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THERMOELECTRICAL ENERGY RECOVERY FROM THE EXHAUST OF A LIGHT TRUCK

2003 DEER Conference
August 24 - 28, 2003
Newport, Rhode Island

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Topics

- Motivation and Project objective
- Team composition and tasks
- Funding and in-kind support
- System modeling and simulation
- Test plan
- Draft commercialization plan results
- Future Studies

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Motivation

- Increase fuel efficiency and reduce emissions
- Increasing electrical loads
- CAFE regulations

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Project objective

Create a prototype exhaust thermoelectric generator that supplies a net 330 W to the vehicle bus

- Designed for nominal 12 V bus.
- Estimated fuel economy increase: 5% for typical driving cycle

Team composition and tasks

Eric F Thacher Project Coordinator Clarkson University Vehicle Integration & System Testing	Brian T Helenbrook Madhav A Karri Clarkson University System Modeling	Marc S Compeau Clarkson University Commercialization
Aleksandr S. Kushch Norbert B. Elsner Hi-Z Technology, Inc. TEG Design & construction	Mohinder Bhatti John O' Brien Delphi Corporation Testing & Engineering services	Francis Stabler General Motors Corporation Test Vehicle

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Funding and in-kind support

New York State Energy Research and Development Authority
Project Funding – Joseph R. Wagner **Senior Project Manager**
Transportation Research

Department of Energy
John W. Fairbanks – Project Manager
Light Truck Clean Diesel Program

Delphi Corporation
Wind tunnel testing services of up to 2 weeks
Engineering services of up to 160 hours

General Motors Corporation
Test Vehicle – 1999 GMC Sierra 1500

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System

- Thermoelectric generator (TEG)
  - Heat source – Exhaust gas from the engine
  - Heat sink – Coolant tapped from the vehicle's Coolant system
  - Thermoelectric modules – Hi-Z's HZ-20
- Power conditioning unit

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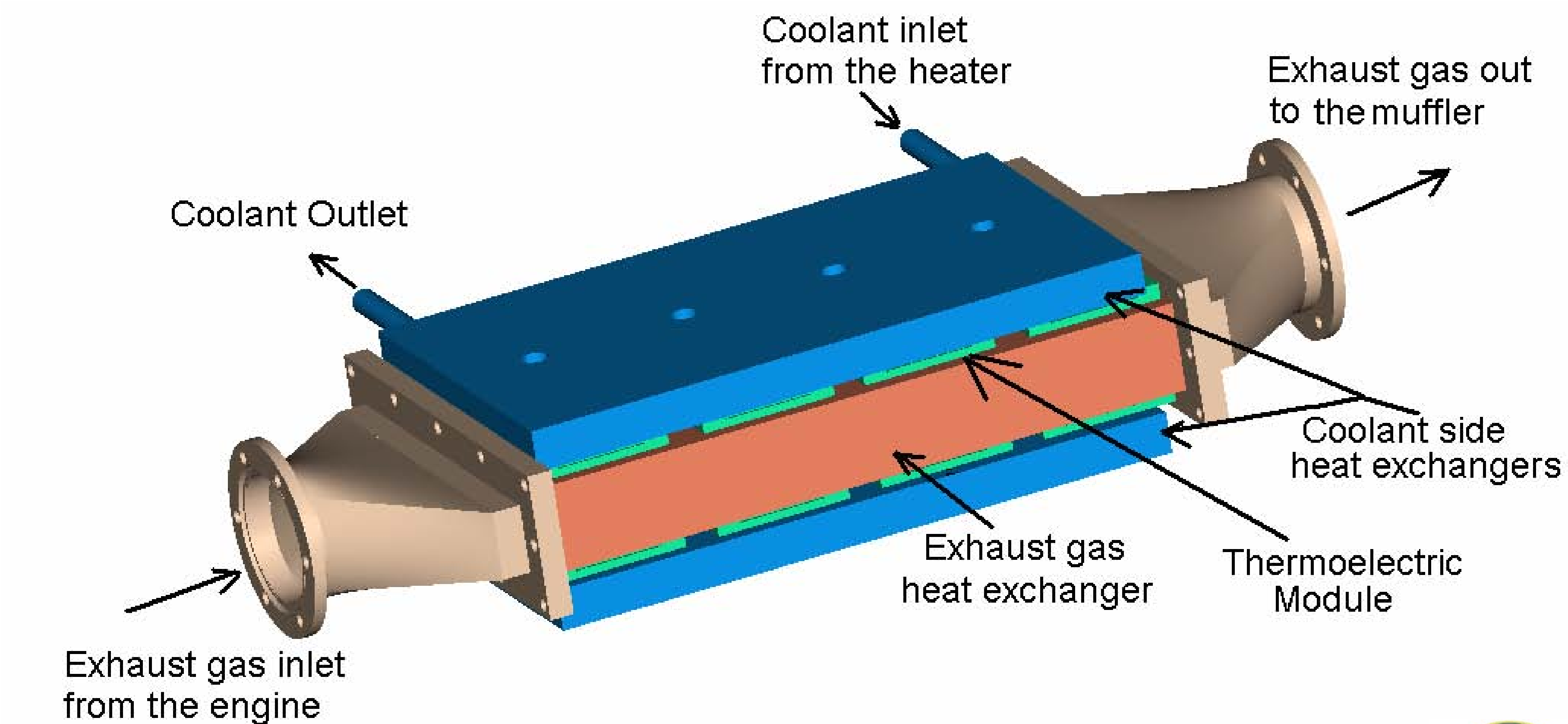
Thermoelectric generator

Shown without case



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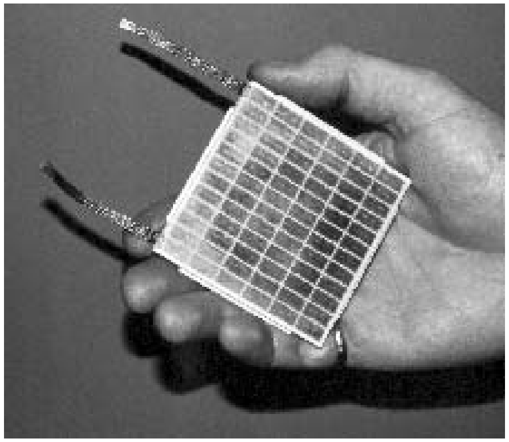
Hi-Z's HZ20 Thermoelectric Module & Properties



	Value
Thermal Properties	
Design hot side temperature	**230 C**
Design cold side temperature	**30 C**
Maximum continuous temperature	**250 C**
Maximum intermittent temperature	**400 C**
Electrical properties at design temperatures	
Power	**19 Watts**
Efficiency	**4.5 %**

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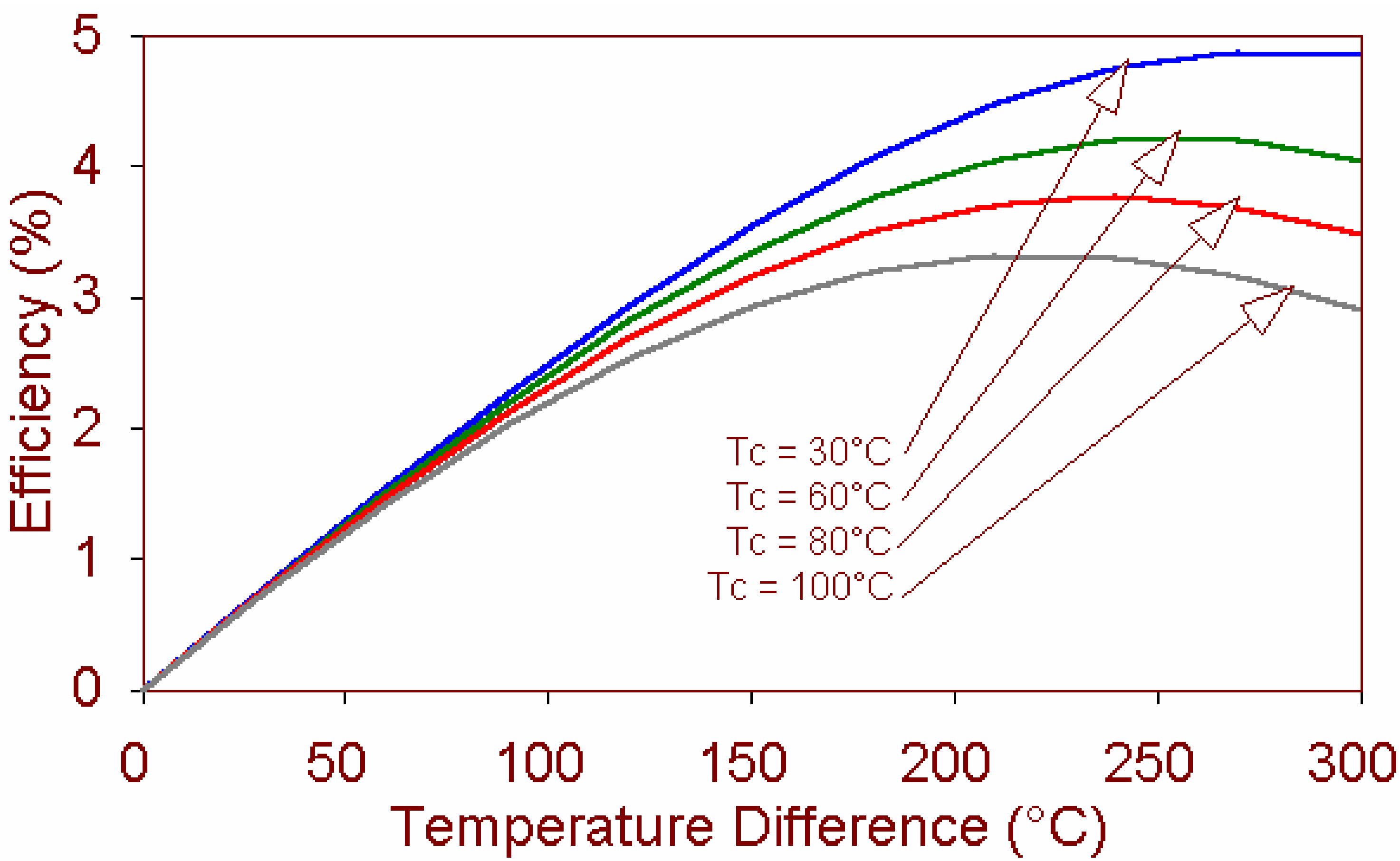
Hi-Z's HZ20 Thermoelectric Module Efficiency Curves



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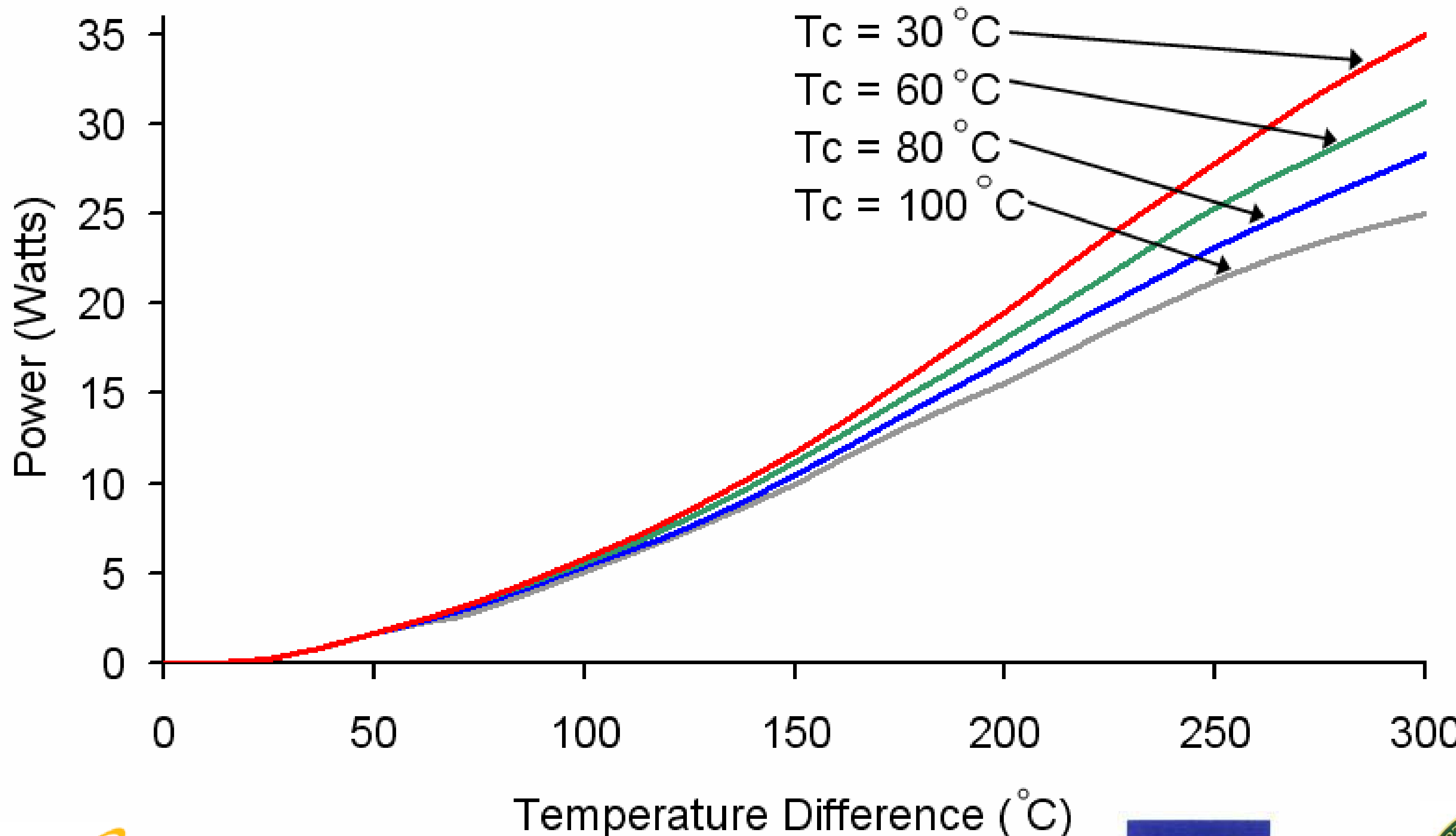
Hi-Z's HZ20 Thermoelectric Module Power Curves



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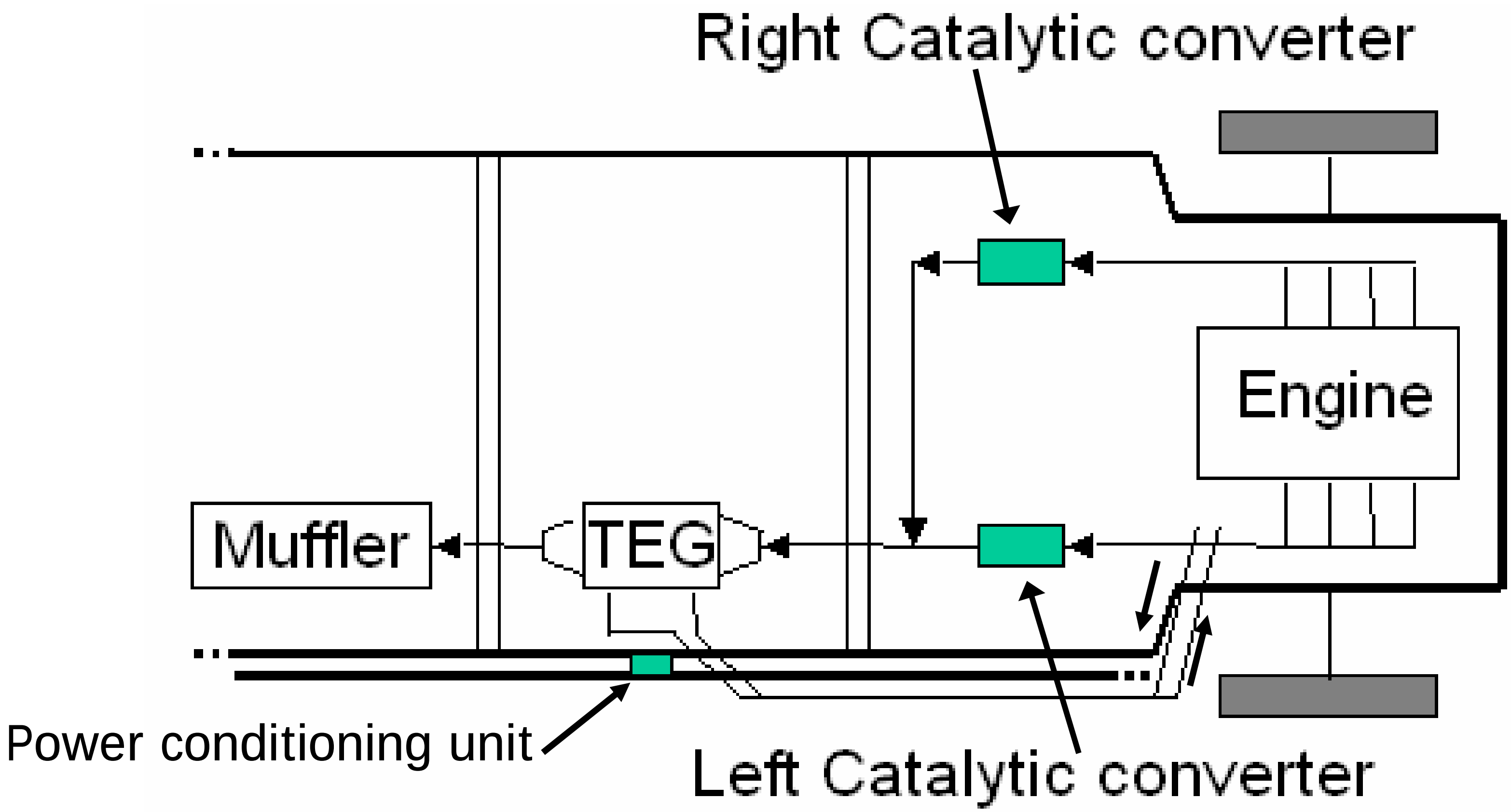
AETEG system physical layout



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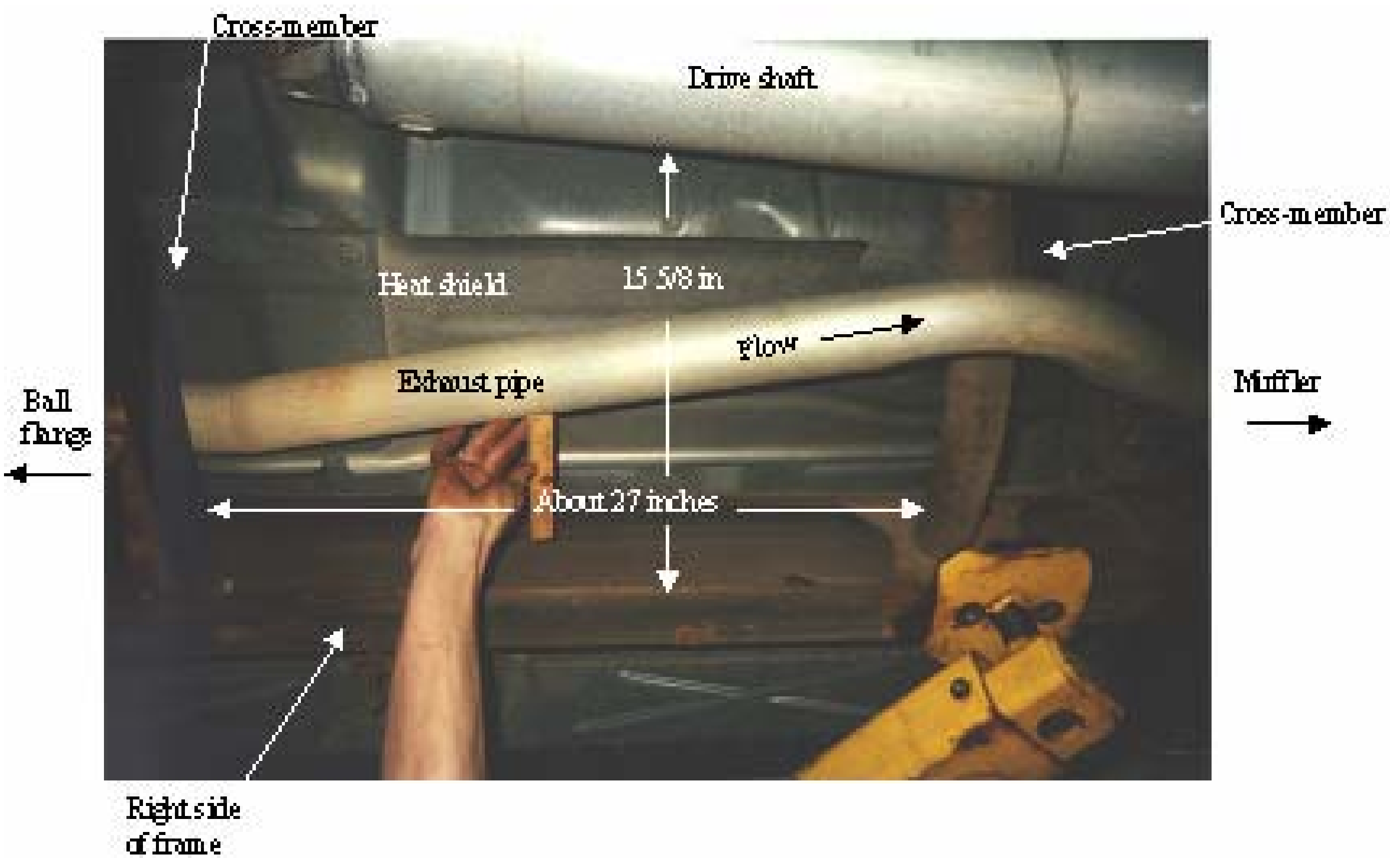
AETEG system physical layout



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System modeling – components

- Exhaust system
- Coolant system
- TEG
- Electrical system
- Simulation platform – Matlab/Simulink ADVISOR

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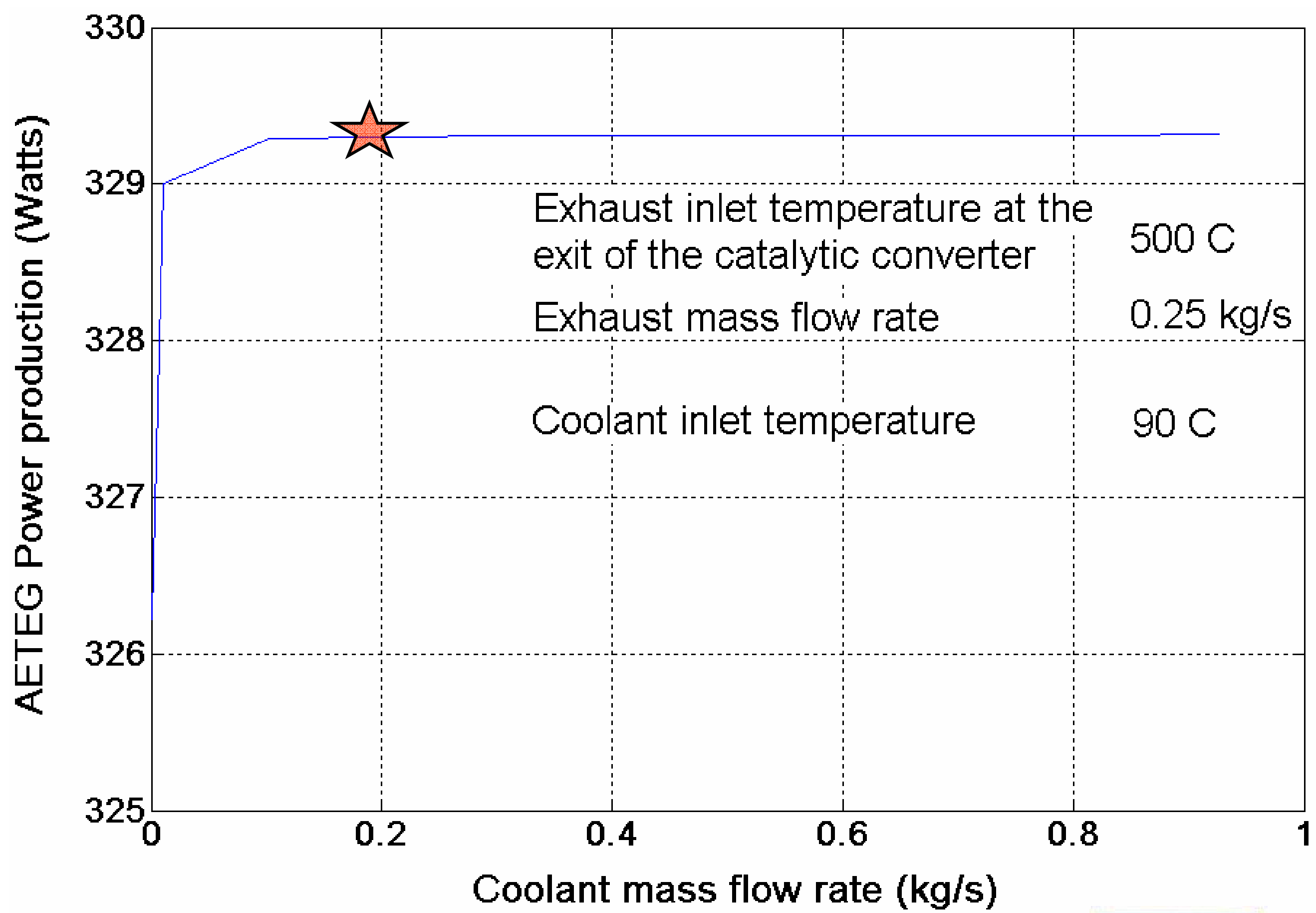
Sensitivity of power to coolant flow rate



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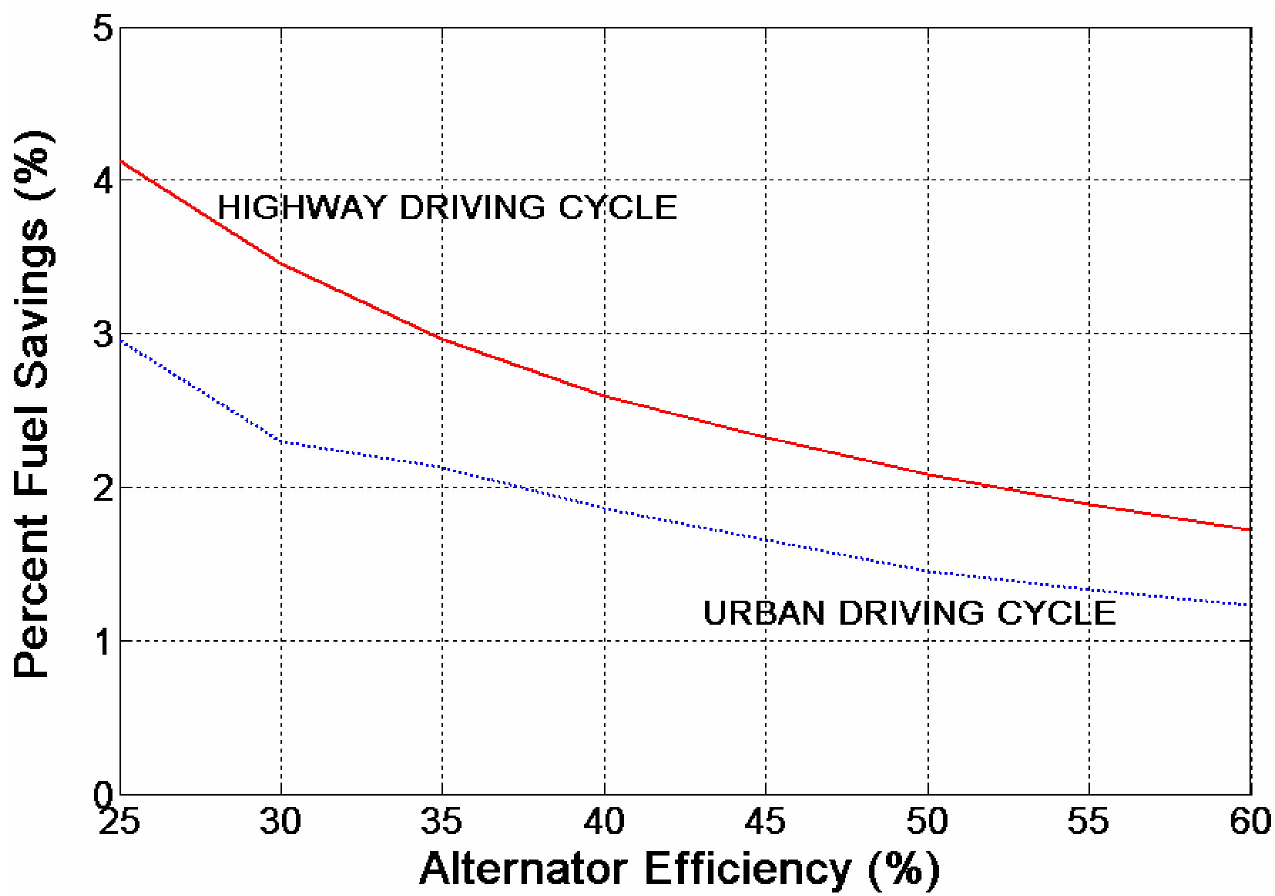
% Fuel savings vs. Alternator system efficiency



Test plan

Objectives

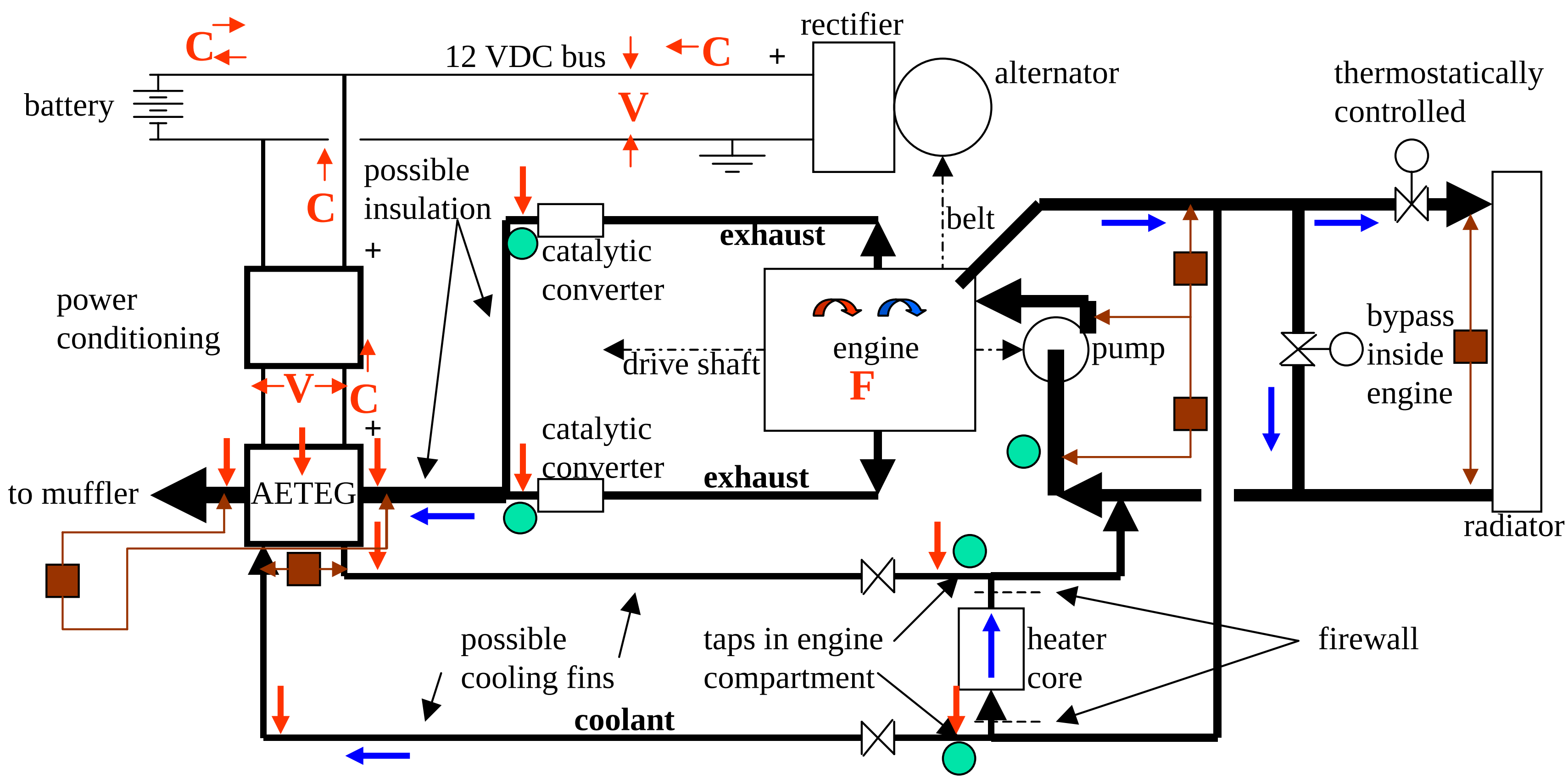
- To evaluate the performance of TEG
- Validation of system modeling and simulation code
- Effect of TEG on the complete system

Test plan

Measurements

Temperature · Mass flow rate · Gauge pressure

Differential pressure · V Voltage · C Current · Torque · r.p.m. · F Fuel consumption



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Draft commercialization plan results

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Future performance studies

- Application of AETEG to HYBRID Vehicles
- Application of AETEG to Natural Gas-fueled generator
- Current and Quantum well modules
- System optimization studies

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Conclusions

- TEG is potentially commercially viable especially with quantum well technology
- 330 Watts generation is feasible
- More work needed in integrated design