WASTE HEAT RECOVERY
LOW- AND HIGH-TEMPERATURE

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PROJECT INFORMATION

Name | WHR – Low Temperature
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Partners | Swedish Energy Agency
| Lund University
| KTH
| Chalmers
| Volvo Cars
| AB Volvo
| Scania
| IAV
| TitanX
| Gnutti Carlo

Project grant | 11 134 000 SEK
PROJECT GOAL

In order to meet future requirements for very low fuel consumption combined with low emissions, heat losses in the engine should be converted to useful work.

The project aims to expand the potential of Rankine based waste heat recovery systems in internal combustion engines by combining low- and high-temperature heat sources.
Trucks
(Indicative figures)

Engine manufacturers have different strategies to improve engine efficiency

Some of them already implemented to reach 50% efficiency, WHR allows for even higher efficiencies
Passenger cars

48V Hybrid gives good fuel consumption benefit for city driving (WLTC)

WHR gives an additional ~4% or up to 10% in highway driving
AVAILABLE HEAT SOURCES IN ENGINES

High-temperature:
- Exhaust gas out → Heat loss: 30% – 40%
- EGR cooler → Heat loss: 5% – 25%

Low-temperature:
- Coolant → Heat loss: 20% – 30%
- Charge air cooler → Heat loss: 5% – 20%
Main components:

- Pump
- Evaporator
- Expander
- Condenser
WORK PACKAGES

WP1: Lund – KCFP
Increased engine coolant temperature

WP2: KTH – CCGEx
Expanders and system integration

WP3: Chalmers – CERC
Thermodynamic cycles for low- and high-temperature heat sources

WP4: Volvo Cars
Light-duty demonstrator
WP1: LUND – RESULTS

• Low-temperature recoverable energy (from the coolant) shows a peak for an optimum coolant temperature
• High-temperature recoverable energy (from exhaust) increased
• Indicated efficiency gain shows a peak for an optimum coolant temperature of up to 2.5%
• Combustion characteristics showed no significant change with changing coolant temperature
WP2: KTH – RESULTS

- Expanders used mostly are either the piston or the turbine types.
- Limited no. of publications on practical design conditions of expanders and their effect on the cycle.
- Analysis and modelling of more expander types for efficient low-temperature heat recovery.
WP3: CHALMERS – RESULTS

• Results from different thermodynamic cycles and working fluids (Thermodynamic potential)

• Potential for all heat sources → combine heat sources

• Best performance depends on combination of heat source, working fluid and thermodynamic cycle

WP4: VOLVO CARS – AIM

- Build a demonstrator WHR system
- Implement on a light duty engine
- Show possibility to reduce fuel consumption in accordance with theory
Mechanical Transfer
- High efficiency to propulsion
- Need to be disconnected when there is no torque demand
- Packaging challenge

Electrical Transfer
- Losses of 30-50%, expander to propulsion (except 12V Board net)
- Can store energy during transients
- Packaging freedom

Electromechanical transfer chosen:
High efficiency through
- Mechanical transfer when possible
- Electric transfer in transients
- Control challenge
- Packaging challenge

System Simulation Study
WP4: VOLVO CARS – SYSTEM LAYOUT

Heat Exchanger/Evaporator

Pump

Expansion/storage Tank, 8 L, with pressure control

Filter

Condenser

Expander with belt system and generator
ACKNOWLEDGEMENTS
THANK YOU
WHY WHR?

2012: $\eta = 20 - 25\%$

2025: $\eta = 40 - 50\%$

Passenger cars

CO$_2$ legislation

Higher loads in WLTP

RDE for CO$_2$

Real-life consumption

Higher engine efficiency needed