

# Explore our Technologies

## ORC (Organic Rankine Cycle)

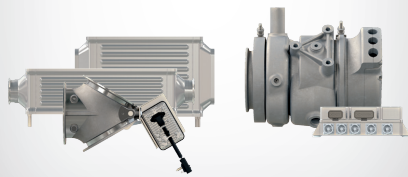
## Waste Heat Recovery System

for commercial vehicles

# ORC (Organic Rankine Cycle) Waste Heat Recovery System

## CHALLENGES FOR COMMERCIAL TRUCKS

- Better fuel economy
- Lower emissions



## Standard CV On-Highway Engine Setup

### Motivation for Waste Heat Recovery Systems

- Almost 50 % of an engine's fuel energy is wasted as rejected heat
- Enables reduced CO<sub>2</sub> output in anticipation of upcoming legislation
- 3-5 % fuel savings potential in long haul trucks

## ORC Waste Heat Recovery System

### How it works

- Converts wasted exhaust heat into usable electrical energy
- The Rankine Cycle makes use of the phase change characteristics of fluids in the same manner as refrigeration and air conditioning systems
- Cycle consists of 4 steps:
  - 1 Pump / 2 Evaporate / 3 Expand / 4 Condense. Then repeat.

### Rankine Cycle Explained

- Step 1: Cool liquid working fluid from the Condenser is pumped to high pressure
- Step 2: Exhaust gas heats the working fluid to a superheated vapor in Evaporators
- Step 3: Superheated vapor drives the Turbine Expander, generating electrical power
- Step 4: Low pressure vapor is cooled by the Condenser to a liquid state and the process repeats

## BorgWarner ORC Waste Heat Recovery Products

### Tailpipe and EGR Evaporators

- 60+ % Tailpipe Evaporator efficiency
- 80+ % EGR Evaporator efficiency
- Based on proven BorgWarner EGR Cooler technology
- Thermally decoupled tube-shell construction
- Compact, modular design for ease of packaging and low cost

### Exhaust Flap Bypass Valve

- Bypasses exhaust around Tailpipe Evaporator when required
- Two types: Exhaust Flap Valve & Throttle Valve (not shown)
- CAN-based eActuators for fast, precise proportional control
- May be installed upstream or downstream of Evaporator
- Low pressure drop minimizes impact on engine performance

### Turbine Expander/Generator/Pump

- 48 V output
- 7 kW nominal, 13 kW max output
- 65 % peak turbine efficiency
- Very low weight < 10 kg mass, compact package
- Integrated high pressure pump
- No oil lubrication required

### Turbine Expander Power Electronics

- Bidirectional high speed motor controller
- For 48 V vehicle systems
- Weighs less than 6 kg, compact package
- Water cooled
- Capable of up to 25 kW (can be scaled down)

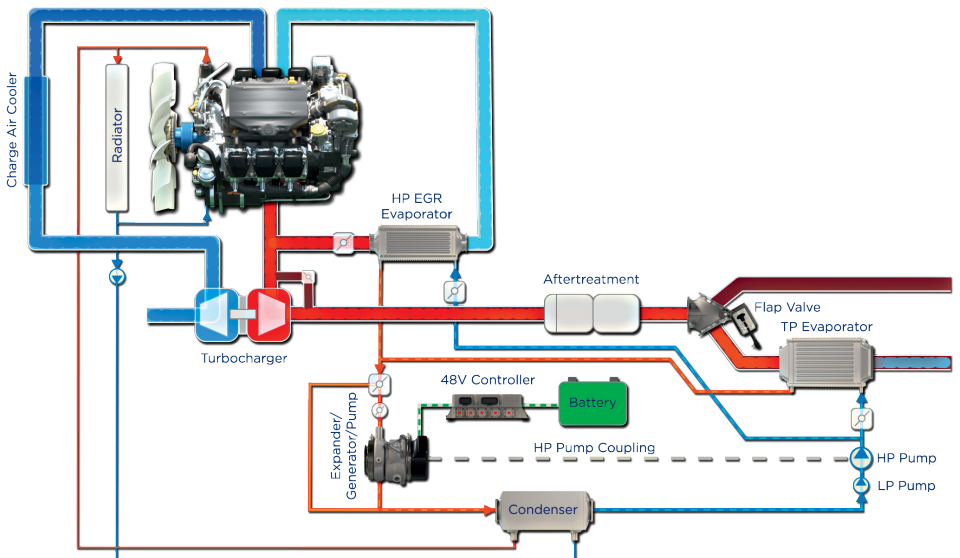
### Heat Exchanger/Condenser

- EGR Cooler technology yields compact, high efficiency design
- Stacked brazed plate & fin construction maximizes efficiency
- Proprietary brazing materials ensure long-term reliability
- Stainless steel provides compatibility for corrosive working fluids (e.g. ethanol)

## BorgWarner ORC Waste Heat Recovery System

### System Level Expertise

- Proprietary software tools enable rapid specification to a customer's engine requirements
- System-level Simulations, Controls, and Testing have resulted in numerous design enhancements
- BorgWarner ORC components have run hundreds of hours on proprietary ORC system test rigs
- A broad product portfolio and system-level approach allow BorgWarner to maximize overall performance and durability at the lowest cost



For Additional BorgWarner  
Turbo Systems Information:  
[turbos.borgwarner.com](http://turbos.borgwarner.com)