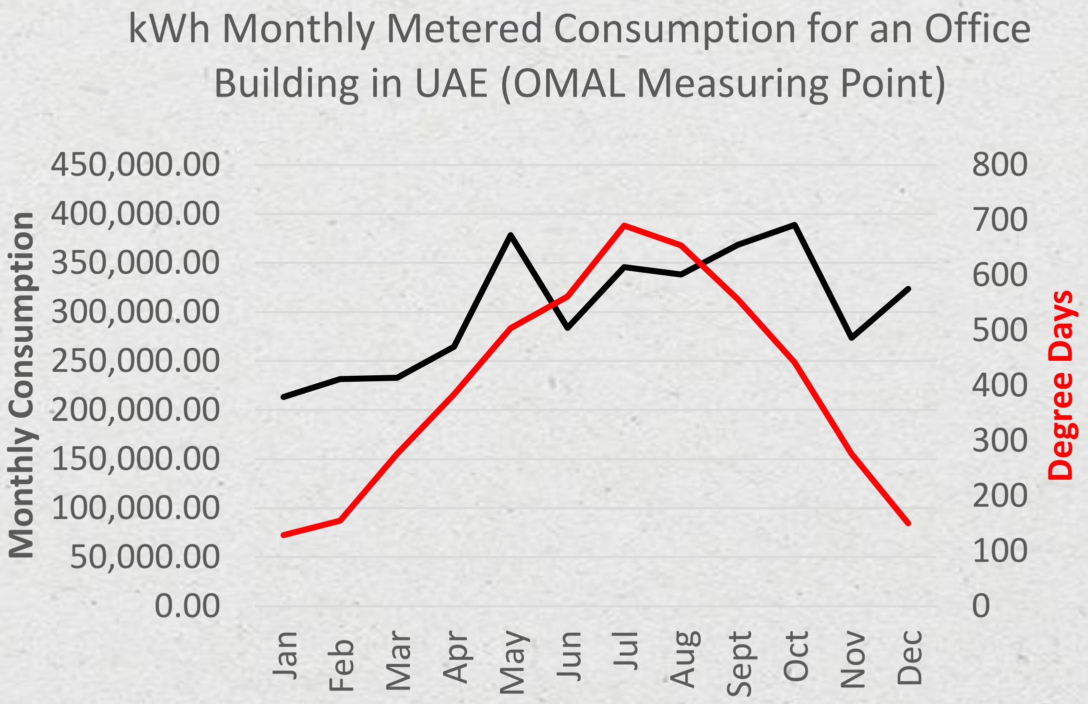
Energy Management Training:
Analysing energy consumption and presenting opportunities

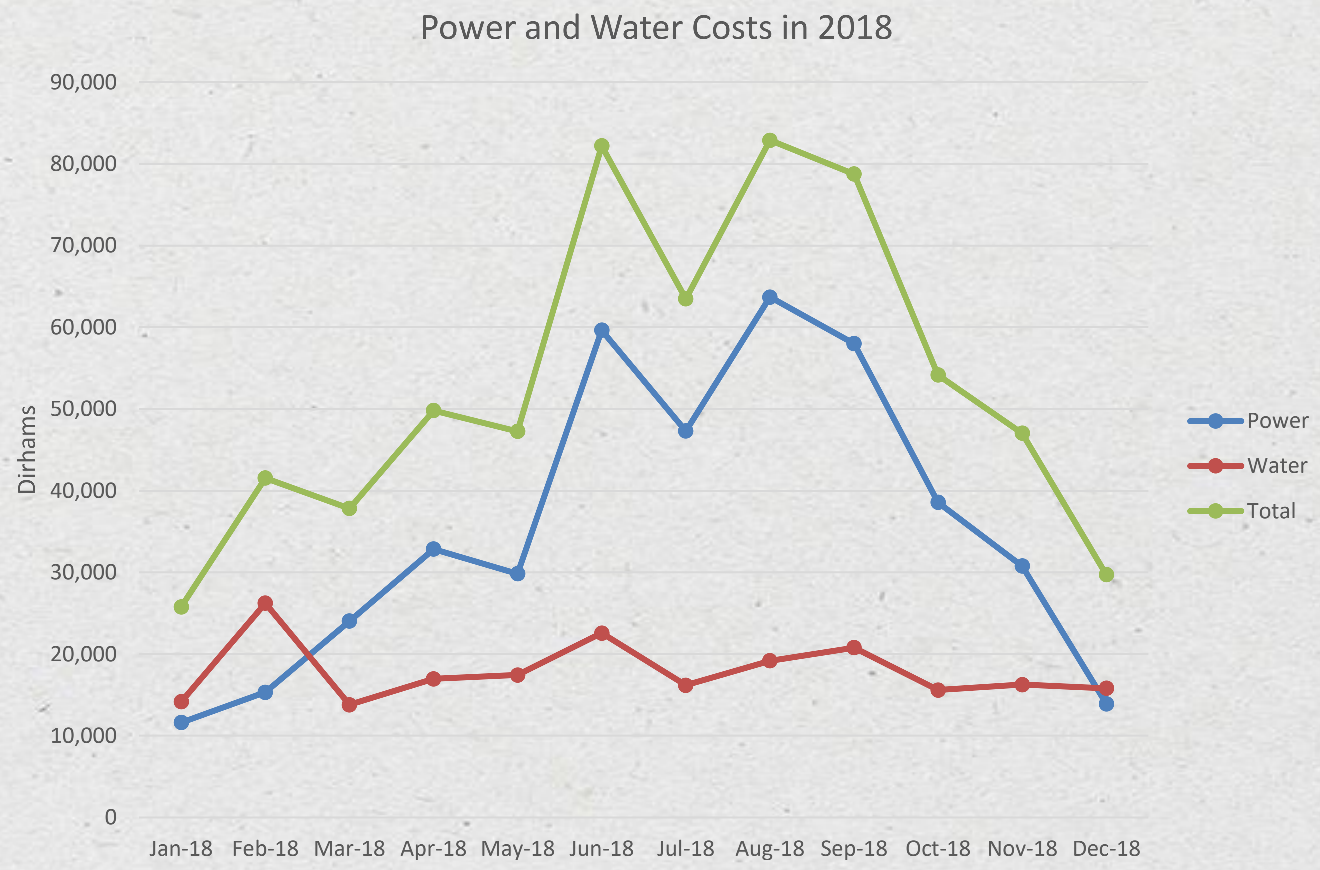
UNDERSTANDING THE SITUATION: ANALYSING ENERGY CONSUMPTION PATTERNS

Looking for clues: Degree days and consumption

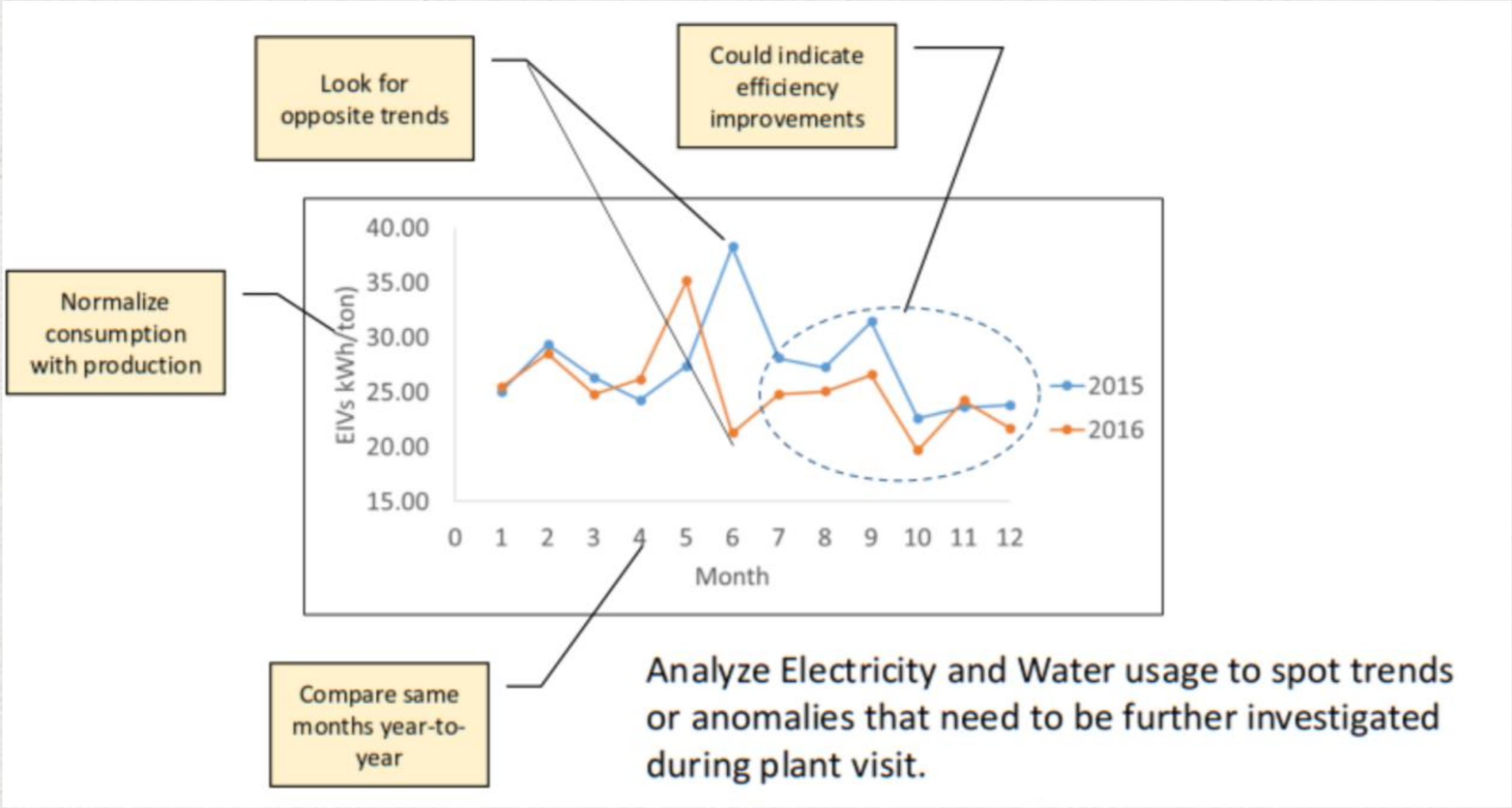


- If HVAC and chiller consumption in an office building is driven by outside temperatures, surely consumption should track the same profile as degree day data?
- If it does not, as in the graph above, then this is clear evidence of poor control and maintenance.

Looking for clues: A more sensible seasonal profile



Insights from annual trends



Courtesy of Gov.uk.

Insights from daily/weekly timing of consumption

- Obtain hourly meter reads, either from your Distribution Company or from installing monitoring equipment on your supply.
- Plot consumption over 24 hours for every day of the week.
- How does consumption change over time?
- How does it match against shift patterns and at changeovers?
- If you do not run for 24 hours, how far down does consumption drop during periods of no production?
- If production varies between different day of the week, such as at weekends, how is this reflected in consumption?

Consumption intensity

- Unlike Commercial and Governmental facilities, where electricity consumption primarily varies with weather and occupancy alone, consumption by industrial manufacturing facilities is overwhelmingly influenced by production rates.
- Intensity Values allow comparison of consumption within a specific manufacturing process. They normalize the energy and water inputs to a process by the output of product manufactured.

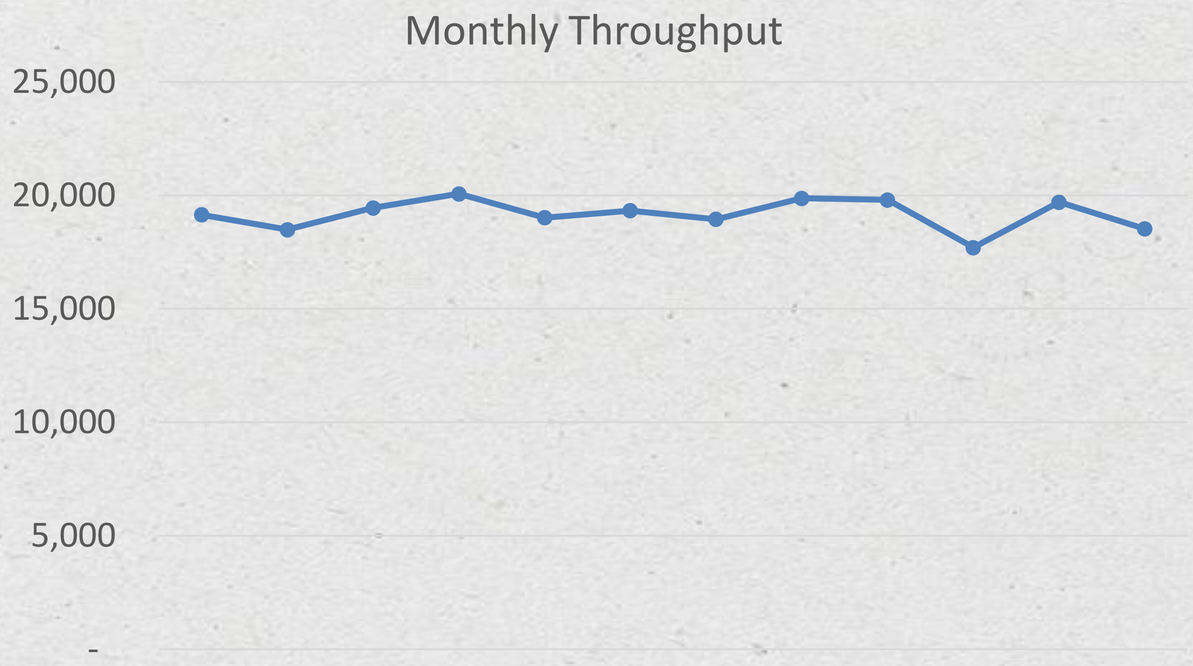
$$EIV = \frac{Power\ Consumption(\text{kWh})}{ProductionOutput(\text{Units})}$$

$$WIV = \frac{Water\ Consumption(m3)}{Production\ Output(\text{Units})}$$

- Intensity Values enable the comparison of consumption from different periods of time, based upon the level of production, allowing for evaluation of different operating practices that might have been employed during each period.

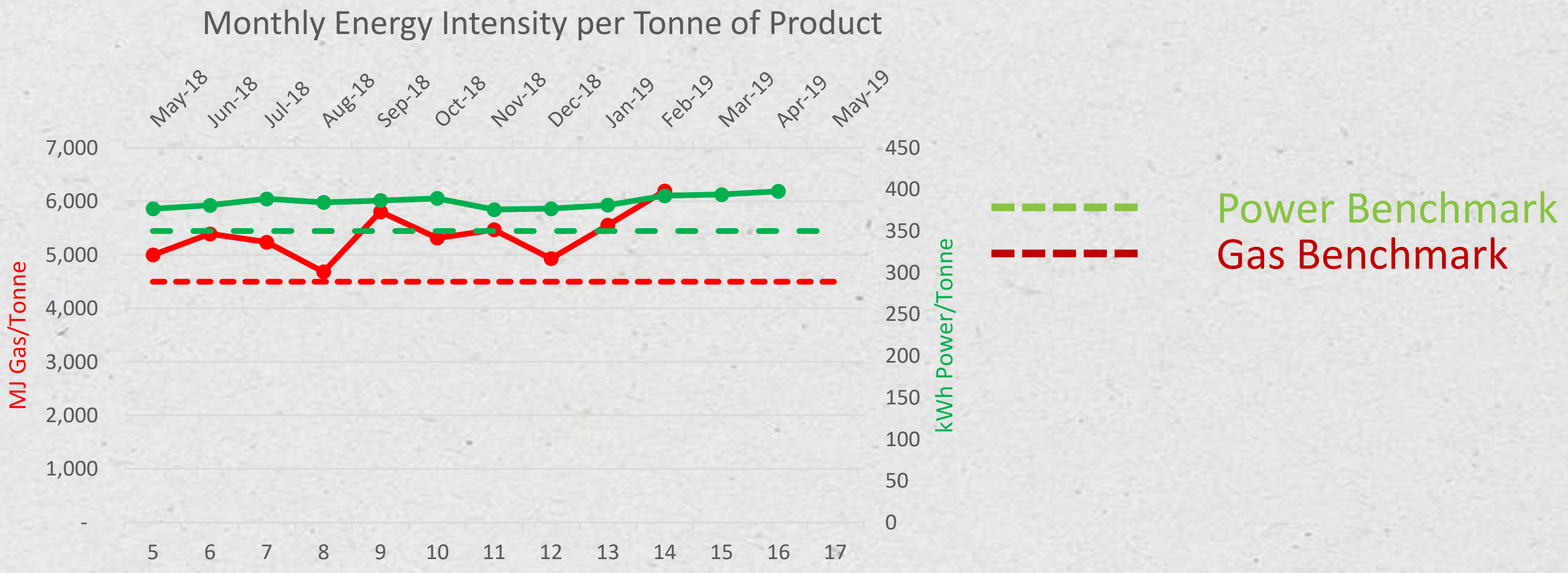
Influence of varying production rates

- Check the rate of production over time.
- Make sure that production variations are understood, otherwise they can distort the findings.



Plot energy intensity

- Hourly power consumption data is available from ADDC metering systems.
- Obtain figures for other fuels – usually available daily, although some gas meters might allow hourly recording.
- Combine with production figures to plot intensity figures per unit of production.
- Plot representative benchmarks to add impact.
- In this example is energy consumption falling or rising?

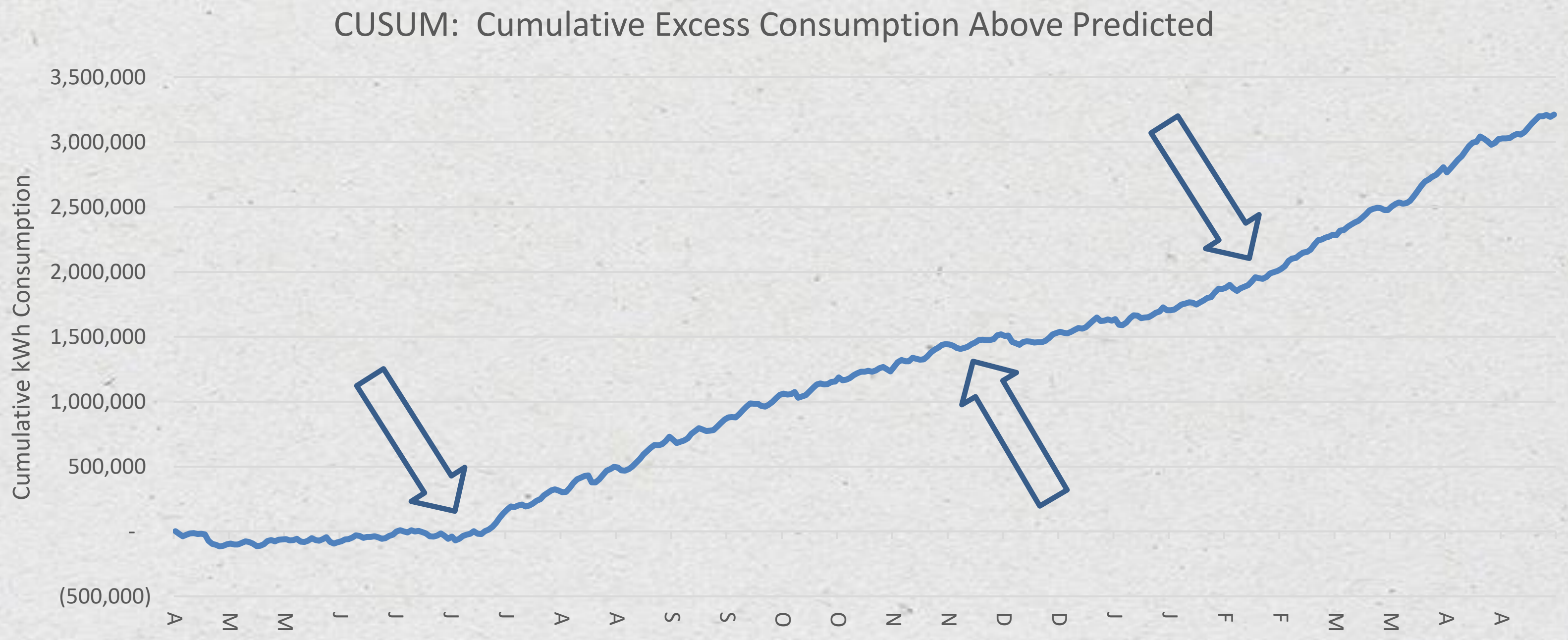


CUSUM analysis: Powerful but can be tricky

- For CUSUM analysis, detailed consumption and production data is required.
  - At least daily readings and preferably hourly.
- Define a baseline period when the process was known to be stable:
  - no changes in product type, equipment or process settings other than volumes.
- Selecting the baseline is critical and requires skill!
- From linear regression develop a model to relate production output to energy consumed.
- Use the model to predict energy consumption based on product output.
- Predicted consumption is then compared with ACTUAL consumption.
- The CUmulative SUM of the difference between actual and expected consumption is plotted to identify the total surplus consumption and changes in the slope of the accumulation curve.

Using the CUSUM curve

- Identified systematic changes in efficiency.
- ~10,500kWh excess power consumed per day, or 3,000 AED per day
- A reduction in the magnitude of the excess consumption was registered in Nov/Dec, but the improvement tailed off. Why?



Potential drivers of changes in efficiency trends

- Deterioration in condition of key utility infrastructure from as-new condition:
  - Boilers, air compressors, AC heat exchangers, motors and drives, etc.
  - Potentially driven by fouling processes on heat exchangers, wear in drives etc.
- Changes in activity mix:
  - Some products have a higher energy intensity than others and are produced within the same facility.
- Changes in process settings to improve product quality:
  - May improve the value of the product but increase the energy intensity.
- Product-driven changes may be good for the business, but this needs to be understood so that management have the full perspective.

Suggested high level approach for CUSUM

- Plot process settings against CUSUM chart.
- Compare magnitude of rate of consumption deviation to levels of energy consumption in key use categories.
- Identify any obvious correlations.
- Add timelines for any settings, process inputs or other changes.
- Build cause-and-effect diagram.
- Develop remediation programme.

GIVING A CLEAR PRESENTATION OF WHAT IS ON THE GROUND

The survey report is the start of the process

- Executive Summary is the most important single element of the report:
  - 1 page that explains at a high level the findings and the expected savings and necessary investment.
  - This is the sales pitch to busy managers!
- Philosophy:
  - Keep initial suggested actions simple and low risk!
- Topic-by-topic presentation of findings
  - Brief explanation of changes and estimate of savings
- Summaries of savings and changes:
  - Tabular.
  - List measures, changes needed investment, savings, simple payback.
  - Describe next steps.

Survey Report Structure

1. Survey report structure.
   - Explains the purpose of the report, who produced it and where to look for key information.
2. Overview of the production process.
   - Describes the production process and sets out the structure according to which subsequent energy-related information will be organized.
3. Walk-around survey results.
   - Describes what was found when staff walked around the site and made observations of the process and site practices and compared them with international best practice.
4. Best practice gap analysis.
   - Mapping of what was found on the site against best practice and approximate mapping of the gap against benchmarks with the opportunities found.
5. Recommendations.
   - High level action plan and clear definition of next steps for the management to take to unlock opportunities.
6. References.
   - Key information and sources.

Important to:

- Differentiate between no-regrets measures and issues that require further study.
- Examples of no regrets measures:
  - Compressed air tiger team.
  - Door and window seal replacement.
  - Clean heat exchanger surfaces.
- Examples of measures requiring further study:
  - Rationalising AC chillers.
  - Compressed air pressure control.
  - Equipment insulation.
  - Process settings.
  - Pump resizing.
  - Variable Speed Drives.

PROVIDING CLEAR AND TRUSTWORTHY GAP ANALYSIS AND PRIORITISATION

Gap Analysis: Best Practice vs. Actual Practice

No.	Target Process	Best Practice	Practice at Plant	Practice Met?	Recommendations	Potential Savings[1]
Pumps						
10	Operation and Maintenance	Preventative maintenance measures are scheduled and conducted accordingly.	Preventative maintenance actions are done routinely.	Yes	N/A	—
11	Monitoring	Monitoring (wear, vibration, pressure, flow, power, temperature, scaling) is conducted regularly at the plant.	Regular monitoring is not conducted at the plant.	No	A study should be conducted on the feasibility of oxygen enrichment.	Up to 40% in energy savings.
12	Controls	Remote controls are used to shut off unneeded pumps or reduce load of individual pumps.	Remote controls are not used efficiently at the plant.	No	Studies should be conducted to implement controls for pumps on-site.	Up to 62% of energy consumption in savings.
13	Efficient Pumps	All pumps on-site have the highest energy efficiency.	Not all the pumps at the plant are running at the highest efficiency.	No		Up to 10% of energy savings.
14	Proper Pump Sizing	All pumps on-site are sized appropriately. Pump capacity matches operation.	Pump capacities do not always match operation.	No	Further studies should be conducted on the feasibility of replacing the pumps with new pumps of proper capacity size.	Up to 25% of electricity consumption.
15	Multiple Pumps for Varying Loads	If VFDs are not utilized, loads are allocated to different pumps according to size.	Multiple pumps are used for varying loads.	Yes	N/A	—

BP = Industry Best Practice
ECM = an energy conservation measure
WCM = a water conservation measure

Identify the potential savings from this practice

Process Sub-Category

Identify whether this practice is met at the plant

Where BP is not met, what action is recommended

Prioritising Energy Efficiency Options

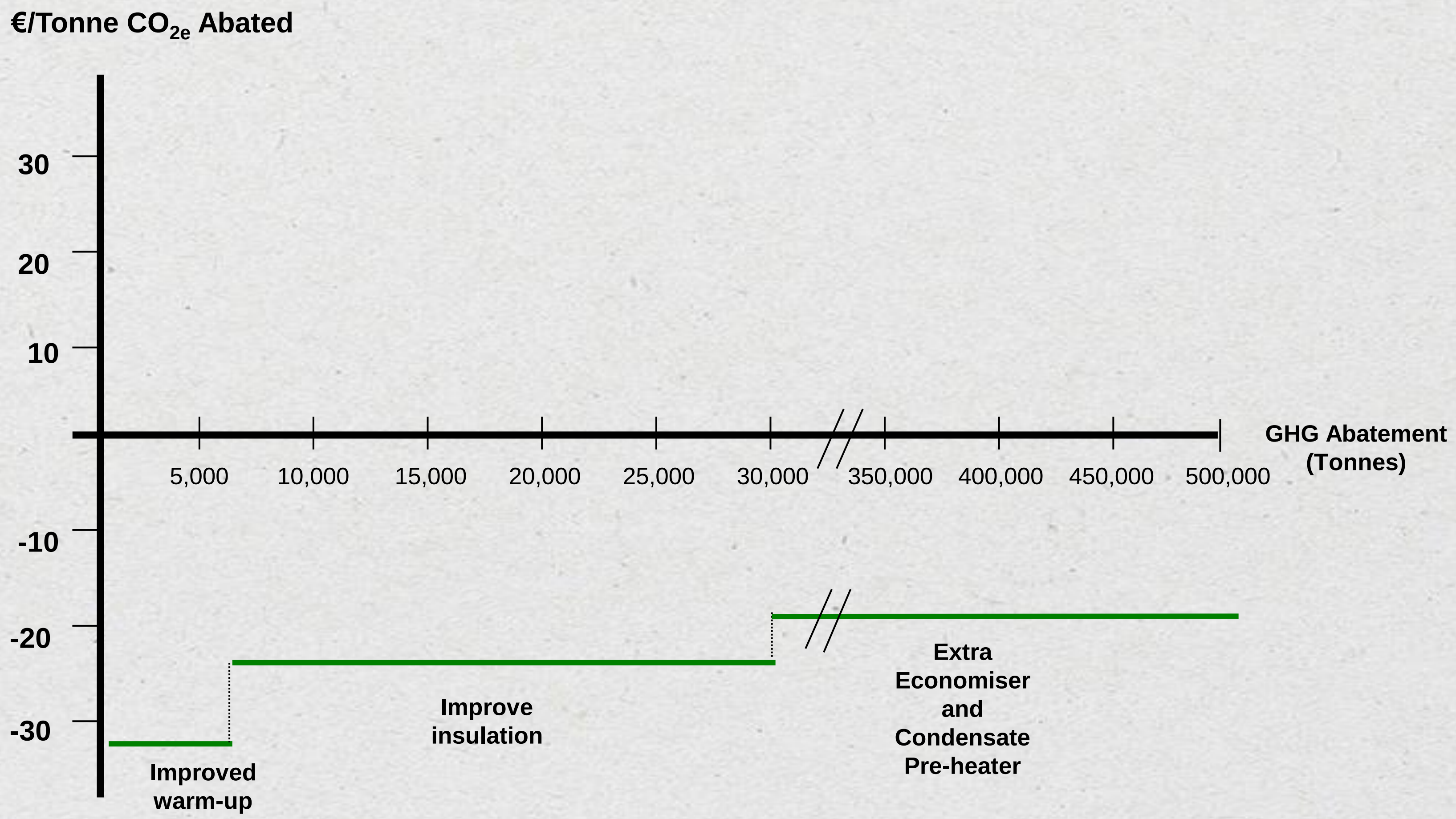
Efficiency Option	Capex	Annual kWh Savings	Annual Cash Savings	Payback	NPV	IRR
Improved Warm Up Procedure						
Improved Insulation						
Upgraded Economiser and Condensate Pre-Heater						
Totals	**A**	**B**	**C**	**-**	**D**	-

- How to prioritise?
  - Simple payback is a very good tool for early stage screening.
  - Capex limits and IRR can offer a second tier of discrimination.
  - NPV assists in identifying the relative magnitude of returns.

Presenting Carbon Efficiency Options

Carbon Abatement Option	Cost Saving per/tonne $CO2_e$	Upfront Capital Costs (€'000)	NPV Excluding CER Allowance Value (€'000)	NPV (€'000) CER Allowance price €10	Emissions Savings over period (Tonnes CO2e)	Payback Period (Years)
Improved Warm Up Procedure	39.31	-	219	270	7,000	0.0
Improved Insulation	27.00	2,000	4,000	4,800	560,000	1.5
Upgraded Economiser and Condensate Pre-Heater	16..10	5,000	5,245	6,340	400,000	3.1 (no allowance sales)
Totals		**7,000**	**9,464**	**11,410**	**967,000**	

Advanced approaches: Marginal Abatement Cost Curve for carbon

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