Cutting Pharma's Carbon Footprint: Reduced Emissions through Solvent Reuse

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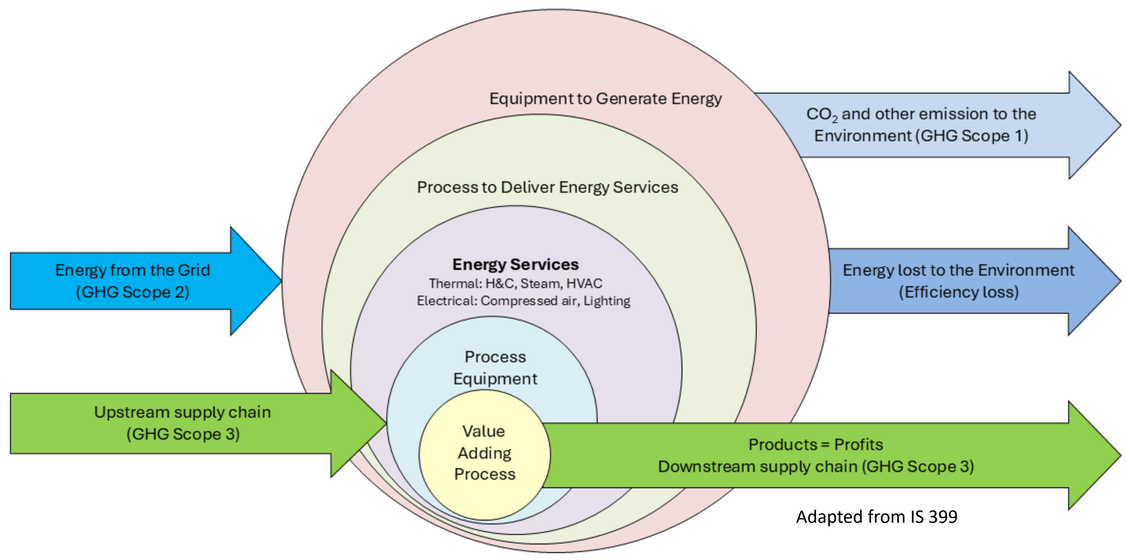
Challenging and Analysing Options to Reduce Emissions

Challenging and analysing is a method suggested in the Irish Standard IS 399 for Energy Efficient Design (EED) management for identifying opportunities to reduce carbon emissions. ETERNAL has adapted the method for the process industries, using one of the project case studies as a demonstration.

The modified "energy onion" identified the layers at which energy efficiency options might exist. We found that the principles of inherently safer design lead almost without alteration to a helpful set of principles and questions to use for challenging and analysing energy efficiency. For our case study the results were captured in a worksheet.



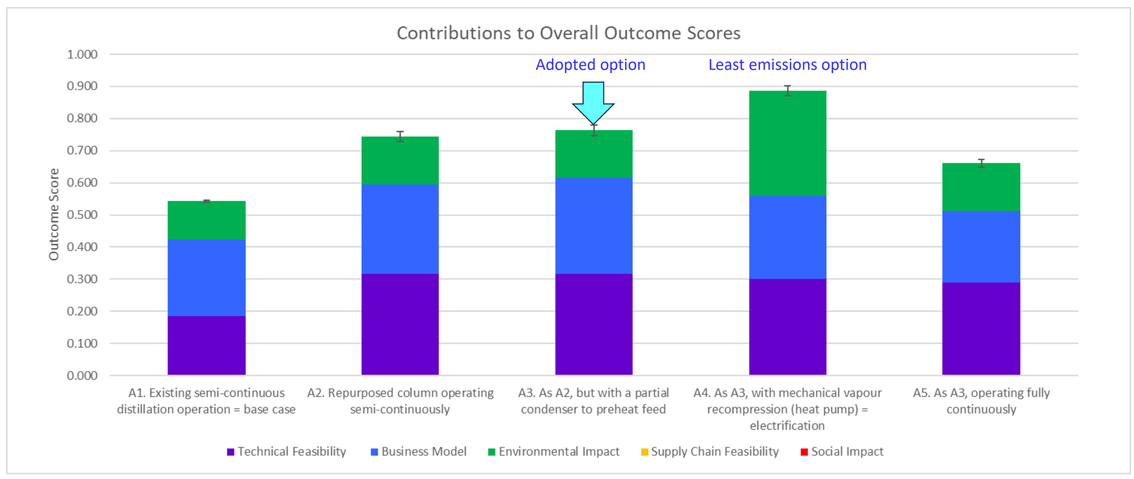
Layer	Baseline Scenario	Challenge	Analyse	Conclusion	Opportunity
Value Add Process	Manufacture of trazadone (step conversion to HCl salt.	Can the acetone be recovered?	Distillation will certainly work, requires input of latent heat of vaporisation. Steam is 'obvious' heat source. Modest temperature. Selective freezing - requires removal of latent heat of fusion and cooling service. Very cold. Handling solids. Membrane filtration - good to remove residual product, starting materials , impurities and co-products. Unlikely to be selective to acetone vs water and IBA.	Use distillation to recover acetone with steam as heat source and cooling water for condensing recovered acetone. This is the baseline.	Implemented
		Can a greater proportion of acetone be recovered?	Redesign/re-use of unused distillation column can do this.	Repurpose existing spare distillation column to give greater recovery capacity (more latent heat = more energy). Large benefit for Scope 3 emissions for small increase in Scope 1.	YES. Distillation upgrade
Process Equipment (Distillation Process)	Conventional distillation column heated with steam using cooling water for condensing recovered acetone	MINIMISE - Can additional energy requirement be reduced?	Recover some of the energy from the acetone vapour?	Add partial condenser to pre-heat distillation column feed. Reduces Scope 1 emissions. Also reduces requirement for cooling service (Scope 2 reduction)	YES. Include in distillation upgrade
		SUBSTITUTION - Can steam be replaced with hot water?	Atmospheric boiling point of acetone is 56°C. Heating with hot water is just about feasible. Reducing pressure in column will reduce boiling point and make boil-up with hot water feasible.	Option doesn't make much difference to energy requirement (latent heat) but reduces required heat grade. Introduced vacuum service requires more electric energy to drive it (increases Scope 2). Only worth considering if a reliable source of hot water at a suitable temperature is already available (eliminates Scope 1 emission). Capital cost may be increased if a large reboiler is necessary.	NO
		MODERATION - Can the steam pressure be reduced?	Atmospheric boiling point of acetone is 56°C. Heating with lowest pressure steam available will work.	Doesn't change the energy required but does lower the grade. Only worth considering if an adequate source of lower pressure steam from elsewhere on site is available. Note that capital cost may be increased if a large reboiler is necessary.	NO
Energy Service	Steam Data required: flowrate XXX [kg/hr] temperature XXX [°C], pressure XXX [bar]	Can the energy rejected by the process be RECOVERED, and REPLACE a process heating service?	Use mechanical vapour recompression (MVR) heat pump to recover latent heat of vaporisation from condenser and return to column reboiler.	Electrification of process. Removes GHP scope 1 emission replacing with Scope 2 emission equivalent to circa 25% of steam energy delivered.	YES. Include as an option, especially for future new build.
Process for Energy Services	Flue gases from burning natural gas burnt pass through tubes with boiling water on shell side to raise steam.	Can the steam be REPLACED?	See above.		

Developed from principles for inherently safer process design

Principle / Criterion	EED Challenge & Analyse Questions
Elimination	Can this energy service be REMOVED?
Minimisation	Can this equipment be REPLACED with more efficient equipment?
Moderation	Can this energy service be SUBSTITUTED with something with a lower carbon footprint?"
Segregation	Can the energy required to maintain this service be REDUCED ?
Simplification	Can the energy rejected by the process be RECOVERED, and REPLACE a process heating service or STORED and REUSED for heating at another time/place?

Deciding Which Option to Develop

ETERNAL has developed a Framework for Early-Stage Sustainability Assessment (FESSA) which was applied by the case study team together using the CURE multicriteria decision analysis tool (also developed in ETERNAL) to identify the most sustainable option and validate the option chosen by the case study in the early stages of the project. The results can be seen below. The case study chose option A3, not the most sustainable option A4. This was a valid decision as although the carbon emissions were least with A4, through GHP Scope 2 savings by electrifying the process, the predominant saving was in Scope 3 (through recycling more acetone). Hence the additional capital and operating costs associated with A4 for not justifiable and A3 was the correct compromise choice for Angelini (the case study leader).



Note: FESSA recommends criteria for supply chain feasibility and social impact. The case study team found no differentiation between options against these criteria leading to their omission from the analysis presented.

I.S 399 Energy Efficient Design Management, Formal Launch, Sustainable Energy Authority of Ireland, 2014. https://www.seai.ie/sites/default/files/publications/IS399-Energy-Efficient-Design-Management-overview-.pdf

White Paper: Cutting Pharma's Carbon Footprint: Reduced Emissions through Solvent Reuse, John A. Henderson, Robert H. Peeling*, Bonny Victor (Britest Limited); Micheál Galvin, (Enviroeye Engineering Ltd.), Tomasso laconangeli, (Angelini Pharma) , March 2026

A framework for early-stage sustainability assessment of innovation projects enabled by weighted sum multi-criteria decision analysis in the presence of uncertainty, John Henderson, Robert Peeling, Open Research Europe 2024, 4:162

Establishing safe and sustainable pharmaceutical life cycles by design

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