NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Introduction to Energy Systems Integration (ESI)

Dr. Bryan Hannegan
Associate Laboratory Director

Dr. Ben Kroposki
Director – Energy Systems Integration

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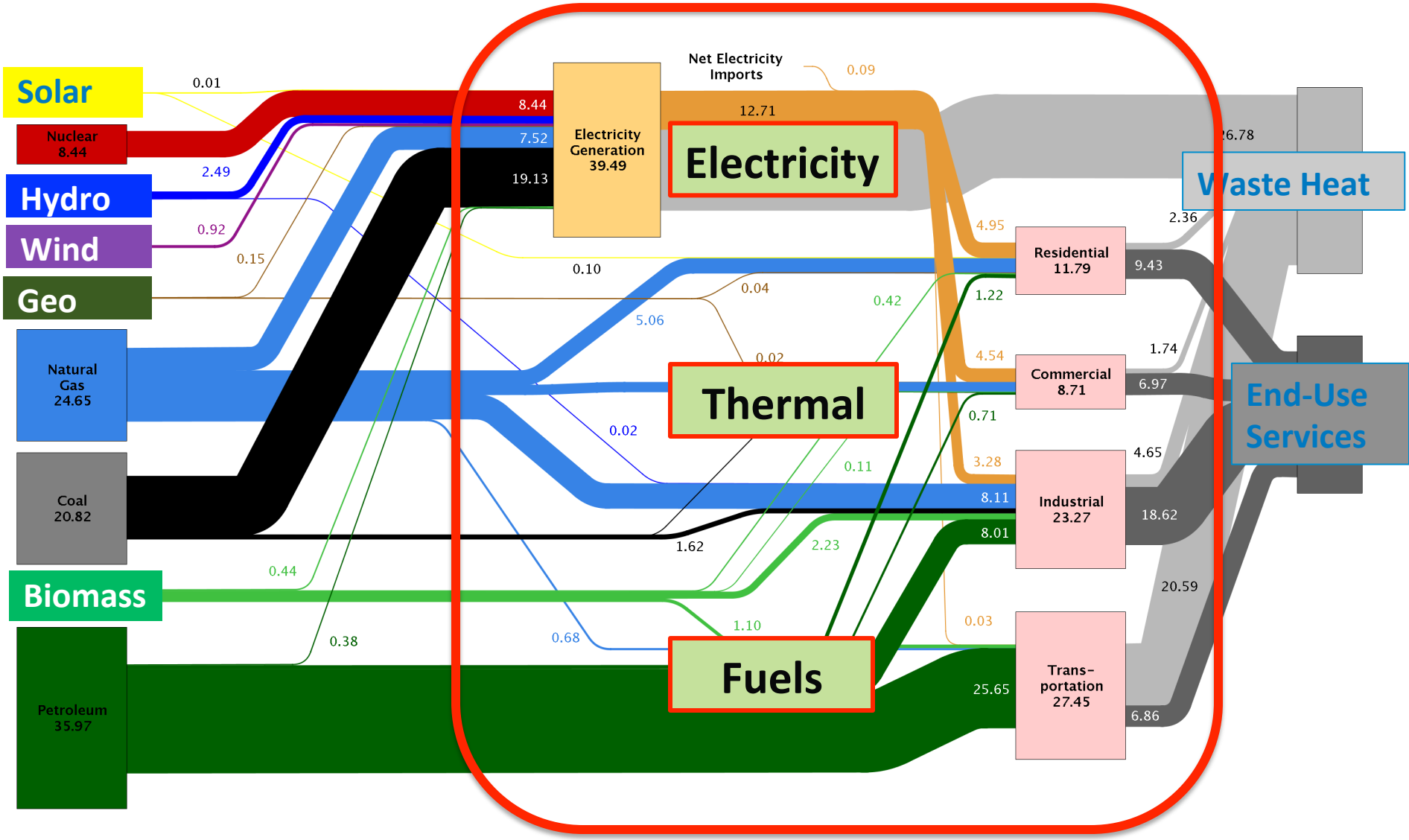
Why Energy Systems Integration?

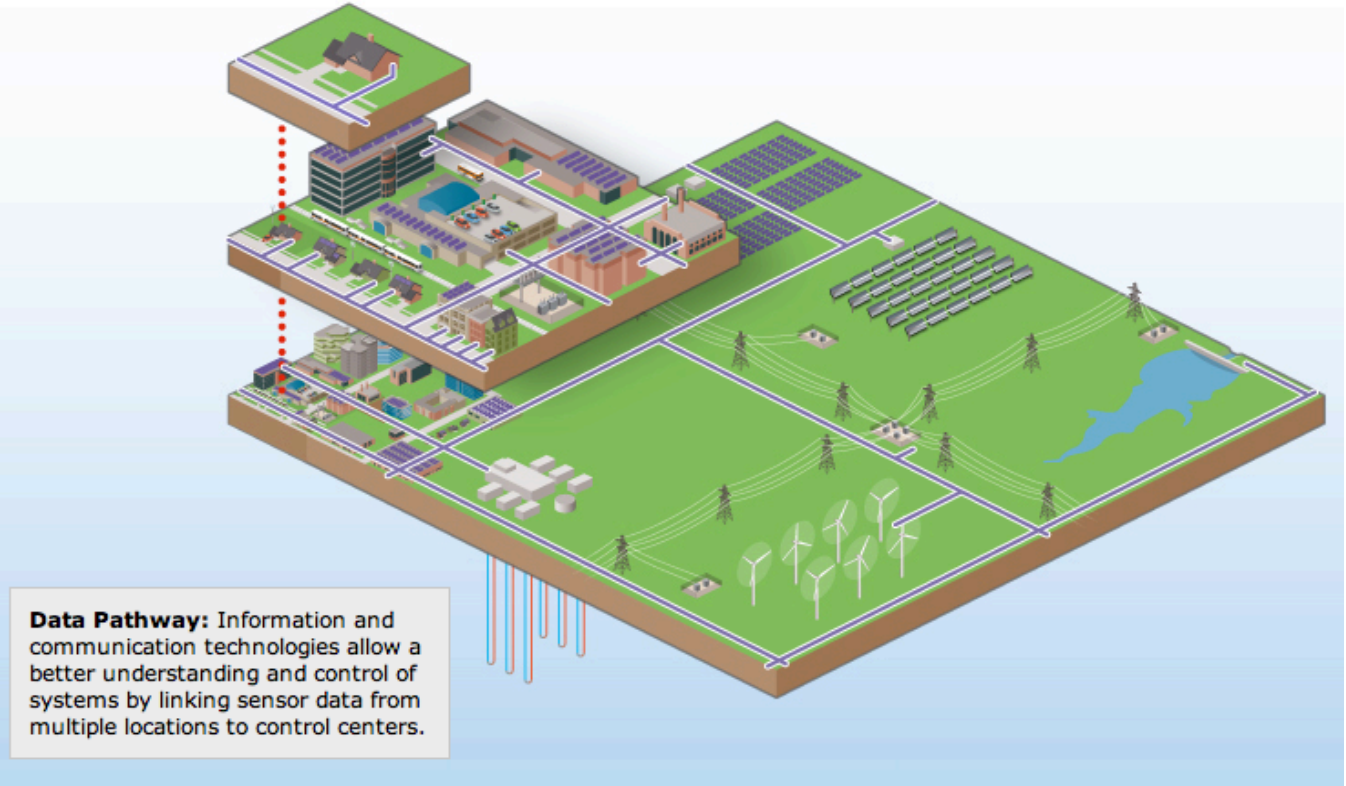
Existing energy systems have served us well… but a clean energy future needs a modernized and integrated infrastructure.

USA Energy System Overview

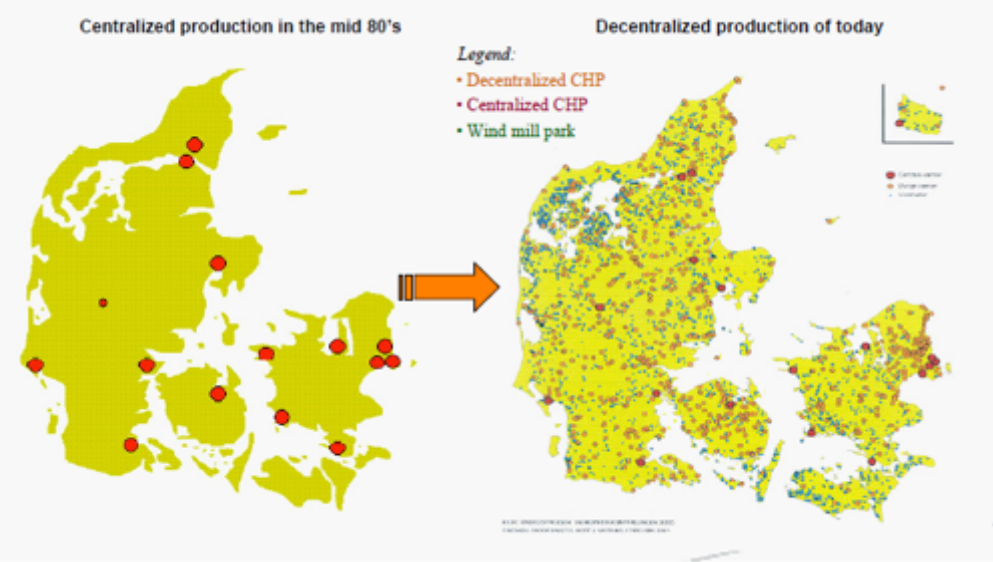


What Do We Mean by Energy Systems Integration?

Energy System Integration (ESI) *the process of optimizing energy systems across multiple pathways (domains) and physical scales*



Example of ESI - Denmark

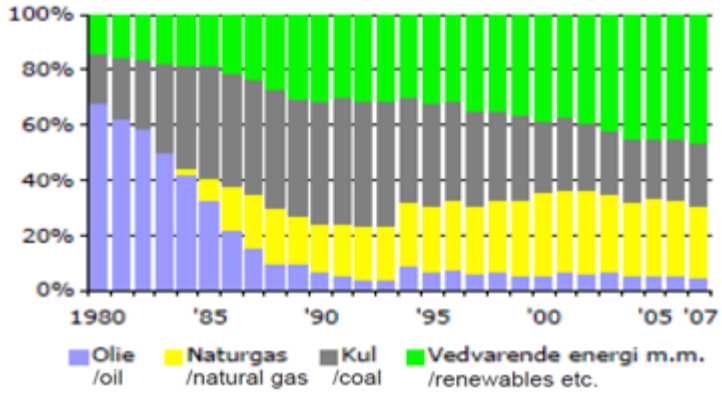


Denmark

- Small Country (5.5M people) -> about the size of the state of Maryland
- Dependent upon interconnections to neighboring countries

- Integrated combined heat and power has:
  - dramatically increased efficiency (30 %)
  - allowed 10 % of electricity from biomass
  - Reduced CO2 emissions by 20 %
  - Increasing the opportunity for natural gas

Figure 3: Fuel consumption for district heating production, percentage distribution

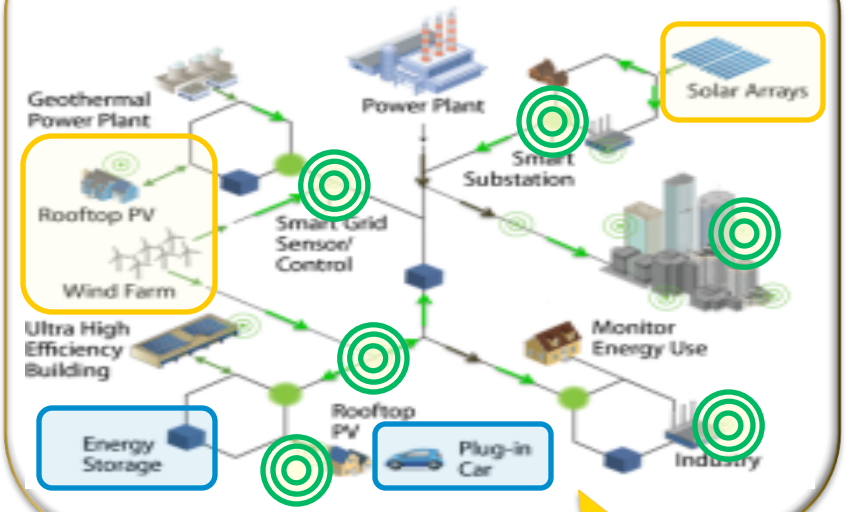


Understanding the Future Energy System

Current Energy System

- Carbon Intensive
- Large Generation
- Central Control
- Highly Regulated

Future Energy System



DRIVERS

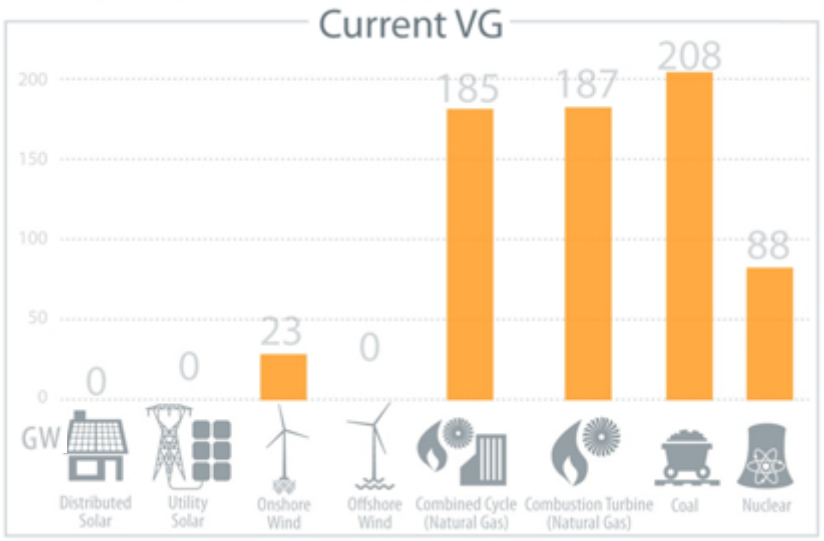
- Increased variable gen
- More bi-directional flow at dist level
- Increased number of active devices
- Evolving institutional environment

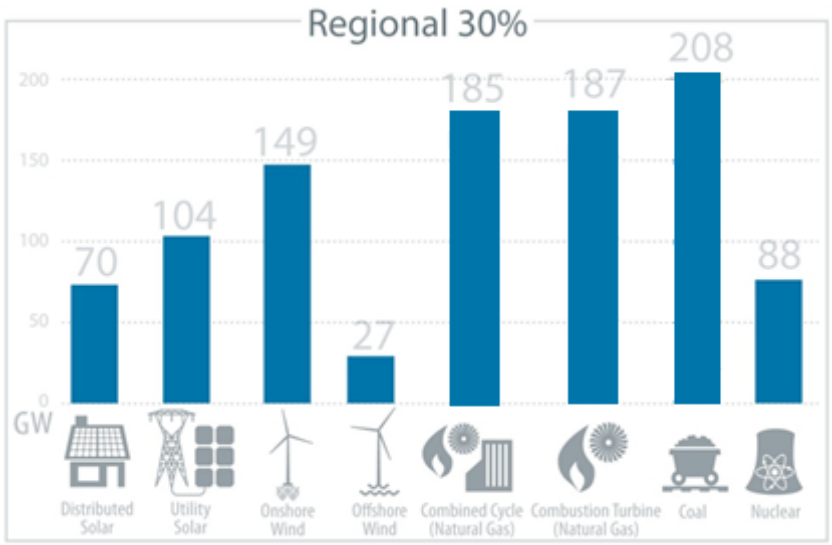
New Challenges to a Modern Energy System

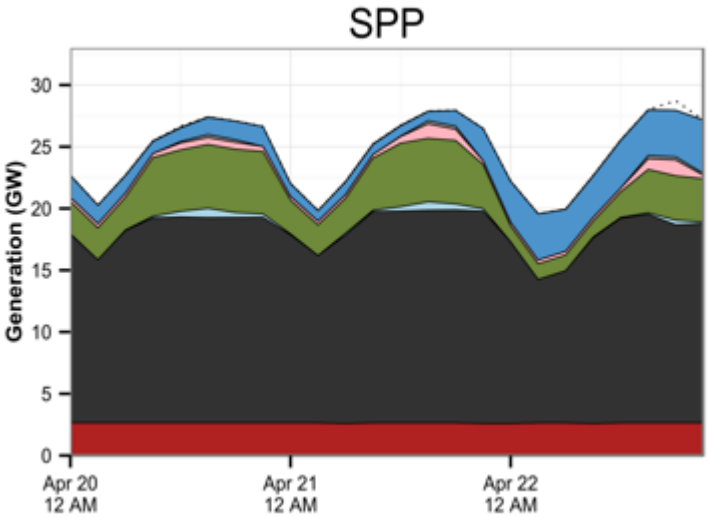
- New energy technologies and services
- Increasing penetration of variable renewables in grid
- New communications and controls (e.g. Smart Grids)
- Electrification of transportation
- Integrating distributed energy storage
- Need to increase system flexibility
- Need to capitalize on interactions between electricity/thermal/fuel systems

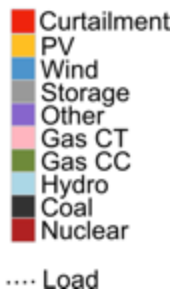
A Look Into the Clean Energy Future?

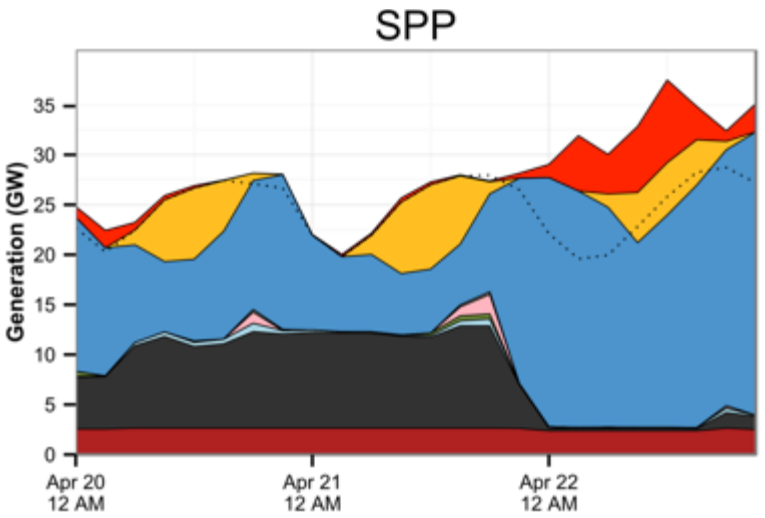
Eastern Renewable Generation Study (ERGIS), study forthcoming



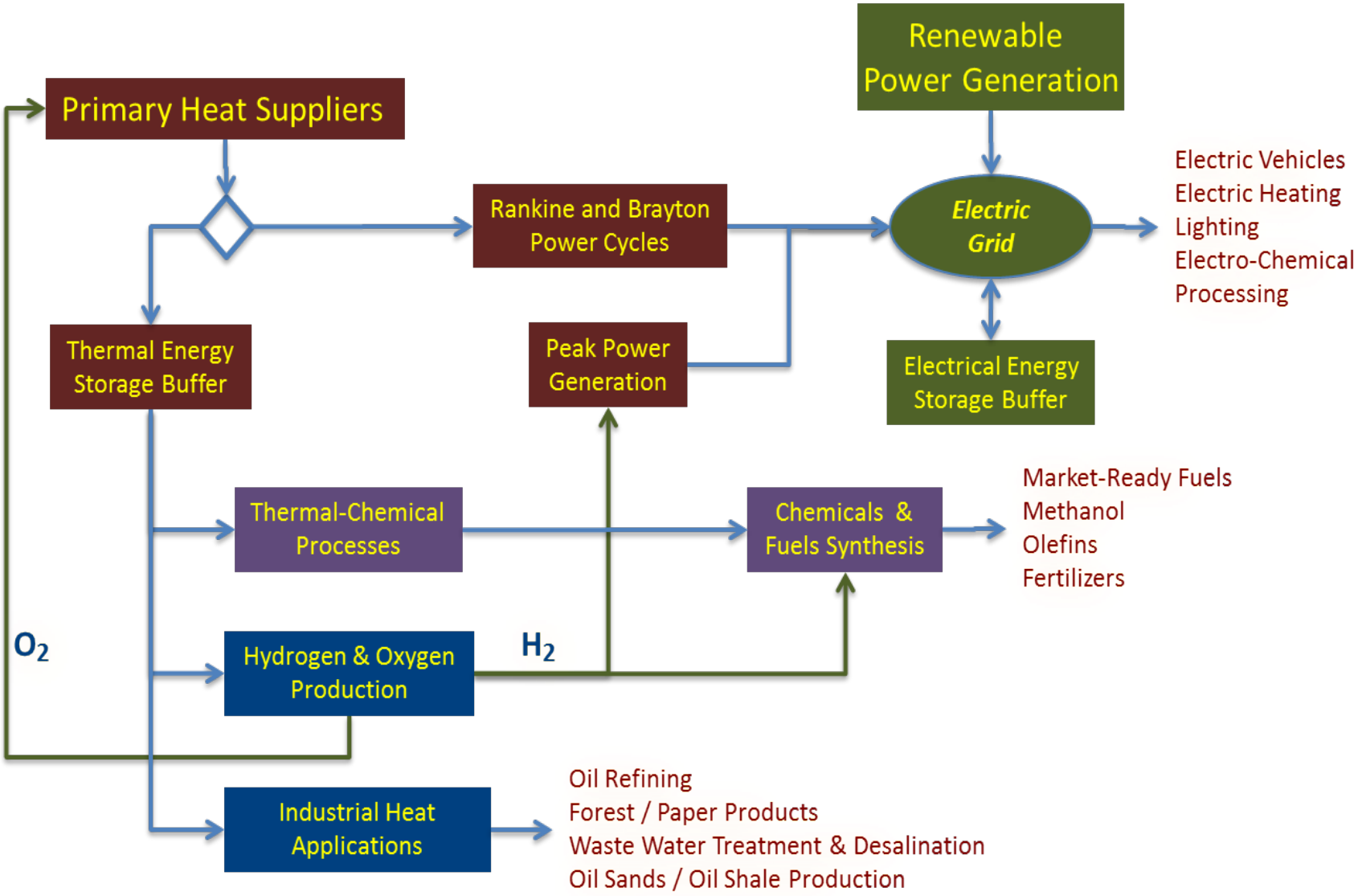






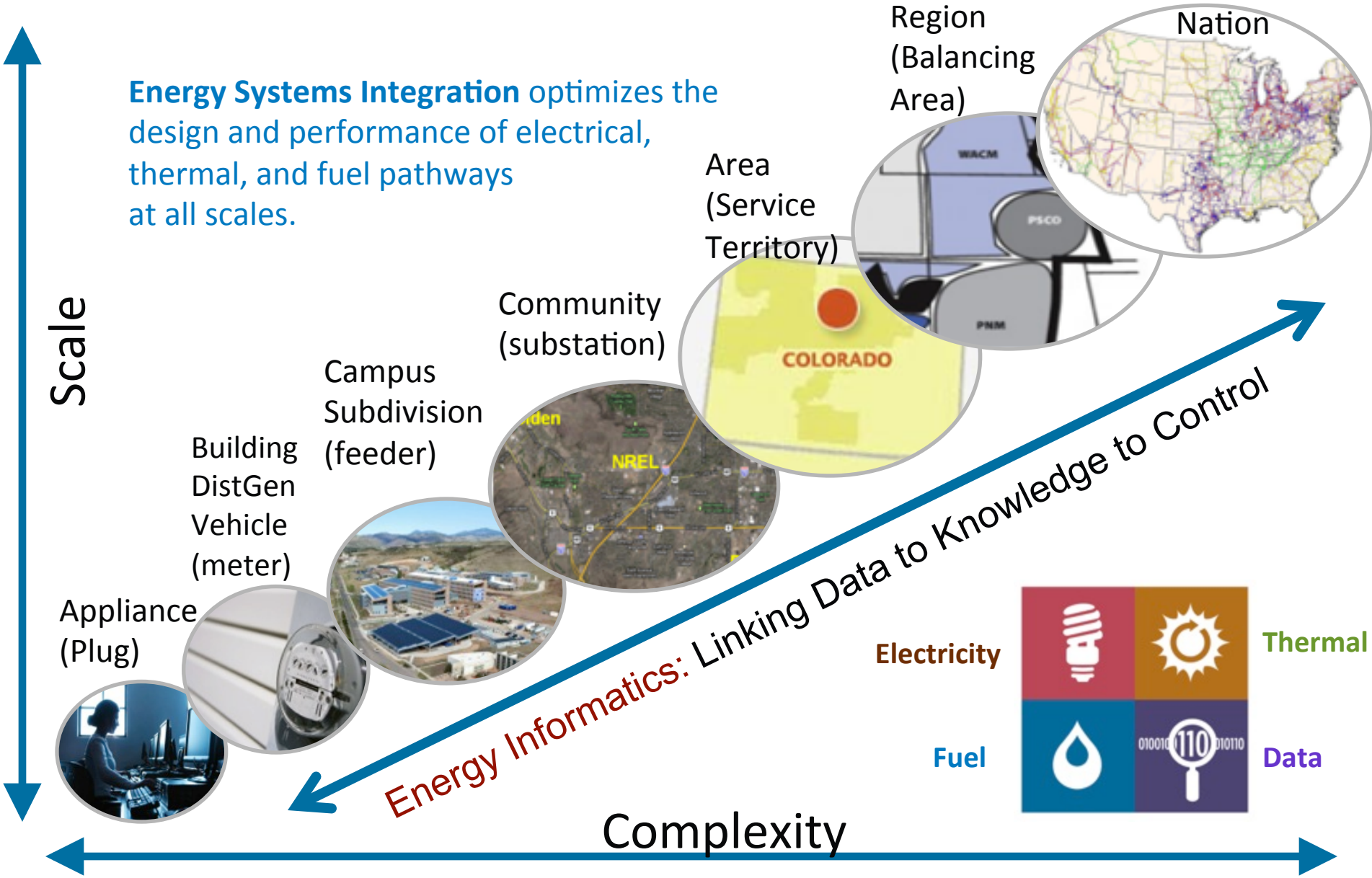


Thinking "Beyond the Grid"



Energy Systems Integration Continuum

Energy Systems Integration optimizes the design and performance of electrical, thermal, and fuel pathways at all scales.



The Value of ESI

Economic

- Cut overall energy use through optimization
- Reduce price volatility through supply diversity
- Increase asset utilization and avoid excess new build
- Capture system losses for valuable reuse
- Enhance system flexibility and resilience to disruption

Environmental

- Enable high penetration of renewable energy
- Reduce air, land and water pollution
- Meet future greenhouse gas reduction goals
- Manage water demands from the energy sector
- Move towards long-term resource sustainability

No single technology or approach can do it alone!

Summarizing the Grid Challenges

Emerging Technologies

Renewable Energy

Sustainable Transportation

Energy Efficiency

Physical Scales

Bulk System

Distribution

Customer

Drivers

More Variable Generation

Greater two-way power flow

Increasing numbers of active devices

Evolving Institutional Environment

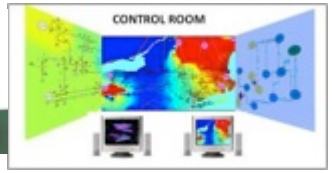
Solutions

Markets and Business Models

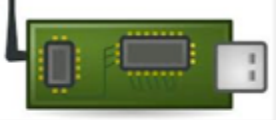
Design and Planning

Forecasting

Controls and Power Flow



Sensors and Measurements



Interoperability

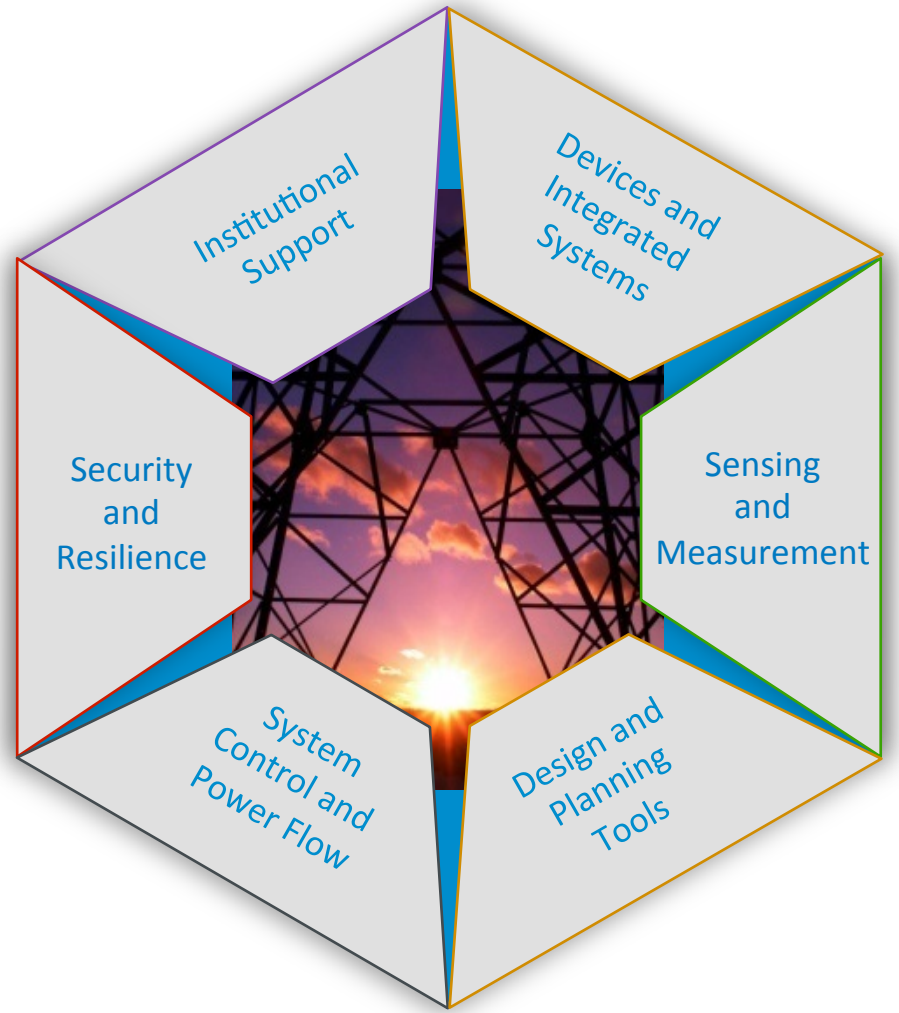
Characterization

Interconnection

Power Electronics

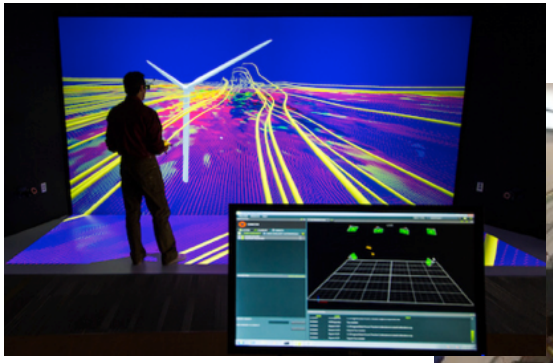
Energy Storage

Grid Modernization Laboratory Consortium



NREL Energy Systems Integration Facility (ESIF)

http://www.nrel.gov/esif



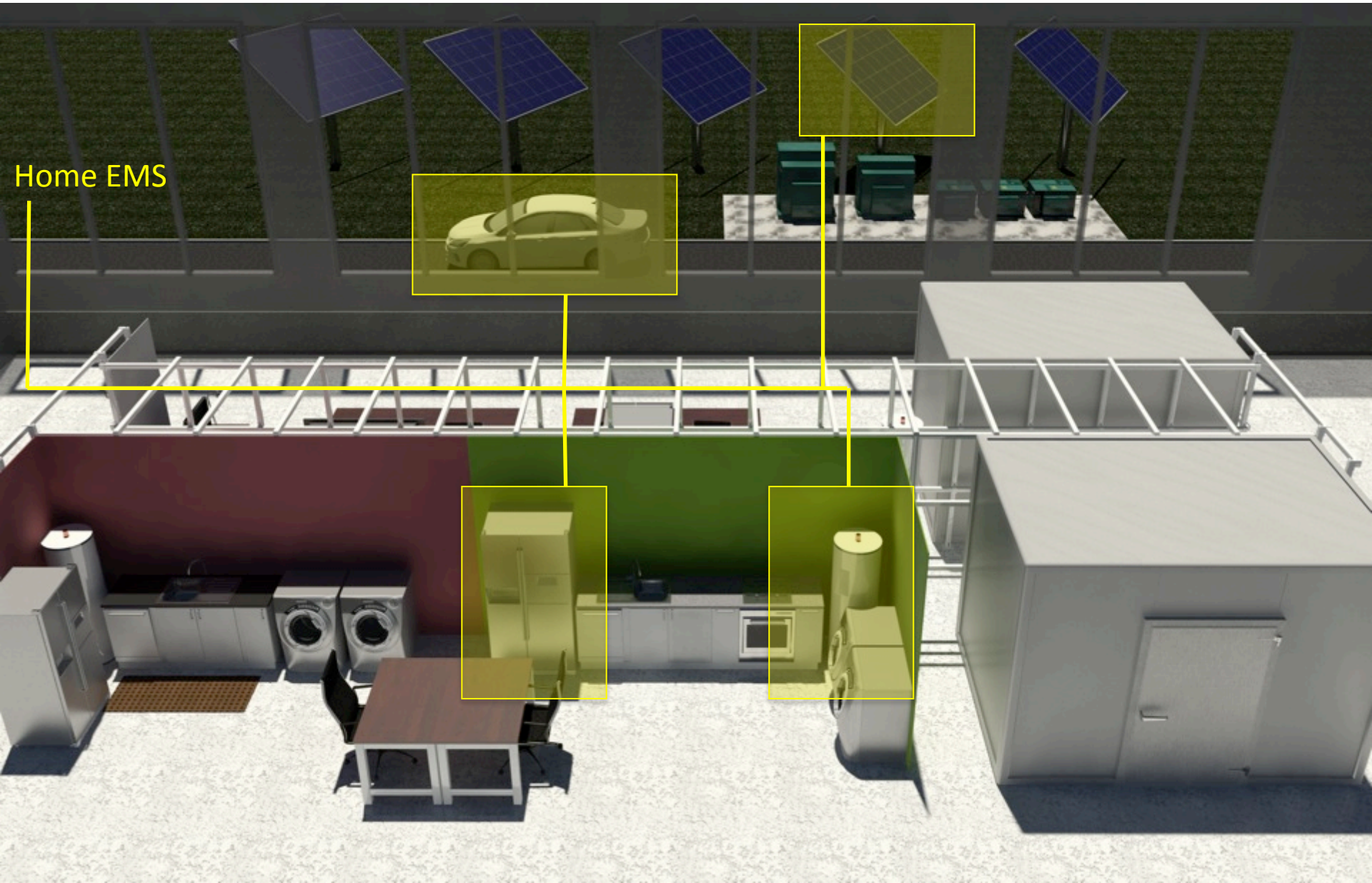
Shortening the time between innovation and practice

NREL | ENERGY SYSTEMS INTEGRATION FACILITY
NATIONAL RENEWABLE ENERGY LABORATORY
U.S. DEPARTMENT OF ENERGY

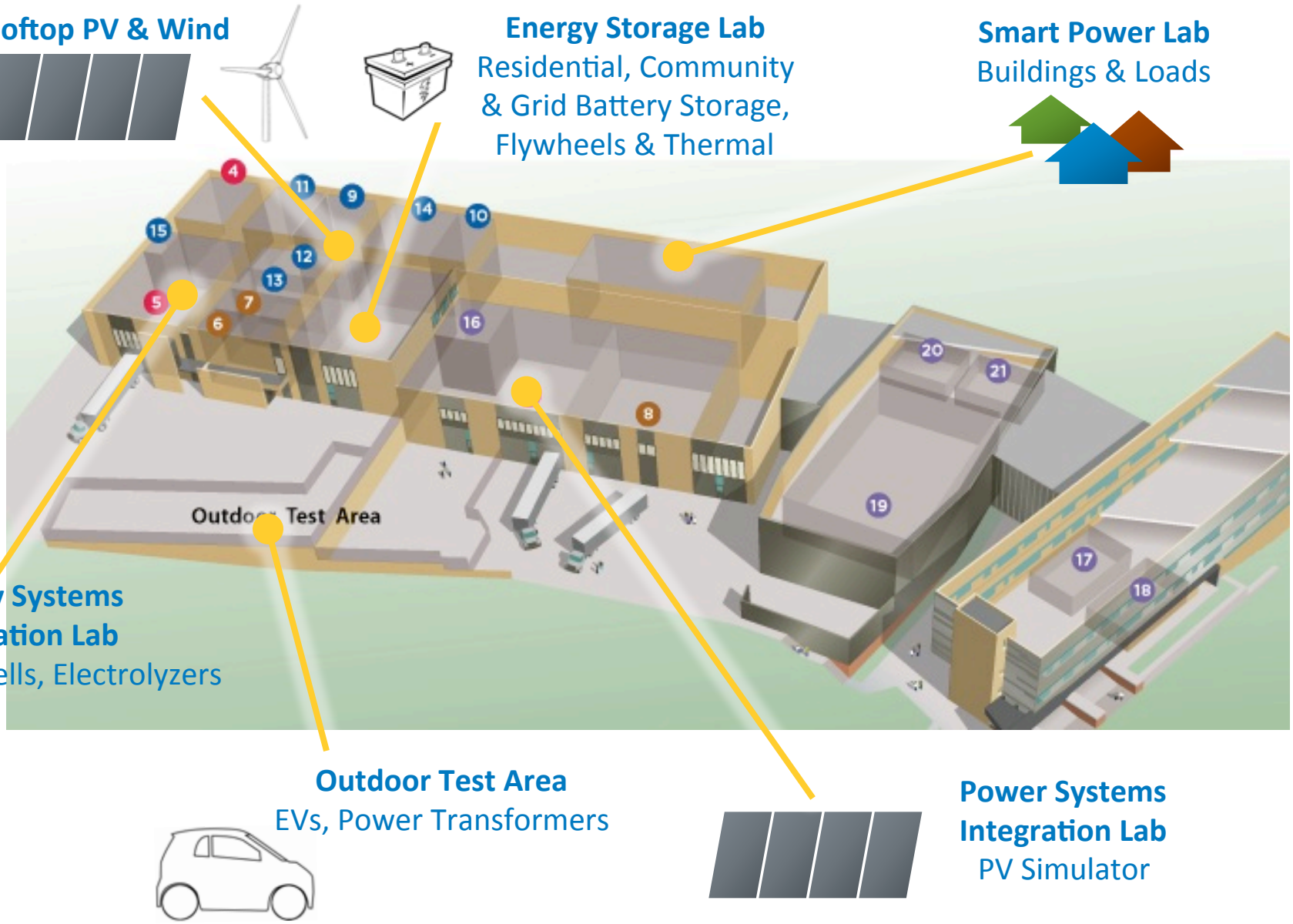
Unique Capabilities

- Multiple parallel AC and DC experimental busses (MW power level) with grid simulation and loads
- Flexible interconnection points for electricity, thermal, and fuels
- Medium voltage (15kV) microgrid test bed
- Virtual utility operations center and visualization rooms
- Smart grid testing lab for advanced communications and control
- Interconnectivity to external field sites for data feeds and model validation
- Petascale HPC and data mgmt system in showcase energy efficient data center
- MW-scale Power hardware-in-the-loop (PHIL) simulation capability to test grid scenarios with high penetrations of clean energy technologies

ESIF Smart Power Lab



ESIF Laboratories



A Design Process for Clean Energy

Hardware Testing

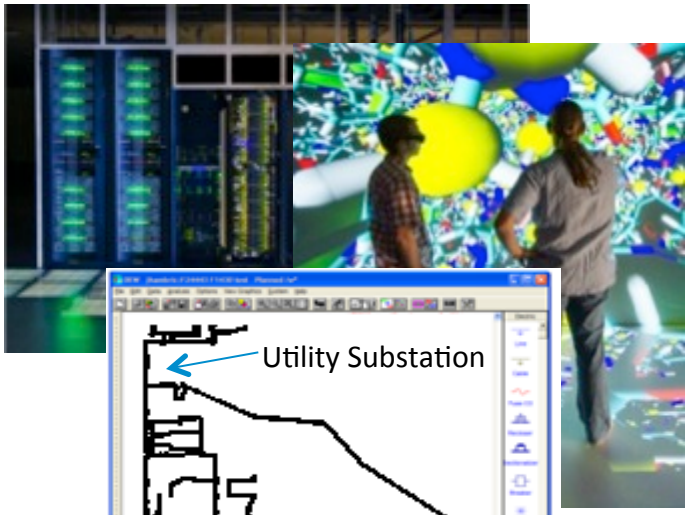
PV Simulator

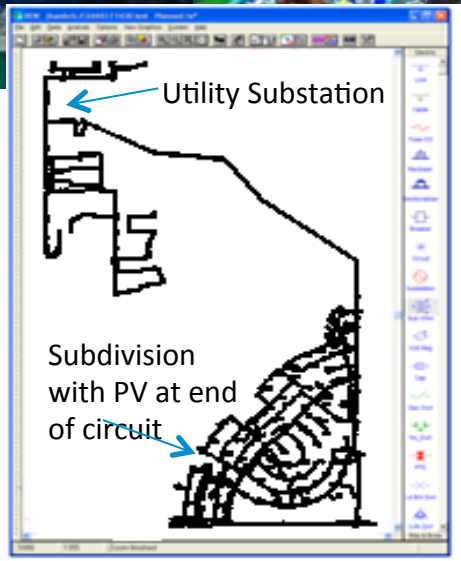
Devices Under Test (e.g. inverter, energy storage, EV, loads)

Load Banks

Grid Simulator

Modeling & Simulation



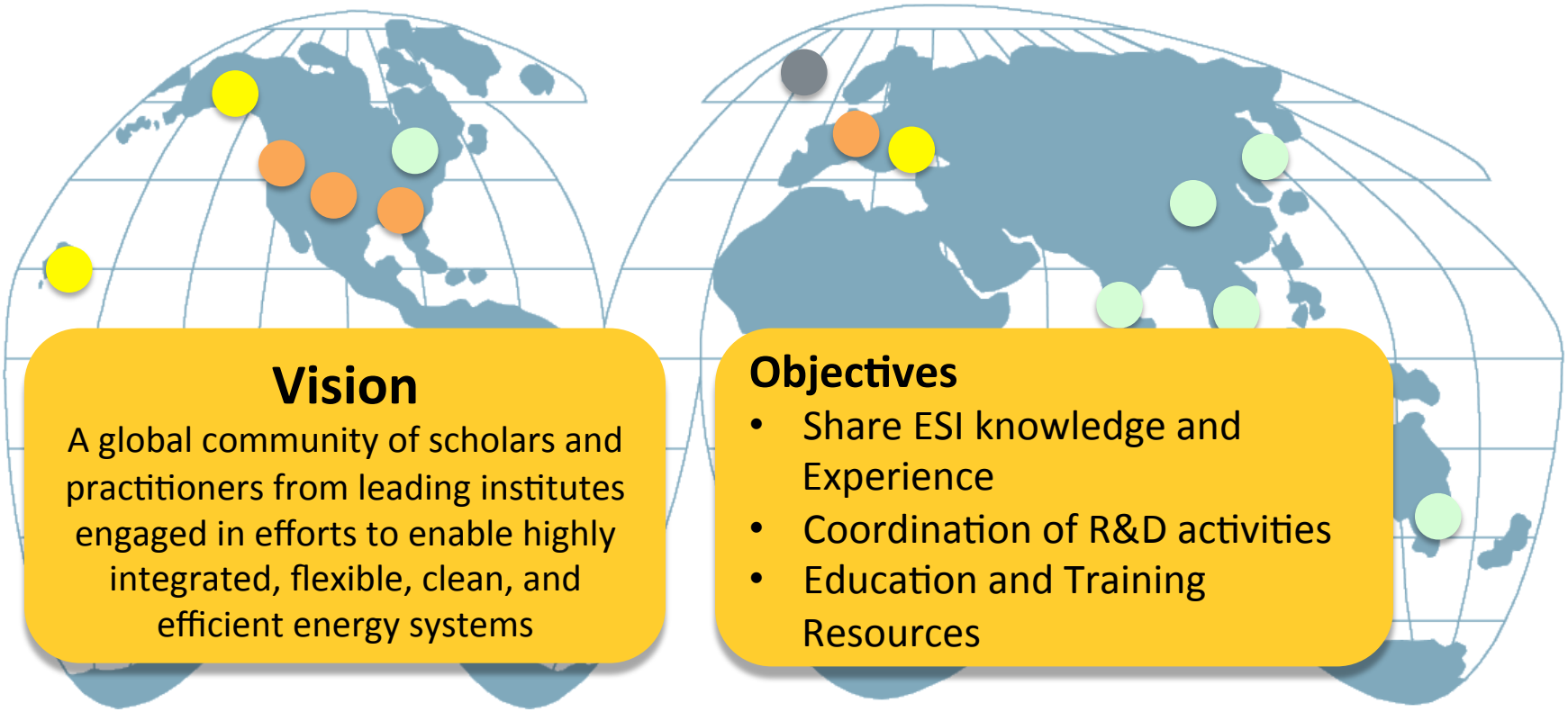


Field Deployment

Continuous Learning and Improvement

iiESI International Institute for Energy Systems Integration

Addressing energy challenges through global collaboration www.iiESI.org



Vision

A global community of scholars and practitioners from leading institutes engaged in efforts to enable highly integrated, flexible, clean, and efficient energy systems

Objectives

- Share ESI knowledge and Experience
- Coordination of R&D activities
- Education and Training Resources

NREL NATIONAL RENEWABLE ENERGY LABORATORY

Pacific Northwest NATIONAL LABORATORY

EPRI ELECTRIC POWER RESEARCH INSTITUTE

UCD DUBLIN

DTU

KU LEUVEN

Scope of Energy Systems Integration (ESI)

Optimizes the integrated suite of electrical, thermal, and fuels pathways at all scales

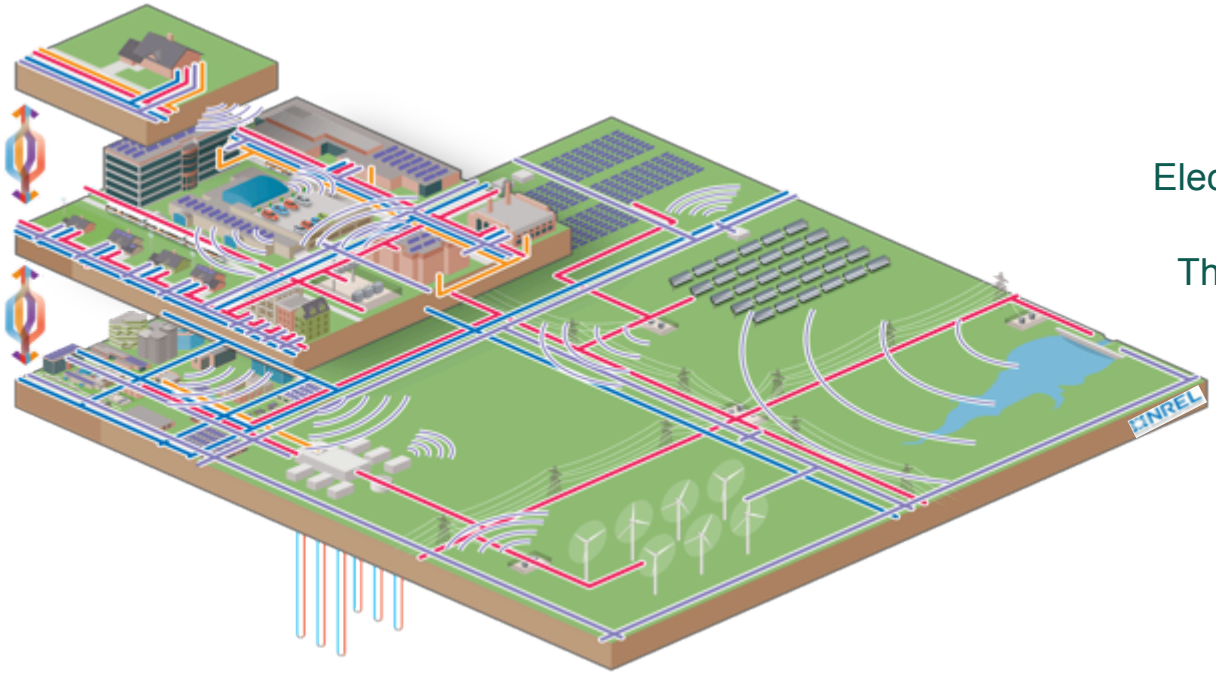
Energy Source

Fossil | Nuclear | Renewable

Single Technologies and Locations

Campus, City Community

Regional, National, Continental



Electricity

Thermal

Fuels

Data

Residential | Commercial | Industry | Mobility

"its scope is potentially vast but it is first and foremost focused on the interfaces where **the coupling and interactions are strong and represent a challenge and/or an opportunity**"

Evolution of Activities iiESI 2014

Feb 18-19th 2014
Workshop, Washington DC
46 attendees, 15 EU, 1 Asia, 30 US, very positive reaction to the concept, but mainly technical need more on policy

Feb 27th 2014
European Union, Energy Research Alliance initiates a process to form a Joint Programme (JP) in ESI

May 27-28th 2014
Workshop, Copenhagen
100 attendees, 10 US, 90 Europe, emphasis on policy & water

Jul 21-25th 2014
ESI 101 at NREL US
Course for PhD students in ESI
40 PhD students from US
Instructors from Europe & US

Jul 27-31st 2014
iEEE PES General Meeting
Panel Session on Energy Systems Integration, Research Challenges and Opportunities.

Sept 16th 2014
Workshop jointly with IEA Renewable Energy Working Party
70 people from all parts of the world

Nov 17th 2014
Asian Workshop
Kyoto

iiESI International Institute for Energy Systems Integration

Near-Term Objectives:

1. Hold regular meetings (2-3 per year; rotating) to foster exchange of ideas, results, lessons learned and best practices from ESI-related activities throughout the world.

2. Create and execute on a framework for knowledge capture, management and transfer from energy systems experiments conducted to date and in future.
   a. Internet portals and bookmarks
   b. Blogs, wikis and other collaborative tools
   c. Repository for institutional capabilities, contacts, publications, data, and current research

Near-Term Objectives:

3. Coordinate, where feasible, institutional investments in future ESI R&D to enable efficient and leveraged use of resources

4. Develop shared resources for ESI workforce development and training
   a. Hands-on research experiences for students
   b. Student support for ESI projects/thesis topics
   c. ESI curricula and summer schools
   d. Online resources to aid continuing education in energy systems

iiESI International Institute for Energy Systems Integration

Participation:

- Open to any institution or entity actively involved in ESI-related R&D
  - Research universities
  - National laboratories
  - Non-profit research organizations
  - Energy companies, suppliers, vendors, etc.

- Core contributions support iiESI function and admin
  - $100K/yr (Institutional Members)
  - $25K/yr (Affiliate Members)

- Members may also serve as Project Sponsors for additional activities and events

iiESI Graduate Student Summer Program

GOAL

Stimulate interest in interdisciplinary energy systems studies by enabling selected students to carry out an intensive research project at an iiESI Member institution, which can be applied to the student's graduate thesis.

DATES

10 week session
TBD June – August 2015

CONTENT

- One-week deep orientation to the concepts of energy systems integration and the challenges of incorporating high levels of energy efficiency and renewable energy into current energy systems.
- Eight-week research project developed and carried out with a iiESI Member institution mentor with parallel scientific interests.
- Final week of public presentations to share results and lessons learned.

Agenda for today

- Opening address – Japan, Europe, US
- Detailed look at the Japanese Energy System
- International collaboration

Thank you - For More Information

Bryan Hannegan

Associate Lab Director, Energy Systems Integration

National Renewable Energy Laboratory

Mail Stop RSF 050, 15013 Denver West Parkway

Golden, CO 80401 USA

+1-303-275-3009 (phone)

bryan.hannegan@nrel.gov (email)

http://www.nrel.gov/esi

Energy Systems Integration

Accelerating the Clean Energy Future

Session – Opening Session

8.30-10.15 Opening Address

Chair: Mark McGranaghan (Vice President, EPRI)

08.30-09.00 Welcome and Energy Systems in Japan

Kazuhiko Ogimoto -Professor, The University of Tokyo

Keywords for presentation:

Overall situation of energy of Japan

09.00-09.25 Introduction to iiESI and the themes of Kyoto Workshop

Bryan Hannegan -Associate Laboratory Director, Energy Systems Integration at National Renewable Energy Laboratory

Keywords for presentation:

Energy Systems in Japan, international collaborations, knowledge exchange, outcomes of past workshops

09.25-09.50 ESI in Ireland and Europe

Fintan Slye -Chief Executive EirGrid- TSO Ireland

Keywords for presentation:

ESI in Europe, drivers of ESI, achievement in Ireland, overview of Irish grid

Session 1 - Technical

10.15-12.30 Session 1- Technical

Chair: Ben Kroposki (National Renewable Energy Laboratory)

10.15-10.45 Current Situation and Integration Potential in Electricity Area in Japan

Fumiaki Ishida -General Manager, Advanced Grid Strategy Group, Corporate Planning Division, Kansai Electric Power Company (KEPCO)

Keywords for presentation:

Power demand and supply structure, electric power grid, renewable power generation deployment and integration, smart grid, smart meter and demand response

10.45-11.15 Current Situation and Integration Potential in Gas Area in Japan

Hisashi Maeda -Manager, Osaka Gas

Keywords for presentation:

Gas demand and supply structure, gas pipe line, centralized heating and cooling system, CHP, smart grid, distributed generation for power system balancing

11.15-11.45 Current Situation and Integration Potential in Transport Area in Japan

Hitoshi Hayashiya -Manager, Electrical and Signal Network System Department, JR East

Keywords for presentation:

Railway in Japan, Power supply system including generation and ac/dc supply, energy storage, battery application to trains, Regenerative energy

Session 2 – Policy

13.30-16.15 Session 2- Policy

Chair: William D'haeseleer (University of Leuven, KU Leuven)

13.30-14.00 Current International Cooperation activities for ESI - A Japanese Perspective

Kazuyuki Takada -Deputy Director, Smart Community Department, New Energy and Industrial Technology Development Organization (NEDO)

14.00-14.30 Potential International Cooperation for ESI- A Japanese Perspective

Yoshiro Owadano -Director-General, Fukushima Renewable Energy Institute, National Institute of Advanced Industrial Science and Technology (AIST)

14.30-14.50 Break

14.50-15.10 Developing International Cooperation between US, Europe and Japan

Kevin Lynn - Director of Grid Integration Initiative Office of Energy Efficiency and Renewable Energy, US Department of Energy

15.10-15.30 Developing International Cooperation between European Commission and Japan

Patrick Van Hove -DG Research for the SET Plan European Electricity Grids Initiative and for the Smartgrids technology Platform

Session 2 – Discussion

15.30-16.15 Open Discussion

Indicative Questions:

Ignoring the political/social perspective in Japan since Fukushima, how suitable is nuclear energy in an integrated energy system? e.g. nuclear energy tends to be inflexible and therefore may not be complementary to large amounts of variable renewables.

Japan is a major importer of primary sources of energy, therefore energy efficiency obviously forms a key part of energy policy in Japan. Energy efficiency can be gained by the energy systems integration approach. Is this on the Japanese agenda with regard energy efficiency?

Can you see any economic/security supply benefits of coordinating with other countries e.g. Russia and Korea?

What are the funding opportunities for international cooperation of Energy Integration?

16.15-16.45 Summary of Kyoto Workshop and Vision of Future Energy Integration

Mark O'Malley – Professor University College Dublin