Case study: InfraBuild Steel

Clean Energy Knowledge Sharing Initiative

Exploring the power of waste heat recovery

InfraBuild Steel's Rooty Hill plant in Sydney's western suburbs is one of the largest electricity users in NSW, consuming 310 gigawatt hours (GWh) annually. In collaboration with the NSW Government's Clean Energy Knowledge Sharing Initiative, InfraBuild Steel (formerly Liberty OneSteel) explored how it could save energy by recycling waste heat.

InfraBuild Steel conducted a feasibility study on the Organic Rankine Cycle (ORC) waste heat recovery method. This technology uses high-temperature waste heat to run a turbine and generate electricity, which means less energy is lost in the process.

The study found energy cost savings could be significant. However, challenges associated with the technology include the limited space available at the plant and the high cost of installation. In the future, InfraBuild Steel will consider implementing an ORC at its other locations.

> ***'The more knowledge you get about the limitations and applications of the various ORC technologies, the more options and ideas you have to utilise waste heat.'***
>
> ***Catherine Skidmore, Sustainability Superintendent, InfraBuild Steel***

Fast facts

Annual energy usage of the steel plant	310 GWh (equivalent to approximately 52,000 households)
Waste heat available for energy generation	30% of input energy
Potential savings	Up to $870,000 per year

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Background

InfraBuild Steel operates a steel mill in Rooty Hill in western Sydney. The plant operates two energy intensive processes that generate large amounts of waste heat.

The electric arc furnace (EAF) uses a large amount of electricity to melt batches of scrap metal, accounting for 82% of the plant's electricity consumption. The other energy intensive process occurs at the rolling mill reheat furnace (RHF), where natural gas is burned to reheat steel for reshaping into the final products. Both steps in the steelmaking process create significant opportunities for waste heat recovery, with waste gas temperatures of 1,100˚C and 450˚C from the EAF and RHF, respectively.

InfraBuild Steel saw an opportunity to install a waste heat recovery method at its Rooty Hill facility and capture the high-temperature waste gases for power generation. Together with technical consultants TTF, InfraBuild Steel conducted a study investigating the technical and economic feasibility of the Organic Rankine Cycle (ORC) technology.

Organic Rankine Cycle

Although it is a new technology in Australia, Organic Rankine Cycle (ORC) is popular around the world, especially in steel manufacturing. ORI Martin steelworks in Brescia, Italy generates enough electricity for 700 homes through its ORC waste heat recovery system.

The ORC works much like a conventional steam turbine, which transforms thermal energy into mechanical energy and finally into electric energy through an electrical generator. However, instead of generating steam from water, the ORC system vaporises an organic fluid that is later cooled and reused. This process presents an attractive energy solution for manufacturers looking to cut costs and lower their carbon footprint.

Journey

To explore the potential use of waste heat recovery for power generation, InfraBuild steel had to consider the nature of the waste heat generated and the medium used to transfer the waste heat.

The steel melting process is done in batches, meaning waste heat is available in bursts rather than as a continuous heat stream. This characteristic makes the use of ORC technology more suitable than a traditional Rankine cycle, which generates electricity by using continuous superheated steam.

Hot water and steam can both be used to transfer the furnace's waste heat into an ORC generator. Because of the high capital cost and sizeable physical footprint required by the hot water option, the study focused on steam.

Figure 1. The EAF at InfraBuild Steel's Rooty Hill plant

To implement the steam solution, InfraBuild Steel would need to convert the EAF's water cooling ducts into steam recovery circuits.

These circuits would use waste heat to produce steam, with the steam then vaporising the organic fluid in the ORC.

The main challenge with installing an ORC unit in the EAF is the cost, and dust in the furnace's waste heat could block the steam recovery circuits.

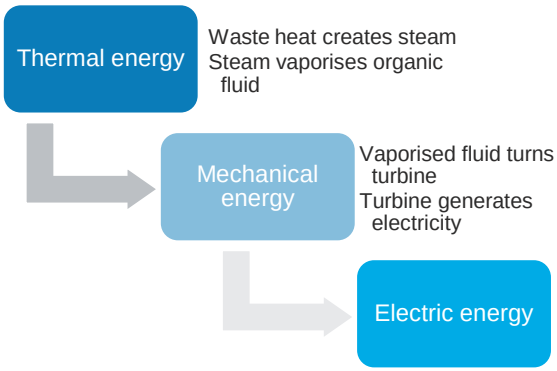

Figure 2. Electric Arc Furnace ORC process

The study also explored the option of installing the ORC system in the RHF where the waste heat has a lower temperature. In this furnace, hot waste gas can directly exchange heat with the organic fluid without needing to pass through a recovery circuit, simplifying the ORC process. The RHF's waste heat is also comparatively cleaner, reducing the complexity of the system.

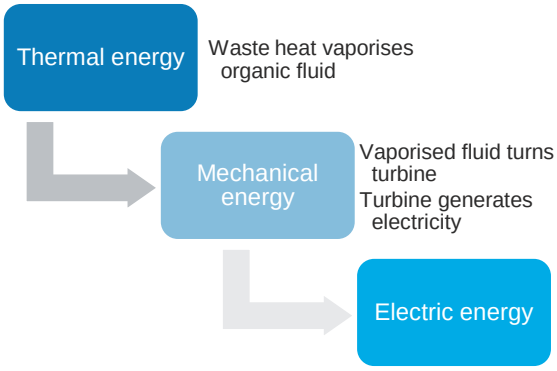

Figure 3. Reheat furnace ORC process

Finally, the study investigated installing a smaller type of ORC system in the RHF to find out if that would be more economical.

Some general challenges and potential solutions for the ORC system are summarised in Table 1.

Outcomes

The study found installing an ORC system in the Rooty Hill plant's EAF could generate a substantial benefit to the plant, delivering $870,000 in energy savings yearly by lowering energy use by 19 kilowatt hours (kWh) for every tonne of steel produced.

At the other end of the scale, a smaller ORC unit for the RHF would be less efficient but could still deliver annual savings of $125,000, with a much lower capital cost. The study concluded that of all the options considered, this smaller ORC generator in the RHF is the most viable solution for InfraBuild Steel to implement.

The different technologies considered in the study, along with their applications and outcomes, are summarised in Figure 4.

Findings

- Waste heat recovery is a viable source of energy if matched with the right application.
- The capital costs of the ORC technology are high and payback periods long, but this should reduce as the ORC market matures and competition grows.
- Greater local engineering expertise would reduce the risks for innovative Australian businesses looking to take up ORC technology.

Next steps

The project presents an opportunity to implement innovative technology that could generate significant savings. However, there is currently no precedent for large-scale, high-temperature ORC systems in NSW and little expertise in building and maintaining them.

InfraBuild Steel will consider alternative suppliers to reduce costs and expects that new suppliers will enter the market in the coming years.

InfraBuild Steel is confident that there will be other applications for ORC in its various operations. For example, InfraBuild Steel will consider installing ORC technology at its Victorian and Newcastle rolling mills when waste heat recuperators have to be replaced.

ORC technology would also be suitable in heat-intensive industrial processes. One example is cement manufacturing, where

rotary kilns run 24 hours a day at high temperatures.

The results from InfraBuild Steel's project highlight the potential of ORC technology to help NSW industry harness waste energy from high temperature processes to reduce energy costs and emissions.

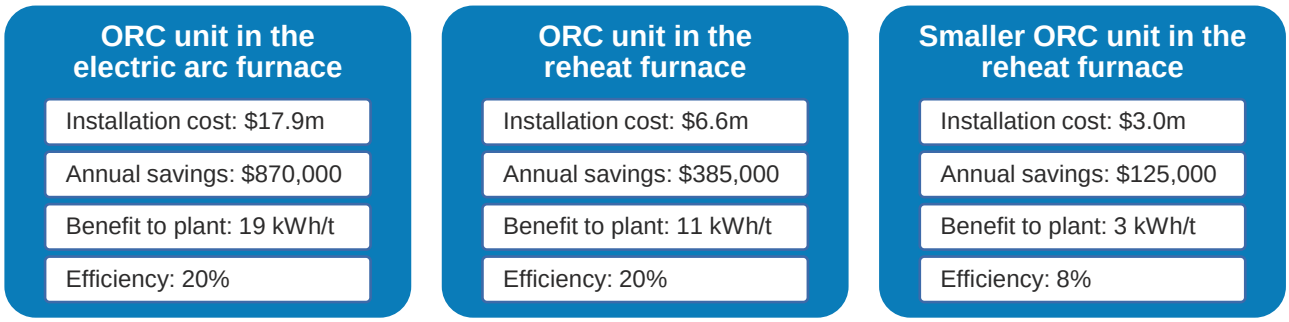

Figure 4. The different technologies considered

Table 1. Challenges and conclusions

Challenges	Potential solutions
High capital costs and long payback periods	As the Australian ORC market matures, competition will drive costs down
Australia's limited market for specialist power generation means lack of support for technical hurdles	The government's research and development of a tax incentive encourages ORC specialists to establish and develop their expertise in Australia
Limited space on-site for additional equipment needed to enhance efficiency and reduce payback period	A greenfield ORC installation would avoid some of the costs and compromises required for the design at the Sydney facility

About the initiative

The NSW Clean Energy Knowledge Sharing Initiative supports the NSW Government's objective to achieve net zero emissions in the state by 2050. The Initiative gives innovators and early adopters an opportunity to test and trial new clean energy solutions. To find out more or learn about similar projects, visit www.energy.nsw.gov.au/clean-energy-initiative