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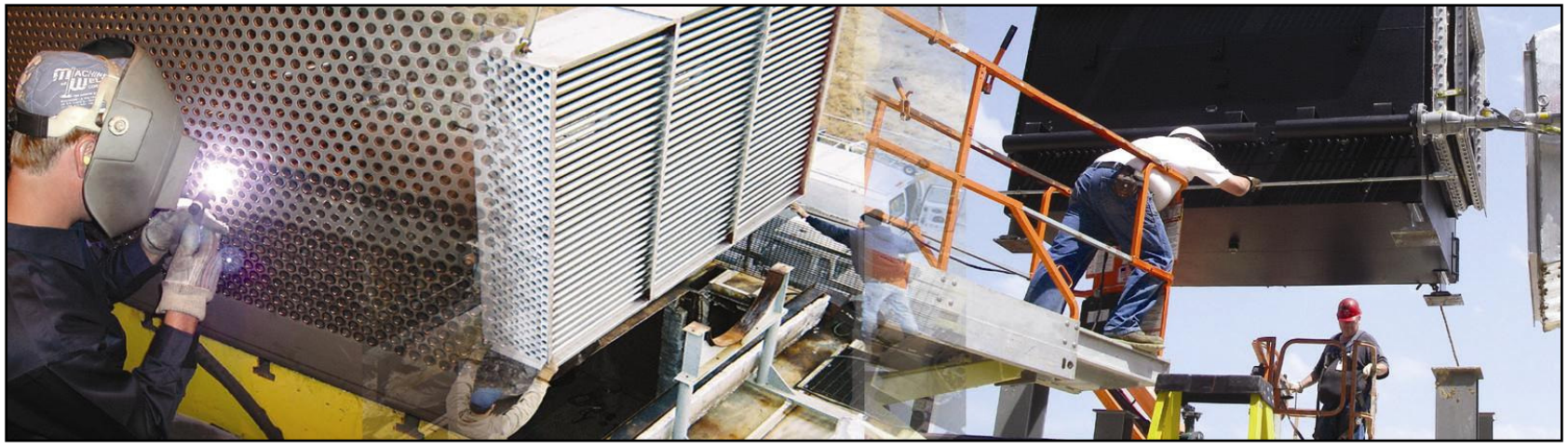
Organic Rankine Cycle (ORC)

Presented For: *Lake States TAPPI*
February 25th, 2009

By: *Gene Anguil / CEO and Founder*

Anguil Environmental Systems



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Background

- Founded in 1978
- Air Pollution Control & Energy Solution Provider
- Headquartered in Milwaukee, WI with additional offices throughout the world

Deb,Gene and Chris Anguil

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Typical Energy Recovery Equipment:

- Air-to-Air Heat Exchangers
- Air-to-Liquid Heat Exchangers
- Air-to-Steam Heat Exchangers

Applications Include:

- Recovering exhaust stack heat for use in industrial ovens and dryers
- Recovering exhaust stack heat for process heating applications
- Upgrading heat efficiency of air pollution control equipment

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Facts About Organic Rankine Cycle:

- Also referred to as Heat-to-Power or Cogeneration
- Invented by Professor William Rankine in the mid 19th century and used as a thermodynamic standard for rating the performance of Steam turbines
- In simple terms, it is a refrigeration loop running backwards which uses a heated chemical instead of steam, as used in the original Rankine Cycle
- Chemicals or refrigerants used in the Organic Rankine Cycle include freon, butane, hexane, ammonia, and the newer “environmentally friendly” refrigerants
- “Organic” is any molecule containing hydrogen and carbon

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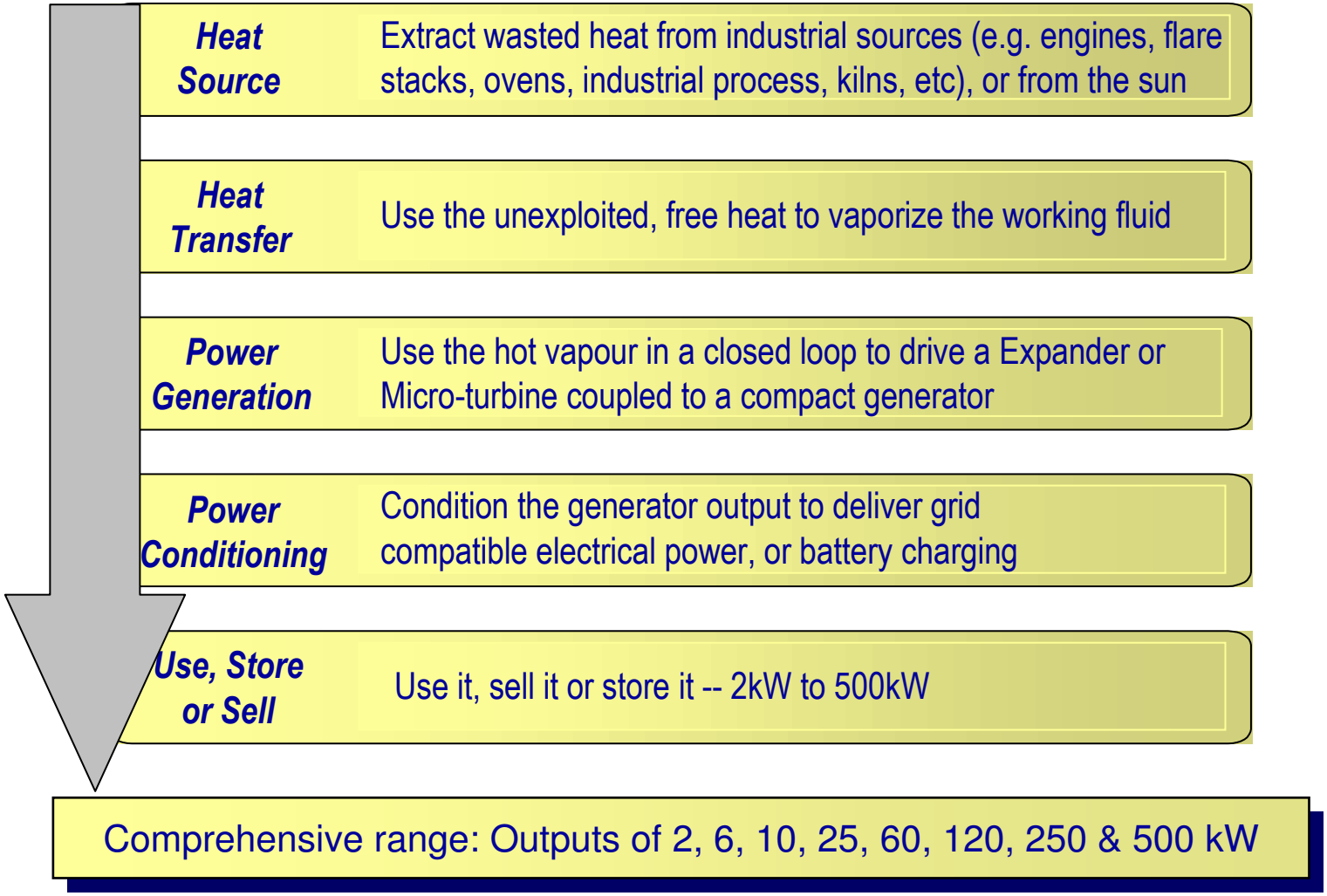
Turning Waste Heat Into Usable Electricity



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ORC Technology Types:

- Micro-Turbine
- Expander Type

Two Options:

1). Hot Air – Water/Glycol to Refrigeration Based ORC

2). Hot Air – Hot Oil to Solvent Based ORC

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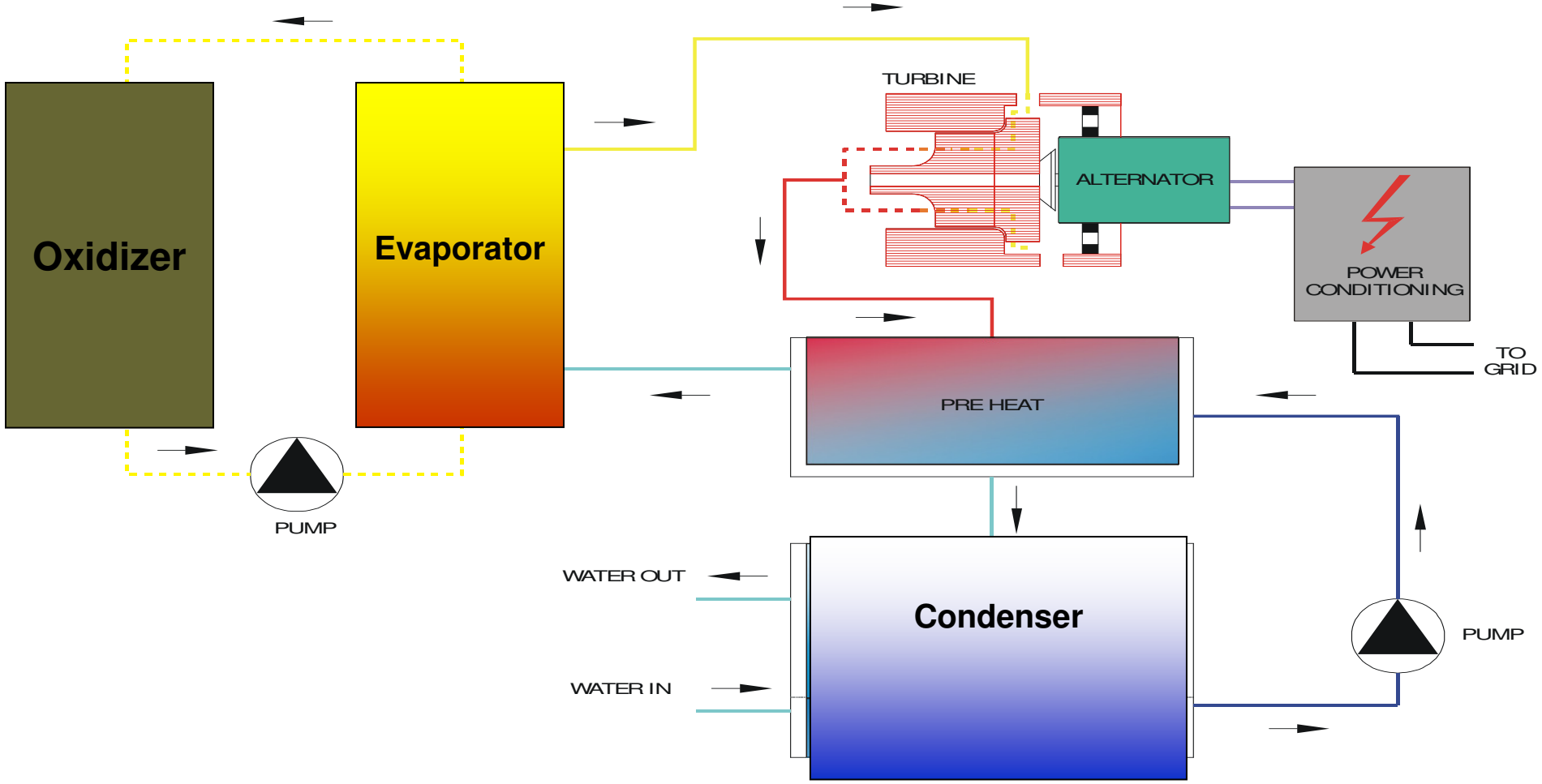
Micro-Turbine ORC: How it works



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Micro-Turbine ORC

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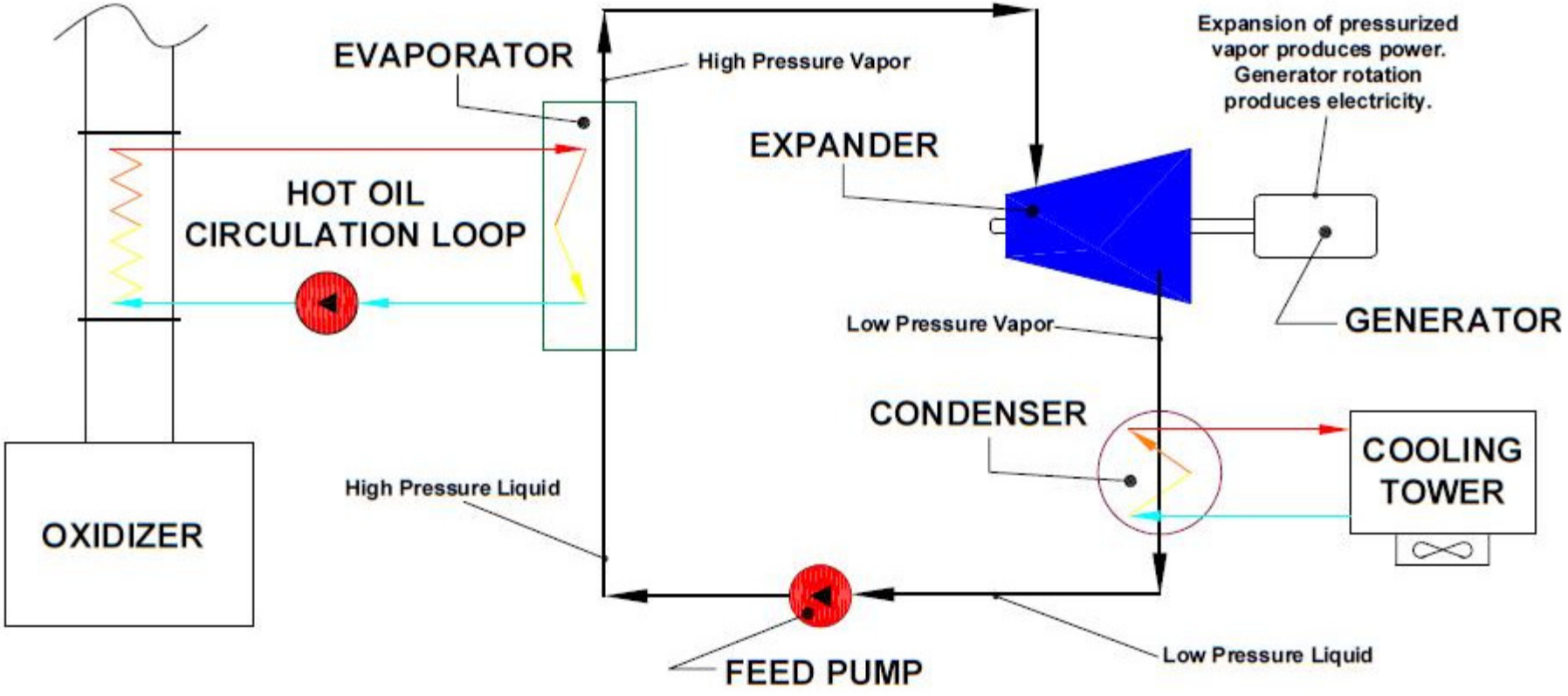
Expander Type ORC: How it works



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Expander Type ORC

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Sample Payback Comparison

Technology	Expander	Micro-Turbine
Kilowatts Generated	50 kw/hr	120 kw/hr
Cost / kwh	$0.10	$0.10
Savings ($ / hr)	$5.00	$12.00
Yearly Savings (8,000 hrs / yr):	$40,000	$96,000
Costs:		
Heat to Power Equipment	$120,000	$120,000
Auxiliary Equipment	$75,000	$75,000
BTU / Hr Required	1.9 MM	2.5 MM

Efficiency defined as power out divided by power in (kw x 3413 / BTU)

50x3413/1.9MM=**9%** 120x3413/2.5MM=**16.4%**

Payback (Equipment Only)	**4.9 Years**	**2.03 Years**

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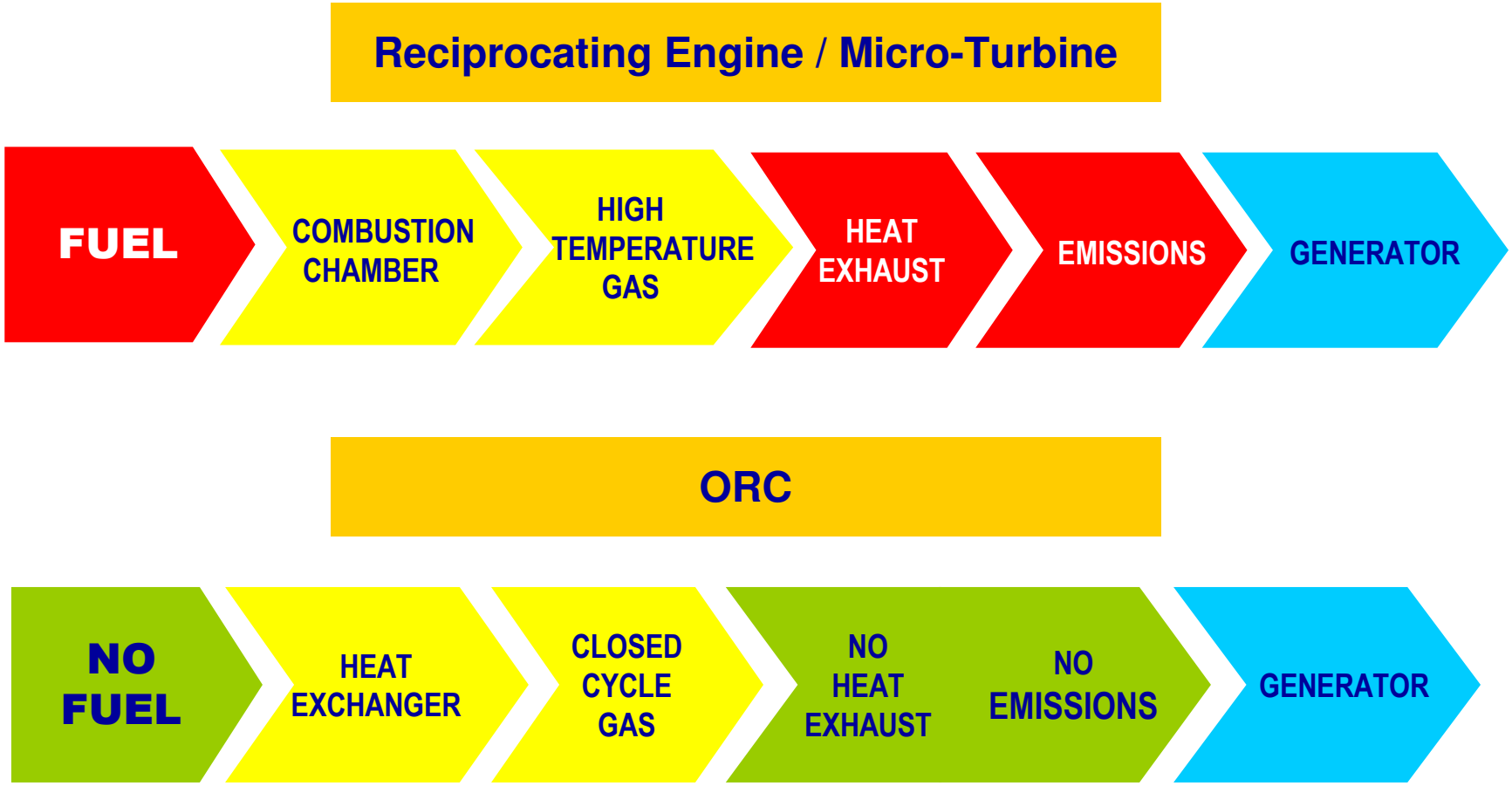
COMPARISON TO CONVENTIONAL FUEL ENGINES



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ORC Benefits

- Zero Fuel
- Zero Emissions
- Free electricity generated from low temperature wasted heat
- Fast Calculable payback
- AC Grid Inject, use or store
- DC output option
- Simple to install
- Low through life maintenance costs

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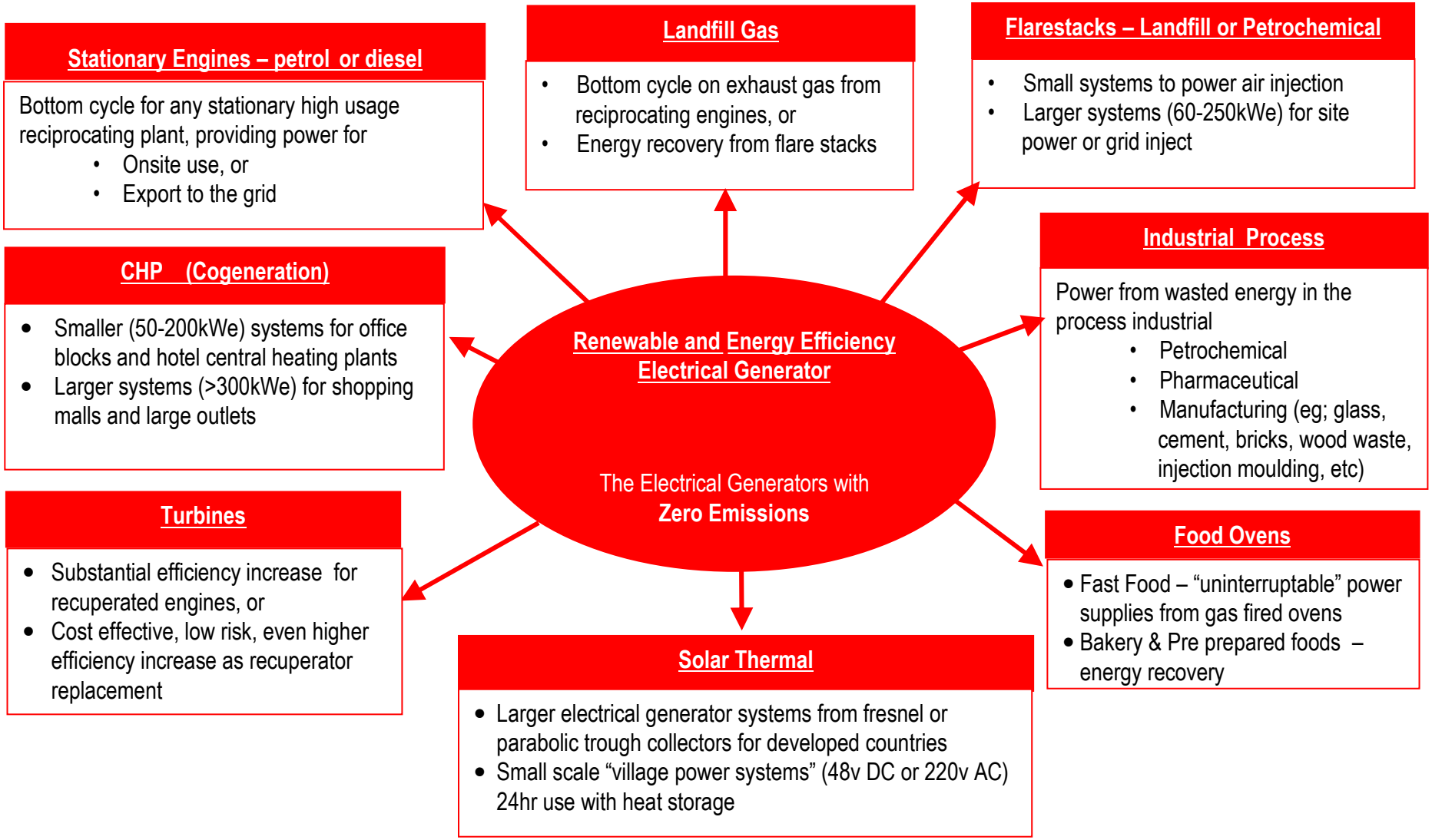
Applications



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Why Now?

- Increasing maturity of small Gas Turbine designs
- Development of High Speed Alternator Technology
- Power electronics becoming cost effective
- Appropriate materials availability at acceptable price
- Environmental focus and demand for reduced emissions
- Fuel volatility costs

Thank You!

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Committed to Cleaner Air.

ANGUIL ENVIRONMENTAL SYSTEMS, INC.

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