Organic Rankine Cycle (ORC) Integration and Optimization for High Efficiency CHP Genset Systems

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ElectraTherm
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Principal Investigator/Tom Brokaw
Business Contact & Presenter/John Fox

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Overview

Project Title: Organic Rankine Cycle Integration and Optimization for High Efficiency CHP Genset Systems

Timeline:

Project Start Date: 10/01/2018

Budget Period End Date: 12/31/2019

Project End Date: 12/31/2021

Barriers and Challenges:

- Beneficial thermal available after ORC power production
  - Current capability ~120F/49C
  - Goals of ~185F/85C
- Cost Effective Engine Waste Heat Recovery

AMO MYPP Connection:

- **CHP fuel to electricity generation efficiency >45% at rated capacity**
  - **30% at 50% capacity**
- **Total CHP (thermal mode) efficiency > 85%**
- **Development of flexibility between CHP mode and prime power mode**

Project Budget and Costs:

Budget	DOE Share	Cost Share	Total	Cost Share %
Overall Budget	$1,437,534	$405,458	$1,842,992	22%
Approved Budget (BP-1)	$647,951	$182,756	$830,707	22%
Costs as of 3/31/19	$270,821	$76,385	$347,206	22%

Project Team and Roles:

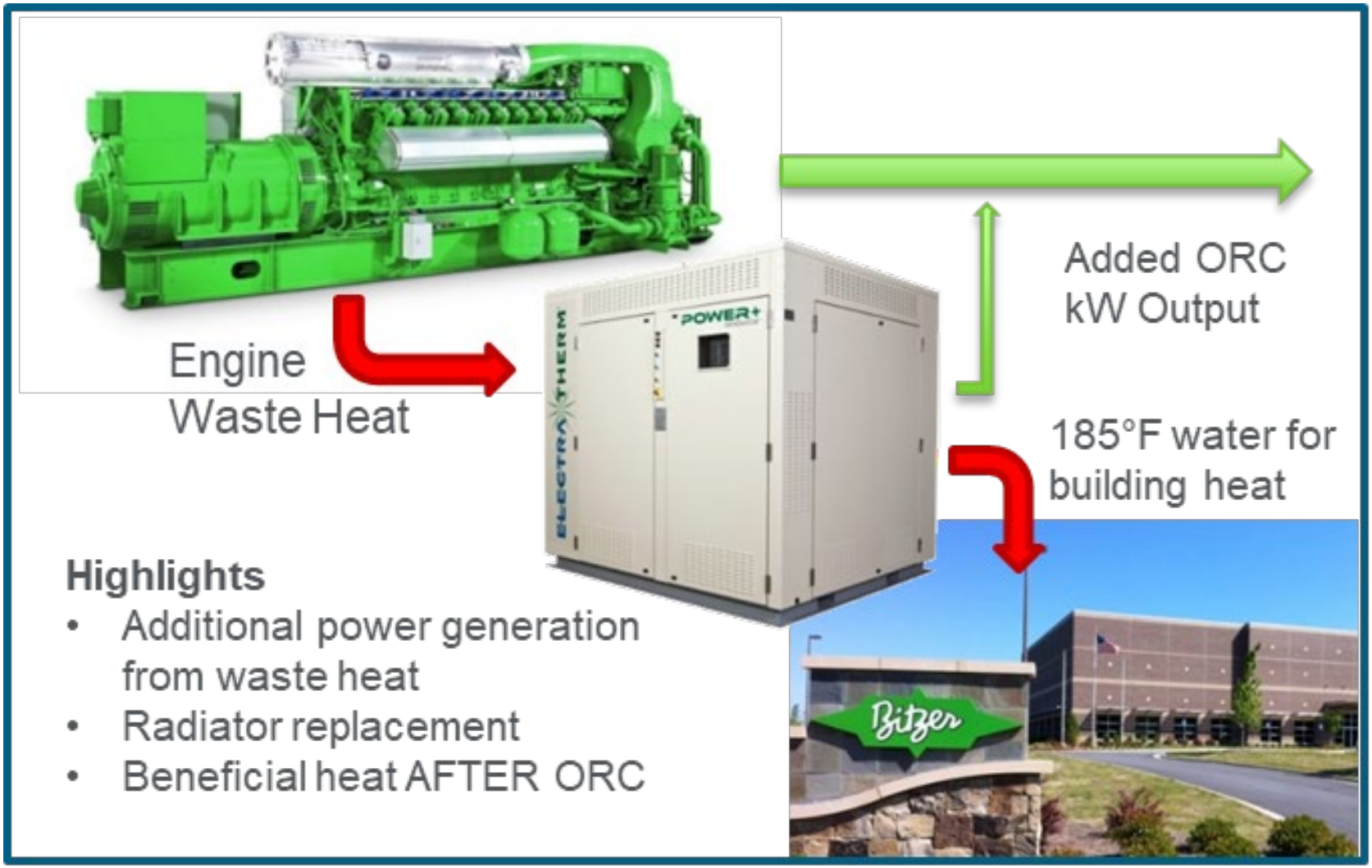
- **ElectraTherm** – development of advanced ORC technology
- **Innio (Jenbacher)** Application Engineering support to optimize ORC to Jenbacher engines
- **Susteon** – Techno/Economic Analysis
- **OneCIS – Bureau Veritas** – Pressure Equipment Certifications

Project Objective(s)

- Traditional CHP Challenge – what to do with all that heat?
  - Create 24/7 thermal demand via ORC
- Advance engine based CHP offerings and enhance market acceptance
  - Generate power from the CHP's excess heat
    - Increase prime power efficiency when heat is not required for the building
    - Add flexibility via CHP mode
- Provide "usable thermal energy" after ORC power production.
- Target condensing side heat at 180F-190F range matching existing building hydronic infrastructure (today's limit ~ 120F)
- This will require new higher pressure expanders with new bearing schemes and lubrication methodology, new controls, new pressure ratings, certifications and potentially new working fluids.

Technical Innovation

Traditional CHP Offerings consist of hot water, steam and absorption chilling – this solution broadens those offerings and adds electrical efficiency and flexibility



Technical Innovation

- Currently engine + ORC packages are not considered for CHP applications
- Barriers are:
  - COST - $/kW of ORC equipment
  - No use for ORC condensing heat – too low value (~120F)
  - Perceived complexity with "new" technology
- Technical Advancements
  - Raise input and exit temps of ORC so beneficial use of thermal energy after power production is possible
  - New expander technology Including:
    - Higher pressure castings
    - New lubrication and bearing schemes
    - New controls
  - Extreme focus on market acceptance and $/kW – largest barrier
- Adding 24/7 thermal demand, added power generation when in **prime power mode** and offering beneficial thermal in **CHP mode** at the right price point will enable further CHP market acceptance and benefit to the US manufacturing sector

Technical Approach

- Utilize ElectraTherm's 1,000,000 hours + of fleet operation and experience to elevate baseline production equipment and advance expander and ORC system capability to meet engine + ORC market requirements
- Introduce and redesign BITZER semi-hermetic expanders to meet expander technical gaps
    - Higher inlet temperature and pressures
    - Establish a 24/7 expander fleet leader commercial site
    - Raise condensing temperatures to match building thermal demands and designs
    - Maintain acceptable system performance while driving for higher ORC condensing temperatures
        - Investigate new low global warming potential refrigerants
    - Address ORC shortfalls as expander weak link is addressed
- Utilize baseline designs as platforms to learn as BITZER expander and new controls are integrated and new capabilities are developed
    - Design/build and test LOW cost clean sheet of paper design to meet strict $/kW barrier to entry

Results and Accomplishments

4400B design complete
– HSE85 expander retrofitted

Existing 24/7 customer's equipment being retrofitted with HSE85 expander for fleet leader endurance hours

- Modeling of new expander at elevated temperatures and pressures initiated
- Alternate refrigerant study underway
- Next steps
  - Integration of BITZER hardware into the Series 6000 platform for larger engine sizes
  - Push the pressure and temperature limits on ORC's with BITZER hardware

Transition (beyond DOE assistance)

- Continue education and discussions with CHP developers, engine distributors, and OEM's to the potential of engine + ORC optimization for CHP
- Continue the search for first commercial application for engine + ORC at a CHP site
- Continued focus on being lowest cost producer for ORC's in this specific size range
- Further understanding and optimization via the Innio/Jenbacher product families
- Further developments to optimize the engine + ORC system as one package

Questions?

Thank You

John Fox

ElectraTherm
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Business Development Manager