Low and high Temperature Dual Thermoelectric Generation Waste Heat Recovery System for Light-Duty Vehicles

Soonseo Park, Jungho Yoo, Sungkyu Cho, Hyunju Lee, and Shiho Kim

Head Director, RAVERS
Department of Electrical Engineering
Chungbuk National University, Korea

2009 DEER Conference
August 5, 2009

RAVERS
Research Center for Advanced Hybrid Electric Vehicle Energy Recovery System

Outline

- Who is RAVERS?
- Goal and Objectives
- Technical Approaches
- Summary and Further works

Who is RAVERS?

- Research Center for Advanced Hybrid Electric Vehicle Energy Recovery System(RAVERS) at CBNU

- Supported by Korean government (Ministry of Knowledge Economy, MKE) and Chungbuk Provincial government

- RAVERS collaborates with Major Korean motor companies and Battery and Ultra Cap makers for development of TE-HEV and Battery management system of HEVs.

RAVERS
Research Center for Advanced Hybrid Electric Vehicle Energy Recovery System

Goals and Objectives

- Goal : More than 10% Fuel Efficiency Improvement for the light-duty vehicles with Gasoline or LPG engines in order to Reduce exhaust emissions.

- Developing a Low and high Temperature Dual Thermoelectric Generation Waste Heat Recovery System for Light-Duty Vehicles
  - Target vehicle is a compact passenger car with engine size from 1500 to 2000 cc
  - Developing superlattice TEM for high temp and low cost material as well as an environmentally nonhazardous substance
  - Design Optimization & Performance Analyses for Integrated TE System
  - System-Level Analysis and Testing of Advanced TE Materials

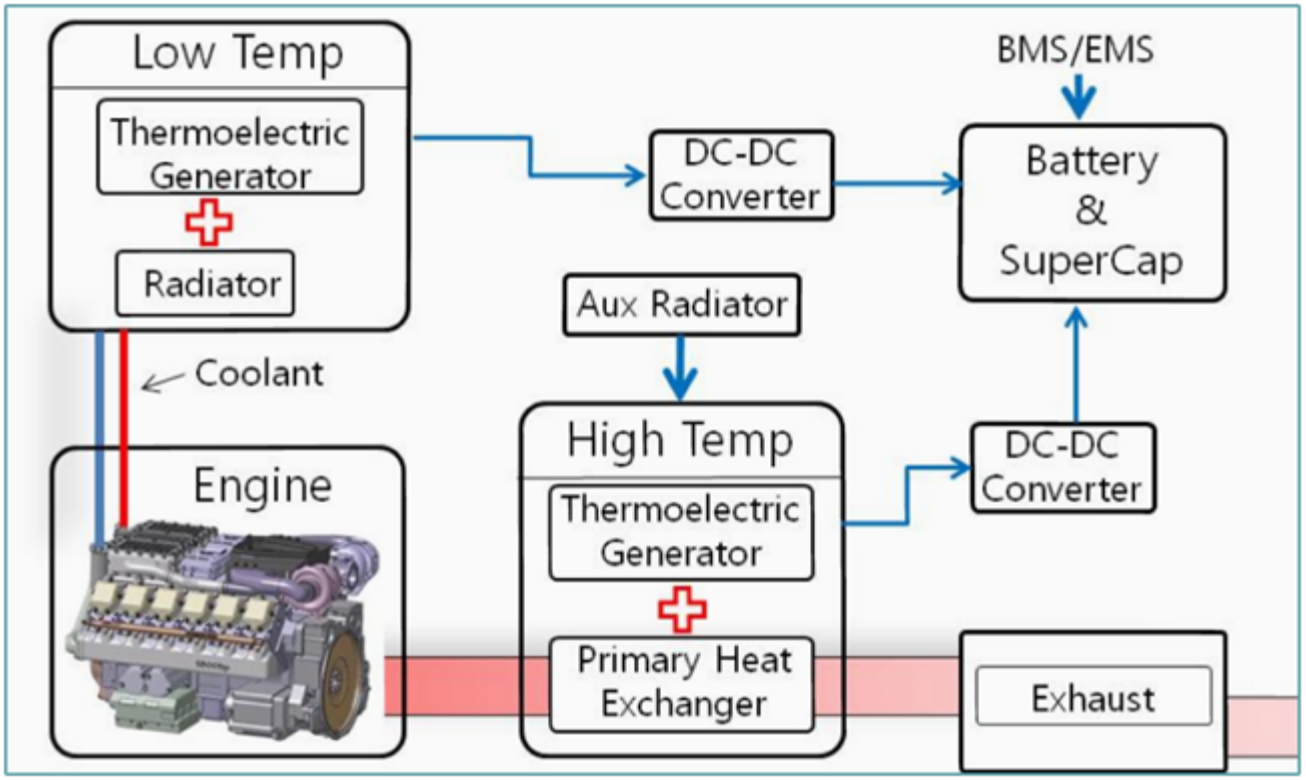
RAVERS
Research Center for Advanced Hybrid Electric Vehicle Energy Recovery System

Achievement Plan

- Phase I
  - Developing 1KW TEG for a light-duty vehicle by the end of FY2010
  - Replacing an Alternator of conventional ICE vehicles
- Phase II
  - Developing 5KW TEG for a light-duty vehicle by the end of FY2012
  - TE module will be adapted to regenerative breaking HEVs
- Phase III
  - Development of TE-HEV for Plug-in HEVs
  - Due to the TE power generation, the engine size can be reduced

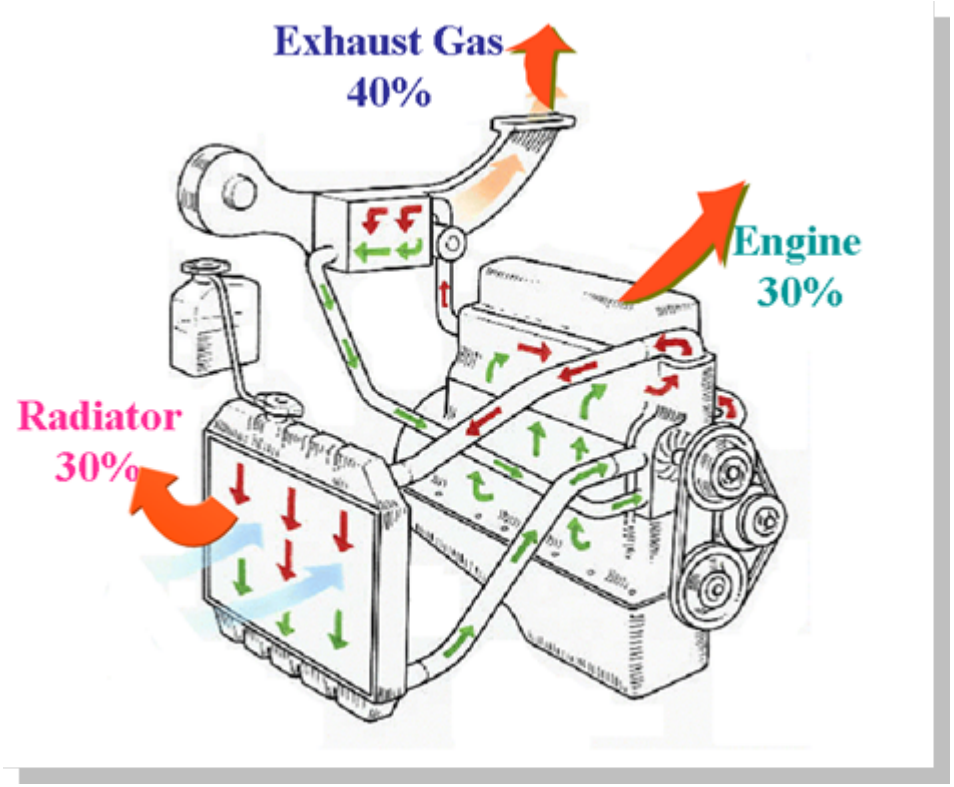
Technical Approaches: Phase I

- Dual Thermoelectric Generation Waste Heat Recovery System
  - Low temperature generator using Radiators : ~100W
  - High temperature generator using exhaust gas : ~1KW

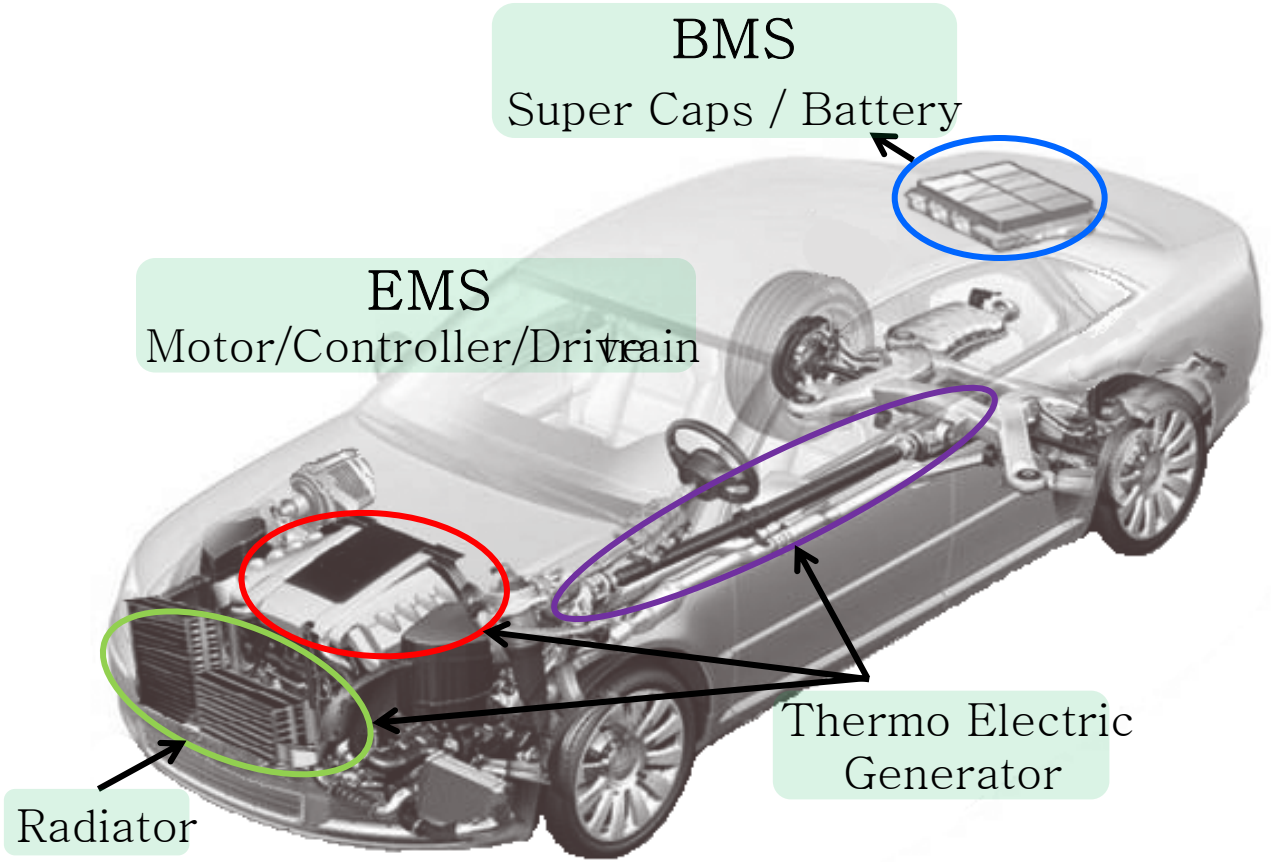


Technical Approaches: research area

- Percentage of Heat Waste for a conventional ICE vehicle

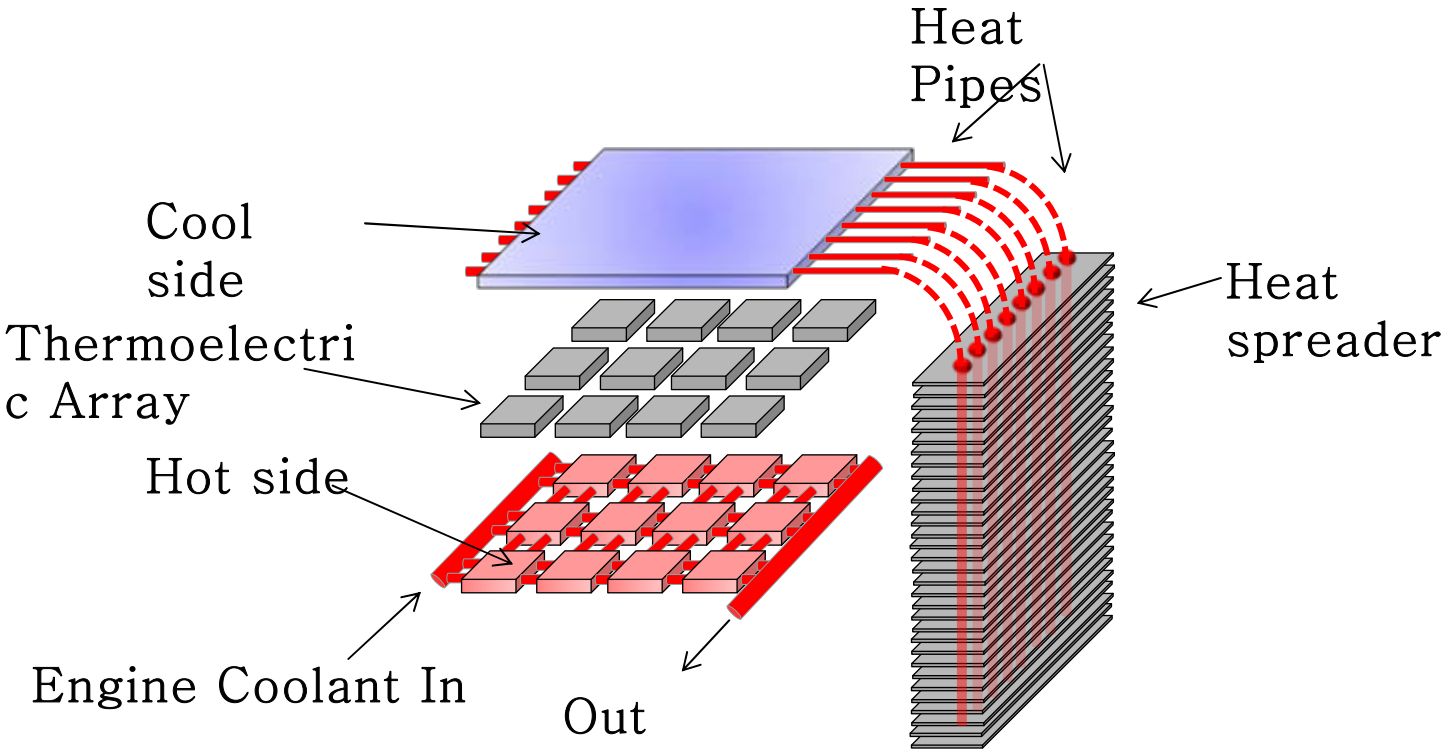


Technical Approaches: research area



Technical Approaches: TEG-R

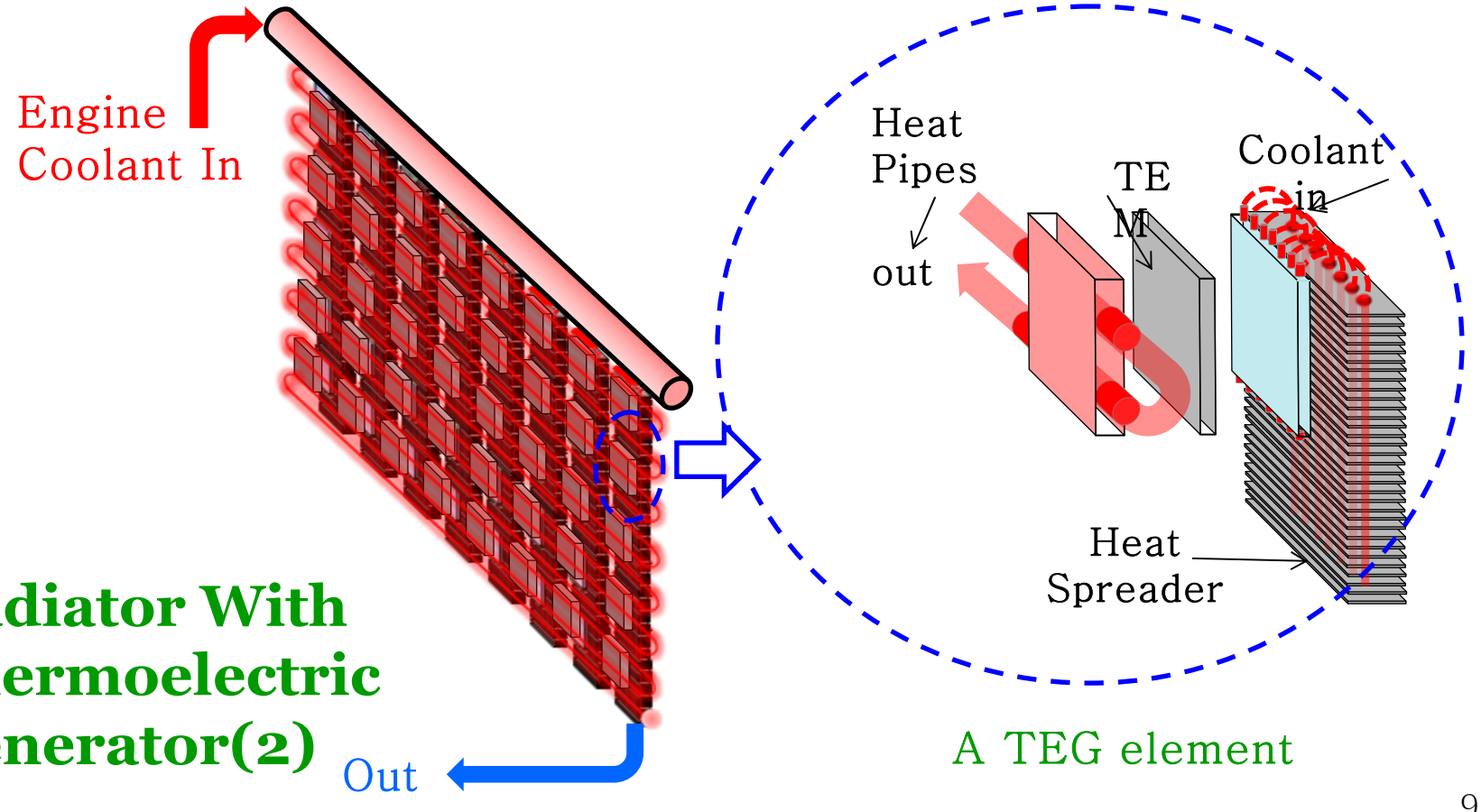
- TEG using Radiator (1)



Radiator With Thermoelectric Generator (1)

Technical Approaches : TEG-R cont'd

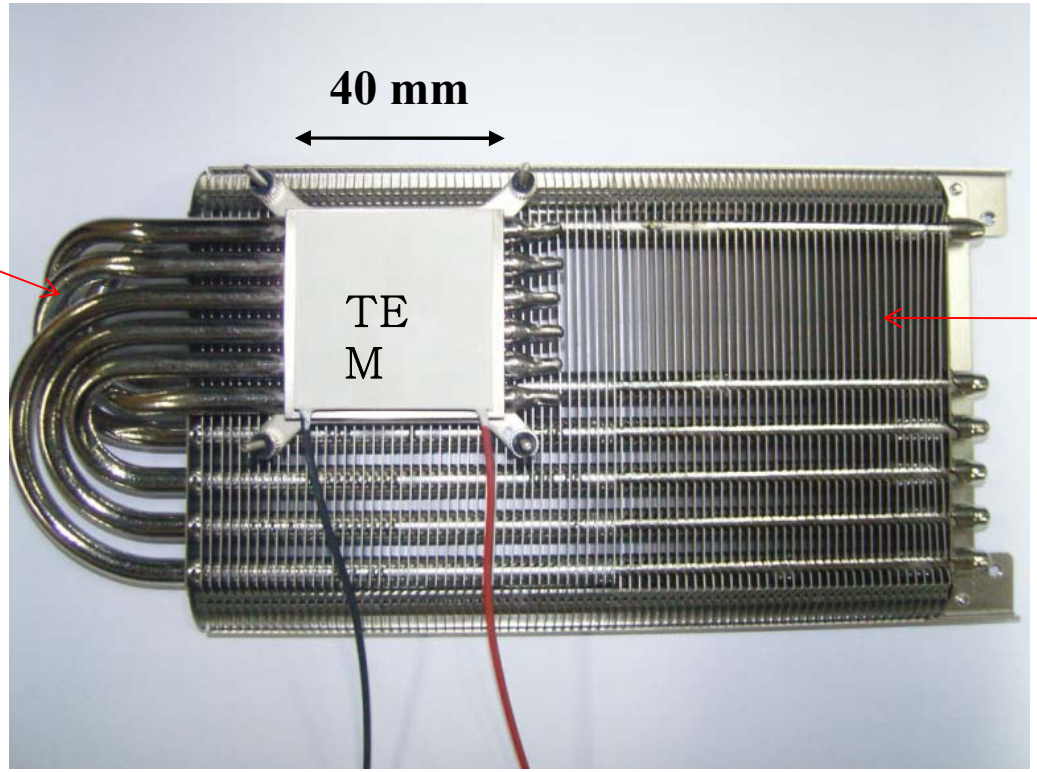
- TEG using Radiator (2)



Radiator With Thermoelectric Generator(2)

Technical Approaches: TEG-R cont'd

- Thermoelectric Generator with loop thermosiphons and heat spreader for air cooling system



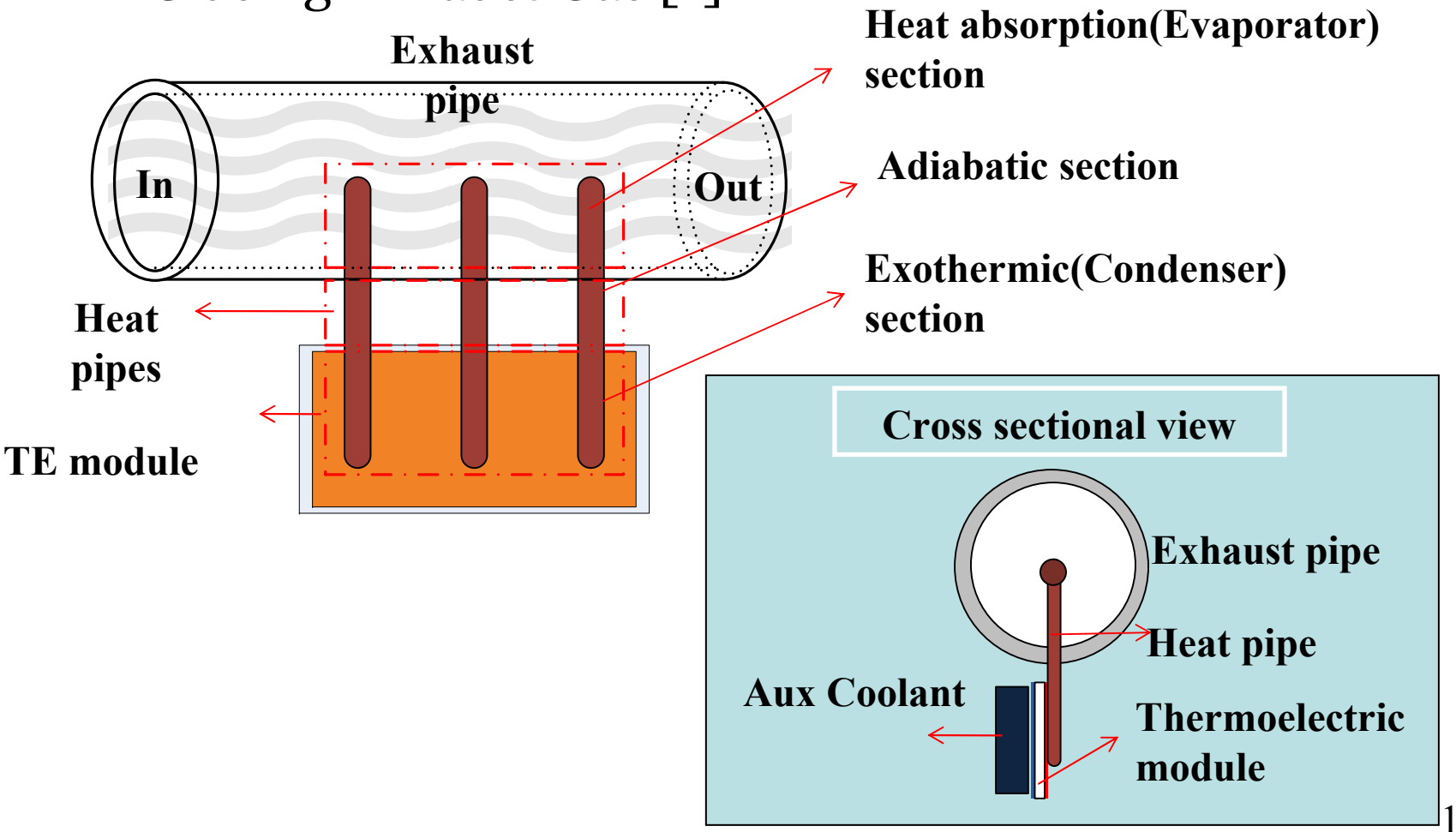
Technical Approaches : TEG-R cont'd

- Experimental Results
  - 4cm x 4cm Bi2Te3 Thermoelectric Device
  - Ambient temperature of Lab is about 30°C

Temp (Hot side)	Power max	V open/I short	Remark
100°C	0.64 Watt	2.2V / 1.2A	Without cooling Fan
100°C	1.44 Watt	3.3V / 1.75A	With cooling Fan
150°C	3.65 Watt	5.2V / 2.8A	With cooling Fan
200°C	5.68 Watt	6.7V / 3.39A	With cooling Fan

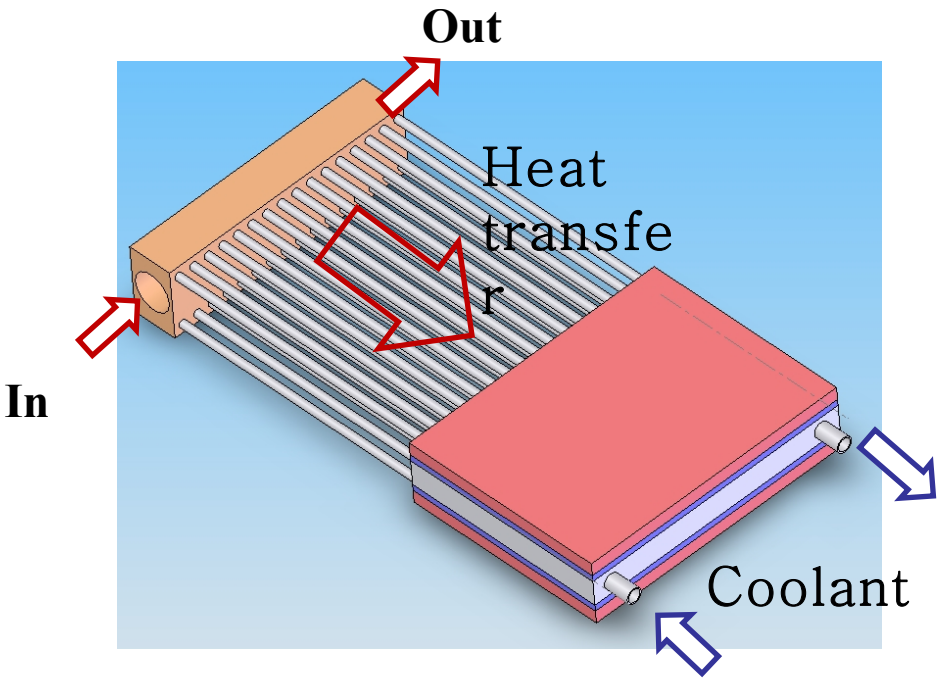
Technical Approaches:TEG-EG

- TEG using Exhaust Gas [1]



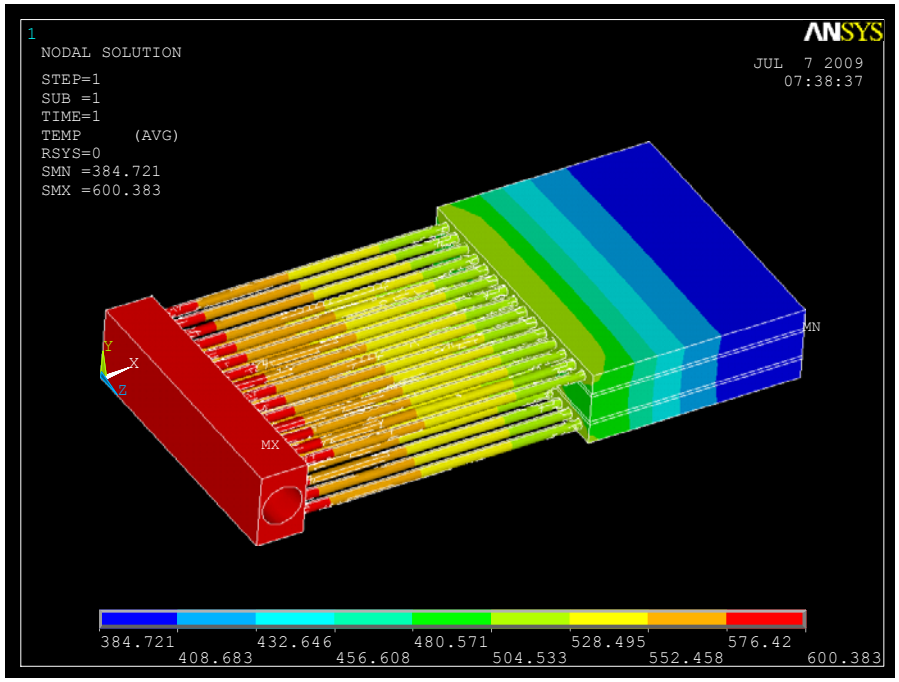
Technical Approaches : TEG-EG cont'd

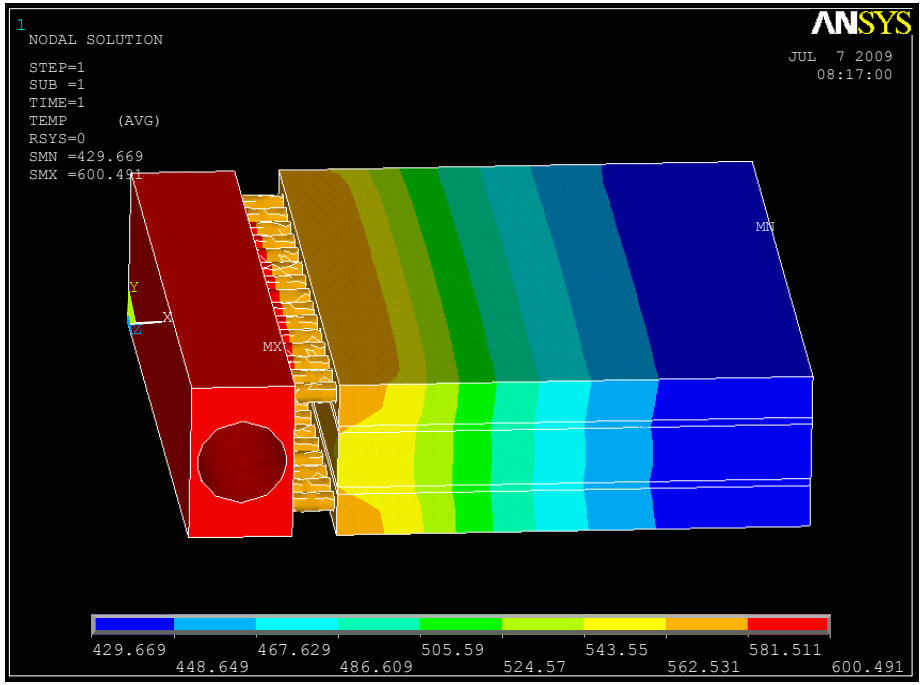
- TEG using Exhaust Gas [1] :
  - modeling for simulation



Technical Approaches : TEG-EG cont'd

- TEG using Exhaust Gas [1] : simulation results

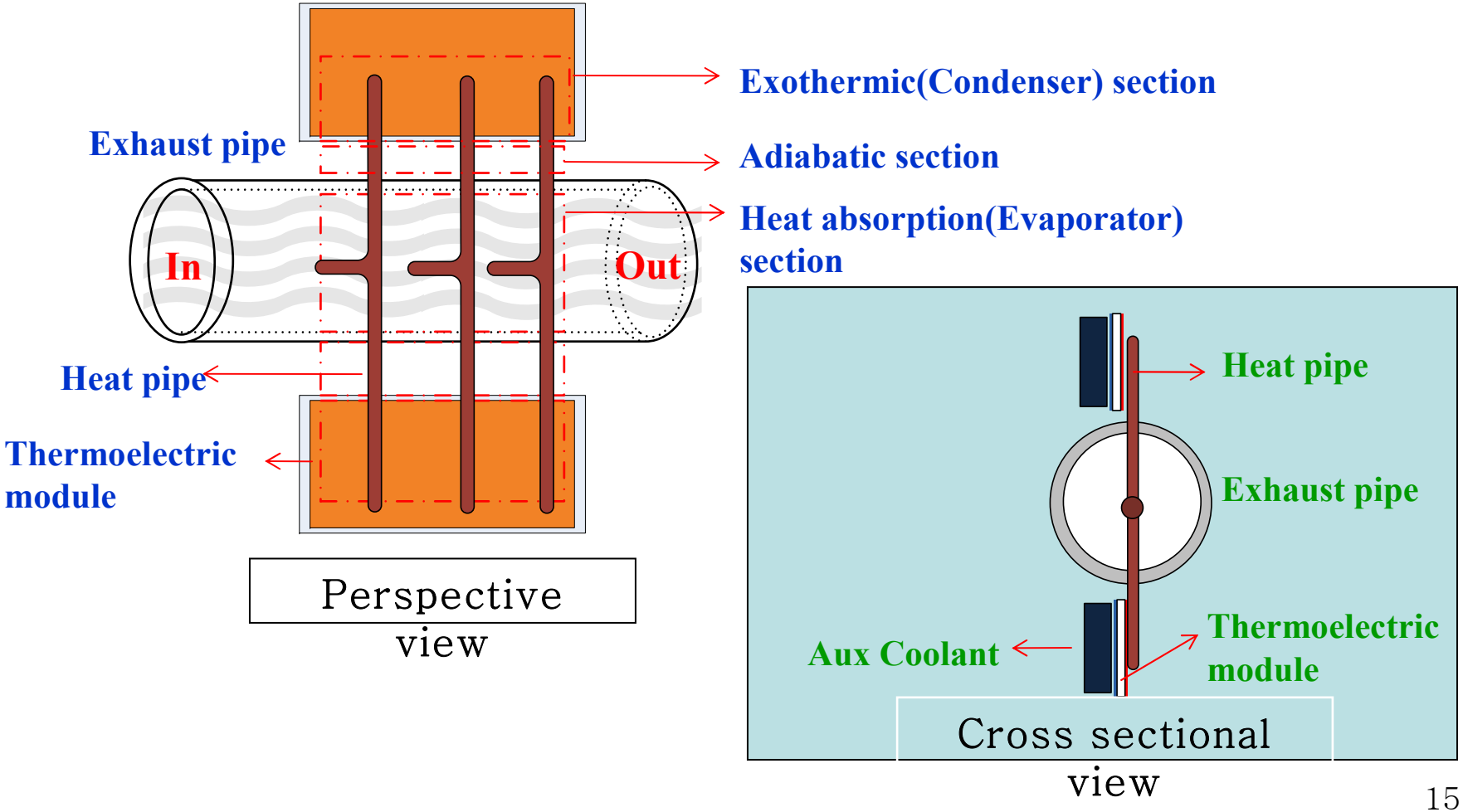




(a) Using long heat pipes, (b) using short heat pipes

Technical Approaches : TEG-EG cont'd

- TEG using Exhaust Gas [2]



RAVERS
Research Center for Advanced Hybrid Electric Vehicle Energy Recovery System

Summary and Further Works

- We have developed a Low and high Temperature Dual Thermoelectric Generation Waste Heat Recovery System
  - For compact size passenger Vehicles
  - Primary high Temperature heat exchanger designed to recover waste heat from the exhaust gas
  - Secondary low temperature Thermoelectric Generator using coolant of a Radiator.
- Manufacturing first Prototype of heat exchanger using Thermosypons will be finished at the end of this year
- Development of superlattice for high temp and low cost TE material as well as environmentally nonhazardous material for Phase II

Thank you for your attention

ACKNOWLEDGMENT

This work was supported by the MKE under the ITRC support program supervised by the IITA(C1090-0904-0007).