## Overview

### Timeline
- **Project start date:** FY15
- **Project end date:** FY17
- **Percent complete:** 7%

### Budget

**Fully Funded FOA Project**
- **Total project funding:** $3,054,817
  - DOE share: $2,443,790
  - Contractor share*: $611,027
- **Funding received in FY14:** $2,443,790
- **Funding for FY15:** $0

* Contractor share represents 20% cost share for the project

### Barriers
- **Risk Aversion:** Manufacturers are reluctant to invest in and introduce new technologies
- **Cost:** Effective, timely evaluation of advanced vehicular components and configurations is needed.
- **Range Anxiety:** Large climate control loads can contribute significantly to electric drive vehicle (EDV) range anxiety

### Partners
- **Interactions/collaborations:**
  - Hyundai America Technical Center, Inc.
  - Halla Visteon Climate Control Corp.
  - Sekisui Chemical Company, Ltd.
  - Pittsburgh Glass Works, LLC.
  - PPG Industries, Inc.
  - Gentherm Incorporated
  - 3M Company
- **Project lead:**
  - National Renewable Energy Laboratory
Relevance

THE CHALLENGE

• 2014 light-duty vehicle (LDV) fuel use estimated at approximately 3 billion barrels oil

• Increased market penetration of EDVs requires overcoming
  o Original equipment manufacturer (OEM) risk adversity in adopting new technologies
  o Limited vehicle range and associated customer range anxiety
  o Elevated cost of EDVs in comparison to existing conventional vehicles

• Climate control loads can significantly impact EDV range

2. Data Source: Argonne National Laboratory’s Advanced Powertrain Research Facility
Relevance

THE OPPORTUNITY

• Reducing climate control loads can increase vehicle range to
  o Enable battery sizing and cost reductions
  o Reduce climate control equipment sizing
  o Enable advanced heating, ventilation, and air conditioning (HVAC) component technologies

• Load reduction system demonstration decreases OEM risk for adoption

• HVAC load reduction and advanced climate control design can positively impact occupant comfort

Alignment with DOE VTP

• Support vehicle systems key goals for 2011–2015 Program Plan:
  By 2015, develop technologies and a set of options to enable up to 50% reduction in LDV petroleum-based consumption

• Support meeting EV Everywhere Grand Challenge targets
Relevance

THE GOAL

Increase grid-connected electric drive vehicle range by 20% during the operation of the climate control system over the standard vehicle configuration by reducing vehicle thermal loads

• Design and implement the thermal load reduction system on a production drivable vehicle
• Test the range impact over the combined city/highway drive cycle at peak heating and cooling conditions
• Maintain occupant thermal comfort in implemented system
## Milestones 2015

<table>
<thead>
<tr>
<th>FY 2015</th>
<th>FY 2016</th>
<th>FY 2017</th>
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<tbody>
<tr>
<td><strong>M1</strong></td>
<td><strong>M1</strong>: Receive award and hold kickoff meeting</td>
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<td>Tech. Development &amp; Specification</td>
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<td><strong>M2</strong>: Select vehicle platform for Phase I and II evaluation <strong>M3</strong>: Complete summer technology evaluation testing</td>
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<td>Modeling and Analysis</td>
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<td><strong>M3</strong></td>
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<td>Technology Evaluation Testing</td>
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<td><strong>M1</strong></td>
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<td>Project Phase I</td>
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<td>April 1</td>
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<td>Vehicle Integration</td>
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<td>Operational Testing &amp; Validation</td>
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<td>Project Phase II</td>
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</table>
Approach – Two-Phase Process

Individual Technologies
- Glazings
- Zonal HVAC
- Paint
- Insulation
- Seating

Design and Development
- Testing
- Analysis

Integration and Validation
- Down-Selected Technologies
- Validated Models

Full System Impact on Range
- Testing
- Analysis

National Results & Occupant Comfort
- Technology Go/No-Go

Phase I

Phase II
Approach – Testing and Analysis Strategy

Testing
- Individual Technology HVAC Load
- HVAC System Baseline Performance
- OEM Full System Vehicle Performance

Analysis
- Vehicle Cabin Thermal Load Modeling
- HVAC Thermal System Modeling
- Occupant Comfort Modeling
- National Level Range Estimation

Validation Data
Approach – Technology Areas

- Solar Control Glass
- Light-weight Glass
- Solar Control Films
- Heated Windshield
- Grid-connected preconditioning
- Solar Reflective Paint
- Individual Door Glass
- Defrost/Defogger
- Ventilated/Cooled seats
- Heated surfaces around driver
- Cabin Insulation
Accomplishments – Business

• Completion of legal obligations between all parties involved
  o Multiparty nondisclosure agreement
  o Intellectual property management plan

• Subcontracts for the following project partners (in progress as of April 1, 2015):
  o Hyundai America Technical Center, Inc.
  o Pittsburgh Glass Works
  o Halla Visteon Climate Control
  o PPG Industries
  o Sekisui
Accomplishments – Vehicle Platform Selection

The 2016 Hyundai Sonata plug-in hybrid electric vehicle (PHEV)* was chosen to be the vehicle platform for both Phase I and Phase II evaluation and modeling.

Prototype vehicles will be used for Phase I and production vehicles for Phase II.

* Photos above are of the 2015 Hyundai Sonata conventional vehicle
## Accomplishments – Phase I Preliminary Summer Test Plan

<table>
<thead>
<tr>
<th>Configuration</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
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<tbody>
<tr>
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<td>Ventilated/ Cooled Seats</td>
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- **Two-phase air conditioning test** (pull-down & steady-state)

- **Vehicle Cabin Solar Thermal Soak Evaluation**

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In the image, the table outlines various test configurations and their timelines for the summer months from May to September. Each configuration is marked with either a sun or a snowflake icon to indicate the expected weather conditions (sunny or rainy) for each month. The table highlights the implementation of baseline and insulative measures, along with the evaluation of solar reflective paint and combined technologies for thermal management.
Accomplishments – Phase I Summer A/C Test Approach

- Split two-component A/C test approach: pull-down and steady-state
- Energy use calculated as cumulative energy during each time interval
- Decoupled pull-down and steady-state components expected to increase repeatability and isolate technology impact on HVAC loads
Response to Previous Year Reviewer’s Comments

This is the first year of this project and therefore does not have previous year reviewer comments.
Collaboration and Coordination

**Hyundai America Technical Center**
- Subtier Industry Partner
- Automotive OEM Supplier
- Lead on Phase II Technology Integration
- Lead on Phase II Full System Experimental Evaluation
- Technology Supplier (Collaboration with Gentherm)

**Pittsburgh Glass Works**
- Subtier Industry Partner
- Glass Package Manufacturer
- Advanced Glass Technology Supplier

**Halla Visteon Climate Control**
- Subtier Industry Partner
- Baseline HVAC System Experimental Evaluation
- HVAC System Modeling Support
- HVAC System Control Support

**PPG Industries**
- Subtier Industry Partner
- Automotive Paint Supplier
- Advanced Paint Technology Supplier

**Sekisui**
- Subtier Industry Partner
- Advanced Glass Technology Material Supplier

**Gentherm**
- Subtier Industry Partner – In Kind
- Door Defrost/Defog Technology Supplier
- Heated Surfaces Technology Supplier (collaboration)
- Advanced Seating Technology Supplier (collaboration)

**3M**
- Subtier Industry Partner – In Kind
- Advanced Solar Control Film Supplier
- Advanced Insulation Technology Supplier
Proposed Future Work

Phase I: Technology Design and Development (FY15–16)
- Complete summer and winter technology evaluation
- Complete baseline HVAC system performance characterization for HVAC model development
- Continue human comfort, HVAC system, and vehicle modeling for technology evaluation(s) and development of national level framework
- Perform Phase I technology evaluation Go/No-Go for Phase II

Phase II: Technology Integration and Validation (FY16–17)
- Integrate thermal load reduction technologies into drivable vehicle system
- Perform operational cold weather, hot weather, and environmental chamber testing at Hyundai America Technical Center facilities
- Refine models with individual technology experimental results and perform national level analysis
- Final vehicle demonstration and project summary presentation to DOE
Summary

• The project’s focus is to implement a thermal load reduction system into a GCEDV production vehicle in order to demonstrate the combined impact of previous and current work in this research area

• Key industry partners enable production-ready and cost-effective technologies and vehicle-level integration

• A combination of load reduction technologies and zonal climate control strategies are used to meet project goals

• Testing and modeling/analysis are used synergistically to quantify system performance and national relevance
Summary

Accomplishments

• Initiated project with kickoff meeting and coordination on completion of multi-party NDA and IPMP documents
• Subcontract negotiations are in progress (as of April 1, 2015) for five subtier partners
• The 2016 Hyundai Sonata PHEV has been selected for the project vehicle platform
• Phase I summer test planning has been completed and A/C testing procedure identified
Acknowledgements and Contacts

Special thanks to:

- David Anderson and Lee Slezak
  Vehicle and Systems Simulation and Testing

For more information:

Principal Investigator:
Cory Kreutzer
National Renewable Energy Laboratory
Cory.kreutzer@nrel.gov
303-275-3772
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• Slide 19: Dennis Schroeder, NREL