Ireland's trusted **energy advisor.**

EXEMPLAR CLIENT CASE STUDY

Manufacturing Steam Decarbonisation

A large energy user in the manufacturing sector, engaged on an SEAI EXEED Stage 1 study to remove natural gas from site by 2030.

Manufacturing | Large Energy User | ISO 50001 Certified

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The Challenge

Steam, the hardest service to decarbonise and the most often replaced like-for-like

The client operates an energy-intensive manufacturing site where natural gas was the only remaining Scope 1 fossil-fuel emission. The business committed to removing gas from the site by 2030 and engaged Exemplar to deliver an **SEAI EXEED Stage 1 study** covering the full natural gas footprint: low-pressure hot water in two buildings, and the production steam system.

This case study describes the steam portion of that scope. Steam is often the most technically challenging service to decarbonise on a manufacturing site, and the one most often replaced like-for-like rather than re-engineered. The client asked for clarity across three fronts.

The client needed clarity on:

- How to decarbonise the steam system without triggering a costly like-for-like electrification or a full site electrical upgrade.
- How to validate, technically and commercially, whether steam was actually required at all.
- How to sequence the work so that demand was reduced before generation was replaced.

> They were looking for an engineering-led partner who would interrogate the process before sizing the solution.

What Exemplar Did To Help

Within the wider EXEED Stage 1 study, the steam workstream took the process back to first principles rather than pricing a like-for-like replacement.

First-Principles Review Of The Cleaning Process

The existing system was a **250 kW steam boiler** (320 kg/h) feeding three steam-jacketed cleaning skids that heated a 20/80 water and nitric acid solution to 100°C. Steam was raised at 13 bar and stepped down to 10 bar at the process, and the boiler ran continuously even though the duty was batch-based.

Exemplar applied the EXEED Challenge and Analyze methodology, putting **fifteen challenge questions** to the system across six layers: energy service, process, equipment, control, operation and maintenance, and management. Operations, facilities and process staff took part. The first question was whether the cleaning duty was necessary at all. It was, because product cannot be sold without it, so the exercise moved from elimination to reduction.

Asked why the water was heated to 100°C, the answer was "because that is the way it has always been." Operations staff recalled that the setpoint had already come down from 120°C over the preceding years without any adverse effect on the product. Exemplar ran a controlled trial at a lower setpoint, and the product came out as clean at **90°C** as it did at 100°C. Sub-80°C was identified as the next-stage objective.

Two options were ruled out during the review. A different chemistry could have allowed a lower temperature, but the alternatives introduce more volatile and hazardous chemicals to the site. Hot water could have replaced steam outright, but the tanks are designed to be heated through steam jackets and converting them in situ would put the process at risk. Removing steam entirely therefore depends on **skid lifecycle rather than retrofit**.

> "Because that is the way it has always been." The original justification for 100°C no longer applied.

Right-Sizing The Steam Load Before Electrifying

The review did open up the generation method. An electric steam generator removes natural gas from the process entirely, but only becomes viable once the installed capacity has come down.

Investigation showed the **250 kW** generator had been sized for a four-skid plant; the site now runs three. Combined with the temperature reduction, line repairs and condensate return, the actual duty could be met by a **150 kW system, a 40% cut in installed capacity**. Specifying two modular units means only one fires when a single skid is online.

That also avoided the full electrical infrastructure upgrade a like-for-like 250 kW electric generator would have required, and allowed the generator to be sited close to the cleaning vats rather than in the boiler house.

250 to 150 kW

Installed steam capacity cut by 40% before generation was specified

2 × 75 kW

Modular electric configuration that scales with skids on line

What The Audit Found

Ten reductions, none of them requiring new generating plant

FROM THE CONDITION SURVEY

- **Estimated condensate losses of 14,000 kWh/yr**, routed to drain rather than returned to the feed tank. Facilities staff supplied the history that made this finding possible. Acid had once been carried back with the condensate, and the routing was never revisited after the reaction changed. Returning it lifts feedwater to a nominal 90°C and raises boiler efficiency.
- **Estimated heat losses of 62,000 kWh/yr** from missing or degraded pipework insulation, which can be refitted to current standards.
- **Estimated steam space heating of 41,000 kWh/yr** across three fan coil units in the chemical store. Thermostatically controlled electric heaters plus heat jackets on the IBCs do the same duty, which allows the steam line to that area to be dead-legged entirely.
- **Uninsulated process tanks, an estimated 9,000 kWh/yr.** Lagging had been ruled out historically because acid overspill damaged it, something only the people who had worked on the plant could explain. The reaction no longer behaves that way.

FROM THE PROCESS AND CONTROLS

1. **Pre-heat the chemicals before injection.** They were added at ambient temperature, so steam did the entire lift. A high-COP heat pump moves that duty onto a far more efficient source.
2. **Match generation to a batch duty.** The boiler held pressure 24 hours a day against an estimated 30 hours a week of real demand. Operators mentioned that production had once stopped for three weeks while it carried on raising steam, which no trend log would have shown.
3. **Drop system pressure from 13 bar to 10 bar.** The extra 3 bar was capacity headroom, because at 10 bar there was not enough stored steam if two skids called at once. Interlocking them so only one calls at a time removes the need for it.
4. **Reduce the steam temperature further.** Even at 10 bar the steam is hotter than the duty requires, and further reduction should be tested incrementally.
5. **Meter the steam.** No meter existed, so useful steam could not be separated from wasted steam. Consumption had to be estimated from the two months the natural gas served steam alone, then projected across the year.
6. **Repair the steam traps.** A significant number were stuck permanently open, venting live steam rather than discharging condensate. Routine maintenance that had drifted.

> The four survey findings alone account for an estimated **126,000 kWh/yr** of recoverable steam energy. Together, the ten are the difference between electrifying the system the client **had** and electrifying the system the client **needed**.

All energy figures are EXEED Stage 1 estimates, derived from site survey, equipment ratings and metered natural gas data. The steam system itself is unmetered, so steam consumption is calculated rather than measured, and figures are stated to the nearest 1,000 kWh/yr accordingly.

The Business Case

What the measures cost, and what they return

The steam system consumed an estimated **450,000 kWh** of natural gas a year, costing €50,000 and emitting 91 tCO_2. The boiler accounted for 410,000 kWh of that and the chemical-store fan coils the remaining 41,000 kWh, both fed from the same boiler.

Two measures were costed in full at Stage 1. The IBC jackets have since been installed. The electric steam generator is the anchor decision, and its economics are set out here in full because they are the reason the demand-side work had to come first.

Scoped, not yet costed

- Pipework insulation and leak repairs
- Steam-trap replacement
- Condensate return to the feed tank
- Skid interlock and the drop to 10 bar
- Steam metering and temperature monitoring

IBC Heat Jackets

IMPLEMENTED

€21,000 Capital cost, six units	36,000 kWh/yr saved
5.5 yr Simple payback	16.5% Internal rate of return

A positive net present value of **€18,600** over a fifteen-year life, and 7 tCO_2 a year avoided. Jacketing the containers directly replaces the duty previously met by heating the air around them.

Electric Steam Generator

DECARBONISATION CASE

€70,000 Installed, incl. €45,000 plant	255,000 kWh/yr saved
14 yr Simple payback	−€18,500 Net present value

38 tCO_2 a year avoided, but on energy cost alone the net present value is negative. This is a **decarbonisation investment rather than an energy-cost one**, and it is why the demand-side measures matter: every kilowatt removed before the generator is specified cuts the capital cost and improves the case for spending it.

Sized against the original 250 kW demand, the same generator would have cost more and required a **site electrical upgrade on top**. The demand-side work is what brought it within reach.

The Impact

A sequenced, evidence-based EXEED Stage 1 design the client can defend at board level

255,000	57%	37.8
kWh/yr of energy savings identified against a 450,000 kWh/yr steam baseline	Estimated reduction in steam-system energy consumption	tCO_2/yr avoided, referenced to 2023 Irish grid average of 0.3478 $kgCO_2$/kWh

- **Installed steam capacity cut by 40%**, from 250 kW to 150 kW, with a modular 2 × 75 kW electric configuration that scales with skid demand.
- **Full site electrical upgrade avoided** by reducing the electrified load before specifying the replacement.
- **IBC heat jackets implemented**, delivering 36,000 kWh and 7 tCO_2 a year on a 5.5-year payback, 16.5% IRR and €18,600 NPV.
- **Control strategy defined** to interlock the skids, allowing system pressure to fall from 13 bar to 10 bar and generation to follow a batch duty rather than run continuously.
- Quick-win measures identified and scoped for immediate implementation: insulation, leak repairs, steam-trap survey, dead-legging and condensate return.
- **Steam metering and temperature monitoring** specified so that future savings are measured rather than estimated.
- End-of-life replacement pathway designed for each cleaning skid, enabling steam to be removed from the site entirely over time.
- A credible, evidence-based **EXEED Stage 1 design report** the client can use to sequence capital decisions through 2030.

A Staged Path Off Steam

Because the cleaning skids are steam-jacketed, fully removing steam is a multi-year decision tied to skid lifecycle. The next skid to reach end of life can be replaced with a hot-water or direct-element system rather than another steam-jacketed unit.

With process temperatures dropping, a high-temperature or two-stage heat pump becomes a credible long-term replacement for the remaining duty. The study set out to build a sequenced decision tree rather than specify a single replacement boiler.

> The engagement turned a complex, ambiguous decarbonisation question into a sequenced engineering plan.

Why This Matters

What this means for other sites

A steam system is often decarbonised by swapping the gas boiler for an electric steam generator or a biomass boiler of the same size. That sizes the new plant against the old demand rather than the demand the process actually has. It locks in legacy oversizing, can trigger an electrical upgrade that was never necessary, and skips the cheapest savings on the site.

The alternative is to reduce demand before replacing generation. Fix the line, return the condensate, validate the process temperature and right-size the plant, then choose the source for what remains.

On this site that sequence took a 250 kW gas boiler down to a 150 kW electric duty, avoided a site electrical upgrade, and left a decision tree the client can step through as capital allows rather than a single all-or-nothing replacement.

None of that comes from a desk study. The reasons a system ended up the size it is are rarely written down. They sit with the people who run the plant, so the only way to find them is to ask, and then to test the answer.

The sequence that works on most sites

- **Establish what the process needs**, not what the plant currently delivers. Temperature, pressure and running hours are the three that carry legacy assumptions, and each one should be challenged with the people who operate it.
- **Fix the losses and the controls before anything is specified.** Insulation, condensate return, steam traps, interlocks and metering are cheap, they are rarely contentious, and they change the size of everything that follows.
- **Size the replacement against the reduced demand**, then choose the source. Doing it in the other order is what makes electrification look unaffordable.

Decarbonise the system you need, not the system you have.

Talk to Exemplar before you replace your steam system.

Whether you have a 2030 commitment in place or are still scoping the question, we will interrogate the process before sizing the solution, and give you a costed, sequenced roadmap your board can defend.

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