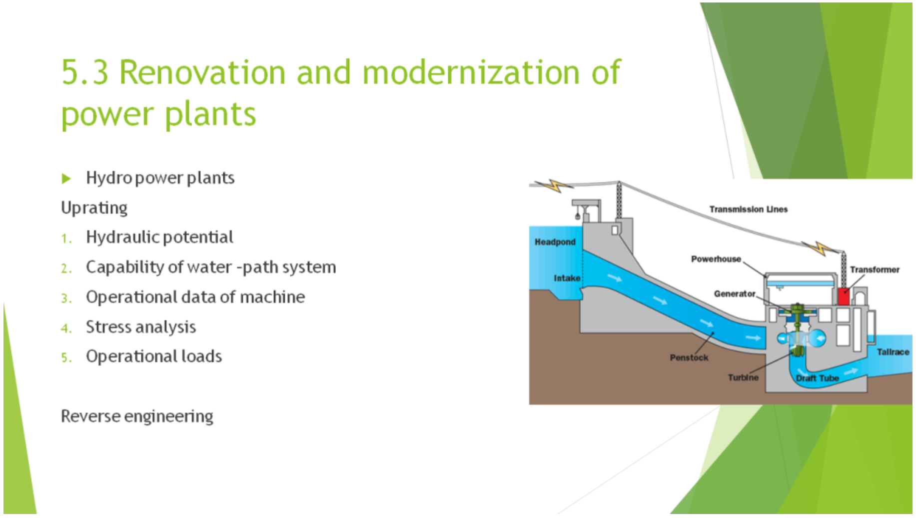
1. Evaluation and planning
2. Outage inspection & testing condition
3. Post outage testing
4. Reports and recommendations

a. Components with finite design life

b. Components with shorted life b/c of operation

c. Premature failures

1. Internal corrosion
2. External corrosion
3. Overheating
4. Over stressing
5. thermal softening
6. Corrosion fatigue



5.3 Renovation and modernization of power plants

- Hydro power plants

Uprating

1. Hydraulic potential
2. Capability of water -path system
3. Operational data of machine
4. Stress analysis
5. Operational loads

Reverse engineering

- Nuclear plant

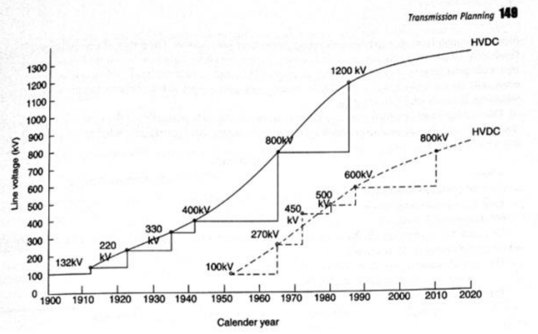
1. 25-40 years of life-time + engineering assessments   40-60 years

Ageing can cause : corrosion , cracking , partial discharges , oxidation

4.

6.4 HIGH VOLTAGE TRANSMISSION

1. **Development of transmission voltages**



HVAC and HVDC transmission voltage development in the world

6.4 HIGH VOLTAGE TRANSMISSION

2. **AC transmission** : power transfer capacity $\rightarrow \frac{V^2}{X}$

1200kV is limit set , reason?

1. Insulation
2. Protection technology becomes costly
3. Increased losses compared to DC

2. a. **Phase shifting transformers** in EHV transmission

2. b. **FACTS**

2.c. **ASC**

6.4 HIGH VOLTAGE TRANSMISSION

2.c. **ASC**

High power electronic devices + series capacitors ,

Parallel reactor with series capacitor,

Control of current in reactor

By varying firing angle of thyristor

Direct and continuous current flow control

6.4 HIGH VOLTAGE TRANSMISSION

3. **HVDC transmission**

a. **Mismatch** in 5 regions

b. **Disturbances** can be transmitted and may become severe

c. **National spinning reserve**

d. Reduce effect of **unavoidable grid collapse**

Advantages of DC

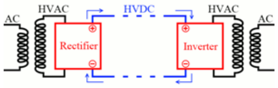
a. Right of way : HVDC is 50-60% of that of AC

b. Connect asynchronous regions

c. High transient stability

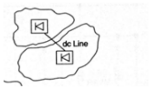
6.4 HIGH VOLTAGE TRANSMISSION

7 HVDC links in India

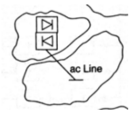


Three different ways of connection , in back to back Rectification and conversion are at same station

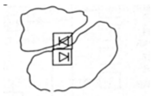
Two terminal DC line



Back to back **DC line**
with **long AC feeder**



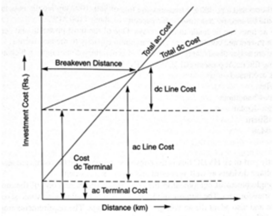
Back to back DC line at
border of blocks



6.4 HIGH VOLTAGE TRANSMISSION

Reasons in favour with HVDC

1. Lower line costs
2. Lower losses
3. Asynchronous connection
4. Controllability
5. Less cable cost, better conductor utilization
6. Backbone system : three cases
7. Costs
8. Longlines
9. Long cables
10. Submarine cables
11. Latest technology

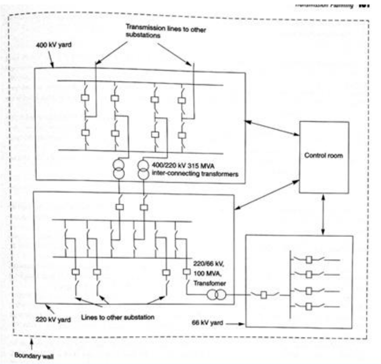


5.

6.6 SUBSTATIONS

Factors to be considered while planning

- **Historical data** of floods
- **Atmospheric** conditions
- **Land approval** (forest and wildlife sanctuary)
- Interference with **communication signal**



1. **Sub-station developments**

Technical and economical aspects

a. Load **density**

b. Load **growth**

c. Transformer **capacity utilization**

d. Max. **fault levels**

e. **Flexibility**

f. **Siting**

Distance b/w Substation: $\left(\frac{Total\ Areas}{Number\ of\ substaions}\right)^{0.5}$

6.6 SUBSTATIONS

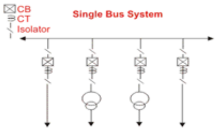
2. Substation busbar schemes

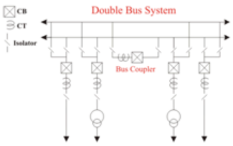
a. **Single- bus system**

Cheap , small substation where outage is permissible

Disadvantage : complete shutdown

Improvement: sectionalisation





b. **Duplicate bus system**

Includes CB and Isolators

Large systems

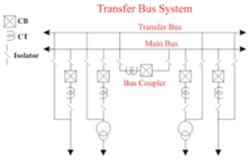
Expensive arrangement

Disadvantage: Feeder-Breaker maintenance without interruption is difficult

c. **Transfer-bus system**

Line CB can be taken out without interruption

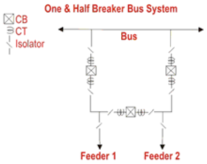
Costly but flexible



d. **Breaker and half system**

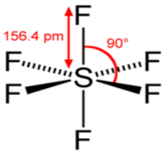
Systems where power outage is not permissible

Cost and area is 90-50% compared to main bus and transfer bus

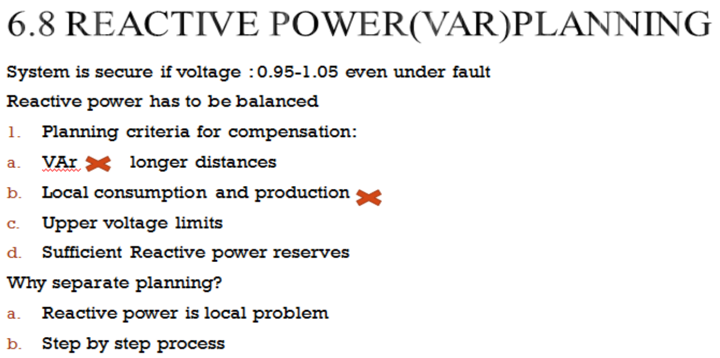


3. **Gas insulated substation** : with SF6 → compact size

a. Indoor installation
b. High reliability less maintenance
c. Low environmental impact
d. Lower cost for site clearances
e. Low erection cost
f. Superior performance with seismic conditions



6. a.



6.8 REACTIVE POWER(VAR)PLANNING

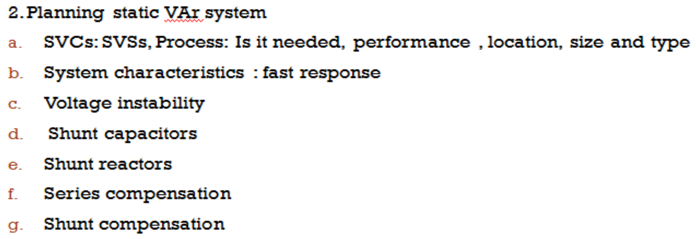
System is secure if voltage : 0.95-1.05 even under fault

Reactive power has to be balanced

1. Planning criteria for compensation:
   a. VAr ✗ longer distances
   b. Local consumption and production ✗
   c. Upper voltage limits
   d. Sufficient Reactive power reserves

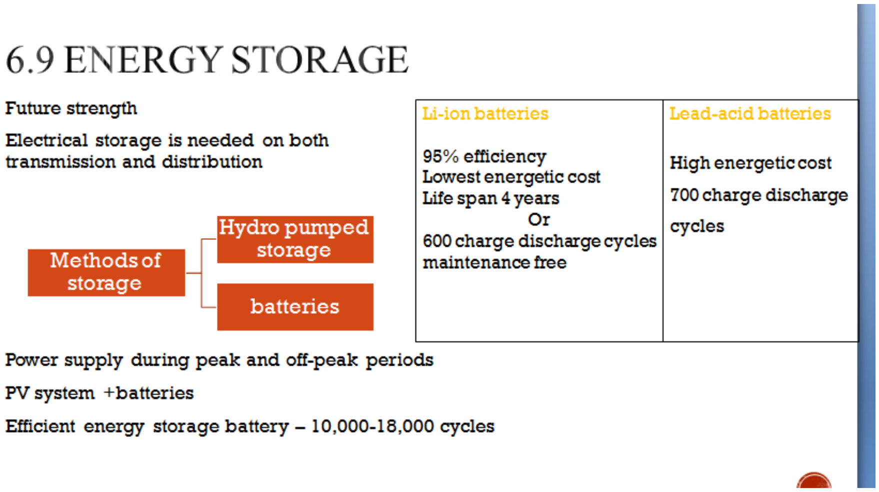
Why separate planning?

a. Reactive power is local problem
b. Step by step process



2. Planning static VAr system
   a. SVCs: SVSs, Process: Is it needed, performance , location, size and type
   b. System characteristics : fast response
   c. Voltage instability
   d. Shunt capacitors
   e. Shunt reactors
   f. Series compensation
   g. Shunt compensation

6.b.



6.9 ENERGY STORAGE

Future strength

Electrical storage is needed on both transmission and distribution

Methods of storage
- Hydro pumped storage
- batteries

Li-ion batteries	Lead-acid batteries
95% efficiency Lowest energetic cost Life span 4 years Or 600 charge discharge cycles maintenance free	High energetic cost 700 charge discharge cycles

Power supply during peak and off-peak periods

PV system +batteries

Efficient energy storage battery – 10,000-18,000 cycles

7 a.

6.5 CONDUCTORS

1. Conductor loading

Thermal loading : ambient temperature + max conductor temp

(variations)

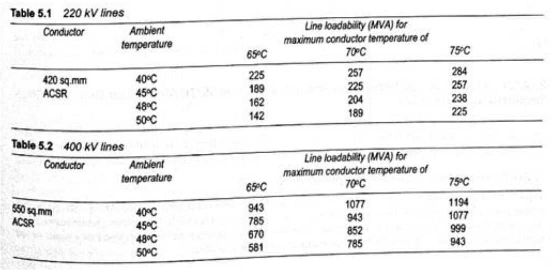


Table 5.1 *220 kV lines*

Conductor	Ambient temperature	Line loadability (MVA) for maximum conductor temperature of		
		65°C	70°C	75°C
420 sq.mm ACSR	40°C	225	257	284
	45°C	189	225	257
	48°C	162	204	238
	50°C	142	189	225

Table 5.2 *400 kV lines*

Conductor	Ambient temperature	Line loadability (MVA) for maximum conductor temperature of		
		65°C	70°C	75°C
550 sq.mm ACSR	40°C	943	1077	1194
	45°C	785	943	1077
	48°C	670	852	999
	50°C	581	785	943

2. High rating conductors

Demand → greater loads on existing system

Existing ACSR should be operated **at <=93℃**

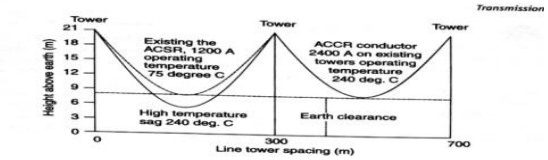
Additional lines are not cost effective

So an alternate was HTLS : low loss , high efficiency

2.a. ACCC

2.b. ACSS

2.c. ACCR

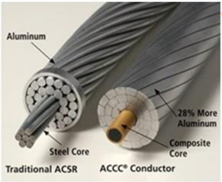


6.5 CONDUCTORS

ACSR

ACCC

- **Composite**(hybrid carbon + glass fibre) core , ↓Weight
- Temp 180℃
- Works at **cooler temp** b/c ↑ Al
- Economical (↓lifecycle costs)
- High strength
- ACSR→ ACCC with same tower best option



ACSS

- Increases capacity by 40%

ACCR

- Drop in replacement of ACSR
- Transmission capacity twice the existing
- Multistrand aluminium matrix core aluminium –zirconium outer wires

7b

6.7 POWER GRID

PGCIL: Takes care of laying and operating transmission system ,

1.Grid formulation: need for a n/w?

Optimal utilization, less spinning reserve

CTU+STU decide inter-state transmission system

Powergrid : pooling functions

a. Supply real power
b. Reactive power supply
c. System control
d. System reliability and security

National power dispatch centres
1. NR: snow fed hydro
2. ER: Low load, Coal
3. WR: Industrial and agricultural
4. NER: Low load, Hydro
5. SR: High load , monsoon hydro

Problems
i. Inadequate capacity
ii. Inadequate T & D system
iii. Wide frequency fluctuations
iv. Abnormal voltage levels
v. Commercial disputes
vi. Reluctance to backdown generation

6.7 POWER GRID

2. Integration grid: REMCs

3. Smart Grid: More power plants is not the solution

a. Demand management
b. Distributed generation
c. Grid management

Self correcting- self healing

4. **Asian power grid**

ASEAN(23 interconnections) SAARC(4 intercountry) and China grid