

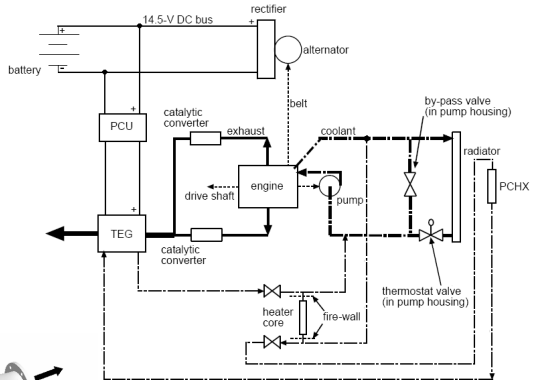
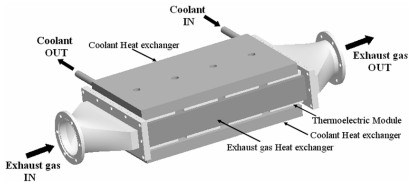
# Thermoelectric Power Generation Systems Design, Testing, Modeling, and Optimization

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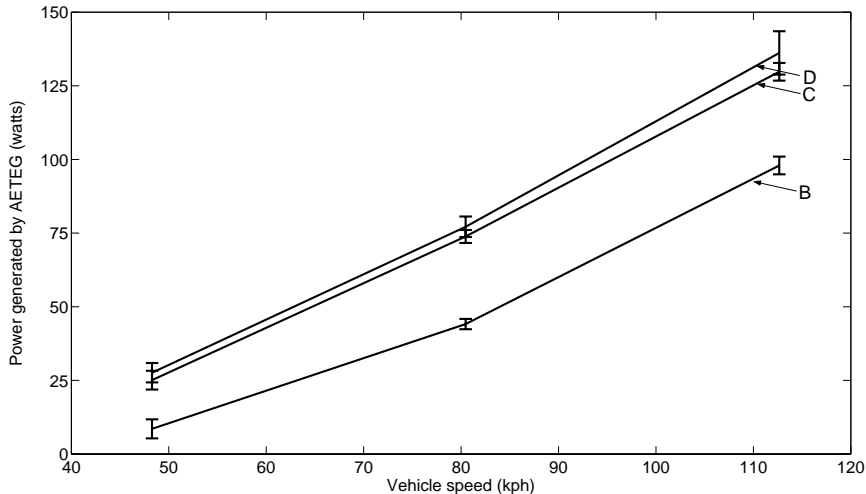
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# AETEG: System Design

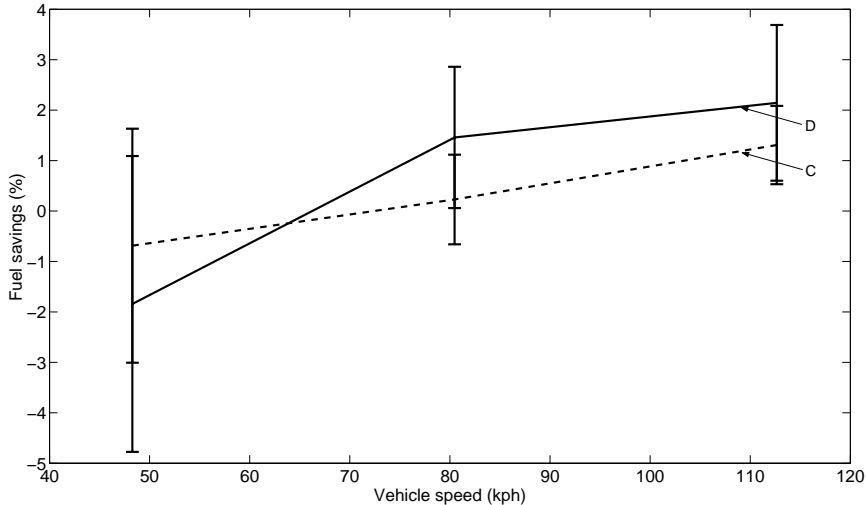
- ▶ TEG design with Hi-Z
- ▶ GMC Sierra Truck donated by GM
- ▶ 16 Hi-Z HZ20 Modules
- ▶ Testing at Delphi-Harrison



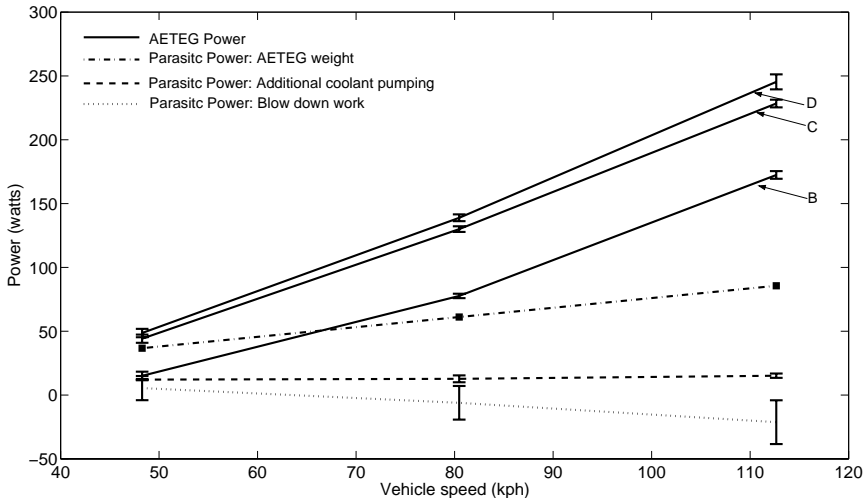
## Results: TEG Power



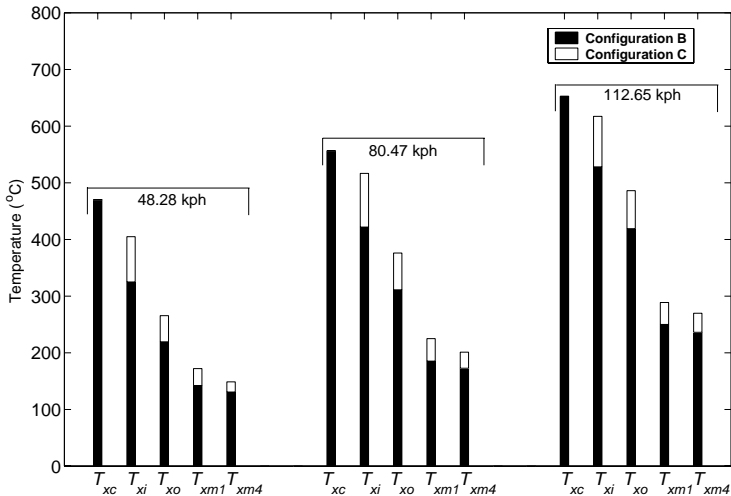
## Results: Fuel Savings



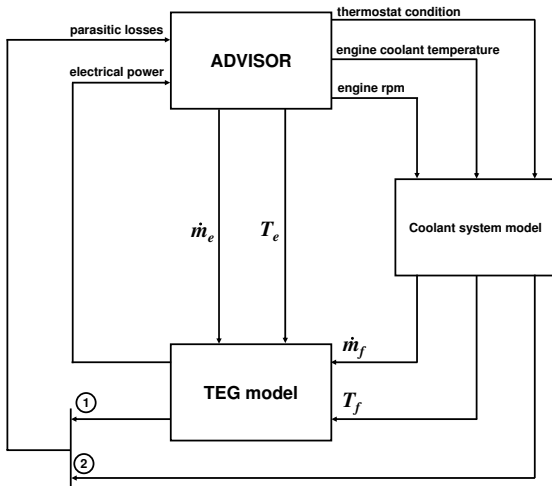
## Results: Parasitic Losses



## Results: Exhaust Side Temperatures



# AETEG: System Modeling



parasitic losses

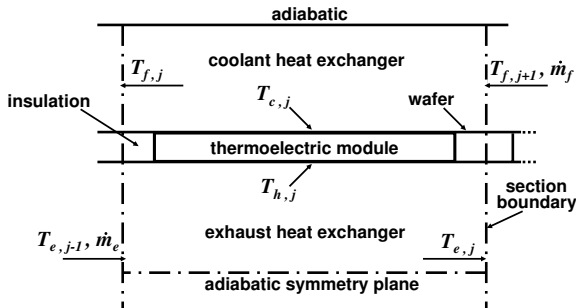
- ① power to overcome back pressure from exhaust heat exchanger & transport TEG weight
- ② additional coolant pumping power

## TEG System Modeling

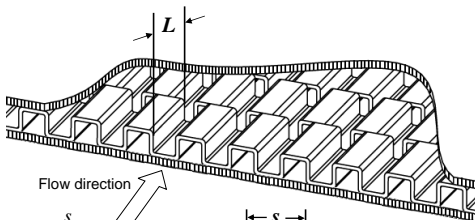
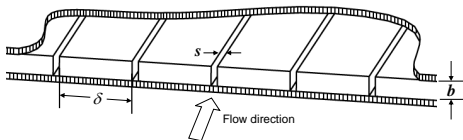
Solve for temperature distribution

Steady state energy balance equations

Newton-Raphson method



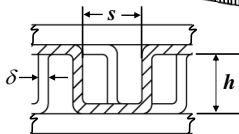
## Heat Exchangers



$$\alpha = \frac{s}{h}$$

$$\delta' = \frac{\delta}{L}$$

$$\gamma = \frac{\delta}{s}$$



## Coolant System Modeling

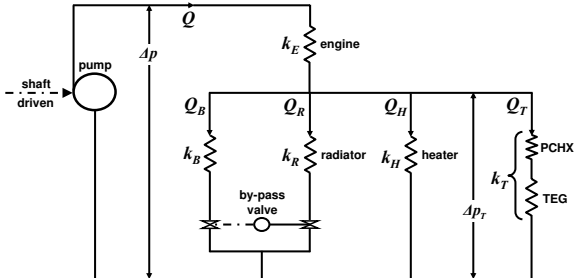
Based on coolant system in the vehicle used in experimental testing

Objectives

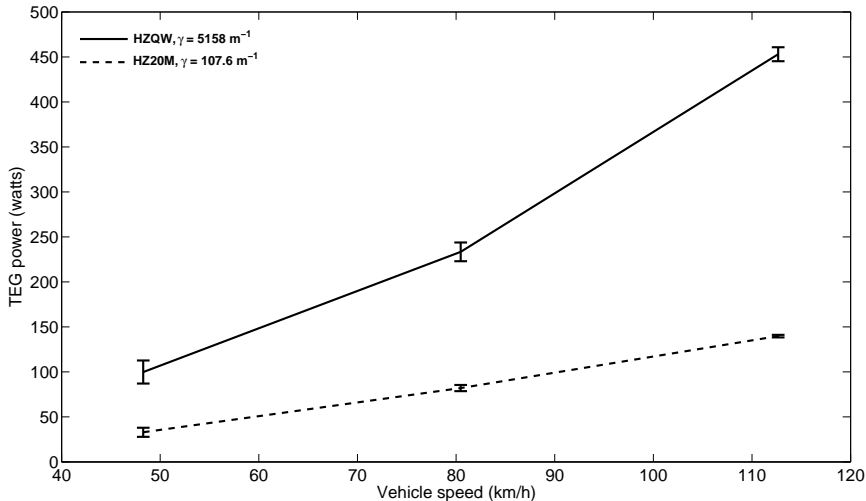
To predict coolant flow through TEG

To predict pumping power needed to cool the TEG

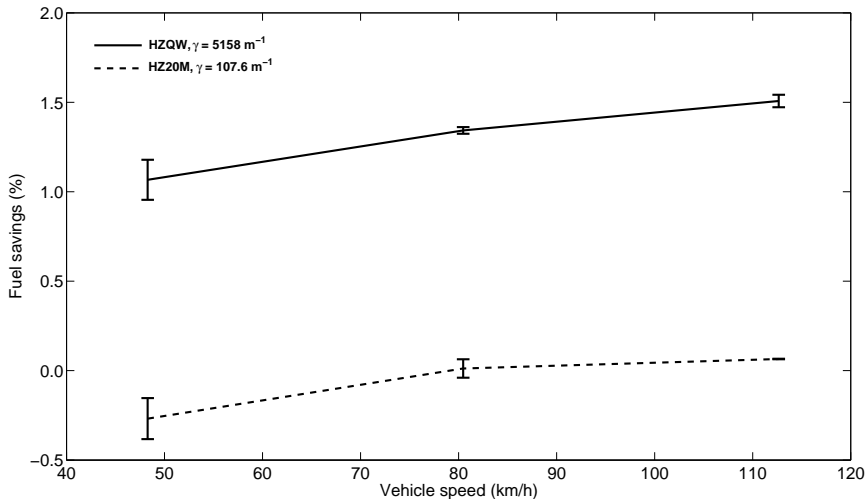
To predict the change in flow rates through the other components of the coolant system



## TEG Power



## Fuel Savings



## Objective function

$$\text{Net Power} = \text{Total TEG Power} - \text{Parasitic Losses.}$$

## Parasitic losses:

Coolant pumping power

Blow down work

TEG weight (mobile application)

## Design Variables:

$L_x$ : length parallel to exhaust flow direction

$L_y$ : length perpendicular to exhaust flow direction

$\dot{m}_c$ : coolant mass flow rate

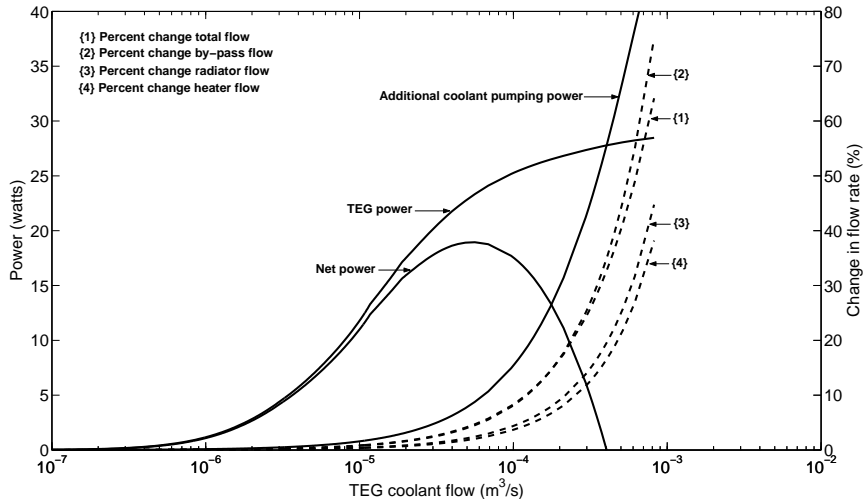
$\rho_{tec}$ : thermoelectric couple density

$\gamma_{te}$ : thermoelectric leg aspect ratio ( $\frac{L}{A}$ )

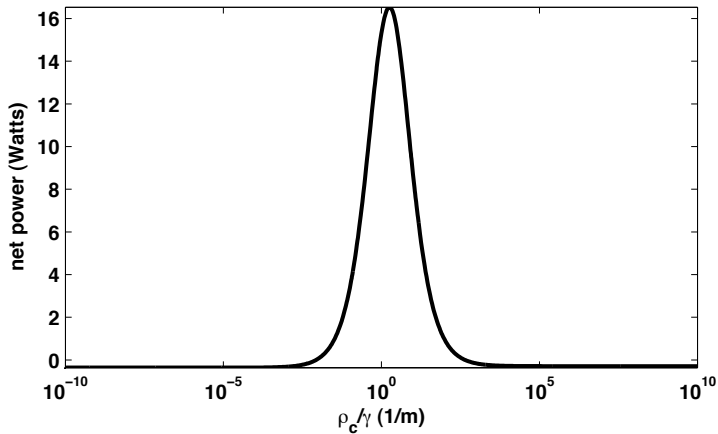
## Constraints:

$$T_h < 275C$$

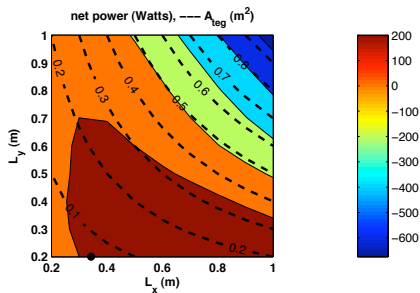
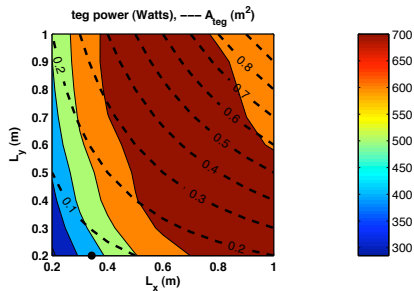
# Optimum Coolant Flow Rate



# Optimum Aspect Ratio



# Preliminary Optimized Results



Designed, tested, simulated, and optimized a TEG

Heat transfer coefficients limit power density

In vehicles, weight is dominant loss, then pumping power

Optimization shows potential for improved designs

Need to increase number of variables in optimizer (heat exchangers)

Optimization code will be available