1.4 – 1.6 Analyzing Energy flows

How to define baseline, set focus areas, reveal source and cause of inefficiency for energy flow?

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Analysis of energy flows at company system boundary
(step 1.4 of TEST)

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Energy Priority Flows

When Energy flow is selected as a **priority flow**, the following analysis is recommended:

- Collect past consumption and driver (production) monthly data by energy source (electrical and thermal energy)
- Calculate the KPI based on monthly records, and regression analysis

Tool – Energy Mapping Tool

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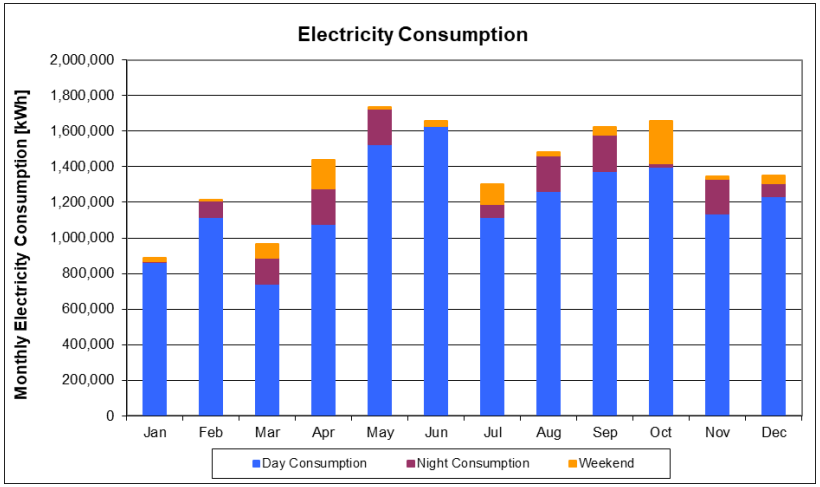
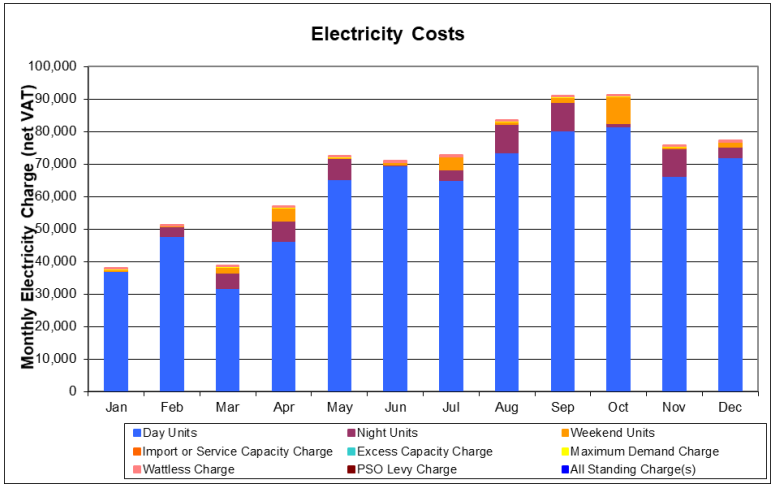
Analysis Results – Sample company

Populating the Energy Mapping tool for a sample company, following analysis can be achieved:

- ✓ Energy sources identified
- ✓ Visualize trends of energy consumption, and cost.





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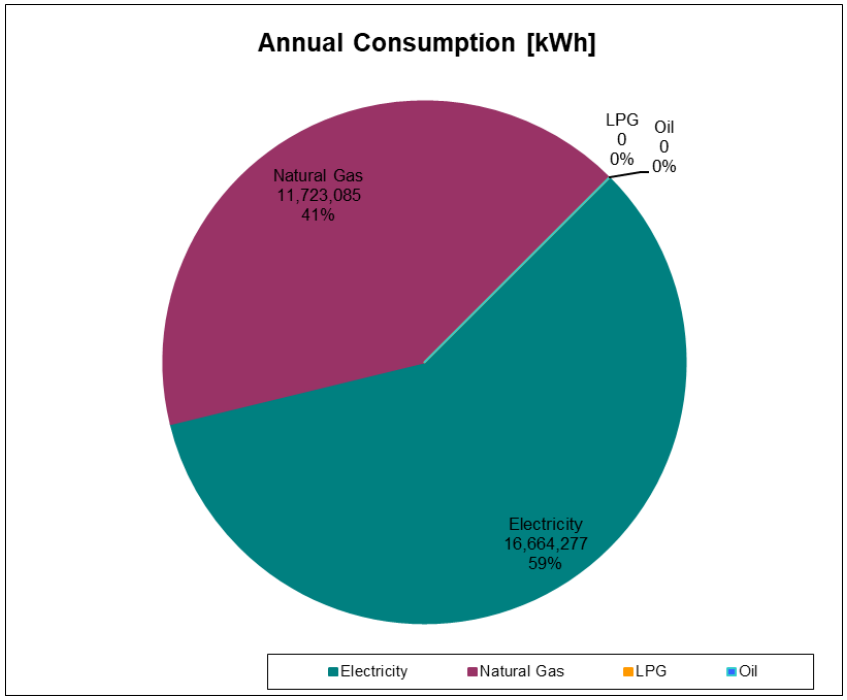
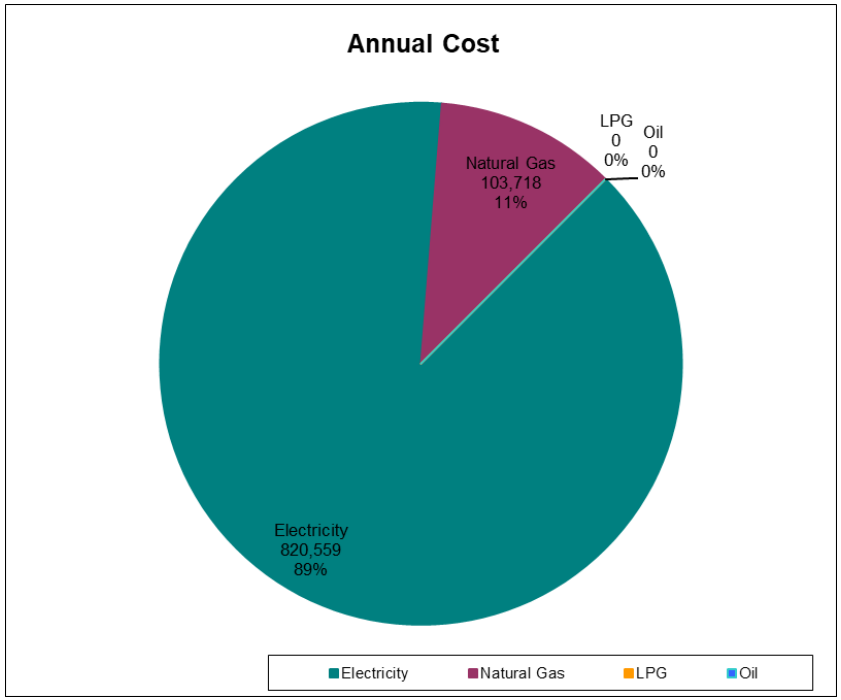
Analysis Results – Sample company

- ✓ Breakdown of Energy among sources (physical, and financial breakdown).





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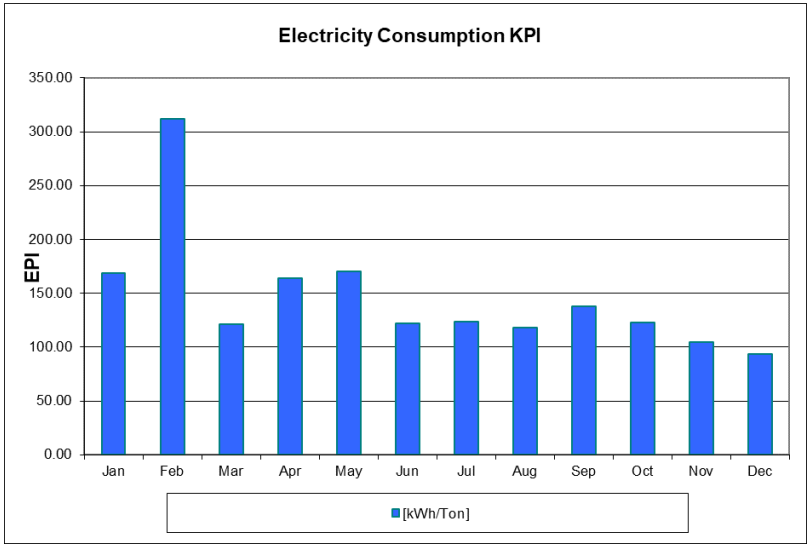
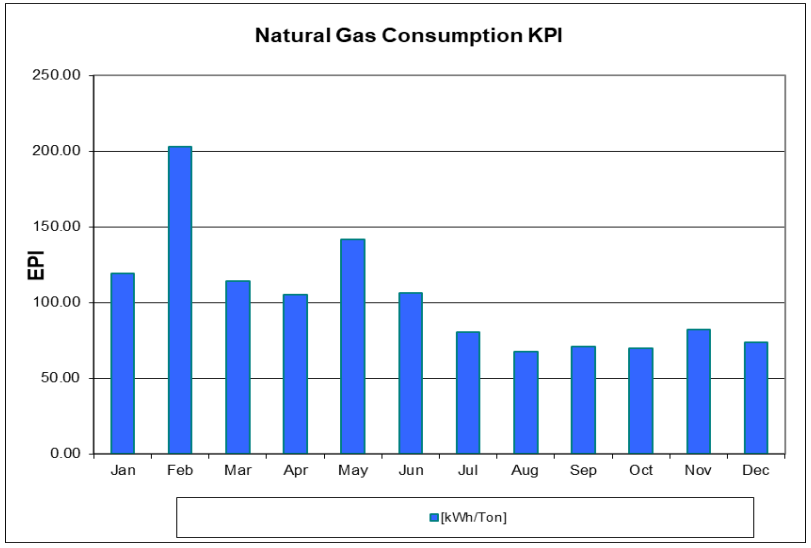
Analysis Results

- ✓ Develop KPI for each energy source.





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Regression Analysis

Used in statistical modelling the regression analysis describes the relationships among variables (consumption and drivers).

- Plotting the consumption versus the potential driver, the criteria for reliable equation is the correlation exceeding 0.75 ($R^2 > 0.75$).
- The equation constant (intercept) represents the baseload.
- The slope of the line reflects the sensitivity of consumption to the variation in the driver.

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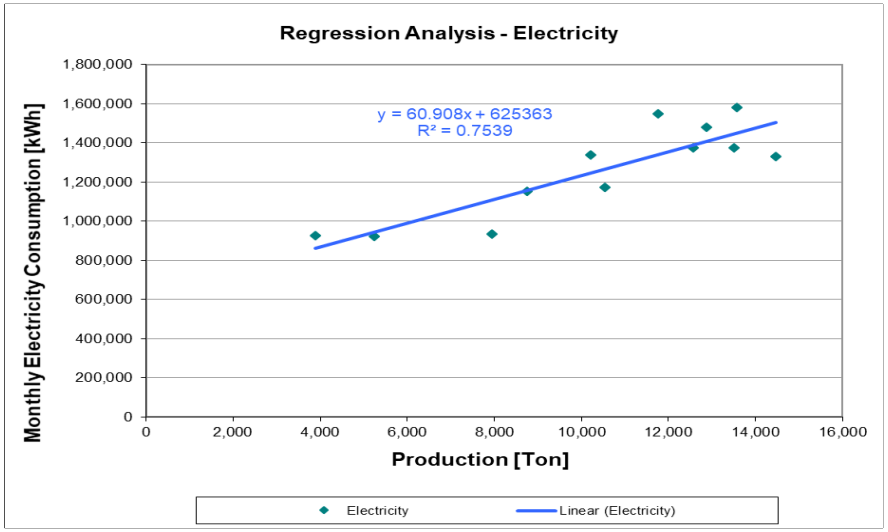
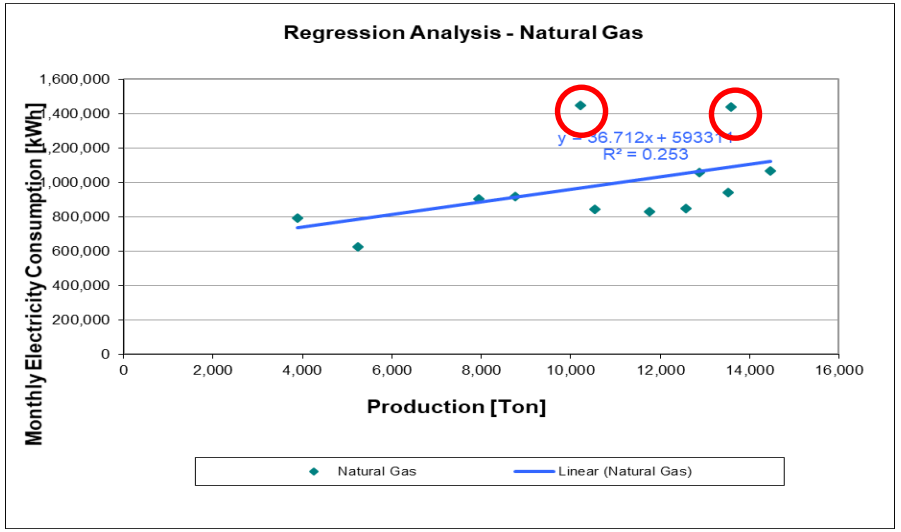
Analysis Results

- ✓ Confirm on Driver for each energy source using regression analysis.





Observations from electricity analysis:

- Strong **correlation** between consumption and production levels (R2>0.75)
- **Baseload** of appr. 650 MWh is on the high side, most probably due to equipment running continuously also when there is no production
- All points above the baseline represent theoretical potential for improvement through better operation of existing technology

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Defining Focus areas and OPIs for energy flows (step 1.5 of TEST)

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Significant Energy Users

- Significant component of the organization consumption
- Equipment, processes, facilities, systems
- Considerable opportunity for improvement

Significant energy users = Focus areas for detailed energy flows analysis

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How to quantify each energy user

For energy flows, the cost allocation process can be based on three different levels of accuracy depending on the existing information system:

- Energy consumption estimates based on nominal plate value of machines;
- Data collected during spot measurement campaigns;
- Real time energy consumptions from metering systems in place

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Tips for analysis

- It is always better to install submeters from the early stages of TEST. However, you have to be cautious not to install submeter on non-significant consumers!
- Production volume is not always the driver for consumption. (A cold store is driven by the ambient temperature, HVAC is driven by ambient conditions and occupancy,…).
- Although on demand measurements can help in analysis, beware the measurement doesn't tell anything on its own. You have to understand the process, and to analyse the readings.
- Companies often have answers to all questions, the important part is how you ask the question to get the right answer.

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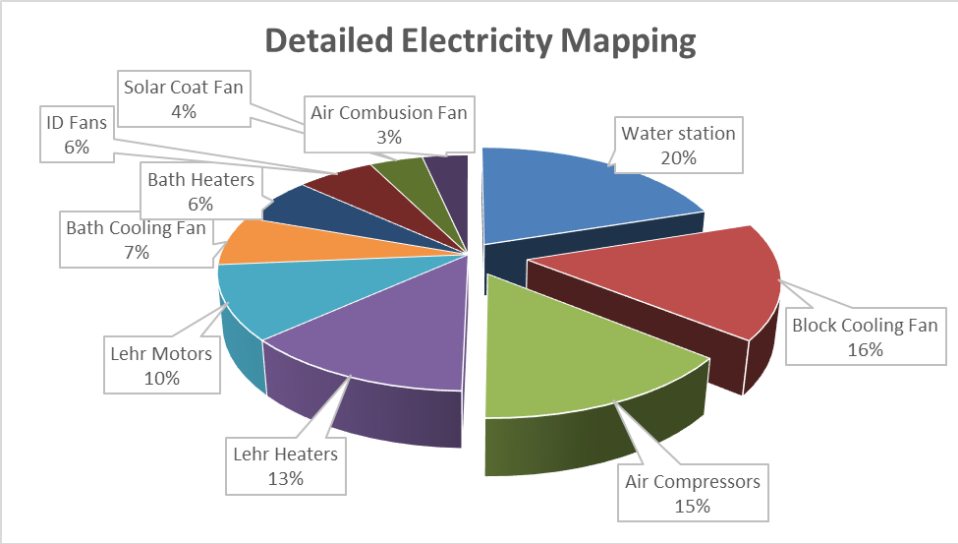
Mapping users based on real time submeter records

- The most accurate method for mapping electricity users.
- Submeter records should reflect the same monitoring duration.

Section	kWh/year
Water station	5,104,890
Block Cooling Fan	4,051,500
Air Compressors	3,723,000
Lehr Heaters	3,330,346
Lehr Motors	2,628,000
Bath Cooling Fan	1,752,000
Bath Heaters	1,600,292
ID Fans	1,496,500
Solar Coat Fan	1,022,000
Air Combustion Fan	876,000
Not Monitored	13,872,472



Mapping users based on nominal plate value of machines

- Not the optimum way of mapping, but is a good start, especially when submeter data is missing.
- Energy Mapping tool is useful for this mapping.
- Results from this mapping highlight the locations to install submeters, if not installed.

Mapping of Annual Energy Consumption													
		Use drop-down lists in all the yellow fields below, to define what the individual energy consumption refers to						Write energy defining values below					Results
Registration Date	Description (free text)	Building	Function/ Department	Process	Energy Form	Technology	Mode of Operation	Max Power Consumption [kW]	Load Factor [%]	Number of Units	Operational Hours [h]	Duty Cycle [%]	Energy Consumption [kWh/year]

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Revealing sources and causes of energy inefficiency (step 1.6 of TEST)

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Approaches to identify source and cause of inefficiency

- Technology Benchmark
- Energy balance over full system
- Energy balance over focus area
- Matching supply and demand
- Optimization of Operating parameters
- Using checklists

Tool – Energy Audit checklist

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Heat (energy) balance

- Use what you know:
  - Steam flow
  - Feedwater flow (= steam flow approximately)
  - Fuel flow (heat flow = fuel flow * efficiency)
  - Gas bills
  - Hot water flow and temperature difference (dT) (Q=m*Cp*dT)
- Build up a balance
  - Heat in = heat out
  - If you have a significant gap, you may need to measure it
  - Ultrasonic flow meters, portable heat meters
- More challenging than electrical power
  - Typically fewer measuring points

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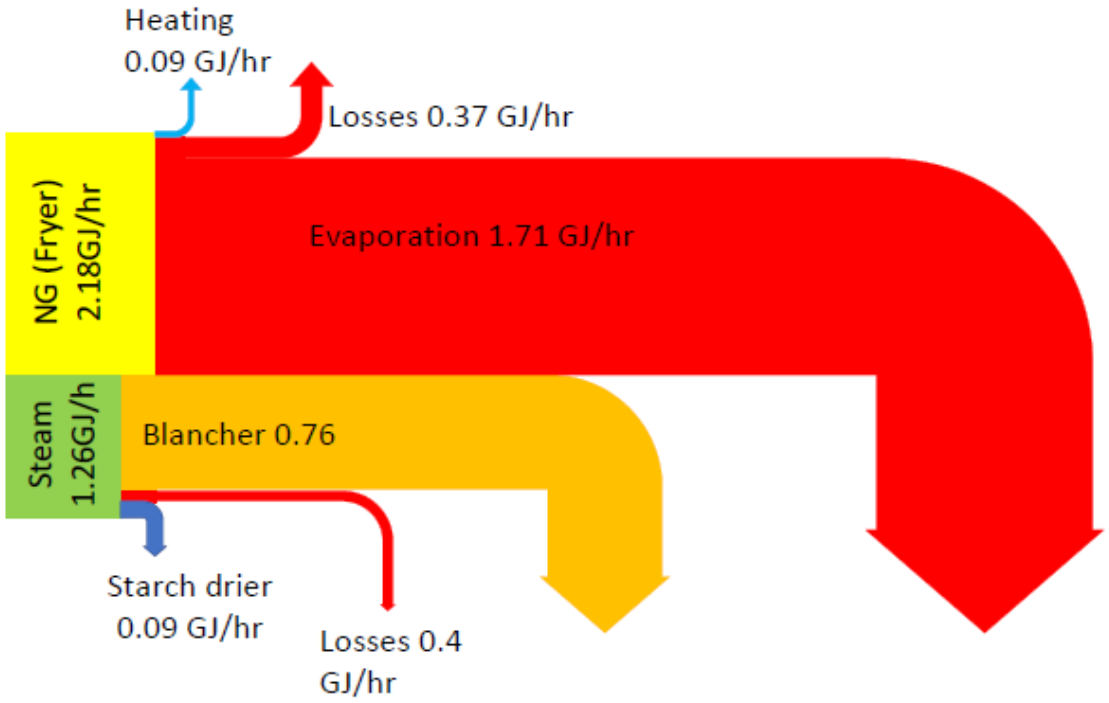
Using Sankey diagram

- Often useful for presenting thermal energy breakdown.



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Technology Benchmark

- Comparing the technology to international best practices quickly identified sources and causes of inefficiency:
  - Pasteurizers
  - Evaporators
  - Compressors
  - Boilers

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Examples from Technology Benchmark

Source	Cause
Pasteurizer	HRR is 57%, while common practice over 85%
Evaporator	Specific steam consumption is 0.31 kg/kg water, best practice is 0.127 kg/kg water
Evaporator	Company using single effect evaporator, multieffect evaporators are more efficient.
Compressor	Single speed reciprocating compressor is used. VSD compressors are more efficient
Large motors	Low efficiency, fixed speed motors. IE3 with VSD motors can be used instead
Light fixtures	Low efficiency sodium lamps are used. LED lamps can consume 80% less energy

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Energy balance over full system

Drawing a mass and energy balance on the whole process illustrates potential reuses, interaction between flows, and optimization opportunities.

This balance is not always easy to conduct as data will be needed on each and every stage of production.

On Spot measurements can serve in developing this balance.

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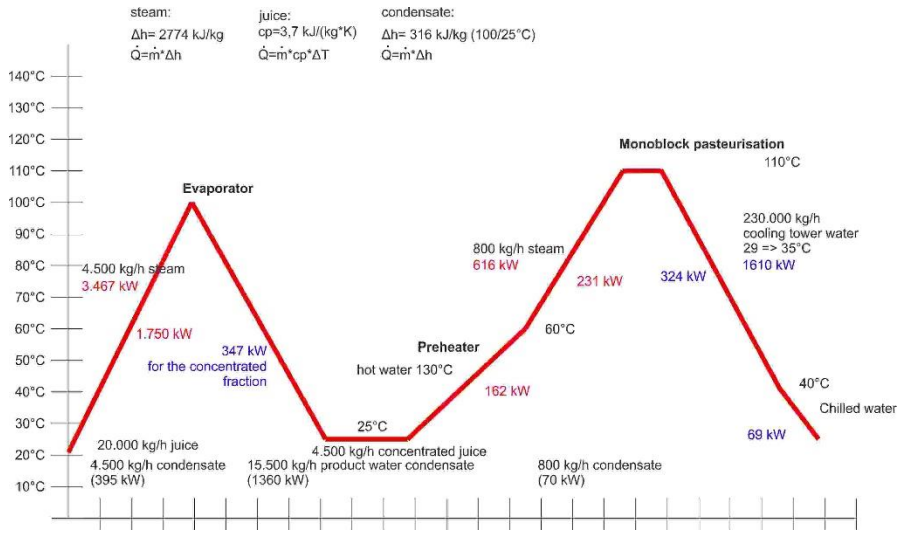
Energy balance over full system

- An energy balance was prepared for a concentrate company. From that balance, one might investigate:
  - The need to intermediate cooling between the evaporator and the pasteurizer
  - If intermediate cooling is a must, should it go down to 25 degrees, or this temperature can be increased slightly (to 35 or 30 degrees)?
  - Should the pasteurizer go to 110? Or would lower temperature be possible (especially there was and earlier thermal treatment)
  - Can we utilize the heat released following the pasteurizer to preheat the product entering the pasteurizer (rather than spending energy on cooling medium and heating medium)?



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Energy balance over focus area

- Drawing a mass and energy balance on the focus area, gives insights to some losses.
- In a concentrate production company, the evaporator was identified as the focus area. Mass and energy balance revealed the following:

Source	Cause
Steam fed to evaporator exceeds the condensate collected	Steam leaks through connections
Condensate from evaporator sent to drain	No condensate recovery unit installed
Specific Steam consumption exceeds the technology benchmark	**Old technology used at the plant**
Condensate removed from juice sent to drain	No user identified to utilize the condensate

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Matching supply and demand

- Having supply exceeding the demand requirements, result in excessive energy consumption, and low efficiency
  - Steam system
  - Compressed air
  - Cooling load
  - Water flow

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Optimisation of operating parameters

- Identification of the different operating parameters (temperatures, pressures, flow rate,...) and evaluating if they are within the common practice. Sectorial experts are needed within this analysis.

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Eliminating/bypassing redundant processes

- A sectorial expert can advise if the production process is optimized, or possibly one or more stages can be bypassed for certain products.
- In a juice factory, the sectorial expert noted that the homogenizers operated on all products. However, some of the produced products were clear juice and didn't require any homogenization. As the homogenizers were among the focus areas, bypassing them for clear products would result in significant savings in energy.

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Parallels with the ISO 50001 management system standard

EnMS – ISO 50001 requirement	TEST approach
Analysis of energy use and consumption in the company, based on measurements and other data (e.g. company energy bills).	Step 1.4 of TEST- setting the energy baseline at the company system boundary.
Identification of the areas with relevant energy use (significant energy uses), such as specific equipment, utility systems, but also an assessment of trends and key influencing factors for energy use.	Steps 1.5 and 1.6 of TEST – identifying priority areas for energy flows and cause analysis.
Identification of the potential for energy performance improvement, energy assessment is updated on regular intervals. It must also be updated if significant changes are introduced in the company operation.	Steps 1.5 and 1.6 (and step 3 for regular monitoring of energy performance) using KPIs/OPIs and benchmarks, as well as regression analysis to monitor actual resource efficiency

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