ELECTRICITY SAVING OPPORTUNITIES IN INDUSTRIAL AND COMMERCIAL SECTORS

WEBINAR FOR
SAARC ENERGY CENTER,
ISLAMABAD
DATE: 28.07.2020

East Coast

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ELECTRICITY SCENARIO

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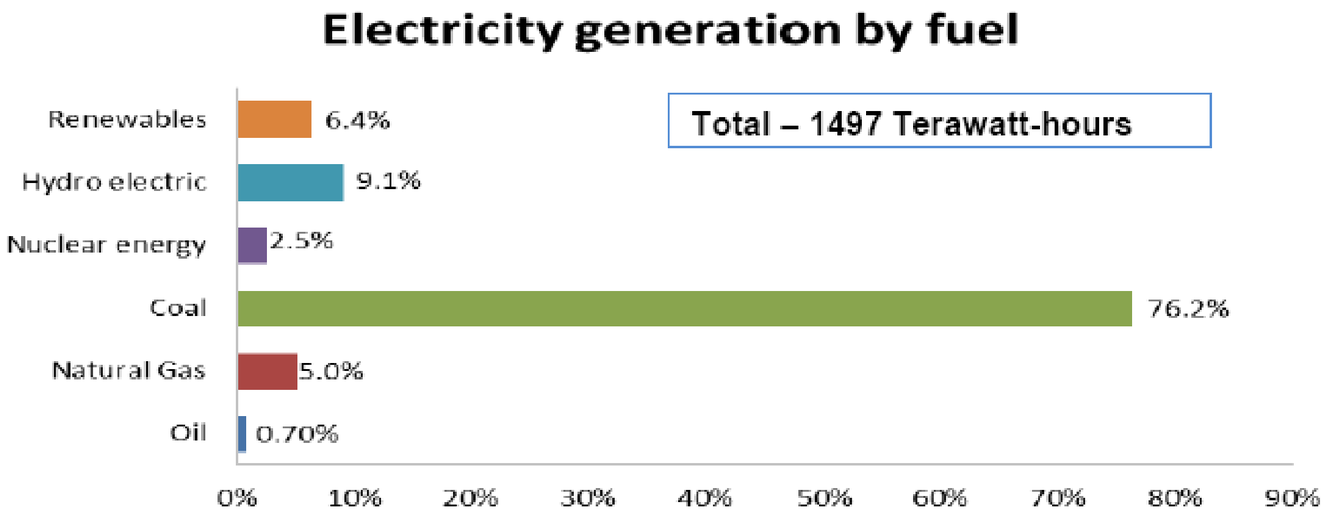
ELECTRICITY



1 Introduction

- India is the world's third largest producer and consumer of electricity with capacity of 344 GW as on 31 May 2018.
- India's electricity sector is dominated by coal-based power plant for meeting about 76.2% of all electricity.

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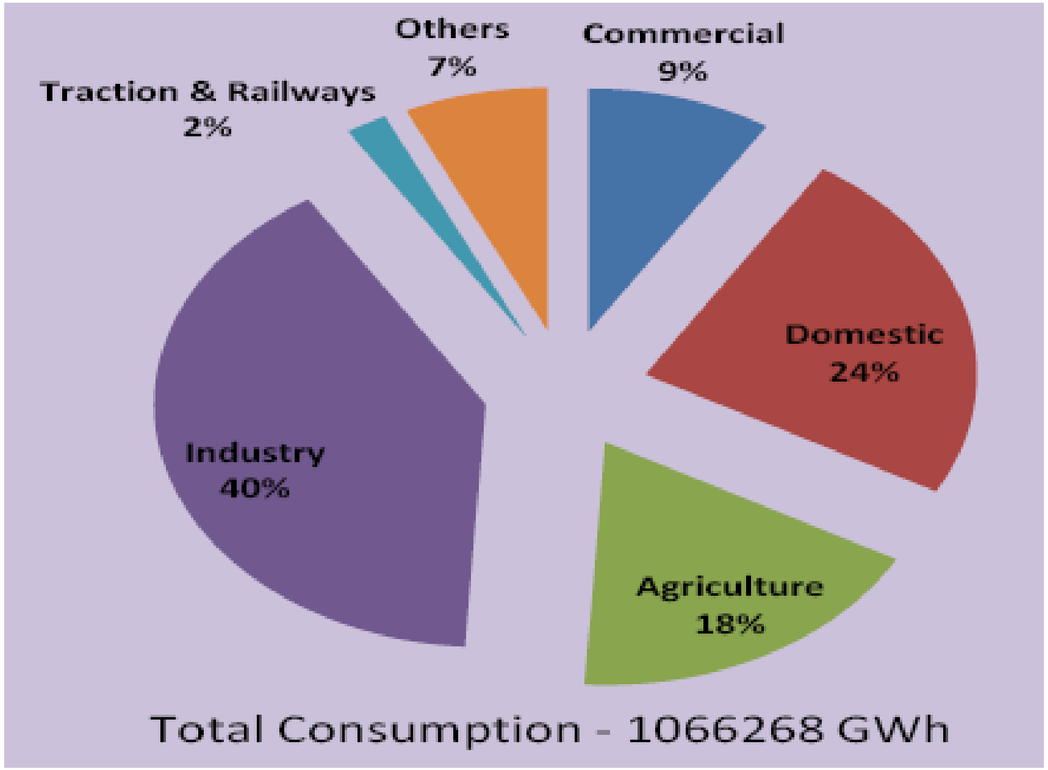
ELECTRICITY



2 Electricity consumption

- The overall plant load factor (PLF) of all thermal power plants is only about 65%.
- Industry dominates electricity consumption (40%) followed by domestic (24%) and agriculture (18%).

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ENERGY PRODUCTIVITY INDICATORS

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1 Benchmarking of Sectoral Energy Efficiency

- Benchmarking is the process of accounting for and comparing a metered industrial facility's current energy performance with its energy baseline or with the energy performance of similar types of industry. The United Nations Industrial Development Organization (UNIDO).

- benchmarked the energy efficiency potential for 26 industrial sub-sectors globally by looking at sector specific indicators of performance in terms of energy per unit of output (UNIDO 2010) (refer Table on the next slide).

- The study broke down the results in developing and developed countries and also presented figures for the global average, the lowest found in the sample and the achievable performance using Best Available Technology (BAT).

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Table: Specific Energy Consumption in Industry – India and the World

Sector	Unit	Industrialized Country	Developing Country	Global Average	Best available Technology	India
Petroleum refineries (2003)	*Energy Efficiency Index (EEI)*	*0.7 – 0.8*	*1.3 – 3.8*	*1.25*	*1*	*0.9*
High Value (HVC)	*Gj/t HVC*	*12.6 – 18.3*	*17.1 – 18.3*	*16.9*	*10.6*	*17.1*
Ammonia (2007)	*Gj/t NH3*	*33.2 – 36.2*	*35.9 – 46.5*	*41*	*23.5*	*37.5*
Methanol (2006)	*Gj/t MeOH*	*33.7 – 35.8*	*33.6 – 40.2*	*35.1*	*28.8*	*40.2*
Aluminium Smelting (2007)	*MWh/t*	*14.8 – 15.8*	*14.6 - 15*	*15.5*	*13.4*	*16*

Benchmarking of Sectoral Energy Efficiency

Table: Specific Energy Consumption in Industry – India and the World

Sector	Unit	Industrialized Country	Developing Country	Global Average	Best available Technology	India
Alumina Production	*Gj/t alumina*	*10.9 – 15.5*	*10.5 – 24.5*	*16*	*7.4*	*--*
Iron & Steel (2005)	*Gj/t steel*	*1.6 – 1.4*	*1.4 - 2.2*	*1.45*	*1*	*1.55*
Clinker (2007)	*Gj/t clinker*	*3.3 – 4.2*	*3.1 – 6.2*	*3.5*	*2.9*	*3.1*
Cement (2007)	*Gj/t cement*	*109 - 134*	*92 - 121*	*109*	*56*	*92*
Lime	*Gj/t lime*	*3.6 - 13*	*5 - 13*	*--*	*--*	*5.6*
Glass (2005)	*Gj/t melt*	*4 - 10*	*6.8 - 7.8*	*6.5*	*3.4*	*6.8*
Brick making (2000s)	*Gj/kg fired brick*	*1.5 - 3*	*0.75 - 11*	*--*	*--*	*3 - 11*

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Table: Specific Energy Consumption in Industry – India and the World

Sector	Unit	Industrialized Country	Developing Country	Global Average	Best available Technology	India
Pulp & Paper	*EEI (heat & electricity)*	*0.93 – 1.73*	*0.43 – 2.29*	*1.31*	*1*	--
Textiles - Spinning	*Gj/t yarn*	*3.5 – 3.6 (ring yarn)* *2.57 (open end)*	*3.5 – 3.6 (ring yarn)* *0.5 – 7.5 (other)*	--	--	*3.57 (ring yarn)* *2.5 (other)*
Textiles - Weaving	*Gj/t cloth*	*11 – 65*	*5 - 43*	--	--	*27 – 32.4*

Table: Specific Energy Consumption in Industry – India and the World

Sector	Unit	Industrialized Country	Developing Country	Global Average	Best available Technology	India
Cast Iron	*kWh/t melt*	*950 (cupola)* *525 – 715 (electric)*	*780 – 850* *--*	*--* *--*	*520* *--*	*780 – 900* *--*
Cast/ alloy steel	*kWh/t melt*	*525 – 715 (electric)*	*--*	*--*	*--*	*--*
Cast aluminium	*kWh/t melt*	*600 – 1250 (fuel fired)* *440 – 590 (electric)*	*735* *590*	*--* *--*	*500* *570*	*735* *--*
Cast copper	*kWh/t melt*	*400 – 1100 (electric)*	*590*	*--*	*400*	*590*

KEY THRUST AREAS OF ENERGY CONSERVATION ACT, 2001

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KEY PROVISIONS OF EC ACT 2001

1 Standard

- Energy-efficiency standards are procedures and regulations that prescribe limits on the energy consumption of manufactured products.

- Intention is to prohibit the sale of products that are less energy efficient than the minimum prescribed standards, called as Minimum Energy Performance Standards (MEPS).

2 Standard

- Energy-efficiency labels are information affixed to manufactured products and usually communicate the product energy performance.

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2 Comparative Labels

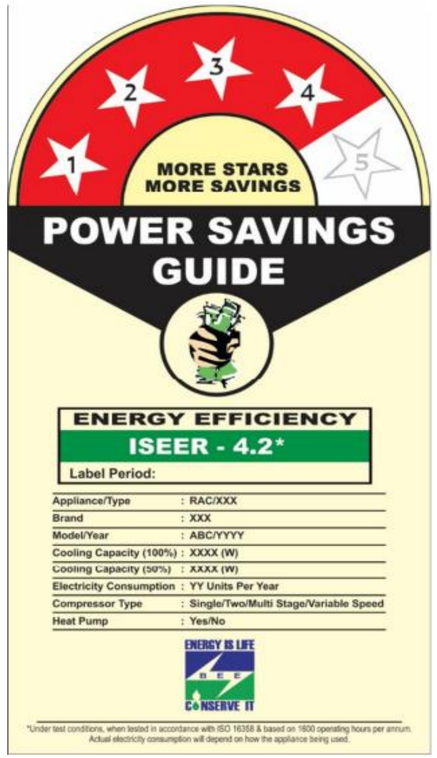
Products notified under mandatory labelling

As of Sep. 2018, the following products have been notified under mandatory labelling:

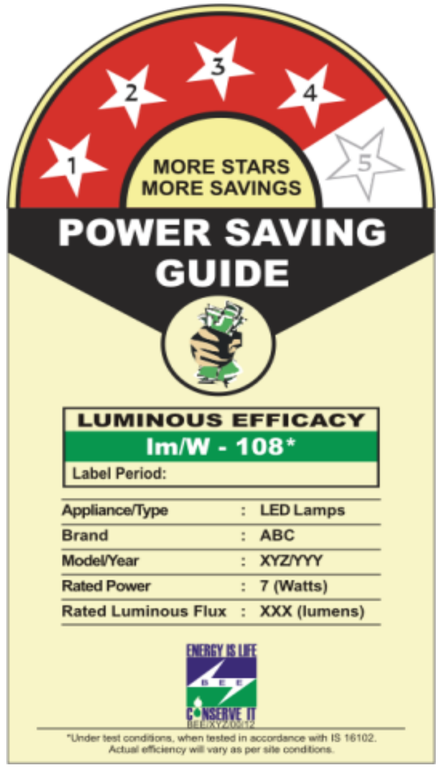
1. Frost Free (no-frost) refrigerators	6. Direct Cool Refrigerators
2. Tubular Fluorescent Lamps	7. Electric Geysers
3. Room Air Conditioner	8. Color TV
4. Distribution Transformers	9. Room Air Conditioners (Inverter type)
5. Room Air Conditioner (Cassette, Floor Standing Tower, Ceiling, Corner, Corner AC)	10. LED lamps

KEY PROVISIONS OF EC ACT 2001

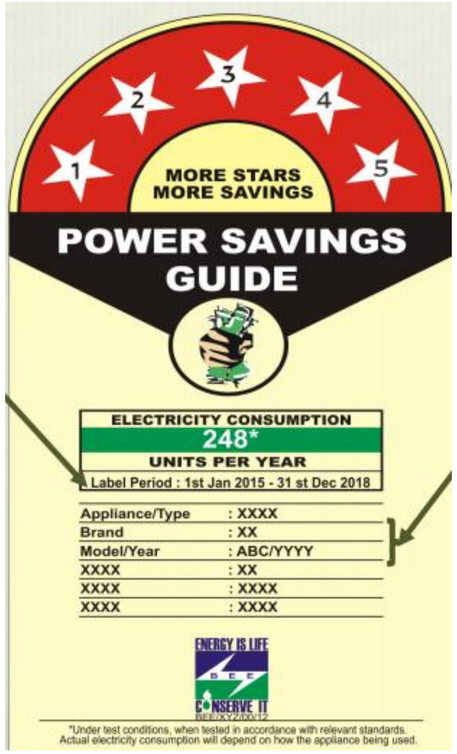
2 Comparative Labels



Sample Label for Air Conditioners



Sample Label for LED lamps



Sample Label for Refrigerator

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KEY PROVISIONS OF EC ACT 2001

3 ECBC

Purpose

- Energy Conservation Building Code (ECBC) encourage energy efficient design of buildings without affecting the building function, comfort, health, or the productivity of the occupants.
- ECBC also addresses local design conditions and helps improve existing construction practices.
- The emphasis of BEE is on Integrated Building Design approach.
- ECBC is also easy to use and encourages continuous improvisations.
- The code was revised and updated in 2017 to match with the technology developments to set higher benchmarks for energy efficiency.

KEY PROVISIONS OF EC ACT 2001

4 PERFORM ACHIEVE & TRADE

National Mission on Enhanced Energy Efficiency (NMEEE) is one of the eight missions which formed India's National Action Plan on Climate Change (NAPCC).

OBJECTIVE

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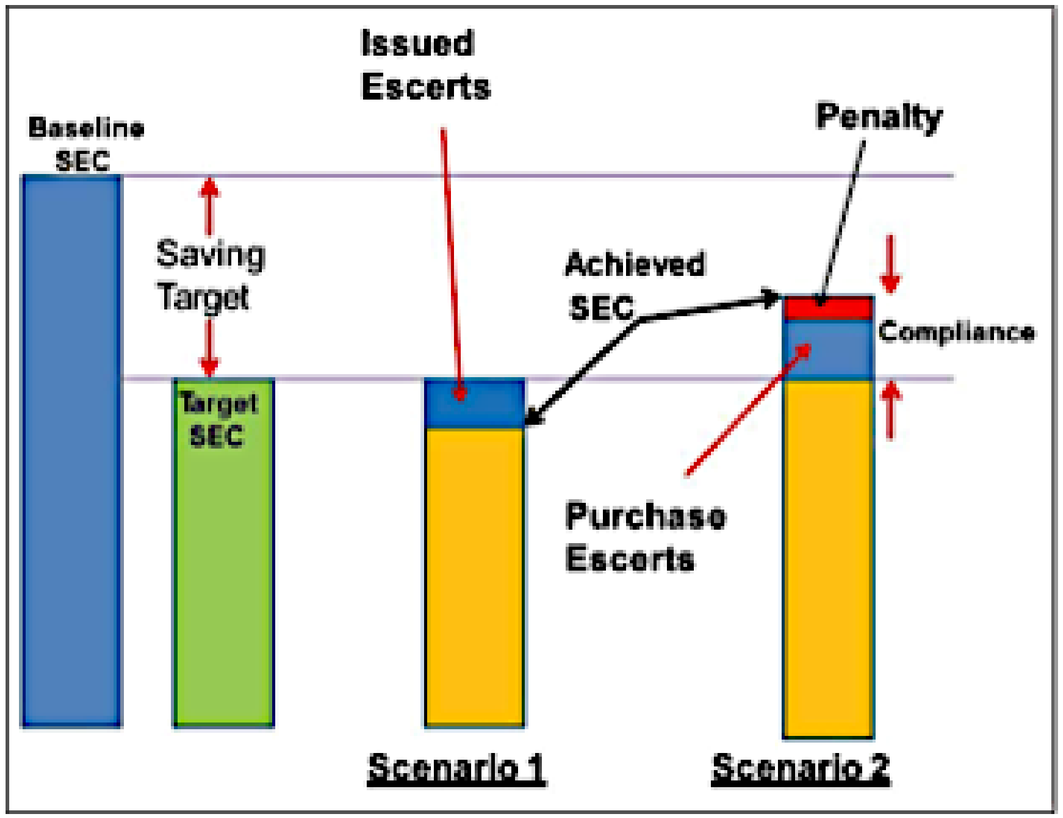
KEY PROVISIONS OF EC ACT 2001



Concept of Target, Compliance, ESCerts and Penalty

4 PERFORM ACHIEVE & TRADE

- PAT mandates specific energy efficiency improvements for the most energy intensive industries.
- The scheme is based on the wide variations in specific energy consumptions (baseline SECs) of different units in each notified sector.
- The units in terms of SECs range from among the best in the world to some of the most inefficient units.

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ENERGY EFFICIENCY IN INDUSTRIAL SECTOR

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1 Introduction

Electrical	Thermal

• Energy Efficient Motors
• Applications of VFD
  ○ Fans
  ○ Pumps
  ○ Compressors
• High COP chillers
• Internet of Things (IOT) Applications for Chiller System
	• Pressure reducing turbine
	• Heat pump
	• Heat Pipe applications
	• Condensing boiler
	• Absorption chillers
	• Trigeneration
	• Organic Rankine Cycle

2 Energy Efficient Motors

Class Type	Class Number
Standard efficiency	IE1
High efficiency	IE2
Premium efficiency	IE3
Super premium efficiency	IE4

2 Replacing IE1 motor with IE3

The information regarding the old motor and the operation pattern is as follows:

Rated Power	37 KW
No. of Poles	4
Efficiency	91.2 (IE1)
Operating hours per day	10
Operating days per year	360

2 Replacing IE1 motor with IE3

The annual energy consumption is calculated as follows:

- Annual Energy Consumption (kWh per Year) =
- 37 kW/0.912 x 10 hours per day x 360 days/ year = 1,46,052 kWh
- It is proposed to replace IE1 is replaced with IE3 motor as per following specifications:

Rated Power	37 KW
No. of Poles	4
Efficiency	93.9 (IE3)
Designed lifespan	400,000 hours

- The percentage of energy-saving and the anticipated annual energy saving is calculated below:

$$\textbf{Percentage of energy savings (\%)} = \left(1 - \frac{91.2}{93.9}\right) \textbf{ x 100\% = 2.88 \%}$$

Annual Energy Savings (kWh per year) *= 1,46,052 kWh per year x 2.88 / 100 =* ***4206 kWh / year***

2 Replacing IE1 motor with IE4

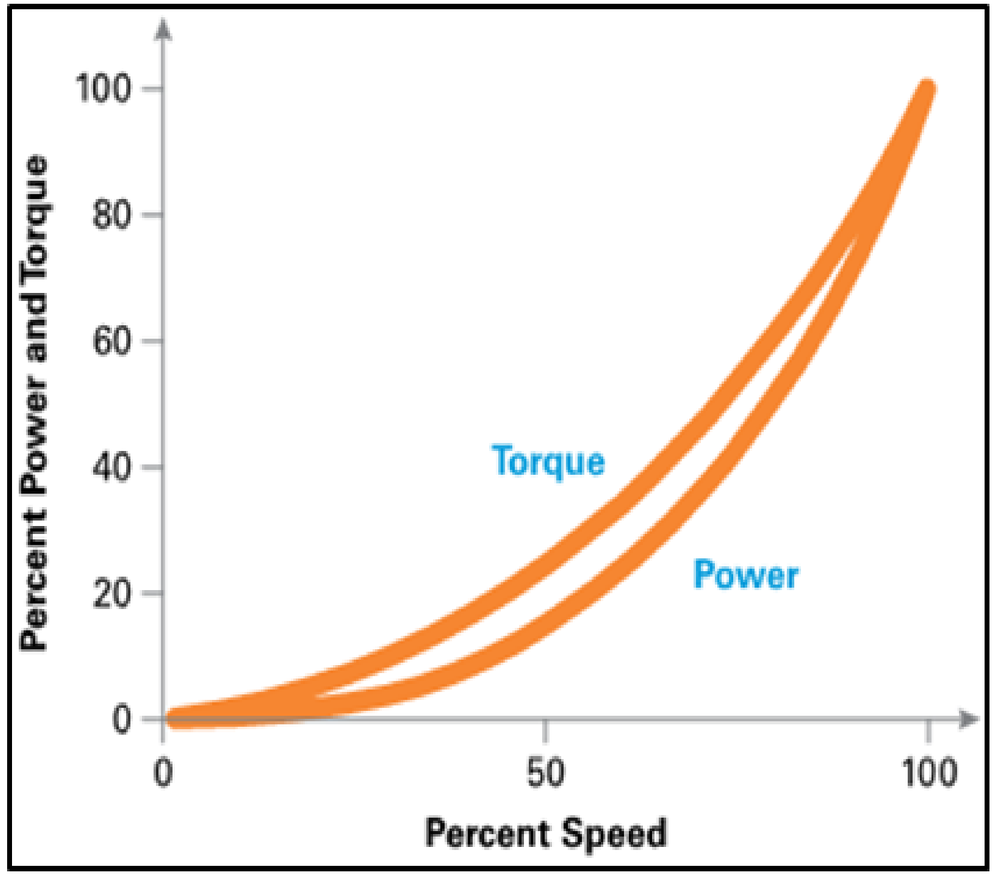
If the new motor is IE4 with following specifications, energy savings is as follows:

Rated Power	37 KW
No. of Poles	4
Efficiency	95.2 (IE4)
Designed lifespan	400,000 hours

- The percentage of energy-saving and the anticipated annual energy saving is calculated as follows:

$$\textbf{Percentage of energy savings (\%)} = \left(1 - \frac{91.2}{95.2}\right) \textbf{ x 100\% = 4.22 \%}$$

Annual Energy Savings (kWh per year) *= 1,46,052 kWh per year x 4.2 %* = ***6134 kWh / year***



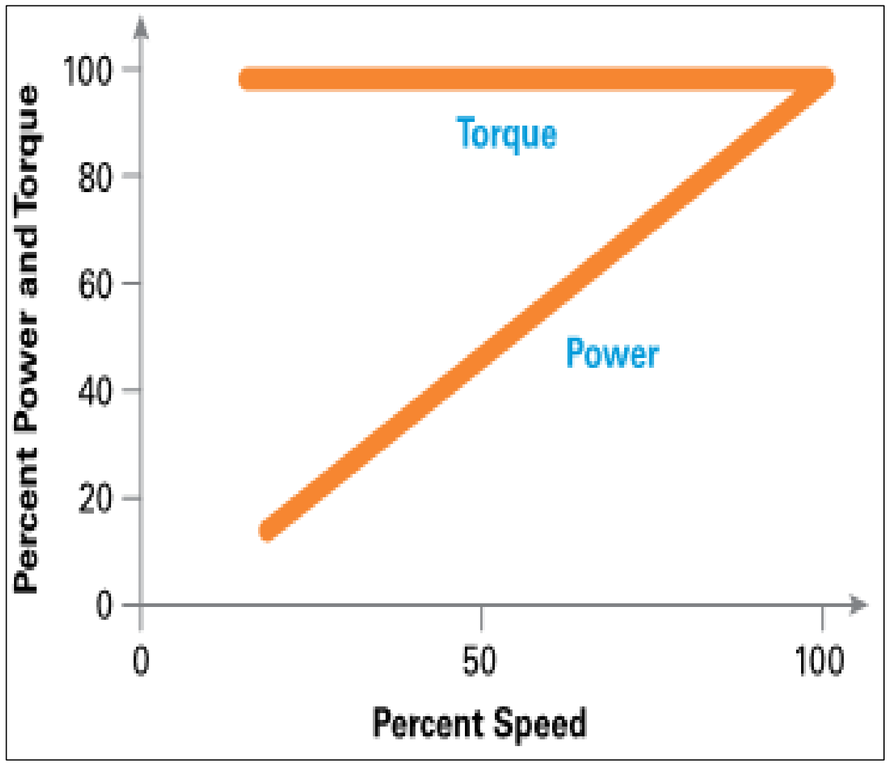
3 VFD-Variable Torque Load

Variable Torque loads are typical of centrifugal fans and pumps and have the largest energy saving potential. They are governed by the Affinity Laws which describe the relationship between the speed and other variables:

- The change in flow varies in proportion to the change in speed: **Q1/Q2 = (N1/N2)**
- The change in head (pressure) varies in proportion to the change in speed squared: **H1/H2 = (N1/N2)2**

The change in power varies in proportion to the change in speed cubed : **P1/P2 = (N1/N2)3**

Where, Q = volumetric flow, H = head (pressure), P = power, N = speed (rpm)



3 VFD-Constant Torque Load

Typical constant torque applications include conveyors, agitators, crushers, positive displacement pumps and air compressor. On constant torque loads the torque remains constant with speed and the power absorbed is directly proportional to the speed this means that the power consumed will be in direct proportion to the useful work done, for example a 50% reduction in speed will result in 50% less power being absorbed or consumed.

3 VFD CASE STUDY

Sl.No	Location	Units	VRM Raw mill Fan With GRR	VRM Raw mill Fan With VFD
1	Design Flow	M3/Hr	580000	580000
2	Design Total Head	mmWG	919	919
3	Inlet Damper Position	%	100	100
4	Speed Control Type		GRR	VFD
5	Gas Temperature	˚C	90	90
6	Volume of gas	m3/s	135.48	135.48
		m3/Hr	487738	487738
		Nm3/Hr	335640	335640
7	Head Developed by the Fan	mmWG	785	785
8	Motor Rated Output Power	kW	2050	2050
9	Motor Rated Efficiency	%	95	95
10	Measured Input Power before VFD/GRR	kW	1522	1424
11	VFD Loss/GRR Loss	kW	155	57
12	Motor Input Power	kW	1367	1367

Replacing GRR control with VFD for Raw Mill Fan drive		
Parameter	**Unit of measurement**	**Value**
Present flow handled by Raw Mill fan	m3/hr	487738
Present head developed by Raw Mill fan	mmWC	785
Present Motor Input Power	kW	1367
Present GRR loss	kW	155
Estimated VFD loss	kW	57
Additional power saved due to smooth control with VFD	kW	68
Total Power savings	kW	166
Operating Hours	Hr/year	4000
Annual Energy Savings	kWh/year	665567
	MU/year	0.67

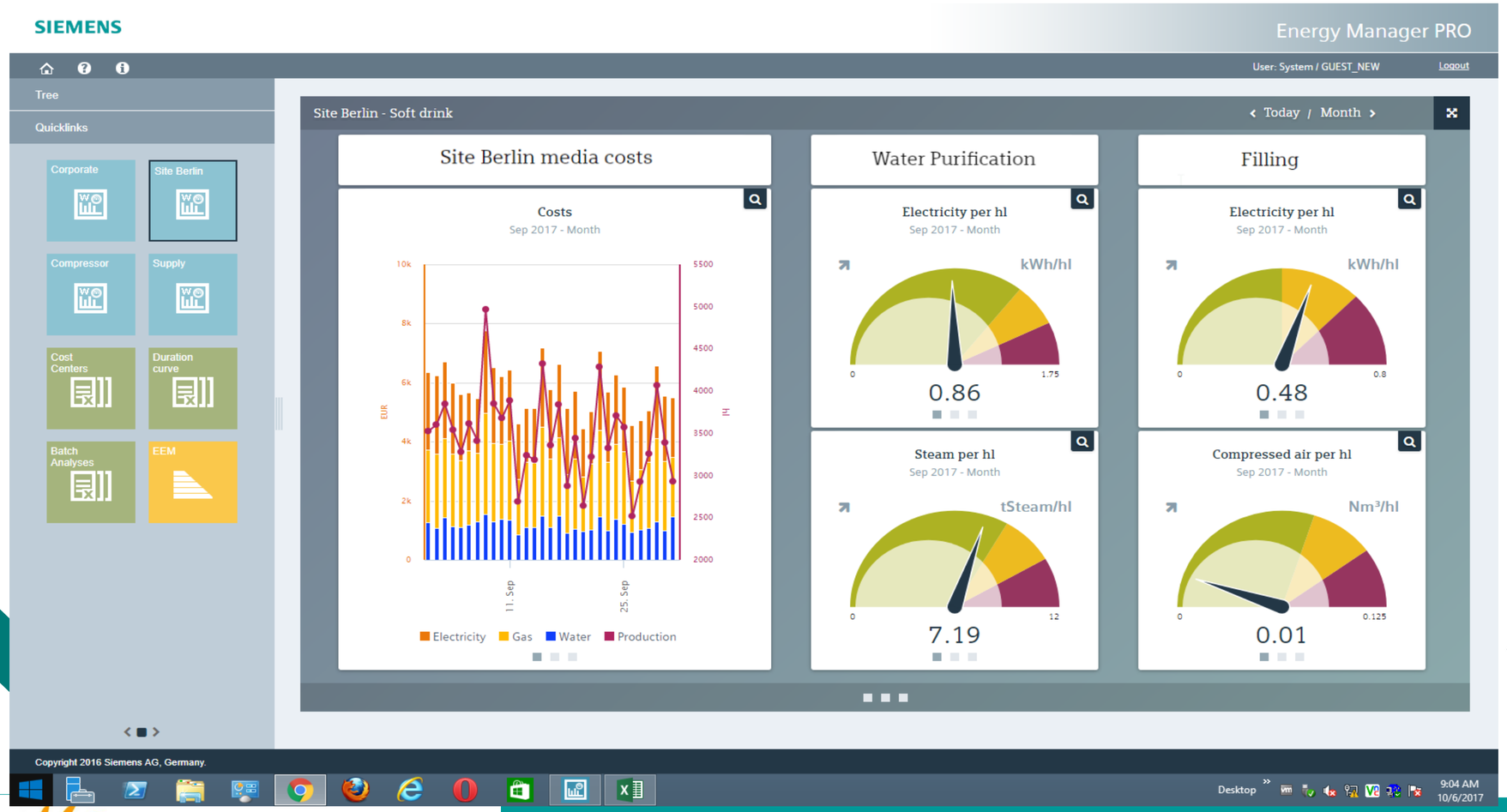
4 High COP Chillers

- Vapour compression chillers are used extensively for large facility space cooling and in industrial process liquid cooling.
- Improving chiller efficiency can significantly reduce energy usage.
- A liquid chilling system cools water or secondary coolant for air conditioning or process refrigeration.
- A chiller has four primary components: compressor, compressor drive, evaporator, and condenser.
- Chillers can be further categorized according to the type of compressor being used.

  - Reciprocating Compressor Chillers
  - Centrifugal Compressor Chillers
  - Screw Compressor Chillers
  - Scroll Compressor Chillers
  - Absorption Chillers

ENERGY EFFICIENCY IN INDUSTRIAL SECTOR

5 IoT & Energy Analytics



Here, the energy manager sees that the consumption of electricity per hl in the department "Filling" is also in the yellow range.

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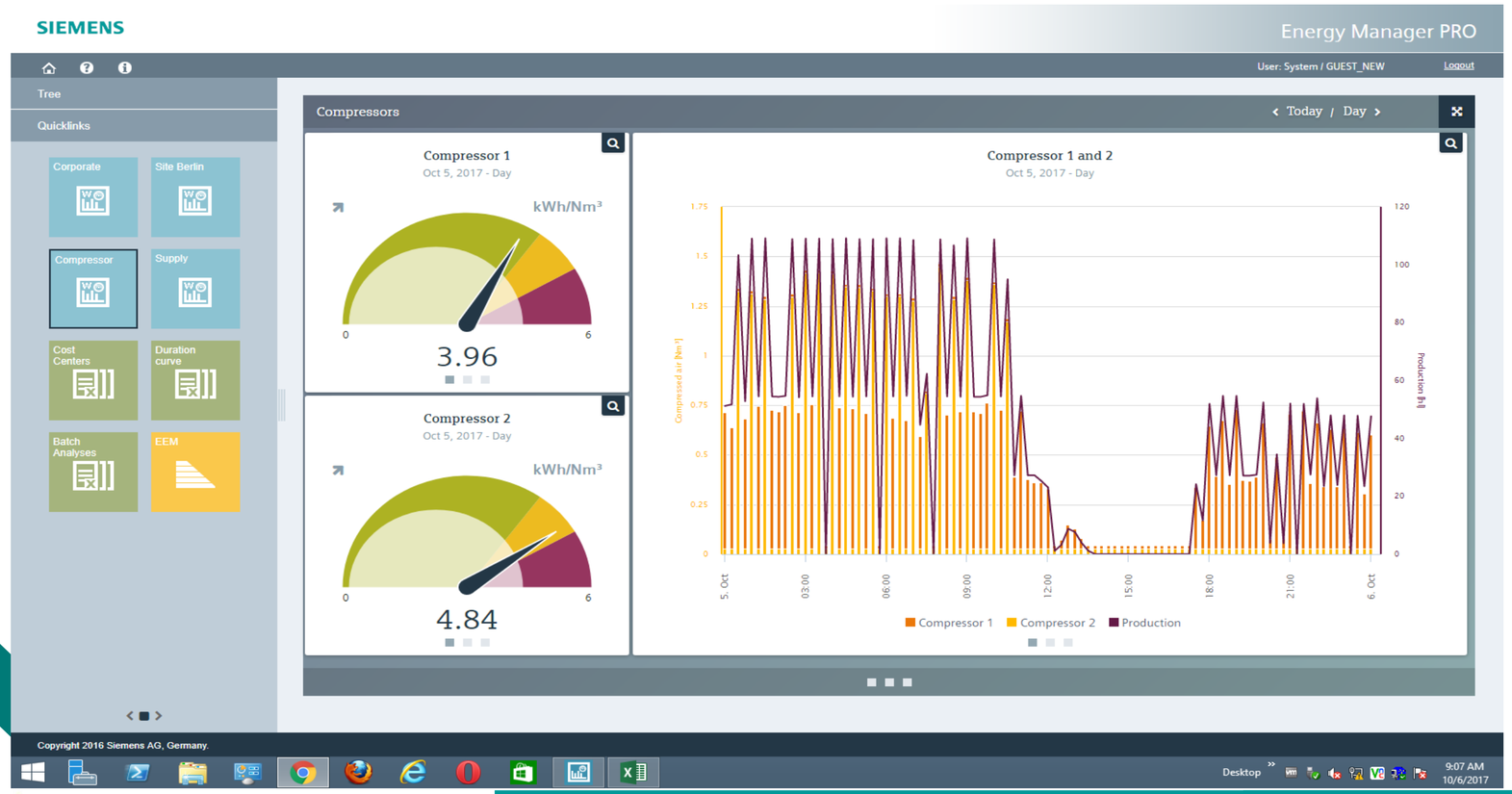
ENERGY EFFICIENCY IN INDUSTRIAL SECTOR

5 IoT & Energy Analytics

- Energy Analytics Visualization helping Decisions



More detailed review of the standby consumptions with the compressors dashboard. There the energy manager realizes:

- *Efficiency of the compressor 2 is substantially in the yellow range*
- *Efficiency of the compressor 1 in the green range*

→ Hence, compressor 2 is more inefficient compared to compressor 1.

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ENERGY EFFICIENCY IN INDUSTRIAL SECTOR

5 IoT & Energy Analytics

- Easy Visual Overview

This Dashboard offers the energy manager statements in order to review the contract with energy supplier:

- Power maximum (Gauge Widget)
- Distribution of peak loads (Carpet Plot)
- Amount of supplied electrical. energy and gas (Sankey Diagram)

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5 IoT & Energy Analytics

- Cost Center report Distribution of the costs according to the causer

Consumption- and Cost overview

Author: ADMIN

Period: 01.07.2017 01.08.2017
Date: 08.29.2017 11:07

Soft drink factory consumptions

	Media	Unit	Total consumption	Soft drink production	Filling/Packaging	Utilities	Administration Building
CC 100% measured	Electricity	kWh	533.714,3	216.820,2	53.162,0	242.328,0	21.404,0
	Gas	kWh	873.163,7	0,0	0,0	872.787,7	376,0
	Water	m³	19.887.190,4	9.827.447,0	9.695.290,4	0,0	364.453,0
	Sugar, aromatic incrediants	kg	1.091.944,0	1.091.944,0	0,0	0,0	0,0

Soft drink factory costs

	Media	Unit	Total costs	Soft drink production	Filling/Packaging	Utilities	Administration Building
CC 100% measured	Electricity	EUR	81.765,0	33.216,9	8.144,4	37.124,7	3.279,1
	Gas	EUR	75.441,3	0,0	0,0	75.408,9	32,5
	Water	EUR	39.774,4	19.654,9	19.390,6	0,0	728,9
	Sugar, aromatic incrediants	EUR	436.777,6	436.777,6	0,0	0,0	0,0
		Sum	633.758,4				

The cost center report offers a fast overview about the energy- and media consumptions as well as the costs for each cost center. The overall costs of the lemonade factory are also calculated.

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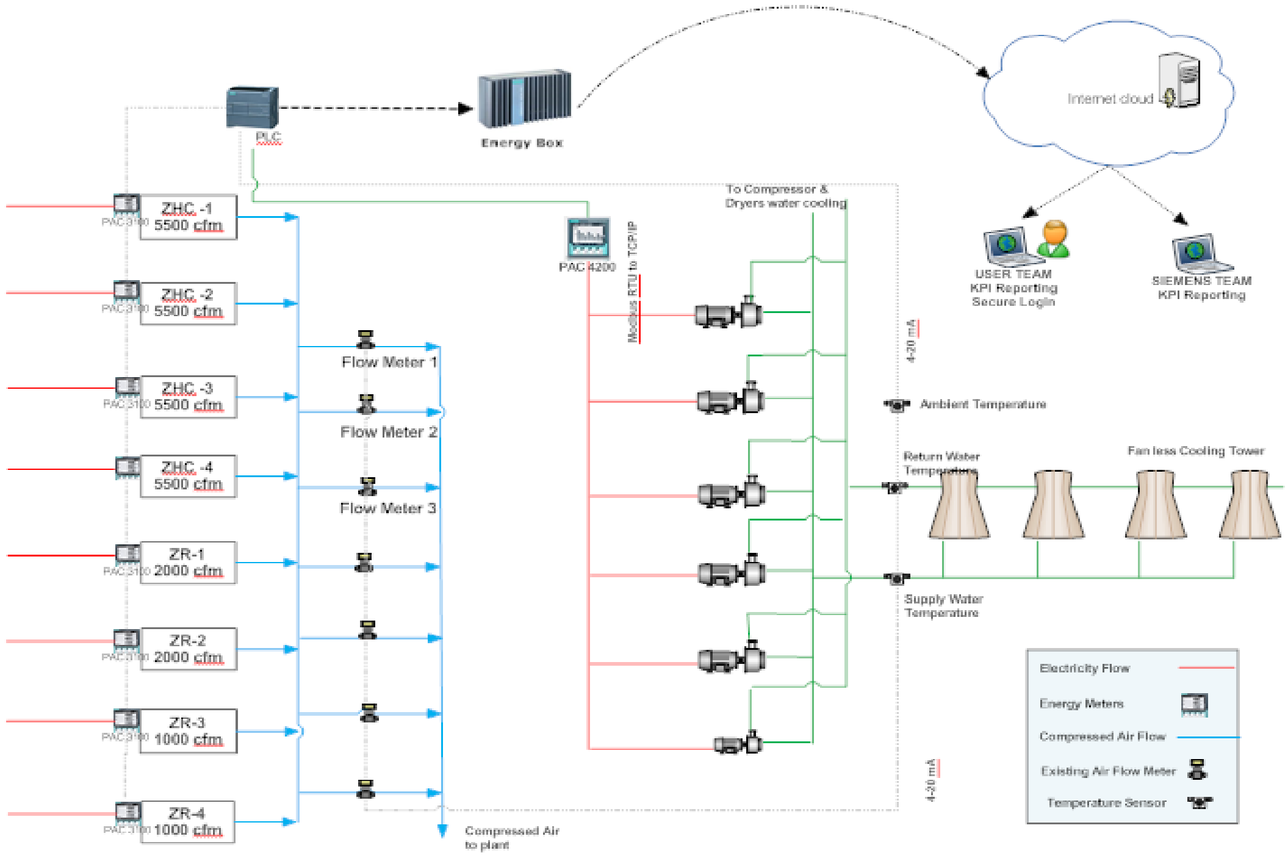
ENERGY EFFICIENCY IN INDUSTRIAL SECTOR

5 IoT & Energy Analytics

- Energy Analytics Use Case @ Utilities

Parameter	Measurement	Instrument	Communication	Sampling time
Active Energy, Reactive Energy	Compressor-1, Compressor-2, Compressor-3, Compressor-4, Compressor-5, Compressor-6, Compressor-7, Compressor-8, Total Pumping Power	Energy Meter PAC 3100 PAC 4200	Modbus RTU, TCP/IP	1 Minute
Compressed Air Flow	Air Flow Meter -1 Air Flow Meter -2 Air Flow Meter -3 Air Flow Meter -4 Air Flow Meter -5 Air Flow Meter -6 Air Flow Meter -7	Existing Air Flow Meter	4-20 mA	1 Minute
Cooling Tower range and approach	Supply Water Temperature, Return Water Temperature, Ambient Air Temperature	Temperature transmitters	4-20 mA	1 Minute
Common header Pressure	Pressure	Pressure Transmitter	4-20 mA	1 Minute



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6 Pressure Reducing Turbine

- The steam pressure is generally throttled and controlled to reduce pressure using pressure reducing valves (PRV).

- The throttling process is isenthalphic which means enthalphy before and after throttling is constant, and no energy output can be produced.

- Alternatively, if pressure is reduced through turbine (backpressure type), energy can be produced along with low pressure steam for process. Although steam consumption is increased marginally, net energy savings can be achieved.

Case Study: Pressure Reducing Turbine Application

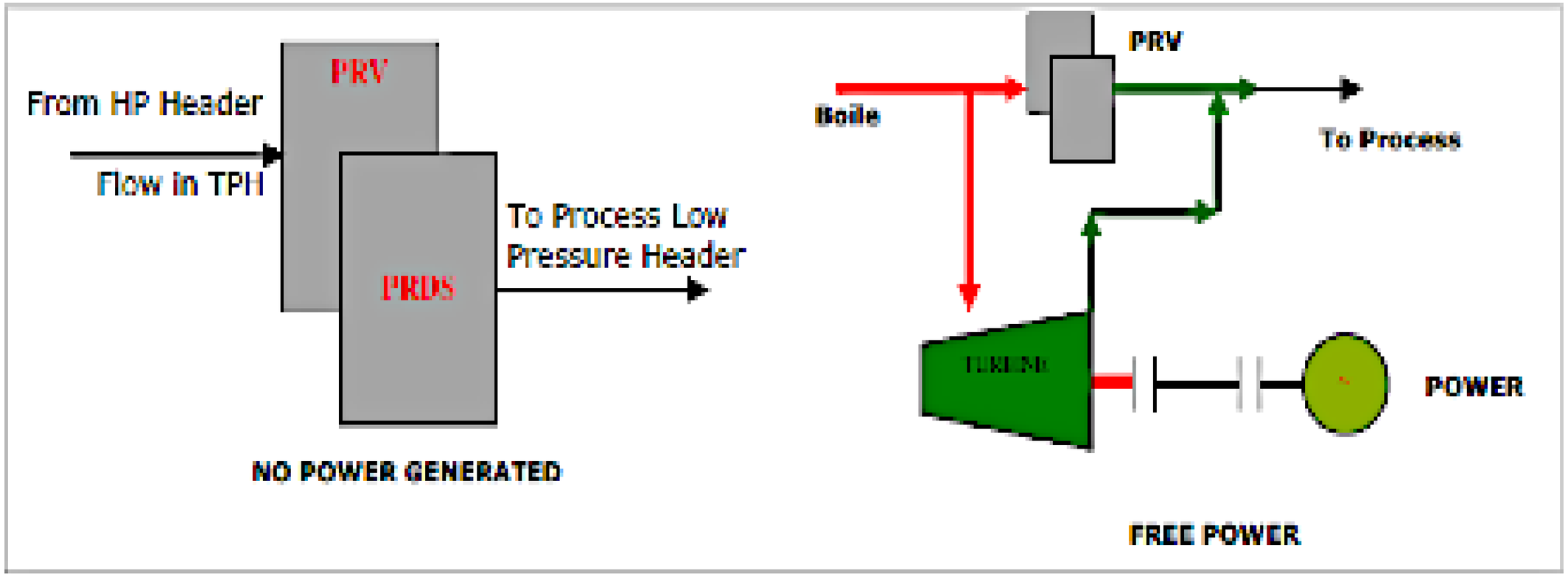
- Steam is generated in the boilers at pressure of 7 - 10.5 kg/cm2 and steam pressure is reduced in the PRV's/PRDS to lower pressure of 2.5 kg/cm2 to 3.0 kg/cm2 required for the process (refer figure on next slide).

- After installation of steam turbine, reduction of steam pressure in PRV's/PRDs is avoided and electrical power is produced from generator coupled to the turbine.

- Steam turbine is installed in parallel to PRV/PRDs, and steam energy which would have been wasted due to pressure reduction, is recovered in the form of electrical power, thus reducing power cost.

6

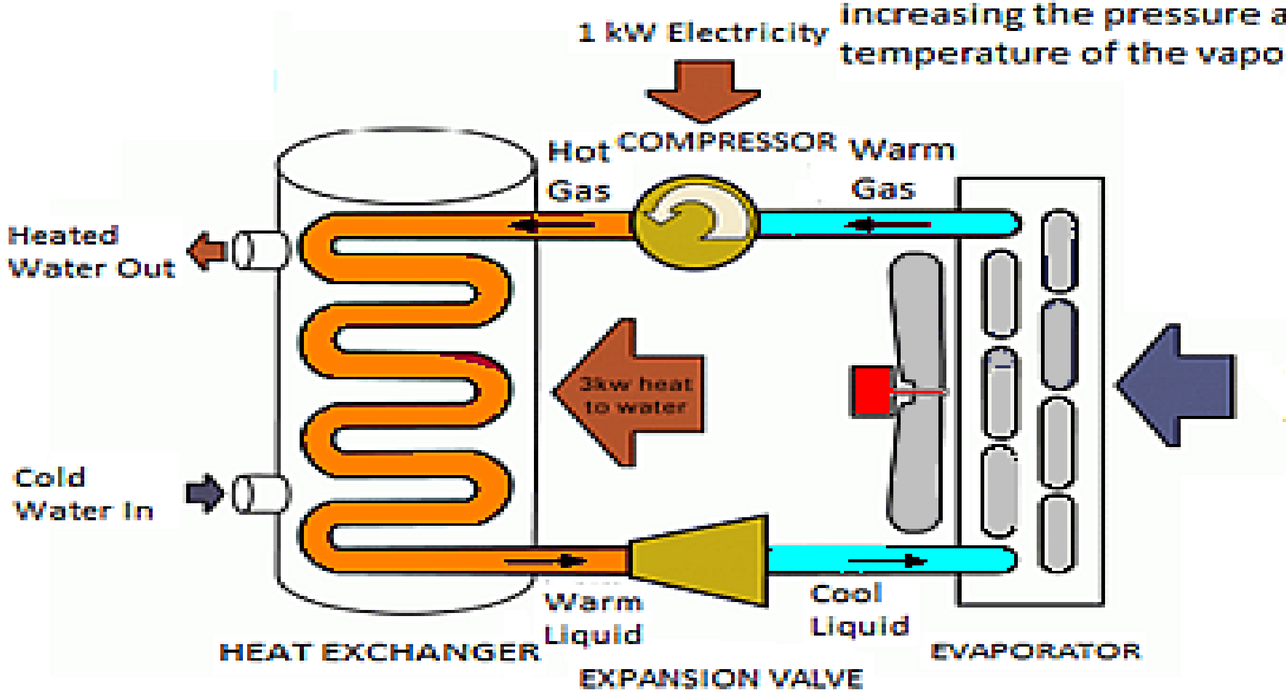
Case Study: Pressure Reducing Turbine Application



ENERGY EFFICIENCY IN INDUSTRIAL SECTOR

7 Heat Pump

2. Vapour
Vapour is channelled into an electric compressor, increasing the pressure and temperature of the vapour



1. Fan
A fan passes ambient air over the evaportor The refrigerant boils and evaporates at low temperatures.

Outside Air

3. Warm vapour
Warm high-pressure vapour enters the heat exchanger producing heat for water or heating system

4. Condensed vapour
Condensed vapour returns to liquid, passes through the expansion valve, reducing pressure and temperature. The cycle repeats.

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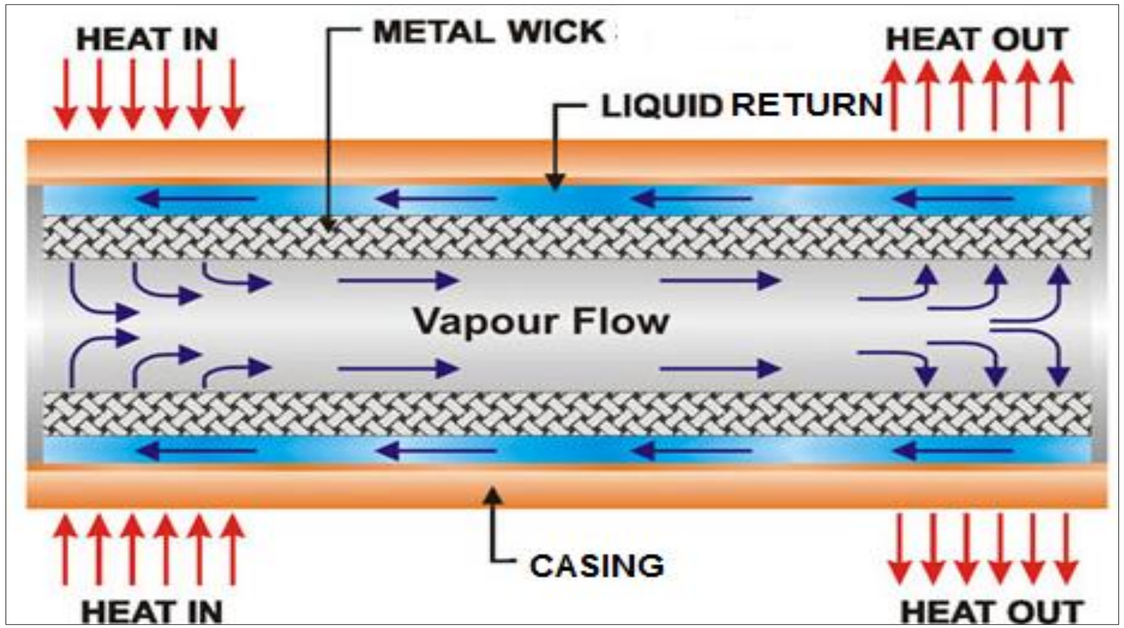
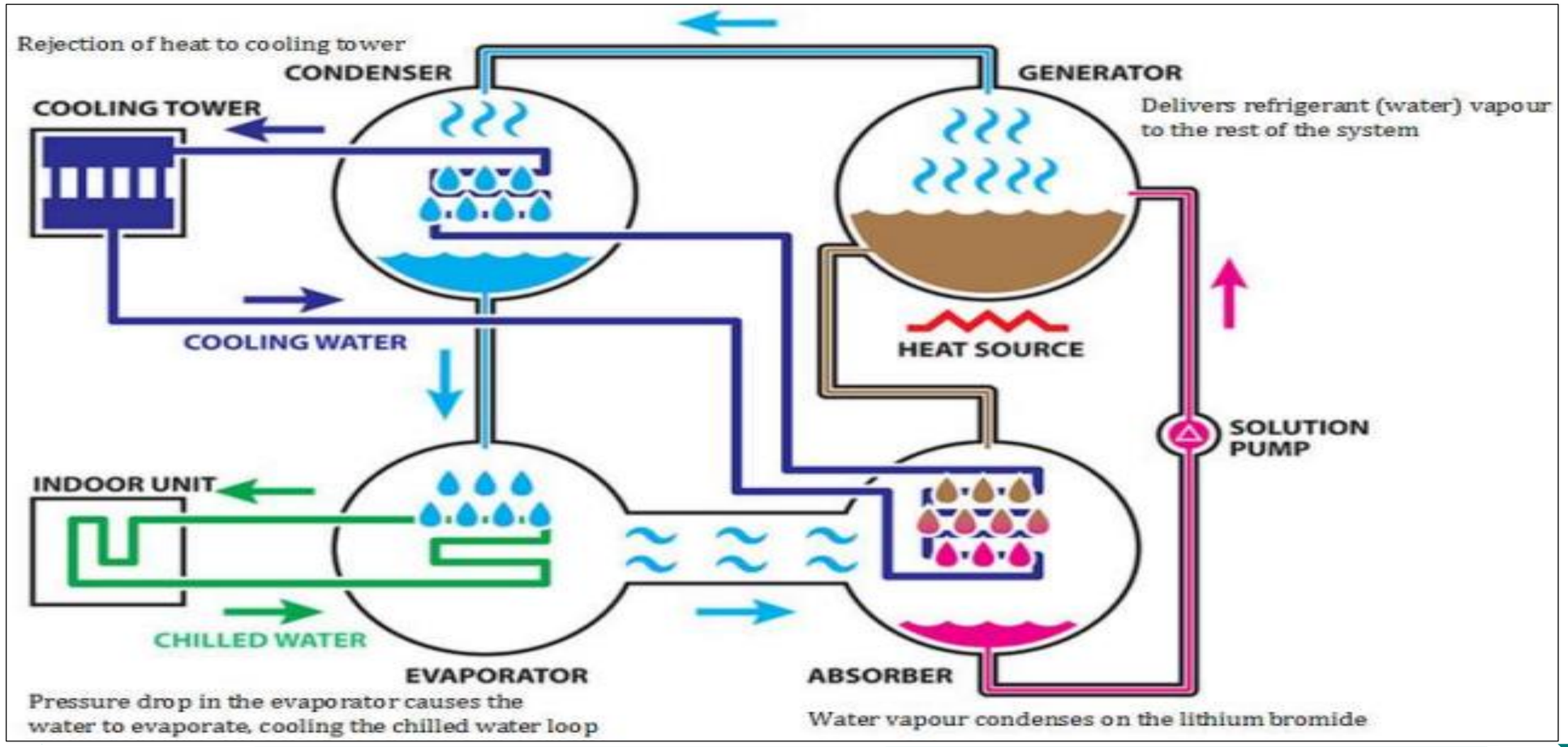
8 Heat Pipe



- Heat Pipes are devices which can transfer 1000 times more thermal energy than copper.
- Heat Pipe is basically a copper tube sealed on both ends with an internal wick or mesh along the interior of the pipe.
- The operating principle of heat pump is based on evaporation/condensing cycle.

9

Vapour Absorption Machine



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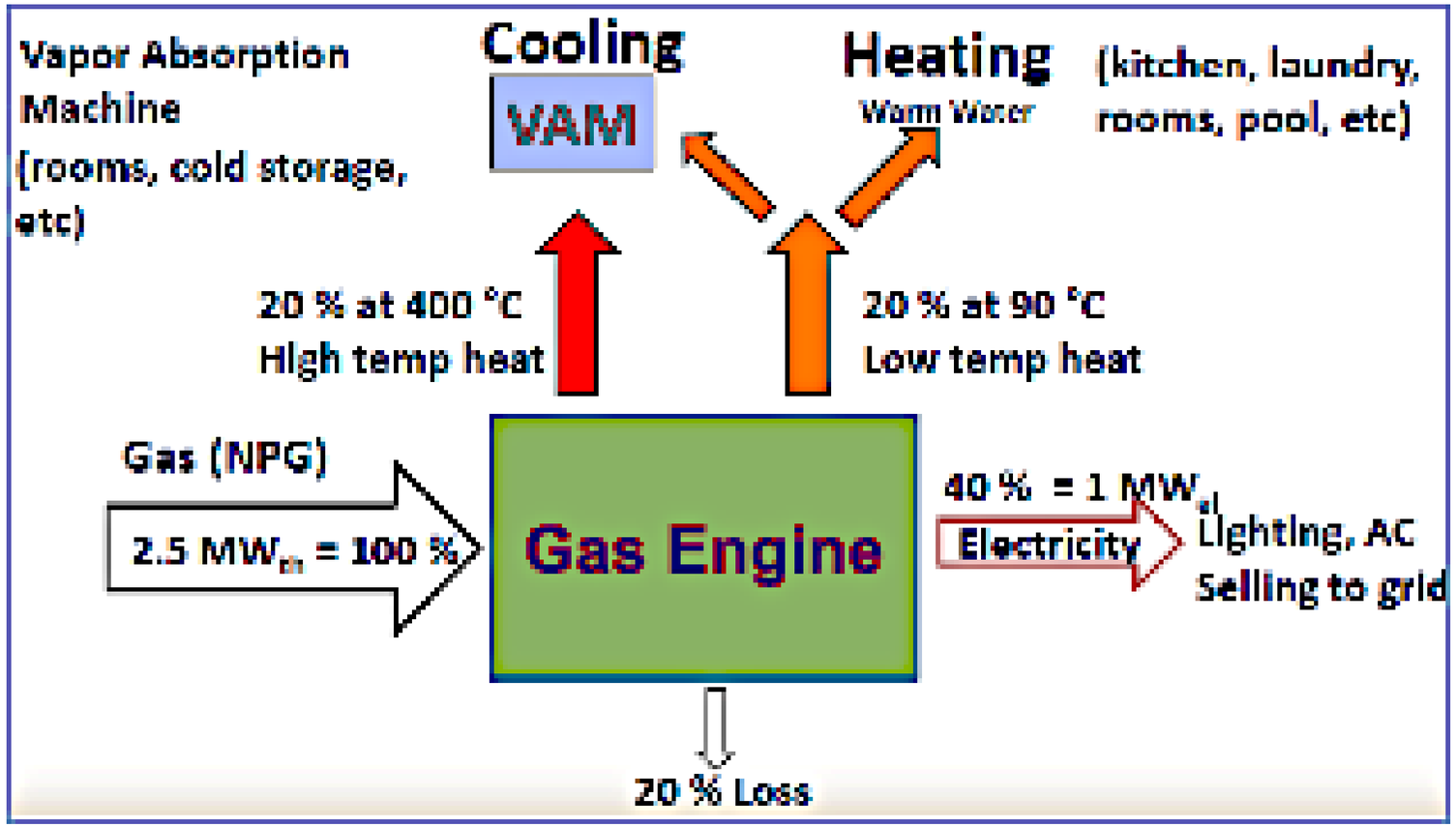
Trigeneration Application



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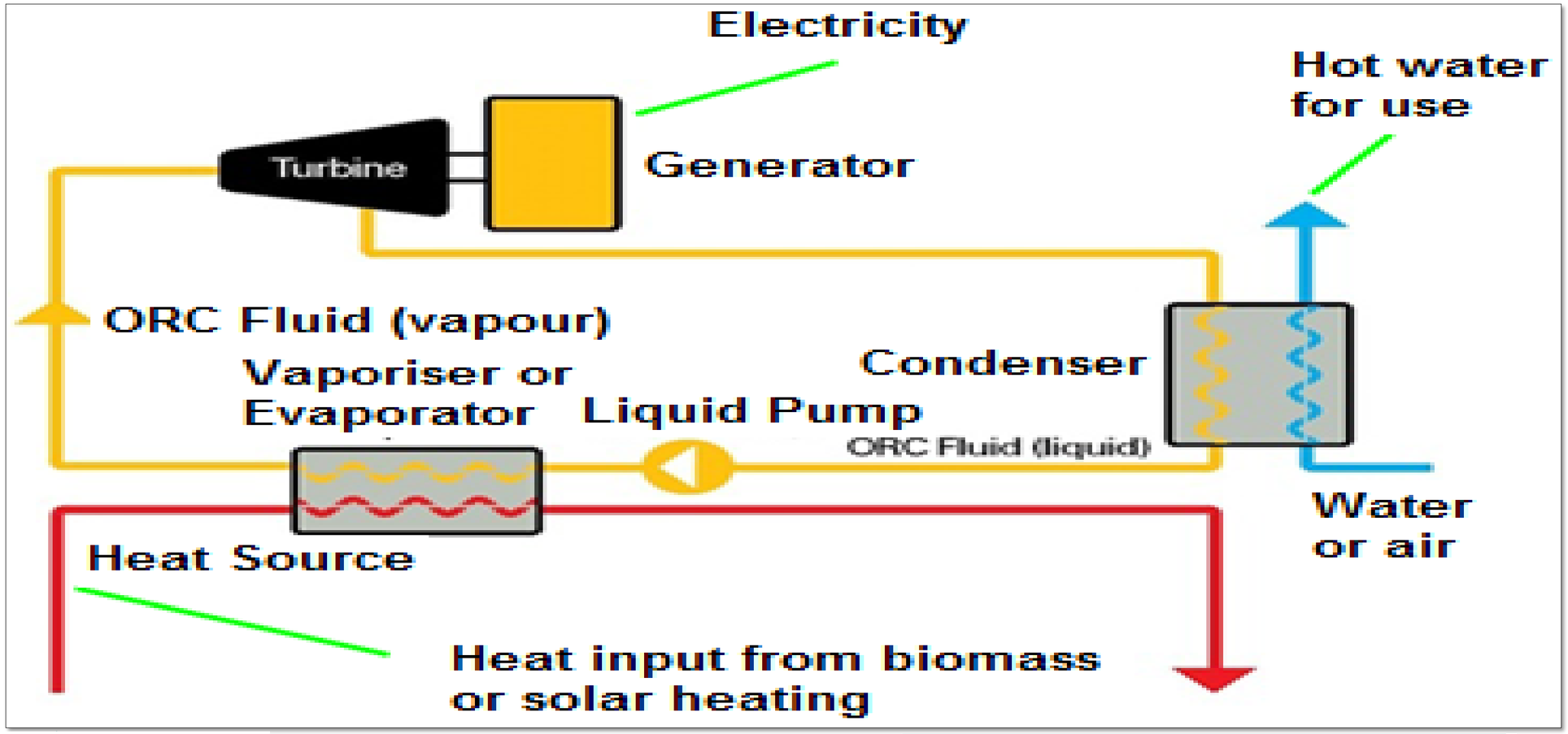
ENERGY EFFICIENCY IN INDUSTRIAL SECTOR

10

Organic Rankine Cycle



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ENERGY EFFICIENCY IN COMMERCIAL BUILDINGS

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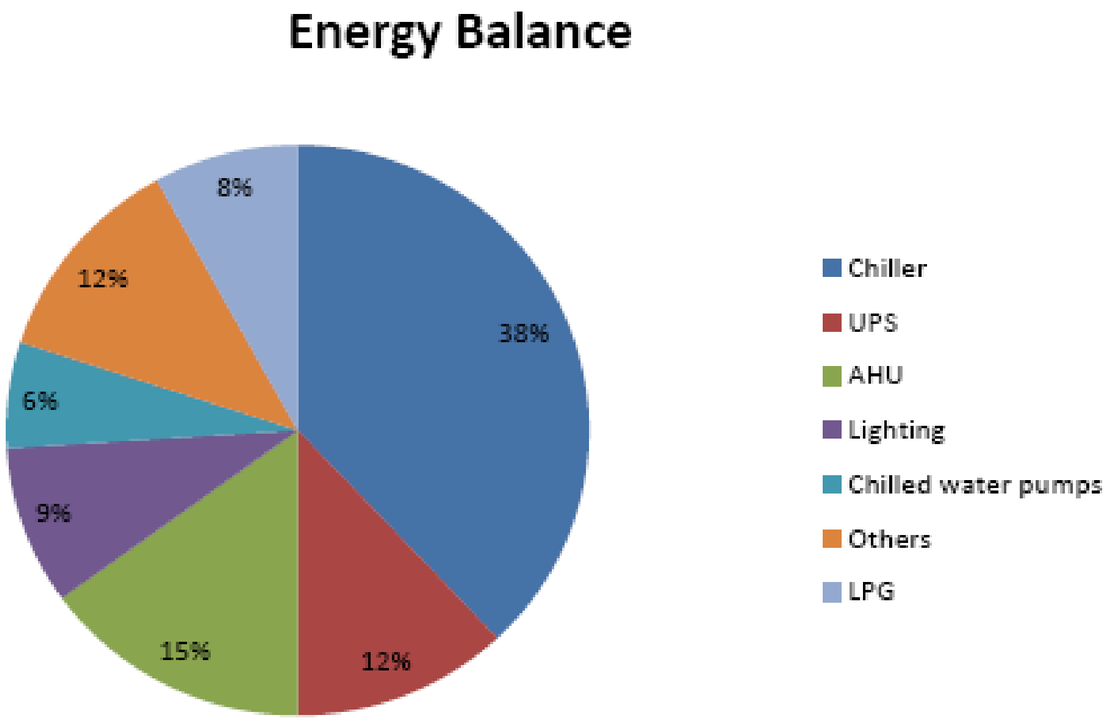
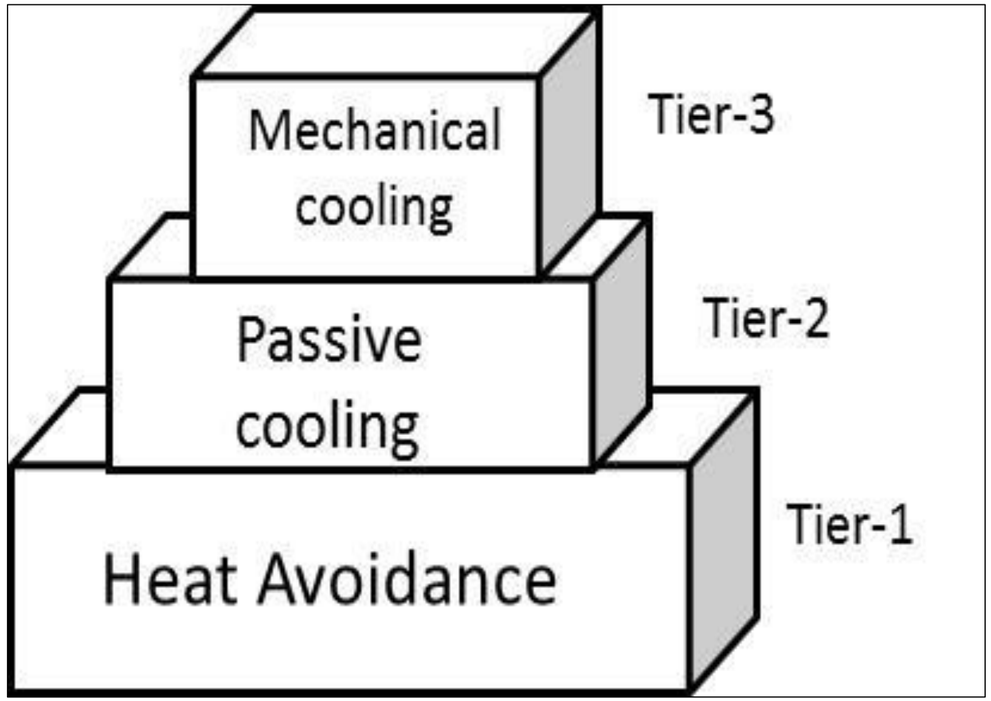
1 Introduction



- Large-scale urbanization and increasing income, and the construction industry growth rate in India is 10% as compared to the world average of 5.2%.
- Projected by 2030 that two-thirds of the buildings have yet to be built and 1 billion $m^2$of new commercial buildings will be added.
- Commercial buildings are the third largest consumers of energy, after industry and agriculture.
- Buildings annually consume about 30–35% of electricity consumption in India.

BUILDING AS AN ENERGY SYSTEM

2 Building Energy System



Sustainable Cooling Strategy

- The Energy Auditor needs to look holistically at the building when recommending efficiency measures to ensure that these energy interactions are taken into account.

- As using passive methods for cooling, the most sustainable approach would be adopting three-tier approach with heat avoidance being the first preference, followed by passive cooling, and mechanical cooling as shown in Figure

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Hospitality
Star/non Star Hotels, Resorts

Religious, Recreation, Social,
Picture hall, Bus/Rail/Airports

:
Healthcare

:
Educational

3 Building Classification

The following are the classifications of building as per ECBC:

- Hospitality: Star/non Star Hotels, Resorts
- Healthcare
- Assembly: Religious, Recreation, Social, Picture hall, Bus/Rail/Airports
- Business: Large >30000 sq.m, Medium: <30000 - 10000 Sq.m, small <10000 Sq.m
- Educational
- Shopping Complexes
- Mixed Building

3 Levels of Energy Efficiency Performance

- **ECBC Buildings**

  Demonstrate compliance by adopting the mandatory and prescriptive requirements listed under ECBC Compliant Building requirements. An ECBC compliant new building should be able to demonstrate minimum **energy savings of 25%** compared to a conventional building.

- **ECBC+ Buildings**

  Shall demonstrate compliance by adopting the mandatory and prescriptive requirements listed under ECBC+ Compliant Building requirements. Buildings should be able to demonstrate **energy savings of 35%** compared to a conventional building.

- **SuperECBC Buildings**

  Shall demonstrate compliance by adopting the mandatory and prescriptive requirements listed under SuperECBC Compliant Building requirements. Buildings should be able to demonstrate **energy savings of 50%** compared to a conventional building.

ENERGY SAVING APPROACHES FOR BUILDING

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ENERGY SAVING APPROACHES FOR BUILDING

4 Energy Saving Approaches

- Some of the key Energy Efficiency Measures covering building envelope (Walls, Roofs, Windows), Heating Ventilation and Air Conditioning (HVAC) System, Lighting (indoor and outdoor), and Electrical Power and Motors are briefly described as follows:

4.1 Passive Designs

- Passive designs take advantage of local climates and reduce energy consumption for heating or cooling the building by optimizing insulation, ventilation, orientation, and shade of a building.
- Some Steps can be used Energy Saving Approach:
  - ✓Form and Orientation
  - ✓Minimizing Heat Gain through roofs
  - ✓Fenestration
  - ✓Low Energy Cooling

4.2 HVAC

- HVAC systems contribute to nearly 40% of the energy used by commercial buildings and over 50% of total energy consumption in IT buildings.

- The HVAC system types are broadly categorized as follows:

  - ✓Centralized system: Central Chilled Water System (Air cooled and water cooled)
  - ✓Distributed system (DX system): VRF, Duct able system, split air conditioners, unitary systems

4.2 HVAC

- Energy saving potential in HVAC System Design is shown in Table

Component	Cooling Load (kW/ton)		Improvement Potential
	Conventional Design	Optimized Design	
Chiller	0.75	0.50	33%
Air Distribution System	0.60	0.06	90%
Water Pump	0.30	0.04	87%
Cooling Tower	0.10	0.02	80%
Total	1.75	0.62	65%

ENERGY SAVING APPROACHES FOR BUILDING

4.3 Other Approaches

- Air tightness
- Mixed Mode Ventilation System
- Demand-Controlled Ventilation (DCV)
- Electronically Commutated Fans
- Low-temperature Variable Air Volume
- Heat Recovery Ventilation (‘HRV’) systems
- Solar Cooling
- Insulated roller doors
- Lighting
  - LED Lighting
  - Occupancy Detection
  - Daylight Dimming
  - Flexible Lighting Control
- Building integrated photovoltaic (‘BIPV’)
- Solar hot water systems
- Sub-metering systems
- Energy Efficient Appliances
- Electrical Energy Storage
- Building Energy Management System (‘BEMS’)
- Crystalline Water proofing
- BM Analytics
- Self-Learning Buildings
- Use of simulation for energy efficiency in building
- Green Leasing

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