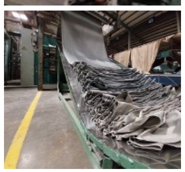






Understanding the processes and their energy consumption

ENERGY EFFICIENCY IN TEXTILE UTILITIES

Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

Resource Efficient Management of Energy (REME)





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 / bio mass
  - 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?

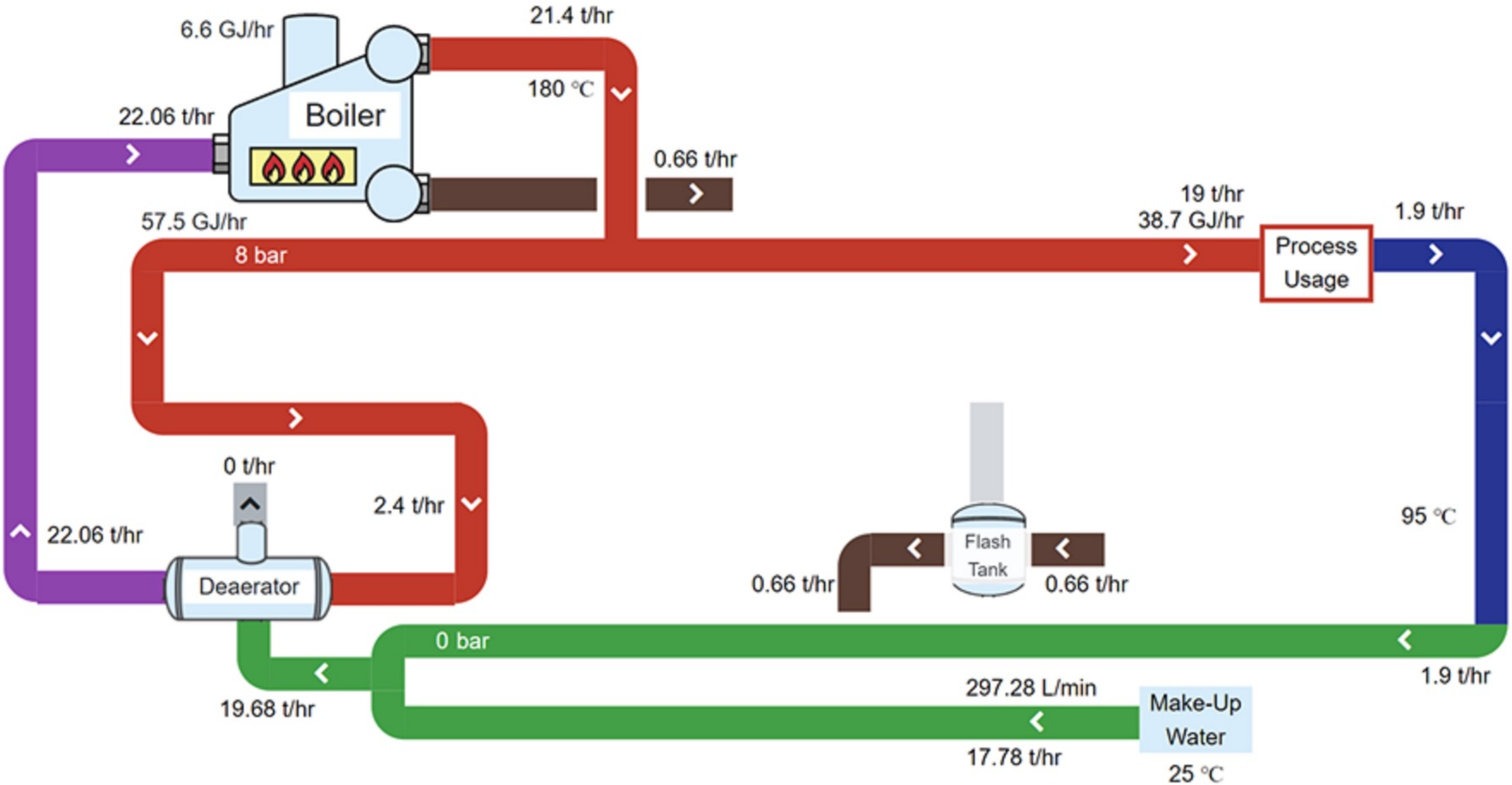
Task!

- In your groups, develop an energy flow diagram of a steam boiler
- Identify which flows need to be monitored and how
- Present your results in an “Information Market”

Time: 30 min

Energy Balance of a Boiler

Example: 25 TPH Coal Fired Boiler



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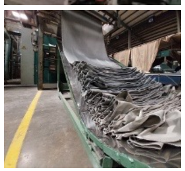

Steam System

Boiler Efficiency Analysis

Question: Why are efficiency values different in both charts?

- 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

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

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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%**

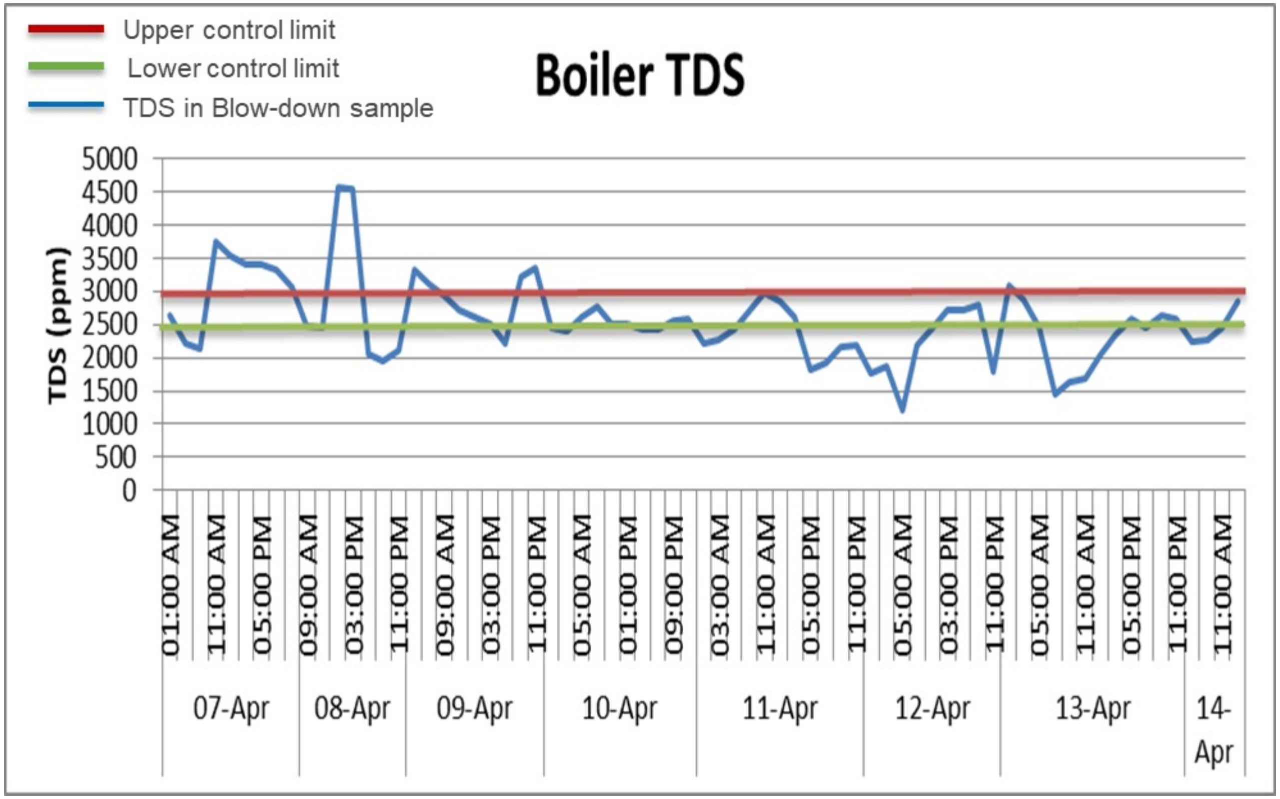




Steam System

Boiler Efficiency Analysis

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







Steam System

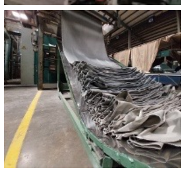
Typical network issues

- 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



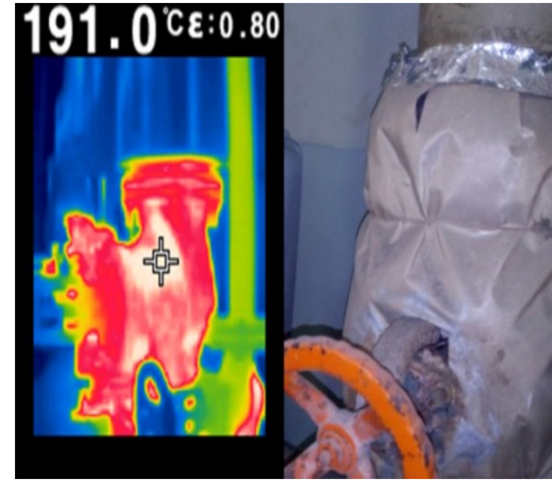




Steam System

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

Flue Gas

KEY QUESTION TO ASK:

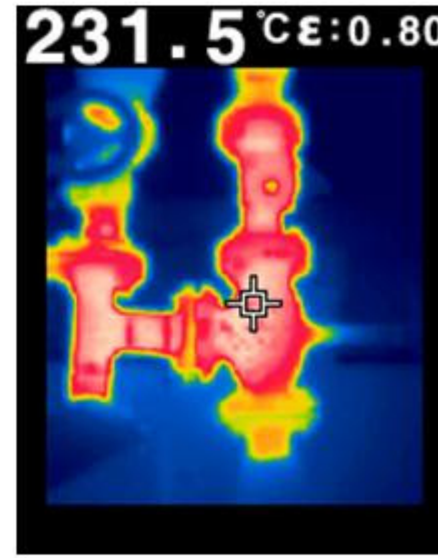
- Why do you need thermal oil when you already have steam boilers?
- What is the required temperature at demand side?

Thermal Oil Heater

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

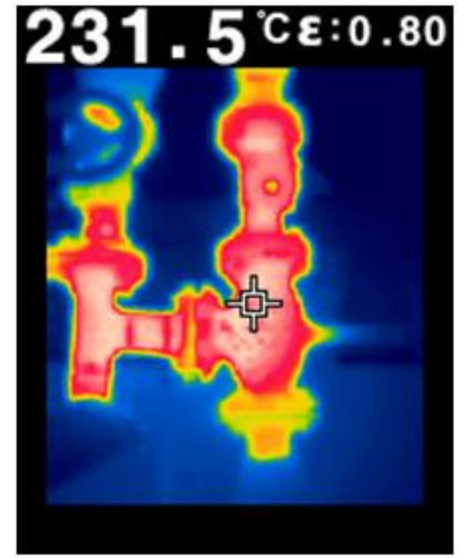


- Uninsulated surfaces, (Lengths, fittings, valves)
- Oil temperature kept too high compared to demand
  - e.g. oil temperature must be ~50 ^{o}C higher than required temperature at Stenter
  - How to check: very low temperature difference between heated and returning oil

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

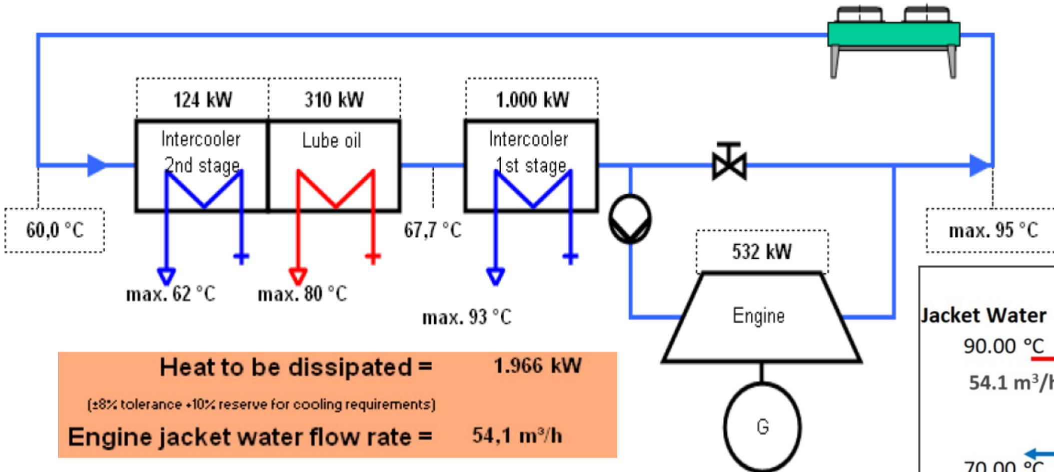


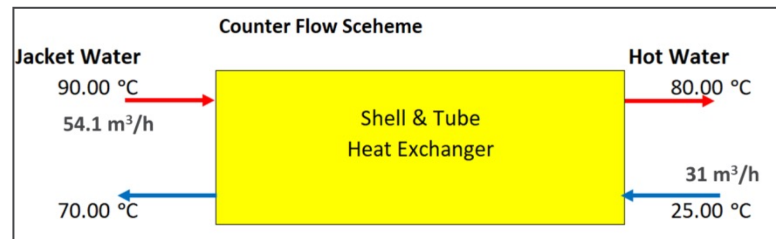
Power Generation

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 m³/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**



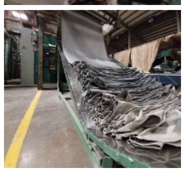


Waste Heat Recovery Boiler - Example

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 Economiser - Example

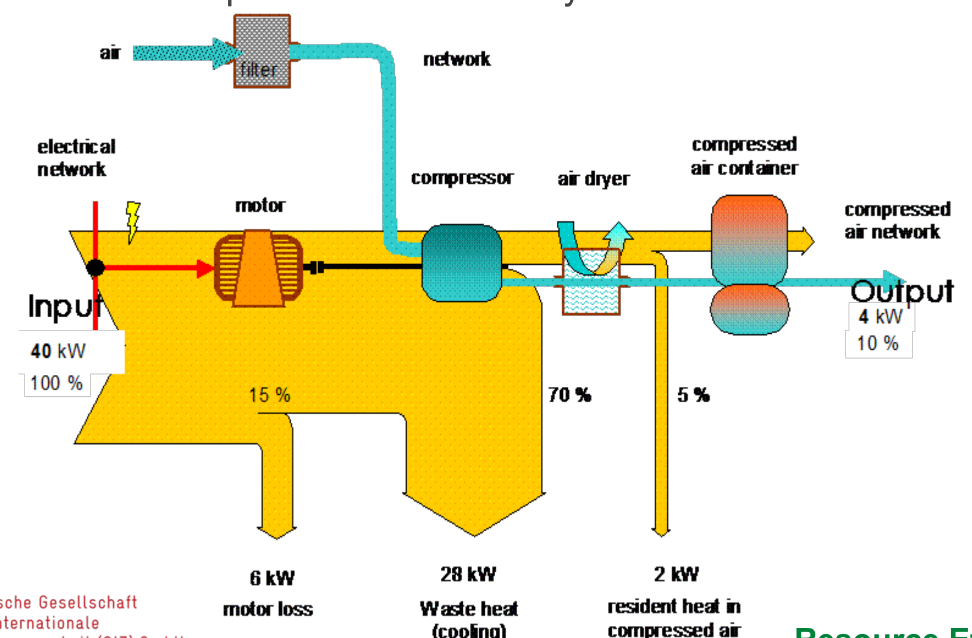
Flu temperature (after WHRB)	155 ^{o}C
Desired flue temperature	**100 ^{o}C**
Desired dT	55 ^{o}C
Available energy	235.8 kW
Raw water temperature T1	25.0 ^{o}C
Hot water temperature T2	90.0 ^{o}C
Hot water dT	65.0 ^{o}C
Hot water flow rate	**3.1 m^3/h**
Steam saving	1,456 Tonne/y
Coal saving	176 Tonne/y
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

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

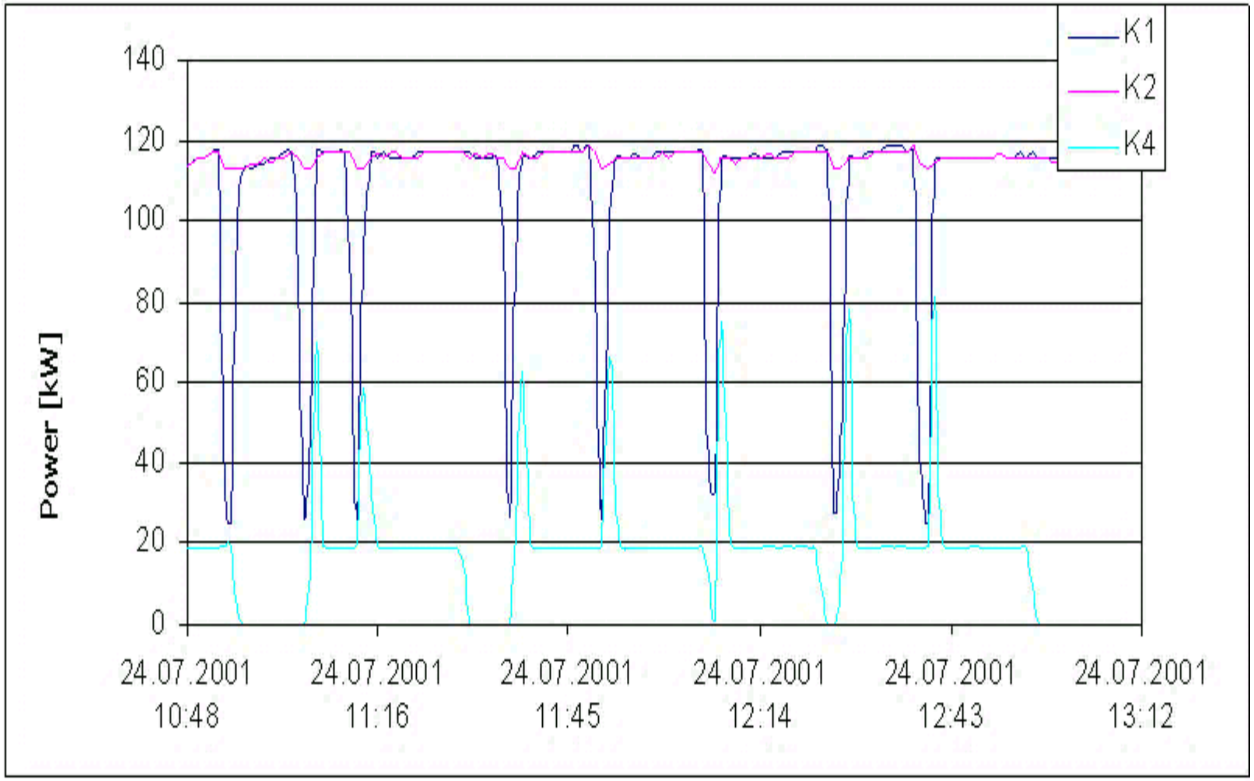


Key Question:
- What is compressed air used for?
- Why is it necessary?

Compressed Air System

Load Profile

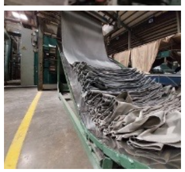
- What do you see in this chart?
- What are possible control options?

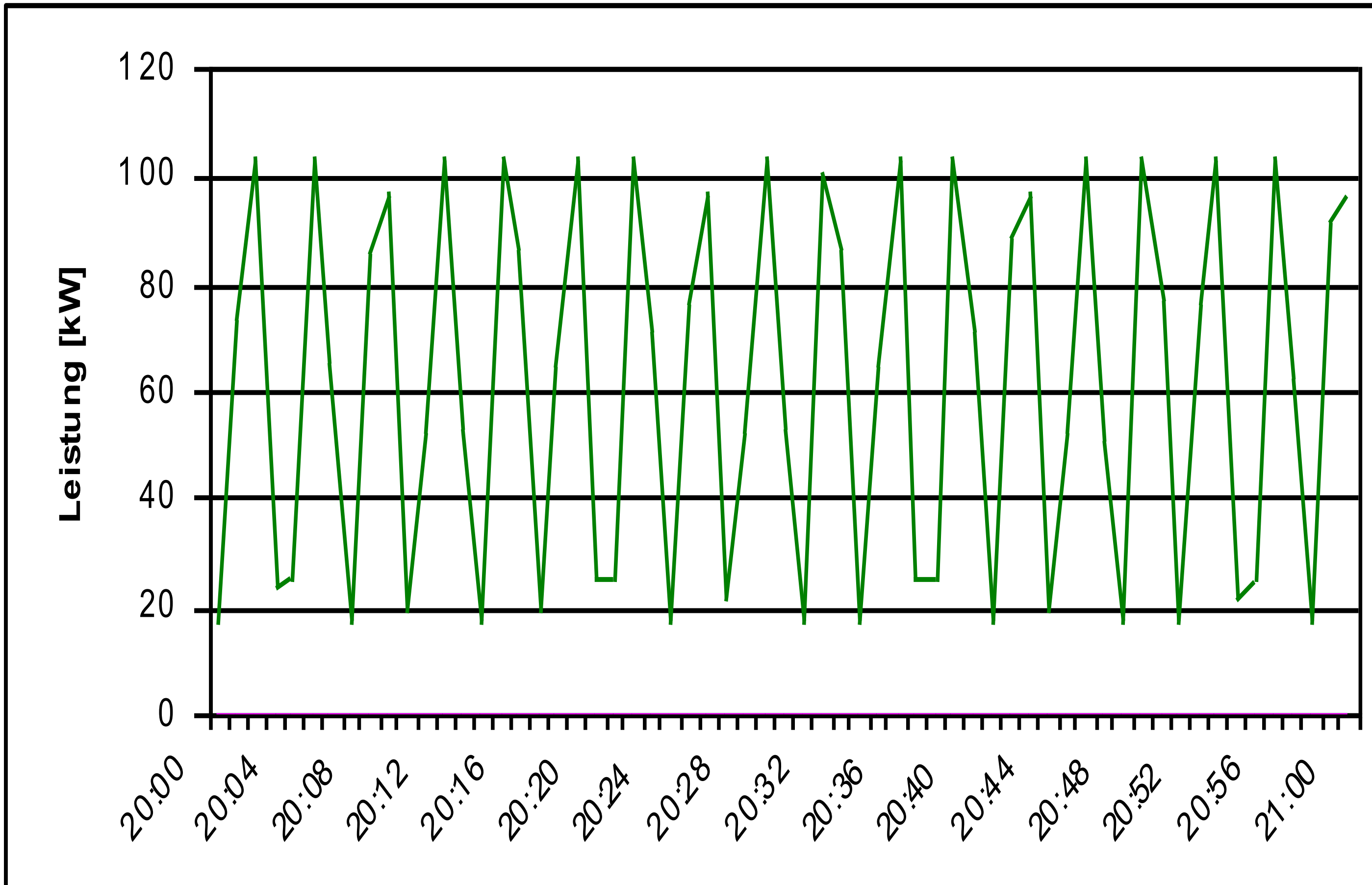


Source: ConPlusUltra

Compressed Air System

Load Profile





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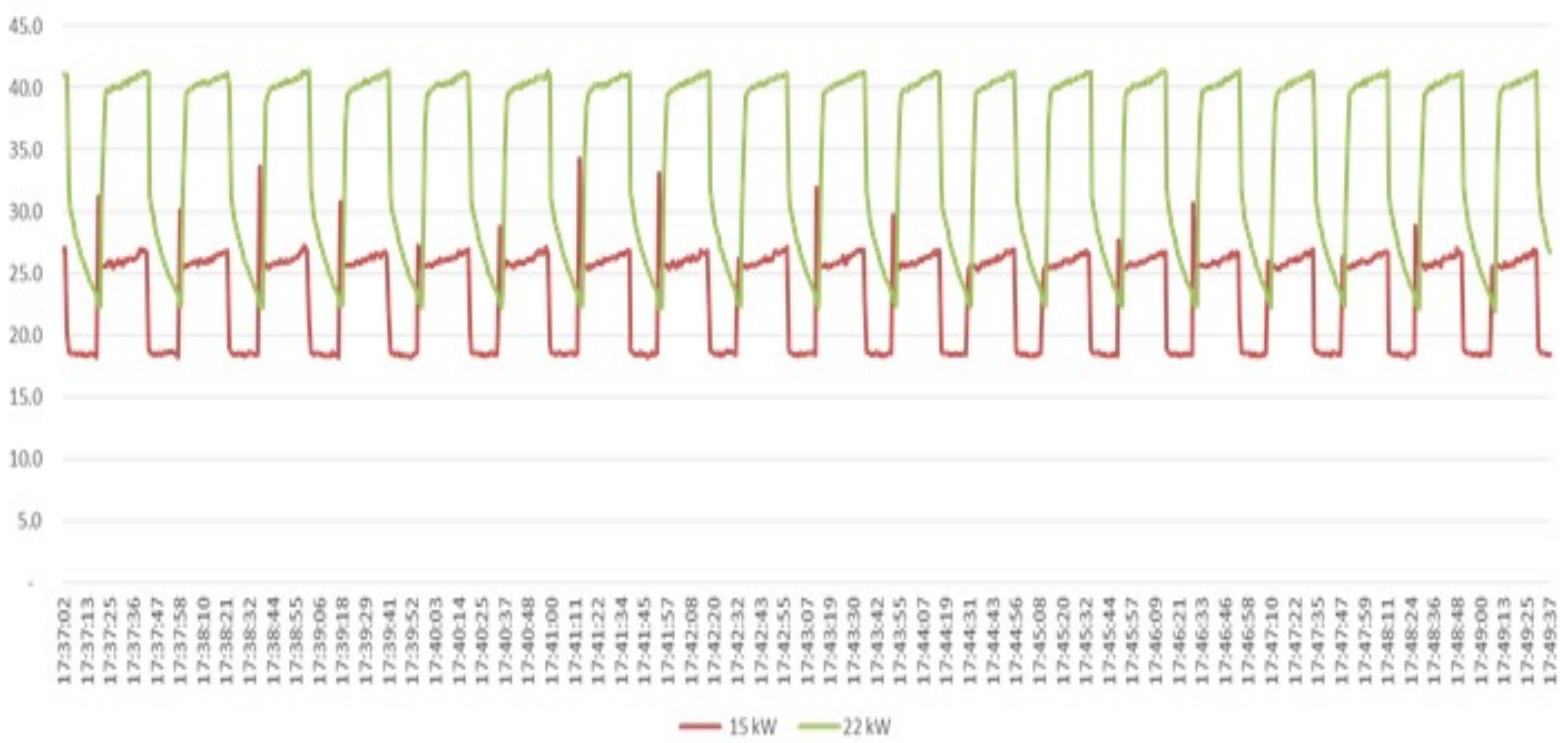
Compressed Air System

Load Profile

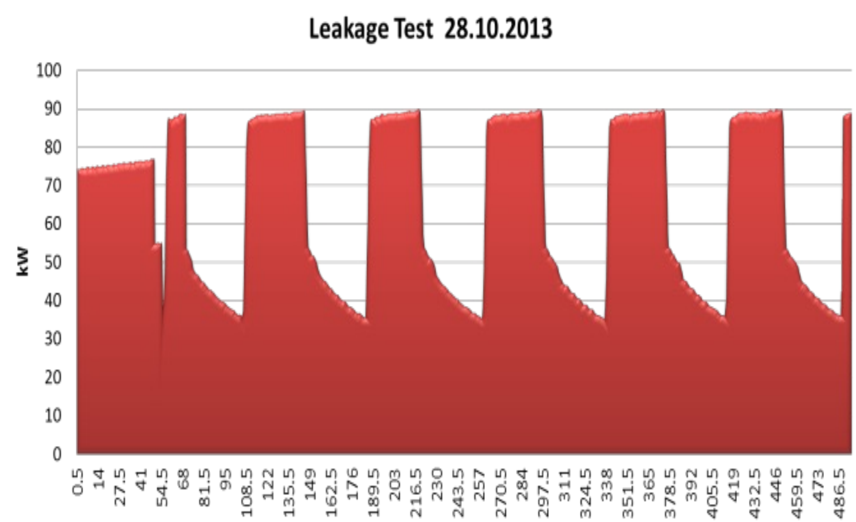


- Compressor control automation may result in 30-50% energy saving
- Typical payback < 1 year

Compressed Air System

Network issues to be addressed

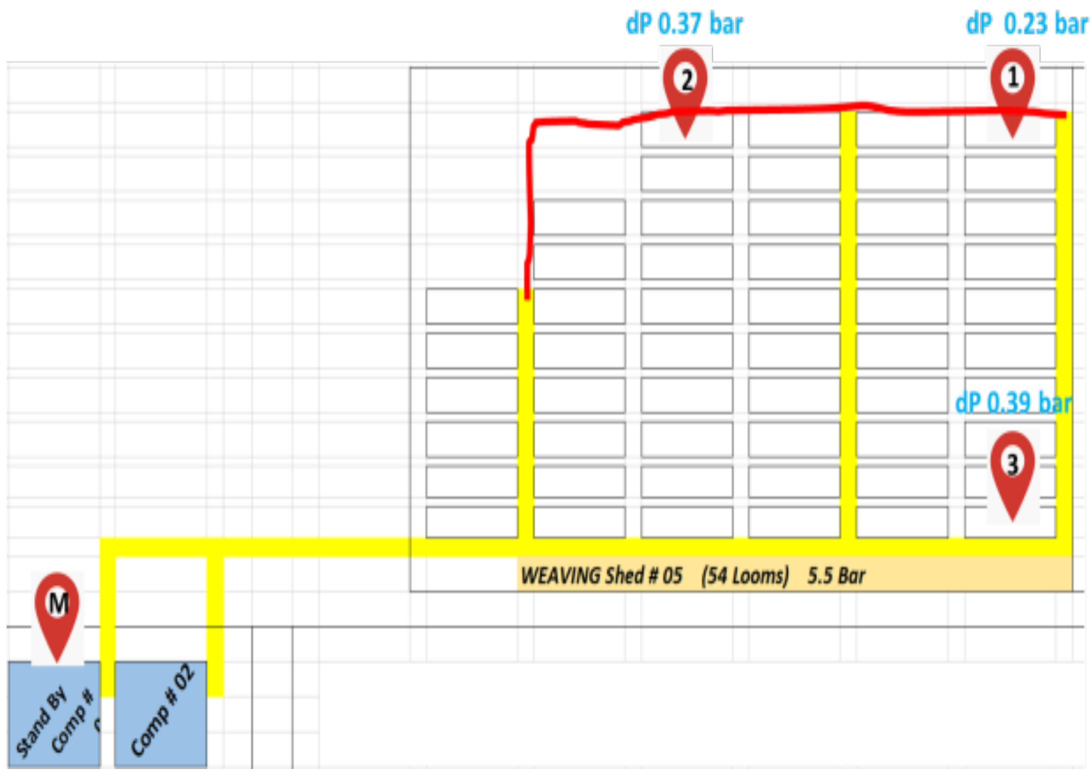
- Leakages may amount to 15-20% of total air demand; at times, leakages as high as 50% of demand have
  also been observed
- Faulty condensate drains and pressure regulators are
  one of the biggest contributors
- These leakages create artificial demand and require higher pressure set-points at compressor



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



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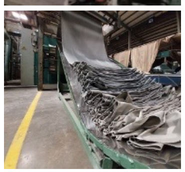


Compressed Air System

Dryers

- Keep Dew Point between 3-5 ^{o}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 ^{o}C**
Dryer 1	**0.7 ^{o}C**
Dryer 2	**0.4 - 0.5 ^{o}C**
Dryer 3	2.4 – 2.5 ^{o}C
Dryer 4	**24.5 ^{o}C**
Dryer 5	**10.1 ^{o}C**
Dryer 6	**10.4 ^{o}C**
Measurements using a dew point data logger	





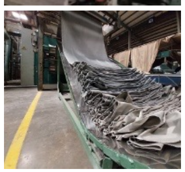
Cooling Towers

- 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 (°C)	Water Temperature at outlet (°C)	Range ΔT (°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







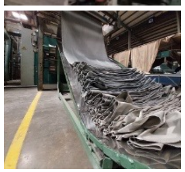
Cooling Towers

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

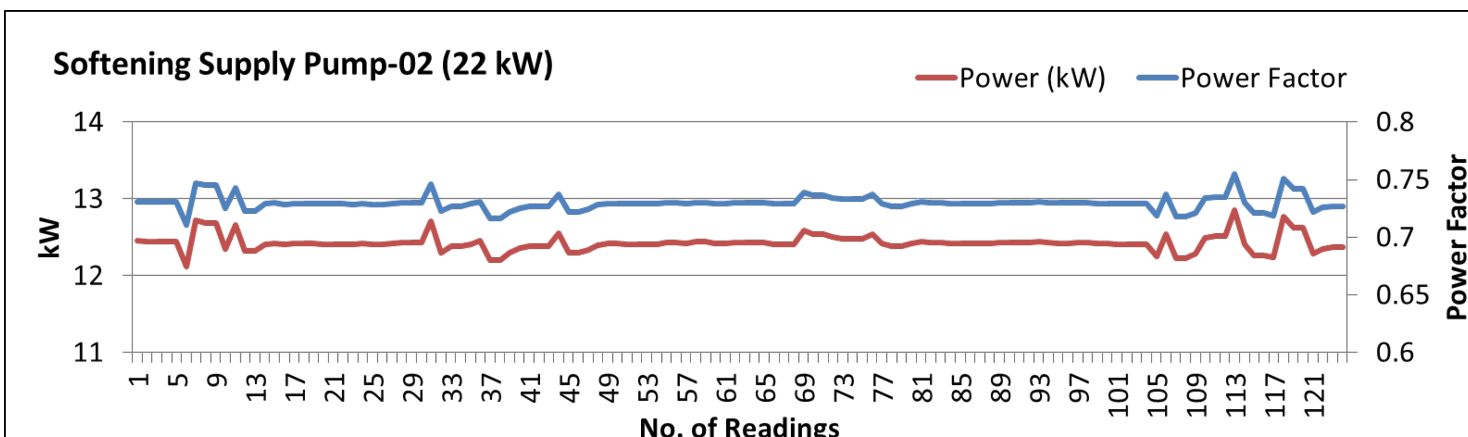






Pumps

- 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.



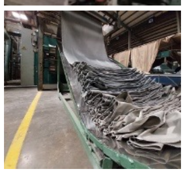
Pumps

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 use

- 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.

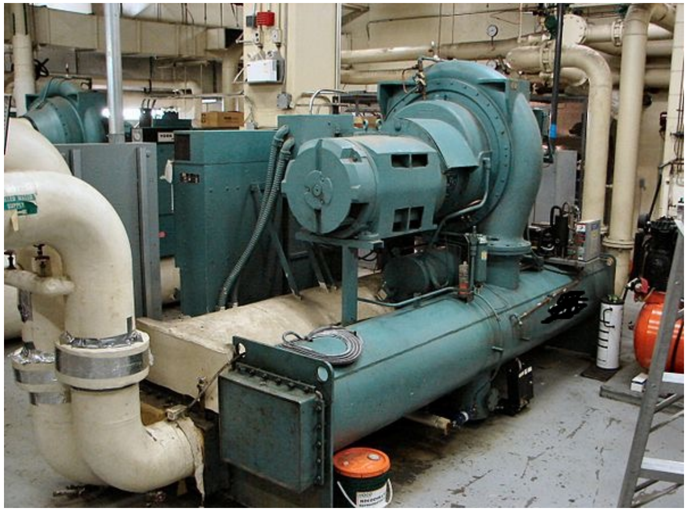
Pumps

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

- 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?



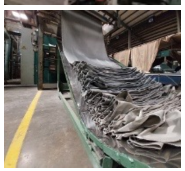
Chillers

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



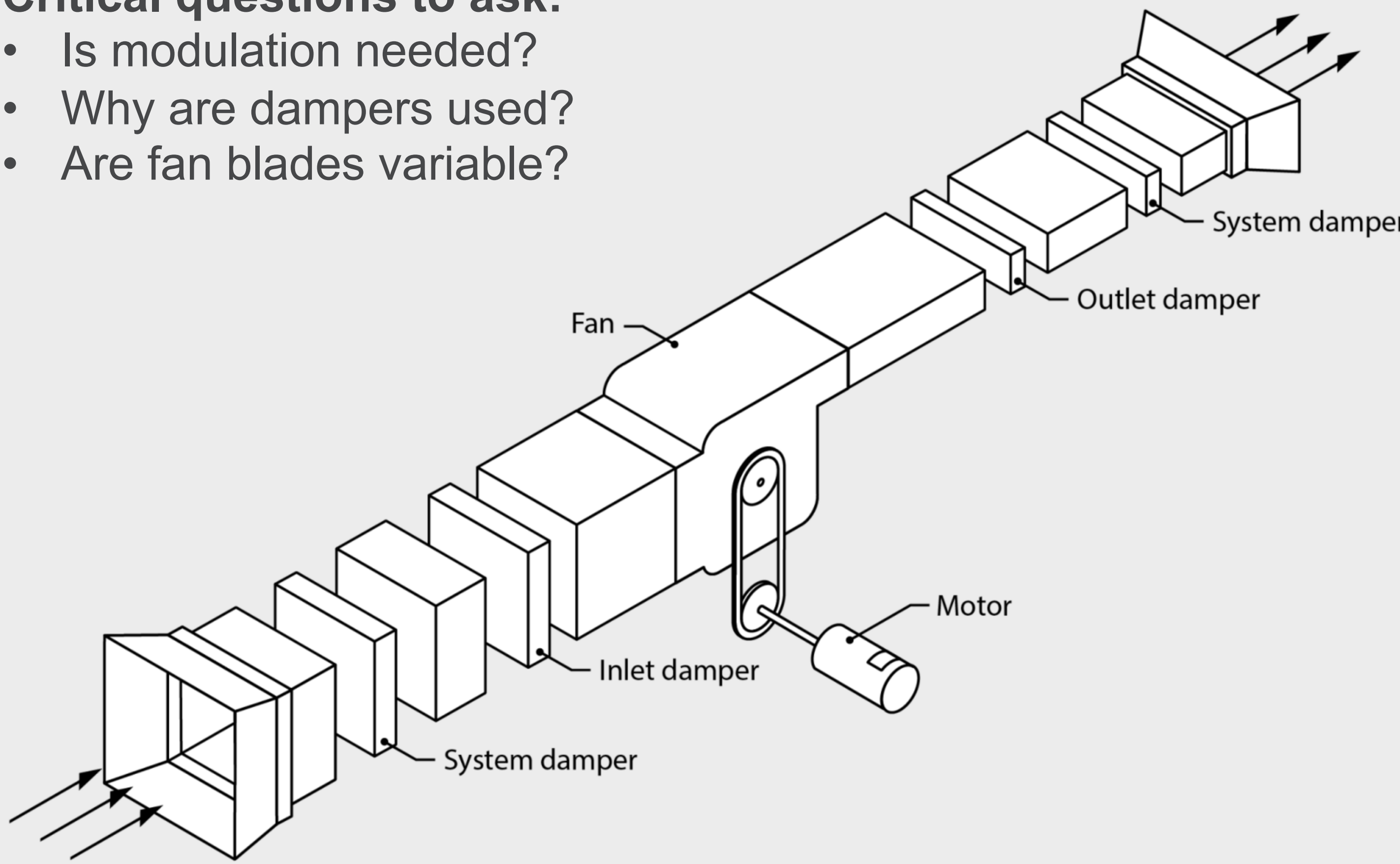




Fans

Critical questions to ask:

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



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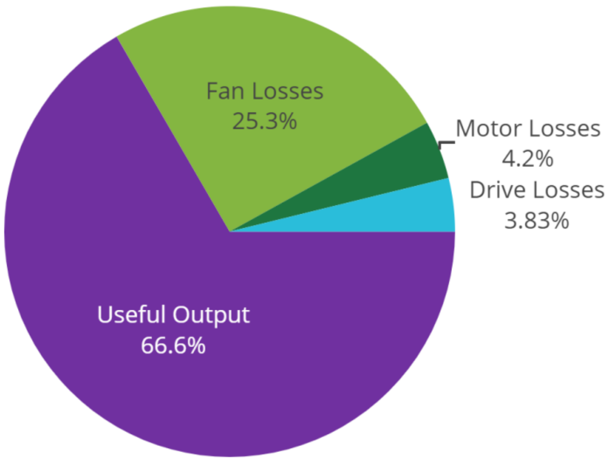
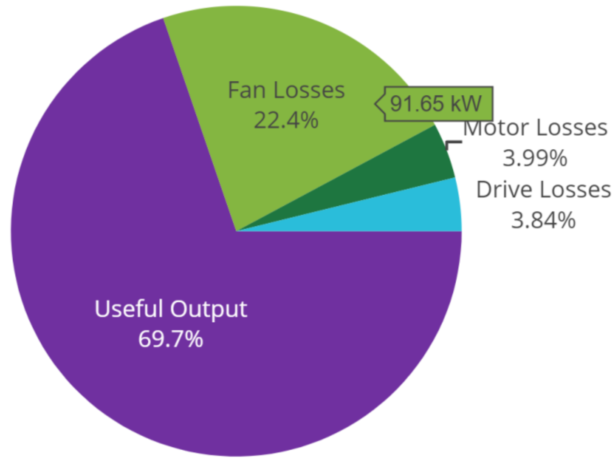
Fans

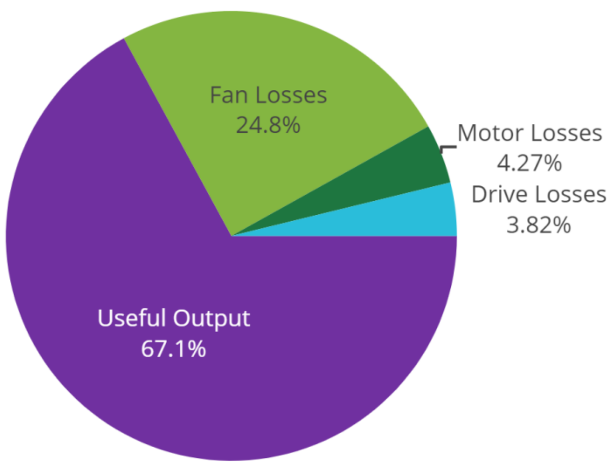
Example assessment



Baseline conditions



Optimized Fan & Motor Combo



Reduced Pressure & Flow

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QUESTIONS?