Clarkson University
Potsdam, New York 13699

THERMOELECTRICAL ENERGY RECOVERY FROM THE EXHAUST OF A LIGHT TRUCK

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

Clarkson University
Potsdam, New York 13699

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

NYSERDA Hi-Z TECHNOLOGY, INC DELPHI Driving Tomorrow's Technology GM

Clarkson University
Potsdam, New York 13699

Motivation

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

NYSERDA Hi-Z Technology, Inc. DELPHI Driving Tomorrow's Technology GM

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

Clarkson University
Potsdam, New York 13699

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

NYSERDA   Hi-Z TECHNOLOGY, INC.   DELPHI Driving Tomorrow's Technology   GM

Clarkson University
Potsdam, New York 13699

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

NYSERDA   Hi-Z TECHNOLOGY, INC   DELPHI Driving Tomorrow's Technology   GM

Clarkson University
Potsdam, New York 13699

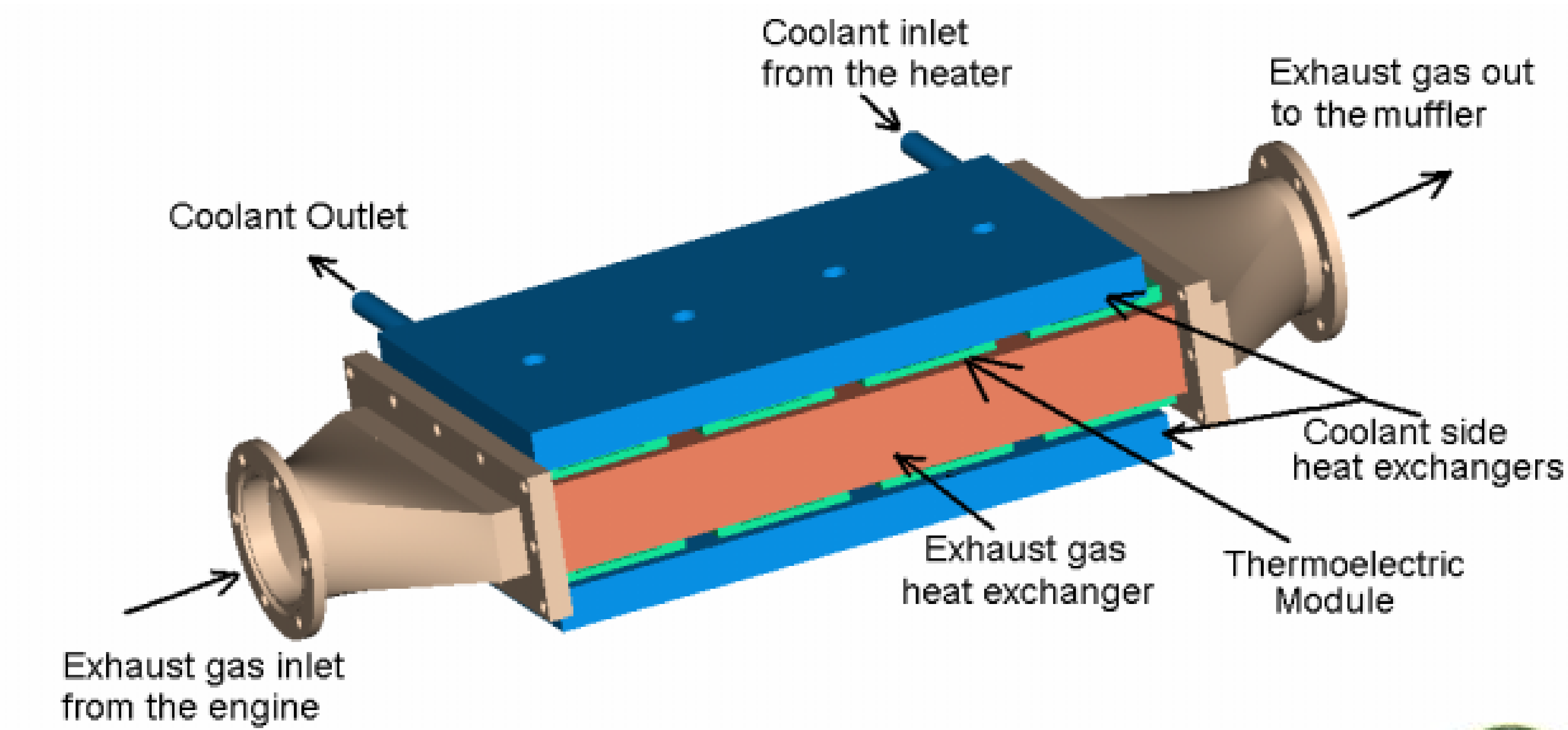
System

- 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

Clarkson UNIVERSITY
Potsdam, New York 13699

Thermoelectric generator

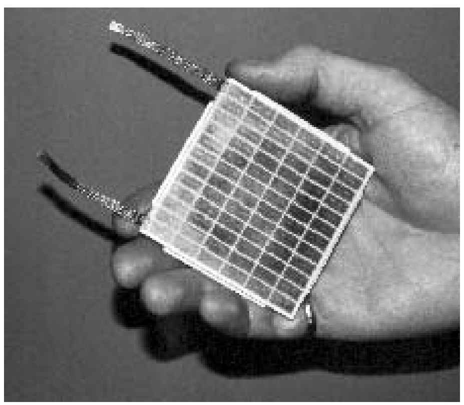
Shown without case



NYSERDA Hi-Z TECHNOLOGY, INC. DELPHI Driving Tomorrow's Technology GM

Clarkson UNIVERSITY
Potsdam, New York 13699

Hi-Z's HZ20 Thermoelectric Module & Properties

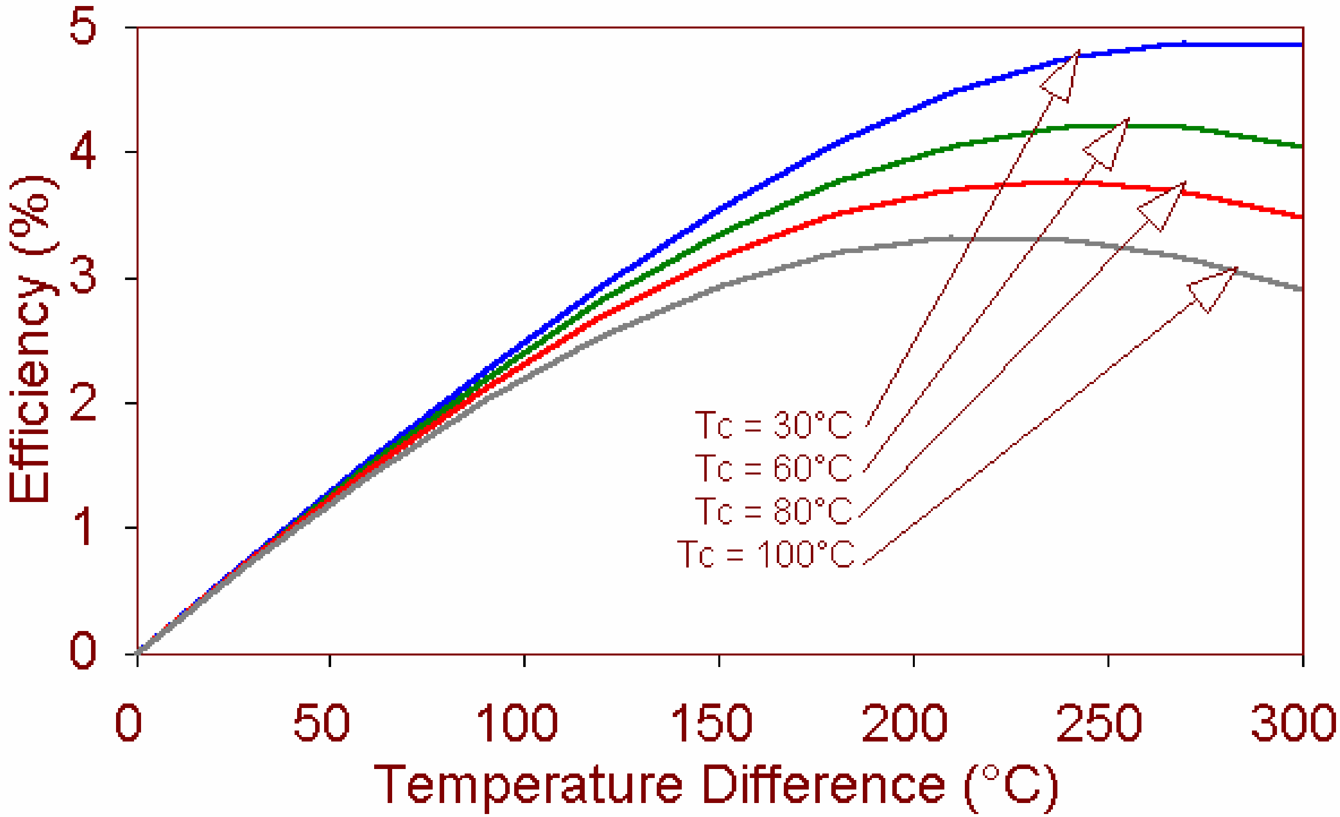


	Value
Thermal Properties	
Design hot side temperature	**230 C**
Design cold side temperature	**30 C**
Maximum continuous temperature	**250 C**
Maximum intermittent temperature	**400 C**
Electrical properties at design temperatures	
Power	**19 Watts**
Efficiency	**4.5 %**

NYSERDA · Hi-Z TECHNOLOGY, INC. · DELPHI Driving Tomorrow's Technology · GM

Clarkson University
Potsdam, New York 13699

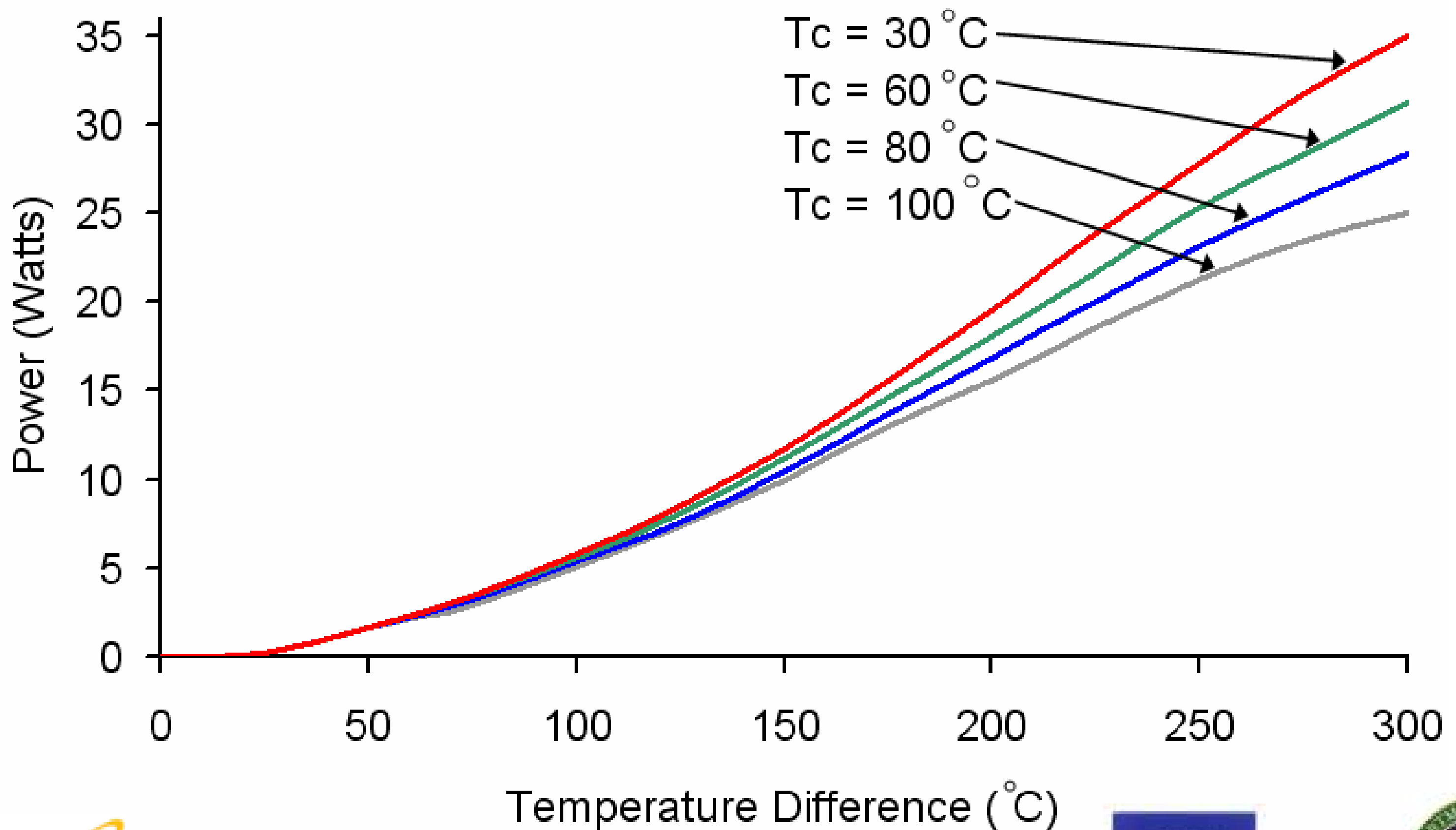
Hi-Z's HZ20 Thermoelectric Module Efficiency Curves



NYSERDA
Hi-Z TECHNOLOGY, INC.
DELPHI Driving Tomorrow's Technology
GM

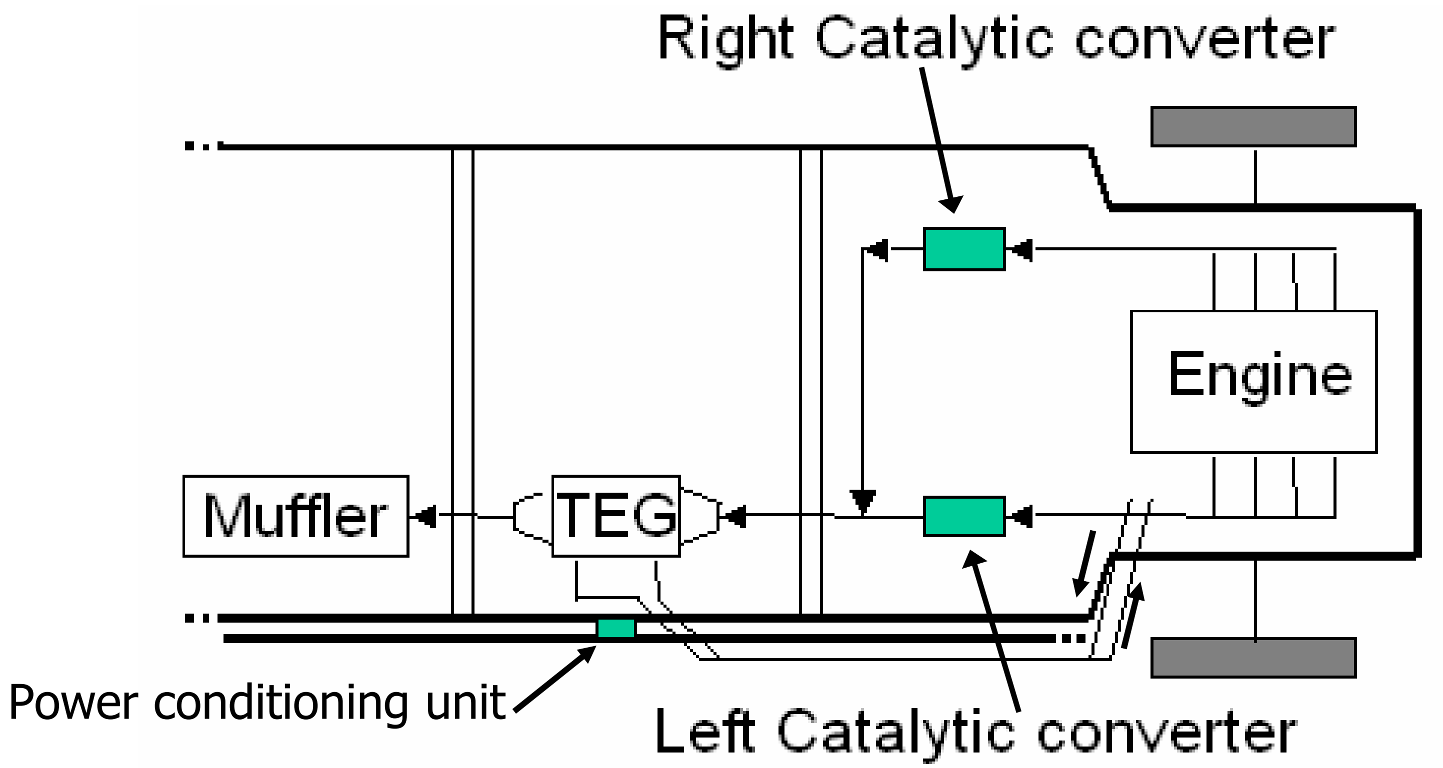
Clarkson University
Potsdam, New York 13699

Hi-Z's HZ20 Thermoelectric Module Power Curves



NYSERDA
Hi-Z TECHNOLOGY, INC.
DELPHI
Driving Tomorrow's Technology
GM

AETEG system physical layout

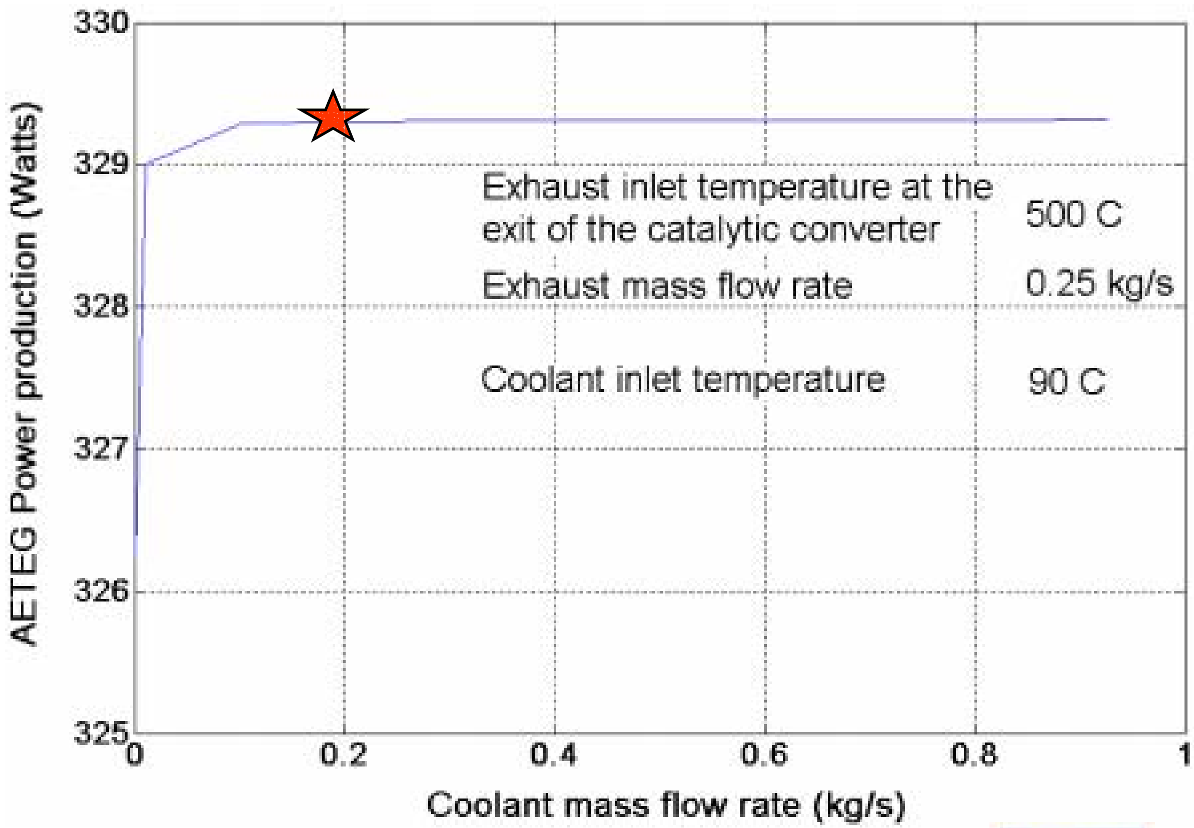


Clarkson University
Potsdam, New York 13699

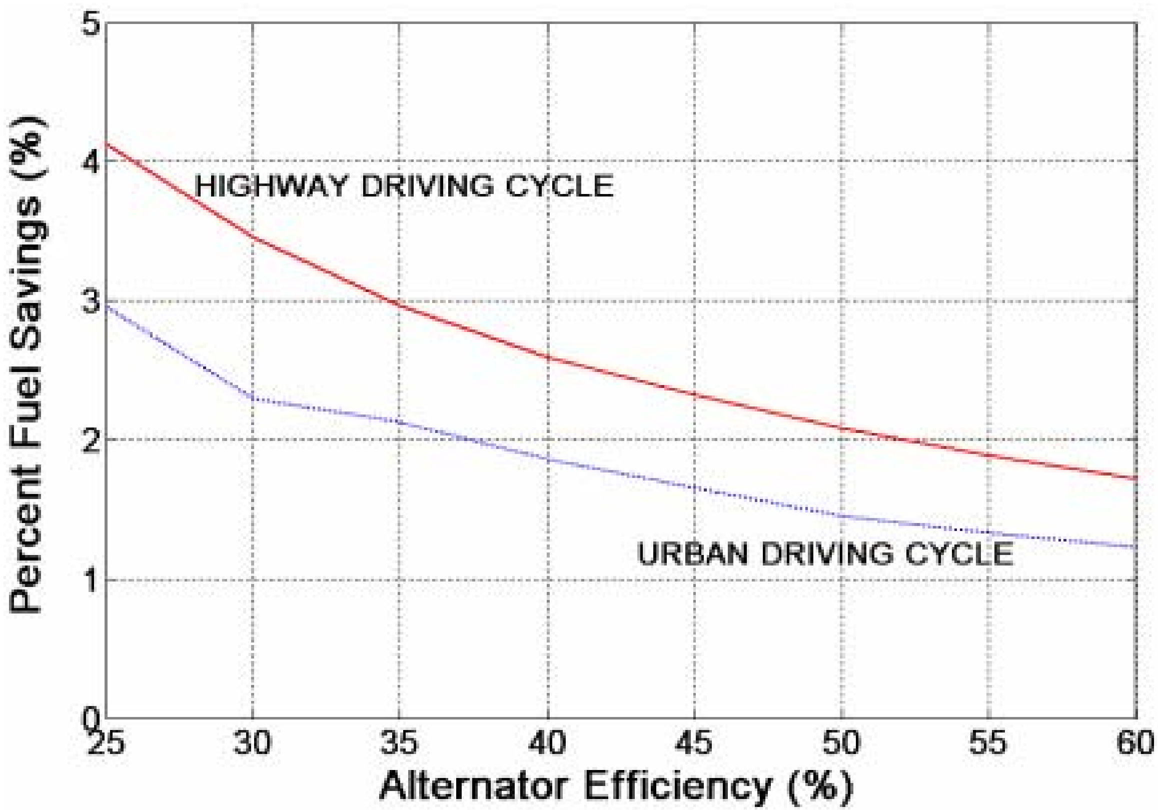
System modeling – components

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

Sensitivity of power to coolant flow rate



% Fuel savings vs. Alternator system efficiency



Clarkson University
Potsdam, New York 13699

Test plan

Objectives

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

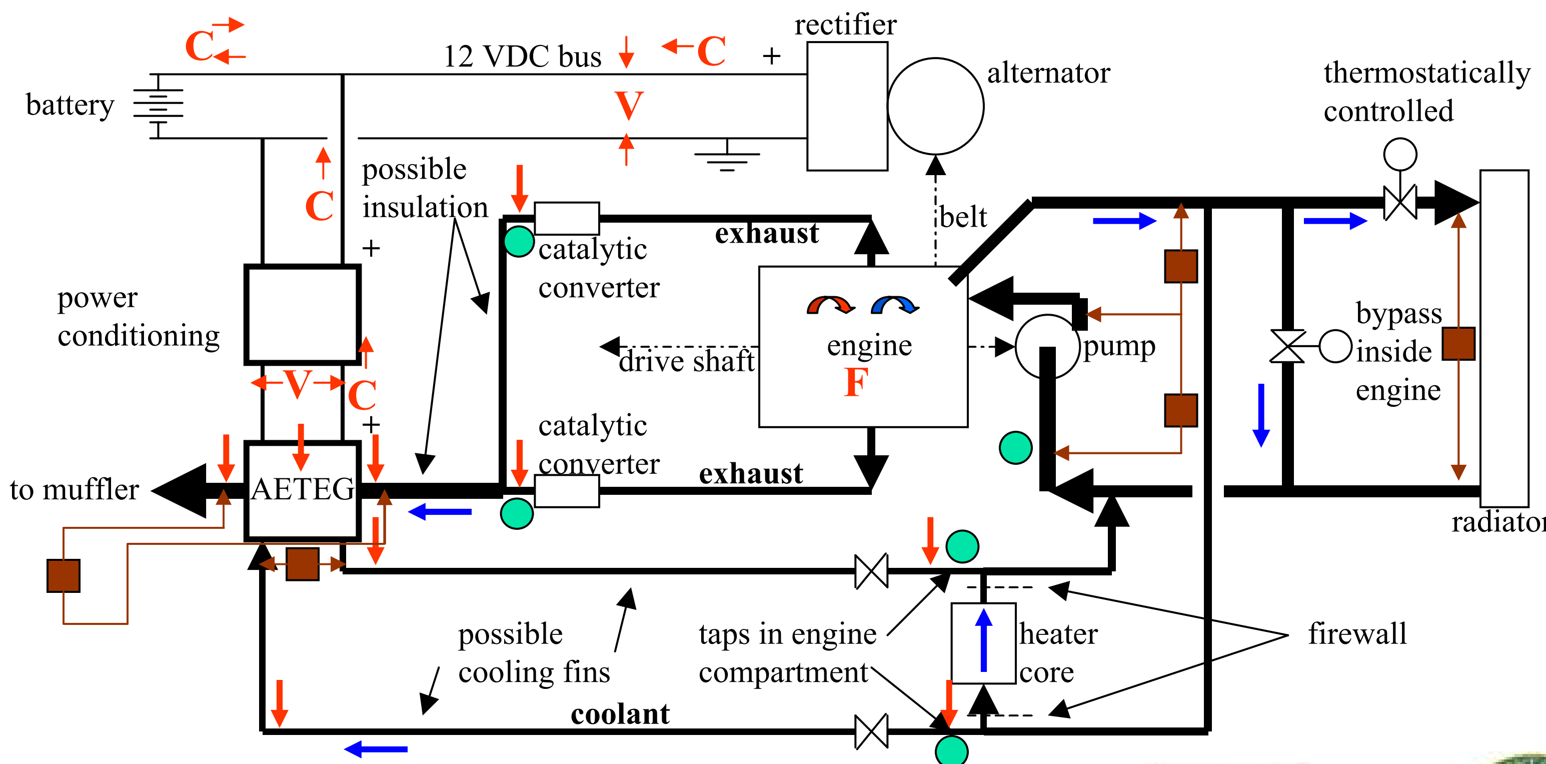
NYSERDA Hi-Z TECHNOLOGY, INC. DELPHI Driving Tomorrow's Technology GM

Clarkson
UNIVERSITY
Potsdam, New York 13699

Test plan

Measurements

F Fuel consumption



NYSERDA

DELPHI
Driving Tomorrow's Technology

GM

Clarkson University
Potsdam, New York 13699

Draft commercialization plan results

NYSERDA · Hi-Z Technology, Inc. · DELPHI Driving Tomorrow's Technology · GM

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

Clarkson
UNIVERSITY
Potsdam, New York 13699

Conclusions

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