SAARC Training Workshop on Energy Audit & Efficiency in Power Sector

Tapping the Energy Efficiency Potential in Processes, Systems and Networks

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Power and energy

- Power
  - Rate at which energy is expended.
  - Power is energy divided by time.
  - Measured in watts, while energy is measured in joules.
  - Watt = joule per second.
- Power is measured in kilowatts, and time in hours,
  - Energy measured in kilowatts x hours
  - kilowatt hours (kW·h).

Potentials for Energy Efficiency & Management

Energy Efficiency

Using **"efficient"** equipments - kWh

100 W

20 W

15 W

0 W

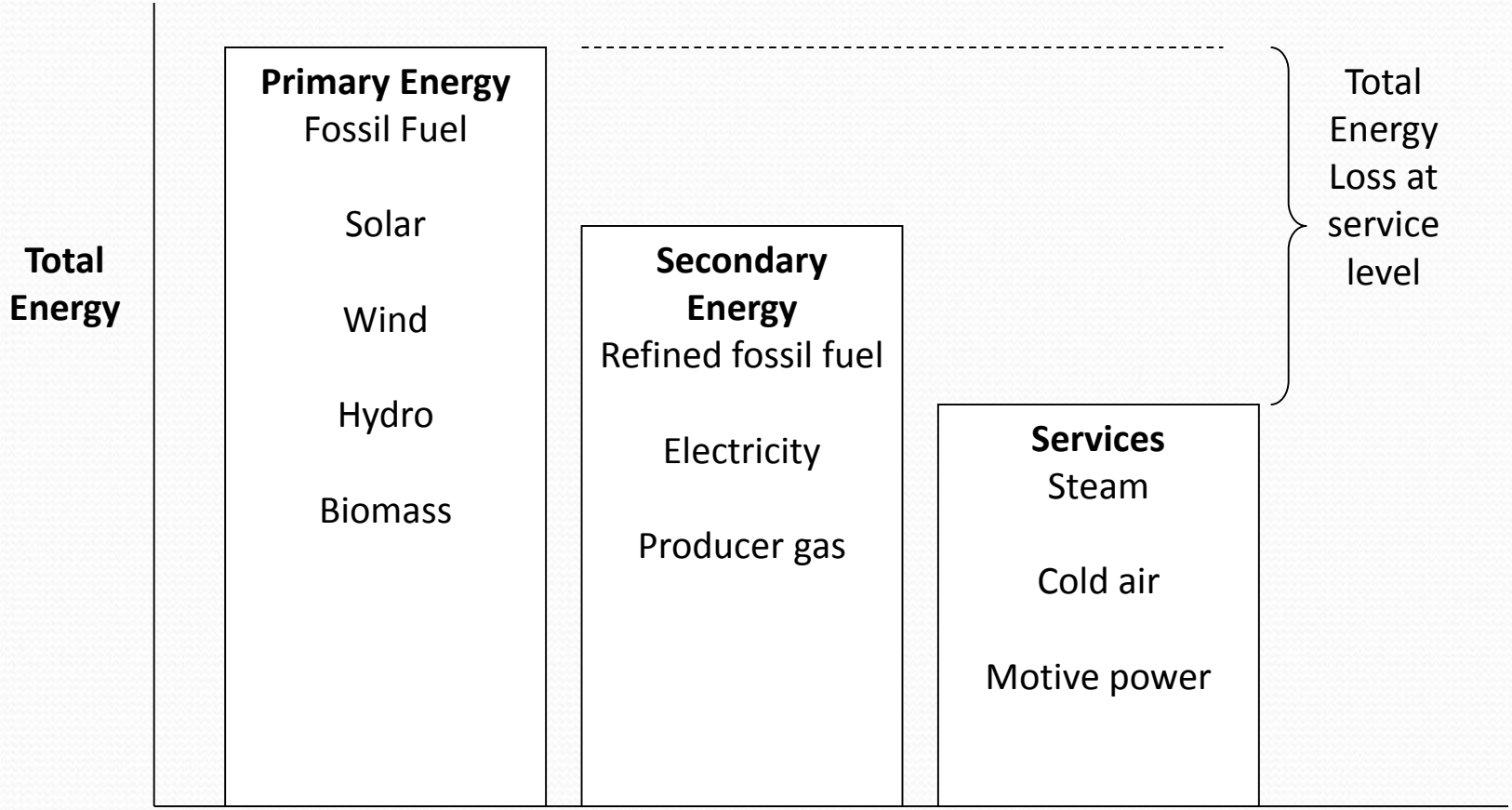
Energy Management

Using equipment **"efficiently"** - kWh

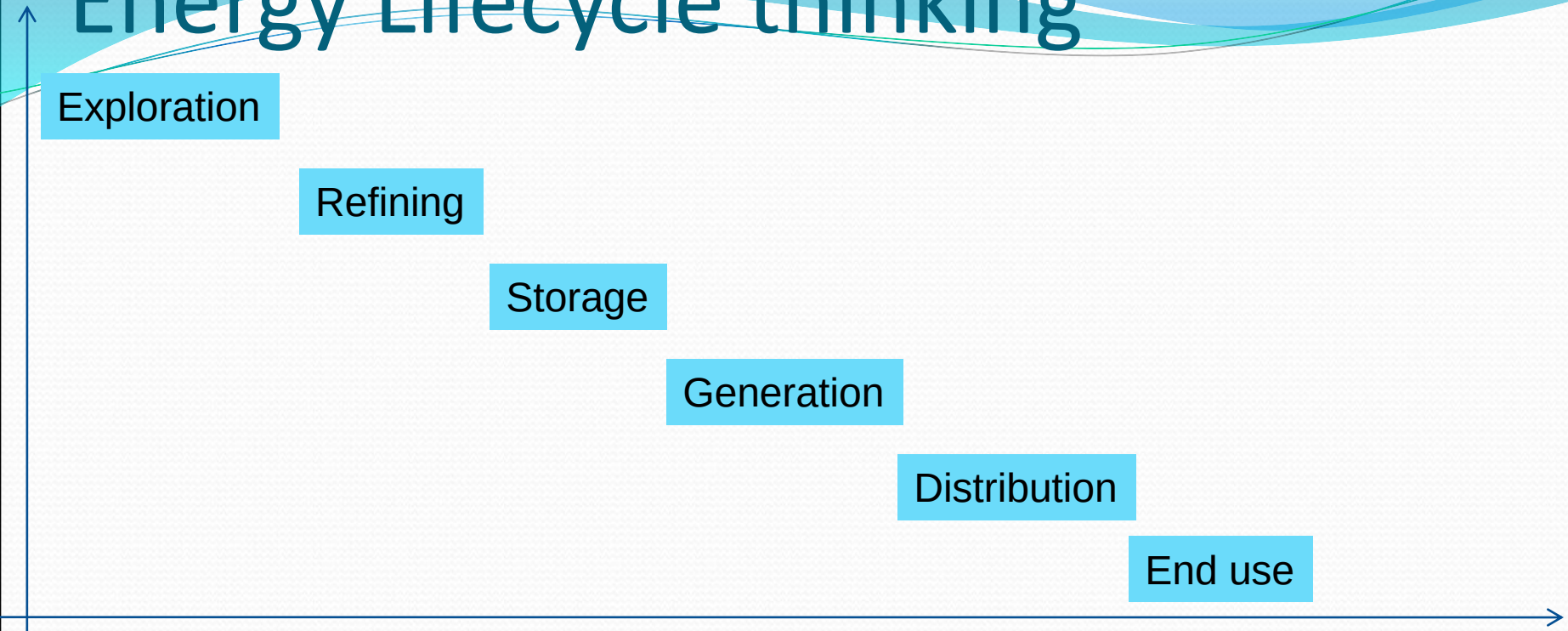
Energy efficiency improvement Opportunities @ different levels

- Resource level
  - Primary
  - Secondary
  - Service
- Generation
- Distribution
- Process utilization
- Storage
- Transport / retailing

Energy flow


Total Energy
Primary Energy
Fossil Fuel
Solar
Wind
Hydro
Biomass
Secondary Energy
Refined fossil fuel
Electricity
Producer gas
Services
Steam
Cold air
Motive power
Total Energy Loss at service level

Energy Lifecycle thinking



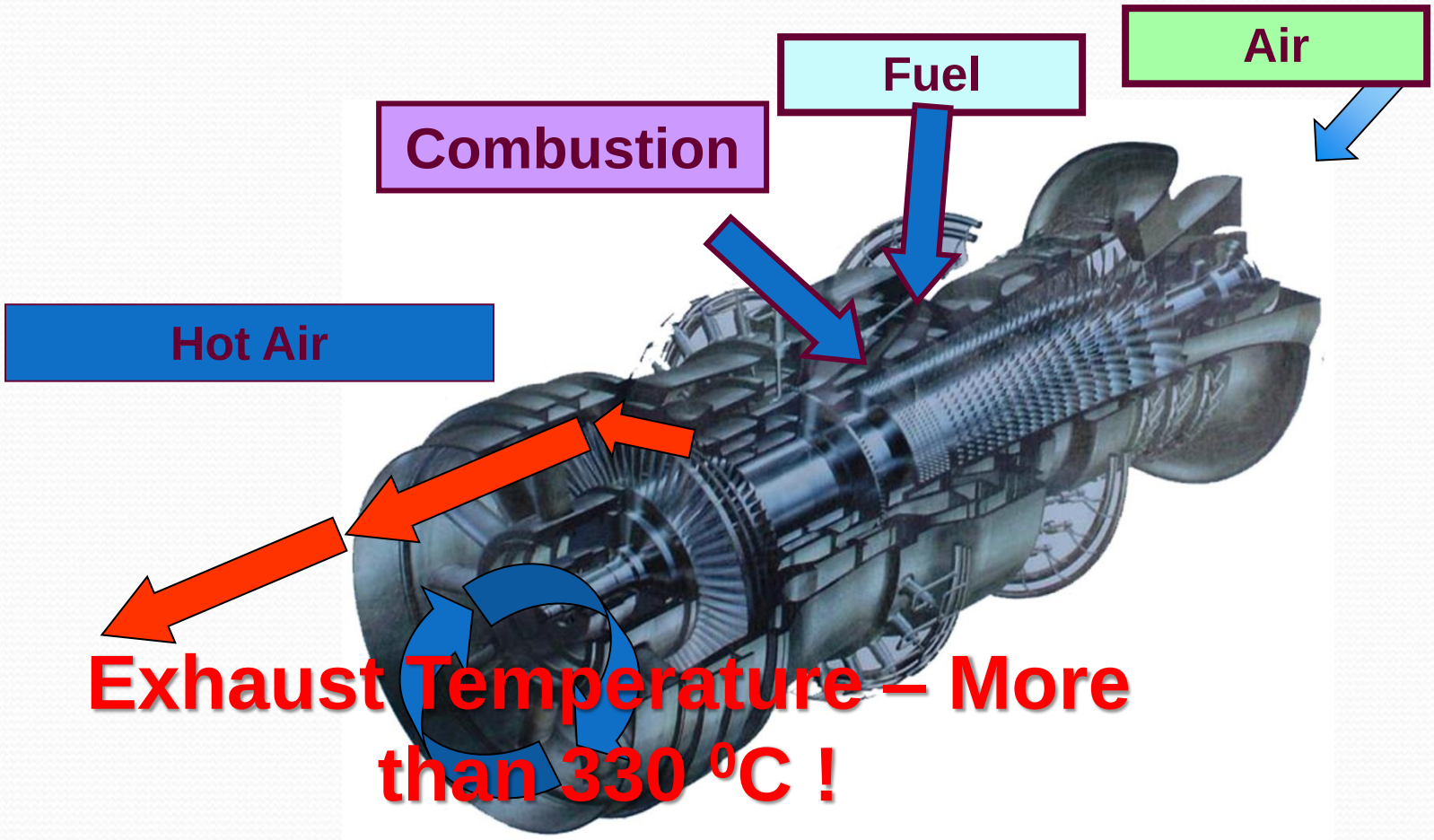
- Planning at Project / process planning level
- Selection of correct / appropriate source
- Waste energy recovery potentials and strategies
- Technology switching
- Energy – audit for baseline study and options generation

Power sector

- **Power generation**
  - Renewable (Hydro, Wind, combined etc)
  - Thermal (Gas / steam turbine, IC engine etc)
  - Captive (individual site based own generation)
  - Recycling of energy (pump storages)
- **Distribution**
  - Self generated (own distribution network)
  - Grid connected (HT, LT intake and distribution)
- **End use**
  - Utilities (steam, Compressed air, Water, HVAC etc)
  - Systems (AC, lighting, Heating, Driving etc)

Power Generation

Gas Turbine

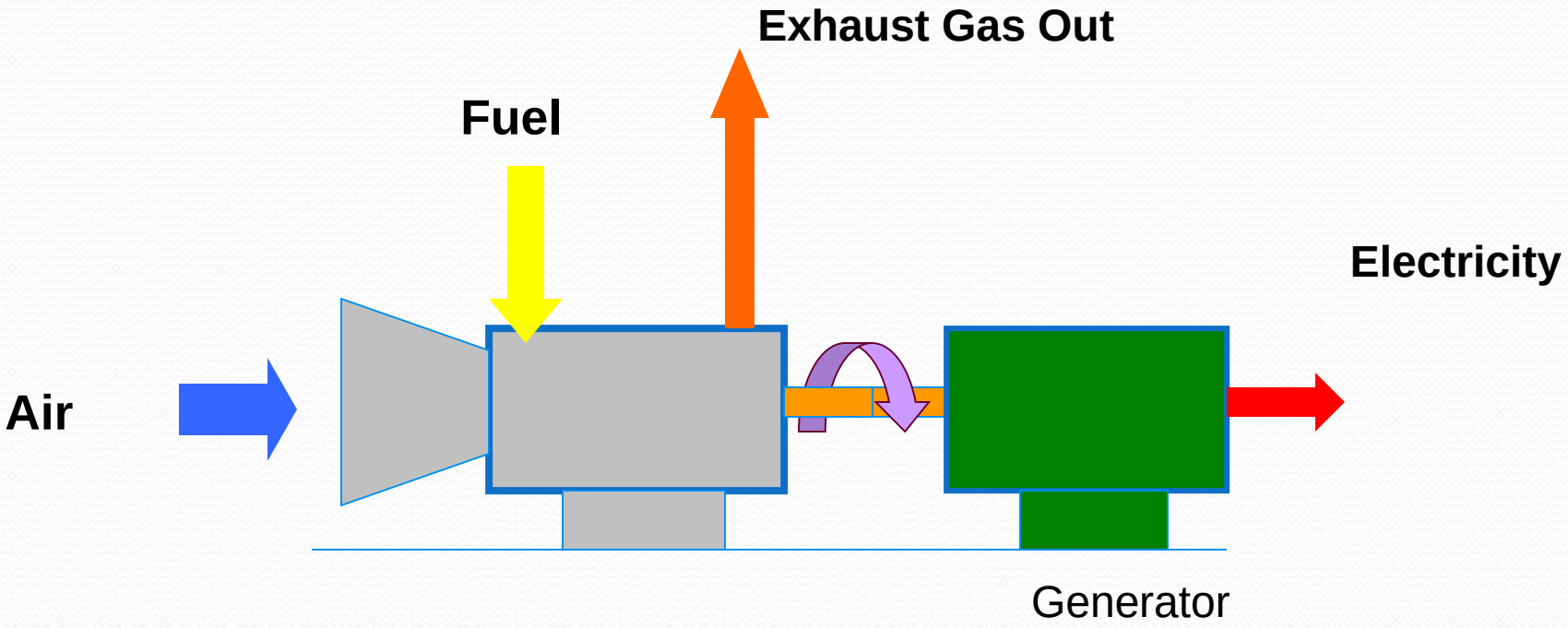


Exhaust Temperature – More than 330 ^{0}C !

= 65% - 70 % of Inlet Energy!

Power Generation

Gas Turbine

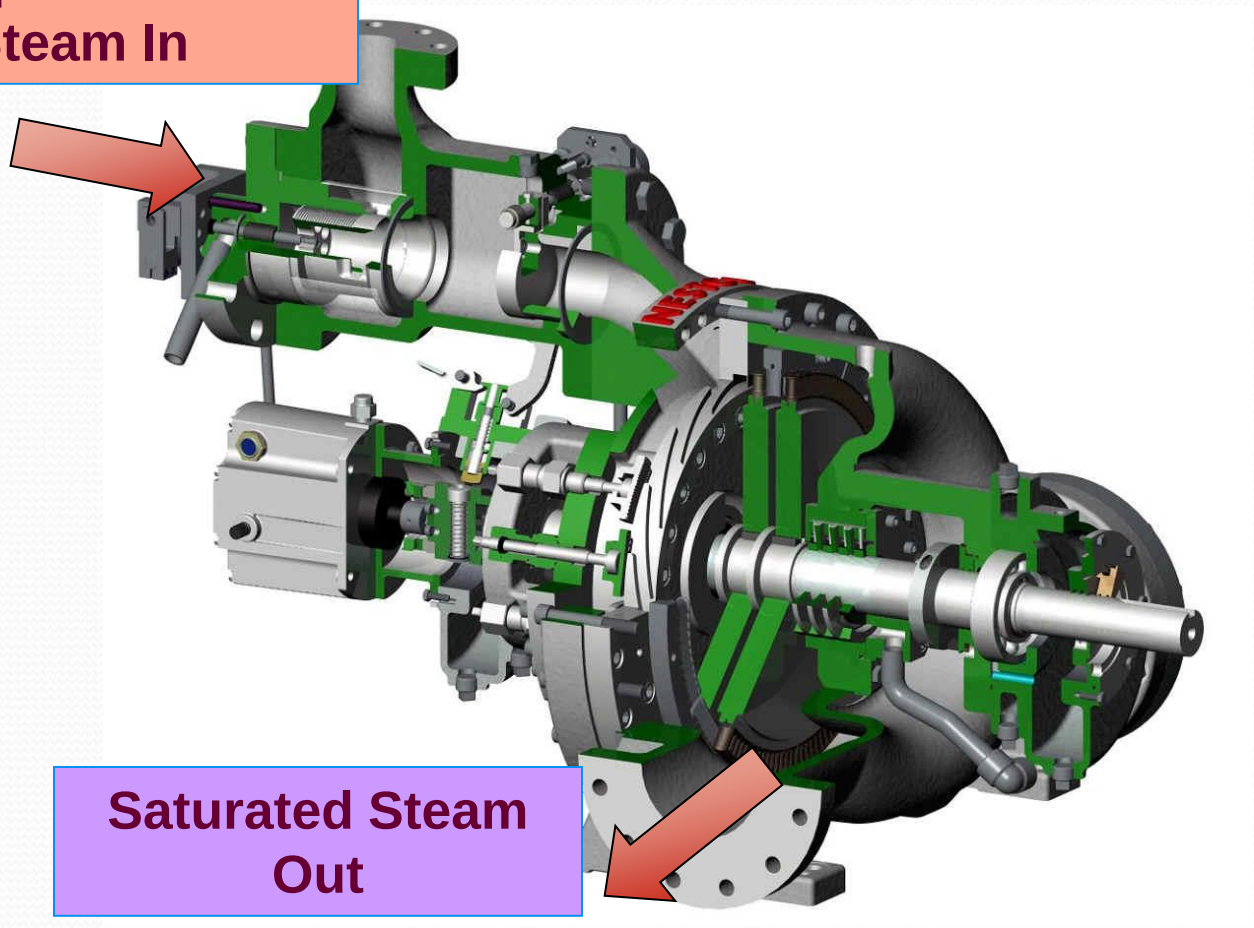


Overall Efficiency– 30% to 35%

Power Generation

Steam Turbine

Supper Heated Steam In



Saturated Steam Out

Power Generation

Chimney

Exhaust 15%

Steam Turbine

Saturated Steam

Fuel

Water

SH Steam

Electricity

Boiler

Steam Turbine

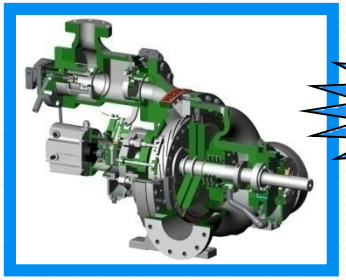
Generator

Overall Efficiency– 26% to 28%

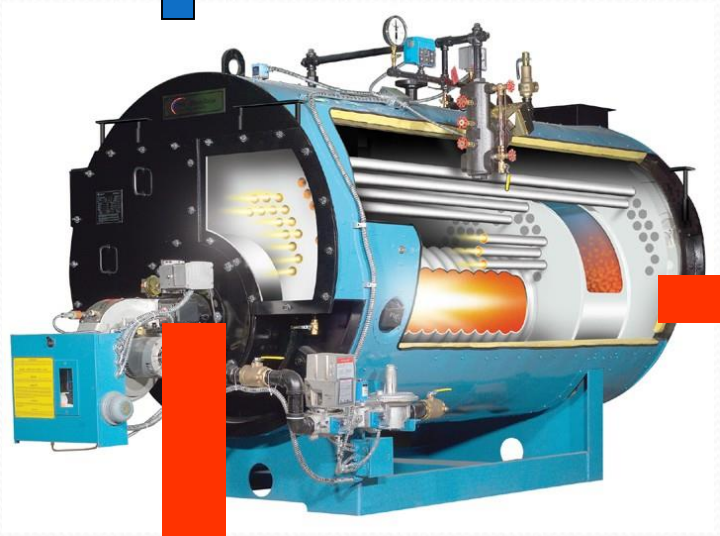
Opportunities

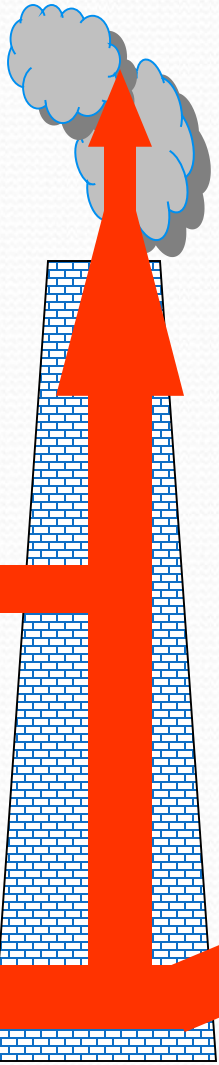
Power Generation

Combined Cycle

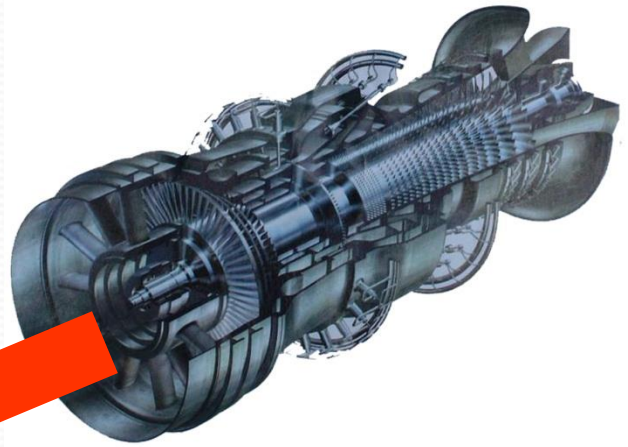


Electricity





Electricity

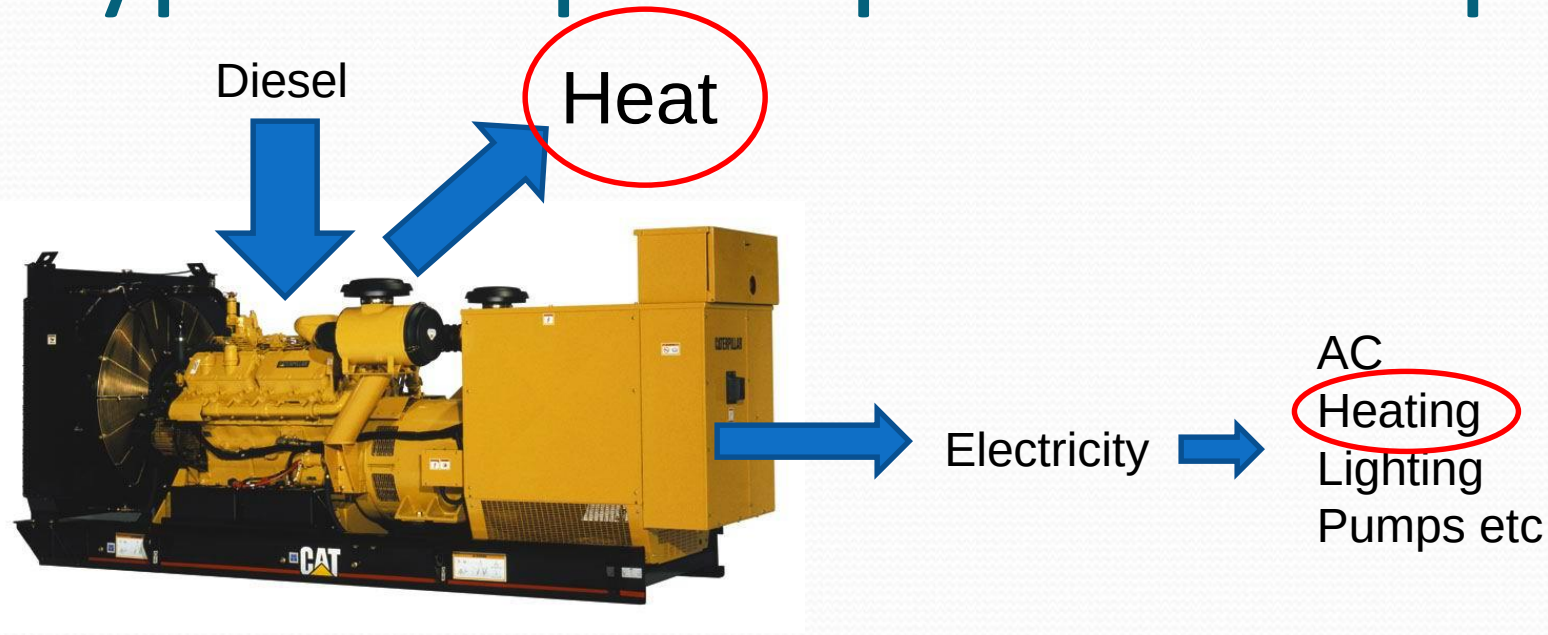


Energy mix – Maldives (2000)

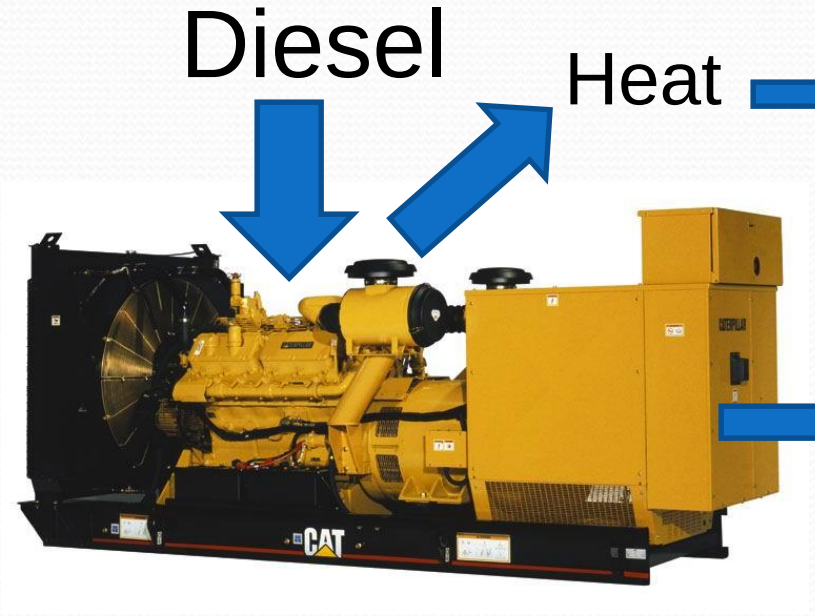
Energy Carrier	Typical Uses	Energy Supply, Mtoe	%
Kerosene	Lighting and cooking	5,070	3.7
LPG	Cooking, Industrial metal works	630	0.5
Diesel	Land and water (domestic and international) transport, industrial operations, and **electricity generation**	**117,998**	**85.5**
Gasoline	Land and water transport	8,979	6.5
Aviation Fuel	Air transport (domestic & international)	5,353	3.9

Ref - WWW

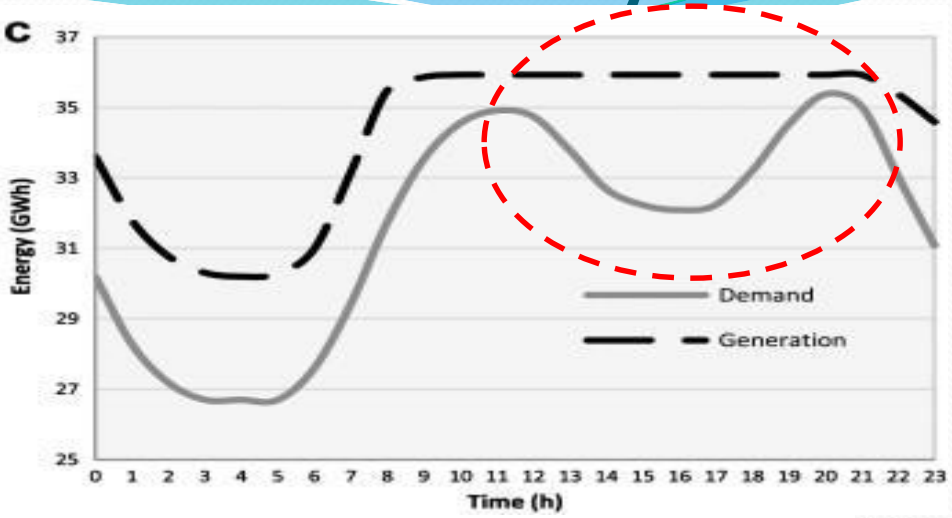
Typical captive power setup

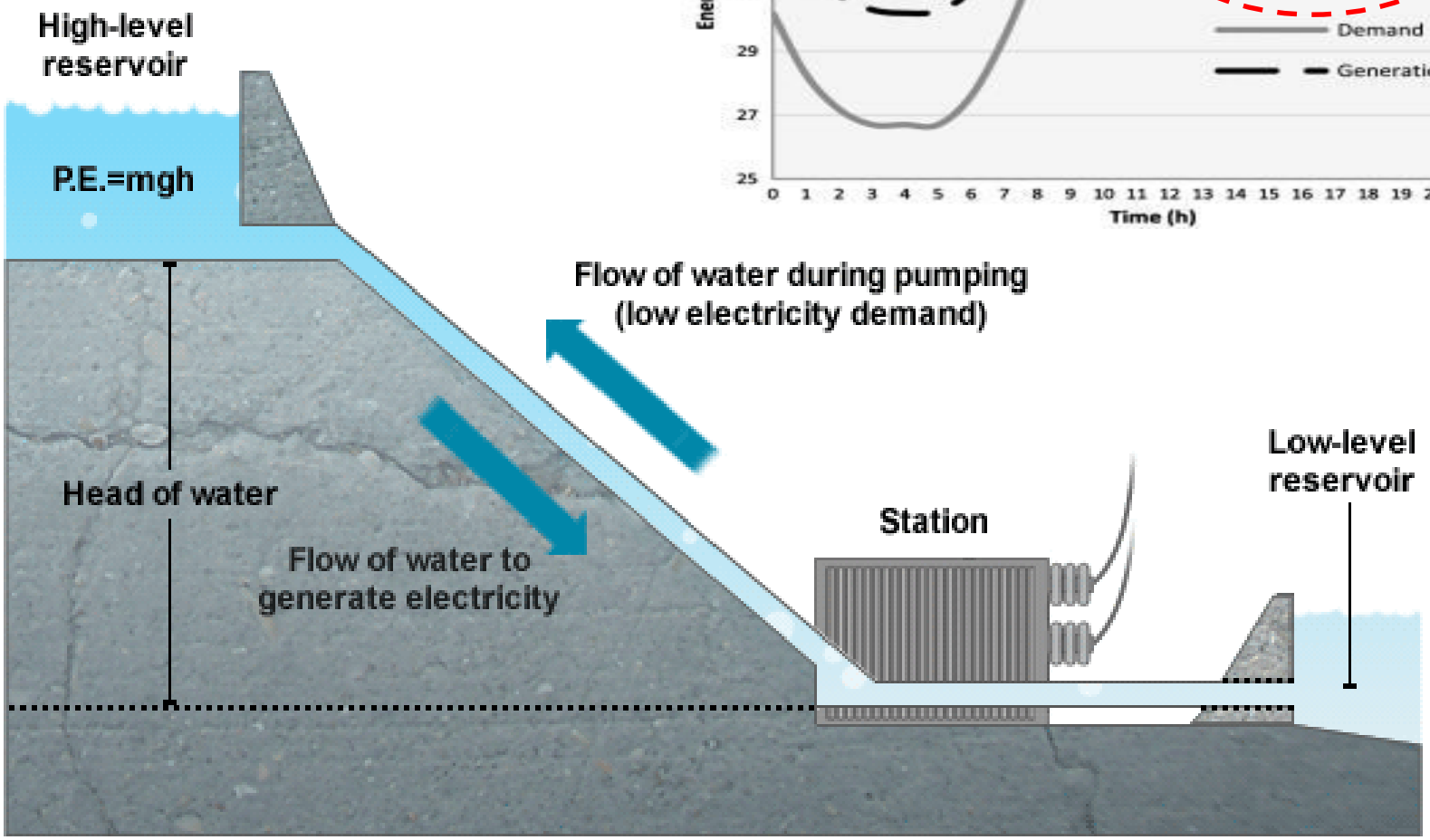


Energy Efficient captive power operation

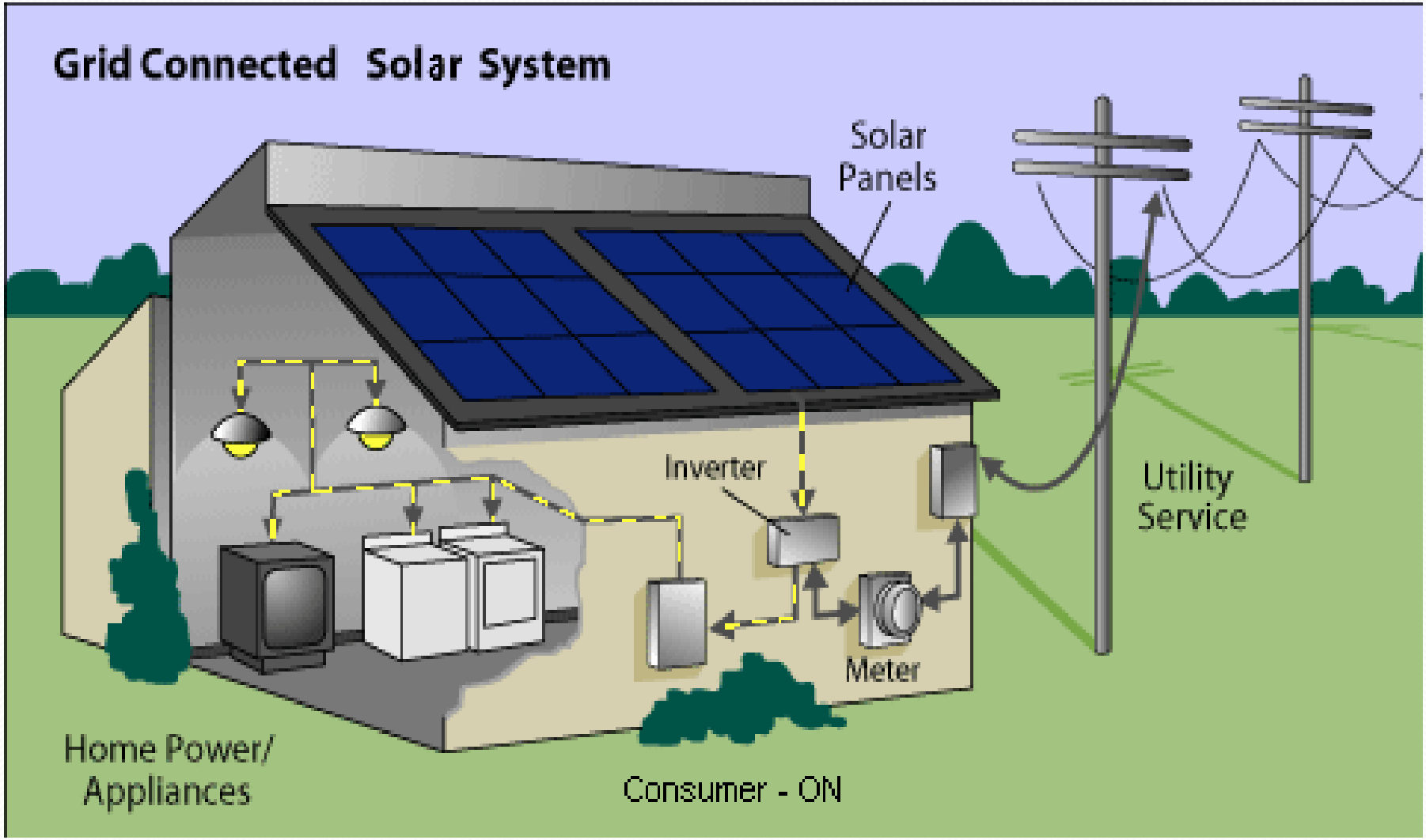


Pump-Storage Hydroelectricity (PSH)



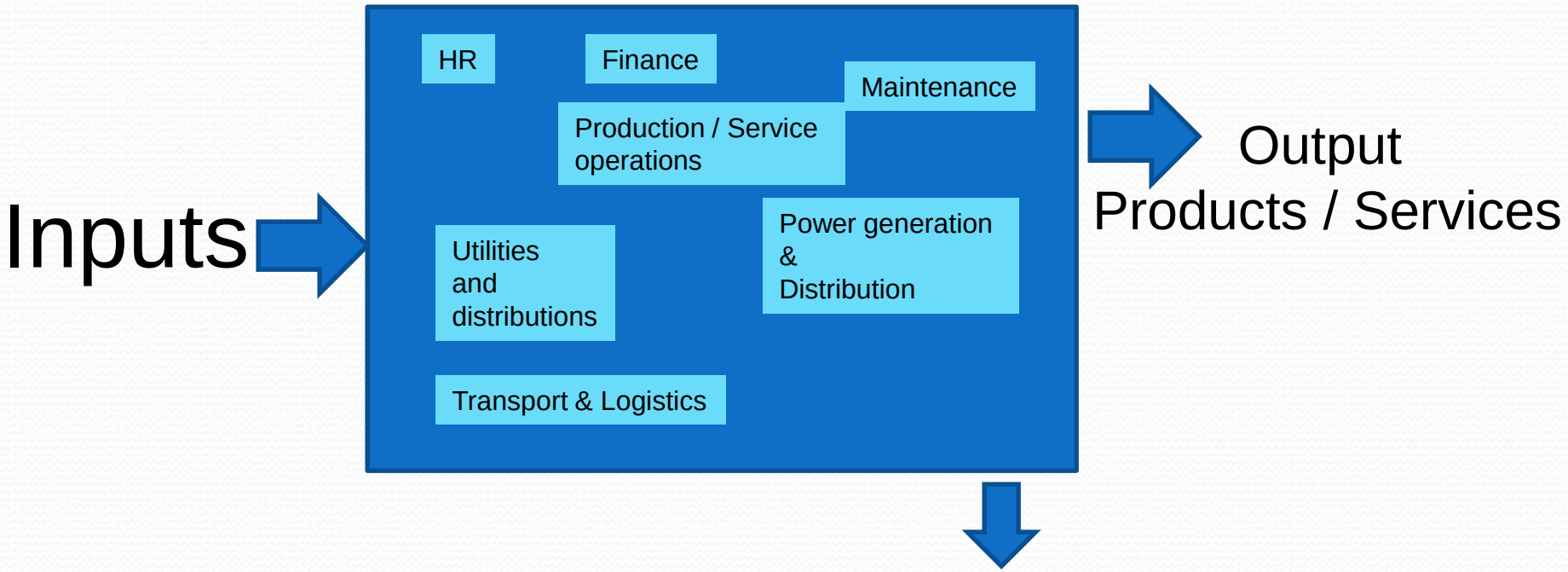


Net metering



Overall business process

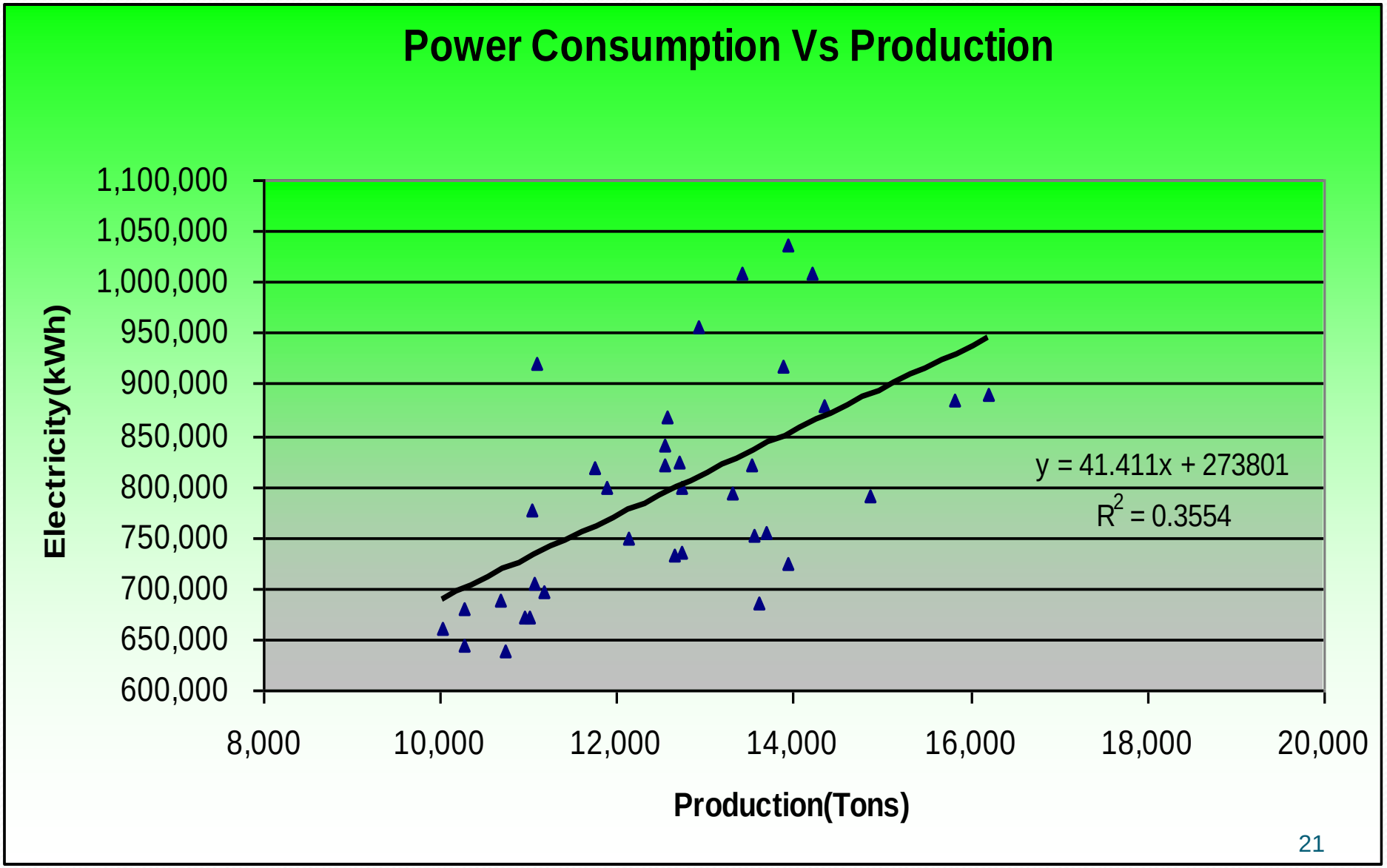
- A combination of different systems for a common goal



Overall performance?

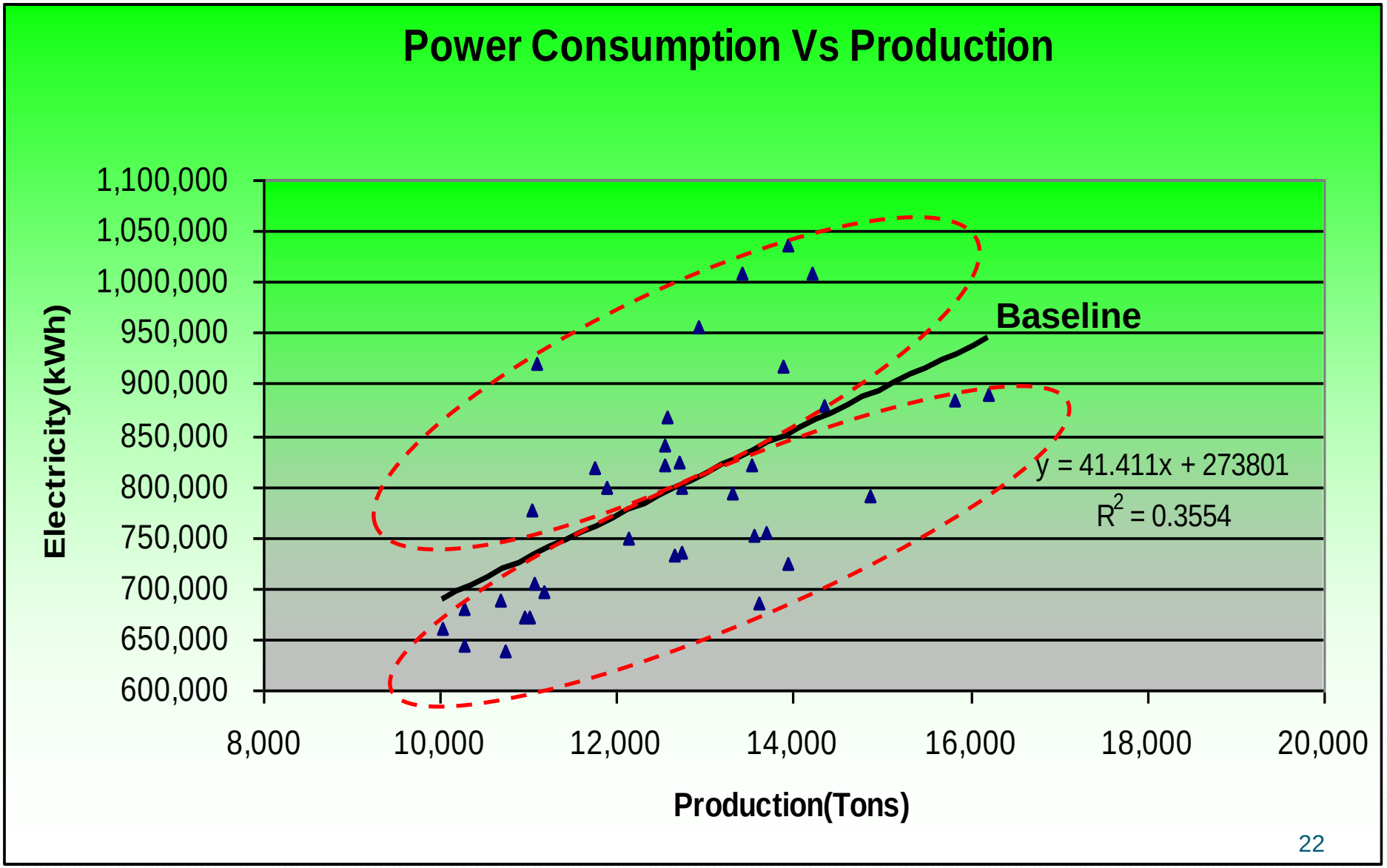
Your process performance

Y = mX + C



Your process performance

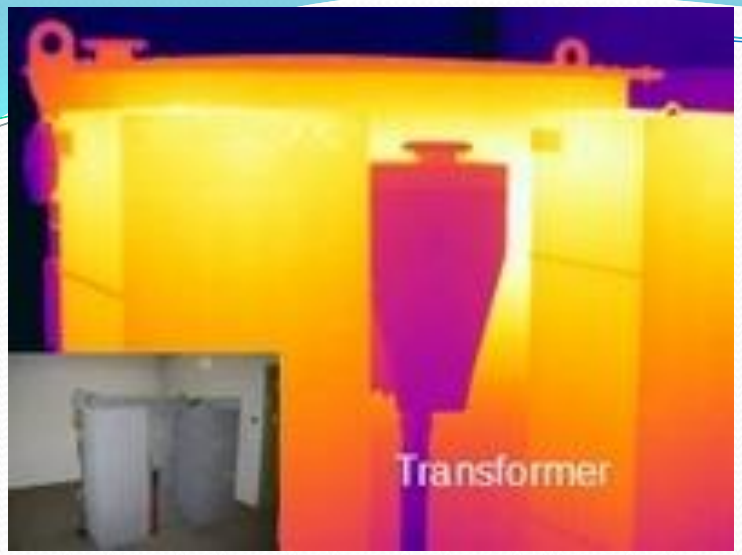
Y = mX + C

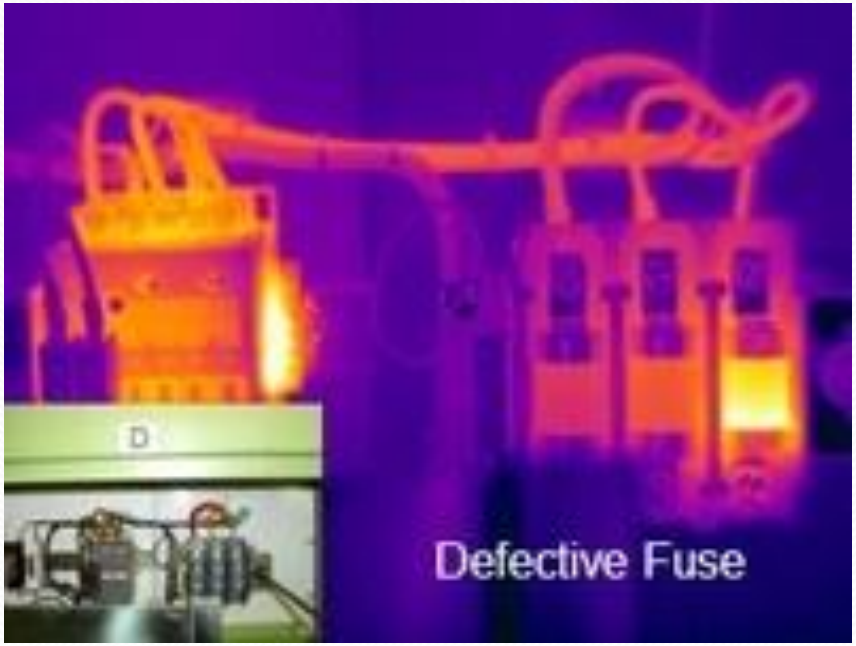


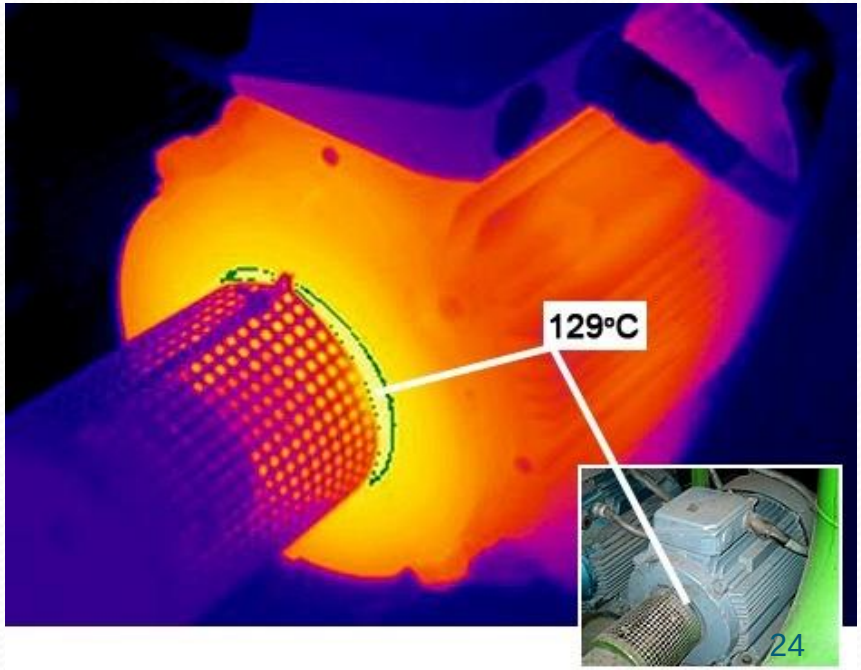
Organizational system scope

- Power distribution
- Utilities
  - Compressed air
  - Steam
  - Chill water
  - Water
- End use equipments
  - Heaters, Dryers
  - Drives, Pumps
  - Lights etc

Opportunities @ glance



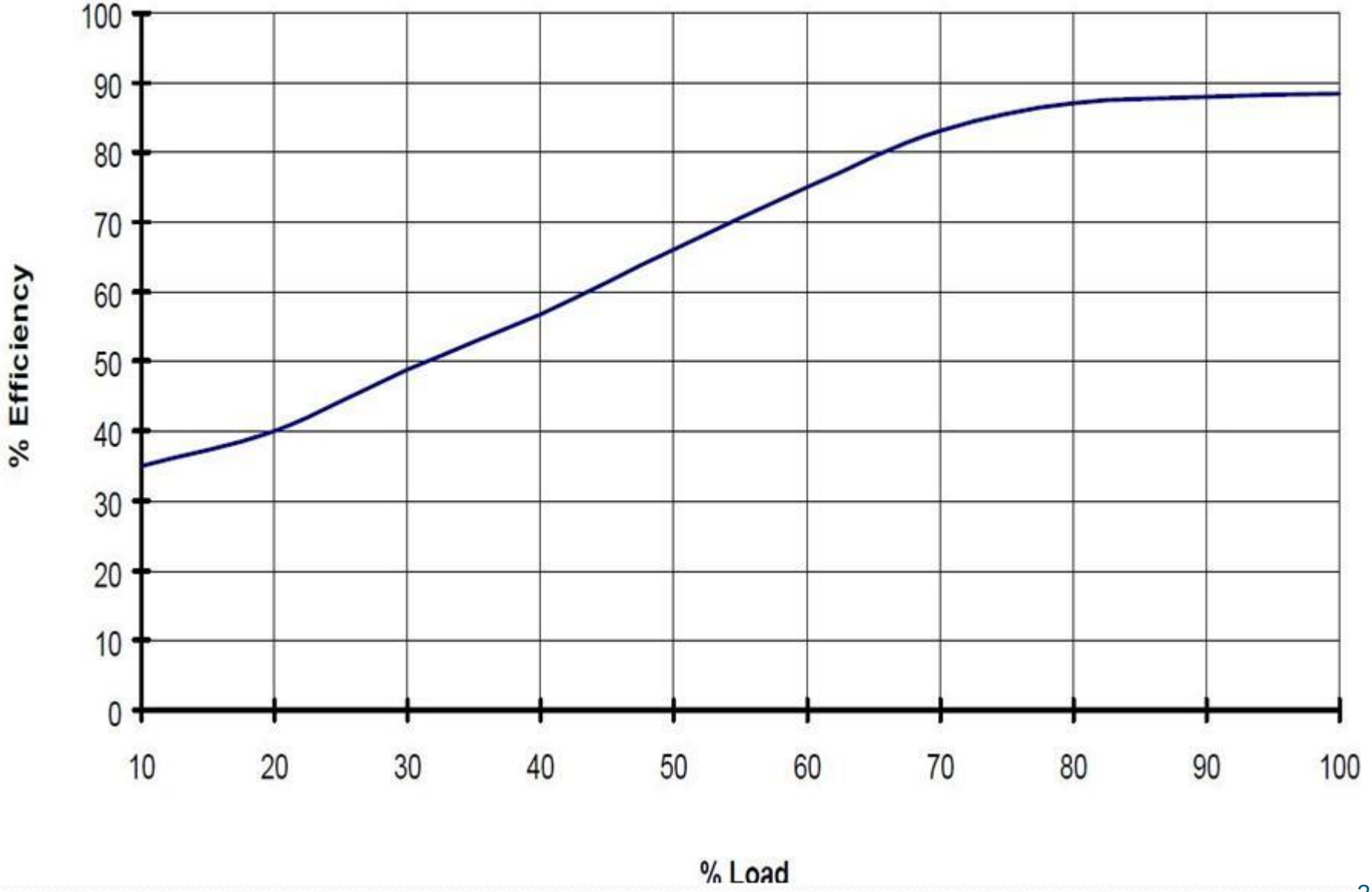




Grid connected

- Transformers
  - Single step / Multi step
  - Capacity matching
  - Installed environment
  - Maintenance
  - Protection
- Cabling
- Switch gear
- Metering
- Tariff

Transformer efficiency Vs Load



High Efficient Transformers

- Maximum allowable losses at full load

  11 kV transformer, 3 phase, oil immersed

Transformer Capacity, kVA	Maximum Allowable Losses at Full Load (% load loss + no-load loss)
100	2.5
160	2.3
250	2.1
400	1.5
630	1.4
800	1.4
1000	1.2

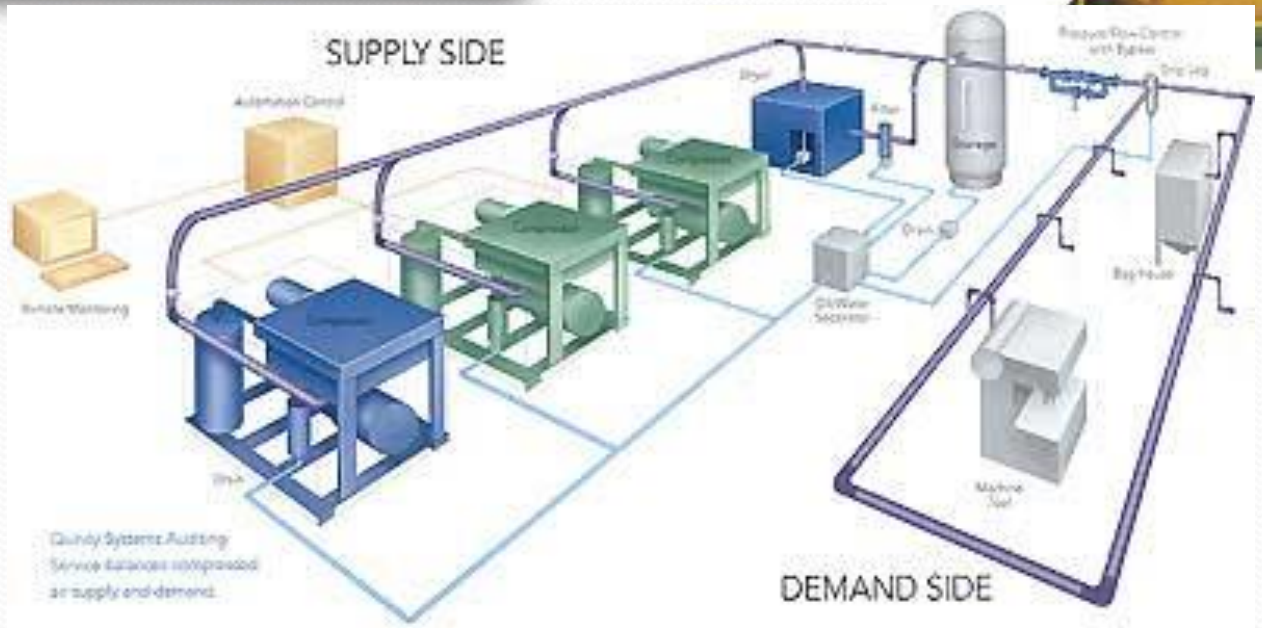
Distribution

- Correct Cable sizing
  - Life cycle costing
- Distribution planning
- Distribution system maintenance & management
- Demand management
- System harmonics
- Facilities for M & V

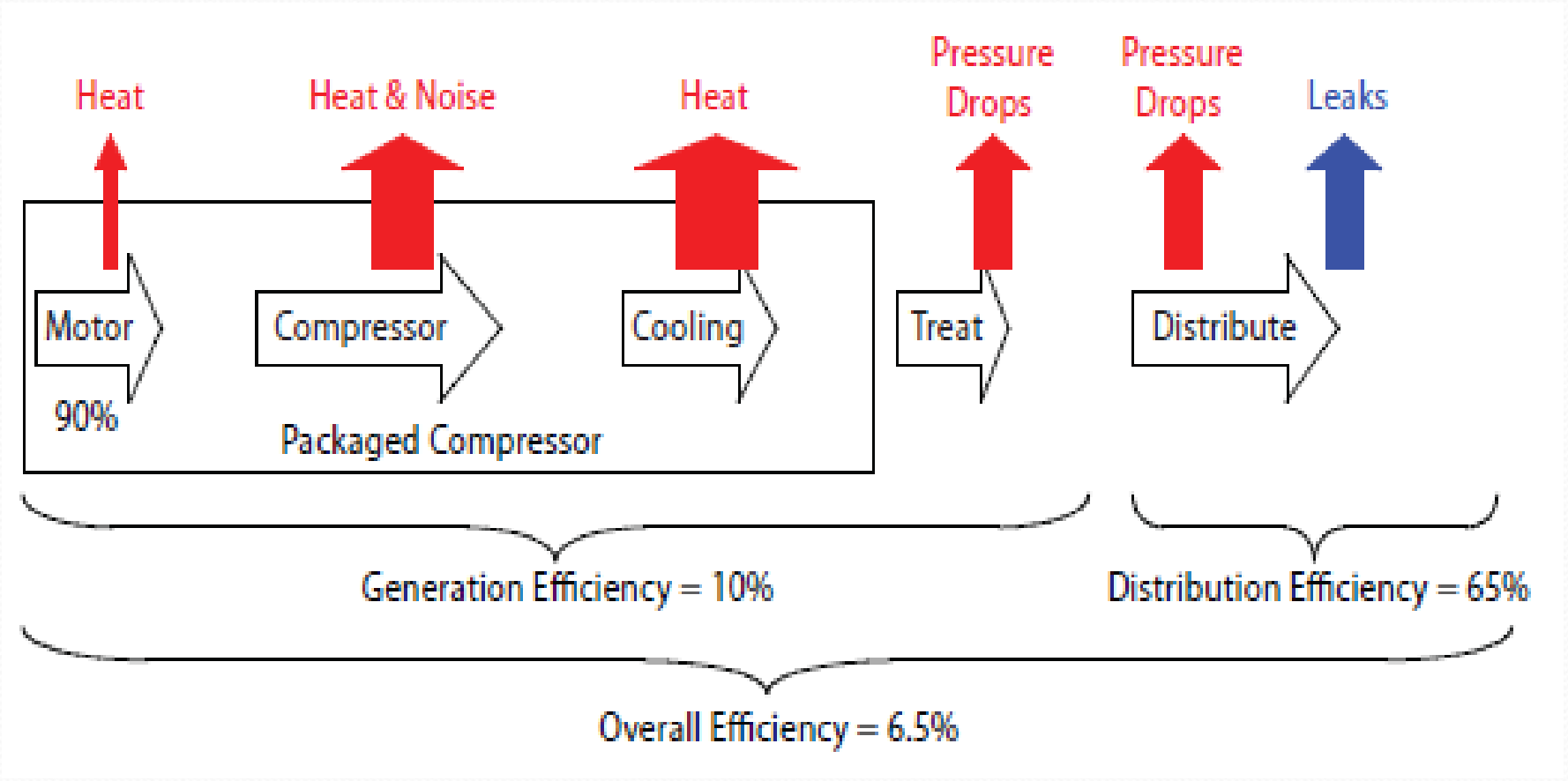
Systems and end user equipment

- Compressed air systems
- HVAC systems
- AC
- Pumps, Fans and motors

Compressors and Compressed air systems

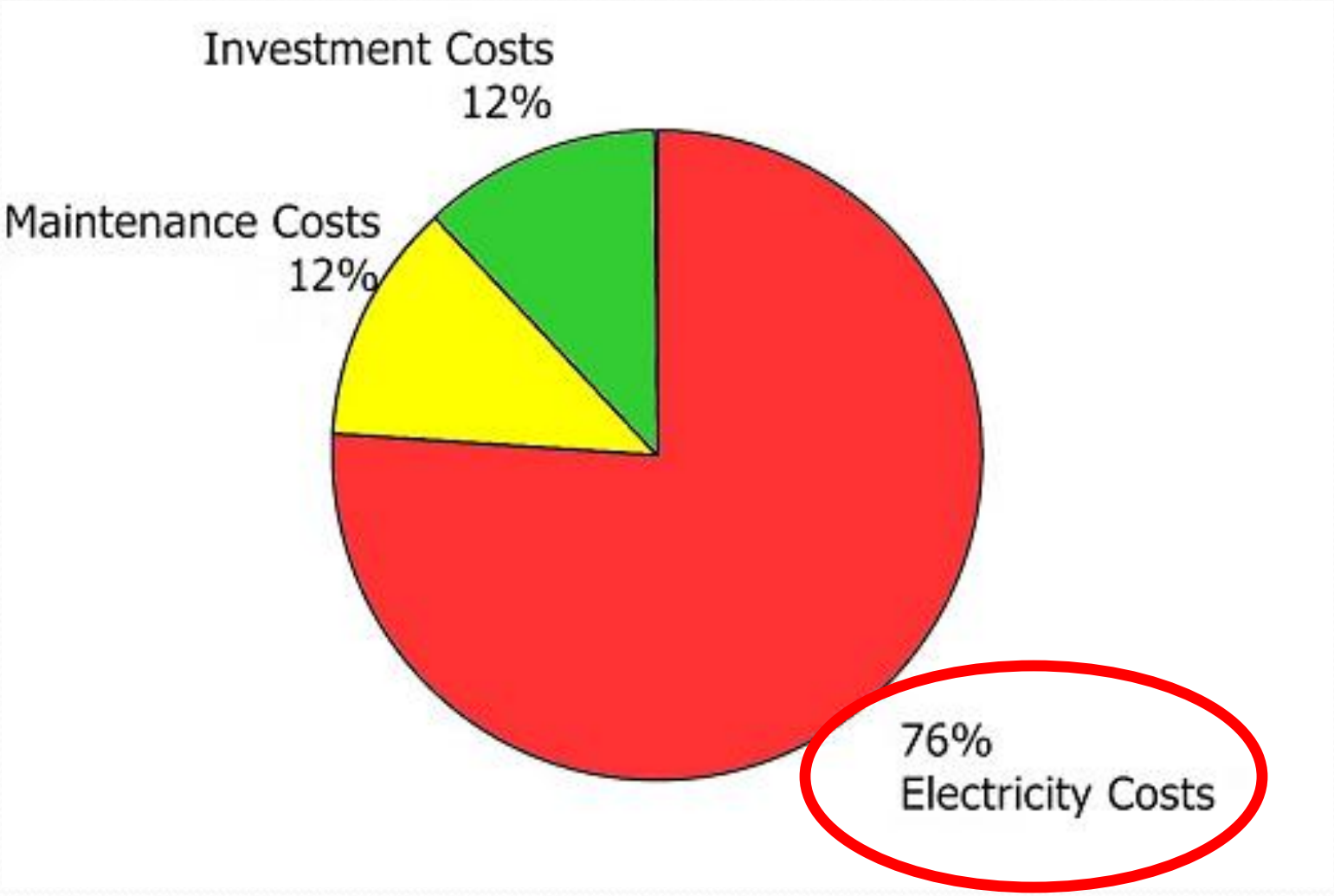


Compressed air systems



Ref: http://oee.nrcan.gc.ca/industrial/cipec.cfm

Life cycle cost

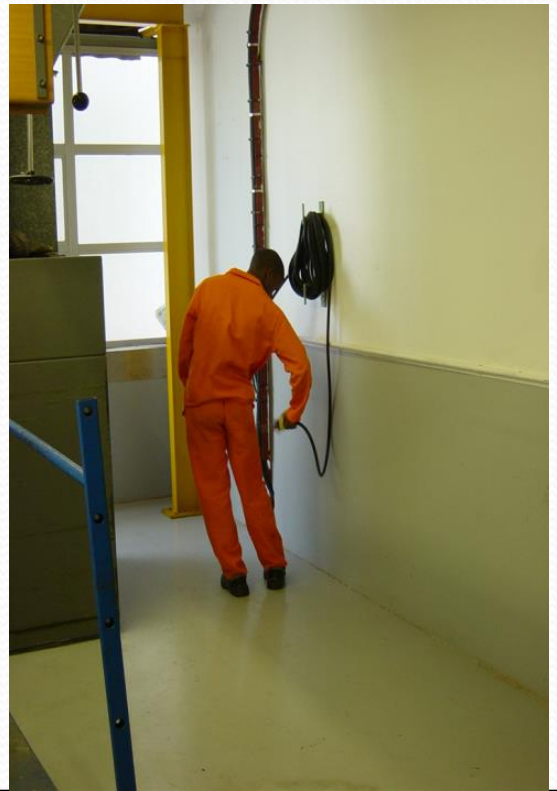


Energy Audit in Compressed Air system

- Investigate compressed Air application (Pressure, Quality, Purpose, Quantity)
- Study distribution (Pipe size, Fittings, drain traps, branching, regulators, filters)
- Study the compressed air treatment system
- Compressor location (inlet air, ventilation, ambient condition)
- Compressor control
- Maintenance practices
- Compressor leak survey

Typical savings with compressed air

- correct size, type, and control of compressor
- good maintenance saves electricity
- reduction of the grid pressure
- reduction of electricity consumption of 6 – 10 % per bar reduction
- Sometimes it pays to divide the grid
- intake air at compressor cool and clean
  - - 5 K (°C) of the intake air = - 1 % electricity
- Avoid nuisance and dangerous use

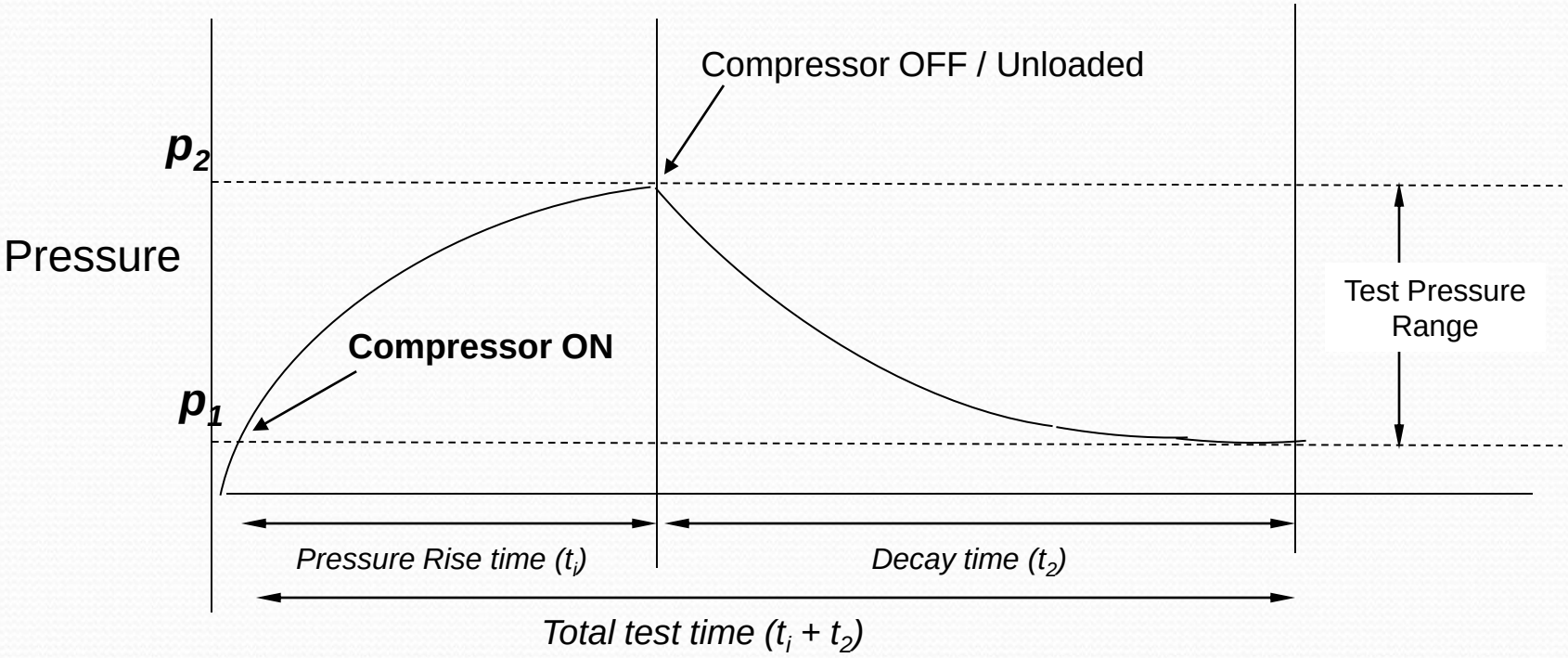


Energy Savings in Compressor

- Every 5 °C reduction in intake air temperature would result in a 1 per cent reduction in compressor power consumption.
- Compressed air leaking from a 1 mm hole at a pressure of 7 kg/cm2 means power loss equivalent to 0.5 kW.
- A reduction of 1 kg/cm2 in air pressure (8 kg/cm2 to 7 kg/cm2) would result in a 9% saving in input power.
- A reduction of 1 kg/cm2 in line pressure (7 kg/cm2 to 6 kg/cm2) can reduce the quantity leaking from a 1 mm hole by 10 per cent.

35

Regular leak test by observing Pressure decay



Energy Losses per year

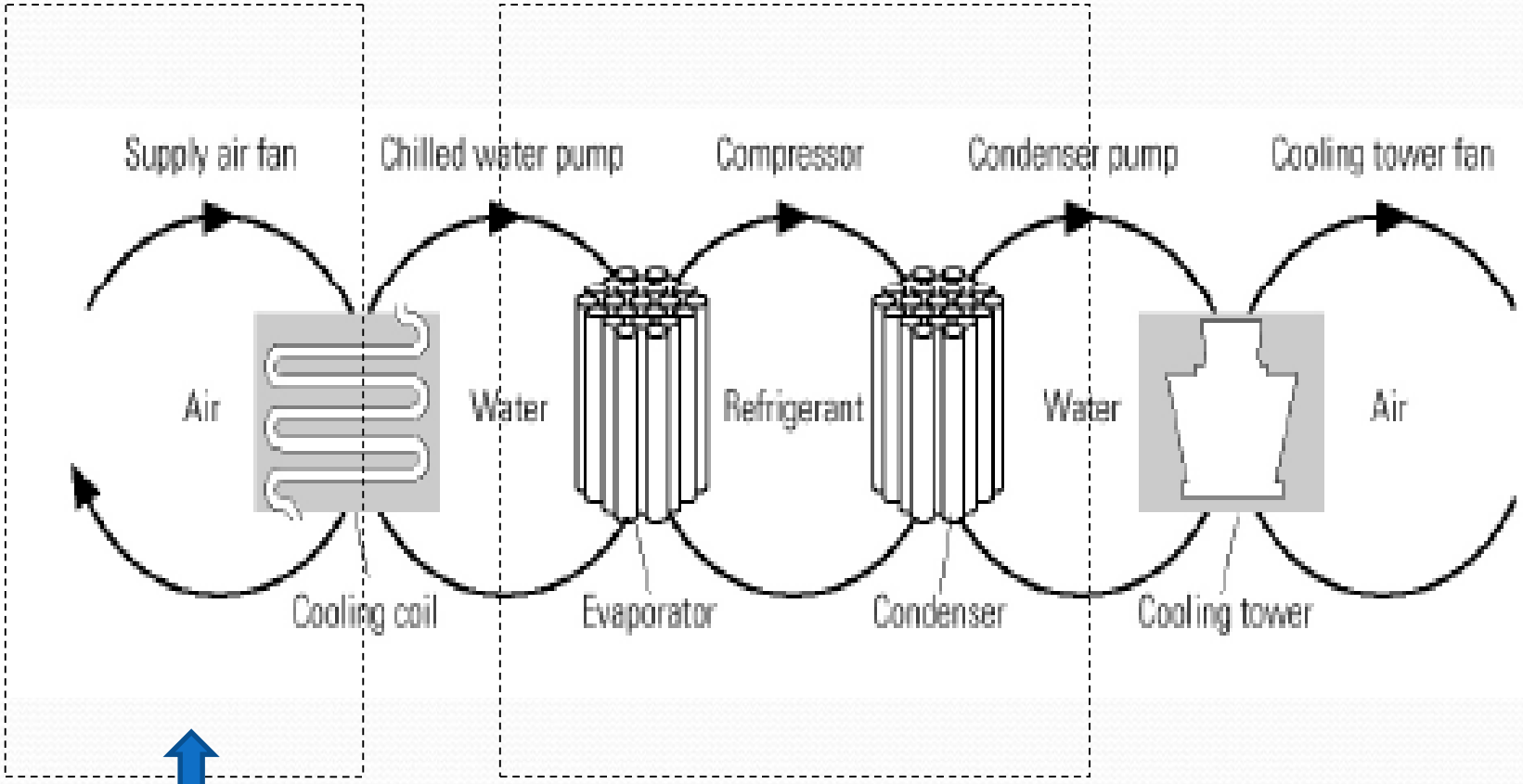
$$= P. \frac{t_1}{(t_1 + t_2)} . h \ kWh$$

(P = Compressor Power consumption)

Chilling and refrigeration Systems

Ref cycle Schematic

Room AHU/ FCU Chiller Outside



Fresh Air

EEI opportunities

- Low/no cost
  - Sizing and configuration
  - Resetting chill water temperature
  - Reset condenser water temperature
  - Chiller Sequencing
  - Regular maintenance
- Medium cost
  - Consolidation of Chiller Plant
  - Heat Gain Reduction Strategies
  - VAV Systems in place of CAV
- High cost
  - Water cool Vs Air cool
  - BAS / BMS
  - New technologies
    - VRV / VRF
    - Absorption / Adsorption systems

Pumps and Pumping systems

Energy efficiency opportunities

- Selecting the right pump
- Controlling the flow rate by speed variation
- Pumps in parallel to meet varying demand
- Eliminating flow control valve
- Eliminating by-pass control
- Start/stop control of pump
- Impeller trimming

Lighting systems

Background

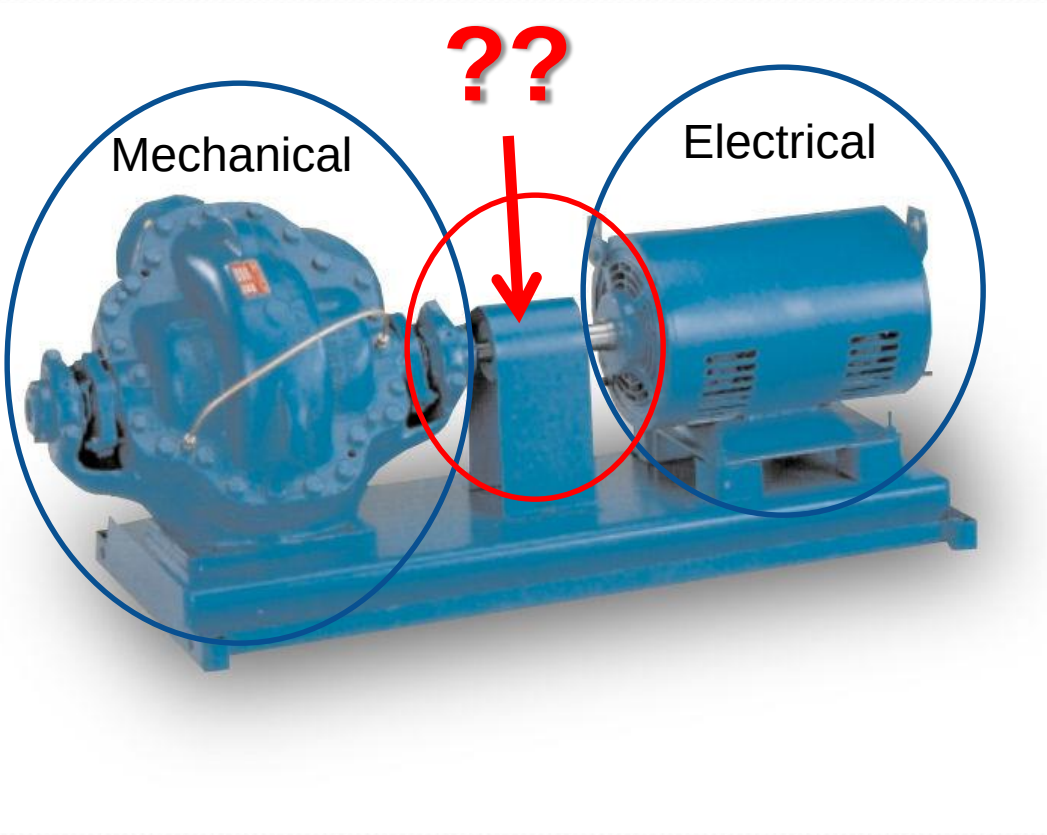
- Lighting energy consumption
  - 20-45% in commercial buildings
  - 3-10% in industrial plants
- Significant energy savings can be realized with a minimal capital investment and common sense
  - Replacement of Incandescent lamps
  - MDL with HPSL

Fans and Blowers

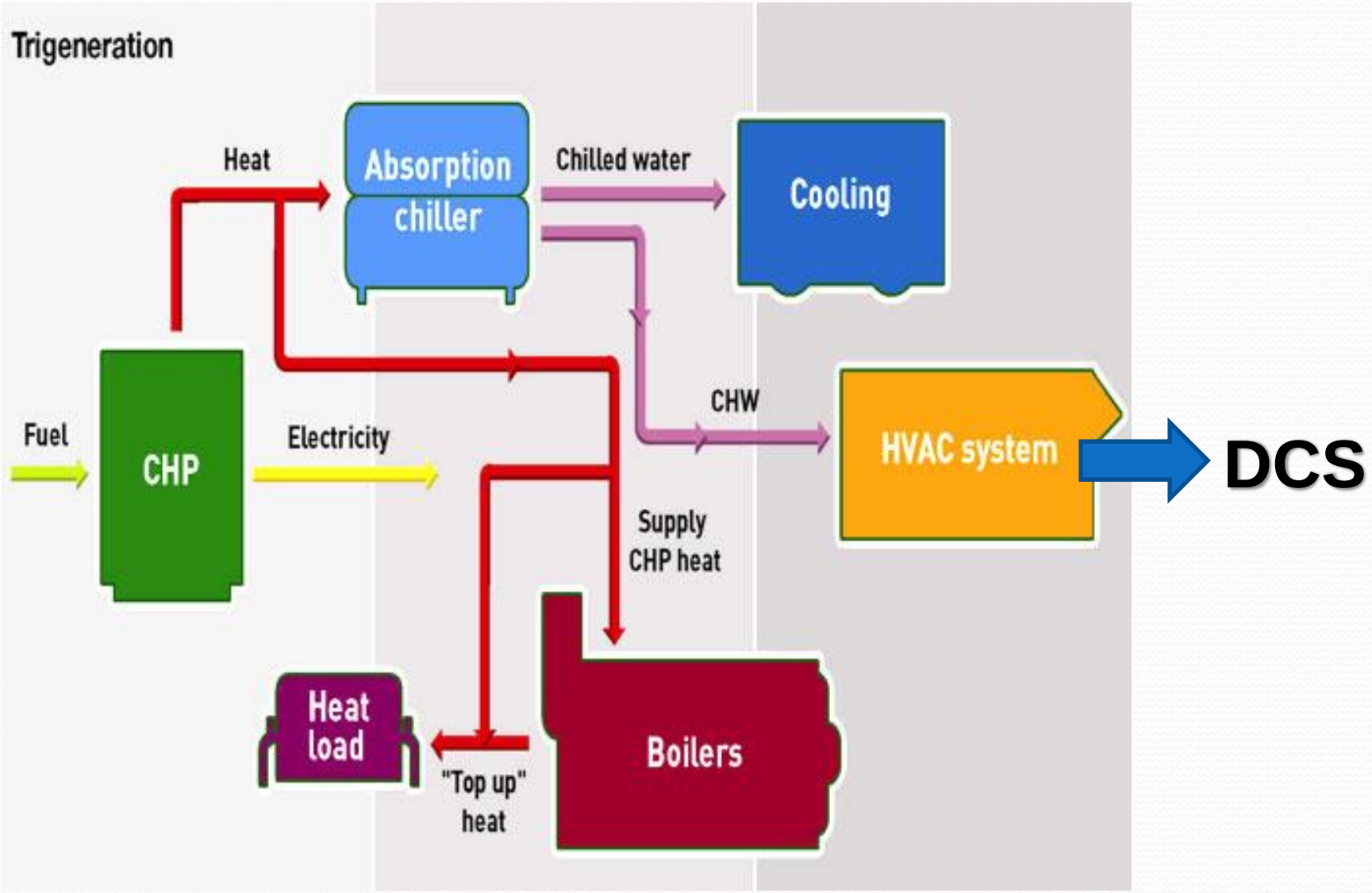
Energy efficiency opportunities

- Choose the right fan
- Reduce the system resistance
- Operate close to BEP
- Maintain fans regularly
- Control the fan air flow

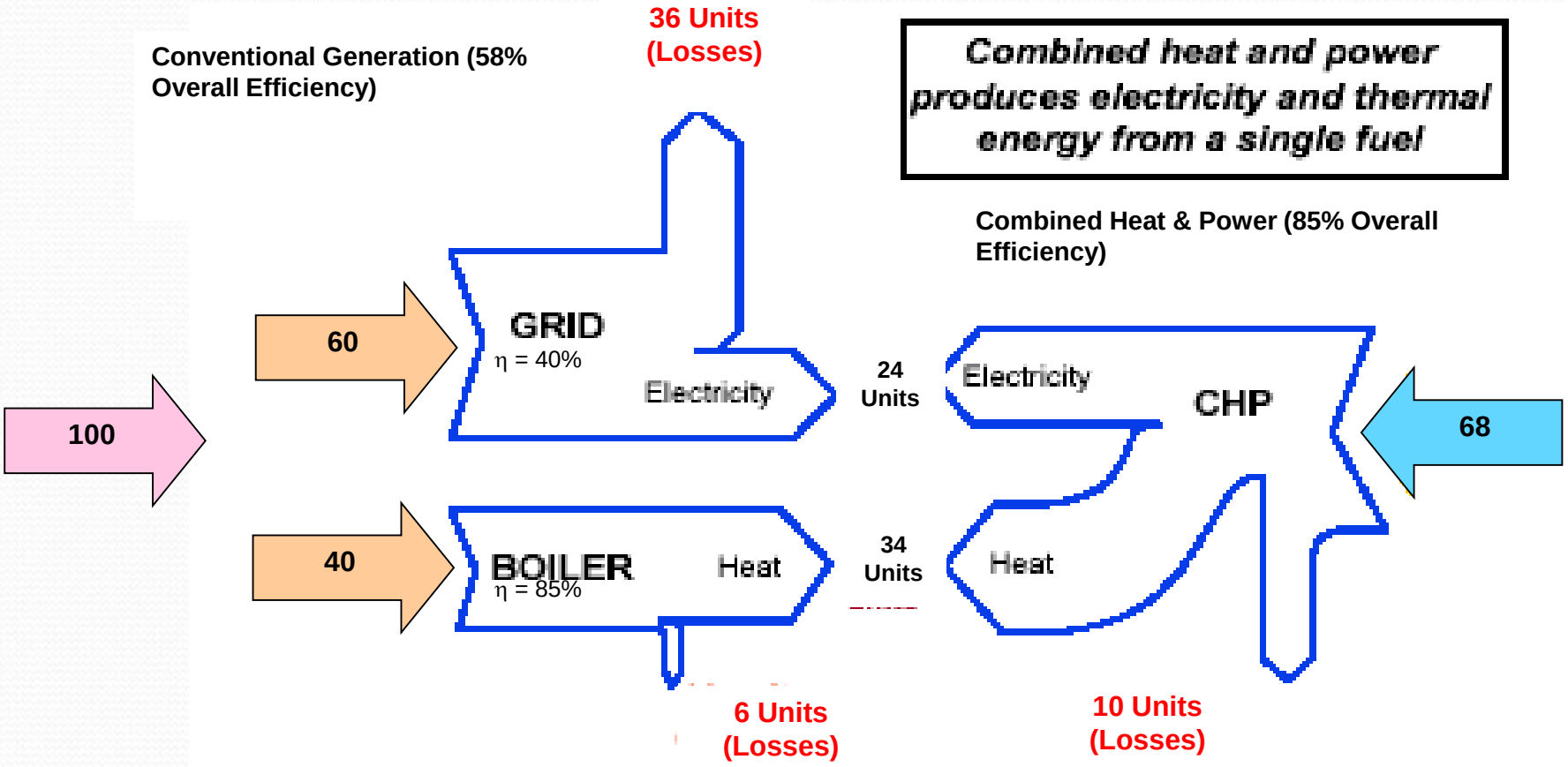
Why Heat and Electricity design separately?



CHP systems


Trigeneration
Heat
Absorption chiller
Chilled water
Cooling
Fuel
CHP
Electricity
CHW
HVAC system
DCS
Supply CHP heat
Heat load
"Top up" heat
Boilers

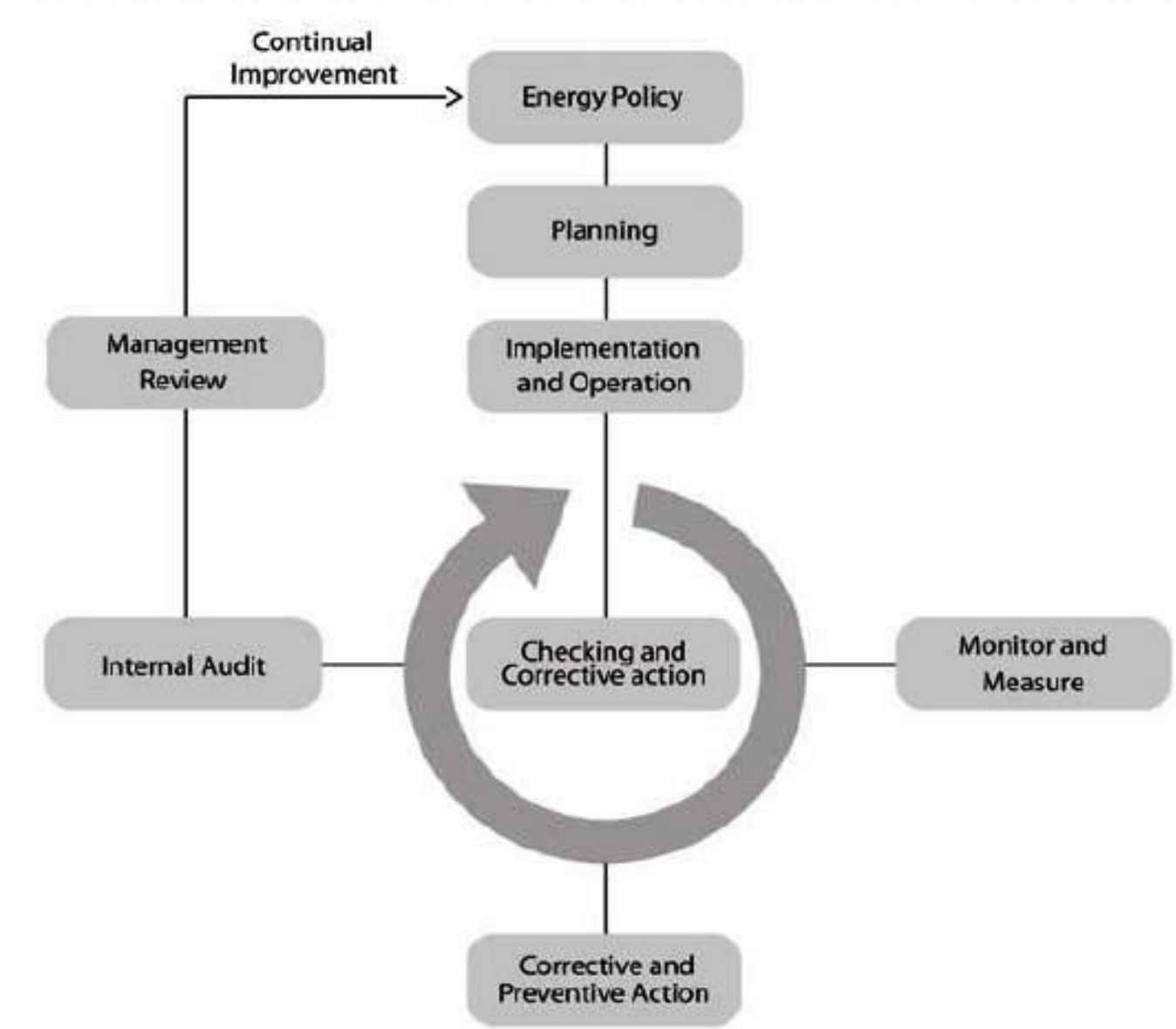
Efficiency Advantage of CHP



Sustaining energy efficiency measures

ISO 50001 -2011 EnMS model

(Source – ISO 50001:2011 standard)



Conclusion

- Potential is high
- Need exploration
- Need synergy between all stakeholders
- SEC is the best ground and driving force

End

Thank you