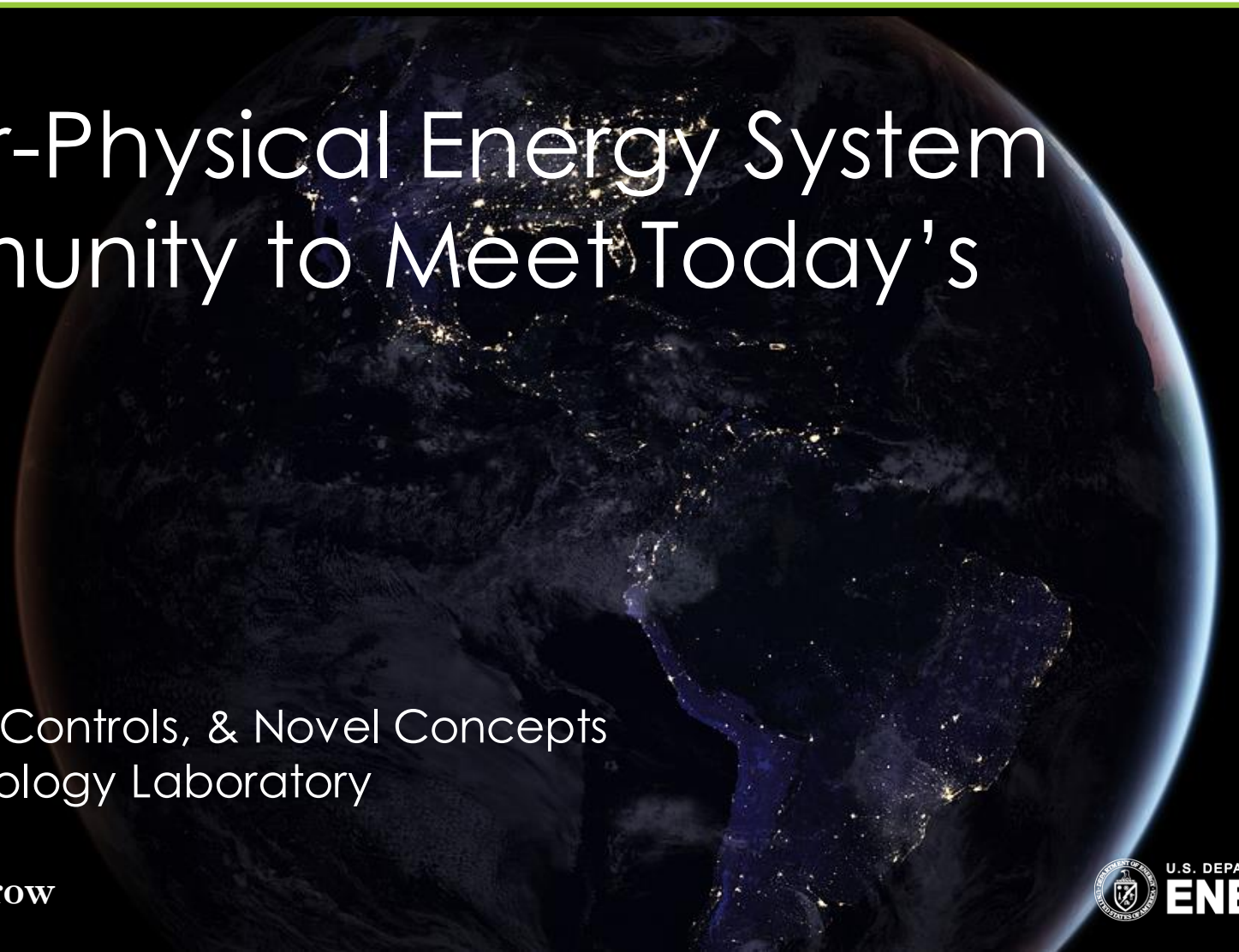
Cyber-Physical Modeling
LEAP Workshop
2021 November 4
Session 11 Cyber-Physical Modeling and Energy System Design

NATIONAL ENERGY TECHNOLOGY LABORATORY

Building a Cyber-Physical Energy System Modeling Community to Meet Today's Challenges



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Solutions for Today | Options for Tomorrow

U.S. DEPARTMENT OF ENERGY

MISSION

Driving innovation and delivering solutions for an environmentally sustainable and prosperous energy future:

- Ensuring affordable, abundant and reliable energy that drives a robust economy and national security, while
- Developing technologies to manage carbon across the full life cycle, and
- Enabling Environmental Sustainability for all Americans

VISION

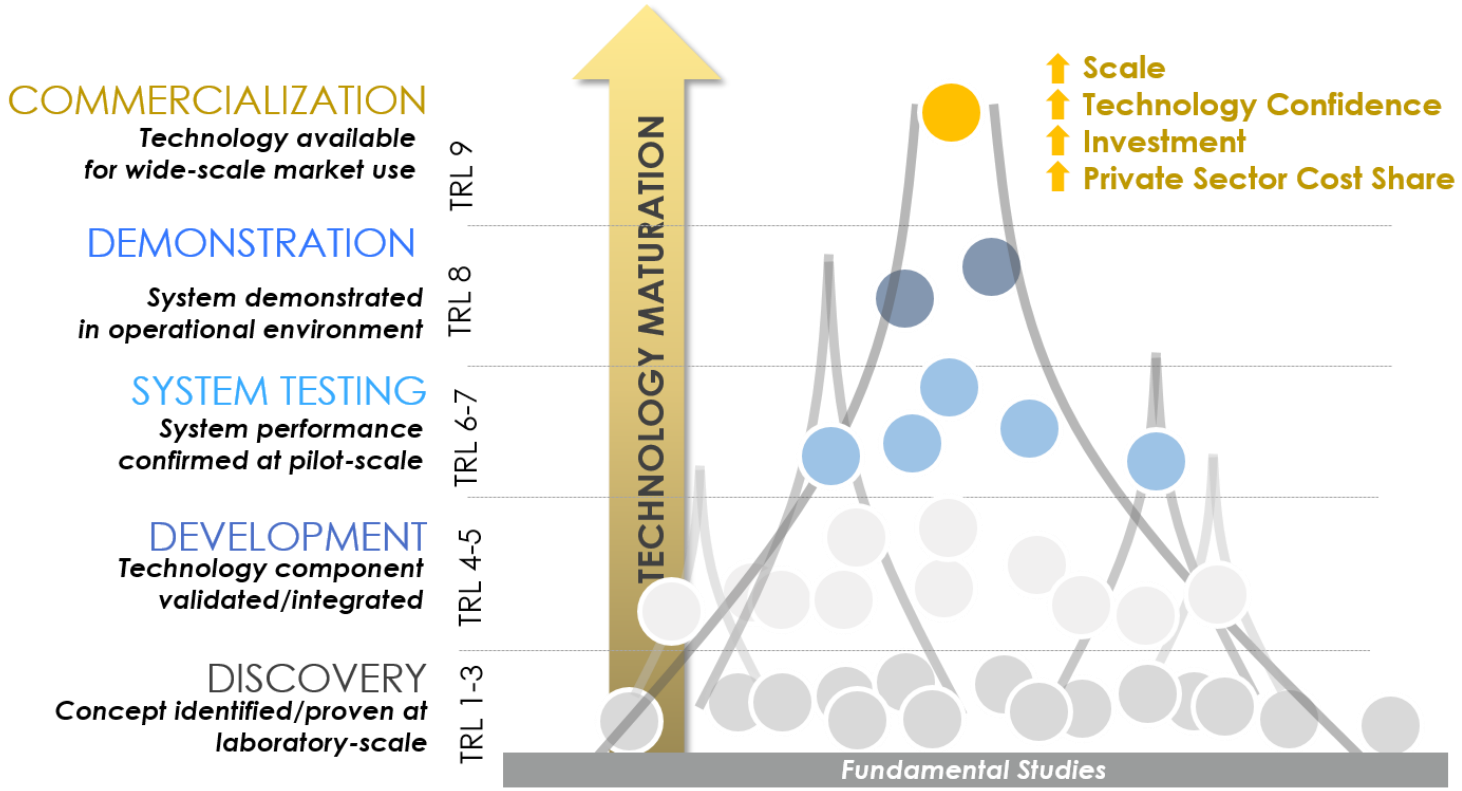
To be the nation's premier energy technology laboratory, delivering integrated solutions to enable transformation to a sustainable energy future.

Carbon Reduction Goals

- **50% reduction in U.S. GHG pollution by 2030**
  - From a 4/22/21 White House Statement: Today, President Biden will announce a new target for the United States to **achieve a 50-52 percent reduction from 2005 levels in economy-wide net greenhouse gas pollution in 2030** – building on progress to-date and by positioning American workers and industry to tackle the climate crisis.
- **Carbon-neutral power sector by 2035**
  - From EO 14008, Sec 205: "The plan shall aim to use, as appropriate and consistent with applicable law, all available procurement authorities to achieve or facilitate: (i) **a carbon pollution-free electricity sector no later than 2035**"
- **Carbon-neutral economy by 2050**
  - From EO 14008, Sec 201: "Despite the peril that is already evident, there is promise in the solutions — opportunities to create well-paying union jobs to build a modern and sustainable infrastructure, deliver an equitable, clean energy future, and put the United States on a path to **achieve net-zero emissions, economy-wide, by no later than 2050**."

Accelerating Technology Development

Nurture technologies from initial idea/concept through the various stages of development, including proof of feasibility, prototyping, field testing, etc.



New Technology Needed

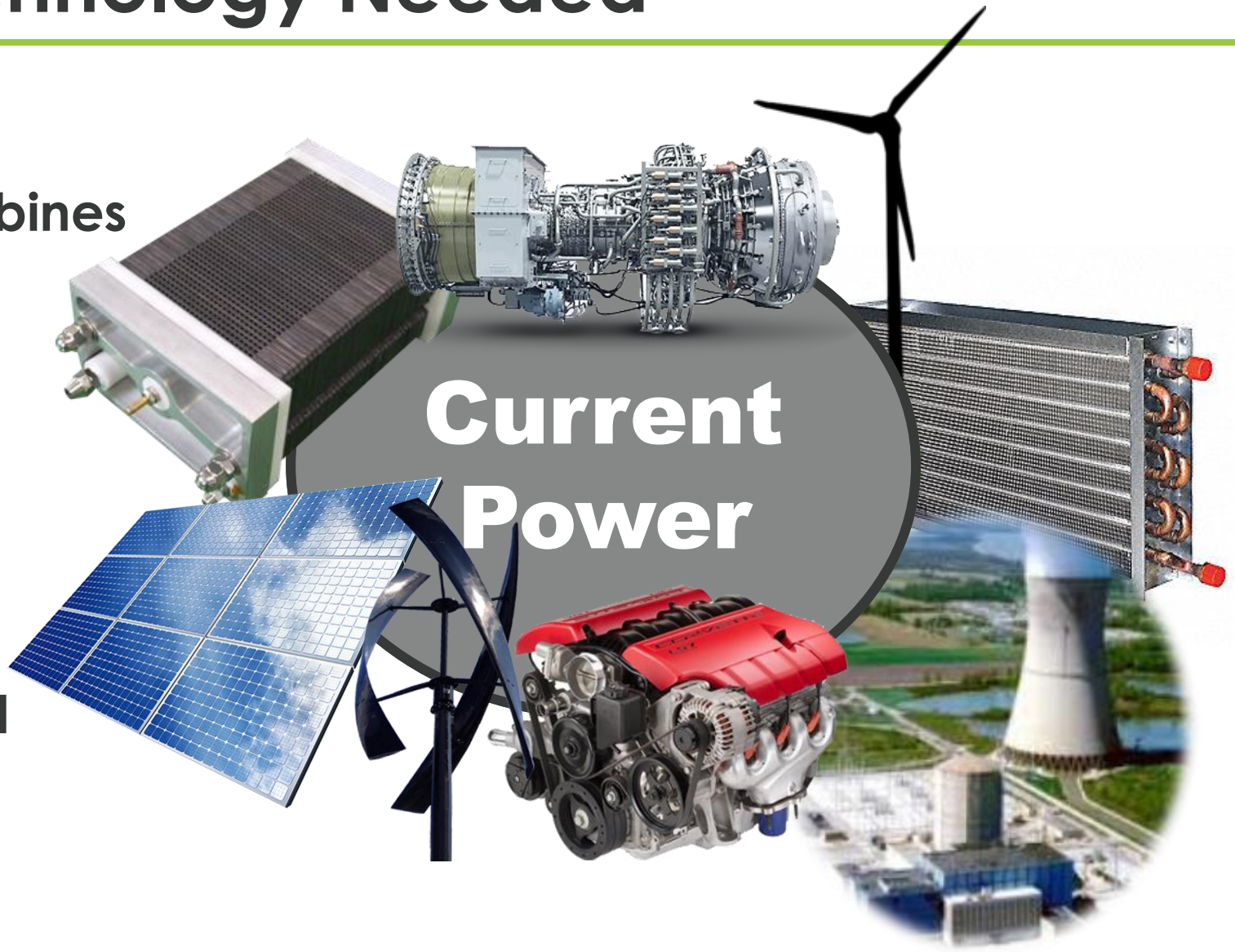
Hydrogen Turbines

Fuel Cells

Electrolyzers

PV Solar

Concentrated Solar



Wind Turbines

Thermal Storage

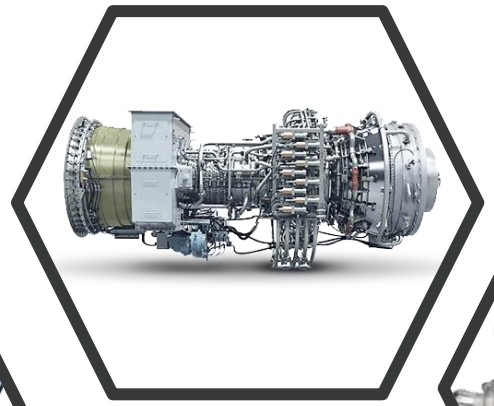
HT Heat Exchangers

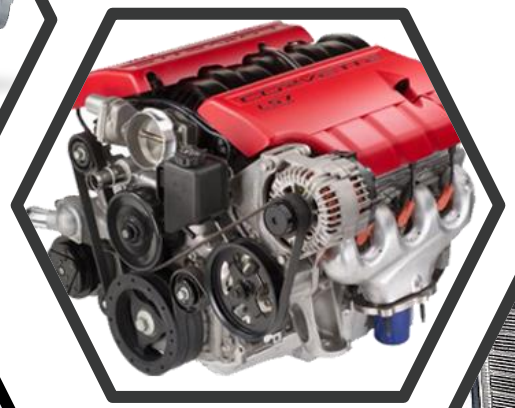
Nuclear

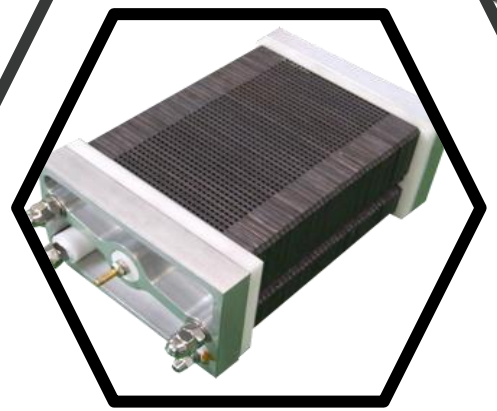
Hydrogen Engines

It's All Connected…

The system needs to be designed for control



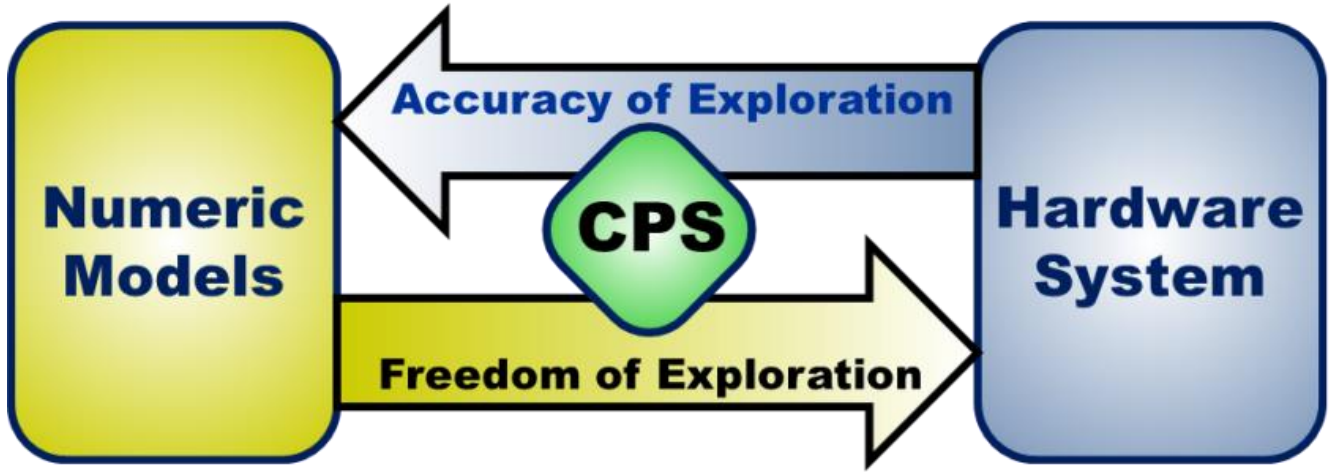


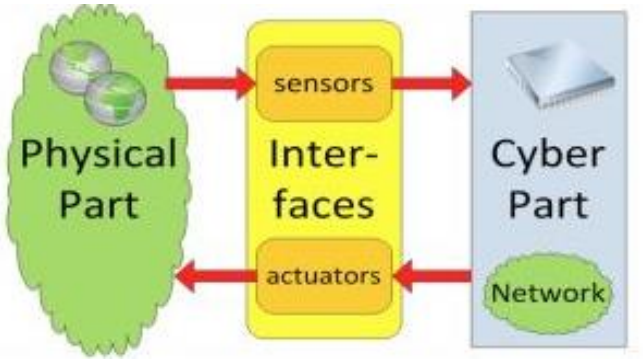


Controls need to be designed for transient operability and intelligence

Components need to be designed for the system

Technology Development in the New World

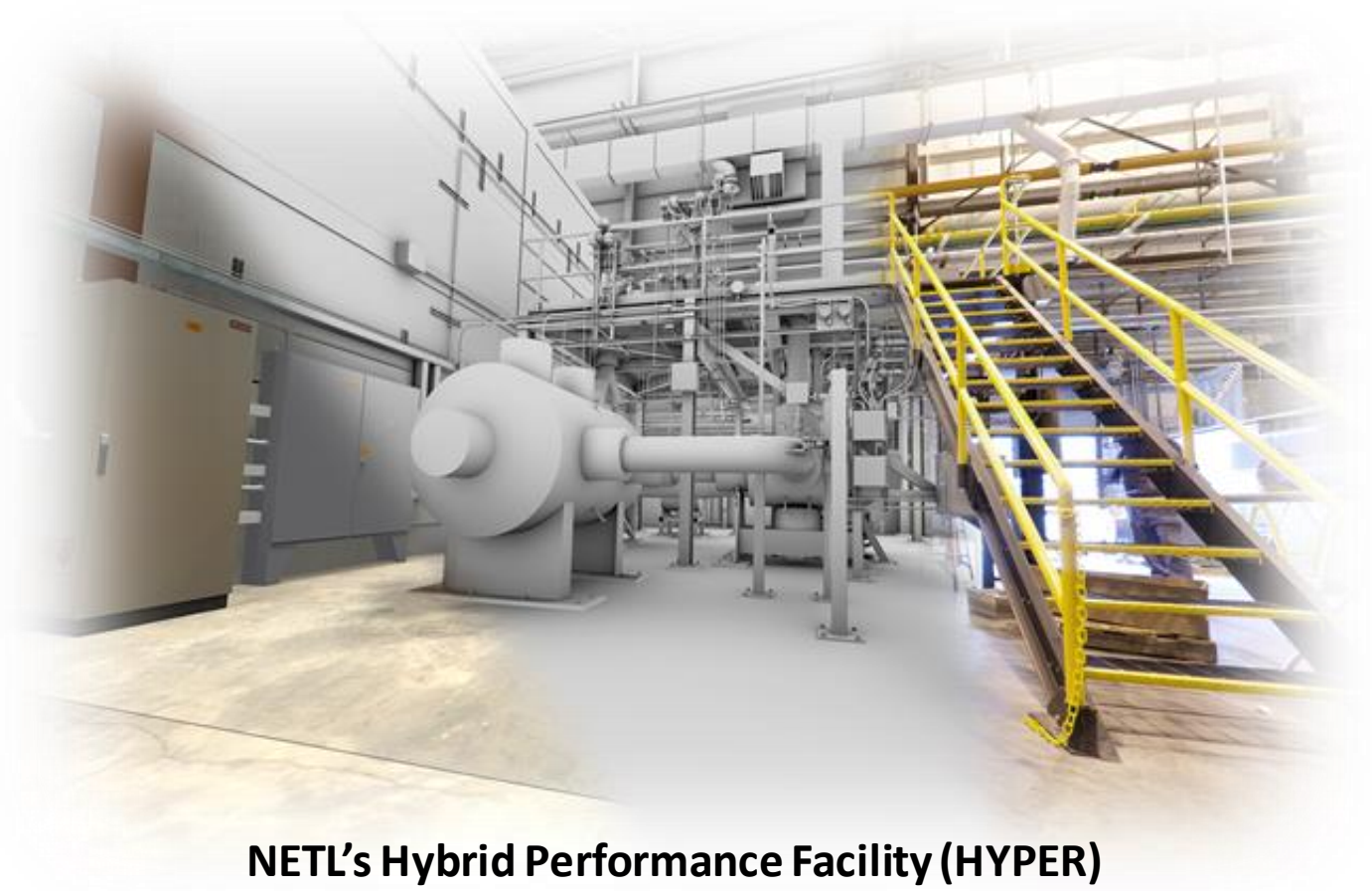




Cyber-Physical Systems (CPS) and Hardware-in-the-Loop (HIL) Simulations provide the basis for Cyber-Physical Modeling and accelerated technology development

Distributed Intelligent Controls

NETL/RIC In-House Research



NETL's Hybrid Performance Facility (HYPER)

NETL HYPER FACILITY

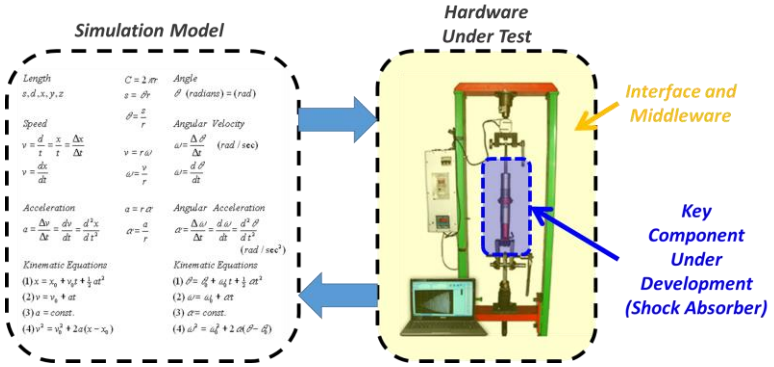
- Pilot-scale experimental test facility
- 300kW solid oxide fuel cell & gas turbine (SOFC-GT) power plant simulator
- Evaluation of advanced control strategies and other novel concepts

RESEARCH & DEVELOPMENT

- Cyber-Physical Systems Methodology
- Agent-Based Control
- System Identification
- Blockchain for Secure Communications

Needs from the Research Community

High-speed numeric models capable of interacting with hardware



Middleware connecting numeric models to hardware actuators

Hardware capable of interacting with the relevant physical environment

Novel sensors designed to communicate information from hardware systems to numeric models

High speed actuators capable of emulating the dynamics of the hardware on the physical environment

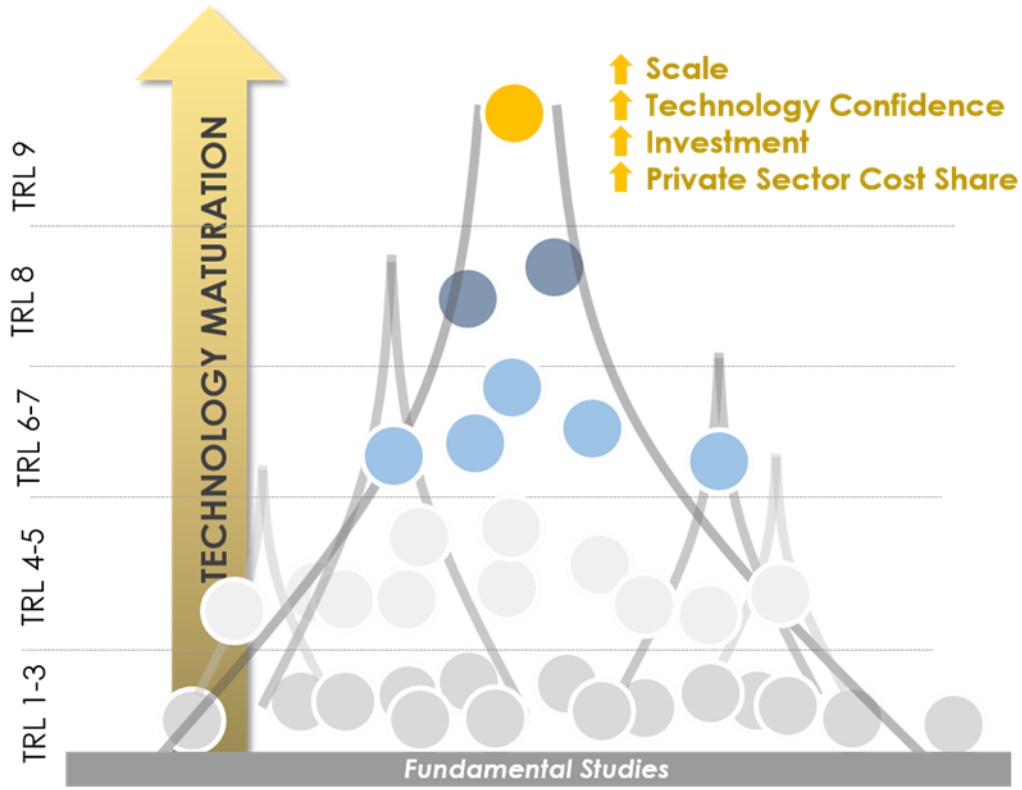
A CPM Community is Needed

Final Remarks …

- Successful achievement of 2035 and 2050 carbon reduction goals will require ***new technology development now***

- ***Cyber-physical Systems (CPS) / Methodology*** represents an integrated, reconfigurable, and flexible scheme that allows for accelerated design of new, low-carbon energy components and systems

- ***Increased collaboration and participation*** is needed within the CPS research community in order to collectively meet these challenges



Thank You!

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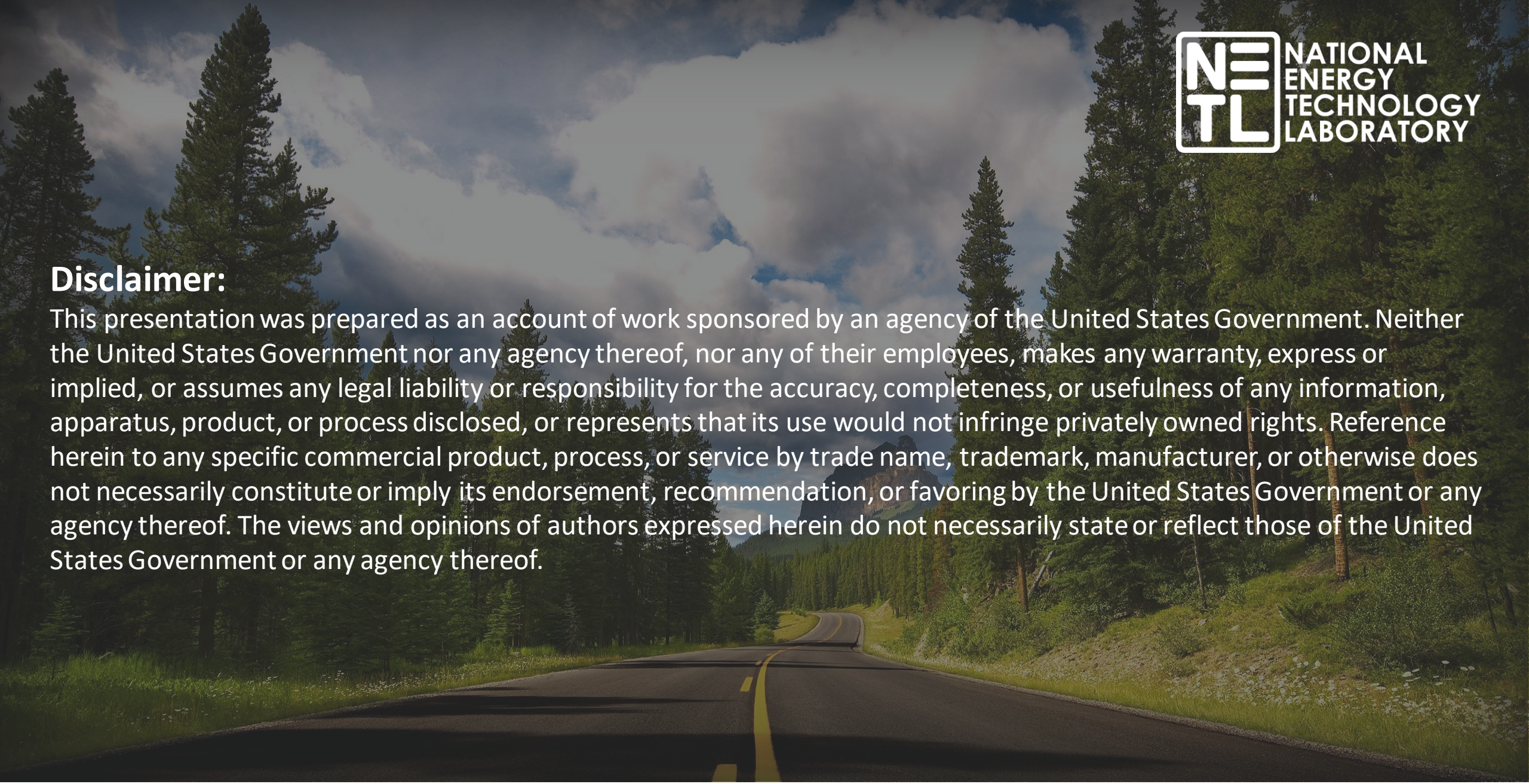
Sensors, Controls, & Novel Concepts Program
Website: https://netl.doe.gov/coal/sensors-and-controls



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