



Future Grid Initiative

**Enabling renewable
energy resources**

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Workshop objectives

- PSERC has embarked on an exciting and challenging research initiative to address national energy challenges associated with the evolution of the electric energy grid. The initiative is funded by **DOE's Office of Electricity Delivery and Energy Reliability**
- A critical component of this initiative is an attempt to encapsulate the engineering building blocks required for the future grid architecture to support an increased penetration of renewable resources – **wind and solar**

Workshop objectives

- The PSERC collaboratory has formulated an approach to tackle this problem taking into account (1) research priorities identified through an extensive interactive process and (2) the technical expertise available to PSERC
- The primary objective of this workshop is to present the proposed approach and to listen to your feedback and comments

Workshop objectives

1. Stimulate discussion on the proposed solution approach related to the building blocks identified by the thrust areas in the initiative
2. Critique the specific technical aspects of the tasks associated with each thrust area
3. Provide feedback and comments on the thrust area tasks and on the broad analysis topics and white papers

National energy challenges

Energy independence, affordability

Energy reliability, security, efficiency

**Economic development
and job security**

**Environmental concerns
and impact of climate change**

**Aging infrastructure, technology
change, workforce needs**

Range of energy solution options



Renewable resource technologies

Energy efficiency

Demand resources

Market solutions

Nuclear energy technologies

Develop domestic resources

Improved asset utilization

Electric transportation

Carbon capture and storage

Energy storage

Overarching issues

- Given this set of national energy solutions, how does the electric grid infrastructure **evolve** to **accommodate** these solutions?
- What elements constitute the **building blocks** of this **evolution**?
- Given the **large capital investment** in the **legacy grid**, what steps are required to **seamlessly transition** from the legacy grid to accommodate the elements of the proposed building blocks?

Critical elements of the evolution

Changing Generation Supply Mix

- T&D additions and changes
- Energy storage
- Enhanced control/communications
- Handling increased uncertainty

Needed evolution/changes to support this element

Drivers of the evolution/changes

- Renewable resources
- Retirement of aging conventional plants
- Questions regarding nuclear addition
- Carbon regulation

Critical elements of the evolution

Demand Transformation

- Expanding digital economy
- Power quality and reliability needs
- Demand flexibility
- Electric vehicles

**Needed evolution/
changes to
support this
element**

**Drivers of the
evolution/
changes**

- Economic constraints
- Changing customer needs
- Green awareness and demand
- Need for higher reliability and efficiency

Critical elements of the evolution

Complexity of Grid

- Expanding footprint
- Impact of markets
- Tighter operating limits
- Greater reliance on communication and control
- Need for advanced analytical tools

**Needed evolution/
changes to
support
this
element**

Drivers of the evolution/ changes

- Spatio-temporal constraints
- Computational complexity
- Stochastic nature of variables
- Need to contain cost

Critical elements of the evolution

Infrastructure Vulnerability

- Reduce footprint of disruptions
- Reliability of communication and control
- Reduced duration of disruptions
- Guard against malicious attacks

**Needed evolution/
changes to
support this
element**

Drivers of the evolution/ changes

- Shortage of skilled personnel
- Inadequate analytical tools
- Interdependence of cyber-physical systems

Key requirements based on NERC operating and planning criteria



1. **Balance power generation and demand continuously**
2. **Balance reactive power supply and demand to maintain scheduled voltages**
3. **Monitor flows over transmission lines and other facilities to ensure that thermal (heating) limits are not exceeded**
4. **Keep the system in a stable condition**

Key requirements based on NERC operating and planning criteria



5. Operate the system so that it remains in a **reliable condition even if a contingency occurs**, such as the loss of a key generator or transmission facility (the "**N-1 criterion**")
6. Plan, design, and maintain the system to **operate reliably**
7. Prepare for **emergencies**

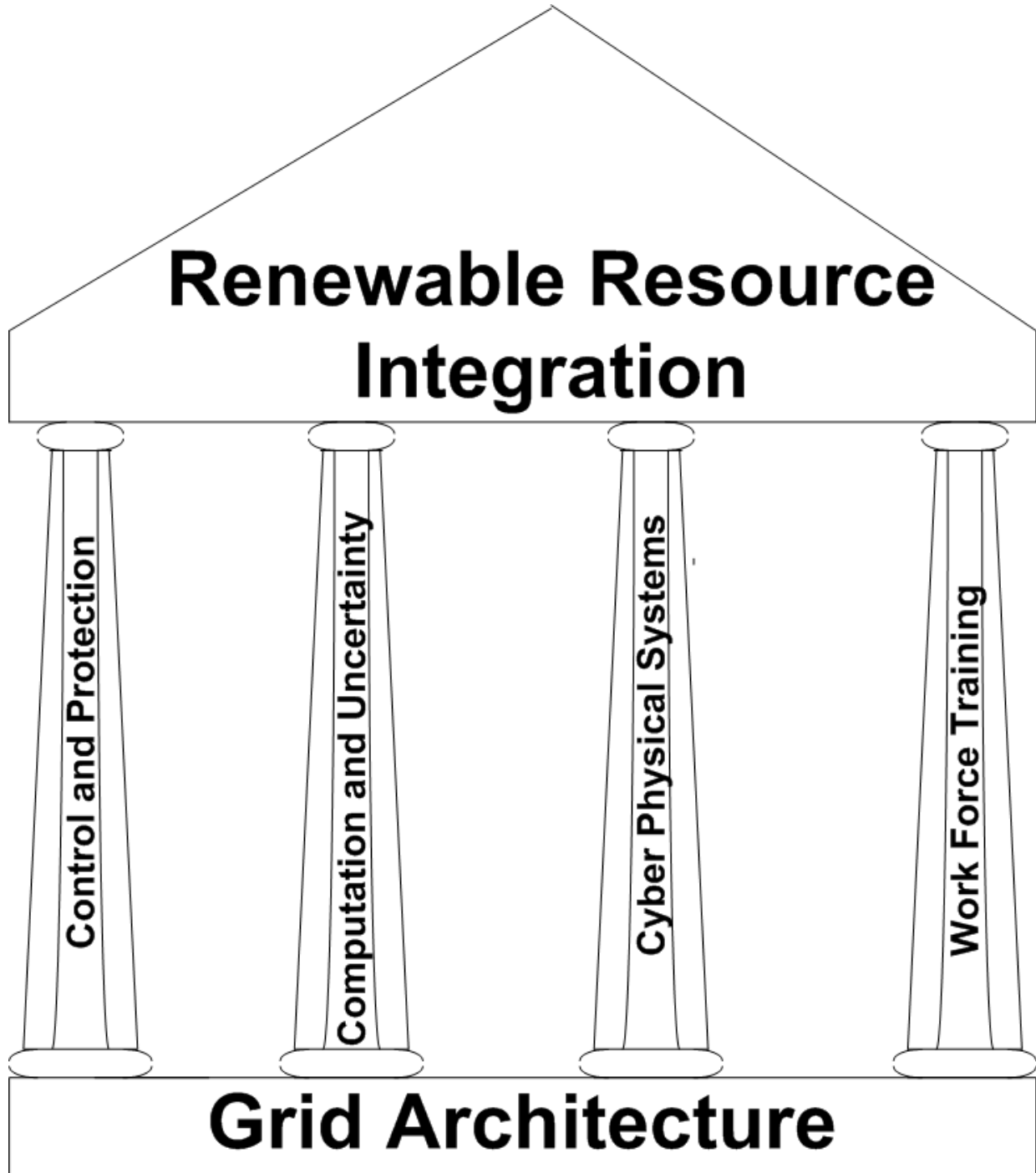
Synthesis of the building blocks in this initiative



- **Plan** and **operate** grid with increased penetration of **renewable resources** while meeting any **carbon regulation requirements**
- **Design grid architecture** to support **renewable penetration** and **transformation of demand as a resource**
- Manage increased dependence on **control, communication** and **cyber-physical systems** to handle **grid complexity**

Synthesis of the building blocks in this initiative

- **Create analytical tools** to account for increased **variability** and **stochastic** nature of elements
- **Prepare needed workforce** training



Questions for Discussion



- What will be the key new capabilities of a future grid that the enables high penetration of wind and solar generation technologies?
- What are the technical challenges in providing those capabilities?