Vehicle Energy Management - includes Keynote Presentation by Martin Pischinger, FEV Inc.

Session Code: EMS100
Room Erie, Ontario, Huron

9:00 a.m. ORAL ONLY

Keynote Presentation: Vehicle Energy Management - Challenges and Opportunities

This presentation will give insight on how vehicle energy management tasks and strategies were developed and evolved within his organization. It will also address the roles of the OEM and their hybrid system component suppliers in energy management.

Martin Pischinger, FEV Inc.

Monday, October 21

Expert Panel Discussion: Total Vehicle Energy Management

Session Code: EMS700
Room Erie, Ontario, Huron

The panelists will present information and provide insight related to 48V Systems, Vehicle Weight Saving Technologies, Tire Road-Load Reduction, 'Smart' Electrical Load / Recharge Management, and Advanced Guidance Systems for traffic flow management.

Chairpersons - Dan Boxeth, Nizar Trigui, Ford Motor Co.
Panelists - Rajat Aggarwal, Michelin Americas R & D Corp.; Erica Klampfl, Ford Motor Co.; Ronald P. Krupitzer, AISI Steel Market Development Institute; Scott R. Pajtas, Michelin North America Inc.; Joachim Wolschendorf, FEV Inc.;

9:00 a.m. ORAL ONLY

Importance of Low Rolling Resistance Tires in Reducing Energy Consumption of Future Vehicles

According to World Energy Outlook 2010, about 27 percent of the total energy consumed worldwide is used for road transport. Under the pressure of dramatic CO2 reduction objectives, the vehicle technologies are evolving rapidly with an objective to reduce energy consumption by increasing overall powertrain efficiency and reducing the need for power. Apart from improving the engine and drivetrain efficiency, the vehicles are now shifting from internal combustion engine to hybrid and fully electric technology. The need for power can be reduced by reducing vehicle inertia, rolling resistance and aerodynamic drag. Of the fuel used by passenger cars today, up to 20 percent is directly related to tire rolling resistance. The National Highway Traffic Safety Administration is working to finalize a new regulation for the US that will establish consumer information and labeling requirements for tire performances namely Rolling Resistance, Traction and Wear. This presentation aims at understanding Rolling Resistance and its impact on fuel consumption for different powertrain architectures. It also discusses the contribution of tire to overall vehicle inertia and aerodynamic drag of the vehicle.

Scott R. Pajtas, Michelin North America Inc.; Rajat Aggarwal, Michelin Americas R & D Corp.
Total Vehicle Energy Management

All Automotive manufacturers are faced with a future where regulators and consumers will demand that automotive products consume less fuel while delivering increasing capabilities, all at an affordable cost. In other words, future vehicles will have to demonstrate that their impact on global resources is "sustainable." This presentation outlines the strategic case for sustainability looking at three stakeholders: shareholders, consumers and society as a whole. Additionally, this presentation explores key areas of the vehicle itself, outside of the Powertrain and/or Hybrid system that contribute to how efficiently energy is utilized. Intelligent, strategic planning and tactical implementation of methods and technologies in these areas will enable new powertrain technologies to be utilized to their maximum potential as part of delivering both a sustainable product to the consumer and a sustainable business for the foreseeable future.

Nizar Trigui, Dan Boxeth, Ford Motor Co.

The Significance of Materials in Total Vehicle Energy and Life-Cycle Emissions Management

The recent corporate average fuel economy (CAFE) and emissions regulations scheduled through 2025 have sparked a full-court press by carmakers and suppliers in nearly all areas of vehicle technology to achieve compliance. While powertrain efficiency gains are clearly a priority, improvements in other fields to reduce vehicle energy demands are also important. Materials, particularly those capable of reducing vehicle mass, can make significant contributions to vehicle fuel economy. The complete role of materials in managing life-cycle energy and emission is best accomplished with life-cycle assessment (LCA) which accounts for the energy and emissions associate with the manufacturing, use, and end-of-life phases of a vehicle. Examples are given of how LCA can avoid unintended consequences as we make vehicles more fuel efficient.

Ronald P. Krupitzer, AISI Steel Market Development Institute

Mobility’s influence on Advanced Guidance Systems

The city ecosystem and urban consumer needs are driving a transition from traditional driving to broader adoption of advanced guidance technologies. The urban environment is transforming itself: trends in populations, pressures on resources, and the incredible increase in data/computing are shaping new responses to the relevant issues of transportation networks and traffic within the city. These trends and market responses are democratizing data and city infrastructure to improve use of the city. This presentation will review a few relevant mobility trends from the city that are affecting advanced guidance systems.

Erica Klampfl, Eric Wingfield, Ford Motor Co.

Vehicle Level "Smart" Electrical Load / Recharge Management

As the future fuel economy requirements are becoming increasingly challenging, every possible consumer of energy in the vehicle needs to be optimized. Even without extensive electrification of the vehicle, the electric system offers the potential for fuel economy gains. This presentation will review some opportunities for the electric system optimization, and will compare actual vehicle data.

Joachim Wolschendorf, FEV Inc.
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| 1:00 p.m. | ORAL ONLY | **Safe, Cost Effective, and Environmentally Friendly Energy for Micro and Mild Hybrids**<br>East Penn Manufacturing Company, Inc. has developed advanced lead acid technology suitable for hybrid vehicles. These batteries are safe. They are cost effective compared to other competing technologies. They are environmentally friendly since they are nearly 100% recyclable.

Perry Kramer, East Penn Mfg Co. Inc. |
| 1:30 p.m. | ORAL ONLY | **New Driving Experience: Start/Stop Coasting**<br>Today’s Start/Stop systems reduce CO2 emissions by avoiding the combustion engine’s drag torque as the vehicle comes to a stop. Start/Stop Coasting aims at avoiding the engine’s drag torque during coasting conditions. This is achieved by decoupling the combustion engine from the powertrain and by turning it off.<br>The driver experiences Start/Stop Coasting by an increased rolling distance, by the tachometer indicating zero engine speed and by a vehicle coasting without engine noise: a feeling almost comparable to electric driving in a hybrid vehicle.<br>Avoiding engine friction during coasting phases results in a real life fuel consumption benefit of about 10 percent. This number can be even higher, rewarding predictive and economic drivers, who put more focus on using vehicle coasting phases. This benefit goes up with bigger engines that have inherently higher friction. And this benefit is in addition to the advantages of today’s Start/Stop technology.<br>Bosch develops and offers vehicle solutions for Start/Stop Coasting, covering all relevant vehicle aspects like engine starting technology, powertrain controls or solutions for power nets.|

Norbert Mueller, Robert Bosch GmbH |
| 2:00 p.m. | ORAL ONLY | **Bridging the Gap between Start-Stop and Vehicle Electrification**<br>Current and future regulations for more fuel economy and reduced emissions are driving significant change in the automotive industry. But are the tests measuring that change gauging the correct markers or evaluating the wrong things? Why are incentives going to niche markets instead of unlocking value for mainstream consumers? And which technology isn’t getting all the hype but will get a majority of the market? Johnson Controls, the world’s largest automotive battery manufacturer, will talk about advancing the energy storage industry by challenging the status quo in battery development.|

Jason Roberts, Johnson Controls Power Systems |
| 2:30 p.m. | ORAL ONLY | **Supporting Electrical System Power Requirements using Regenerative Braking Energy with Ultracapacitor Storage**<br>Current fuel economy regulations necessitate a variety of approaches to meet increasingly stringent requirements. A variety of approaches are being implemented across the automotive industry, including improvements in engine efficiency, hybrid powertrains, start/stop systems, and mass reduction. One promising approach is the use of regenerative braking energy to support the needs of the vehicle electrical system. These types of systems have been introduced in both passenger cars and transit buses, and can provide up to a 10% improvement in fuel economy. An essential component of these systems is the electrical storage device, and ultracapacitors are uniquely suited to this application. This paper will show the potential improvements in fuel economy available with such a system and survey the systems currently in production.|

David Wright, Charles H. Cook, Maxwell Technologies |
Monday, October 21

Electric Power Management

Session Code: EMS800
Room Erie, Ontario, Huron

Session Time: 3:30 p.m.

Increasing requirements from industry, the end consumer and legislations are driving the demand for highly efficient and adaptive generation, storage, charging of energy in vehicles. These issues, including new alternatives for electric and hybrid vehicle applications are addressed in this session.

Chairpersons - Varsha K. Sadekar, Mark J. Rychlinski, General Motors Co.

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<td>ORAL ONLY</td>
<td>Daisy Chain based Battery Management System for Lithium Ion Batteries</td>
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In order to make electric mobility affordable for the mass market, the price of battery systems must continue to decrease. The cost reduction is a cross-cutting concern. In the field of electronics, new technologies and architectural approaches provide cost-savings and a high degree of standardization.

In this article we address a new communication architecture between the battery management system ECU and the cell measurement units. A Daisy Chain communication offers major benefits over traditional CAN-based solutions. Our approach results not only in the reduction of components, complexity and installation space, but also in an advanced architecture of the CMU as well.

Carsten Hoff, HELLA
4:00 p.m.  ORAL ONLY  

**Road Load Based Energy Management Strategy for a Parallel-Through the Road Military Hybrid Prototype Vehicle**

In collaboration with ASRC Primus, AVL has developed a hybrid propulsion system integrated into a military demonstrator vehicle. Vehicle drive power comes from a diesel internal combustion engine and integrated starter generator operating the rear wheels, and an independent electric motor producing assistive propulsion torque and capturing braking energy at the front wheels. Control system development and tuning were accomplished both in a simulation environment as well as at multiple proving grounds, and a balance was struck between fuel economy, drivability and military-grade functionality.  

The developed energy management algorithm calculates component energy availability, driver demanded torque and manages the distribution of power between propulsion components. This includes a real-time, road load calculated power split between the three propulsion sources, namely Internal Combustion Engine (ICE), Integrated Starter Generator (ISG) and Front Motor (FMOT). Additionally, unique challenges of power split arose between the different propulsion sources due to the particular powertrain architecture selected for this vehicle i.e. a combined through the road and parallel hybrid structure.  

For the optimization task, an objective function is constructed that reflects the overall potential power losses from the main powertrain components. This constitutes a minimization problem that requires evaluation over several iterations. It is important to stay well within the limits of processing requirements for the hardware target, while maintaining acceptable algorithm accuracy. That essentially means that in order to minimize the computational effort, a careful compromise is required between the number of iterations and the minimization goal.  

This paper discusses the novel road load based power split and optimization method designed for the somewhat unique powertrain architecture of this vehicle, as well as the vehicle/model correlation effort, lessons learned through the development process, and preliminary fuel economy results.

Jeffrey Brian Holtz, Faisal Uppal, AVL Powertrain Engineering Inc.

5:00 p.m.  ORAL ONLY  

**Next Generation Combat Vehicle Electrical Power Architecture Development**

Presentation discusses the next generation open power architecture TARDEC is developing for the Army combat platforms including the driving requirements, implementation goals, and technologies (SiC, LED Lighting, GaN, Power Management, Lithium batteries) TARDEC is investing in to implement this electrical architecture.

George Hamilton, TARDEC

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**Tuesday, October 22**

**Energy Savings and Harvesting**

**Session Code: EMS600**

**Room Erie, Ontario, Huron**

**Session Time: 8:30 a.m.**

This session will dwell on advances in technology and system control and design that are aimed at reducing the energetic requirement of the systems and components to increase their overall efficiency, without incurring losses in function or performance.  

Key topics include future applications, and how these concepts fare in reaching energy saving goals, Experts will share their insights, focusing on key technology aspects for advancing products and initiatives and management of energy storage, distribution, regeneration, on-demand power systems and thermal energy recuperation.

**Chairpersons** - Donald J. Christian, CODA Automotive Inc.

**Time**  **Paper No.**  **Title**
8:30 a.m. ORAL ONLY Energy Harvesting in Low Voltage Hybrids

In the quest for ever-increasing fuel economy, global adoption of engine start/stop systems is on the rise. The next development frontier in this field is brake energy recuperation without substantially increasing the system cost or complexity. The evolving requirements are placing additional strain on conventional battery technology and this presentation will explore the energy management potential enabled by advanced energy storage in low voltage systems.

Jeffrey Kessen, A123 Systems Inc.

9:00 a.m. ORAL ONLY Direct Coupling® Power Distribution Platform

Electrical energy recovery and storage is being applied to increase power systems efficiency wherever power is used. Abundant and inexpensive fuel sources have in the past hindered development in this area, but there is now renewed interest because of its economic benefits. New technological improvements have improved energy recovery yield and storage capacity, and have reduced initial purchase and operating costs. Two key application areas are building power (stationary) and automotive transportation (mobile). The two areas can benefit by sharing techniques and components. Also, synergistic new applications areas are appearing as a result of their common exchange medium: DC power. This paper will examine the common energy recovery and storage technologies and transportation benefits from stationary power.

The key to new energy system strategy is the utilization of Direct Coupling® power distribution platform. This technology delivers superior efficiency, flexibility, reliability, and security to interior electrical circuits and power scavengers and generators. Direct Coupling® additionally:
- Lowers overall power consumption
- Boosts on-board power generation efficiency by 10% to 50%
- Improves use of on-board stored power by 20% to 30%

Direct Coupling® strategy connects direct current (DC) produced by scavenging, recovery, and alternative energy generators allowing integration of alternative energy sources such as solar, wind, wave, biomass and others to a user’s power system without the wasteful conversions to alternating current (AC) and back. This reduces the amount of energy lost to heat. It also takes advantage of reduced upfront system cost. The Direct Coupling® system provides for reliable uninterrupted power by incorporating battery storage for occasions when the alternative energy sources are unavailable (such as nighttime for solar systems), and can connect to the AC grid for plug-in operation. Power can be exchanged between buildings and vehicles through electric vehicle charging stations, or inverted and sold back to the AC grid, generating additional cost savings.

John Jahshan, Nextek Power Systems Inc.

9:30 a.m. ORAL ONLY Efficient Energy Management of Electric Vehicle Energy Storage using an Innovative Integrated Electric Drive Unit

Most Electric Vehicles, including PHEV and EREV vehicles, utilize a single speed gearbox or direct drive and size the main propulsion motor such that all required vehicle propulsion requirements are met. The drawback is that the electric machine is large and will operate for longer periods of time in less efficient power regions, resulting in a reduction in range for the vehicle. This paper will present an innovative Integrated Drive Unit concept that addresses the single speed inefficiencies inherent in the existing designs while also integrating many components that results in a reduction of total vehicle weight.

Joseph Lemieux, IAV Automotive Engineering Inc.

10:00 a.m. Networking and Refreshment Break
10:30 a.m. **ORAL ONLY**

**Cycling Variable Displacement Compressors to Further Increase A/C System Energy Efficiency**

Variable displacement piston compressors exhibit improved energy efficiency over fixed displacement piston compressors in mobile A/C applications. The improved energy efficiency is primarily due to the de-stroking aspect instead of the cycling associated with fixed displacement compressors to prevent the evaporator from freezing. Cycling an internally controlled variable compressor is counterintuitive, yet test results on multiple vehicle applications show a 15-20% reduction in energy consumption. Externally controlled variable compressors have the highest energy efficiency and extending cycling to these compressors during cool temperatures reduces the compressor energy up to 10%.

Mark J. Zima, Delphi Corp.

11:00 a.m. **ORAL ONLY**

**Benefits of Electrification – Case study for Electric Vacuum Pumps**

As fuel efficiency and emissions regulations become ever more stringent all approaches to reduce fuel consumption are being explored. This includes both new technology as well as those tried and true approaches that have for various reasons been underutilized in the past. The overarching strategy of electrification is one such approach that relies in many cases on existing technologies that can reduce fuel consumption without introducing technical risk upon implementation. Simply put, electrification involves replacing a mechanical engine function with one that is electrically powered. The benefit is usually found in reduced energy consumption by providing the function ‘on-demand’, eliminating parasitic losses that accumulate over time to be quite significant. 

One such example is replacement of mechanical vacuum pumps with electric vacuum pumps. Vacuum assisted braking relies on vacuum supplied by the intake manifold or a vacuum pump to provide consistent and reliable brake performance and pedal feel to the driver. As engine technologies such as turbocharging, low pressure EGR, reduced pumping loads, etc. are employed on more powertrains to meet tough fuel economy targets, the once reliable manifold vacuum has all but evaporated and brake subsystem architects are faced with choosing between a mechanical vacuum pump or an electric vacuum pump.

This presentation explores the tradeoffs between Mechanical Vacuum Pumps and Electric vacuum pumps from an energy management perspective. Comparative energy consumption data for various Mechanical Pumps is used to compare via drive cycle simulation, the performance of Hella’s Electric Vacuum pumps in terms of Fuel efficiency in gasoline and diesel engines.

Mark D. Weier, Hella Electronics Corp.

11:30 a.m. **ORAL ONLY**

**Challenges and Opportunities for a Cost-Optimized Micro and Mild Hybrid Powertrain Architecture on a 48 V DC Bus Application**

The fuel consumption in next generation vehicles and, furthermore, the emission target for complete fleets will be a major driver for technical development of alternative drivetrain architectures. To enjoy the benefit of downsized engines, as well as small size vehicles, micro or mild hybridization will be an option. Besides reaching a maximized function (e.g. stop/start or boost for driver acceptance of new technology), achieving affordable cost will be a challenge in targeted A/A0 segment cars. Since a considerable share of sales will continue in traditional powertrains, we assume that a conversion or even co-production of both powertrains must be realized in the same body structure and packaged with minimum modifications or intrusions to other functions. Analyzing the driving cycles of target applications, balancing of recuperation, and, in parallel, shifting from fuel-dependent to electrical energy management will be considered. The sum of power requirements and energy optimization gives the potential of a stand-alone, highly integrated cost-optimized 48 V system for hybridization consisting of BSG; PEU. As a result, battery and optionally electric A/C compressors could be a way for lower carbon dioxide emission.

Rico Heinrich, IAV Automotive Engineering Inc.
To maximize the energy economy potential of hybrid vehicles, further development of conventional and alternative powertrain components must be addressed. In addition, a general convergence of CO2 emission rules drive the development of powertrain components and system designs and strategies considered to increase efficiency. The presentations of this session will address these.

Chairpersons - Byungho Lee, US EPA

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<td>1:00 p.m.</td>
<td>ORAL ONLY</td>
<td>Valvetrain Technologies: Robust, High Value Solutions for CO2 Reduction and Improved Fuel Economy</td>
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Regulatory trends throughout the world are placing increased pressure on vehicle CO2 emissions and fuel consumption. Over the next 10 years, vehicle electrification will clearly play an increasing role, as will efforts to reduce vehicle mass, friction, aerodynamic drag, and rolling resistance. Major upgrades are also coming to improve the efficiency of internal combustion engines, which will remain the dominant automotive propulsion source for many years to come.

This presentation will describe recent innovations in variable valve activation. The focus will include both 2-step valve lift as well as cylinder deactivation. These technologies offer a strong foundation for improved engine efficiency through reduction of pumping losses and as enablers for improved combustion efficiency. They provide high value solutions to reduce CO2 and fuel consumption while maintaining excellent vehicle performance expected by today’s customers.

James Zizelman, Delphi Corp.

| 1:30 p.m. | ORAL ONLY | Powertrain Strategies for the 21st Century: 2013 Survey Results |

This presentation will focus on the results from our recent survey of powertrain experts from manufacturers, suppliers, universities, government, and consultants about what they consider the powertrain trends will be in 2016 and 2025. I will pay particular attention to the role hybrid and electric vehicles will play and the adoption challenges they face over the next decade.

Bruce M. Belzowski, Univ. of Michigan - Ann Arbor

| 2:00 p.m. | ORAL ONLY | Energy Management Design Flexibility in Powertrain Development using Liquid Sealants |

As vehicles move to improve overall energy management through weight/cost reduction, alternative energy supply sources and improved fuel economy, liquid adhesive sealants will play a critical role in achieving these goals. With the improved adhesion and chemical resistance of liquid formed-in-place gasket sealants, the use of plastics and light weight alternative metals can now be incorporated into the design of the various vehicle power plants. This process reduces the overall weight and cost of the vehicle, giving manufacturers increased flexibility in design.

Matthew Boback, Henkel Loctite Corp.
How can Connectivity Support Energy Management?

Session Code: EMS500
Room Erie, Ontario, Huron

Vehicle platforms with reliable networks, including telematics, embedded applications, and infotainment, are becoming increasingly prevalent. Affordable connective technologies are no longer considered an avoidable option and therefore will offer - both for V2V and V2I connectivity - the opportunity to optimize the energy consumption of vehicles considering the traffic system rather than just relying on the vehicle system. This session will cover examples of such a future approaches.

Chairpersons - Marc Rosenmayr, Hella Electronics Corp.

Time | Paper No. | Title
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3:30 p.m. | ORAL ONLY | Green and Connected: Communications for Increased Fuel Economy and Lower Emissions

Two of the most important developments in automotive technology currently underway are the introduction of vehicle communications and the modification, including electrification, of the powertrain to meet ever more rigorous emissions standards. While these two trends largely have evolved separately, their future evolution likely will not be in isolation. Furthermore, the technologies underlying these trends have great potential to reinforce one another, leading mutual benefits. Recognizing this potential, the Center for Automotive Research (CAR), with support from the Michigan Department of Transportation (MDOT), a recognized leader in connected vehicle technology, investigated the linkages and synergies between evolving communications and powertrain technologies and prospects for their coincidental development. This document presents CAR's thoughts on the potential of these two technology areas to reinforce one another. Ultimately, the goals of this paper are to raise awareness of the potential added benefits of being green and connected and to further a dialogue on how best to achieve these benefits.

Richard Wallace, Center For Automotive Research
4:00 p.m.  ORAL ONLY  Connectivity-Enhanced Route Selection and Adaptive Control for the Chevrolet Volt

Energy security, fuel cost, and air quality concerns have been driving increased powertrain electrification in new vehicles. At the same time, ubiquitous availability of advanced vehicle telematics systems, such as OnStar, has made real-time information on driving routes, traffic, and road topology readily accessible. Taken together, these trends offer a potential to increase powertrain efficiency, particularly in vehicles containing both a traction battery and a combustion engine. Such vehicles can leverage route-specific information to anticipate road loads and schedule power flows in the most efficient manner possible. In collaboration with the U.S. Department of Energy (DOE), the National Renewable Energy Laboratory (NREL) and General Motors (GM) are evaluating connectivity-enhanced route selection and adaptive control techniques to even further increase energy efficiency in the Chevrolet Volt platform. This presentation will describe both simulation and testing results from energy prediction algorithms applied to the Volt over multiple real-world driving profiles. The results will highlight ideal scenarios for connectivity enhancements to further increase electrified vehicle energy savings.

Eric Wood, National Renewable Energy Laboratory; Sai S V Rajagopalan, General Motors Co.

4:30 p.m.  ORAL ONLY  Energy Management of PHEV with Dynamic Programming, Neural Networks, Genetic Algorithm, and Quadratic Programming

This presentation will discuss how to achieve efficient, online, and intelligent energy management aimed at improving fuel economy of a plug-in hybrid electric vehicle (PHEV). In a PHEV, the battery current can be optimized to improve the fuel economy by applying Dynamic Programming, Neural Networks, Genetic Algorithm, and Quadratic Programming. It was found that based on the proposed method, the fuel economy can be improved by at least 5% for various driving cycles such as highway, urban, and urban (congested) cycles. Experimental results and analytical methods validated the proposed methods.

Chunting (Chris) Mi, Univ. of Michigan-Dearborn

5:00 p.m.  ORAL ONLY  Optimal Vehicle Energy Management using Trip Prediction

Research has shown that applying optimal control theory to hybrid electric vehicles (HEVs) or their plug-in versions (PHEVs) can significantly reduce their fuel consumption. This presentation shows how to implement optimal control theory under real-world conditions. Two key parameters in optimal control need to be considered: the trip prediction and the online controller itself. Trip prediction is necessary for optimal control because an optimum for the entire trip cannot be reached simply relying on the present and past states of the system. Our trip prediction method combines stochastic processes and geographical information. For a given itinerary, information about the route is pulled from a Geographical Information System (GIS), including such information as speed limit, stop signs, and traffic speed. Markov chains are then used to generate a vehicle speed profile that falls within the constraints obtained from the GIS. The result is a speed profile that can then be used for control optimization. The online optimum control strategy follows the Pontryagin minimization principle, which is based on instantaneously minimizing a cost function consisting of fuel rate and battery power. The factors in that cost function depend on the trip, and we use the prediction to define them. The optimum controller is then tested in Autonomie, a powertrain simulation tool developed at Argonne, which allows for a comparison with baseline controllers.

Dominik Karbowski, Vivien Smis-Michel, Namwook Kim, Larry Michaels, Argonne National Laboratory

Tuesday, October 22

Networking Reception
Session Code: EMSR  5:30 p.m.
Room Michigan  Session Time: