Improving Energy Efficiency by Developing Components for Distributed Cooling and Heating Based on Thermal Comfort Modeling

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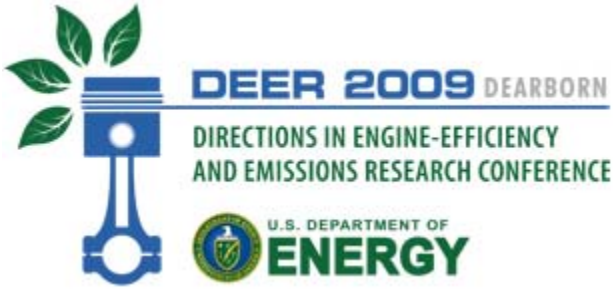

Outline

- ❑ Objectives
- ❑ Milestones
- ❑ Approach
- ❑ Future work
- ❑ Critical Assumptions and Issues
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Overall Objectives

- **Develop distributed HVAC components to supplement the central HVAC system to reduce the energy required by current compressed gas air conditioners by at least one-third**
- **Develop TE HVAC components that have a coefficient of performance > 1.3 for cooling and > 2.3 for heating**
- **Integrate & test in 5-passenger demonstration vehicle**
- **Develop new thermoelectric materials to improve the efficiency of thermoelectric generators for engine waste heat recovery**

Milestones

- **Identify initial set of locations for distributed heating / cooling – September 30, 2009**

Examples of thermal comfort testing (UC-Berkeley)




Approach

- Develop Thermal Comfort model of human responses to potential locations for distributed heating & cooling
- Use Thermal Comfort model to identify an optimal combination of distributed HVAC components (including location and size of thermoelectric units)
- Develop new thermoelectric HVAC components to supplement a downsized central HVAC system
- Integrate & test in 5-passenger demonstration vehicle

Future Work

Work thru FY2010 includes the following Phase I activities:

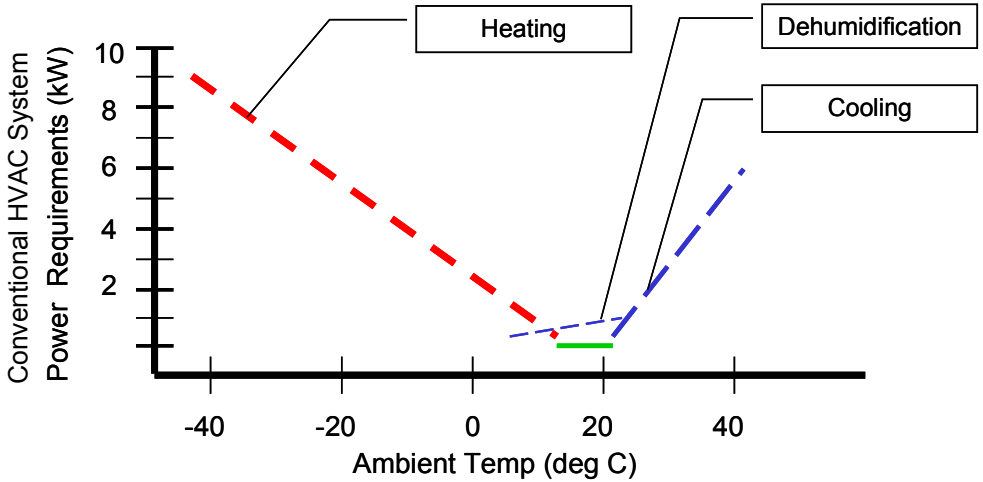
- **Human subject testing to characterize the response to localized heating and cooling of body segments**
- **Expand the existing UC-Berkeley Thermal Comfort model to include potential locations for distributed heating and cooling**
- **Define and perform a Design of Experiments to validate the UC-Berkeley Thermal Comfort model**

Milestones during this period include the following:

- **Definition of Design of Experiments Completed**
- **Build Mule Vehicle for Thermal Comfort Evaluation Completed**
- **UC-Berkeley Thermal Comfort model update released**
- **Identify final set of locations for distributed heating / cooling**

Critical Assumptions and Issues

Q. Why are we only supplementing the HVAC with thermoelectric devices?
Why can't we completely eliminate the conventional A/C compressor?



A. The electrical power required for a thermoelectric-only heat exchanger to provide adequate comfort is quite significant and sometimes not practical.

- Occupants are not satisfied with the cooling effect and even feel clammy, because the thermoelectric does not dehumidify the air. Since the dew point temperature is below the thermoelectric cooling temperature, little to no dehumidification occurs. At very high humidity levels in the occupant cabin, the thermoelectric device will collect condensed moisture without being able to eliminate it. The conventional A/C compressor provides dehumidification for the new distributed HVAC system.

(See Delphi Thermal SAE Paper 2007-01-1193 "Cooling with Augmented Heated and Cooled Seats")

Critical Assumptions and Issues

Q. Why are we spending so much time and effort on the development and validation of UC-Berkeley's Thermal Comfort model?

A. The mathematical model of human response to various potential locations for distributed heating / cooling units allows us to optimize the selection of distributed HVAC system components

- The UCB Thermal Comfort model is the key component of the Virtual Thermal Comfort Engineering process used by both GM and Delphi. This process can be applied to the thermal characteristics of different vehicle models. As technologies and regulations evolve, the optimal solutions specified by the model can be updated to reflect the changes.

Q. Is the enhancement of the Virtual Thermal Comfort Engineering process under this DOE-funded project an exclusive benefit for General Motors?

A. While GM will utilize VTCE for GM vehicles, Delphi has a similar VTCE process that they can apply to the development of HVAC systems for other vehicle OEMs. In addition, the foundation of the VTCE process is the UCB Thermal Comfort model. UC-Berkeley uses their ever-evolving model on projects with other organizations (e.g., NREL) as needed.

(See Delphi Thermal SAE Paper 2007-01-1193 "Cooling with Augmented Heated and Cooled Seats")

Summary

- **This project provides a demonstration of the savings possible from a distributed HVAC system that utilizes thermoelectric components**
- **By developing a Thermal Comfort model of human responses to potential locations for distributed heating & cooling units, the team is able to optimize the specification of distributed HVAC components**