Module 6: Understanding processes and assessing energy performance of textile and garment factories

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

FABRIC Asia

LU 6.2: Energy Performance in Textile Utilities

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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At the end of this module you will be able to…

Assess and conduct energy balance of textile and garments utilities.

Resources

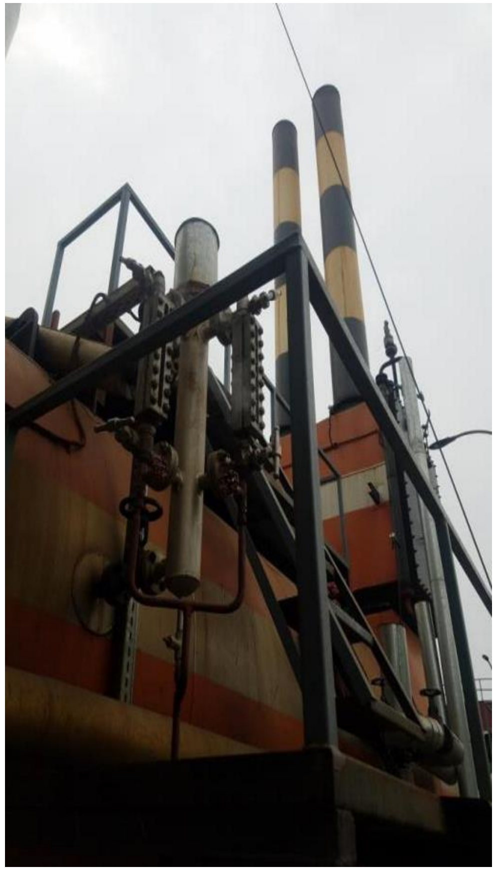
IFC Environmental, Health, and Safety Guidelines for Textile Manufacturing

Content

Steam System

- In your groups, develop an energy flow diagram of a steam boiler
- How can efficiency be measured? Identify which flows need to be monitored and how.
- Present your results in an "Information Market"

Time: 30 min



Steam System

Initial assessment

STEAM BOILERS THAT ARE THE USUAL SUSPECTS:

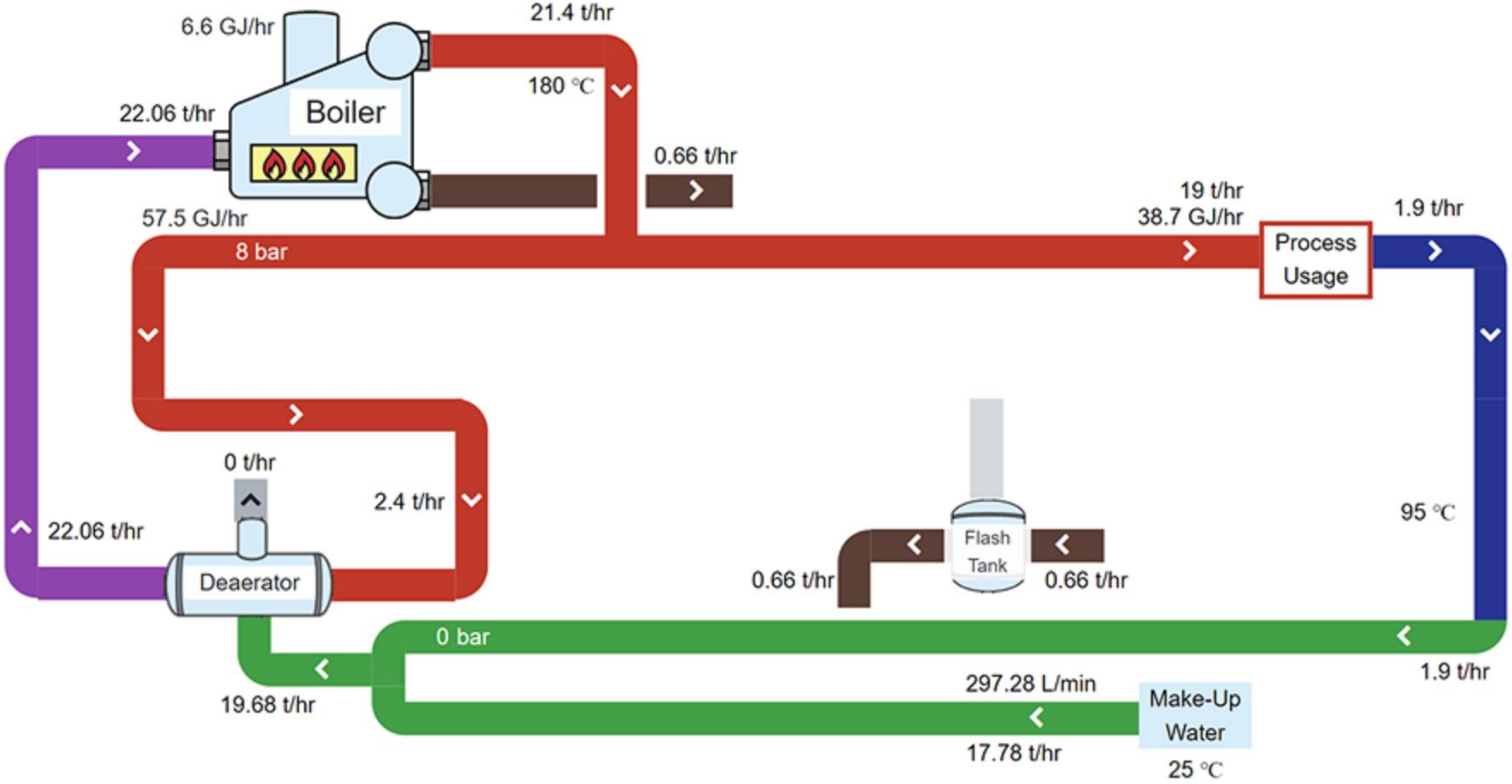
- Boilers that are already 20 years old
- Fire-tube boilers with 1 or 2 passes
- Boilers that use coal / biomass
- Large boilers (> 25 tons/h) that have no economizers and air preheaters
- Fire-tube boilers and superheated steam (Must be a small installation that generates power very inefficiently)
- Backup / Standby boilers connected with Common Steam Header

KEY QUESTIONS TO ASK:

- What is the temperature required in the process?
- If its always lower than 110°C, then why are they using steam?
- What is happening inside a boiler?

Energy Balance of a Boiler

Example: 25 TPH Coal Fired Boiler



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Steam System

Boiler Efficiency Analysis

Automated Air:Fuel ratio controllers help achieve much higher efficiency compared to damper controlled systems Flue gas temperatures as low as 110 °C are achievable on gas and liquid fuel boilers; 120-130 °C on solid fuels depending upon dew point.

Steam Production		Specific Energy Consumption	
No. of Boilers	Total Steam Production	Specific Fuel Consumption	Hourly Fuel Consumption
1	66.00	2.63	0.72
	Ton/d	mmBtu/Ton	mmBtu/h
Net Energy Requirement	Daily Energy Input	Total Energy Cost	Steam Cost (Fuel only)
144.55	173.70	0.11	1718.58
mmBtu/d	mmBtu/d	MPKR/d	PKR/Ton

Overall Efficiency of Steam Boiler
83.2%

Parameters	Units	Standard	Low Fire	25% damper	50% damper	High Fire
O2	%		3.34%	1.75%	3.04%	1.48%
CO	ppm	PEQ: 649	1044	8367	3758	7570
NOx	ppm	PEQ: 195	49	86	54	49
NO	ppm		49	86	54	49
CO2	%		9.93%	10.26%	9.88%	10.47%
Excess Air	Liters	14.7	17.346	15.729	16.905	15.435
SO2	ppm		0	0	0	145
Flue Temp.	°C		211	241.1	259.5	219.6
Efficiency	%	85%	81.6	78.5	78.7	79.7
Dew Point	°C		58.4	60.1	59	60.1
Amb. Temp	°C		28	29.2	29.9	27.9

Question: Why are efficiency values different in both charts?

Steam System

Boiler Efficiency Analysis

Coal (Proximate and/or Ultimate) and ash analysis reveal a lot about fuel quality and burning efficiency

Coal Analysis	
Fixed carbon	51.21%
GCV	5914 kCal/kg
Ash Analysis	
Unburnt carbon	15.47%
GCV of ash	1412 kCal/kg
Total ash residue	18%
Saving Potential	
Total Efficiency loss = Total ash collected per kg of coal fired x GCV of Grate Ash / GCV of Coal Fired	**CALCULATE**

Steam System

Boiler Efficiency Analysis

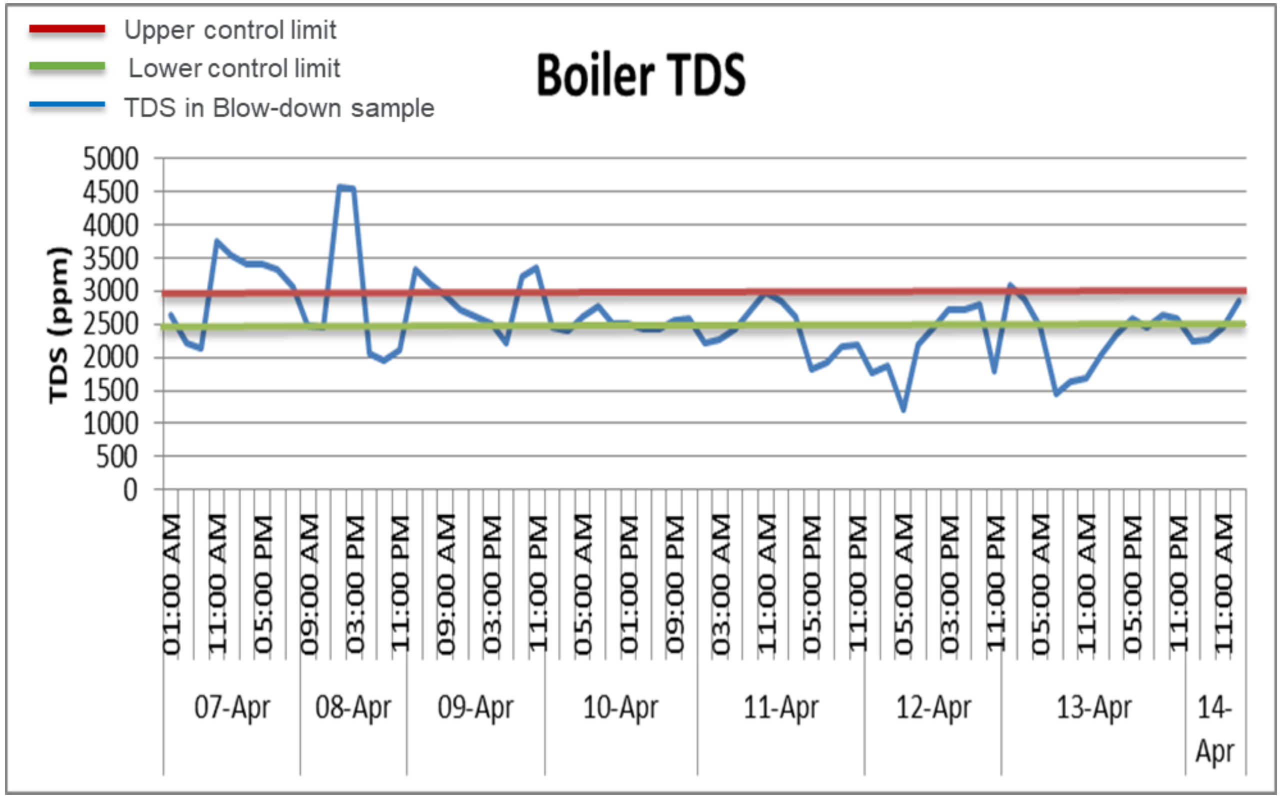
Coal (Proximate and/or Ultimate) and ash analysis reveal a lot about fuel quality and burning efficiency

Coal Analysis	
Fixed carbon	51.21%
GCV	5914 kCal/kg
Ash Analysis	
Unburnt carbon	15.47%
GCV of ash	1412 kCal/kg
Total ash residue	18%
Saving Potential	
Total Efficiency loss = Total ash collected per kg of coal fired x GCV of Grate Ash / GCV of Coal Fired	5.4%
Allowance for Unburnt Carbon	5% (Ideally 0%)
Possible efficiency improvement	**3.7%**

Steam System

Boiler Efficiency Analysis

An automated blow-down system significantly reduces loss of steam and water



Steam System

Typical network issues

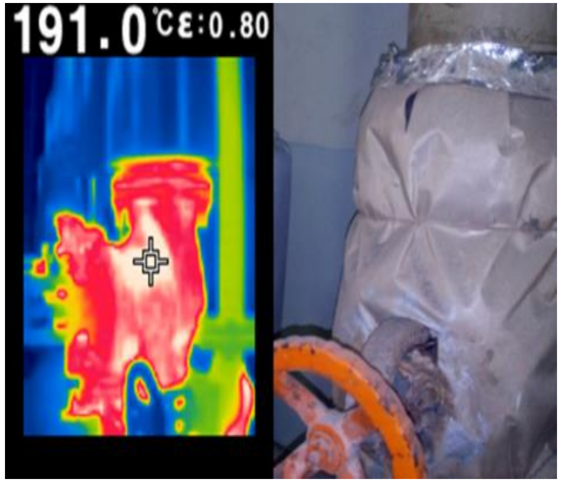
- Pressure drop study may reveal losses in the system due to piping network.
  - ✓ Often, high system pressure is maintained to compensate such losses
  - ✓ Need for installing Pressure Reducing Valves
- Wastage of condensate
  - ✓ Distance to boiler
  - ✓ Contamination in condensate
- Lifted Condensate lines (without pumps) resulting in back pressure on steam traps
- Flash steam at condensate recovery tank meaning that the steam traps are not functioning properly.

Location	Pressure [Bar]
Boiler	9
Washing	7
Dryers	7
PD Washing	7

Steam System

Typical network issues

- Steam pressure and temperature gauges missing at important consumers
- Undersized condensate return lines
- Absence of Pressure Reducing Valves (PRVs) – every consumer is supplied same pressure
- Leakages in steam network – usually Valves and link pipe joints
- Uninsulated surfaces (pipes, valves) resulting in condensation while distribution and results derating of distribution network.
- Leakages in steam network – usually Valves and link pipe joints
- Using condensate in WHRBs – Useless as it reduces heat recovery from flue gases



Thermal Oil Heater

- In your groups, develop an energy flow diagram of a thermal oil heater
- How can efficiency be measured? Identify which flows need to be monitored and how.
- Present your results in an “Information Market”

- Time: 30 min

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Thermal Oil Heater

KEY QUESTION TO ASK:

- Why do you need thermal oil when you already have steam boilers?
- What is the required temperature at demand side?

Thermal Oil Heater

What do you see in this video?

- Why does this happen?
- How could this be prevented?

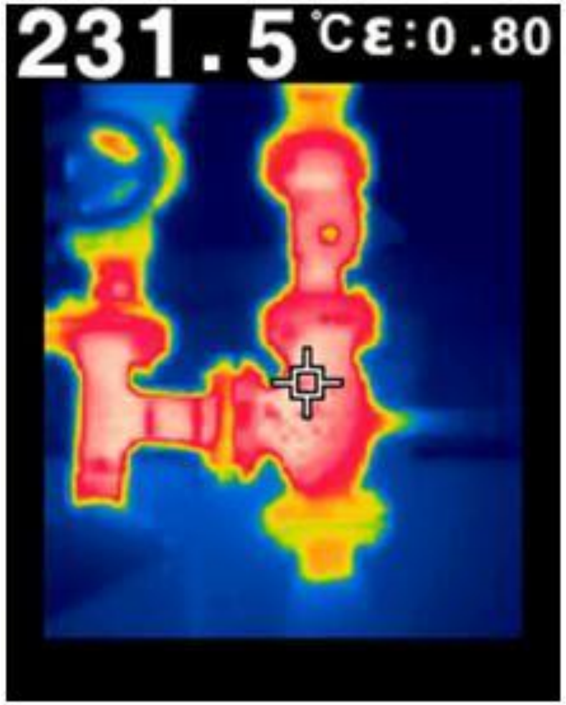
Thermal Oil Heater

Typical Issues

- Efficiency issues similar to boilers e.g.
  - ✓ Air-Fuel ratio (Excess oxygen)
  - ✓ Waste heat in flue gas
  - ✓ Working mode (Full Fire, High/Low Fire modes, Modulating)

Caution: Cross check optimum excess oxygen from equipment manufacturer

- Uninsulated surfaces, (Lengths, fittings, valves)
- Oil temperature kept too high compared to demand
  - ✓ e.g. oil temperature must be ~50 ^{o}C higher than required temperature at Stenter
  - ✓ How to check: very low temperature difference between heated and returning oil



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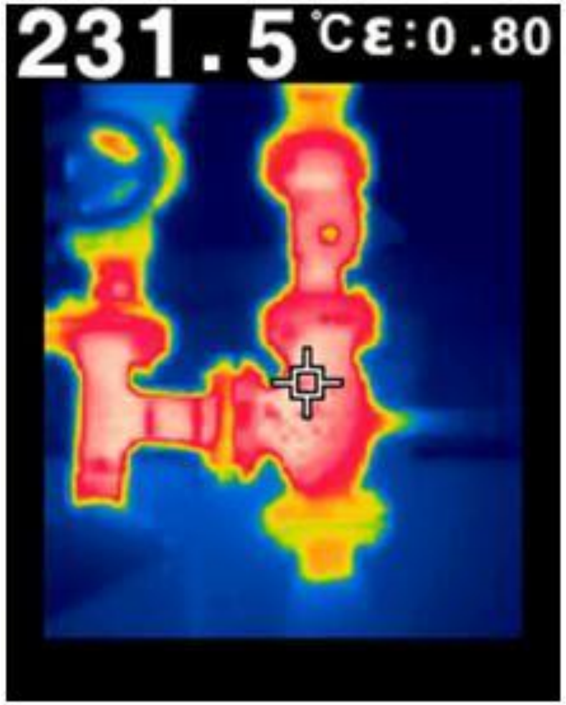
Thermal Oil Heater

Typical Issues

- Safety is the biggest concerns of these oil heaters.
- Always check if oil heaters are inspected on annual basis like boilers
  - ✓ In Pakistan these are not inspected as these are not considered as pressure vessels by law
  - ✓ Many accidents have been observed recently



Power Generation

- In your groups, develop an energy flow diagram of a power generation system including both electrical and thermal energy flows
- How can efficiency be measured? Identify which flows need to be monitored and how.
- Present your results in an “Information Market”

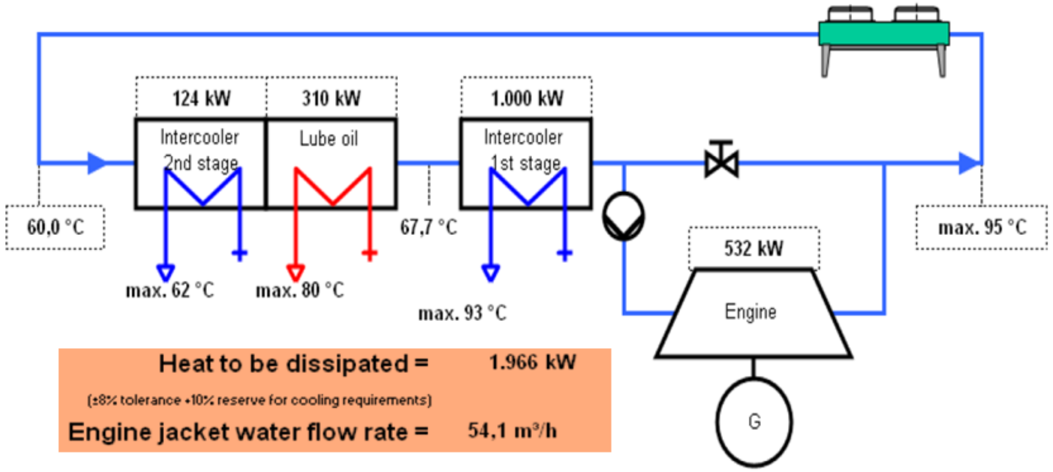
Time: 30 min

Power Generation

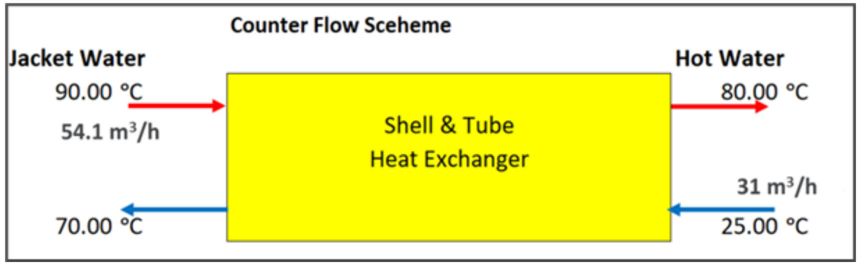
Waste Heat Recovery

- Generating steam from engine exhaust using Waste Heat Recovery Boiler (WHRB)
- Recover heat from WHRB using a condensing economizer
- Recover heat from Jacket Water to operate an absorption chiller or supply hot water for system results in significant thermal energy saving

Jacket Water Heat Recovery - Example



Jacket Water Flow (3.4 MW Engine)	54.1 m^3/h
Energy in Jacket Water Circuit	1,966 kW
Recoverable energy	7.1 GJ/h
Steam reduction	2.17 Tonne/h
Coal Saving	1,883 Tonne/y
Financial Saving	235,407 USD/y
Investment for JWHR	157,895 USD
O&M JWHR	3,158 USD/y
Investment for Cooling tower automation	8,000 USD
Total Investment	165,894 USD
Net Savings	232,249 USD/y
Payback	9 months
GHG emission reduction	3,938 TonneCO2/y



Jacket Water Heat Recovery - Example

WHRB Capacity (example)	2.0 TPH
Recoverable energy	1,393 kW
Steam generation	**1.7 TPH**
Coal Saving @ GCV 6,200 kCal/kg	206 kg-coal/h
Coal Saving	1,483 Tonne/y
Financial Saving	185,329 USD/y
O&M WHRB	1,579 USD/y
Investment for WHRB	**78,947 USD**
Net Savings	**183,751 USD/y**
Payback	**6 months**
GHG emission reduction	**3,100 TonneCO2/y**

Waste Heat Recovery Economizer - Example

Flu temperature (after WHRB)	155 ^{o}C
Desired flue temperature	**100 ^{o}C**
Desired dT	55 ^{o}C
Available energy	235.8 kW
Raw water temperature T1	25.0 ^{o}C
Hot water temperature T2	90.0 ^{o}C
Hot water dT	65.0 ^{o}C
Hot water flow rate	**3.1 m^3/h**
Steam saving	1,456 Tonne/y
Coal saving	176 Tonne/y
Financial Saving	**21,957 USD/y**
Investment	**19,737 USD**
Payback	**11 months**
GHG emission reduction	**367 TonneCO2/y**

- It is advisable to feed warm water (boiler feed water at 70^{o}C) otherwise the tubes will go under thermal shock. The output temperature is normally above 95^{o}C if fed at 75^{o}C.
- Hot water flow rate must be according to the need of hot water at demand side

Compressed Air System

- In your groups, develop an energy flow diagram of a compressed air system
- How can efficiency be measured? Identify which flows need to be monitored and how.
- Present your results in an “Information Market”

Time: 30 min

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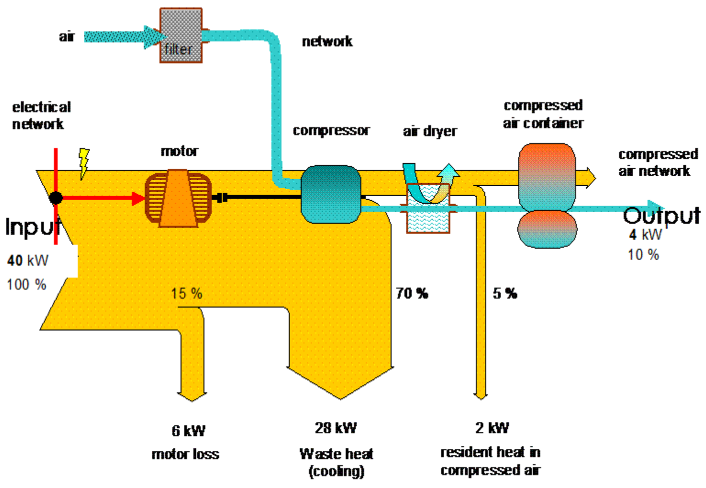
Compressed Air System

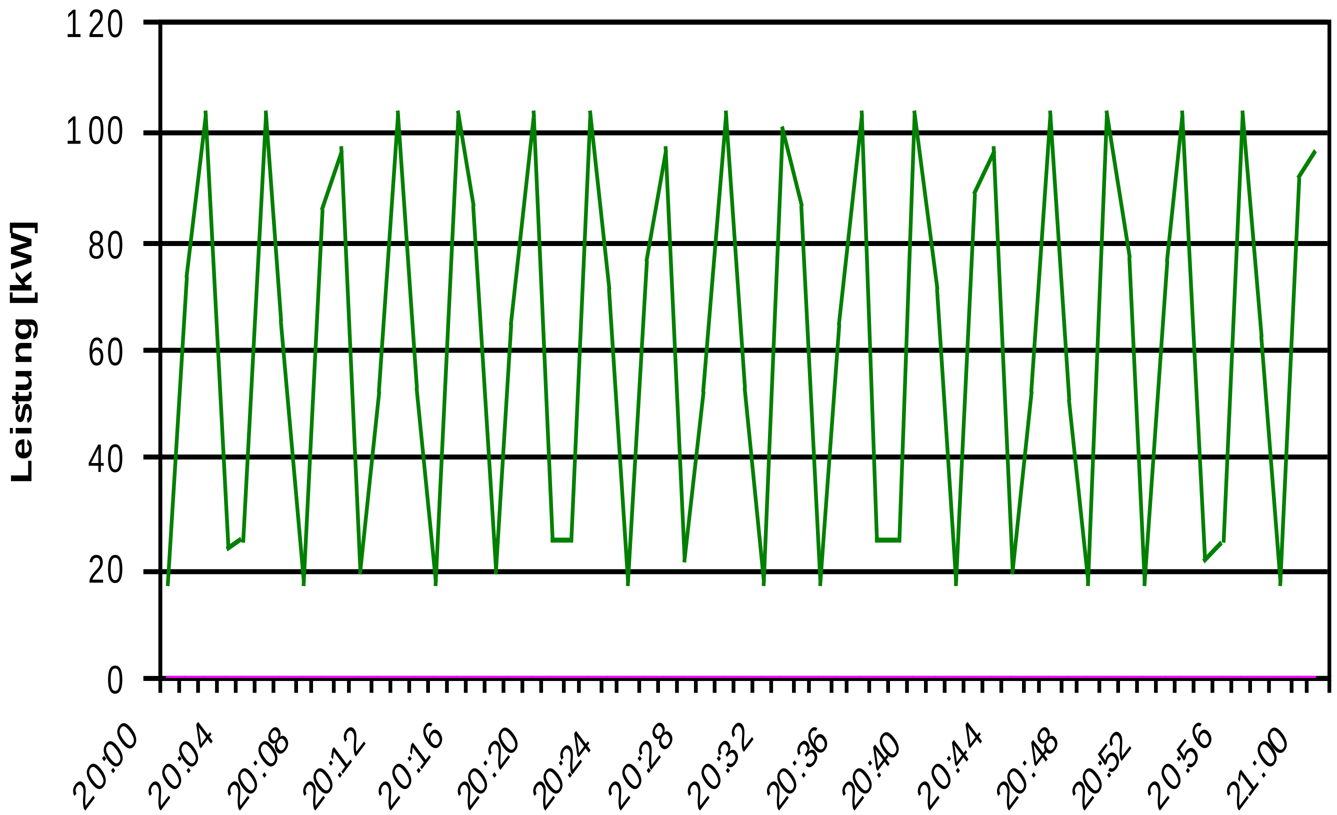
Waste Heat Recovery

- ~85% energy in a compressor is wasted in form of heat through the cooling circuit and only ~10% is converted into useful energy in form of compressed air
- A heat recovery system (parallel oil circuit) may provide return on investment in about 1 year
  - ✓ Important to keep automated stand-by cooling towers in case of failure in waste heat recovery system
  - ✓ Installing such system with individual compressors may increase investment but provides better safety and control

Key Question:
- What is compressed air used for?
- Why is it necessary?



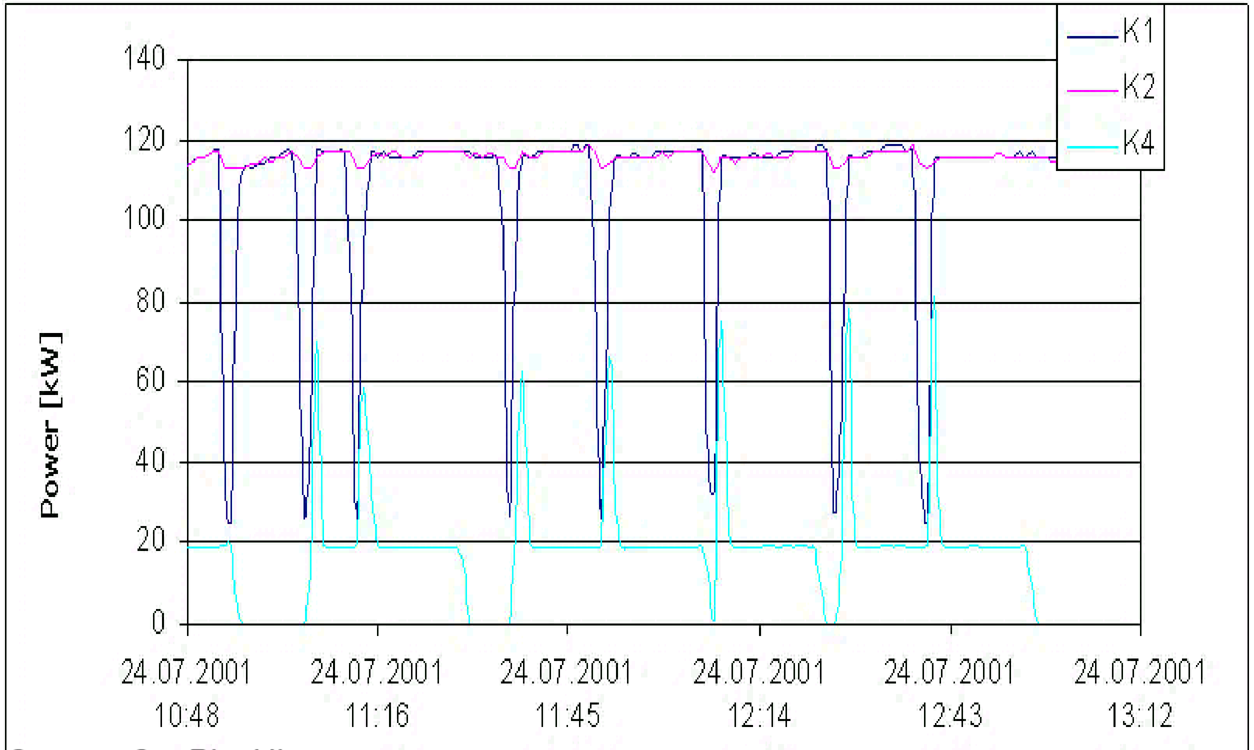
Compressed Air System



Source: ConPlusUltra

Compressed Air System

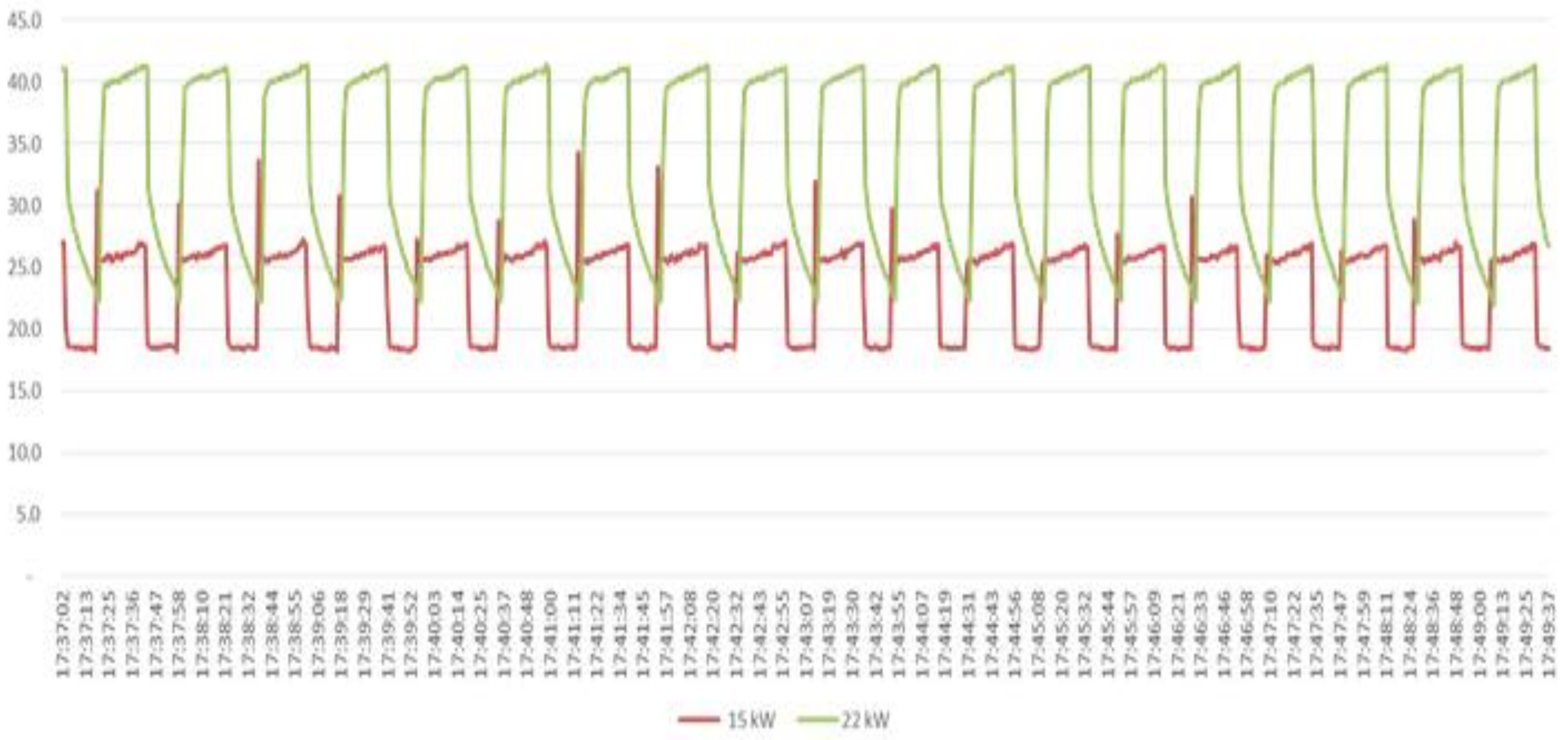
Load Profile



Source: ConPlusUltra

Compressed Air System

Load Profile

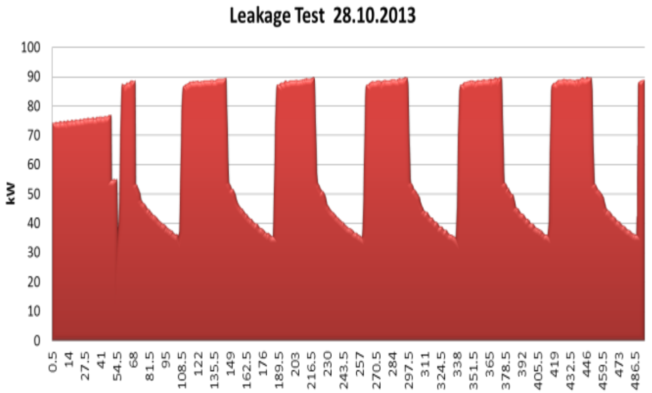


- Compressor control automation may result in 30-50% energy saving
- Typical payback < 1 year

Compressed Air System

Network issues to be addressed

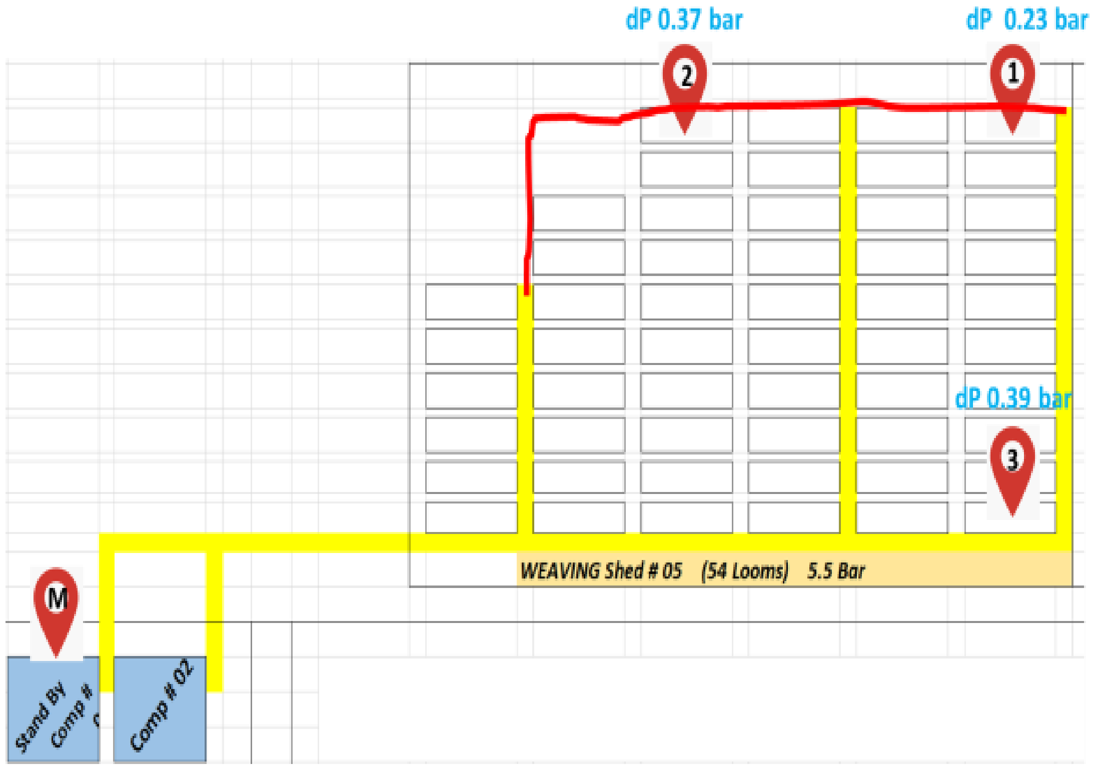
- Leakages may amount to 15-20% of total air demand; at times, leakages as high as 50% of demand have also been observed
- Faulty condensate drains and pressure regulators are one of the biggest contributors
- These leakages create artificial demand and require higher pressure set-points at compressor



Compressed Air System

Network issues to be addressed

- Pressure drops can be reduced by using closed loop system
- Matching supply and demand air pressure reduces air consumption and leakages
- Properly sized Receiver Tank can also improve stability of system



Compressed Air System

Dryers

- Keep Dew Point between 3-5 °C to avoid condensation in the network
- Very low dew point value represents potential to reduce number of dryers
- Investment: installation of Dew point sensors
- Typical payback less than 1 year

Name of Dryer	**Dew Point**
Main discharge	**1.5 °C**
Dryer 1	**0.7 °C**
Dryer 2	**0.4 - 0.5 °C**
Dryer 3	2.4 – 2.5 °C
Dryer 4	**24.5 °C**
Dryer 5	**10.1 °C**
Dryer 6	**10.4 °C**
Measurements using a dew point data logger	

Cooling Towers

- In your groups, develop an energy flow diagram of a cooling system using cooling towers
- How can efficiency be measured? Identify which flows need to be monitored and how.
- Present your results in an “Information Market”

Time: 30 min

Cooling Towers

- Monitor heat exchange at cooling tower and modulate / sequence accordingly (In relation to range and approach temp)
- Automated control (PLC), VFDs on all pumps and fans, and temperature sensors
- The savings are escalated due to;
  - ✓ Variation in temperature during the 24 hrs
  - ✓ Seasonal variation in average temperature
  - ✓ Variation in cooling demand
- Return on investment = ~3 years

Cooling Tower No.	Water Temperature at Inlet (^{o}C)	Water Temperature at outlet (^{o}C)	Range ΔT (^{o}C)	Observations / Remarks
1	42.6	35.7	**6.9**	Uneven distribution of water droplets across the fills was observed that may cause the lower range
2	42.6	35.4	**7.2**	
3	42.6	33.7	8.9	Satisfactory range
4	42.6	33.2	9.4	Satisfactory range

Cooling Towers

Water Quality

- Use soft water to makeup the water level in cooling towers
- Engineering Benefits
  - ✓ Low Scaling of Fills
  - ✓ Better heat exchange rate
- Financial Benefits
  - ✓ Decreased water pumping cost
  - ✓ Decreased water treatment chemical use
  - ✓ Low maintenance cost of cooling towers

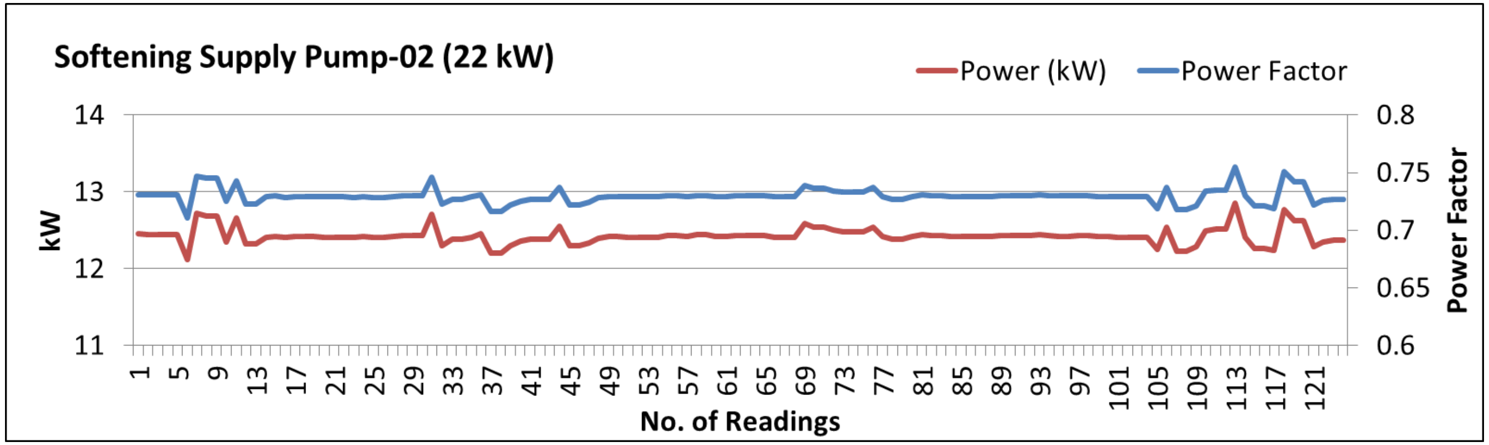
Pumps

- In your groups, develop an energy flow diagram of a water pumping system
- How can efficiency be measured? Identify which flows need to be monitored and how.
- Present your results in an “Information Market”

Time: 30 min

Pumps

- Average pumping efficiency in manufacturing plants can be less than 40%; with many pumps operating below 10% efficiency.
- Oversized pumps and the use of throttled valves are major contributors to the loss of efficiency.
- Energy savings of 30% to 50% in pumping systems could be realised through equipment or control system changes.
- Efficiencies of 50% to 60% or lower are quite common.



Pumps

Typical issues to consider in pump selection

- Select pump size appropriate to the load for optimum efficiency. Avoid purchasing of oversized or undersized pumps. Evaluate Net Positive Suction Head for your system prior to ordering for a Pump.
- Select the pump type appropriate to the requirement i.e. axial, centrifugal etc. with right impeller size.
- Ensure that the selected pump is compatible with variable-speed drives.
- Ensure basic instrumentation of pumps [e.g. pressure gauges, flow meters, energy meters, etc.]
- Reduce system resistance by pressure drop assessment and selection of right pipe size and material.
- Optimize the plant design and pipe layout to minimize pumping need and pressure losses. Maximize the pipe diameter.
- Develop purchasing specifications of all pumps, including criterion to judge energy performance.
- Setup multiple sized pumping system for varying flows.

Pumps

Typical issues to consider in pump selection

- Conduct water balance analysis to identify wastages
- Ensure that the pumping demand is reduced and system has a low required flow rate.
- Ensure that the operating pressure of the pumping system is kept low.
- Optimise number of stages in multi-stage pump in case of head margins.
- Increase fluid temperature differential to reduce pumping rates in case of heat exchangers.
- Adapt to wide load variation with variable speed drives or sequenced control of multiple pumping units.
- In the case of over designed pump, provide variable speed drive, or downsize / replace the impeller / Impeller Trimming or replace it with the correct sized pump for efficient operation.
- Use booster pumps for small loads that require higher pressures or higher heads.

Pumps

Typical issues to consider in pump maintenance

- Regularly monitor pumping efficiency and energy performance of pumping system.
- Monitor vibration of pumps periodically
- Monitor differential head and temperature rise across the pump (also known as thermodynamic monitoring).
- Perform distribution system inspection for scaling or contaminant build-up.
- Monitor leaks in pumps regularly and immediately fix identified leaks.
- Avoid Cavitation
- Conduct bearing inspection for increased noise and repair / replace based on conditions.
- Put pressure or flow sensors in the location that will help ensure process requirements are met without excess pumping energy.
- Replace worn impellers, especially in caustic or semi-solid applications.
- Inspect pumps for wear in seals, rings, impellers and bearings and take immediate corrective and preventive measures.

Chillers

- In your groups, develop an energy flow diagram of a cooling system using chillers
- How can efficiency be measured? Identify which flows need to be monitored and how.
- Present your results in an “Information Market”

Time: 30 min

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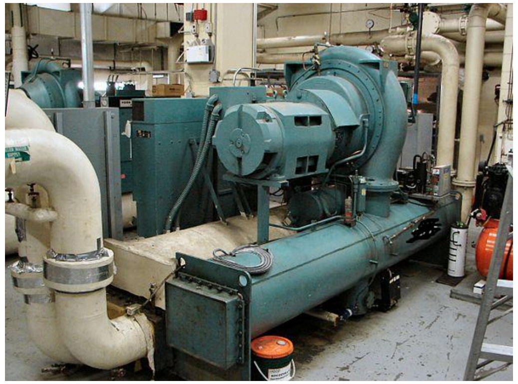
Chillers

- **Used in textile industry to cool down;**
  - ✓ Process Water (e.g. for some dye preparation)
  - ✓ Machine cooling
  - ✓ Space cooling (in combination with ventilation system)
- **Typical questions to ask;**
  - ✓ Why is chilling needed?
  - ✓ What is the REQUIRED temperature?
  - ✓ Does temperature demand vary?



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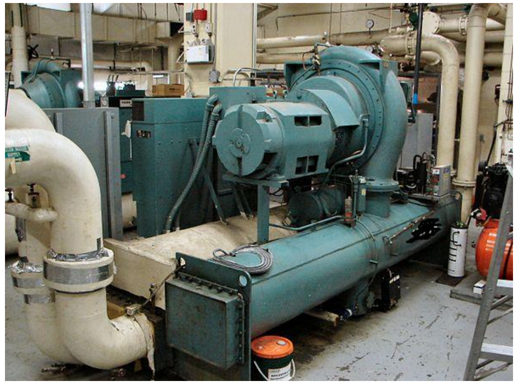
Chillers

Typical issues

- Temperature monitoring
  - ✓ Automated Modulation of chillers and cooling towers according to varying temperature needs
- Refrigerant quantity to be optimized
  - ✓ Refrigerant leakage → GHG emissions, Energy Loss
  - ✓ Consider Switching to refrigerant with low global warming potential (GWP)
  - ✓ Monitor refrigerant pressure to ensure ~ZERO Leakage
- Heat exchanger performance to be monitored
  - ✓ 20% reduction in condenser water flow → 5% increase in energy demand
- Right-sizing



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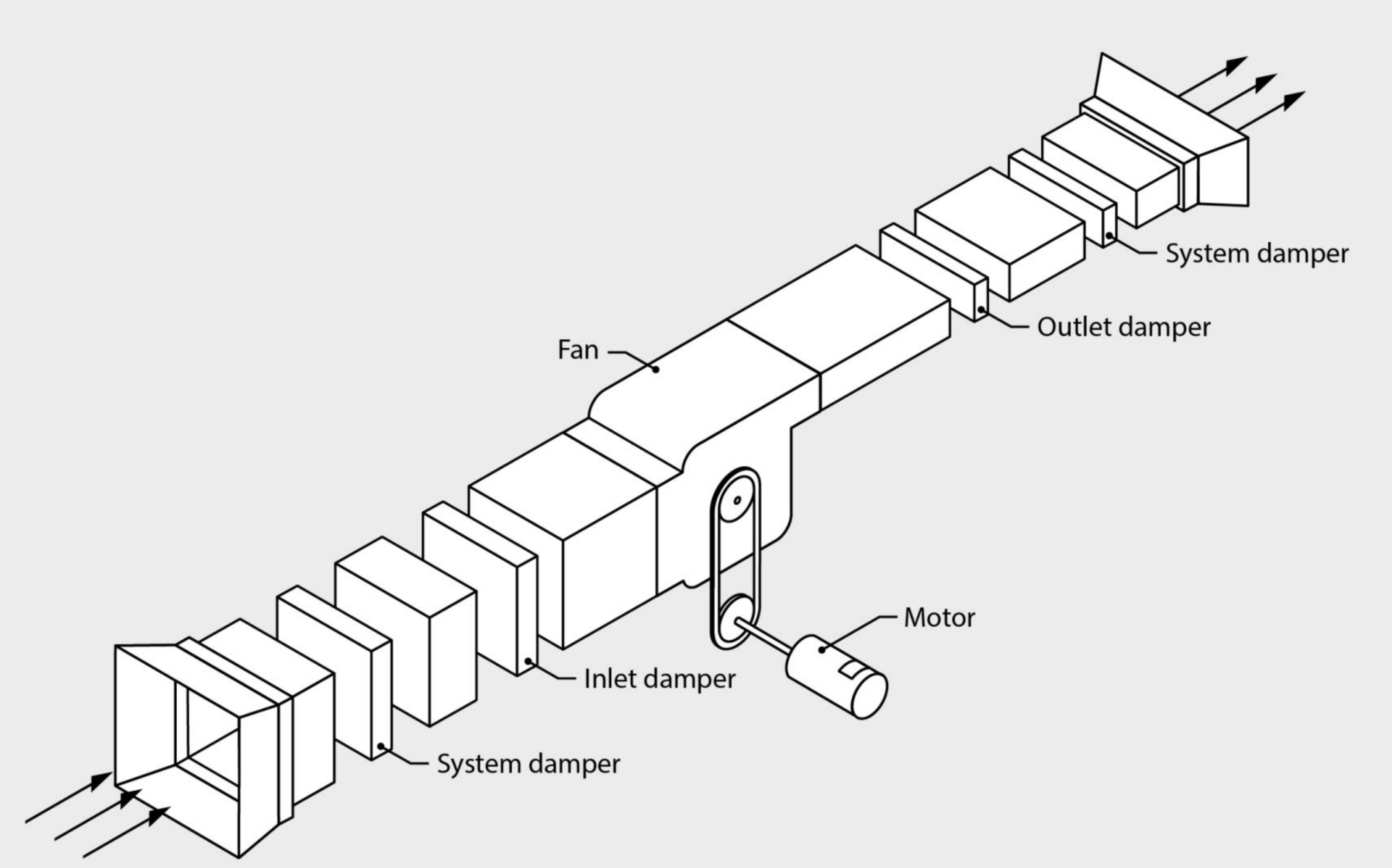
Fans

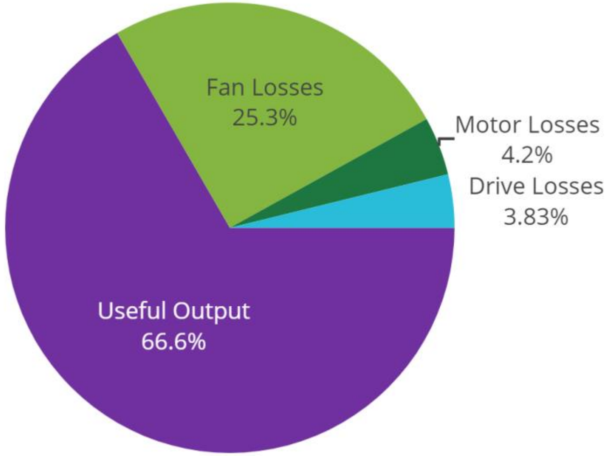
Critical questions to ask:

- Is modulation needed?
- Why are dampers used?
- Are fan blades variable?

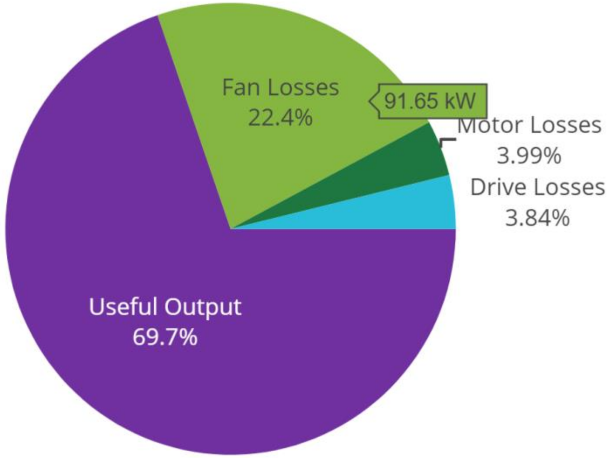


Fans

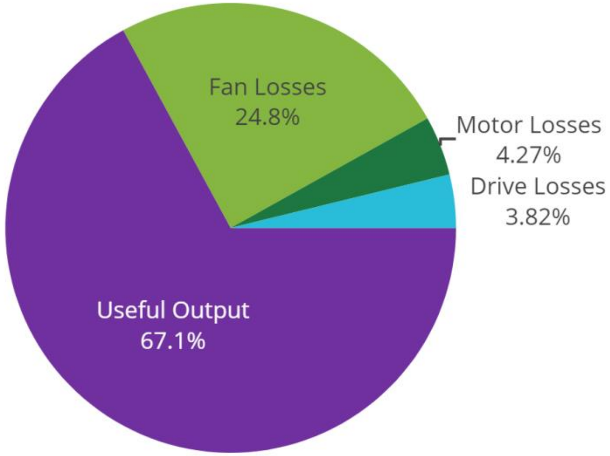
Example assessment



Baseline conditions



Optimized Fan & Motor Combo



Reduced Pressure & Flow

Key takeaways

- Often assessment of energy utilities is conducted based on symptoms and pre-defined checklists instead of in-depth evaluation of the whole system a utility is connected to. E.g., compressors and network devices may be assessed in silos but are usually not assessed as a whole system
- In order conduct meaningful assessment, first step is to develop an Input-Process-Output diagram or an energy balance of whole system e.g., Steam System, Compressed Air System etc. This reveals many facts about the nature and manner of energy use and thus opens new avenues for energy saving

Plan next steps

- Identify which utilities are significant energy uses (SEUs) and develop their Input-Process-Output diagrams with quantification of energy balance
- Identify which variables significantly affect energy performance of these utilities
- Calculate cost impact of the energy NPOs / wastes
- Select improvement measures to reduce energy NPOs and calculate their financial payback

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