AMPC

SNAPSHOT

INVESTIGASTING THE POTENTIAL APPLICATIONS FOR MEDIUM TO HIGH TEMPERATURE SOLAR THERMAL TECHNOLOGISES AT AUSTRALIAN ABATTOIRS

Project Report Reference: 2016-1006 **Date: 30 April 2016**

Project Description

This project involved a detailed investigation of whether there is a case for selection and deployment of solar thermal technology for an Australian abattoir. The research saw a detailed technical review of linear-focus and point-focus technologies. A techno-economic analysis was performed using the U.S. National Renewable Energy Laboratory's System Advisor Model (SAM) software to determine feasibility. Potential applications, configurations and O&M implications for abattoirs' were also discussed.

Project Content

While the red meat processing industry's use of coal, gas or oil-fired boilers and related process system technologies (pumps, pipes, valves) to produce hot water, saturated or superheated steam and/or electricity is well-proven, reliable and reasonably acceptable practice, the use of these fossil fuel sources has become decreasingly palatable for environmental, productive efficiency and cost reasons. With some abattoir facilities and equipment being decades old, the question of replacement vs. refurbishment becomes rather pertinent considering the new technologies presently available. Replacing a fossil-fuelled boiler with a solar thermal boiler is a very realistic and viable prospect, and should be thoroughly considered.

Thermal energy makes up between 40 – 80% of an abattoirs' energy consumption. With cumulative growth rates of installed capacity averaging 25 – 35% year-on-year over the past decade globally, installed costs steadily decreasing in lock-step with further technology deployment, and incremental improvements in performance, solar thermal technology has strong potential to at least supplement fossil-fuelled boilers, if not eventually replace them as the primary source of thermal energy at Australian abattoirs. A review of commercially available technologies and how they can be implemented within existing abattoirs was undertaken in this project.

Project Outcome

The most appropriate and applicable technologies was found to be Parabolic Trough Collectors (PTC) and Linear Fresnel Reflectors (LFR) given their typical thermal performance output, scalability and relative ease-of-integration into an abattoir. With respect to abattoir integration, the main implications for operations would be the learning curve that comes with operating new technology to ensure optimal performance; maintenance would see minor labour cost increases associated with mirror washing, and quarterly checks and annual adjustments for reflector/collector alignment.

The most appropriate 'solar boiler' arrangement, given a typical abattoir's saturated steam requirements, is a once-through configuration (as opposed to a recirculation-type boiler which can produce superheated steam). The best application of a once-through solar boiler would be in parallel operation to an abattoir's existing boiler.

For solar thermal technology, the design-nominal irradiation needs to be 5.5 kWh/m2/day or higher (irradiance of 230 W/m2 or higher) with an occurrence throughout the year that is frequent enough to ensure availability and production is met. The Case Study site met this requirement.

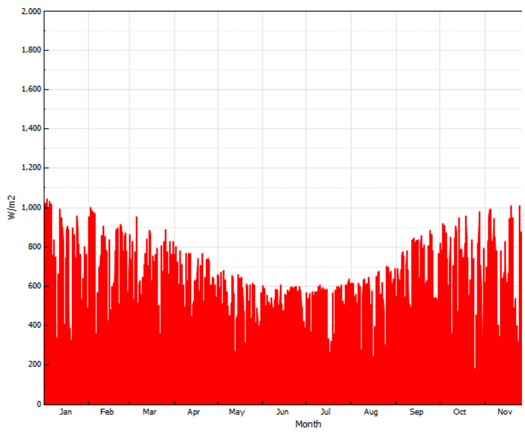

Figure 1 – 12-months irradiance data at the case study site

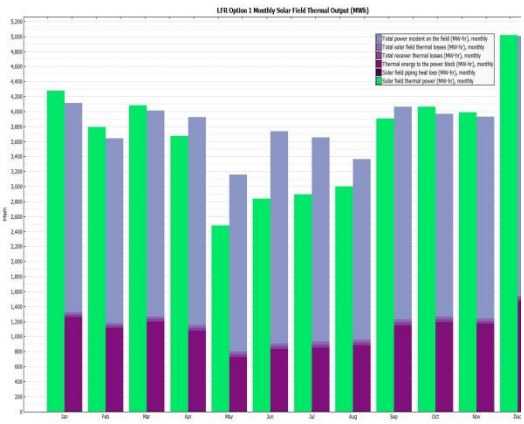

Figure 2 – Monthly Linear Fresnel solar field thermal output

It was found there is an optimal solar field size (aperture area) for all solar thermal technology sited at a given location, with the system sized to meet certain parameters of useful output, for example MegaWatt-hours (MWh) of steam. An aperture area too small will not produce enough thermal output, even at peak solar radiation; an aperture area too large will end up wasting energy and costing too much, despite an seemingly attractive Levelised Cost of Energy.

The financial modelling indicated that solar thermal technology is infeasible for Australian abattoirs. However, this was predicated on an incomplete or deficient model not suited for Australian energy policy and regulatory settings. Furthermore, incomplete data on coal consumption and costs did not enable a comparison between the value of solar thermal steam and the marginal cost of coal producing the equivalent steam. Additional and customised financial modelling should be performed external to the System Advisor Model software to obtain a more appropriate indication of financial feasibility.

Benefit for Industry

The research indicated a 'solar boiler' can produce enough thermal energy to supplement, if not replace, a typical 8 MW coal-fired boiler at an Australian abattoir with PTC and LFR able to generate average monthly thermal energy of 4670 MWh and 3668 MWh respectively, for an annual total of 56,046 MWh and 44,011 MWh, respectively. These technical benchmarks can be compared against a coal-fired boiler.

If an abattoir has limited space available, then PTC should be strongly considered over LFR as it has an aperture efficiency of 1.172 MWh/m2 which is higher than LFR's 0.765 MWh/m2. Aperture efficiency is an indication of energy obtained per unit area of solar radiation collection. In effect, this results in 7.47m2 and 11.45m2 of space needed for PTC and LFR, respectively, to displace 1 MW of coal-fired boiler capacity.

While LFR may have lesser aperture efficiency than PTC, it does have a significantly lower cost of installed capacity at $2.167/MW against PTC's $4.118/MW. While the financial modelling in SAM was not suited for Australian conditions, there is scope for appropriate financial analysis to incorporate these cost benchmarks to find an optimally-sized and scaled solar thermal technology to achieve the technical benchmarks.

RESOURCES

N. Blair, A. Dobos, J. Freeman, T. Neises, M. Wagner, T. Ferguson, P. Gilman and S. Janzou. (2014). System Advisor Model, SAM 2014.1.14: General Description. National Renewable Energy Laboratory, United States.

System Advisor Model (SAM). National Renewable Energy Laboratory, 2016. Available: https://sam.nrel.gov/ (accessed September 2015 – April 2016).

Lovegrove, K. and Stein, W. (2012). Concentrating solar power technology. Oxford: Woodhead Publishing.