Heat to power generation

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ESMAP World Bank presentation

Dec. 4, 2012

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Agenda

Sources of waste heat

How heat is converted into electricity

Benefits of heat to power

Case studies from the field

Heat source: industry

Using the US as an example[1]

- The United States industrial sector accounts for 1/3 of all energy used in the United States
- During these manufacturing processes, as much as 20 to 50% of the energy consumed is ultimately lost via waste heat contained in streams of hot exhaust gases and liquids…"
- "About 60% of waste heat losses are at temperatures below 450°F [230°C]."

Metrics may be applied to developing world[2]

- "Non-OECD countries account for 93% of the increase in industrial energy demand" (*IEA projection*)

Sources:
[1] 2008 DOE report: "Waste Heat Recovery: Technology and Opportunities in US industry"
[2] International Energy Agency, World Energy Outlook 2012

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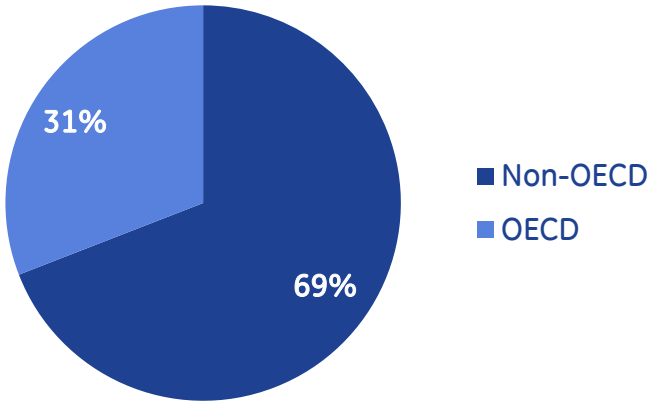
Heat source: power generation

1,000TWh oil fired generation (2010)



Source: Energy Information Administration, World Energy Outlook 2012

- Represents 10,893 MT of CO2 / yr
- 69% is in Non-OECD countries

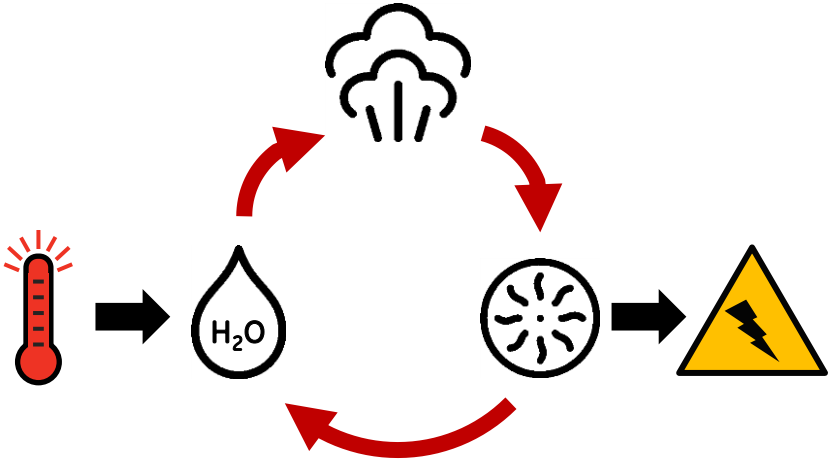
What a lot of the generation looks like

- Typical diesel engine efficiency <40%
- Much of this energy is lost as heat

Heat recovery can make power generation more efficient

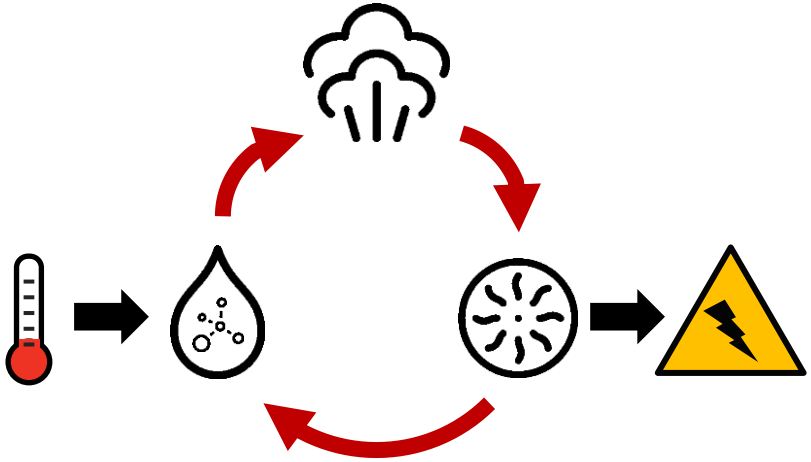
Understanding ORC's

Steam Cycle



- Converts water to steam to drive a turbine
- Requires high temperature heat source

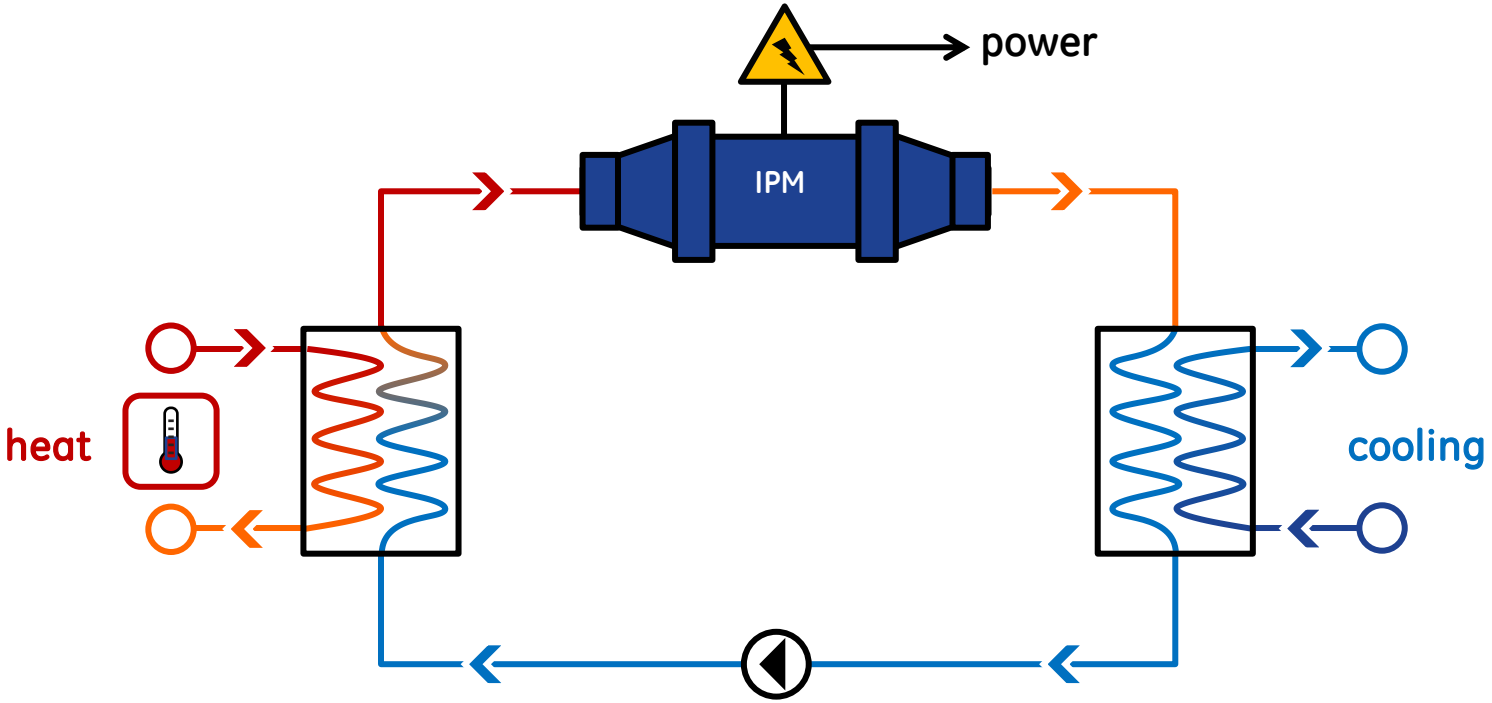
Organic Rankine Cycle



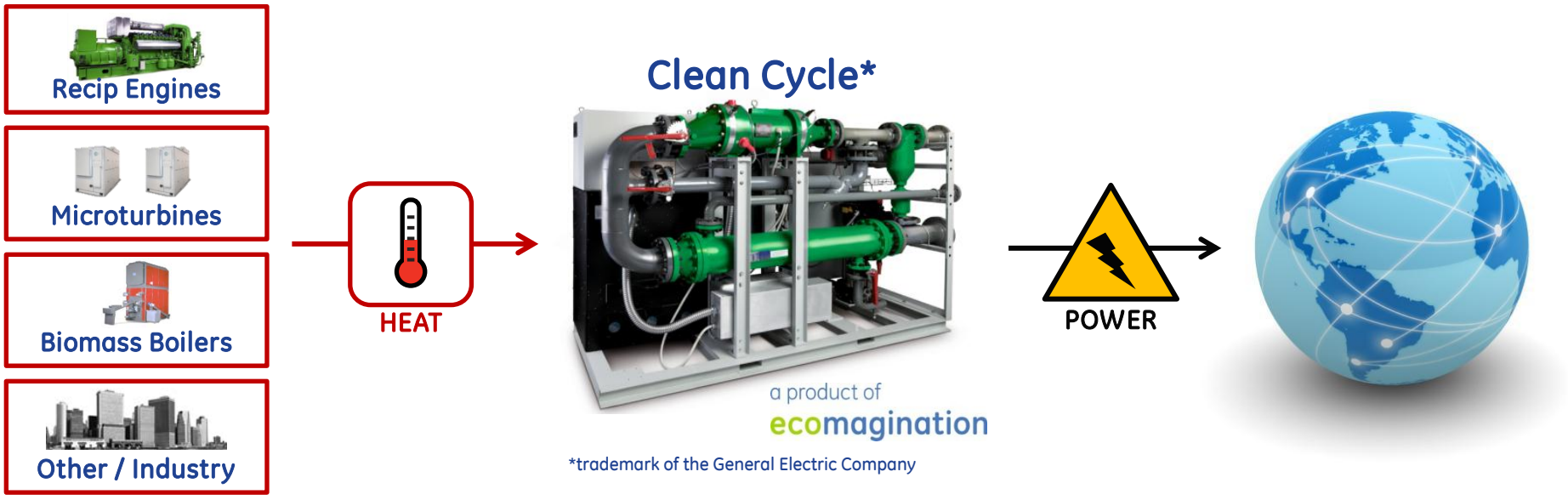
- Refrigerant used with a low boiling point
- Utilize lower grade heat sources

How the Clean Cycle generator works

- Closed loop process with no combustion



Clean Cycle[1] heat to power generator



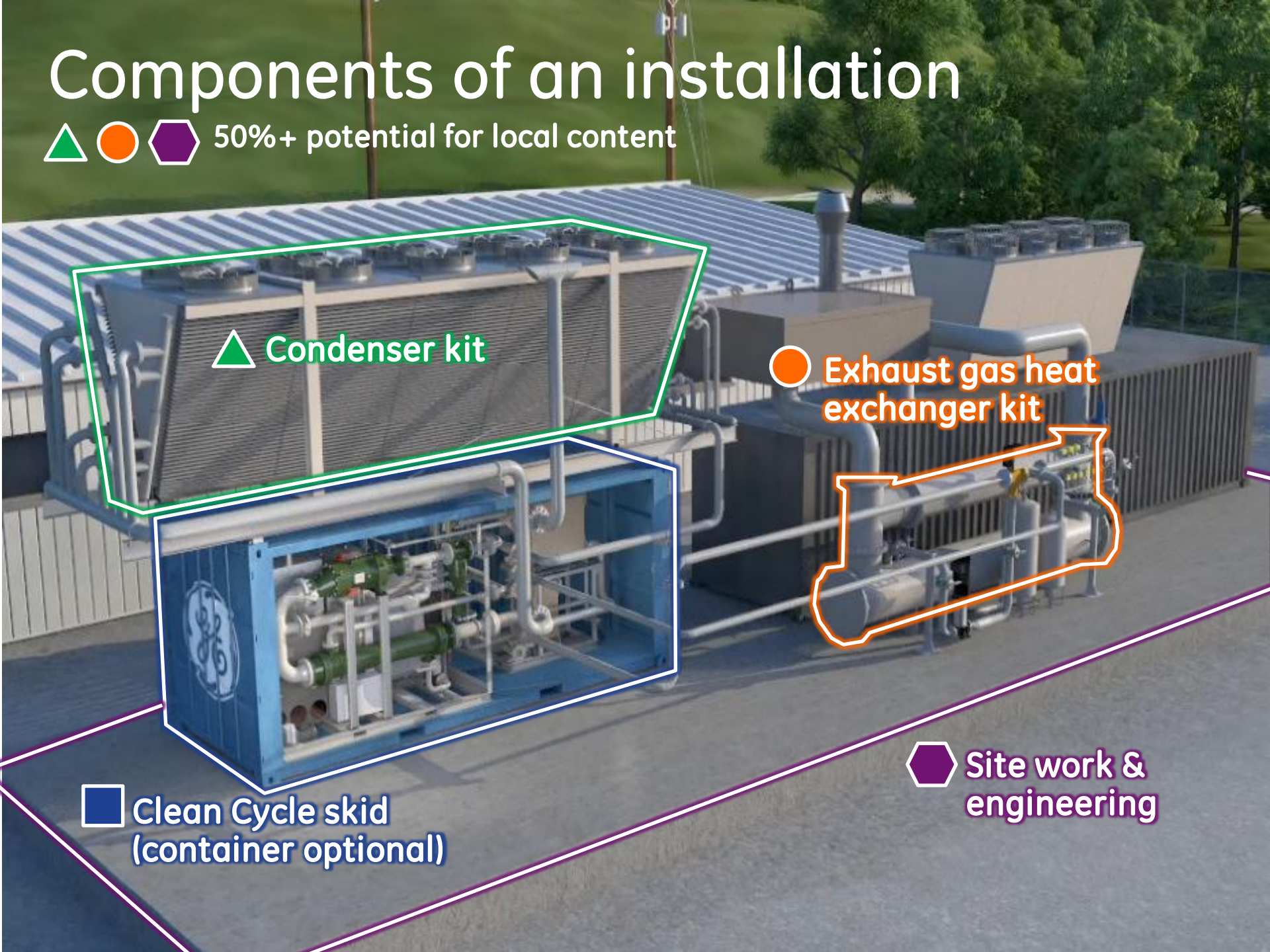
Benefits

- One unit **generates between 50 - 140kW** of electricity from a heat source
- 251F+ heat is the only input; **no additional fuel** required **or emissions** generated
- **Low maintenance:** magnetic bearing generator, no lubricants, no overhauls
- Called an ORC because it utilizes the **"Organic Rankine Cycle"** to generate power from heat

[1]Trademark of the General Electric Company

Components of an installation

50%+ potential for local content



Environmental benefits

No added fuel

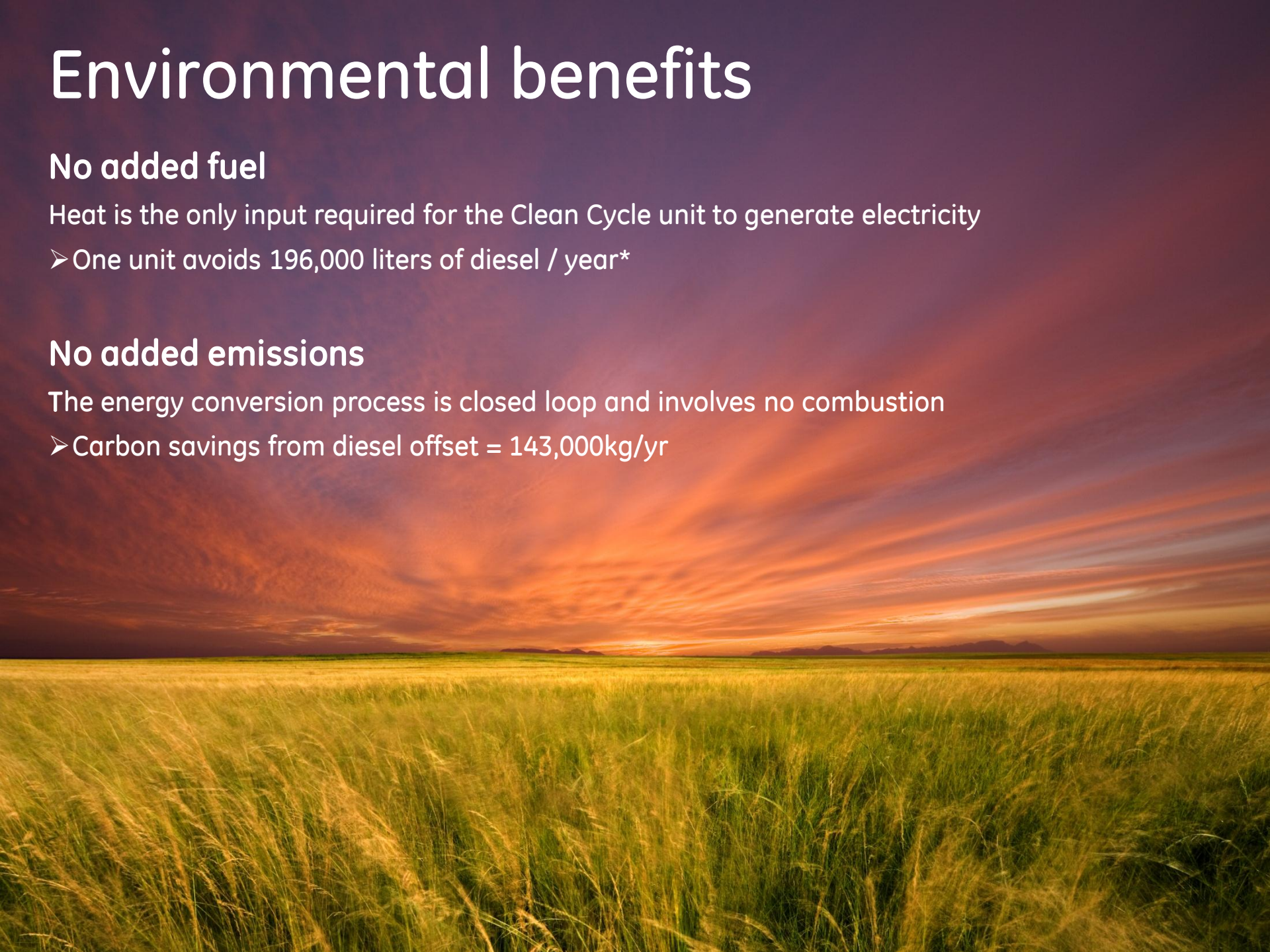
Heat is the only input required for the Clean Cycle unit to generate electricity

- One unit avoids 196,000 liters of diesel / year*

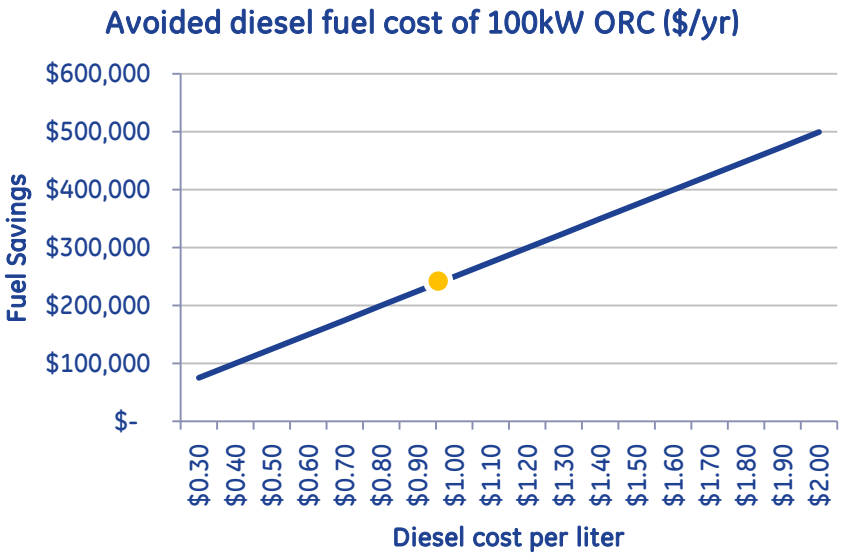
No added emissions

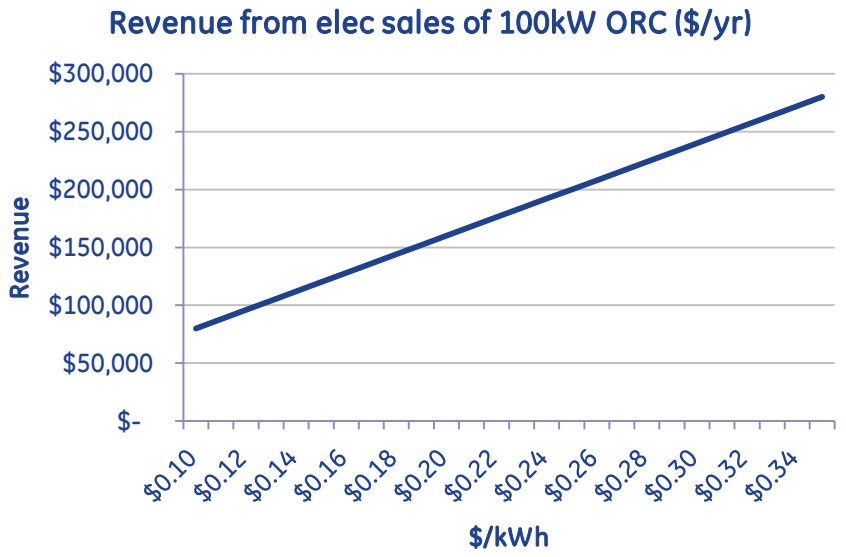
The energy conversion process is closed loop and involves no combustion

- Carbon savings from diesel offset = 143,000kg/yr



Savings or revenue





- At $1/L, 100kW offsets ~$250k/yr in fuel
- Option to 'add' ORC power to grid, or offset (turn-down) the diesel engine

Assumptions: Diesel engine uses 429.6L/hr. 90% availability; ORC output directly offsets diesel power output

- Revenue = 100kW x 8,000 op hrs x $/kWh
- Unlike most other technology that doesn't require fuel, the Clean Cycle has high operational availability (>90%)

Assumptions: 100kW net ORC production, 8,000 operating hours

Reliable electricity

Consistent power production

Electrical output is grid quality, at a power factor of 1, and often at a capacity factor that exceeds 90%

Low maintenance

Requires no major overhauls, no lubricants, unmanned operation

Proven performance

Hundreds of thousands of operating hours accumulated, globally

Incinerator exhaust - Michigan

Location:	Michigan, USA
Heat Source:	Incinerator stack at Warren facility
kW output:	4 Clean Cycle generators at 400kW gross
Configuration:	Pressurized hot water system
Challenge:	4 units on a single incinerator heat stack

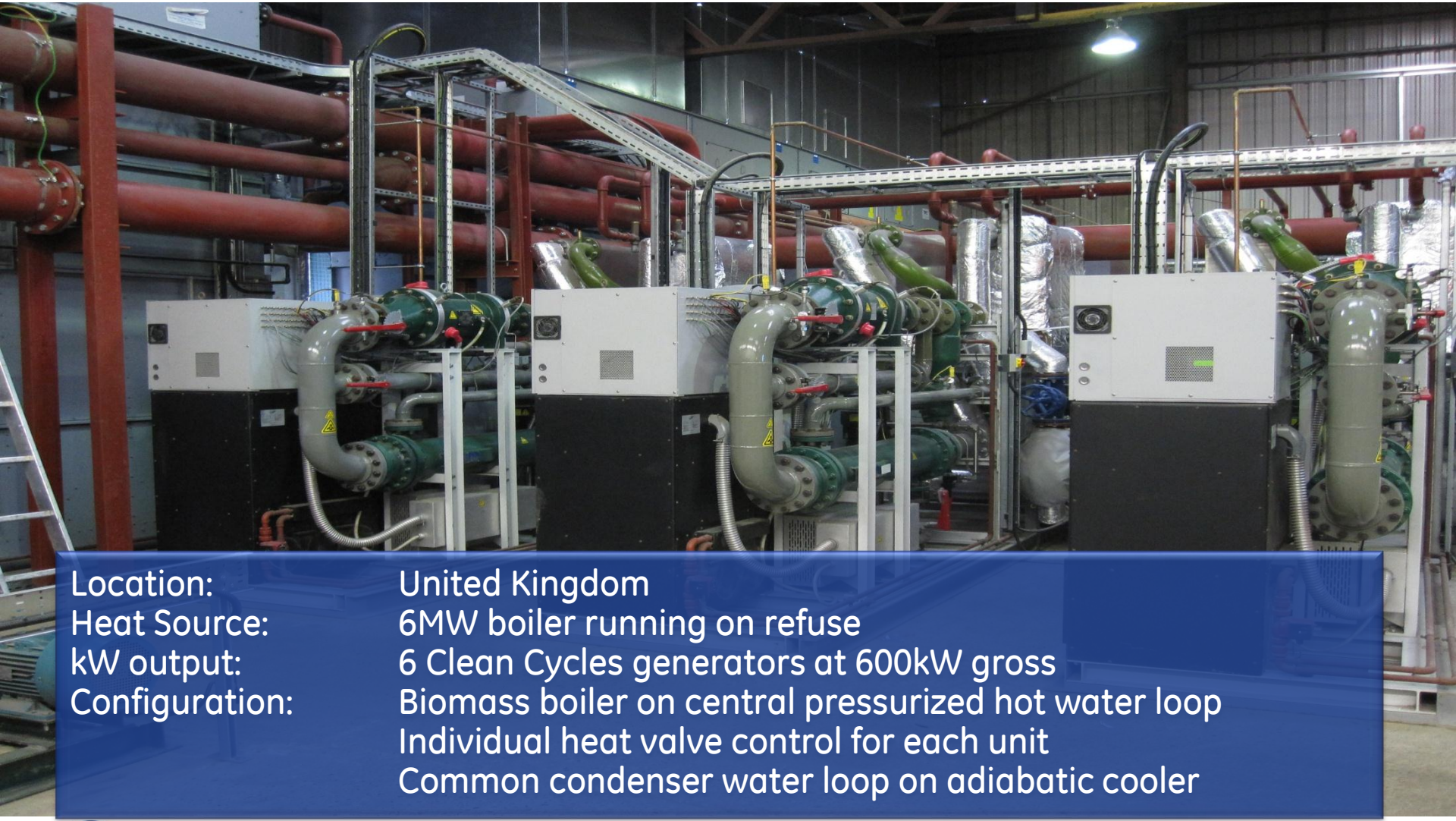
4 microturbines

Location:	Celaya, Mexico
Heat Source:	(4) 200 kW microturbines
kW output:	1 Clean Cycle generator at 100kW gross
Configuration:	Direct evaporation, Direct Condensing
Challenge:	Collecting thermal energy from 4 heat sources

Sawmill biomass boiler

Location:	Italy
Heat Source:	3MW boiler running on sawdust
kW output:	1 Clean Cycle generator at 100kW gross
Challenge:	Heat supply for wood drying system & ORC
Configuration:	Biomass boiler generating steam
	Indirect evaporation via steam loop to ORC
	Steam loop used to dry incoming wood

Converting skip hire waste to energy



Location:	United Kingdom
Heat Source:	6MW boiler running on refuse
kW output:	6 Clean Cycles generators at 600kW gross
Configuration:	Biomass boiler on central pressurized hot water loop Individual heat valve control for each unit Common condenser water loop on adiabatic cooler

2 landfill gas engines

Location:	Risley, United kingdom
Heat Source:	2 GE J320 landfill gas engines
kW output:	1 Clean Cycle generator at 100kW gross
Configuration:	2 separate exhaust gas heat exchangers
	Common pressurized hot water loop
	Direct condensing
	Containerized unit

Questions

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