Heat Rate – Current status and possible improvements

By

Dhiraj Kr. Srivastava,

Chief Engineer, Central Electricity Authority

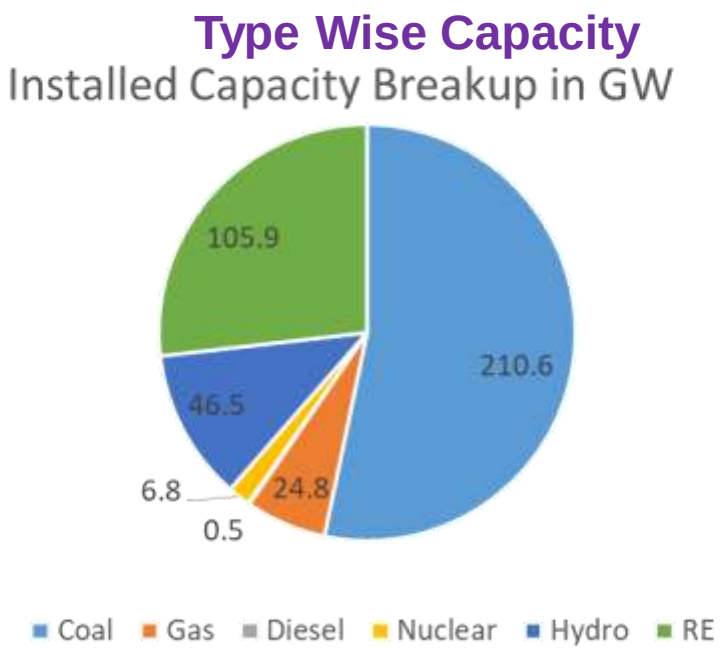
Indian Power Scenario - Present

FY 2021-22

Total Installed Capacity ~ 395.1 GW

Peak Demand ~203 GW

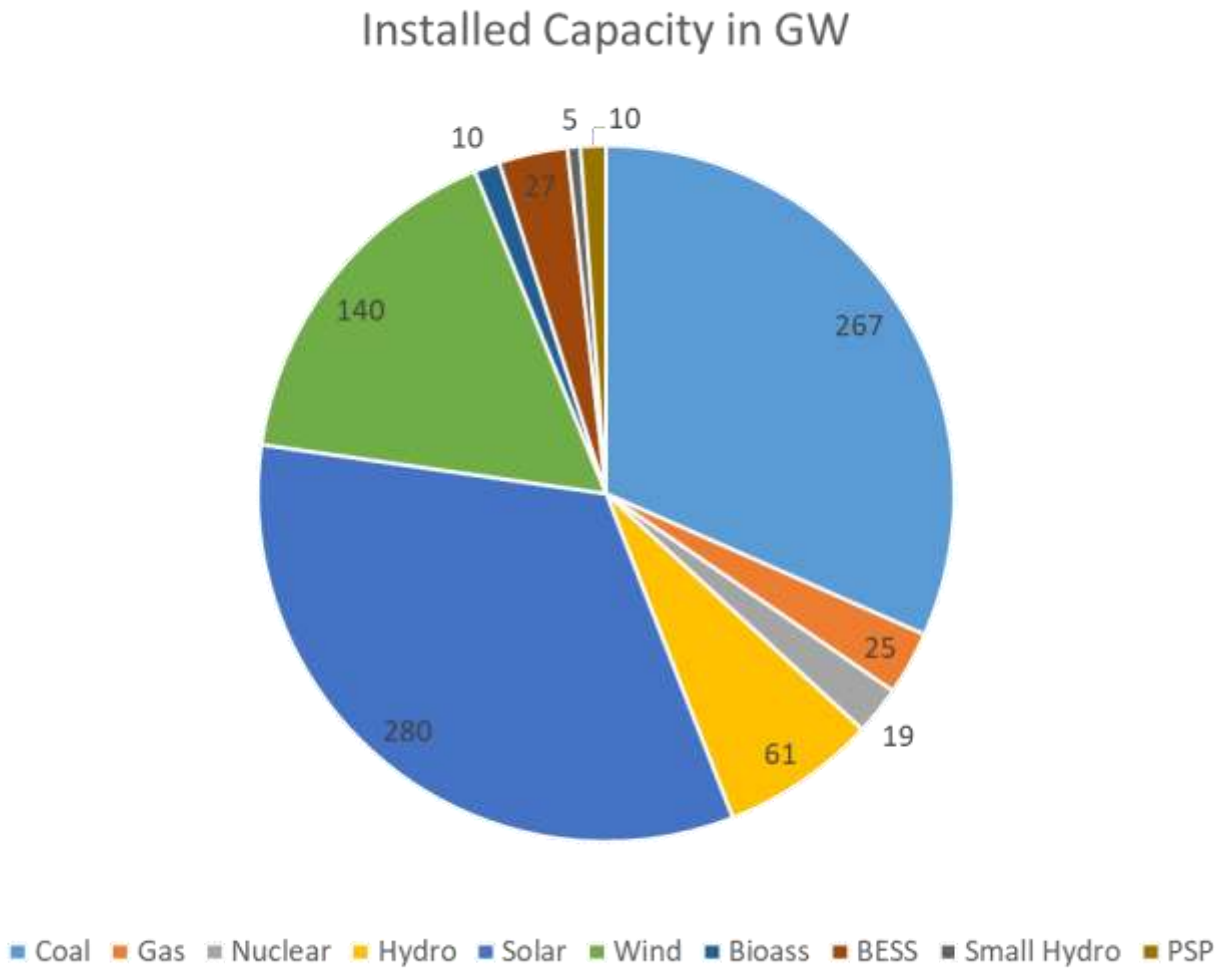
Renewable 105.9 GW



Power deficit ~ 1.2% (MW) and .4%(MU)

All India Average PLF ~ 60%

Expected Installed Capacity by 2030



- Per capita electricity consumption – increased from 592 kWh (2003-04) to **1181 kWh (2018-19)** around 11k in US and 3k in China
- Supply gap of peak electricity demand and electrical energy requirement - **in the range of 1-1.5%**
- India is aiming to have **40 %** of total installed capacity by year 2030 based on non-fossil fuel sources – Intended Nationally Determined Contributions (INDCs).
- Projected gross electricity generation (BU) during year 2029-30 is likely to be 2,518 BU -broadly comprising of

  1,393 BU - Thermal (Coal, Gas and Lignite),

  801 BU - RE Sources,

  207 BU - Hydro, 4.4 BU - PSS and 113 BU - Nuclear

Proviso of CEA Regulation

- Gross Turbine Cycle Heat Rate - in relation to coal or lignite based thermal generating station, means the external heat energy input to the turbine cycle required to generate one kWh of electrical energy at generator terminals

(General Practice - *The integrated readings of fuel burned and generation are (i.e. daily, weekly, or monthly) used to calculate the actual heat rate. Actual heat rate includes fuel burned during startups, and includes the negative net generation during off-line periods*)

- The gross turbine cycle heat rate as guaranteed by the equipment manufacturer shall not exceed the following values:

Heat rate* (kcal/ kWh) at 100% MCR

Unit rating (MW)	with motor driven BFP	with turbine driven BFP
50 to less than 100 MW**	2280	
100 to less than 200 MW**	2000	
200 to less than 250 MW**	1970	
250 to less than 500 MW**	1955	
500 MW and above	1895	1935
Supercritical units	1770	1830
Ultra Supercritical units	1725	1790

*corresponding to reference conditions of 33 degree centigrade cooling water temperature and 0% de-mineralised water make up.
** sub-critical units (< 221.2 bar).

state	Design HR*	Actual HR*	Deviation
Jharkhand	2382	2450	103%
Odisha	2295	2454	107%
West Bengal	2255	2393	106%
Haryana	2264	2459	109%
Punjab	2517	2451	97%
Rajasthan	2312	2500	108%
Uttar Pradesh	2327	2413	104%
Andhra Pradesh	2132	2395	112%
Karnataka	2163	2355	109%
Tamil Nadu	2364	2601	110%
Telangana	2145	2233	104%
Chhattisgarh	2260	2440	108%
Gujarat	2361	2517	107%
Madhya Pradesh	2312	2373	103%
Maharashtra	2262	2593	115%

*Mostly >210 MW units except few 130 and 110 MW in Raj, Kar, Guj

Previous years FY 19-20 and 18-19

Sl No.	Description	SHR	Remarks
1	Av SHR FY 19-20	2504	51 stations
2	Av SHR FY 18-19	2473	78 stations
3	Private FY 18-19	2727	8 stations (Av Des. 2500)
4	Private FY 19-20	2744	8 stations (Av Des 2500)
5	Private FY 20-21	2700	8 stations (Av Des 2500)
6	State FY 18-19	2492	18 stations (Av Des 2294)
7	State FY 19-20	2490	18 stations (Av Des 2294)
8	State FY 20-21	2166	18 stations (Av Des 2294)

Salient Points – Heat Rate improvement in plants

- 100% conversion of chemical energy in fuel to electricity – HR of 860 kcal/kWh
- Improvements are possible easily in range of 1-2 percentage points in few plants.
- Can start with small improvements, concentrating on one or two areas, (condenser performance and or burner balancing) or by concentrating on one or two activities (i.e., monitoring primary process indicators, testing, etc.)
- Efforts need to be made not just to maintain current status, but even more effort need to make improvements.

Salient Points – Heat Rate improvement in plants

- Detailed plan listing specific activities that are to be carried out to make improvements needed with continuous review of improvement activities.
- Heat rate improvement is a continuing process
  - must be made part of normal work activities,
  - must be considered at par with, reliability, safety, environmental concern, etc., when operating unit, scheduling maintenance, and all other routine activities.
- Heat rate improvement is responsibility of everyone. It cannot be assigned to one individual or organization, but requires active involvement of entire plant staff.

Basic enquiry

- Foremost thing –
  - whether actual heat rate of the unit known accurately and checked regularly?
- Design heat rate of the unit compared to the actual?
- Gap between actual and design - further broken down into to various parameters and is this information tracked over time and comparisons made between similar units?
- Root cause analysis of recurring gaps?
- Is there a written action plan developed- listing specific verifiable actions to improve the heat rate ?

Aspects of Heat Rate Variation

1. Steam Extractions

- Several pieces of auxiliary equipment may be present in plant that are supplied with steam.
- Such steam is extracted either from turbine extraction or from the drum, or some other location.
- Regardless of the source of steam, its use comes at some price. – i.e. loss of KWh production
- Therefore use (or excessive use) of this steam causes a heat rate deviation

Aspects of Heat Rate Variation

2. Condenser pressure

- Generally one of the largest cause for heat rate deviations at a plant.

- With rise of pressure in the condenser, amount of energy extracted from each kilogram of steam is reduced.

- Approximately 1% of output of IP/LP turbine will be lost for every 6 mm Hg increase in condenser pressure.

Aspects of Heat Rate Variation

3. Final feed water temperature. For a typical unit, for every 1°C, decrease in final feed water temperature, boiler has to absorb 0.24 % more heat.

4. Loss due to reduced turbine section efficiency is calculated for each turbine that operates entirely in superheated steam region

5. For once through boilers (boilers without a drum), pressure drop through circuit can increase significantly, causing boiler feed water pumps to work harder than normal

Aspects of Heat Rate Variation

6. Unburned carbon in fly ash samples (collected periodically) represents chemical energy that was supplied to the boiler, but was not converted to thermal energy, extracted, rather it was lost.

7. Exit gas temperature, energy that is lost out the stack.

8. Amount of moisture in fuel increases, boiler efficiency decreases - as some of the heat released goes into heating and vaporizing the moisture.

9. Hydrogen content of the fuel increases, boiler losses increase as water is formed from burning of hydrogen.

Modifications that may improve HR

- **BOILER ISLAND**
  - Materials handling
  - Boiler operation/overhaul with new heat transfer surface
  - NN control system
  - Intelligent soot blowing system
  - Air heaters

Modifications that may improve HR

- **TURBINE ISLAND**
  - Turbine overhaul
  - Feedwater heaters
  - Condenser
  - Turbine drive/motor-driven feed pumps
- **FLUE GAS SYSTEM**
  - Improved FD and ID fan efficiency
  - VFDs

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- **FLUE GAS SYSTEM**
  - Improved FD and ID fan efficiency
  - VFDs
    - Single-speed motors with variable inlet vanes (VIVs) as a throttling mechanism
    - Variable-speed as either a fluid-coupling or VFD
    - Two-speed motor with damper or VIV
    - Variable-pitch blades (VPBs)

THANK YOU