The Heat Transformers

gTET

Hot Wire

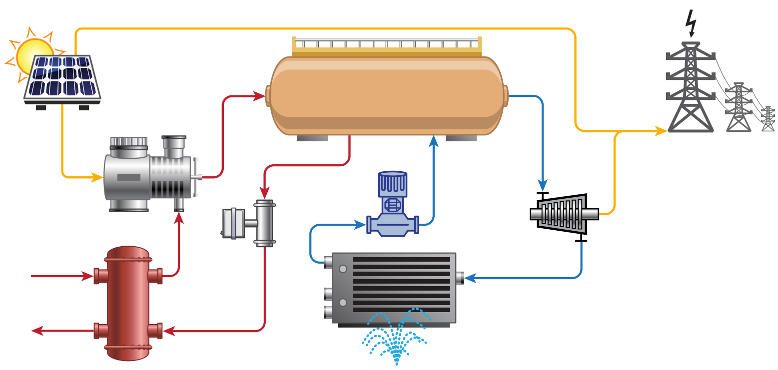
ISSUE 10 Q2 2022

News & Updates from green Thermal Energy Technologies

gTET is open for business as usual after COVID lockdowns

IN THIS SPECIAL ISSUE...

- CEO Paul Keen's Notable Presentation to the Australian Alliance for Energy Productivity (A2EP) Event 'Energy Recovery in Industrial Applications'



Turn-key solutions to transform waste into useful energy, delivering economic and climate change benefits

gTET

gTET specialises in innovative solutions at industrial scale for thermal energy management, in particular redeploying waste or renewable streams to reduce opex and carbon footprint.

gTET's revolutionary ORC generators enable thermal energy to be effectively converted into electrical power where this is the most efficient and effective use of the energy.

As we like to say here "*WASTE* is the new *OIL*"

www.g-tet.com

Refer to www.g-tet.com/news for previous editions of Hotwire

gTET
2/12 Mosrael Place Rowville Victoria 3178 Australia
Phone: +61 413 884 231 email: enquiries@g-tet.com

CEO Message:

Presentation from the 'Energy Recovery in Industrial Applications' Event

We welcomed the opportunity to participate in the Australian Alliance for Energy Productivity (A2EP) webinar on Energy Recovery in Industrial Applications held Jun 1-22 and gratefully thank Bill Parkinson, from Jeffries Group, supporting with their biochar project case study incorporating our ORC generator.

A2EP provides a valuable resource to Australian industry and gTET is proud to be an active member.

This edition of Hotwire includes the presentation material which, in addition to the Jeffries case study, provides a number of thermal waste to energy technologies that gTET can deliver.

Paul Keen, CEO

green Thermal Energy Technologies

A2EP Heat Recovery & Utilisation Webinar
June 2022

Presented by:

Paul Keen - CEO gTET (pkeen@g-tet.com)

Bill Parkinson - Process Engineer Jeffries Group (bnp@jeffries.com.au)

For a complete recording of the actual webinar, visit:

https://www.youtube.com/watch?v=xqDlGN-OC6o&feature=youtu.be

Introduction

Capability Statement

gTET is an engineering focused business delivering innovative turn-key solutions in thermal energy efficiency equipment.

Beginning in 2010, leveraging expertise and capabilities from the founders long history in the global automotive industry, the business was established to commercialise and refine its core technology in ORC generators while also delivering solutions around a range of other industrial thermal energy technologies delivering innovative high value solutions.

Our business has heavily invested into R&D and in-sourcing core system and component technologies, not least of which is our own high speed micro turbines of which we are the only company in Australia, and of a select few globally, with this capability. We have a proven track record in managing complex bespoke projects, including green field sites in remote locations.

gTET has implemented projects for an impressive range of multinational and local clients and supports industry bodies in clean energy and waste recovery. Through our TORC joint venture, we are technology members of the prestigious global long duration energy storage council announced at COP 26.

Expertise & Qualifications

- Industrial Thermal Energy Solutions
- Revolutionary ORC generator technology.
- Thermodynamic modelling
- Automotive derived lean design manufacturing and supply chain
- Innovative and optimised solutions
- Turn-key or consultant
- Green field site or Plant integration
- Australian owned and operated
- ISO9001:2015 accredited
- QBCC Open Licenced
- IEA and RPEQ accredited engineering
- Proven remote location experience

Member of A2EP and LDES-C

Australian Alliance for Energy Productivity

LDES Long Duration Energy Storage Council

Multinational Client Base

RioTinto, HATCH, Howden, NEWCREST MINING LIMITED, Oyu Tolgoi, Outotec, bhpbilliton, VEOLIA, Worley, JACOBS

Waste to Energy Technologies

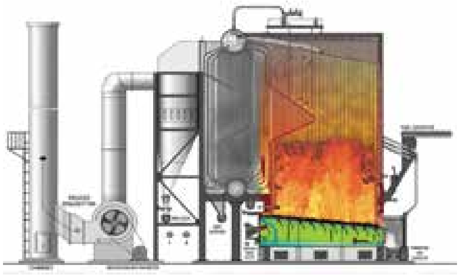
Solid/Liquid Waste to Energy Technologies

gTET has been involved in a range of waste to energy projects and technologies some of which are detailed below...

Combustion

Likely the most common and robust technology for converting solid waste into thermal and/or electrical energy is the solid fuel boiler or oil heater. Fuel handling and emissions treatment are the most critical factors and must be tailored to the requirements. The process produces heat which can then be used in a heat engine to produce electrical power.

- Solid fuel boiler or oil heater
- Robust proven technology
- Emissions treatment is critical and can be expensive
- Provides a thermal output requiring a heat engine for power generation



Pyrolysis

Pyrolysis is the process of combusting organic material under closely controlled combustion resulting in lower emissions. The process can produce syngas that can be used in a standard gas turbine or ICE generator or thermal energy that can be utilised by a heat engine generator. Quenching the fuel during combustion produces char used for soil enhancement in agriculture.

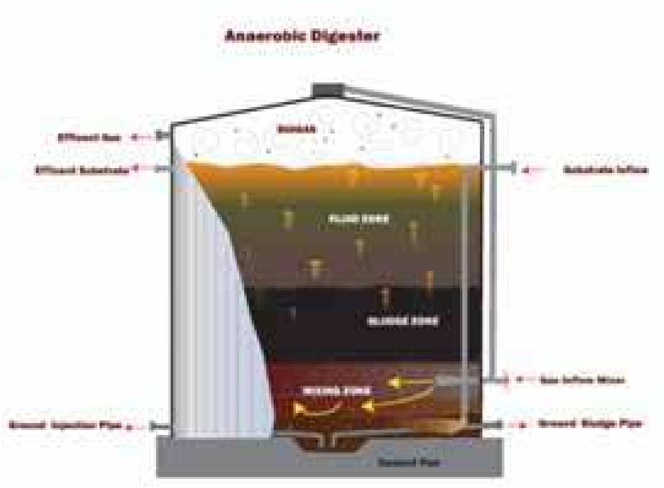
- Organic solid fuel with closely controlled combustion, lower emissions
- Produces syngas (for gas turbine or ICE power generation) and/or biochar (used in agriculture)
- Provides a thermal output that can be used by heat engine power generation

Anaerobic Digestion

Anaerobic digestion of liquid organics produces methane which, similar to Landfill gas, can be combusted or used in power generation after scrubbing.

• Chemical breakdown of biodegradable materials producing combustible gases eg methane

• Combustible gas output can be used in conventional gas turbine generators or ICE generators depending upon biogas quality.

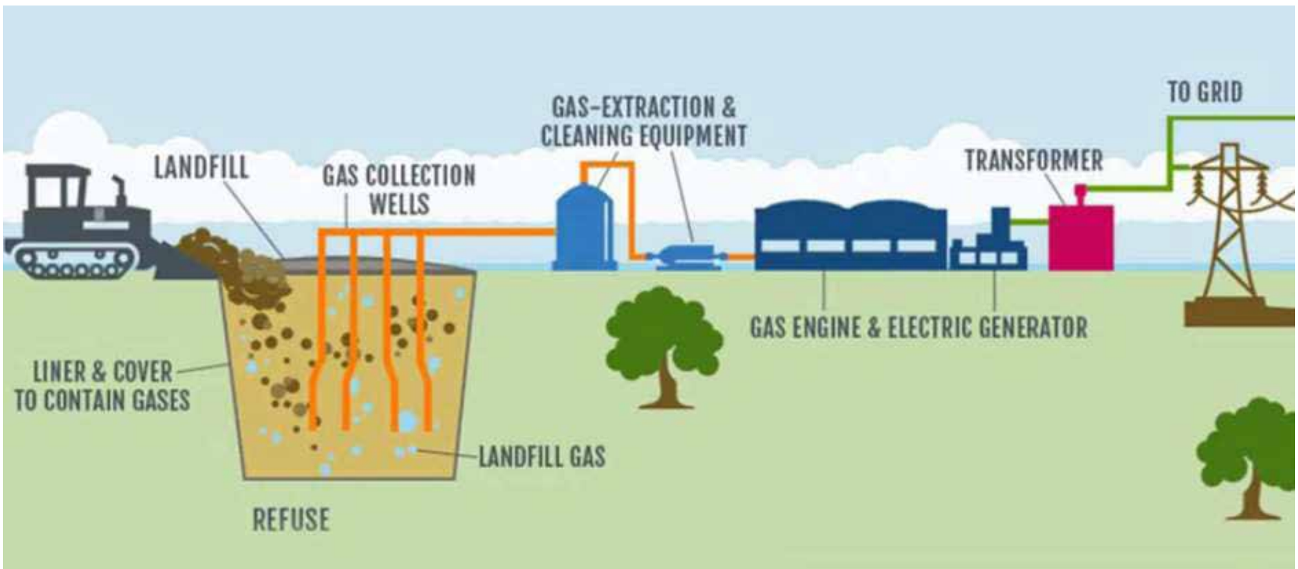


Landfill Biogas

• An AD process occurring from decomposition of organic material in landfill sites

• Combustible gas output that can be used in gas turbines or ICE generators

• Poor quality gas can be directly combusted in a boiler or oil heater providing a thermal output that can be used in heat engine power generation



Thermal Waste to Energy Technologies

More than 50% of the worlds energy is used in thermal applications and of that close to 50% is used in industrial thermal systems. Low grade heat, which we categorise as less than 200°C, wasted from industrial processes has often proven challenging to economically utilise but can provide a significant opportunity in thermal waste to energy projects.

Heat Transfer

Often waste heat streams can be utilised by simple heat transfer techniques such as changes in the medium (e.g exhaust to water) or cleaning up the waste stream (e.g exhaust to clean air).

- Transfer of a waste thermal stream into another useful thermal process using heat exchange and/or heat transfer fluids

Heat Pumps

Heat pumps allow low temperature waste streams to be economically lifted to higher more useful temperatures.

- Carnot cycle using an appropriate refrigerant for the temperature range
- Can effectively "amplify" a low temperature source to a higher temperature
- The COP (coefficient of performance) of at least 2 for a 100°C temperature difference to over 5 for <30°C temperature difference

Thermal Storage

Thermal storage technologies allow for variable or intermittent waste or consumed streams to be stored and load shifted to match demand improving utilisation. The heat can be stored as simple heat, so that temperature reduces as energy is consumed, or latent heat in phase change material so that temperature remains constant as energy is consumed.

- Energy can be stored in energy dense solid or liquid media as "simple heat" returning heat over a temperature range
- Use of PCM (phase change materials) for latent heat storage returning heat at a constant temperature
- Provides the advantage of load shifting to match thermal generation and to reduce the peak demands of thermal generation which, in turn, reduces capacity.

Thermal Battery:

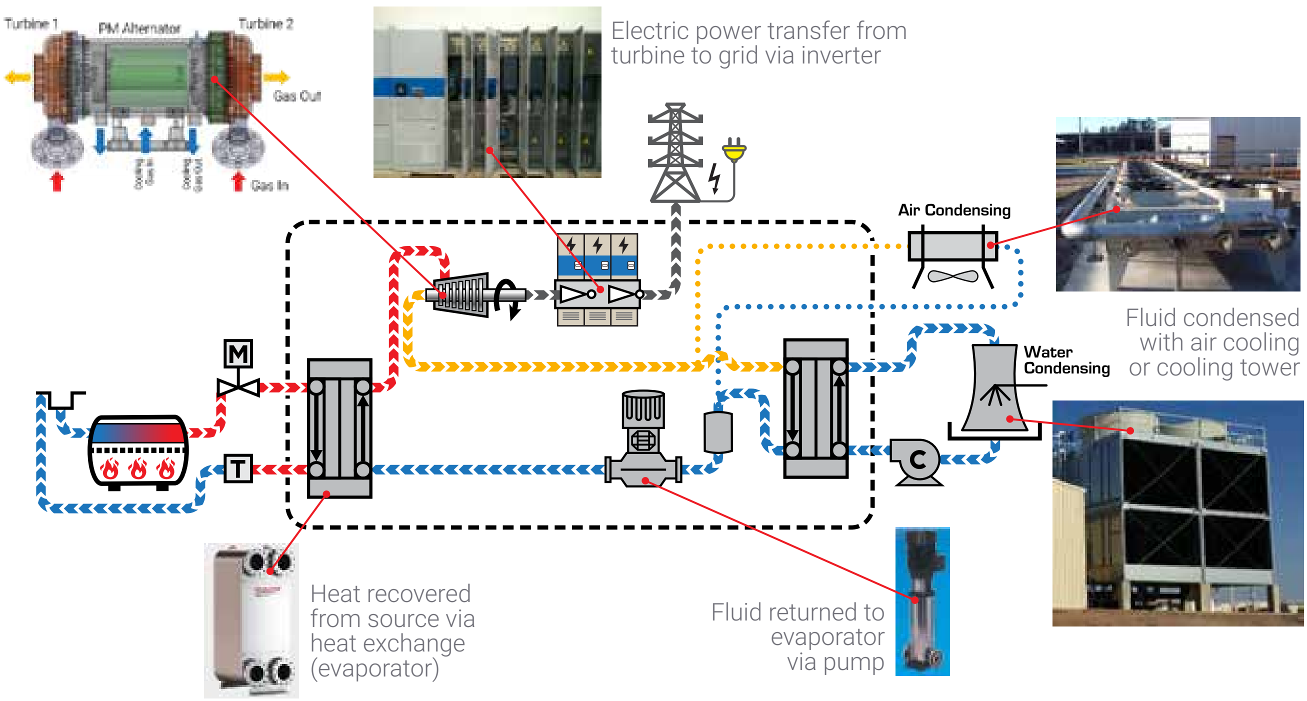
Stored thermal energy can be sourced from and generated into electrical power thereby providing a long duration low cost thermal battery solution. I'll discuss this technology later.

- Electrical to electrical storage using thermal energy as the storage media
- gTET's unique technology uses high temperature heat pump charging and ORC discharging with PCM storage

ORC (Organic Rankine Cycle)

Organic Rankine Cycle heat engines are the most common and robust technology to convert low grade heat into shaft power.
ORC is a closed loop cycle transferring heat from the source into a low boiling temperature organic working fluid via an evaporator or heat exchanger, in turn heating and pressurising the fluid to drive a turbine. The fluid is then condensed by transferring the residual heat through to the cooling system before being accumulated and pumped back to the evaporator.
As with refrigeration, condensing can be achieved by cooling towers, air coolers, adiabatic coolers or as a secondary heat transfer process, such as drying. The organic working fluid is selected for the particular operating range of the application.
Efficiency is a combination of Carnot cycle efficiency, turbine efficiency, electrical system efficiency and auxiliary loads. Overall electrical to thermal efficiencies range from 5% in a low temp resource to over 15% on an ideal resource.

- Closed loop cycle transferring thermal energy from source to mechanical energy in a turbine using an organic fluid
- Turbine mechanical energy is transferred to electrical energy by the integrated PM alternator
- Carnot Efficiency=1-TC/TH as well as turbine efficiency (~85%), electrical efficiency (~95%) and aux loads
- At $2k-$3k/kW >150°C source up to $10k/kW <90°C source



Leading Edge Technology

gTET has developed innovative high performance ORC generator technology. We are one of a select few high speed turbo-machinery producers in the world using aerospace derived gas, oil free bearing technology. Our integrated hermetically sealed permanent magnet turbo-alternators operate at 45,000rpm with electrical efficiency over 95% and turbine efficiency over 85%.

The high rotational speed results in significant power from a relatively small package, such that our turbine is only 300mm dia x 600mm long. Multiple turbo-alternators are manifolded in parallel to produce up to 1MW generators.

Each turbo-alternator is connected to a high speed regenerative drive providing DC via a common bus to a single AS4777:2020 certified inverter. The regenerative drive operates the PM alternator as a motor during starting and then adjusts electrical load transfer to match gas pressure in order to maintain a constant operating speed.

The integrated drive includes the system auxiliary drives including the working fluid pump, cooling tower pump and fan which enables the ORC generator control system to select the most energy efficient operating point.

gTET's ORC installations also manage power factor output of the generator to improve the sites overall power factor.

A significant advantage in this asynchronous solution is the turn-down it can provide, often required in highly transient waste to energy applications.

Exclusive Turbo-alternators

- High speed (45,000rpm)
- Gas 'foil' bearing technology;
- Integrated hermetically
- High Frequency AC alternator
- Unique twin turbine
- High temp (170kW) & Low Temp (60kW)

High Speed Electronic Drive (AS4777-2020 certified)

- Customised to gTET's HFAC Turbo-Alternator (750Hz)
- Asynchronous.
- Ancillary loads integrated into drive
- Fast acting electrical turbine braking
- PFC and FCAS capability
- High turn-down

ORC Heat Recovery-Design Process

In order to investigate a heat recovery opportunity using ORC we must define the boundary conditions to the ORC system.

Primary inputs include the thermal source where we need to identify the temperature, fluid and dynamics. A Secondary loop may be used to parallel multiple heat sources or heat sources exceeding working fluid conditions. The dynamics are often challenging where interfaces have rapid transients or the ORC is used to load level the resource.

The cooling system typically utilises ambient conditions and therefore average annual and diurnal conditions will impact the output.

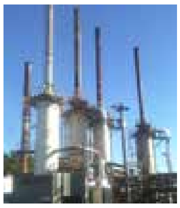
Various aspects must be considered on the power connection such as voltage, grid/island, export/none export with many aspects dictated by respective regulations.

The output boundaries to be considered include

1. For power, the power quality (typically AS4777), PFC/ FCAS compensation and power authority controls
2. Transient responses such as thermal load following, ramp up/down times and interface process variations
3. Plant integration including interaction with other processes, alarms/trips, HMI and remote access etc

Defining the Boundaries






System Inputs

Thermal Source

- Temperature: 200-220°C max WF.
  Higher temps using 2nd loop
- Fluid: gas, water, steam, oil etc
- Dynamics: Transients, interface processes etc.

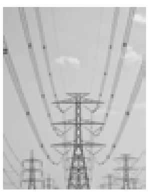
Cooling

- Temperature: ambient conditions
- Fluid: cooling tower, air cooler, adiabatic, 2nd process etc
- Av annual and diurnal impact dry/wet bulb cooling, ambient temp cooling effects

Power connection: LV/MV, grid, island, export/none export.

System Outputs

- Electrical power: Power quality, Load follow site power, PFC and FCAS compensation, Regulator output control
- Transient response: Thermal load following, ramp up/down times, interface process changes
- Plant integration: interaction with other processes, alarms/trips, HMI, remote access etc




System Modelling & Design:

With boundary conditions defined the system can be modelled. Our computer models have been refined to optimise the working fluid selection, optimal turbine configuration, optimised heat exchanger performance and series/parallel ORC combinations. The objective being to optimise the capex $/kW output.

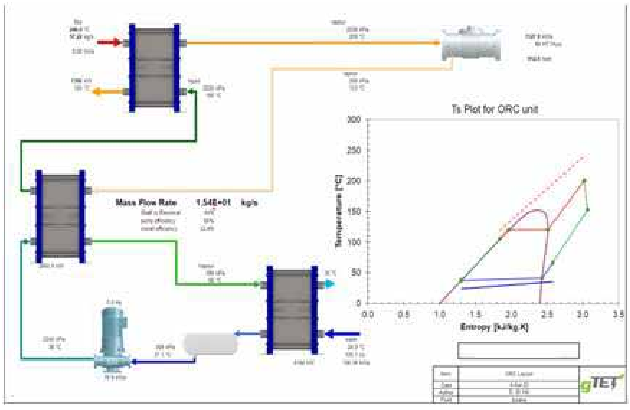
System interface will be detailed with process flow and piping and instrumentation diagrams, functional descriptions and single line electrical drawings.

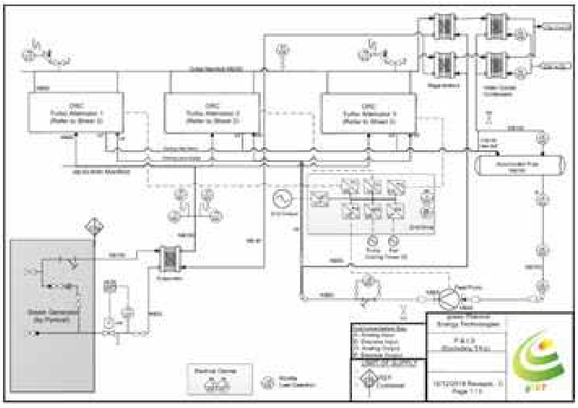
Performance modelling-objective to optimize $/kW

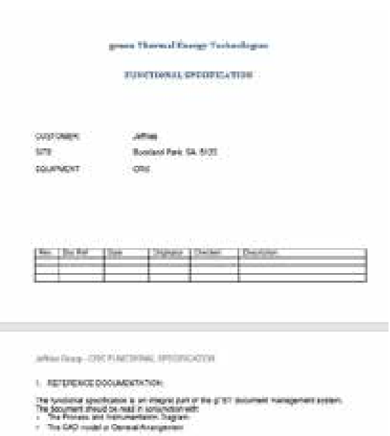
- Optimise working fluid (refprop)
- Optimise turbine configuration
- Optimise Hx performance
- Series/parallel ORC combinations

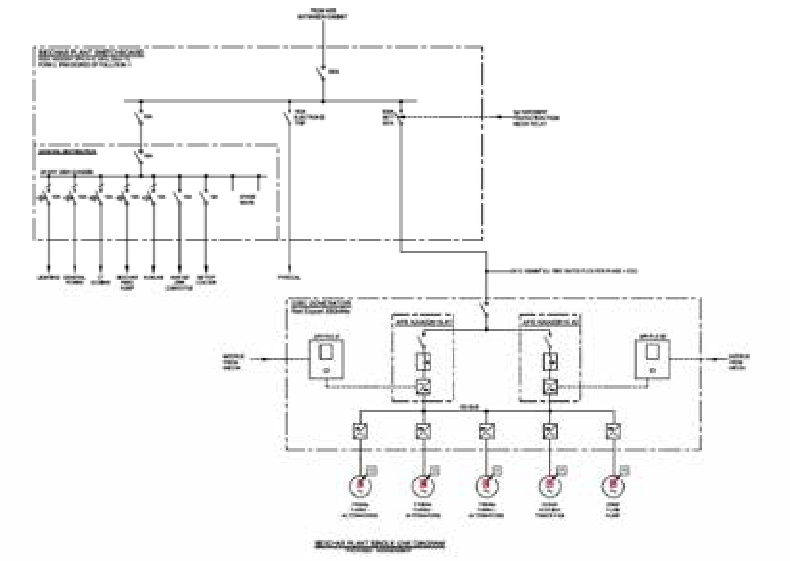
System interfaces

- PFD, P&ID
- FD
- SLD and other electricals









Thermal Storage

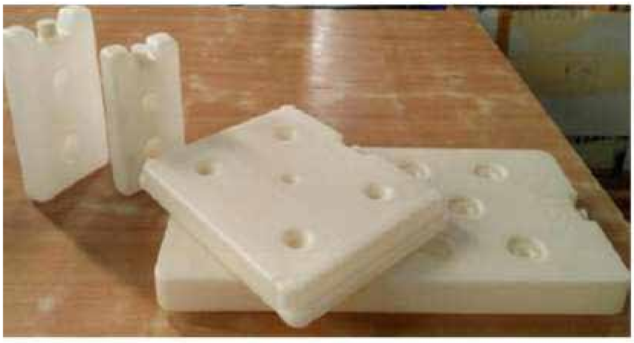
Thermal storage is key to enabling intermittent and variable waste thermal energy to be available when needed by load shifting to match demand.

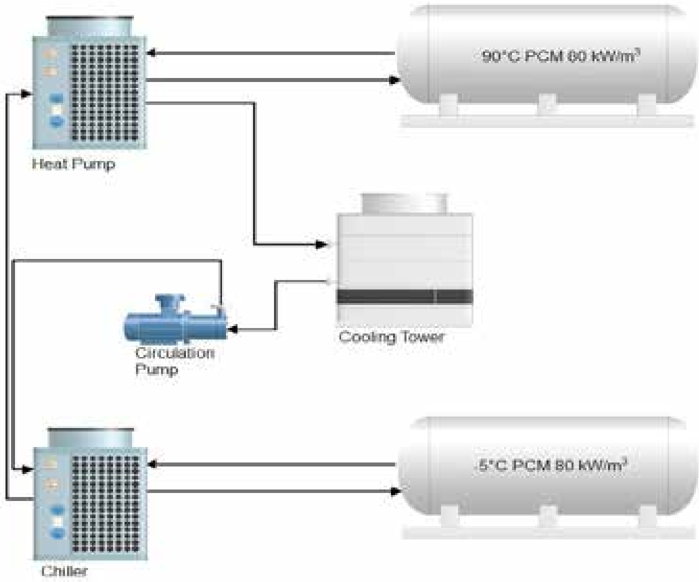
Phase change materials selected to match the application enable the heat to be released at a constant temperature. gTET can provide PCM storage from -20°C up to 90°C with 130°C currently in development.

The high energy density associated with gTET's phase change materials typically delivers 1MWh of thermal storage in a 7m^3 vessel.

Lower cost sensible heat storage solutions including insulated water tanks or cementitious materials can also be used where the process doesn't require a constant temperature.

- -20°C to 90°C PCM's storage temperatures
- Using PCM 1MWh(th) = 7m3 at around $3k-$4k/m3
- Levelise transient applications of thermal energy
- Latent heat (PCM) delivers constant temperature
- Simple heat (water or cement) has varying temperature





Industrial High Temperature Heat Pumps

Heat pumps provide a very effective means of producing thermal energy and supporting electrification. Operating on the Carnot cycle, heat pumps can move thermal energy with COP of at least 2 on a temperature lift over 90°C up to a COP of at least 5 on a lift below 20°C.

This means that heat pumps are excellent for leveraging low temperature waste thermal heat into more useful high temperature streams.

gTET currently has heat pumps delivering up to 120°C hot water with versions exceeding 150°C hot water currently in development.

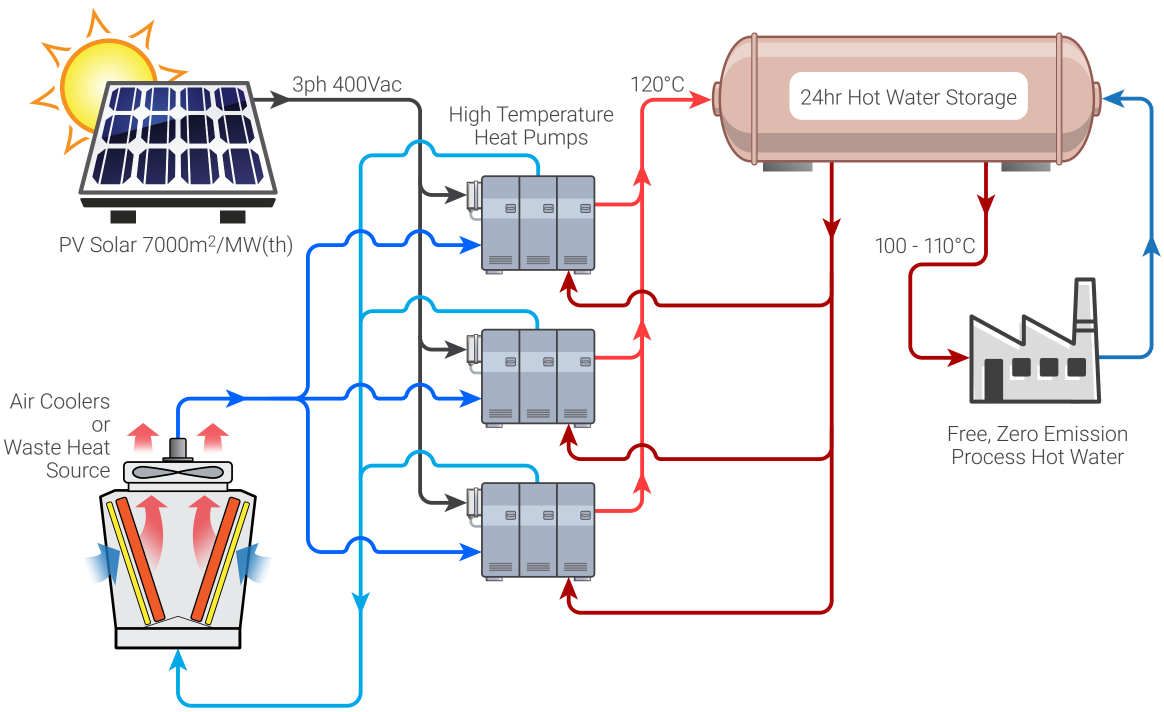
The ability for heat pumps to efficiently modulate and turn-down to match consumer heat loads results in a much greater energy efficiency and lower emissions compared to more traditional technologies including gas boilers, driers or burners.

The electrification of thermal energy using heat pumps means that when combined with thermal storage and variable renewable generation such as rooftop PV a zero emission/zero fuel cost thermal energy solution can be delivered.

Heat pumps can also be used to leverage renewable sources such as low temperature geothermal or low temperature thermal solar into more useful applications.

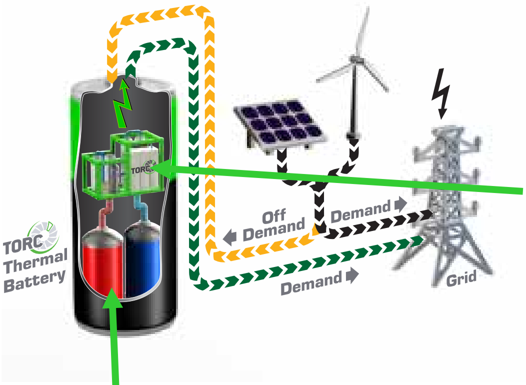
VRE powered heat pumps and chillers

- Up to 120°C hot water or saturated steam
- Air cooler or waste source for increase performance on the evaporator side
- Coupled with PCM storage and PV for free, zero emission hot water



Thermal Battery Electrical Storage

gTET is currently developing, through its TORC Clean Energy joint venture, innovative and novel technology in a low temperature thermal battery.
The thermal battery is intended for long duration behind the meter load shifting of variable renewable energy generation such as PV solar used in rooftop applications in the C&I sector and mining.
The COP advantages in heat pump charging coupled with ORC discharging, with the energy stored in phase change material, result in leading round trip efficiencies compared to many other long duration storage peers which can be leveraged when the site has a waste thermal stream e.g data center cooling, cold store condensers and air compressor cooling to name a few.
The thermal battery also delivers very competitive LCOS (levelized cost of storage) leveraged by its use of commodity materials and long design life components.



Patented low temperature Phase Change Materials (PCM)

- Technology developed at Monash University.
- PCM's selected on both hot side and cold side of the Thermal Pump for optimal efficiency.
- PCM's selected for world leading energy density at the required operating temp's
- PCM's selected for earth abundant ingredients while achieving required performance metrics

Storage Performance to Rival Competitors

- Energy storage solution targeted for delivery >12hrs (as opposed to peaking)
- Round trip efficiency target >50% or 70% when pushing from low grade waste heat
- Deployable at the generating source
- 100% depth of discharge
- Commercial targets easily leading Li Ion at <$100/MWh
- Design life >20yrs/>10,000cycles

Patented high efficiency Thermal Pump

- Transfers electrical energy source into thermal energy to store in the PCM's with COP>3
- Transfers thermal energy from the PCM's to electrical energy with efficiencies ~15%
- Very low (1-2%/day) self discharge rates
- Thermal pump comprises novel integrated high temp heat pump and ORC generator using world leading turbine and power converter technology

Jeffries Group

Overview

Established in 1930, Jeffries Group is the largest kerbside green waste processing facility in South Australia. Initially started life as a trucking company moved into the selling soils and with a requirement in the 80s to improve the soils we were selling we started composting green waste. We are leaders in our field for the removal of contamination from kerbside green waste collection utilising Xray and NIR technologies for this purpose We are a ISO9001 accredited organisation selling AS certified products. We recycle over 150,000T of green organics annually and employ over 70 staff.

The project was developed with a need to find a sustainable end use for our oversize fraction from our screening plant. In the years prior to the project, independent studies were completed to investigate viable options for this output. Multiple biochar technologies were investigated as biochar has many beneficial properties for soils. Pyrocals CCT technology was chosen as the best fit as it can deal with the levels of contamination inherent in kerbside green waste.

- Established in Adelaide in the 1930s
- Green organics from Adelaide metro kerbside, supermarkets, hotels, restaurants and food processors
- Raw materials sorted, mulched and composted
- End products are certified to Australian Standards (AS4454, AS4422, AS3743, AS4419)
- 2018, Biochar project to leverage significant market opportunity to agricultural industry
- Pursuit Qld based Pyrocal's technology
- Carbon negative process

Jeffries Biochar Facility

The plant is designed to consume 30tn per day of biomass and produce 10tn of biochar @ 50%MC. It is designed as an unmanned operation with once a day monitoring of the unattended boiler in accordance with AS2593. Pyrocal suggested gTET as a project partner to make use of the waste heat from the carbonisation process through the use of Heat recovery Steam boiler supplying 4.5tn/hr @ 193C to the ORC.

The project was funded in part with a 1/3 contribution from the State Government under the Energy Productivity Implementation Grant with a project cost of around $3.3m with the ORC costs contributing to approx. $1m of these costs. The revenue profile has changed from the initial project investigation with lower energy cost and lower LRECs than initially estimated but the introduction of carbon offsets through PURO earth CORCs Scheme to balance this out. The biochar is blended with our finished compost on site to fill the biochar with nutrients and microorganisms and sold into our current viticulture and horticulture markets. It is also part of the blend for our fertiliser pellet produced on site.

Project

- Green waste biomass fuel source derived from ROSS (Recycled Organics Screening System)
- Pyrocal Dual CCT 18 (continuous carbonisation technology) gasifier (10tn/day @ 50% moisture content)
- 12bar Heat Recovery unattended Steam Boiler (4.5tn/hr @ 193 °C)
- Raked feed bunker supplying 30tn/day of feedstock
- Circa $3.3m total investment with $1.1m Energy Productivity implementation grant
- Revenues from biochar sales, carbon offsets, power generation and LREC's with anticipated returns of $300k pa
- Biochar demand from current market sectors in Viticulture and Horticulture

Power Generated	Up to 330kW net
Annual Power Produced	Up to 2GWh
Power Plant	Circa $1m

Jeffries Power Generation

The project size was based to produce enough power to offset the energy consumption of ROSS. The Site is integrated with SAPN SCADA as the generation is between 200kw and 5MW.
The steam is utilised by a 300kW ORC generator to produce power for the site with approval for export. The green fuel source be classified as renewable enable the installation to claim LREC's on the output.
The ORC generator uses a Danfoss Vacon integrated drive with parallel AFE's. The ORC control system controls the AFE for PFC and a SAPN RS485 comm's interface enable them to regulate output.
The installation includes a Schneider Micom protection and power quality relay at the site grid connection which can also trip the plant.

Project

- 380kWe skid based ORC Generator
- 3 x parallel turbo-alternators
- 'Clean' temperature modulated control room
- 60lps cooling tower
- Grid connected. SAPN SCADA interface for generators between 200kw and 5MW
- 24/5 operation providing consistent power at all hours for self consumption and export

Be sure to follow gTET on

LinkedIn

to stay up-to-date on news, updates, past and present project info

www.linkedin.com/company/gtet-green-thermal-energy-technologies-/