Combustion Research towards Net-Zero Emissions Mobility and Power

Saudi Arabian Section of the Combustion Institute (SAS-CI)

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Virtual Conference

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Keynote Talks

Keynote

Tailored Measures for Net-Zero GHG Emissions with PtX Fuels

Thomas Körfer

VICE PRESIDENT
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About the Speaker: Thomas Körfer is currently the Group Vice President at FEV group GmbH. He has nearly 30 years of professional experience in engine development in several positions & responsibilities. FEV is an internationally recognized leader in design and development of advanced gasoline, diesel and hybrid powertrains and vehicle systems.

Abstract: The entire mobility industry is facing significant challenges and is currently in a phase of transformation, driven both by public perception and by a corresponding legal framework. The agreed European Green Deal intends to make Europe the first greenhouse gas neutral continent by 2050. Nevertheless, a simultaneous pursuit of general well-being, prosperity and further economic growth will require additional amounts of energy for industrial production and transportation.

An increased emphasis on sustainability throughout society and economy will not only drive the use of sustainable raw materials, it will also motivate and stimulate a closed loop economy for non-renewable materials, especially for so-called critical materials, such as rare earths and other materials whose supply is potentially threatened by political conflicts, increased use or by restrictions in trade or mining. As refining such materials from alloys is sometimes also very energy-intensive, Europe's need for energy will likely not become smaller but rather greater, despite all activities aiming at better overall energy efficiency. Consequently, it is predicted that Europe will continue to import large amounts of energy from abroad.

This contribution presents ongoing research activities and project results on sustainable, carbon-neutral mobility using green electricity to produce renewable fuels. This

approach represents a complementary way to shift traffic to electrically powered propulsion systems. In view of the real-world, everyday market requirements, there are many applications in the transport sector where purely electric propulsion systems do not offer a suitable solution. This applies at least to the heavier commercial vehicles and to long-distance vehicle operation as well as to large non-road mobile machinery. For such applications, liquid fuels with their high energy densities will remain the prime choice for the foreseeable future. This refers especially to the entire EU. In the mid-term future, some of these energy carriers will be produced cost-efficiently from renewable energy sources in worldwide areas with the most favorable climatic conditions. Thus, besides powertrain electrification, newly designed Power-to-X (PtX) fuels from renewable electricity and carbon dioxide from various sources, so called e-fuels, are a highly attractive alternative to ensure mobility with a closed carbon cycle.

New synthetic e-fuels also show considerable potential for solving the classic trade-offs between CO2 and pollutant emissions of ICE based powertrains. Consequently, they provide a worthwhile solution for a clean and sustainable mobility in the next decades. However, to achieve a short-term reduction of CO2 emissions of the transportation sector, these fuels must be compatible with the technology of the current vehicle fleet and the existing refueling infrastructure, and, ideally, they should be miscible with fossil fuels. Fischer-Tropsch (FT) products for example are very similar to petroleum-based fuels and meet the latter requirement so that they can be mixed with conventional fuels without any problems. However, despite the principal similarity to fossil Diesel fuel, major differences in the combustion behavior of FT-Fuels can arise. Besides all benefits of synthetic fuels, these potential divergences pose also some challenges, since they cannot be comprehensively considered within the standard powertrain development process. The presentation concludes with a summary on functional benefits and associated cost estimations.

Keynote

The Circular Carbon Economy

Dr. Thang Pham

Research Science Consultant
Saudi Aramco

About the Speaker: Dr. Thang Pham is a Research Science Consultant at Saudi Aramco Technology Strategy and Planning Department. He is currently engaged in hydrogen related strategy and technology development activities while providing advices to the wider Sustainability Technology Portfolio. Dr. Pham has been working in the hydrogen and fuel cell technology development area for several decades. Prior to joining Saudi Aramco in 2018, he was working in the O&G industry and several technology start-ups in Australia and Canada. He holds a Bachelor of Engineering and a PhD, both in Chemical Engineering, from the University of Queensland.

Abstract: Today we face the dual challenge of meeting the world's growing energy needs in a reliable and affordable manner, while ensuring a sustainable environment for our future generations. The Kingdom of Saudi Arabia recently introduced and championed the concept of the Circular Carbon Economy (CCE) as an alternative pathway for the energy transition, together with key technologies and solutions under a 4Rs (reduce, reuse, recycle, and remove) framework. The CCE is a framework in which emissions of carbon from all sectors are managed in a way that allows the carbon to move in a closed-loop system, much like the natural carbon cycle. This circularity has the advantage of allowing maximum utilization of existing infrastructure while addressing the emissions challenge, directly and economically and across national circumstances. The CCE offers a new way of approaching climate goals that values all options and encourage all efforts to mitigate greenhouse gas emissions.

This talk will briefly share the concept of the Circular Carbon Economy (CCE) and highlight Saudi Aramco's efforts on high impact CCE technologies that reduce the cost and create significant environmental advantages.

Keynote

Decarbonization of Transport: Synergies between Hydrogen & Alternative Engine Concepts

Prof. James Turner

Professor, Engines and Energy Systems
University of Bath, UK

About the Speaker: James Turner is Professor of Engines and Energy Systems at the University of Bath. He has a Master of Engineering degree from City University London and a Ph.D. from Loughborough University. He is a specialist in the field of spark-ignition combustion, pressure charging systems, alternative fuels, and engine/fuel interactions. He has over 30 years of experience in the field of internal combustion engines, and has published or co-authored more than 100 papers and book chapters in the field. He spent over 21 years working at Lotus Engineering, latterly being Chief Engineer for Powertrain Research, in which role he worked on many novel engine, transmission, and fuel concepts. He is a board member of the IMechE's Powertrain Systems and Fuels Group, a past-chairman of the SMMT's Fuels Working Group, is current chairman of the UK's Universities' Internal Combustion Engines Group (UnICEG), and a member of the Society of Automotive Engineering's Horning Award Committee.

Abstract: The complete decarbonization of transport requires a portfolio approach; there is no one solution to replace transport's historical silver bullet of the internal combustion engine operating on fossil fuels. One potential energy carrier to achieve this end is hydrogen, which can be made fully renewably ("green hydrogen") or in a carbon-neutral manner by dehydrogenation of oil using catalysts ("black hydrogen"), leaving a solid carbon residue which can then safely be buried or used in other industrial processes requiring carbon; the atmospheric release of fossil CO2 is completely avoided by either process.

The heavy duty sector is the one which will likely need to adopt hydrogen as an energy carrier, because the energy storage and recharge time requirements for HD vehicles preclude the use of batteries. In this sector, it is argued, it is pragmatic to start with hydrogen combustion engines in order to limit vehicle costs during a deployment ramp-up phase, while providing a draw for fuel infrastructure investment. Fuel cells can be adopted at a later date, the ICE having pulled the infrastructure forward; to an extent the approach decouples the prime mover from the infrastructure problem.

As a fuel hydrogen has some very interesting characteristics which arguably better suit several alternative engine concepts than the traditional 4-stroke reciprocating engine. While the 4-stroke is the incumbent technology, other concepts may offer greater potential for increased efficiency or cost reduction, and so it is argued that a meaningful assessment should be conducted before deciding on which direction to go.

The talk will discuss some of the routes to clean hydrogen and then the synergies between hydrogen and some of these engine concepts individually. It will conclude with a new concept designed to maximize the efficiency of hydrogen energy conversion to electricity while minimizing emissions.

Keynote

Carbon Capture for a Sustainable Energy Future

Prof. William L. Roberts

Director, Clean Combustion Research Center,
KAUST, Saudi Arabia

About the Speaker: Dr. Roberts is the Director of Clean Combustion Research Center and a Professor of Mechanical Engineering at KAUST. He received his PhD in Aerospace Engineering from the University of Michigan in 1992. Prior to this, he worked in the Strategic Defense Initiative Office for two years and worked at NASA Langley on SCRAMJET concepts after defending his dissertation. He joined NC State University in 1994, where he rose through the academic ranks until leaving for KAUST the end of 2011. He was an early member of the Clean Combustion Research Center and became the Director in 2014. He is an NSF CAREERS and Army Research Office Young Investigator Award recipient, former chairperson of the Eastern States Section of the Combustion Institute and current vice-chair of the Saudi Section, Fellow of the Combustion Institute, current member of the AIAA Pressure Gain Combustion TC and Associate Fellow, and former UC Berkeley Springer Professor.

Abstract: In this talk, I will review the necessity of carbon capture if we are going to meet the 2.0C temperature rise limit, let alone the 1.5C goal. I will put this in context of the Kingdom's vision of a Circular Carbon Economy and how this fits into the G-20 events hosted by the Kingdom. I will then compare and contrast traditional and emerging CO2 capture technologies, and how these different technologies may be applicable based on concentration of CO2. The bulk of the talk will focus on a thermodynamic process where the CO2 is desublimated out of the carrier gas stream and captured as dry ice. I will discuss the current state of the project, and where we go from here.

Keynote

Digital Twin of the Vehicle Powertrain based on Virtual Prototyping and Testing

Prof. Kambiz Ebrahimi

Head of Advanced Propulsion group
Loughborough University, UK

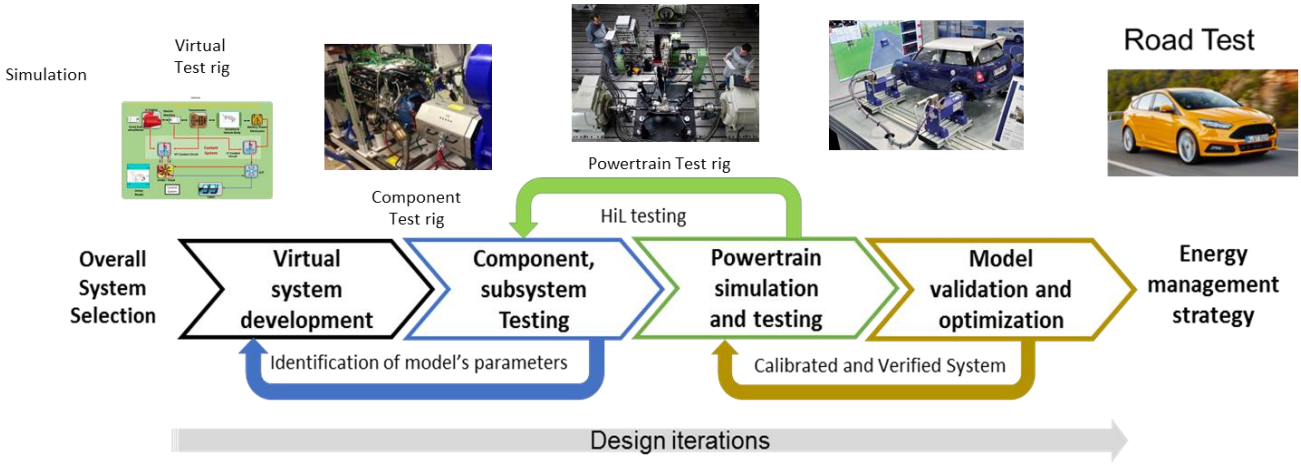
About the Speaker: Kambiz Ebrahimi is a Professor of Advanced Propulsion at the Department of Aeronautical and Automotive Engineering, Loughborough University. His research interest is mainly in the systems dynamics and control with applications in powertrain design and testing. He received his Ph.D. in dynamic modelling and MEng in system engineering from Cardiff University. Much of his work has been on modelling, performance evaluation and testing of propulsion systems. He is the author and co-author of more than 100 articles in national and international journals and conferences. He is a chartered mechanical engineer and member of ASME and SAE and the chair and organizer of Powertrain Modelling and Control Conference since 2012; a member of Editorial Board, International Journal of Powertrains, since 2012; and the Organizer of Meeting the Challenges in Powertrain Testing, in 2009. He is also a member of the Editorial Board for the Journal of Multibody Dynamics, Part K, Proceeding of IMechE.

Abstract: Automobiles are a major part of our daily life and one of the most personal items that we depend on for our livelihood. Powertrain development has experienced a series of gradual evolutionary changes based on demands such as legislation, customer requirements and costs.

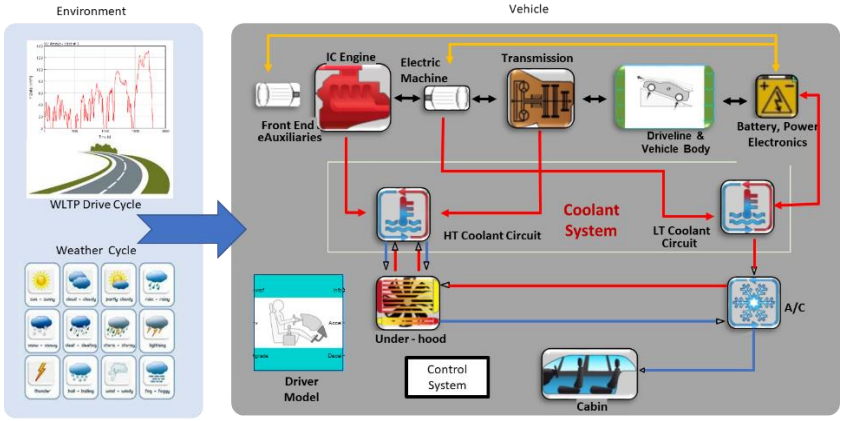
Currently, the common impression is that future cars will be electrified, connected, autonomous and shared. Electrification of the powertrain is one of the major automotive developments in the last two decades that results in the reduction of vehicle emissions which is one of the most prevalent environmental problems. The electrification of powertrain is a gradual move from conventional combustion engines to hybrid and full electric vehicles that is transforming the propulsion technology in the

automotive industry. The UK is a major stakeholder in this change and the British automotive industry is a leading contributor in this arena. This talk looks at the way powertrain is developing within the overall vehicle design and considers the past and future. It specifically considers the virtual prototyping and testing and the role that Loughborough's propulsion group is playing in the design and control of future powertrains.

The aim is to determine the optimum use of mechanical, electrical and thermal energy at different points in the drive cycle so that electrical and thermal energy can be used to minimize the draw on the mechanical energy supplied by the ICE



CAE tools developed within this work package will effectively show the CO_2 benefit and measured output, hence scale of success from this project.



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