CH2356 Energy Engineering

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Hydro Power

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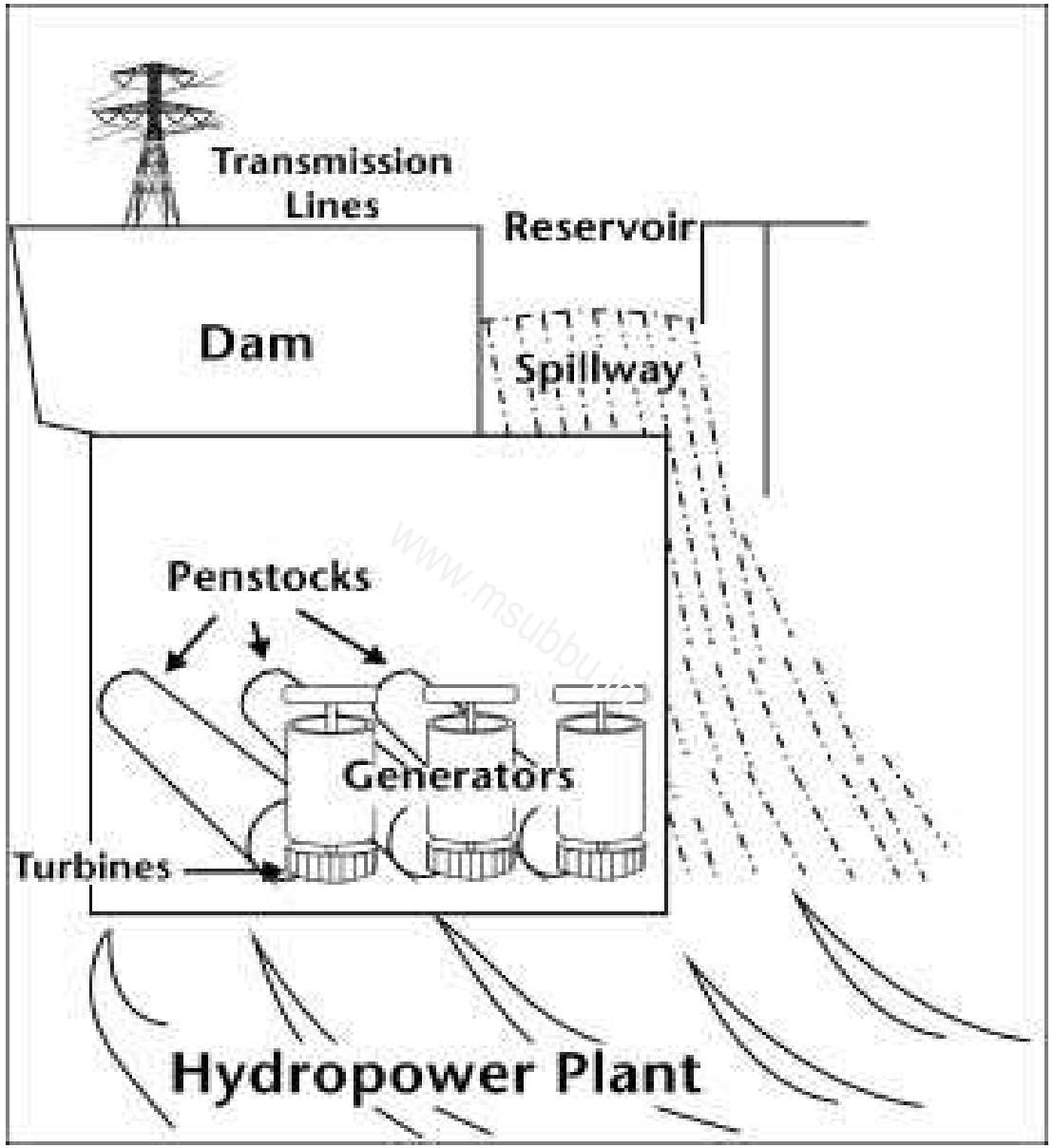
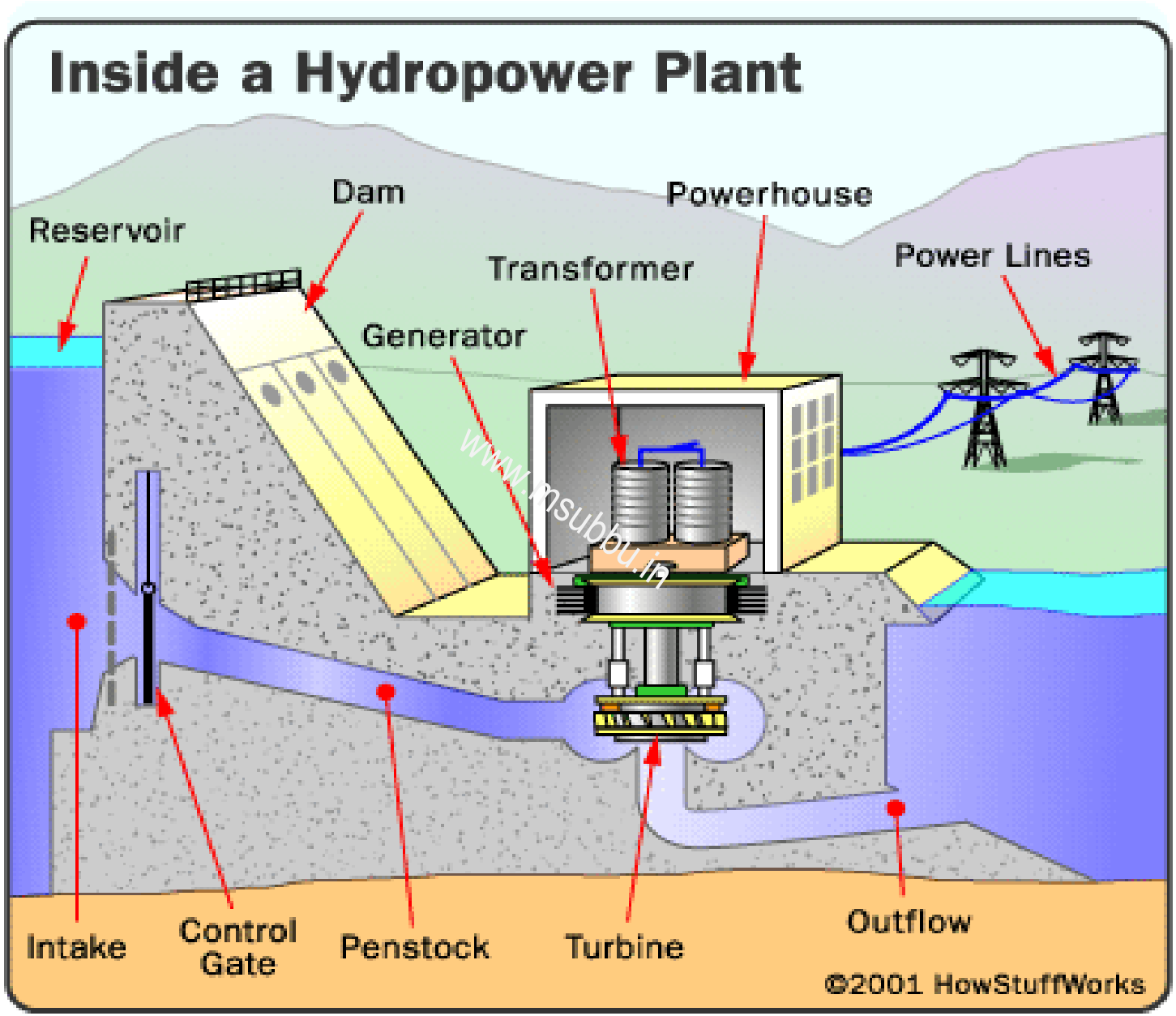

Transmission
Lines
Reservoir
Dam
Spillway
Penstocks
Generators
Turbines
Hydropower Plant

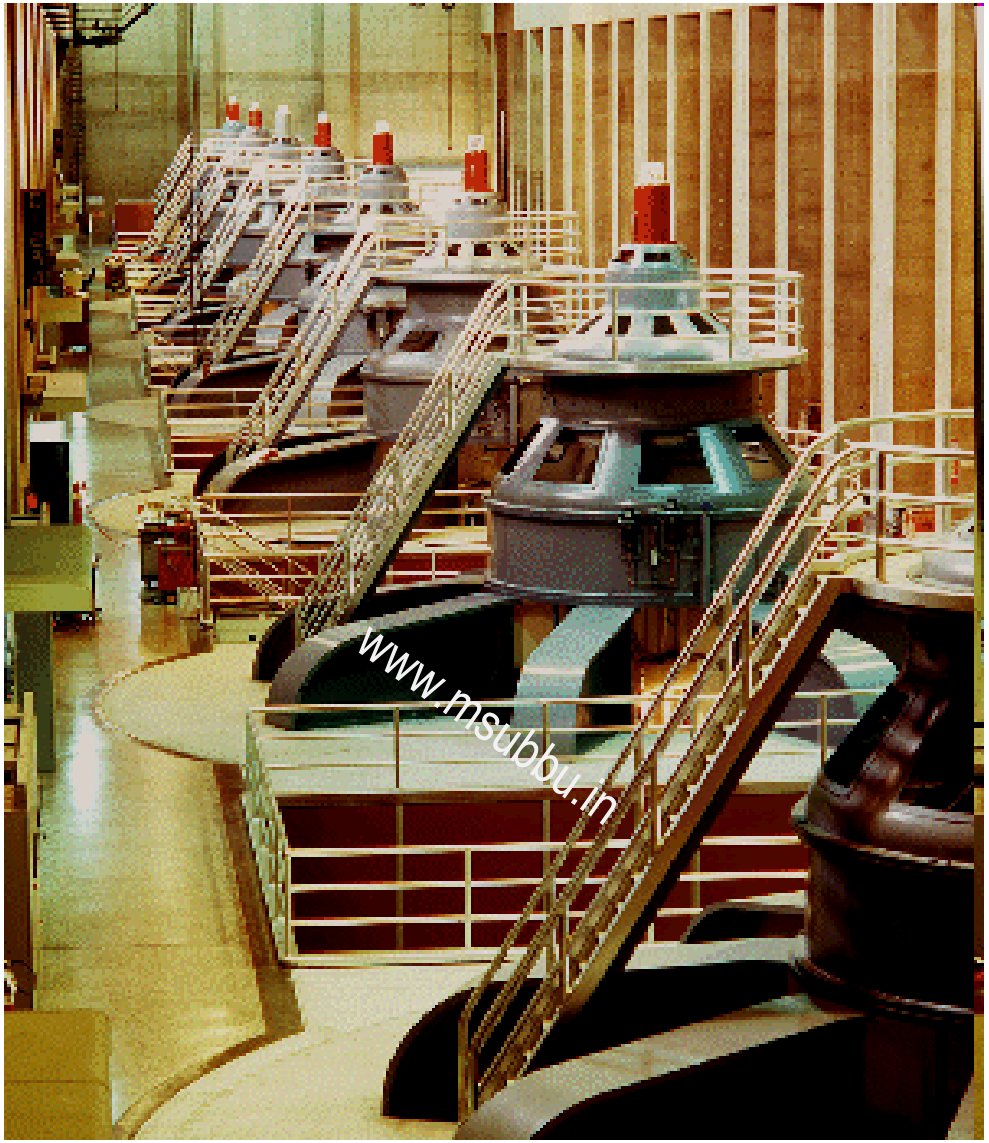


Power output from a dam

$$P = \eta \rho g h \, Q$$

- Modern water turbines are typically over 90% efficient.

The shaft that connects the turbine and generator



The Hoover Dam (USA) has a total of 17 generators, each of which can generate up to 133 Megawatts.

The total capacity of the Hoover Dam hydropower plant is 2,074 megawatts. When completed in 1936, it was both the world's largest electric-power generating station and the world's largest concrete structure. It is currently the world's 35th-largest hydroelectric generating station

Three Gorges Dam (China)

- On the Yangtze river, Three Gorges Dam is the largest hydropower project ever built, and the largest building project in China since the Great Wall.

- The Three Gorges Dam is the world's largest hydro-electric power station by total capacity (as of now) - 22,500 MW

Three Gorges hydropower turbine. The turbines are 35 feet in diameter (11m) and 17 feet high (5m).

Three Gorges Dam

Introduction

- The power from the natural cycle:
  Solar heat → sea water evaporation → rainfall → rivers → sea

- Well-established technology. Accounts for 20% of global electricity production. By far, it is the largest source of renewable energy

- Low operating costs, minimal impact on the atmosphere, quick response to sudden changes in electricity demand, long plant life

- High capital cost, long payback period, serious social and environmental issues to be considered for new hydroelectric schemes

- Mountainous countries like Norway and Iceland are virtually self-sufficient in hydropower. In countries where the resource is less abundant, hydropower is mainly used to satisfy peak-load demand

Global Status

- Worldwide, an installed capacity of 777 GW supplied 2998 TWh of hydroelectricity in 2006. This was approximately 20% of the world's electricity, and accounted for about 88% of electricity from renewable sources.

Global Status

Ten of the largest hydroelectric producers as at 2009.

Country	Annual hydroelectric production (TWh)	Installed capacity (GW)	Capacity factor	% of total capacity
China	585.2	197	0.37	22.25
Canada	369.5	89	0.59	61.12
Brazil	363.8	69	0.56	85.56
USA	250.6	80	0.42	5.74
Russia	167.0	45	0.42	17.64
Norway	140.5	28	0.49	98.25
India	115.6	34	0.43	15.80
Venezuela	86.8			67.17
Japan	69.2	27	0.37	7.21
Sweden	65.5	16	0.46	44.34

Developments in India

- India's first major hydroelectric power installation started generating electricity in 1902, in Sivasamudram, upper course of the Cauvery river, in South India
- Sivasamudram power station initially transmitted 3 MW, for use in Kolar gold field mines.
- Started based on the technology and machinery first developed by Westinghouse and then by General Electric (GE) at Niagara falls for Nayagara Power Company, USA

India's Status as on 2007

- India has an assessed hydropower potential to the tune of 84,000 MW at 60% load factor (148,701 MW installed capacity).; out of this only about 20% has been developed so far.

- India is endowed with rich hydropower potential; it ranks fifth in the world in terms of usable potential. However, less than 25% has been developed or taken up for development.

India's Hydro Potential

Basin/Rivers	Probable Installed Capacity (MW)
Indus Basin	33,832
Ganga Basin	20,711
Central Indian River system	4,152
Western Flowing Rivers of southern India	9,430
Eastern Flowing Rivers of southern India	14,511
Brahmaputra Basin	66,065
Total	**1,48,701**

In addition, 56 number of pumped storage projects have also been identified with probable installed capacity of 94,000 MW. In addition to this, hydro-potential from small, mini & micro schemes has been estimated as 6 782 MW from 1,512 sites. Thus, in totality India is endowed with hydro potential of about 2,50,000 MW. However, exploitation of hydro-potential has not been up to the desired level due to various constraints confronting the sector.

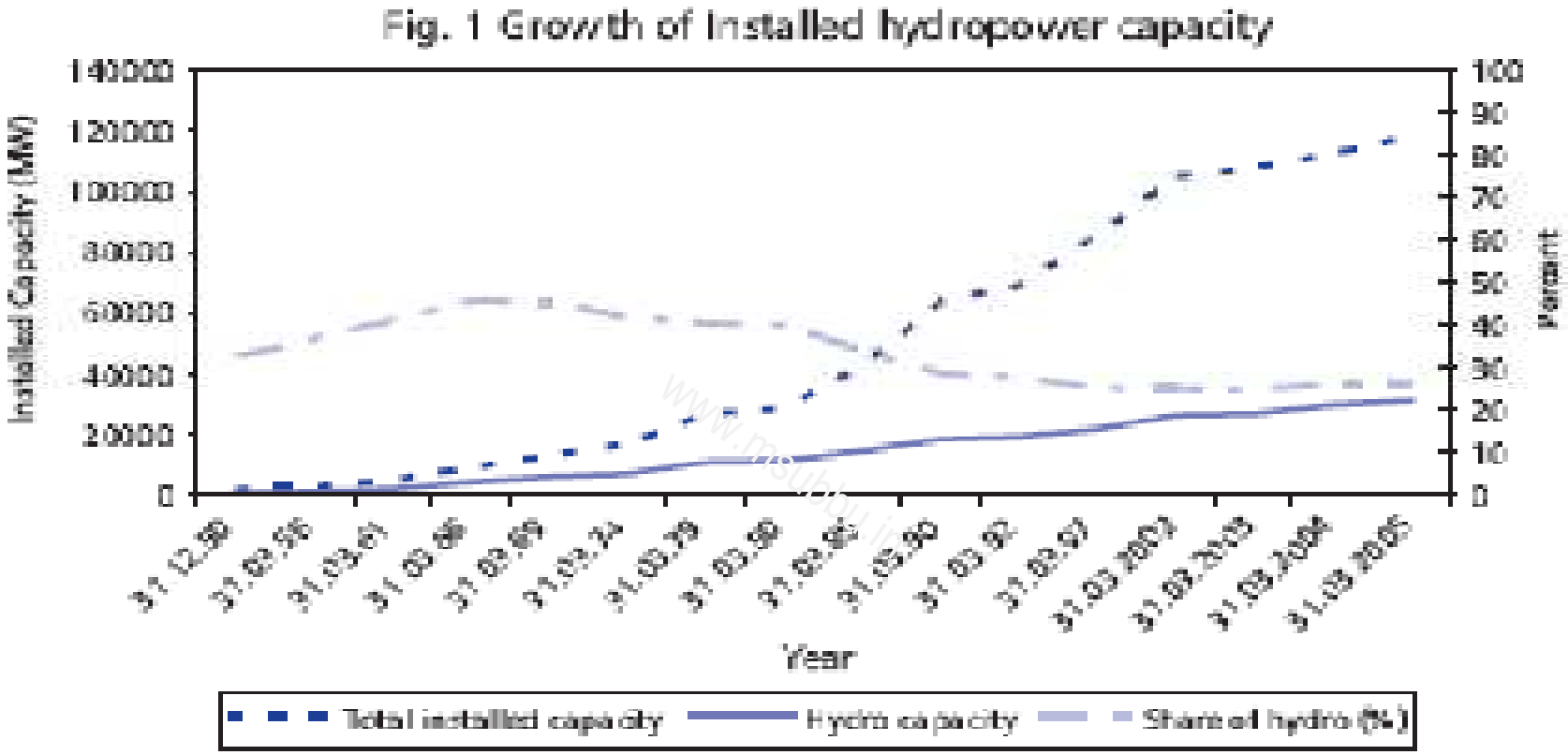
India's Status as on 2007

- The installed generating capacity in India (in utilities) as of 31 March 2006 was nearly 125,000 megawatts (MW). This included thermal (coal, gas and liquid fuel), hydro, nuclear, and renewable based generation. Hydropower constituted about 32,325 MW.

- The energy resources of the country are unevenly distributed with bulk of the hydro resources in the northern and north-eastern part, and fossil fuel resources in the central and western parts.

- The Indus, Brahmaputra and Ganga together account for nearly 80% of the total potential.

- India has an identified small hydro (up to 25 MW) potential of nearly 10,000 MW distributed over 4,000 sites. It is estimated there is still an unidentified potential of almost 5000 MW. Nearly 1,500 MW of potential has already been tapped and projects amounting to around 600 MW are under construction.



Hydropower growth in India

Installed Capacities of Electricity

Fuel	GW	%
Total Thermal	**96.8**	**64.6**
Coal	79.2	53.3
Gas	16.4	10.5
Oil	1.2	0.9
Hydro	36.9	**24.7**
Nuclear	4.1	**2.9**
***Renewable Energy Sources** (MNRE)	13.2	**7.7**
Total	**151.1**	

*Includes: wind, small-hydro (capacity < 25MW), and bio power.
As on July 31, 2009, Source CEA

Advantages of Hydropower

- It is totally renewable and non-polluting and can also provide a more stable price regime over a long period of time.
- It has inherent capability for quick starting, stopping, load variations, etc. and is thus ideally suited for meeting the peaking demand.
- Generation cost is not only inflation free but it also reduces with time.
- Development of hydropower projects is also in many cases associated with irrigation, drinking water, flood control, navigation and tourism benefits.

Advantages of Hydropower (contd.)

- Pumped storage plants can effectively regulate the energy availability during the day by pumping up water into the reservoir during off-peak hours when there is surplus energy in the grid and generating power from this stored water when needed during peak hours. They can also quickly reverse their mode of operation from pumping to generating and vice versa. Thus pumped storage plants can play an important role in meeting the peak demand and also in improving the grid stability and load factor of thermal power stations.

- Small hydro plants have least environmental impacts and would be ideally suited for rural electrification particularly in remote areas.