Impacts of Advanced Combustion Engines

Principal Investigators:
Scott Curran, Presenter
Zhiming Gao, David Smith, Stuart Daw


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## OVERVIEW

<table>
<thead>
<tr>
<th>Timeline</th>
<th>Barriers for VSS* and ACE*</th>
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</table>
| • Project start date: Oct. 2013  
• Project end date: Continuing  
• Activity scope changes to address DOE & industry *needs* | • Constant advances in technology (VSS)  
• Computational models, design, and simulation methodologies (VSS)  
• Lack of modeling capability for combustion and emission control (ACE)  
• Lack of actual emissions data on future engines (ACE) |

### Budget (DOE share)
- FY14 funding: $150k
- FY15 funding: $250k

### Partners
- DOE ACE and FLT research projects
- DOE Advanced Engine Crosscut Team
- CLEERS Collaborators
- Oak Ridge National Laboratory
  - Fuels, Engines, & Emissions Research Center
  - Center for Transportation Analysis

*from 2011-2015 VTP MYPP
OBJECTIVE: Evaluate the benefits and challenges of advanced combustion concepts on a vehicle systems basis

“WHY”

- Advanced combustion achieves high thermal efficiency with low engine-out emissions
- Transient/drive cycle benefits and challenges of advanced combustion in light-duty vehicles is not well understood
- Evaluation and analysis are important for supporting U.S. automakers to meet 2025 CAFE standards and EPA Tier III emissions regulations

“HOW”

- Generate experimental steady-state advanced engine maps
- Integrate engine maps into transient vehicle models along with full aftertreatment-trains
- Evaluate fuel economy and emissions of multi-mode combustion using vehicle systems simulations over realistic light-duty drive cycle conditions
- Identify promising paths for improving LD energy efficiency, fuel mileage and emissions with advanced combustion modes in conventional and hybrid-electric vehicle powertrains

“Without aftertreatment constraints in the simulation, the model might allow engine system operation outside the emission-constrained envelope.”

RELEVANCE (1)*

- **Directly** supports ACE R&D program goals including a JOULE level milestone
- **Directly** supports FLT R&D program goals including a JOULE level milestone
- **Directly** supports 3 VSS cross-cutting activities:
  - Modeling and simulation; component & systems evaluations; vehicle systems optimization.
- **Directly** supports US Drive ACEC/VSATT activities
- **Addresses the following VSS Barriers (2.2.1 e,f):**
  - Computational models, design and simulation methodologies
  - Constant advances in technology.
- **Addresses the following ACE/FLT Barriers (2.3.1 a,c,d,f):**
  - Lack of fundamental knowledge of advanced combustion regimes
  - Lack of modeling capability for combustion and emission control
  - Lack of effective engine controls for LTC
  - Lack of actual emissions data on future engines

*Reference: Vehicle Technologies Multi-Year Program Plan 2011-2015:
**RELEVANCE (2):** Exploits knowledge and tools generated in other parts of the Vehicle Technologies Office and Office of Science for VSS

- **Automotive Component Level Model Development (Engine-Input Ready)** [capable in real engine exhaust]
- **Coated Catalyst (Automotive Product) Studies & Model Development** [based on controlled simulated exhaust]
- **PreCompetitive R&D** [Catalyst chemistry studies for new formulations (e.g., low-temperature catalysts)]
- **CLEERS** [Collaboration, Kinetics measurement, model development]
- **Lean Emissions R&D** [Engine-based catalyst studies & model validation for advanced lean engines]
- **Advanced Combustion R&D** [Engine-based combustion mode & stretch efficiency modeling, analysis, & demonstration]
- **EERE Advanced Combustion & Fuels**
- **EERE Vehicle Systems Simulation**
- **Vehicle System Models Accountable for Emissions**
- **Office of Science**
  - **Industry Access to Specialized Tools & Data**
  - **Basic Combustion and Surface Chemistry Measurement & Modeling** [CRF, CNMS, HTML, EMSL]
## Milestones

All Milestones Completed or On-Track

<table>
<thead>
<tr>
<th>Date</th>
<th>Milestone/Deliverables</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec 2014</td>
<td>Hardware-in-the-loop transient support for ACE and FLT advanced combustion projects</td>
<td>Completed</td>
</tr>
<tr>
<td>April 2015</td>
<td>Vehicle level simulation support for advanced combustion including after treatment modeling including multi-mode operation</td>
<td>Completed</td>
</tr>
<tr>
<td>June 2015</td>
<td>Vehicle level simulation support for octane optimized vehicle for renewable super premium project</td>
<td>On track</td>
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</tbody>
</table>

**Engine Efficiency**

**Emissions Aftertreatment**

**System Integration**

**Fuel Economy**
APPORACH (1): Vehicle Systems Simulations with Advanced Combustion

- **Advanced combustion engine maps for use in vehicle systems simulations**
  - Steady-state advanced combustion engine maps from dynamometer measurements with exhaust species
- **Evaluate advanced combustion engine operation in conventional and hybrid LD powertrains**
  - Fuel economy potential of advanced combustion engine multi-mode concepts
- **Evaluate the effect of fuels on advanced combustion engine drive cycle coverage**
  - Complete drive-cycle coverage has implications on aftertreatment requirements for multi-mode operation

![Diagram showing the integration of different measurement and simulation techniques in vehicle systems development](image)
Approach: Multi-cylinder investigations of LTC including aftertreatments leading to vehicle systems simulations

- GM 1.9 ZDTH Diesel Engine with dual-fuel system
- Emissions characterization and aftertreatment evaluation
- Vehicle systems simulations using experimental data/ HIL experiments

Multi-cylinder engine
- GM 1.9L ZDTH
- Dual Fuel (DI + PFI)

Emissions controls
- Aftertreatment
- PM/HC characterization

Transient Capable AC Dyno

Microprocessor based control system

DSPACE Hardware-in-the-loop

US Drive Guidelines

VSS140

AUTONOMIE Simulink®/ Stateflow

Rest of Vehicle Simulated
## Technical Accomplishments – Summary 2014

<table>
<thead>
<tr>
<th>Tasks</th>
</tr>
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<tbody>
<tr>
<td>1 Model fuel economy potential of RCCI using vehicle systems simulations</td>
</tr>
<tr>
<td>2 Update and refine multimode CDC/RCCI engine maps in collaboration with ACE</td>
</tr>
<tr>
<td>3 Conduct fuel economy simulations of RCCI-enabled HEVs in city and highway cycles</td>
</tr>
<tr>
<td>4 Compare and evaluate fuel economy and emissions control among RCCI and other HECC engines in HEVs/PHEVs</td>
</tr>
<tr>
<td>5 Update DOC catalyst models for multi-mode RCCI combustion for both CDC and RCCI conditions</td>
</tr>
<tr>
<td>6 Estimations for the Aftertreatment efficiency needed for EPA Tier III standards for RCCI, CDC, lean-GDI</td>
</tr>
<tr>
<td>7 FY 15 Model fuel economy potential of RCCI using vehicle systems simulations (on-track)</td>
</tr>
</tbody>
</table>
Accomplishment (1.1) FY 14 Supporting Accomplishments: ACE/FLT

This project supports other VTO programs leveraging activities in meeting VTO goals

• Support FLT R&D Program FY 14 Q2 JOULE Milestone
  – Drive Cycle Expansion Enabled by Biofuels – Completed
  – Demonstrate an increase in the RCCI operating range due to the use of renewable fuels allowing 75% coverage of non-idling portions of the city (UDDS) and highway (HWFET) light-duty federal drive cycles
  – Vehicle systems simulations used to model drive cycle coverage

• Support ACE R&D Program FY 14 Q4 JOULE Milestone
  – RCCI Fuel Economy Modeling - Completed
  – Demonstrate improved modeled fuel economy of 25% for passenger vehicles solely from improvements in powertrain efficiency relative to a 2009 PFI gasoline baseline
  – Vehicle systems simulations used to model fuel economy
Accomplishment (1.2) Vehicle Systems Simulation Using Experimental Engine Data

Vehicle system modeling using experimental/industry engine maps on same vehicle in Autonomie.

• **Base vehicle**
  - Mid-size passenger sedan, 1580kg, Automatic transmission
  - Transmission shifting optimized for fuel economy for each engine (BackUp)

• **Engine maps based on steady state experimental data**
  - 1.9L, Q3 RCCI Map – ORNL Experimental map from Q3 Joule milestone
  - 1.9L, Diesel Map (CDC) Experimental ORNL map
  - 1.8L, 2.4L, 2.7L and 4.0L, 2009 PFI Maps – Automotive OEM supplied

• **Multi-mode RCCI/Diesel strategy used**
  - RCCI map covers most of light-duty drive cycles
  - Must switch to diesel mode outside of RCCI envelope
  - Mode switching behavior not accounted for in this study (perfect step change)

AUTONOMIE

Engine map includes:
- Fuel consumption
- E/O temperature
- E/O NOx, HC, CO,
Accomplishment (1.3) Developed Multi Mode Strategy

- Combustion mode switching may be required for complete map coverage
- Self-imposed boundary conditions used to keep implementations realistic
  - High Load – cylinder pressure raise rate
  - Low Load – CO and HC limit
- First order lag approximations used to model mode switching
Accomplishment (1.4) Modeled RCCI Drive Cycle Fuel Economy

- Modeling results show up to a 22 - 28% improvement in fuel economy with RCCI over UDDS compared to 2009 PFI baseline on same vehicle
- ORNL chassis dyno and EPA fuel economy data mined for other PFI engine sizes
ACCOMPLISHMENT (1.5) Q4 RCCI Fuel Economy Modeling
Providing Insights Into Drive Cycle Coverage + Fuel Economy

- RCCI fuel economy improvements despite lack of complete drive cycle coverage (Further development possible)
  - UDDS = 62.7% drive cycle coverage by distance
  - HWFET = 62.8% drive cycle coverage by distance
  - Hardware changes being considered (FY 15)

- Results based on steady state engine data
  - Does not currently address transient operation (FY 15)

- Does not address aftertreatment effectiveness
  - Ongoing research at ORNL

Modeled RCCI fuel economy improvements compared to PFI baselines

<table>
<thead>
<tr>
<th>Cycle/PFI Baseline</th>
<th>1.8L</th>
<th>2.4L</th>
<th>2.7L</th>
<th>4.0L</th>
</tr>
</thead>
<tbody>
<tr>
<td>UDDS RCCI improvement</td>
<td>30.1%</td>
<td>28.1%</td>
<td>42.6%</td>
<td>55.7%</td>
</tr>
<tr>
<td>HWFET RCCI improvement</td>
<td>36.1%</td>
<td>31.5%</td>
<td>40.0%</td>
<td>49.3%</td>
</tr>
</tbody>
</table>
Accomplishment (2.1) Simulations show high potential for RCCI to further improve fuel economy with hybrid configurations

- Though power density of RCCI is limited requiring multi-mode strategy for full drive cycle coverage
- There may be opportunities for decoupling engine speed and load from drive cycle requirements through vehicle electrification
  - Help ensure engine operates in efficiency “sweet spot”
- Could allow RCCI multi-mode to maximize fuel economy and minimize NOx emissions (next slide)

BTE Delta with RCCI compared to CDC

<table>
<thead>
<tr>
<th>Powertrain</th>
<th>UDDS</th>
<th>BTE</th>
<th>Hybrid Powertrain</th>
</tr>
</thead>
<tbody>
<tr>
<td>UDDS</td>
<td>39MPGGE</td>
<td>72MPGGE</td>
<td></td>
</tr>
</tbody>
</table>

Conventional Powertrain

Hybrid Powertrain
Accomplishment (2.2) Engine-out emissions simulations provide insight in integration challenges

- RCCI compared to stoich-PFI, CDC and lean-GDI
  - Better representing ACEC technology portfolio
  - Conventional powertrains and hybrid powertrain considered

- Simulated conventional vehicle drive-cycle engine-out emissions. Compared to PFI, lean GDI achieves substantially less NOx and CO emissions while producing higher HC and PM emissions.
  - Thus, enabling RCCI to meet Tier 3 regulations will require high HC oxidation efficiency by catalysts while lean GDI engines will require high NOx reduction efficiency in lean operation.

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Conventional</th>
<th>Power-split HEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine</td>
<td>PFI/GDI/CDC/RCCI*</td>
<td>PFI/GDI/CDC/RCCI*</td>
</tr>
<tr>
<td>Motor</td>
<td>N/A</td>
<td>PM Motor, 78kW@6500rpm, 275V</td>
</tr>
<tr>
<td>Battery</td>
<td>Std. ignition battery only</td>
<td>NiMH 275 V/ 1.5 kWh</td>
</tr>
<tr>
<td>Transmission/Gear</td>
<td>6-speed manual</td>
<td>Planetary Gear[30/78]</td>
</tr>
<tr>
<td>Final drive ratio</td>
<td>3.56</td>
<td>3.56</td>
</tr>
<tr>
<td>Wheel radius</td>
<td>0.332 m</td>
<td>0.332 m</td>
</tr>
<tr>
<td>Front area</td>
<td>2.25 m²</td>
<td>2.25 m²</td>
</tr>
<tr>
<td>Mechanical accessory load</td>
<td>200 W</td>
<td>50 W</td>
</tr>
<tr>
<td>Electrical accessory load</td>
<td>100 W</td>
<td>200 W</td>
</tr>
</tbody>
</table>
Accomplishment (2.3) Impact of aftertreatment systems on emissions control in RCCI-enabled HEVs/PHEVs

- **Simulated ORNL aftertreatment devices and systems**
  - CO and HC oxidation: DOC
  - NOx reduction: LNT or SCR
  - PM trapping and oxidation: DPF
  - Aftertreatment systems: DOC/LNT/DPF or DOC/SCR/DPF

- **Simulated driving cycle for emissions control: FTP75**
  - Cold start transient phase

- **Modeling results of the potential tradeoff between the LNT regen fuel penalty and NOx tailpipe emissions**
  - The solid markers are CDC/RCCI and the open markers are CDC.

![Diagram of aftertreatment systems](image)
Accomplishment (2.4) Exhaust Temperature effects

- Improved Fuel Economy via improved fuel efficiency results in lower engine out temperatures
- Particular challenge for competing needs for advanced combustion
  - Enthalpy needed to drive turbo-machinery
  - Sufficient temperatures needed to maintain catalyst effectiveness
  - Anticipates direction for LT Catalyst Research - ACEC report to be issued soon

Leveraging ACE research into catalyst light-off with RCCI

Prikhodko, V., et al., "Effectiveness of Diesel Oxidation Catalyst in Reducing HC and CO Emissions from Reactivity Controlled Compression Ignition," SAE Int. J. Fuels Lubr. 6(2):329-335, 2013,
Accomplishment 5: Update DOC catalyst models for multi-mode RCCI combustion

- **Fitted reaction rates of CO/HC/NO oxidation as a function of the DOC operating temperature**
  - The reaction rates were optimized using MATLAB® optimization functions for each DOC performance at 1500rpm and 3000rpm engine series operations
  - The slope and intercept can be used as active energy and pre-exponential factor

- **Critical to update moving forward simulating aftertreatment effectiveness with RCCI multimode (CDC complete – currently working on RCCI data)**
  - Simultaneously high HC and CO with lower temperatures effects with RCCI not well understood for DOCS (competing)
  - Not only the amount of HC and issue but the composition of RCCI HC for DOCS developed for CDC HC, CO and Temps
  - DOC light-off criteria being incorporated into next multi-mode control strategy (critical for Tier III standards HC+NOx)

**Comparison of the simulated and measured CO/HC oxidation efficiency with CDC**

- In coordination with CLEERS Activity
  - ACE022 CLEERS Analysis and Coordination
Accomplishment 6: Estimations for the Aftertreatment efficiency needed for EPA Tier III standards

- Examine how these technologies compare in their achievement of the new U.S. EPA Tier 3 emission standards.
- These standards require the fleet average CO, non-methane organic gases (NMOG) + NOx, and PM emissions to reach 1.0 g/mile, 30 mg/mile, and 3.0 mg/mile (i.e., Tier 3 Bin 30), respectively, by 2025.

<table>
<thead>
<tr>
<th>Combustion</th>
<th>Type</th>
<th>CO reduction</th>
<th>NMOG+NOx reduction</th>
<th>PM reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFI</td>
<td>Conv.</td>
<td>87.2%</td>
<td>99.4%</td>
<td>0.0%*</td>
</tr>
<tr>
<td></td>
<td>Hybrid</td>
<td>79.2%</td>
<td>99.2%</td>
<td>0.0%*</td>
</tr>
<tr>
<td>Lean GDI</td>
<td>Conv.</td>
<td>81.0%</td>
<td>99.3%</td>
<td>34.3v</td>
</tr>
<tr>
<td></td>
<td>Hybrid</td>
<td>74.0%</td>
<td>99.1%</td>
<td>0.0%*</td>
</tr>
<tr>
<td>CDC/RCCI</td>
<td>Conv.</td>
<td>84.2%</td>
<td>99.1%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Hybrid</td>
<td>66.8%</td>
<td>98.6%</td>
<td>-</td>
</tr>
<tr>
<td>CDC-only</td>
<td>Conv.</td>
<td>75.1%</td>
<td>98.2%</td>
<td>82.6%</td>
</tr>
<tr>
<td></td>
<td>Hybrid</td>
<td>0.0%*</td>
<td>96.8%</td>
<td>85.9%</td>
</tr>
</tbody>
</table>

* meets the emission standard without aftertreatment.
Accomplishment (7) FY 15 Supporting Simulations On Track Supporting Advanced Combustion Engines Milestones

- **Q3 Milestone – High Efficiency RCCI Mapping**
  - Develop RCCI multi-mode combustion map on a multi-cylinder engine suitable for light-duty drive cycle simulations
    - Transient effects on light-off effects

- **Q4 Milestone – RCCI Vehicle Systems Modeling**
  - Demonstrate modeled fuel economy improvement of 30% for passenger vehicles solely from improvements in powertrain efficiency relative to a 2009 PFI gasoline baseline
    - Perform drive cycle simulations on same vehicle platform to estimate fuel economy and engine out emissions
Responses to Previous Year Reviewer Comments

Positive Comments
- Reviewers noted the project demonstrates excellent coordination and collaboration with VTO Advanced Combustion Engines, Fuels & Lubricant Technologies and VSST
- Reviewer stated that the ideal activity for a national laboratory is to explore and define advanced technology and transfer to industry.
- Reviewers noted strong technical approach and growth strategy with good relevance to industry with cooperative relationships through crosscut committee
- Sound approach taken in support of 2025 CAFE standards
- Excellence relevance of work, excellent progress has been made for the funding level of the project

Addressing Questions/ Recommendations from 2014 Reviewers
- Reviewers noted that there should be more parallel validation of the model against advanced systems under test at OEMs or at DOE labs
  - Very good point – first step was taken to evaluate an RCCI hybrid at ORNL and FORD chassis dyno labs to validate models under ACE subprogram
- Reviewers encouraged more OEM/ Powertrain suppliers as partners to enable model verification and validation
  - Already working with OEM on baseline PFI maps – starting to work with more on model validation
  - Slide 17 shows model validation to real vehicles + AEJ paper did more comparisons (ANL D3 Database)
- Reviewer requested acronym list
  - FY 15 Slides include in backup

Comments cited above were paraphrased as appropriate from 2014 Annual Merit Review document, http://www1.eere.energy.gov/vehiclesandfuels/pdfs/merit_review_2012/2012_amr_04.pdf
COLLABORATION AND COORDINATION

- USDRIVE Advanced Combustion and Emissions Control Technical Team
- DOE Advanced Engine Crosscut Team
  - Crosscut Lean Exhaust Emissions Reduction Simulation (CLEERS) Focus Group Collaborators
- VTO and BES programs at ORNL supporting basic emission control component R&D
- Large network of industry and university partners
- Related ORNL Activities
  - Advanced LD Engine Systems and Emissions Control Modeling and Analysis (VSS041)
  - High Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines (ACE016).
  - Fuel Effects on Emissions Control Technologies (FT007).
Remaining Challenges and Barriers

Challenges

• Need for transient LTC validation for approach

• Need to validate exhaust emissions against actual transient LTC operation
  – Current collaboration with the university of Wisconsin RCCI Hybrid team for test validation

• Applicability of current aftertreatment models to LTC exhaust including PM
  – Being addressed at ORNL with ACE research on multi-cylinder engines

Barriers

• Lack of production LTC modes being addressed by this project on a vehicle systems basis
PROPOSED FUTURE WORK

**FY2015**

- Continue working closely with the ORNL-FEERC experimental teams to improve the low-temperature and RCCI exhaust HC/CO response of DOC catalyst models and NOx reduction device models based on the latest available experimental catalyst and device data.
- Continue improving and validating the ORNL methodology for adjusting steady-state engine-out emissions maps to account for drive cycle transients using the most recently available dynamometer data.
- Refine simulations of fuel economy, engine-out, and tailpipe-out emissions for RCCI-enabled HEVs and PHEVs in city and highway driving.
- Utilize experimental data for refinement of aftertreatment component models including low-temperature catalyst in support of ACEC goals.
- Integration of transient engine data for refinement of multi-mode engine model.
SUMMARY: VSST collaboration with the VTO ACE and FLT programs enhances the U.S. DOE mission of improving vehicle energy efficiency within emissions constraints

- Significant progress has been made toward simulating fuel consumption and emissions for advanced combustion
- Focused on investigating fuel economy potential of LTC using comprehensive engine systems approach
  - Multi-cylinder advanced combustion experiments
  - Aftertreatment integration
  - Vehicle systems level modeling
- Collected and integrated 1.9L GM dual-mode CDC/RCCI engine map into transient engine model enabled to switch CDC and RCCI
- Simulated LD hybrid vehicle powered by an RCCI-enabled engine over realistic driving cycles
- We continue to expand the capabilities of our engine and aftertreatment models to enhance their accuracy, flexibility, and relevance to the most advanced engine and emissions technology

**FUEL ECONOMY**

**2025 CAFE Standards**
(U.S. EPA and U.S. NTSA standards)

The fleet-wide average will be 54.5 MPG
ACKNOWLEDGEMENTS

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Gurpreet Singh, Ken Howden, Leo Breton and Kevin Stork
of the United States Department of Energy Vehicle Technologies Office ACE and FLT programs

Contacts
Zhiming Gao
Project Principal Investigator
Fuels, Engines, and Emissions Research Center (FEERC)
(865) 946-1339
gaoz@ornl.gov

Scott Curran
Project Co-Investigator
Fuels, Engines, and Emissions Research Center (FEERC)
(865) 946-1522
curransj@ornl.gov

P.T. Jones
Program Manager
Advanced Vehicle Systems
(865) 946-1472
jonespt@ornl.gov
Backup Slides
Background: Dual-fuel Reactivity Controlled Compression Ignition (RCCI)

- Reactivity controlled compression ignition (RCCI) allows precise reaction and heat-release control
  - A low-reactivity fuel is introduced early and premixed with air.
  - A high-reactivity fuel is injected into the premixed charge before ignition.

- RCCI increases engine operating range for premixed combustion
  - Global fuel reactivity (phasing)
  - Fuel reactivity gradients (pressure rise)
  - Equivalence ratio and temperature stratification

- RCCI offers both benefits and challenges to implementation of LTC
  - Diesel-like efficiency or better
  - Low NOx and soot
  - Controls and emissions challenges
**APPRAOCH Details**: ORNL’s comprehensive approach to vehicle systems research

- **2007 GM 1.9-L multi-cylinder diesel engine**
  - OEM (CR 17.5) and modified RCCI pistons (CR 15.1)
  - Dual-fuel system with PFI injectors

- **Aftertreatment integration & emissions characterization**
  - Modular catalysts / regulated and unregulated emissions

- **Vehicle systems simulations using Autonomie**
  - Create multi-mode engine maps and controls
  - Experimental engine maps used for drive cycle simulations
  - Comparison between 2009 PFI, diesel and diesel/RCCI
  - Multi-mode (RCCI to conventional diesel combustion) used for areas of the drive cycle outside the RCCI operating range

- **Model Details**
  - Simplified low-order correction methodology to estimate transient exhaust properties from steady-state engine maps (*Gao et al., Int. J. Engine Res., 11(2), 2010*)
Assess benefits of using passive sorbent traps to reduce NOx and HC emissions in RCCI-enabled LD hybrids

- Cold start and repeated engine off delay catalyst heat-up, leading to significant CO, HCs, and NOx emissions
  - Significant cold start impact in HEVs and PHEVs
  - HEVs and PHEVs engine intermittent operation
- Significant HCs released from RCCI
  - Lower-load exhaust temps < 260°C
- Sorbent trapping is an innovative technology
- Our approach and plan for this simulation
  - Update our previously published passive sorbent trap models
  - Implement and demonstrate adsorber model in Autonomie
  - Simulate the potential benefits of using a passive adsorber device to reduce the NOx and HC tailpipe emissions during initial cold-start and repeated engine restarts
List of References for the VSST models

• Transient Engine Simulation Methodology

• DOC/DPF/SCR Component models

• HD Hybrid Truck Simulation

• Advanced Diesel Combustion Simulation
Acronym list

- ACE = Advanced Combustion Engines Subprogram
- ACEC = Advanced Combustion and Emissions Controls Technical Team
- CAFE = Corporate Average Fuel Economy
- CDC = Conventional Diesel Combustion
- DI = Direct Injection
- DOC = Diesel Oxidation Catalyst
- DPF = Diesel Particulate Filter
- FLT = Fuels and Lubricant Technologies Subprogram
- GM = General Motors
- FEERC = ORNL Fuels Engine and Emissions Research Center
- HEV = Hybrid Electric Vehicle
- PFI = Port Fuel Injection
- PM = Particulate Matter
- LD = Light-Duty
- LTC = Low Temperature Combustion
- LNT = Lean NOx Trap
- LT = Low Temperature
- ORNL = Oak Ridge National Laboratory
- RCCI = Reactivity Controlled Compression Ignition
- SCR = Selective Catalytic Reduction
- UDDS = Urban Dynamometer Driving Schedule
- VSI = ORNL Vehicle Systems Integration Laboratory
- VSS = Vehicles Systems & Simulations
- VTO = Vehicle Technologies Office