The 6th Low Emission Advanced Power (LEAP) Workshop – Virtual

Hosted by
U.S. Department of Energy
National Energy Technology Laboratory

AGENDA

The sixth LEAP workshop will be held by the U.S. Department of Energy, National Energy Technology Laboratory (NETL), with a focus on the transition to net-zero carbon and the associated technology development. The workshop is composed of a three-day section "Advanced Systems Integration" focused on integrated energy systems and a two-day section "Cyber-Physical Modeling" focused on merging numeric and hardware simulations to develop cyber-physical models for accelerating technology development.

Section 1: Advanced Systems Integration

Online
Monday November 1 – Wednesday November 3

The goal of the "Advanced Systems Integration" section is to review and discuss integrated energy systems technology development, which will support the transition to a net-zero carbon energy sector, by promoting dialog among the leading international researchers from national laboratories, industry, and universities.

Section 2: Cyber-Physical Modeling

Online
Thursday November 4 – Friday November 5

The purpose of the "Cyber-Physical Modeling" section is to bring together the academics, national labs, and industry to explore how cyber-physical systems can be used as a modeling tool in energy system development, design, and deployment; identify the opportunities for cyber-physical modeling of energy systems, and define the infrastructure, software, and components needed.

Please Note:

1. This meeting is considered "open- to-the-public". All information presented at this meeting must meet criteria for public sharing or have already been published and available in the public domain or expects the material to be made available soon after the conclusion of the proceedings. Please do not communicate information that is considered official use only, proprietary, sensitive, restricted or protected in any way during the presentations or during any sidebar or casual conversations.
2. This meeting will be recorded. Information content in presentations and discussion, including technology barriers and potential solutions, will be made publicly available. Key conclusions from the workshop are anticipated to be published in a technical note.

2021 Low Emission Advanced Power (LEAP) Workshop

			Advanced Systems Integration			Cyber-Physical Modeling	
PDT (Pacific Daylight Time)	**EDT** (Eastern Daylight Time)	**CET** (Central European Time)	**Monday 11/01/2021**	**Tuesday 11/02/2021**	**Wednesday 11/03/2021**	**Thursday 11/04/2021**	**Friday 11/05/2021**
7:00AM - 8:30AM	10:00AM - 11:30AM	3:00PM - 4:30PM	**Session 1** Goal net-zero	**Session 4** Microgrids	**Session 7** Paths to Commercialization	**Session 10** An Introduction to Cyber-physical Modelling	**Session 13** Intelligent, Reconfigurable, Adaptive Energy Systems
9:00AM - 10:30AM	12:00PM -1:30PM	5:00PM - 6:30PM	**Session 2** Renewables and Integration	**Session 5** Thermally/Chemically Integrated Systems	**Session 8** Controls Development for Energy Systems	**Session 11** Cyber-physical Modeling and Energy System Design	**Session 14** Report out & Open Discussion
11:30AM - 1:00PM	2:30PM - 4:00PM	7:30PM - 9:00PM	**Session 3** Transition Cost and Impact	**Session 6** Dynamic Performance	**Session 9** Open Discussion and Conclusions	**Session 12** Building Cyber-physical Energy System Models	

Monday November 1, 2021

(Meeting Link https://doe.webex.com/doe/j.php?MTID=m97d81a415dd176147831a87501c9fe35)

Session 1 – Goal Net-zero (10:00 am – 11:30 am Eastern Time)

Session Chair: **Dr. Sydni Credle**, *Technology Manager, National Energy Technology Laboratory, U.S. Department of Energy*

09:50 - 10:00 Log-on, Welcome, Introduction

10:00 - 10:10 **Opening Remarks and Introduction**

Dr. David Tucker, *Research Scientist, PI for the Hybrid Performance (HYPER) Project, National Energy Technology Laboratory, U.S. Department of Energy*

10:10 - 11:10 **Panel Discussion**

Welcome from NETL and the Research and Innovation Center

Dr. Bryan Morreale, *Executive Director of the Research and Innovation Center at National Energy Technology Laboratory, U.S. Department of Energy*

Carbon Pollution Free Energy Sector by 2035 and DOE Strategies for Transition

Dr. Bhima Sastri, *Director, Integrated Carbon Management, Office of Fossil Energy and Carbon Management, U.S. Department of Energy*

Mr. Sotirios (Sam) Thomas, *Director, Hydrogen with Carbon Management Division, Office of Fossil Energy and Carbon Management, U.S. DOE*

Opportunities and Challenges for High Temp. Fuel Cell with Carbon Neutrality in China

Prof. Minfang Han, *Vice Chairman of Chinese Fuel Sell Committee, Chairman of Technical Committee for Standardization of High Temp Professor at Department of Energy and Power Engineering in Tsinghua University, China*

European Perspective of Carbon Free Economy

Prof. Aristide Massardo, *UNESCO Chair on Innovative, sustainable and clean energy, Director Rolls-Royce Fuel Cell Systems University Technology Centre (FCS-UTC); Professor and Chair of Energy Systems at University of Genoa, Italy*

11:10 - 11:30 **Open Discussion**

Break & Social Session – 30 minutes (breakout rooms available)

Session 2 – Renewables and Integration (12:00 pm – 13:30 pm Eastern Time)

Session Chair: **Dr. Jennifer Kurtz**, *Director of Energy Conversion and Storage Systems Center at National Renewable Energy Laboratory (NREL), U.S. Department of Energy*

12:00 - 12:05 **Introduction**

Dr. Jennifer Kurtz, *Director of Energy Conversion and Storage Systems Center at National Renewable Energy Laboratory (NREL), U.S. Department of Energy*

12:05 - 13:00 **Panel Discussion**

Dr. Jennifer King, *Research Engineer – Controls and Hybrids at National Renewable Energy Laboratory*

Prof. Sairaj Dhople, *Associate Professor, Electrical and Computer Engineering, University of Minnesota*

Mr. Steve Szymanski, *Vice President, Sales and Marketing at Nel Hydrogen*

Mr. Jason MacDowell, *Senior Director – Technology, Strategy & Policy, GE*

13:00 - 13:30 **Open Discussion**

Break & Social Session – 60 minutes (breakout rooms available)

Session 3 – Transition Cost and Impact (14:30 pm – 16:00 pm Eastern Time)

Session Chair: **Dr. Lawrence Shadle**, *Research Scientist, National Energy Technology Laboratory, U.S. Department of Energy*

14:30 - 14:35 **Introduction**

Dr. Lawrence Shadle, *Research Scientist, National Energy Technology Laboratory, U.S. Department of Energy*

14:35 - 15:30 **Panel Discussion**

Overview of NETL Analyses Supporting Low-Carbon Emissions and/or Carbon-Negative Energy Generation

Dr. Travis Shultz, Research Scientist, *Energy Process Analysis Team, National Energy Technology Laboratory, U.S. Department of Energy*

Overview of the cost of hydrogen transportation

Michael Shelton, CEO of *Advanced Comprehensive Technology Solutions*

Economics of Flexibility

Michael Caravaggio, *Senior Program Manager at the Electric Power Research Institute*

Grid Transition Costs from a Utility Perspective

Steve Steffel, *Executive Advisor at Quanta Technology*

Societal impact to energy transition, acceptability and social barriers

Prof. Simone D'Alessandro, *Associate Professor at the Department of Economics and Management of the University of Pisa*

15:30 - 16:00 **Open Discussion**

Closing

Tuesday November 2, 2021

(Meeting Link: https://doe.webex.com/doe/j.php?MTID=ma3fb93e775a50a446f127be7d691ab4b)

Session 4 – Microgrids (10:00 am – 11:30 am Eastern Time)

Session Chair: **Mr. Rick Lank**, *CEO/Business Development, Resilient Power Works*

09:50 - 10:00 Log-on

10:00 - 10:10 **Introduction: Hydrogen Hybrid Microgrids & Advanced Power Controls**
Rick Lank, *CEO/Business Development, Resilient Power Works*

10:10 - 11:00 **Panel Discussion**

Utility Perspective on Power Generation for a Sustainable Future
Steve Steffel, *PE, BSME, MBA - Executive Advisor, Quanta Technology (Raleigh, NC)*

The Role of Advanced Power Controls & Achieving Interoperability
Matt Baker, *Director Microgrids and Critical Power, Typhoon HIL, Inc.*

Mastering Reliability and Resiliency: A New York Case Study & A World-Wide Perspective
Roni Clark, *Energy Optimization Sales Executive, Centrica Business Solutions (Mt. Joy, PA)*

Optimizing Microgrid Designs for the Behind-the-Meter Client
Geoff Oxnam, *CEO - American Microgrid Solutions -- (Easton, MD)*

Small-scale Compressed Air Energy Storage (CAES) systems coupled with Micro Gas Turbines
Martina Raggio, *researcher at the University of Genoa*

Long Lasting BATteries (LOLABAT) and Energy Harvesting Technologies
Avinash Renuke, *researcher in mechanical Engineering at the University of Genoa*

11:00 - 11:30 **Open Discussion**

Break & Social Session – 30 minutes (breakout rooms available)

Session 5 – Thermally/Chemically Integrated Systems (12:00 pm – 13:30 pm Eastern Time)

Session Chair: **Prof. Alberto Traverso**, *Professor of Energy Systems at University of Genoa, Italy*

12:00 - 12:05 **Introduction**

Professor Alberto Traverso, *Professor of Energy Systems at University of Genoa, Italy*

12:05 - 13:00 **Panel Discussion**

180 kWh Cold Thermal Energy Storage: Experimental Assessment

Mr. Tommaso Reboli, *Research fellow, Department of Mechanical, Energy, Management and Transport Engineering, University of Genoa, Italy.*

Storage in Heat Pump and Heat Management

Dr. Ningwei Justin Chiu, *Associate Professor in Renewable Energy at Heat and Power Division (HPT) of Energy Technology Department (EGI), KTH Royal Institute of Technology, Sweden.*

The Carbon Dioxide for energy storage application

Mr. Simone Maccarini, *Research fellow, Department of Mechanical, Energy, Management and Transport Engineering, University of Genoa, Italy*

Clean energy solutions towards zero emissions for maritime applications

Prof. Massimo Rivarolo, *Assistant Professor in Systems for the Energy and the Environment at University of Genoa, Italy.*

Feasibility Study for PEMFC and Metal Hydrides Coupling for the Zero Emission Ultimate Ship (Zeus)

Mr. Matteo Cavo, *Researcher in mechanical Engineering, University of Genoa, Italy*

Introduction of a high electrical efficiency combined heat and power cycle

Prof. Comas Haynes, *Principal Research Engineer, Georgia Institute of Technology*

Perspective on nuclear hybrid systems

Dr. Richard Boardman, *Laboratory Relationship Manager) Fuel Cell and Hydrogen Technology Office, Idaho National Laboratory, U.S. Department of Energy*

Integrated systems for Decarbonisation

Dr. Michalis Agraniotis, *Mitsubishi Power Europe GmbH*

A novel concept of an integrated energy system

Dr. David Tucker, *Research Scientist, PI for the Hybrid Performance (HYPER) Project, National Energy Technology Laboratory, U.S. Department of Energy*

13:00 - 13:30 **Open Discussion**

Break & Social Session – 60 minutes (breakout rooms available)

Session 6 – Dynamic Performance (14:30 pm – 16:00 pm Eastern Time)

Session Chair: **Dr. Jack Brouwer**, *Professor of Mechanical and Aerospace Engineering, director of National Fuel Cell Research Center and Advanced Power and Energy Program at the University of California, Irvine (UCI).*

14:30 - 14:50 **Introduction & Presentation**

Dr. Jack Brouwer, *Professor of Mechanical and Aerospace Engineering, Director of the National Fuel Cell Research Center (NFCRC) and Advanced Power and Energy Program (APEP) at the University of California, Irvine (UCI).*

14:50 - 15:30 **Panel Discussion**

Dynamic performance of the 240-kW PEMFC HI-SEA power system
Ms. Eleonora Gadducci, *Researcher in mechanical Engineering, University of Genoa, Italy*

Rapid Load Response of SOFC-GT Hybrid Systems to Grid Demand

Dr. Biao Zhang, *Research Engineer, National Energy Technology Laboratory, U.S. Department of Energy*

Hybrid Dynamics for Aviation Applications

Dr. Rory Roberts, Professor at Tennessee Tech University

Opportunities and Challenges in SOFC/GT Hybrid Dynamics

Dr. David Tucker, *Research Scientist, PI for the Hybrid Performance (HYPER) Project, National Energy Technology Laboratory, U.S. Department of Energy*

Incipient surge detection in large volume energy systems

Carlo Alberto Niccolini, Researcher in mechanical Engineering, University of Genoa, Italy

15:30 - 16:00 **Open Discussion**

Wednesday November 3, 2021

(Meeting Link: https://doe.webex.com/doe/j.php?MTID=m6a717494e4bc3b589f38124afadaa651)

Session 7 – Paths to Commercialization (10:00 am – 11:30 am Eastern Time)

Session Chair: **Dr. David Tew**, *Program Director at the Advanced Research Projects Agency – Energy (ARPA-E)*

09:50 - 10:00 Log-on

10:00 - 10:05 **Introduction**

Dr. David Tew, *Program Director at the Advanced Research Projects Agency – Energy (ARPA-E), U.S. Department of Energy*

10:05 - 11:00 **Panel Discussion**

Dr. Scott Swartz, *Founder and CTO at Nexceris, LLC*

Prof. Robert Braun, *Professor of Mechanical Engineering at Colorado School of Mines*

High Temperature Fuel Cell Technology for the Energy Future
Mr. Michael Pastula, *Senior Manager, Engineering at FuelCell Energy*
Dr. Hossein Ghezel-Ayagh, *Vice President, Advanced Technology Programs at FuelCell Energy, Inc.*

EVERYWH2ERE: Making hydrogen affordable to operate in EU cities fueling temporary power gensets

Dr. Stefano Barberis, *Project Coordinator the EVERYWH2ERE H2020 Project, RINA CONSULTING SpA*

11:00 - 11:30 **Open Discussion**

Break & Social Session – 30 minutes (breakout rooms available)

Session 8 – Controls Development for Energy Systems (12:00 pm – 13:30 pm Eastern Time)

Session Chair: **Dr. Paolo Pezzini**, *Research Engineer, Ames Laboratory*

12:00 - 12:05 **Introduction to the session**

Dr. Paolo Pezzini, *Research Engineer, Ames Laboratory, U.S. Department of Energy*

12:05 - 12:15 **Model Predictive Control of Power Plant Cycling**

Prof. Fernando Lima, *Associate Professor of Chemical Engineering at West Virginia University*

12:15 - 12:20 **Open Discussion**

12:20 - 12:30 **Modern Power Plant Controls**

Mr. Steve Seachman, *Principal Technical Leader at Electric Power Research Institute (EPRI)*

12:30 - 12:35 **Open Discussion**

12:35 - 12:45 **Pump-heat combined cycle controls and ROBINSON MPC in Microgrids**

Dr. Luca Mantelli, *associate researcher at the University of Genoa, Italy*

Prof. Mario L. Ferrari, *Associate Professor of Energy Systems at the University of Genoa, Italy*

12:45 - 12:50 **Open Discussion**

12:50 - 13:00 **Control Strategies for an Integrated SOFC/GT System**

Dr. Michael Sprengel, *Senior Engineer/Analyst at Czero*

13:00 - 13:05 **Open Discussion**

13:05 - 13:15 **Gain-Scheduled Model Predictive Control for SOFC fuel cell control**

Dr. Tyrone Vincent, *Professor at Department of Electrical Engineering at Colorado School of Mine*

13:15 - 13:20 **Open Discussion**

13:20 - 13:30 **Path to Control Viability**

Mr. Issac Frampton, *Senior Staff Engineer,Kohler Co. Power Systems Division*

Break & Social Session – 60 minutes (breakout rooms available)

Session 9 – Open discussion and conclusions (14:30 pm – 16:00 pm Eastern Time)

Session Chair: **Dr. David Tucker**, *Research Scientist, National Energy Technology Laboratory, U.S. Department of Energy*

14:30 - 15:30 **Open Discussion**:

Challenges and opportunities

Summary of Advanced Systems Integration

15:30 - 16:00 **Conclusion and Report**

Closing

Section 2: Cyber-Physical Modeling of Energy Systems Workshop

Online
Thursday November 4 – Friday November 5

Overview and purpose

Cyber-physical systems are systems in which physical and software systems are deeply intertwined to create intelligent systems which integrate sensing, computation, controls, and communication with physical structures. Examples of cyber physical systems include smart devices (e.g., autonomous cars, smart grids, smart cities), medical monitoring devices, robotics systems, industrial control systems.

In addition, cyber-physical systems provide a new modeling platform in which the behavior of complex systems can be modeling and understood. Computational modeling is flexible and very accurate for many aspects of energy system performance, but it cannot address all the issues. In the same way, physical bench-, lab-, and pilot-scale testing based in hardware is expensive and lacks flexibility but provides key insights and data and provides validation of the models. In contrast, cyber-physical modeling provides a new modeling paradigm that has the potential to accelerate the design, deployment, and scale-up of advanced energy systems by providing both the flexibility of computational modeling and the accuracy and "hard truth" of physical components. In addition, these cyber-physical models can grow and change during the design and deployment process and ultimately support development of the digital twin and the physical system of the embodied power plant. In the cyber-physical design paradigm, cyber-physical models provide a new type of model that can be used in conjunction with (and as a part of) other modeling tools (e.g., bench-scale models and computational models).

The purpose of this workshop to bring together the academics, national labs, and industry to explore how cyber-physical systems can be used a modeling tool in energy system development, design, and deployment; identify the opportunities for cyber-physical modeling of energy systems, and define the infrastructure, software, and components needed.

Thursday November 4, 2021

(Meeting Link: https://doe.webex.com/doe/j.php?MTID=m8f233ad63ec11bfb75933b533f3368d7)

Session 10 – An Introduction to Cyber-physical modeling (10:00 am – 11:30 am Eastern Time)

09:50 - 10:00 Log-on

10:00 - 10:20 **What is cyber-physical modeling?**

Prof. Mark Bryden, *Program Director for Simulation, Modeling and Decision Science at Ames Laboratory, U.S. Department of Energy*

10:20 - 10:40 **Keynote—Energy: A quickly changing landscape**

Prof. Nathan Johnson, *Assistant Professor in the Polytechnic School at Arizona State University*

10:40 - 10:50 **Cyber-physical modeling of novel power systems**

Prof. Mario Ferrari, *Associate Professor of Energy Systems at the University of Genoa, Italy*

Mr. Tommaso Reboli, *Research fellow, Department of Mechanical, Energy, Management and Transport Engineering, University of Genoa, Italy*

10:50 - 11:30 **Discussion – Introductions**

Break & Social Session – 30 minutes (breakout rooms available)

Session 11 – Cyber-physical modeling and energy system design (12:00 pm – 13:30 pm Eastern Time)

12:00 - 12:10 **Building a cyber-physical energy system modeling community to meet today's energy challenges**

Dr. Sydni Credle, *Technology Manager, National Energy Technology Laboratory, U.S. Department of Energy*

12:10 - 12:30 **Rethinking the traditional "feedforward" design flow path for energy systems**

Dr. David Tucker, *Research Scientist, PI for the Hybrid Performance (HYPER) Project, National Energy Technology Laboratory, U.S. Department of Energy*

12:30 - 12:45 **Cyber-physical modeling for marine application**

Alessandro Boveri, *Research and Consultant Engineer at CETENA S.p.A.*

Prof. Federico Silvestro, *Professor at University of Genoa, Italy*

12:45 - 13:00 **Cyber physical modeling: does it breakdown design barriers – can it be a continuum?**

Prof. Mark Bryden, *Program Director for Simulation, Modeling and Decision Science at Ames Laboratory, U.S. Department of Energy*

13:00 - 13:30 **Large group discussion**

Break & Social Session – 60 minutes (breakout rooms available)

Session 12 – Building cyber-physical energy system models (14:30 pm – 16:00 pm Eastern Time)

14:30 - 15:30 **Panel discussion: What is needed to support cyber-physical modeling?**

Mr. Jesus Arias, *Research Engineer I, Georgia Tech Research Institute*

Dr. Paolo Pezzini, *Research Engineer, Ames Laboratory, U.S. Department of Energy*

Mr. Mike Shelton, *CEO of Advanced Comprehensive Technology Solutions, LLC*

Ms. Franca Giannini, *researcher director at the Institute for Applied Mathematics and Information Technologies of the National council of Research in Genova, Italy.*

15:30 - 16:00 **Large group discussion**

Closing

Friday November 5, 2021

(Meeting Link: https://doe.webex.com/doe/j.php?MTID=m229bd8b4c4a0aaf17dca5f30fa779659)

Session 13 – Intelligent, reconfigurable, adaptive energy systems (10:00 am – 11:30 am Eastern Time)

09:50 - 10:00 Log-on

10:00 - 10:20 **Keynote: Adaptive design for a changing world**

Prof. Scott Ferguson, *Associate Professor at Mechanical and Aerospace Engineering at North Carolina State University*

10:20 - 10:40 **A cyber-physical modeling energy system development process: creating intelligent, reconfigurable, adaptive energy systems**

Prof. Mark Bryden, *Program Director for Simulation, Modeling and Decision Science at Ames Laboratory, U.S. Department of Energy*

10:40 - 11:30 **Breakout sessions**

- What should we do next?
- How do we move forward?

Break & Social Session – 30 minutes (breakout rooms available)

Session 14 – Next steps in cyber-physical modeling of energy systems (12:00 pm – 13:30 pm Eastern Time)

12:00 - 12:10 **Summary of the workshop**

Dr. Alberto Traverso, *Professor of Energy Systems at University of Genoa, Italy*

12:10 - 13:00 **Report out & open discussion**

Dr. Paolo Pezzini, *Research Engineer, Ames Laboratory, U.S. Department of Energy*

13:00 - 13:30 **Next steps – an invitation to participate – our plans for the next two years**

Prof. Mark Bryden, *Program Director for Simulation, Modeling and Decision Science at Ames Laboratory, U.S. Department of Energy*

Dr. Dave Tucker, *Research Scientist, PI for the Hybrid Performance (HYPER) Project, National Energy Technology Laboratory, U.S. Department of Energy*

Closing