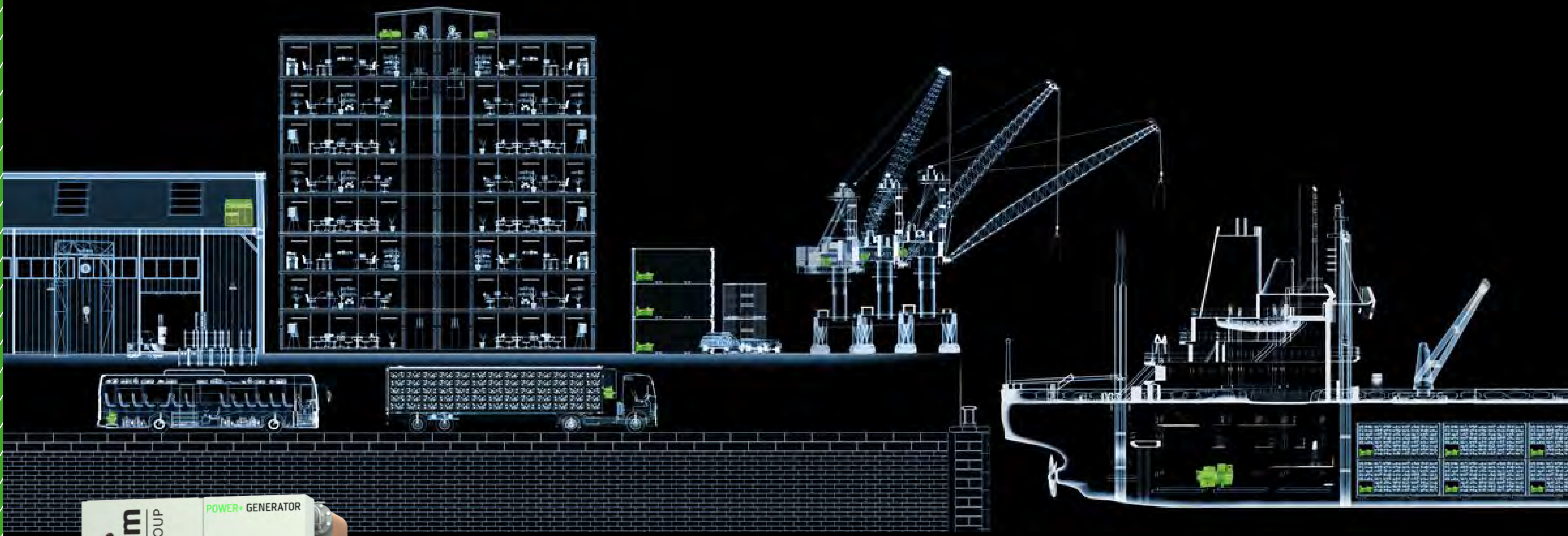


29th PPA CONFERENCE – BRISBANE

USE OF ORC TECHNOLOGY FOR THE GENERATION OF RENEWABLE ENERGY

ELECTRATHERM ORC SOLUTIONS

ElectraTherm
BY BITZER GROUP

ELECTRATHERM – WHO WE ARE

ElectraTherm
BY BITZER GROUP

- Renewable Energy Company focussed on Heat to Power Generation
- Founded in 2005 – Part of **BITZER GROUP** since 2016
- Leading Engineering Team with expertise in Organic Rankine Cycle design and application
- Successful development of **Power+Generator** with 100+ Units installed worldwide and combined fleet time of 2.2 Million Hours
- First commercial unit installed 2011 – still in operation
- Office and Manufacturing Located Flowery Branch Georgia USA
- World Class ORC Research and Development Centre Flowery Branch

HOW IT WORKS

ELECTRATHERM ORC TECHNOLOGY → Heat Boils Refrigerant → Under pressure, the vapor is fed to a twin-screw expander, spinning an electric generator which then produces power. → Vapor then re-cooled in condenser (cold side) → Refrigerant pumped to higher pressure and cycle repeats

ELECTRATHERM ORC TECHNOLOGY KEY POINTS

ElectraTherm
BY BITZER GROUP

- The standardised design and modular package enables the fully assemble unit to be factory tested prior to shipment – with opportunity to prove operation and output against simulated site operating conditions

- Why the use of hot water as the heat input - fact is water is an excellent carrier of heat, is non toxic and environmentally safe – not a silent killer, can be easily transferred through piping systems and provides opportunity for downstream processes.

- The Twin Screw Expander is a commercially proven semi hermetic design, accommodates fluctuations in heat input safely whilst operating at a lower speed 3600 rpm at 50Hz

- The process of transferring heat to/from the working fluid results both cooling of the heated water providing opportunities for process fluid/gas cooling and heating of the condensing circuit providing opportunities for CHP applications

- The working fluid R245fa is non flammable, environmentally safe and non ozone depleting. Testing of different working fluid blends with low GWP is currently in progress with aim to enhance performance at different heat input.

ORC SYSTEMS

ElectraTherm
BY BITZER GROUP

Power+6500B/6500B$^+$
Output up to 125 kW
Heat Input 70^0C – 150^0C

Power Module PM75
Output up to 75 kW
Heat Input 65^0C – 132^0C

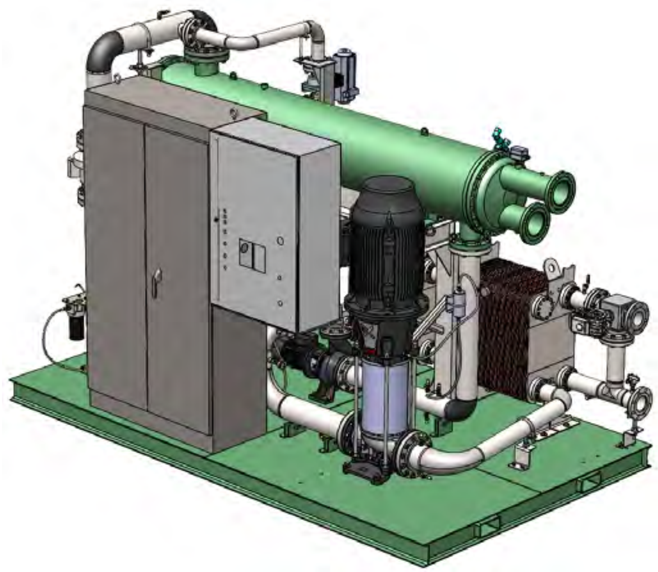
Active Cooler AC800
Output up to 75 kW
Cooling Capacity – 800 kWth

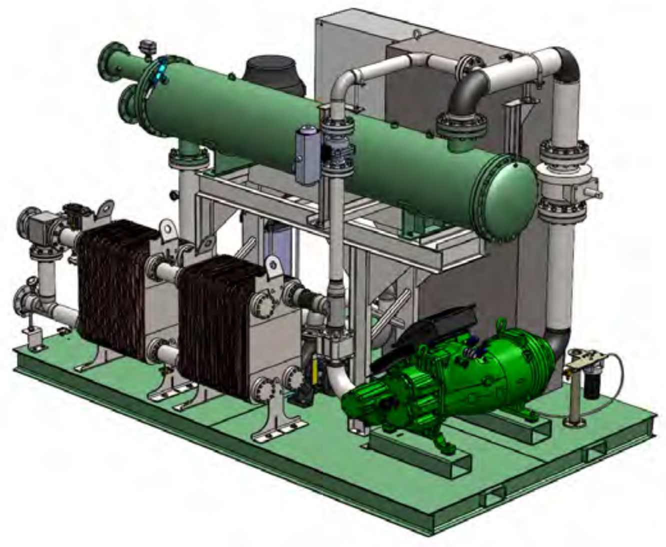
All **ElectraTherm ORC Systems** are Standardised, Modular and Relocatable

Smart Allocation of Assets Over Time / "Asset Efficiency"

RESEARCH AND DEVELOPMENT

ElectraTherm
BY BITZER GROUP





ElectraTherm current Research and Development projects:

- Development of the Power+250B which will have a gross output of up to 250 kWe.   A prototype has been assembled and product testing has commenced. Expected release mid to late 2023.

- Next Generation Working Fluid. R & D based on testing of blends with ultra low GWP and enhanced performance at lower temperatures.

- Testing has commenced on the compatibility of a twin inverter virtual grid system with the ORC operation and control system to enable the ORC to operate safely in “islanding mode”.   This will allow operation as the principal generating unit for micro grids or as part of a hybrid system

JOURNEY TO ENERGY EFFICIENCY AND NET ZERO CARBON EMISSIONS

ElectraTherm
BY BITZER GROUP

There are many pathways to achieve energy efficiency and net zero carbon emissions by 2050.

For Energy efficiency the key is using the energy released by the fuel more than once. This can be achieved by using waste heat for either power generation or other processes. ElectraTherm have solutions based on our ORC technology to achieve energy efficiency.

To achieve Net Zero the pathway includes the use of waste heat/ energy efficiency, solar and wind power, new technologies, next generation renewable fuels, biomass and biogas and geothermal.

The pathway to net zero does NOT preclude the use of engine based power generation which will remain an important component of power generation by providing network “firming and stability” whilst meeting future additional power demand.

Energy efficiency through waste heat to power and next generation fuels will provide the opportunities to reduce carbon emissions whilst still providing an essential service at affordable prices.

HEAT RECOVERY PROJECT
WHY & WHAT IS THE AIM

The First Step is to establish the reasons for embarking on a heat recovery project.

Why?

- Improved Energy Efficiency from Your Generating Assets
- Environmental Reasons – Meeting your Emission Reduction Targets
- A Better Way of Doing Things – worlds best practice
- Financial Benefit - Improving the profitability of your operation by utilizing waste streams for additional revenue or reducing the amount of fuel consumed in the generation of electricity.

HEAT RECOVERY PROJECT SOURCES AND USES OF HEAT

ElectraTherm
BY BITZER GROUP

Second Step – Which Heat Source and How to Use It

- Generator Engine Jacket Water – Use heat within the Jacket Water to provide the power to operate the cooling system – saving parasitics and excess energy for the grid
- Generator Engine Exhaust – High temperature waste heat for the generation of additional power for the grid for no additional fuel use.
- Combination of Jacket Water and Exhaust Waste Heat – achieve both power free engine cooling and additional energy for the grid – useful for smaller capacity engines
- Other Potential Heat Sources Biogas/ Methane, Biomass, Waste to Energy and Geothermal
- Secondary uses of heat include provision of heat input for Absorption Chillers, How Water System, Heating of Buildings/ Greenhouses and other industrial processes.

HEAT RECOVERY PROJECT
SELECT THE RIGHT TECHNOLOGY

ElectraTherm
BY BITZER GROUP

Third Step – Selecting the Right Technology

The factors that make the **ElectraTherm ORC Solution** the right technology

1. Heat source is a low temperature – The hot water heat input into the **ElectraTherm ORC's** is in the range of 70^0C to 150^0C.
2. The source of heat fluctuates. The twin-screw expander operates under "wet" conditions and has a turndown capability of 10 to 1
3. Flexibility to provide power generation and useful heat – the **Power+Generator** can be configured for Combined Heat to Power (CHP) operation.
4. Installation is simple and unobtrusive and operates quietly in the background
5. Installation is cost effective in both capital cost and lifetime maintenance

HEAT RECOVERY PROJECT IMPLEMENTATION

Forth Step – Implementation

ElectraTherm will be your partner throughout all stages of the project process from the initial concept through to installation and commissioning.

For turnkey projects such as the installation in Pohnpei we support our system integrator partner **B:Power** who are specialists in the design and implementation of ORC based Power Generation Projects.

After commissioning and handover, both **ElectraTherm** and **B:Power** will continue to provide technical support and maintenance services as required.

APPLICATIONS FOR THE PACIFIC

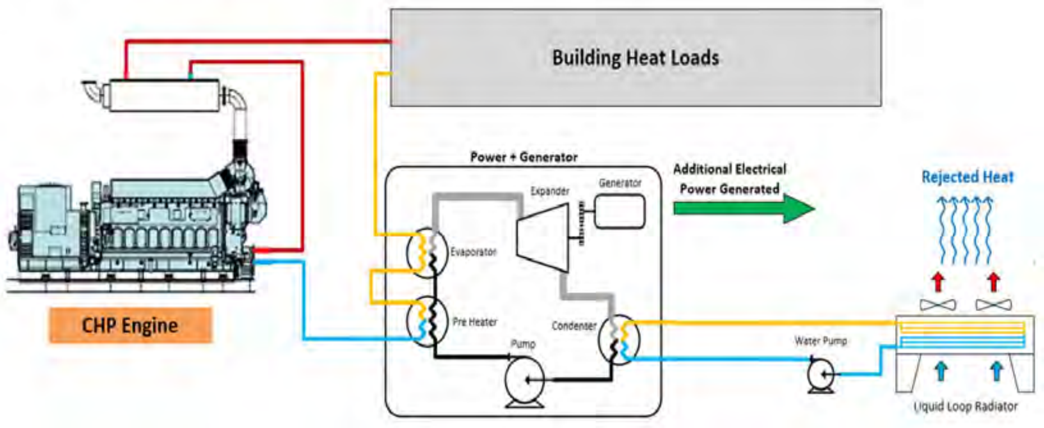
DIVERSE AND FLEXIBLE

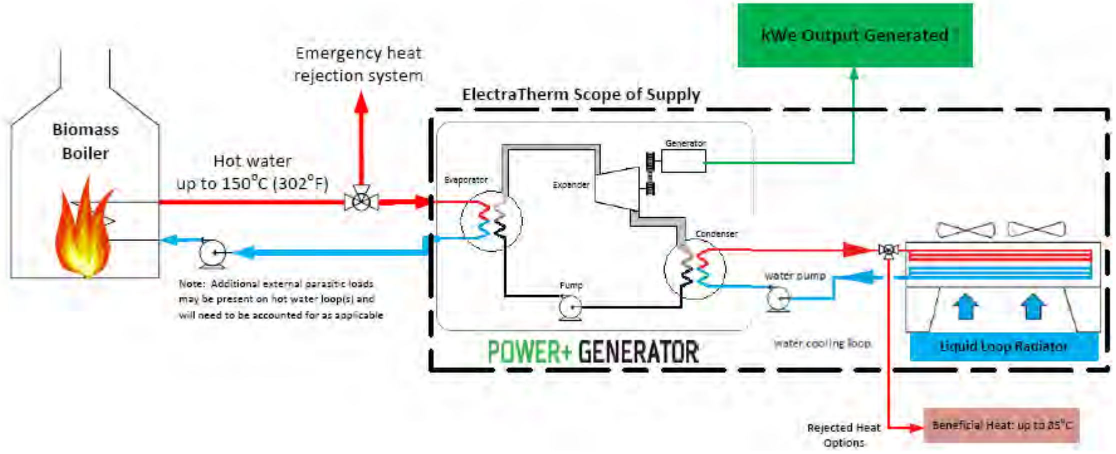
BOTTOMING CYCLE VS PRIMARY GENERATING

Bottoming Cycle

- A Bottoming Cycle is an extra cycle added to a process that is different from the primary driver.
- The main process will drive the conditions
- Other thermal users will take priority over the bottoming cycle

Standard low temp ORC acting as bottoming cycle



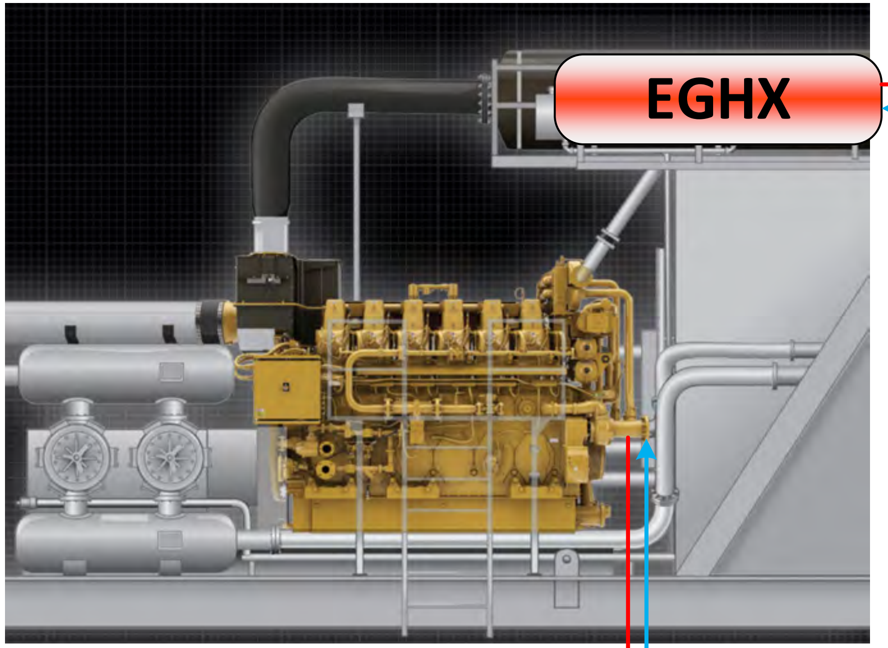


Primary Generating

- The ORC is the first/ primary user of the heat to generate electricity
- The ORC establishes the required hot water conditions from the heat source.
- Other thermal users have secondary use of the heat exiting the ORC from the hot water cycle or rejected from the condensing circuit

STATIONARY ENGINES - ENERGY EFFICIENCY

ElectraTherm
BY BITZER GROUP



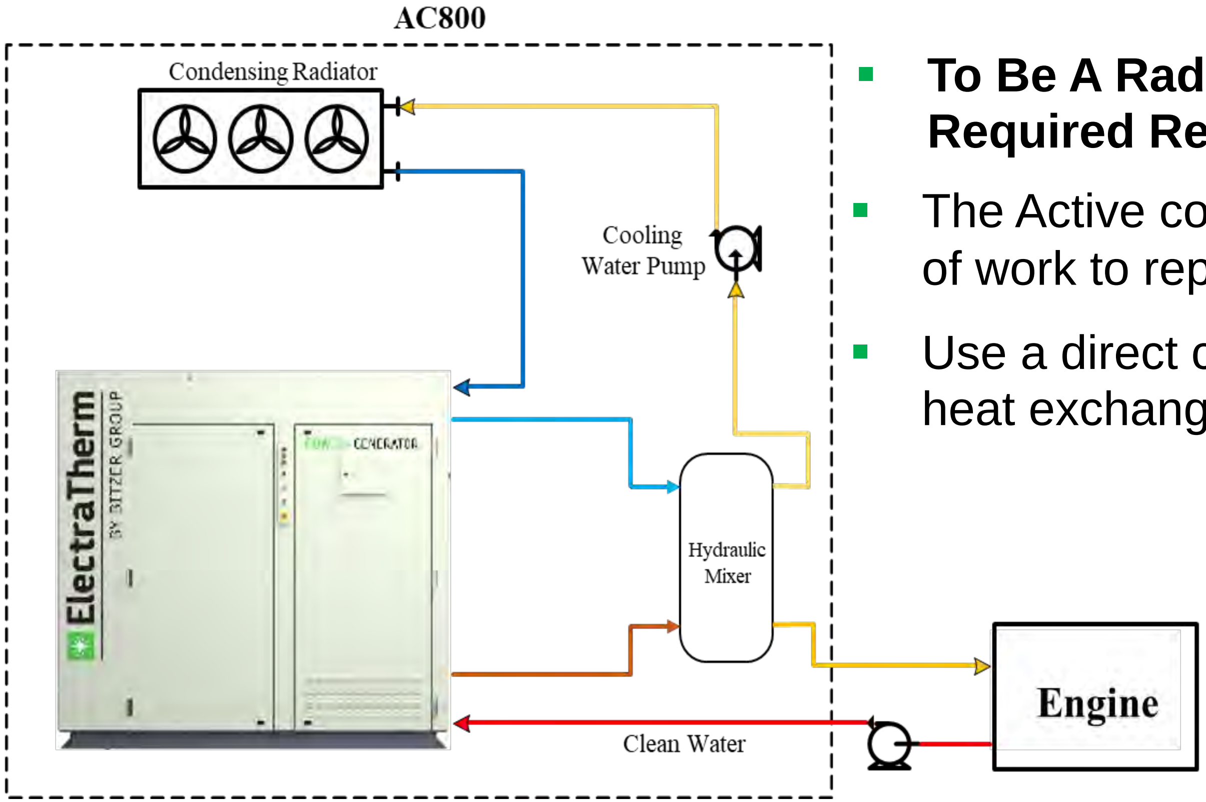
Issue: Energy Inefficiency due to non use of waste heat.

Solution: Energy Efficiency - Installation of **Power+ Generator** to use waste heat from engine exhaust and **Active Cooler** for Engine Cooling. Result saving in operating costs and improved energy efficiency.

Simple solution for immediate action

NEXT GENERATION ENGINE COOLING
AC800 OVERVIEW – RETURN TEMPERATURE CONTROL

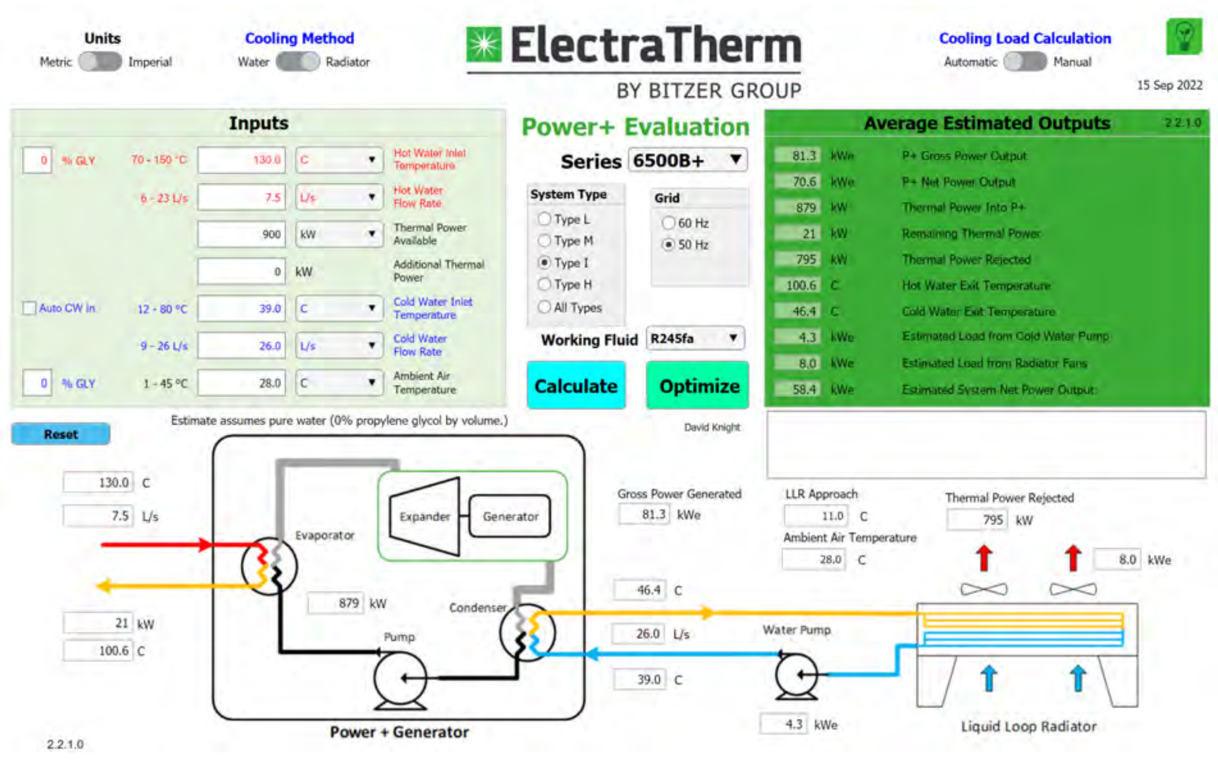
Traditional Engine Cooling Systems require either direct mechanical or electrical energy to provide the necessary rejection of heat. As the engine operator you are paying to create the waste heat (fuel cost) and you are paying again to reject that heat (power consuming radiator). The Active Cooler replaces the cost for rejecting the heat and can provide additional power for your customers



- **To Be A Radiator Replacement the AC800 Must Maintain the Required Return Temperature!**
- The Active cooler design aims to include and supply the entire scope of work to replace traditional power consuming radiator cooling.
- Use a direct contact method of heat transfer instead of traditional heat exchanger

APPLICATION POWER+6500B+ OUTCOME

Manufacturer		Model		Qty	1	Rated Output	2500	kW	Fuel	Diesel		
Heat Source	Exhaust	No of Engines to ORC	1	No of Systems	1	No of ORC's	1					
Application	Active Cooler JW		Active Cooler Boosted JW		ORC JW Cooling		Exhaust Heat	Yes				
Jacket Water	H/Temp		C	R/Temp		C	Flow		m3/hr	Total Heat	900	kWth
Heat to Reject	Lube Oil		kWth	I Cooler		kWth	Engine		kWth	Available Exhaust Thermal	900	kWth
Hot Water Circuit	Temp	130	C	Flow Rate	7.5	l/sec	Standard Radiator Offset		kW			

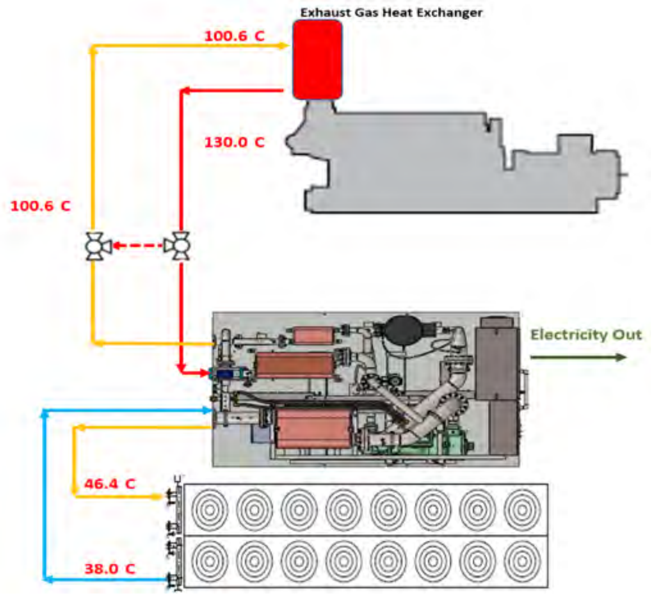


MONTH ANNUAL AVERAGE
AVERAGE AMBIENT TEMP 27.9 C

Power+Generator 6500B+
Expander Expander I
NO OF UNITS 1

OUTPUT PER UNIT
GROSS OUTPUT 81.3 kW
SYSTEM OUTPUT 57.4 kW

OUTPUT PER INSTALLATION
GROSS OUTPUT 81.3 kW
SYSTEM OUTPUT 57.4 kW



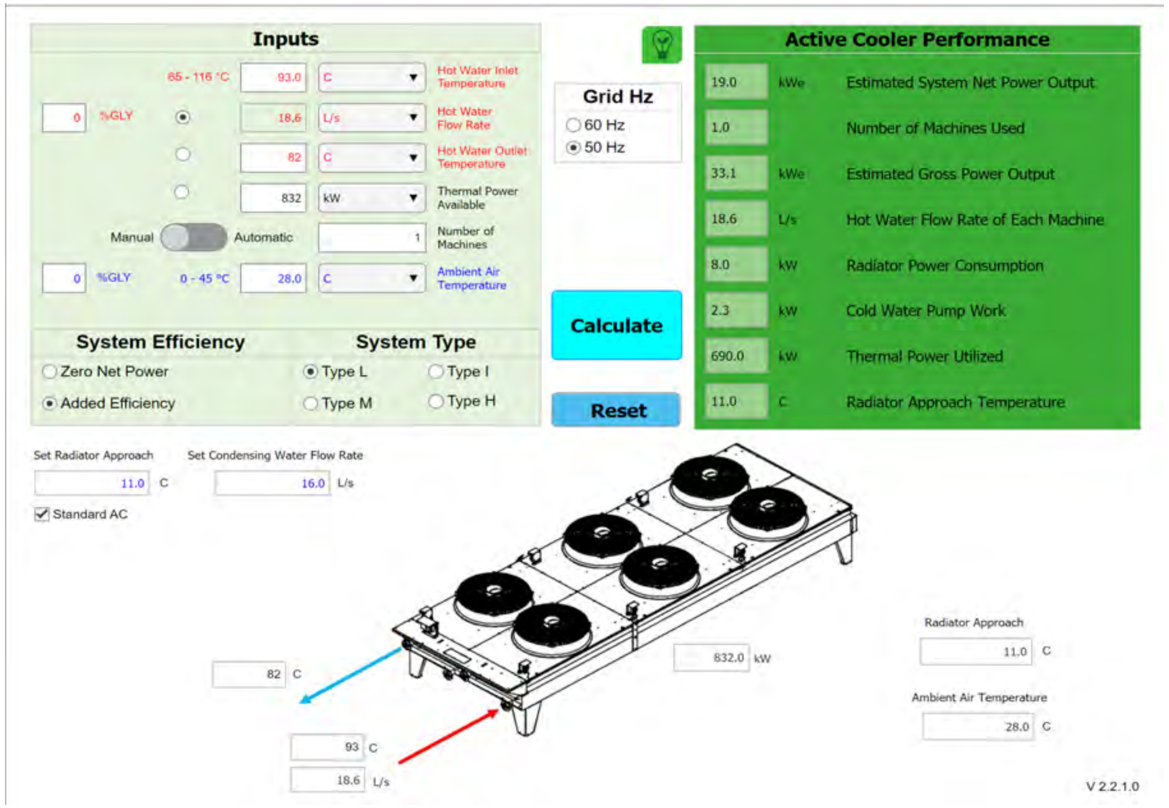
Month	Median Ambient Temp	Average Hot Water Input			Estimated ORC Output		Parastic Power Loads				ORC System Nett Outputs			Est Annual Output Median Temperature	
		Temp	Flow	Heat	Gross	Nett	HW Pump	CW Pump	Rad Fans	Total	Std Rad Offset	System Nett	Total Systems		
	C	C	l/sec	kWth	kWe	kWe	kW	kW	kW	kW	kW	kWe	kWe	Hrs	Output kW
Jan	28.5			877.0	81.3	70.6	1.0	4.3	7.9	13.2		57.4	57.4	722	41,459
Feb	28.5			877.0	81.3	70.6	1.0	4.3	7.9	13.2		57.4	57.4	652	37,447
Mar	28.5			877.0	81.3	70.6	1.0	4.3	7.9	13.2		57.4	57.4	722	41,459
Apr	28.5			877.0	81.3	70.6	1.0	4.3	7.9	13.2		57.4	57.4	699	40,122
May	28.0			877.0	81.3	70.6	1.0	4.3	7.9	13.2		57.4	57.4	722	41,459
Jun	28.0	130.0	7.5	877.0	81.3	70.6	1.0	4.3	7.9	13.2		57.4	57.4	699	40,122
Jul	27.0			879.0	81.3	70.6	1.0	4.3	8.0	13.2		57.4	57.4	722	41,445
Aug	27.0			879.0	81.3	70.6	1.0	4.3	8.0	13.2		57.4	57.4	722	41,445
Sept	27.0			879.0	81.3	70.6	1.0	4.3	8.0	13.2		57.4	57.4	699	40,108
Oct	27.5			879.0	81.3	70.6	1.0	4.3	8.0	13.2		57.4	57.4	722	41,445
Nov	28.0			877.0	81.3	70.6	1.0	4.3	7.9	13.2		57.4	57.4	699	40,122
Dec	28.0			877.0	81.3	70.6	1.0	4.3	7.9	13.2		57.4	57.4	722	41,459
Annual	**27.9**	**130.0**	**7.5**	**878**	**81.3**	**70.6**	**1.0**	**4.3**	**7.9**	**13.2**		**57.4**	**57.4**	**8,500**	**488,089**

Project Budget $US500,000 – Value of Power $US 0.25/kWh
Estimated Payback **4.2 yrs**

APPLICATION – ACTIVE COOLER OUTCOME

ElectraTherm
BY BITZER GROUP

Manufacturer			Equip	AC800	Expander L		Units	1	No of Engines Per ORC		1	Waste Heat Source		Jacket Water	
Model		Qty	1	Rated Output		2500	kW	Grid	50	Hz	Fuel	Diesel	Operating Hours		8500
Jacket Water	H/Temp	93	C	R/Temp	82	C	Flow	18.6	l/sec	Heat	832	kWth	Modules		
Heat to Reject	Lube Oil		kWth	I Cooler		kWth	Engine	832	kWth	Total	Standard Radiator Offset			8	kWth
Exhaust Heat	Temp		Mass Flow					Heat		kWth	Radiator Approach			11	C

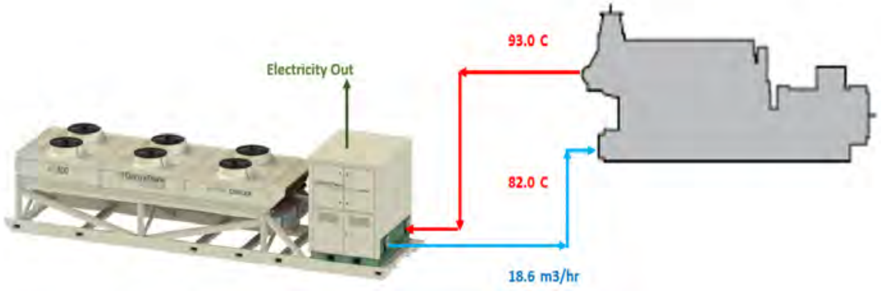


MONTH ANNUAL
AVERAGE AMBIENT TEMP 27.9 C

POWER+GENERATOR AC800
Expander L
NO OF UNITS 1

OUTPUT PER UNIT
GROSS OUTPUT 33.1 kW
SYSTEM OUTPUT 19.0 kW

OUTPUT PER INSTALLATION
GROSS OUTPUT 33.1 kW
SYSTEM OUTPUT 19.0 kW



Month	Median Ambient Temp	Jacket Water Input			Per Module		Estimated AC Output		Parastic Loads		AC System Nett Outputs			Est Annual Output Median Temperature	
		Temp	Flow	Heat	Flow	Heat	Gross	Nett	CW Pump	Rad Fans	Std Rad Offset	System Nett	Total Systems		
	C	C	l/sec	kWth	l/sec	kWth	kWe	kWe	kW	kW	kW	kWe	kWe	Hrs	Output kW
Jan	28.5			685			31.9	17.8	2.3	8.0	8.0	25.8	25.8	722	18,625
Feb	28.5			685			31.9	17.8	2.3	8.0	8.0	25.8	25.8	652	16,823
Mar	28.5			685			31.9	17.8	2.3	8.0	8.0	25.8	25.8	722	18,625
Apr	28.5			685			31.9	17.8	2.3	8.0	8.0	25.8	25.8	699	18,025
May	28.0			690			33.1	19.0	2.3	8.0	8.0	27.0	27.0	722	19,492
Jun	28.0	93.0	18.6	690			33.1	19.0	2.3	8.0	8.0	27.0	27.0	699	18,863
Jul	27.0			695			34.3	20.1	2.3	8.0	8.0	28.1	28.1	722	20,286
Aug	27.0			695			34.3	20.1	2.3	8.0	8.0	28.1	28.1	722	20,286
Sept	27.0			695			34.3	20.1	2.3	8.0	8.0	28.1	28.1	699	19,632
Oct	27.5			690			33.1	19.0	2.3	8.0	8.0	27.0	27.0	722	19,492
Nov	28.0			690			33.1	19.0	2.3	8.0	8.0	27.0	27.0	699	18,863
Dec	28.0			690			33.1	19.0	2.3	8.0	8.0	27.0	27.0	722	19,492
Annual	**27.9**	**93.0**	**18.6**	**690**			**33.0**	**18.9**	**2.3**	**8.0**	**8.0**	**26.9**	**26.9**	**8,500**	**228,503**

Project Budget $US245,000 – Value of Power $US 0.25/kWh
Estimated Payback **3.9 yrs**

BIOGAS/ BIOMASS – POWER GENERATION/ CHP SYSTEMS

ElectraTherm
BY BITZER GROUP

Power Generation / Useful Heat – Power+6500B^{+} / Power Module

- Heat From Biomass/Biogas Fueled Boilers
- ORC as Heat Balancing Unit allowing Boiler to operate 100%
- CHP Capability Meeting Downstream Requirements
- Bottoming Plants

WASTE TO ENERGY INCINERATION/ PYROLYSIS

ElectraTherm
BY BITZER GROUP

Waste Heat Power Generation

– Power+6500B^{+}/Power Module

- ➢ Waste Heat From Incineration/ Pyrolysis Plants
- ➢ CHP Capability Meeting Downstream Requirements
- ➢ Bottoming Plants

ElectraTherm
BY BITZER GROUP

Turning Thermal Energy Into Geothermal Electricity

- **Geothermal is Abundant and Renewable**
  - Millions of existing wellbores
- **Geothermal is Baseload**
  - Wind and solar are intermittent and require carbon-intense batteries for reliability
- **Geothermal is Distributed and Dispatchable**
  - Geothermal Systems can be scaled from 10 kW to 100+ MW distributed systems
- **Geothermal is Cost-Effective**
  - Reusing existing infrastructure and wellbores reduces capital intensity and eliminates new surface disturbance
- **Partnering with Specialist Companies** – working with Transitional Energy to repurpose existing oil well infrastructure

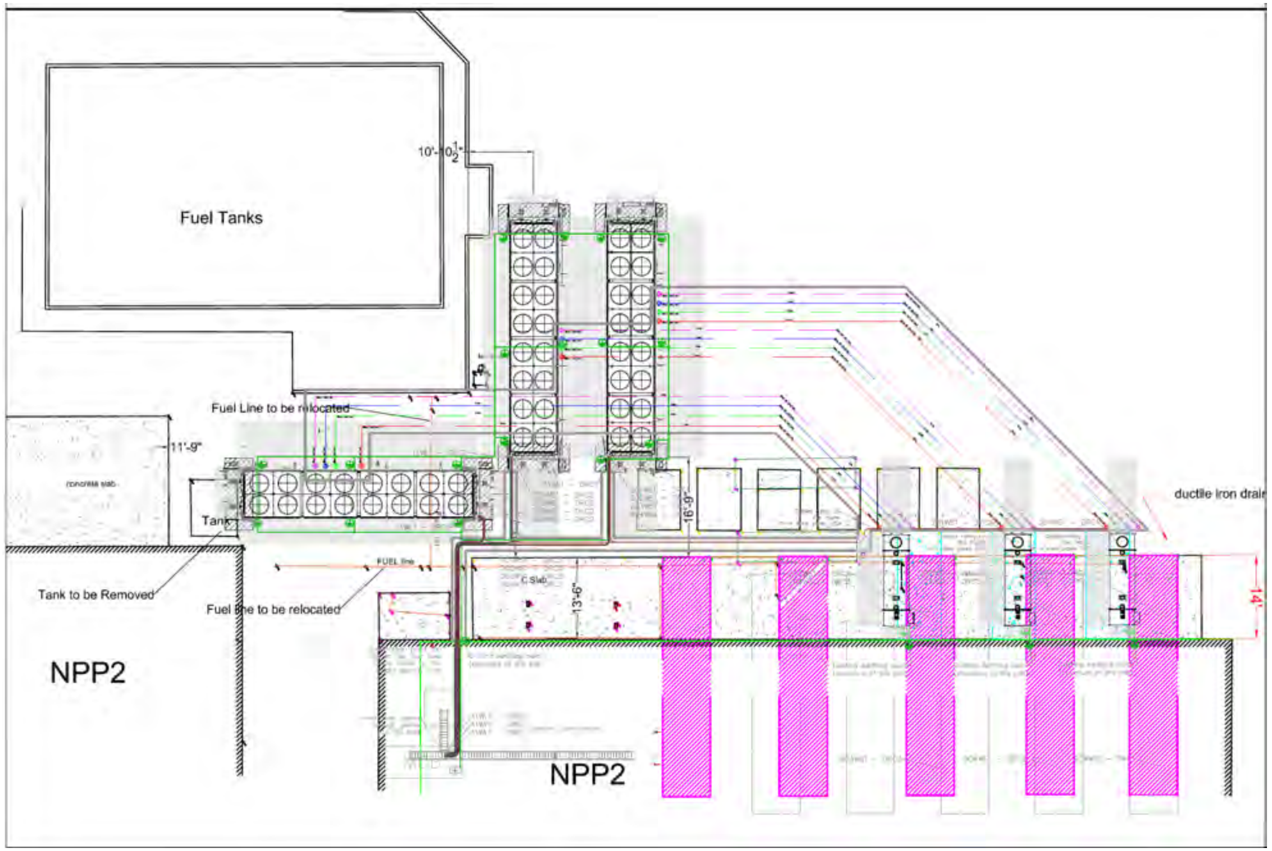
** Photo courtesy of Transitional Energy*

POHNPEI UTILITIES CORPORATION NANPOHNMAL POWER STATION ORC PROJECT

ElectraTherm BY BITZER GROUP

The project consists of three ElectraTherm Power+6500B+ ORC's that have been installed inside 40' shipping containers, to recover waste heat from the diesel generators, both engine exhaust and jacket water. These units will significantly increase the efficiency of the existing diesel generators by producing about 200 kWe as well as replacing the existing engine coolers providing a further saving on heat rejection power requirements.

Implementation of this project is being undertaken by B:Power



POHNPEI UTILITIES CORPORATION
NANPOHNMAL POWER STATION ORC PROJECT

ElectraTherm
BY BITZER GROUP

POHNPEI UTILITIES CORPORATION
NANPOHNMAL POWER STATION ORC PROJECT

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POHNPEI UTILITIES CORPORATION
NANPOHNMAL POWER STATION ORC PROJECT

ElectraTherm
BY BITZER GROUP

B:Power have six personnel onsite, who together with local staff and the support of the PUC under the leadership of Nixon Anson, have commenced the installation of the equipment. One of the big challenges has been the local climate conditions with excavation work being at times compared to swimming lessons.

The advantage of containerisation of the ORC's, apart from protection against the weather conditions, has been reduced onsite installation time as key components were preassembled at B:Power's facility in Europe.

Full start-up of all units is scheduled for early 2023 when the equipment will be commissioned and officially handed over to the Pohnpei Utilities Corporation. Training of PUC staff in the operation and maintenance will be provided as will long-term support to ensure continued optimum performance of the Project.

FUNDING FOR ENERGY EFFICIENCY PROJECTS

The are several international "green" funds and aid programmes from key donor countries that are available to support installation of renewable energy projects. Unfortunately many of these funds preclude funding for projects where the heat source uses fossil fuel or a fuel not considered "green" enough.

We should all recognise that engine based power generation in the Pacific will remain an important component of power supply for many years to come.   Until new generation "green" fuels are available the use of diesel or gas will remain as the principal fuel for these generating assets.

To achieve Net Zero there is a need **Now** to achieve energy efficiency and projects using waste heat from engine based generation are just as important as solar, battery and wind projects to achieve climate goals.

I am pleased to note that ADB funding criteria does allow funding for energy efficiency projects based on retrofit of existing facilities. My request to other fund mangers and aid donors is not to ignore the opportunities to mitigate climate change just because fossil fuels are out of favour but to look to the long term benefit that can be achieved by supporting the Power Authorities with funding for heat to power projects.

ElectraTherm
BY BITZER GROUP

The use of ElectraTherm ORC Solutions
for the conversion of waste heat resources
into high value electricity
is only limited

By The Bounds of Your Imagination

Thank you!

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