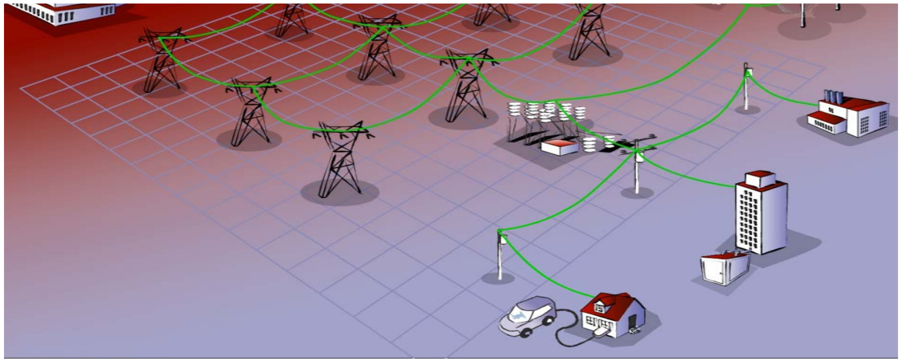
NATIONAL ENERGY TECHNOLOGY LABORATORY



METERING BILLING/MDM AMERICA

Back-up Generation Sources (BUGS)

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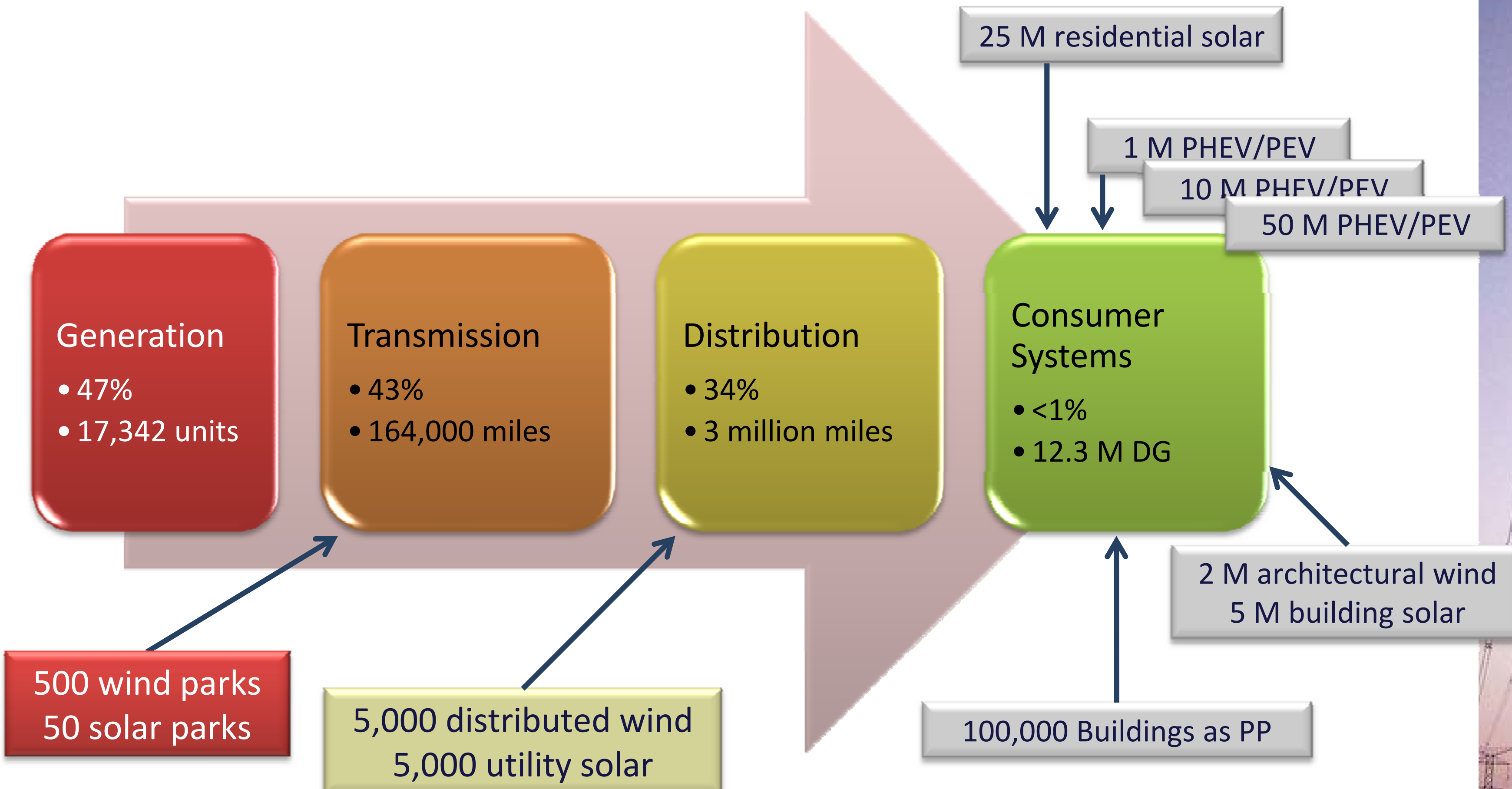
Today’s Discussion

- What is the 21st Century telling us?
- What are the lessons from Denmark and Japan?
- Can back-up generation sources (BUGS) help?
- Can we mange, integrate, and control DG under variable conditions?

What is the 21st Century Telling Us?

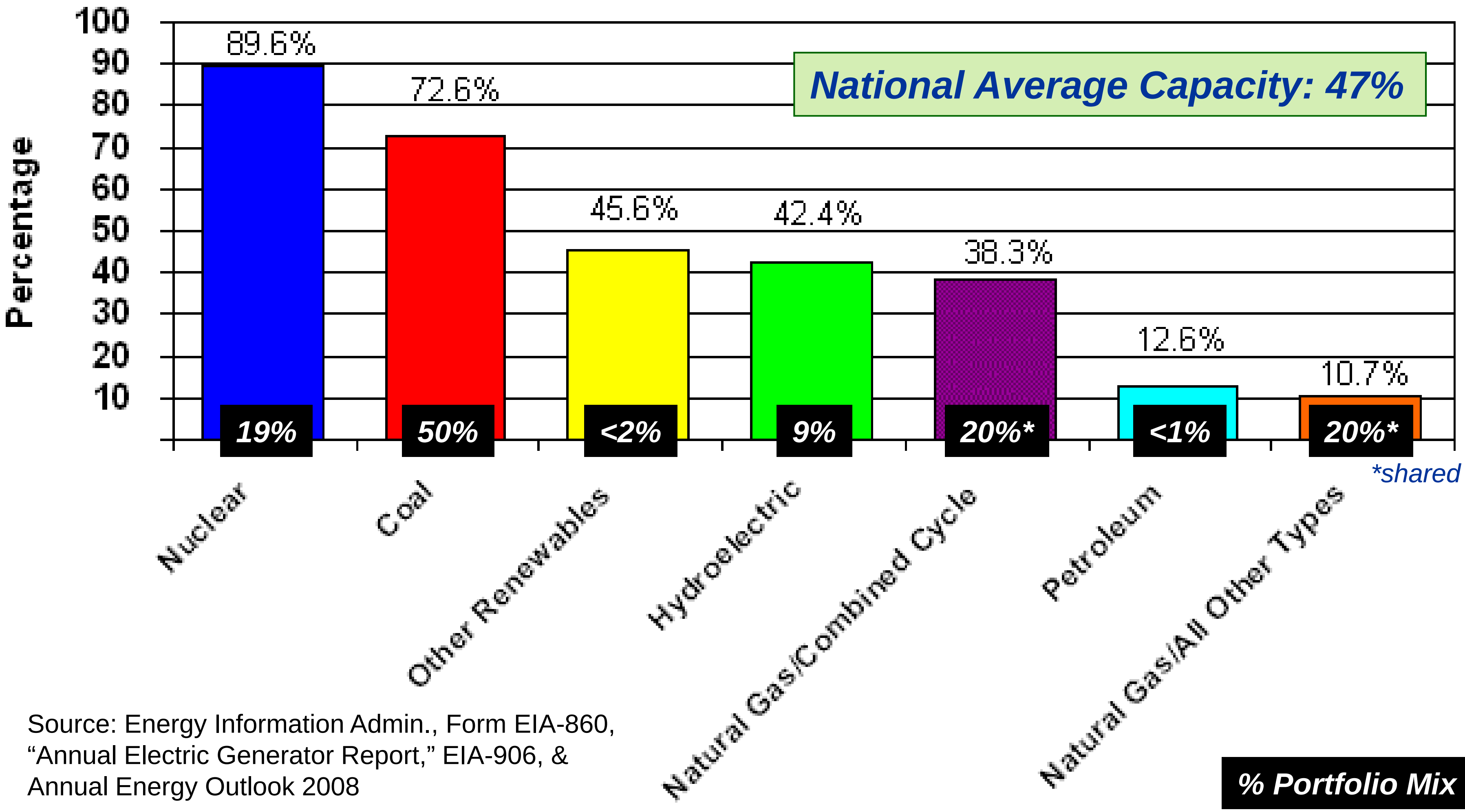
From the 20th to the 21st Century



Result – Sea Change in the Network

- Consumer engagement with resources to solve power issues locally
- Two-way power flow in Distribution
- As prices increase, local renewables will increase in residential, commercial, and industrial
- Imperative to transform from passive to active control in Distribution
- New ways for Distribution to become a Transmission resource

Generation Capacity Factors by Type



Source: Energy Information Admin., Form EIA-860, "Annual Electric Generator Report," EIA-906, & Annual Energy Outlook 2008

Renewables Growth (2004* – 2008)

Renewables Global Status Report – 2009 Update (145 countries reporting)
** Baseline – Bonn Renewables Conference 2004*

- Grid connected PV now 13GW – 600% increase
- Wind now 121GW – 250% increase
- Total from all renewables now 280GW – 75% increase
  - Includes large increase in small hydro, geothermal, & biomass generation
- Solar heating now 145 GWth – 200% increase
- Biodiesel production now 12B liters/yr – 600% increase
- Ethanol production now 67B liters/yr – 200% increase
- Annual renewables investment in new capacity now $120B/year – 400% increase

Smart Grid Characteristics

The Smart Grid is “transactive” and will:

- Enable active participation by consumers
- Accommodate all generation and storage options
- Enable new products, services, and markets
- Provide power quality for the digital economy
- Optimize asset utilization and operate efficiently
- Anticipate & respond to system disturbances (self-heal)
- Operate resiliently against attack and natural disaster

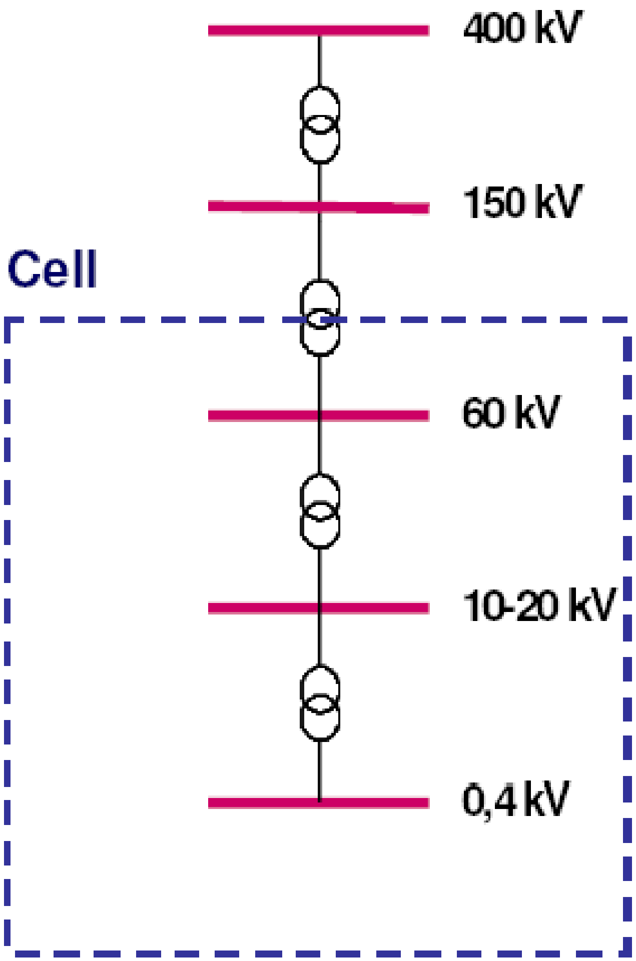
…the enabler

Lessons from Denmark and Japan

Denmark Changed in Two Decades

Source: Danish Energy Center

Denmark DG Penetration and Cell Structure



4 central CHP units (1488 MW)

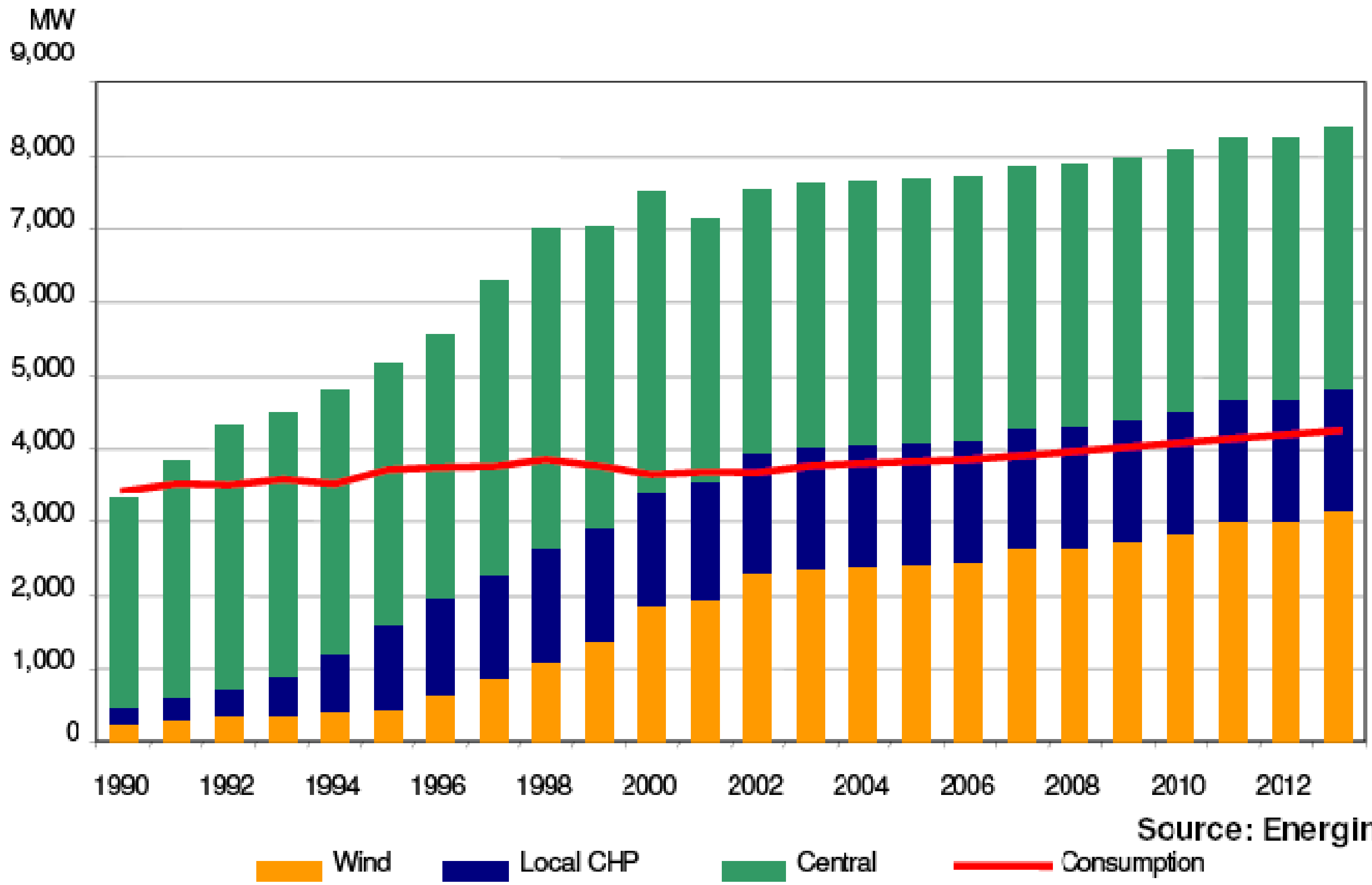
6 central CHP units (2014 MW)
Horns Rev offshore wind farm (160 MW)

17 dispersed CHP units (569 MW)
34 wind turbines (41 MW)

475 dispersed CHP units (991 MW)
2180 wind turbines (1597 MW)

260 dispersed CHP units (83 MW)
1860 wind turbines (576 MW)

Denmark Energy Contribution



Source: Energinet.dk

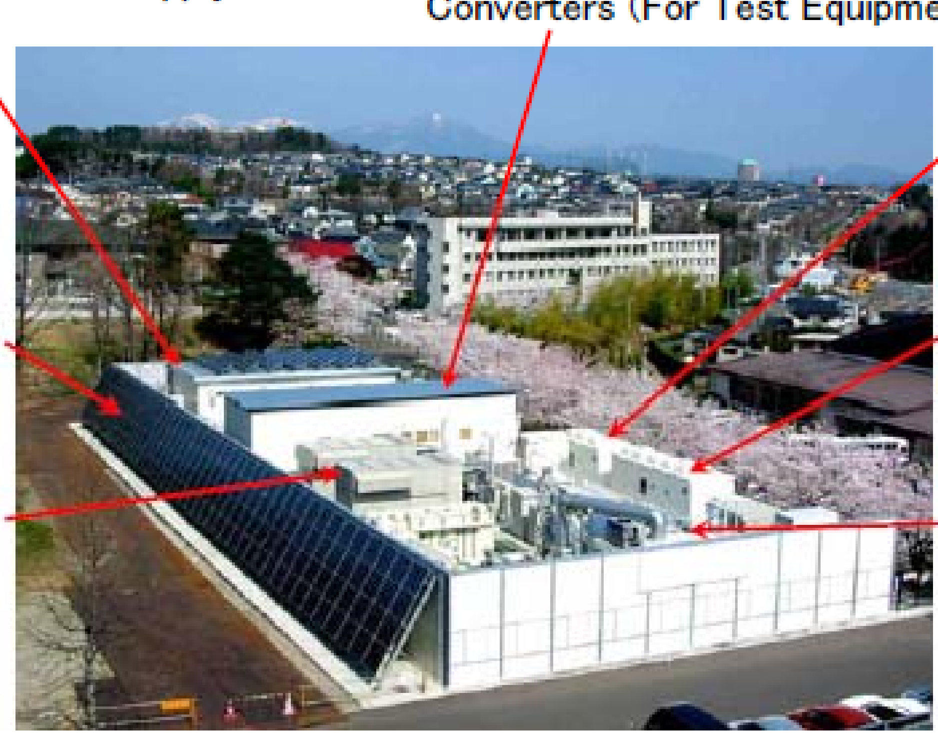
Japan Advancements

- **Transformation in distribution network to a nearly 100% automated system**
- **Experienced a significant drop in “SAIDI” to less than 3 minutes**
- **PV installed: 1,400 MW (2005), 14,000 MW (2020)**
- **NEDO (New Energy and Industrial Technology Development Organization) developed prototypes in microgrids and DG integration**
- **Advanced systems show 23% space reduction – important goal in Japan**

Smart Grid Concept in Japan

1. Accumulation of historical PV output data
2. Develop PV output prediction system
3. Develop :
    - Control system to integrate supply and demand side
    - Monitoring system for real-time PV output
    - Highly reliable battery system

NEDO Microgrid Prototype



NEDO = New Energy and Industrial Technology Development Organization

Lessons from Active Intelligent Control

- Increase local reliability using sensing and automation for real-time control
- Increase use of local community resources
- Increase use of local grid resources
- Increase the responsiveness to disturbances (pre- and post-)
- Predict and eliminate potential failure points
- Reduce the effects of variability from renewable resources (local and far away)

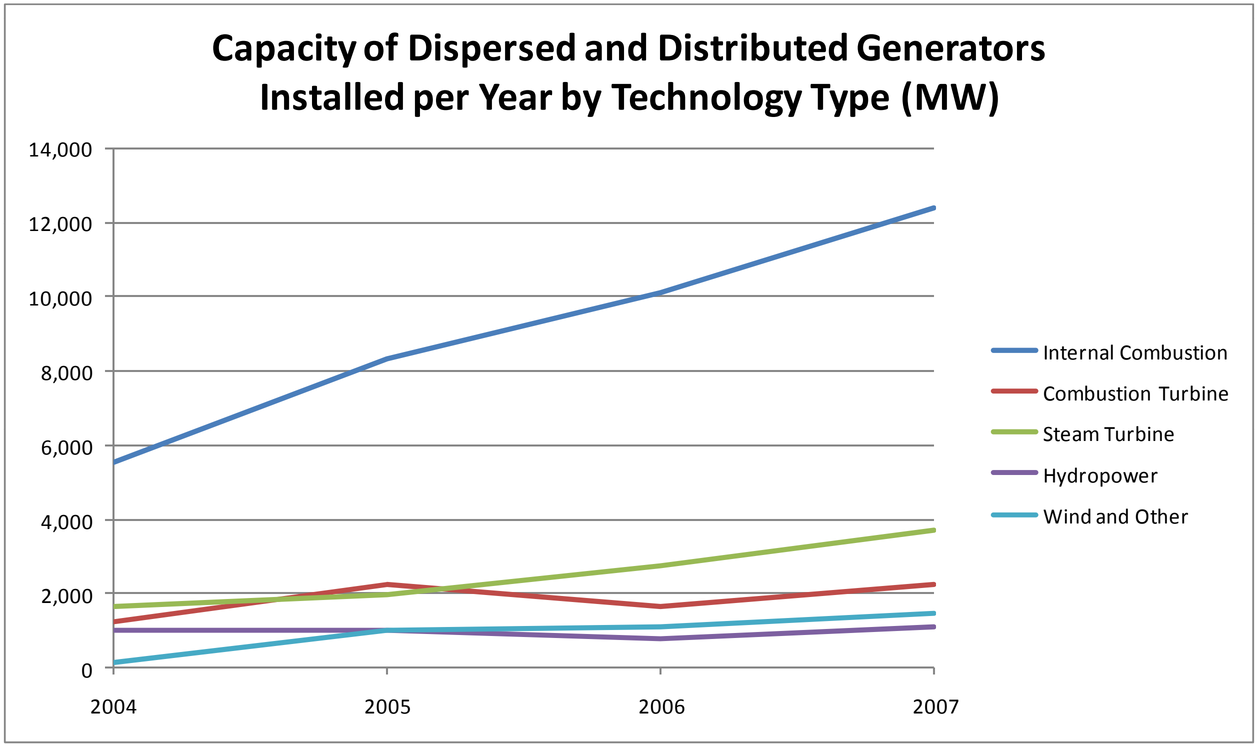
Back-up Generation Sources

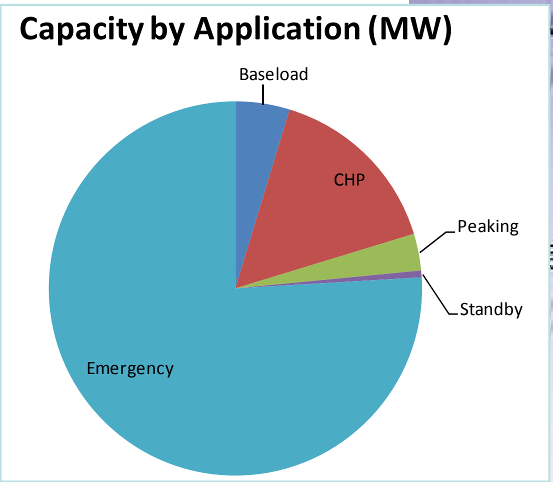
What if?

- What if there were a capacity and energy solution that could completely address the peaking load, located at the peak areas, could immediately respond, would cost 1/3 the cost of natural gas peakers, operate cheaper, be immediately$_{res}$ ponsive (< 90 sec), and reduce the CO2 emissions?
- Would the industry embrace it?
- BUGS – an example grid transformation considered radical by the US norm

Back-up Generation Sources (BUGS)

Of the roughly 220 GW (2005) of installed DG in the US, 170 GW are BUGS at a capacity factor of 0.9%





Source: "BUGS: The Next Smart Grid Peak Resource," report by NETL Smart Grid Implementation Strategy team, February 2010

BUGS Myth Busting

- Integration Issue
  - BUGS successfully utility-dispatched at several utilities
  - Hundreds of successful international examples
- Economics
  - CapEx conversion for dispatching ~1/6 cost of traditional peaking generation
- Environment
  - Actual diesel BUGS experience (peaking operations) shows less CO_2 emissions than same energy delivery with traditional peaking generation
- VVV (variability, volts, VARs)
  - Microgrid projects show BUGS help

Management, Integration, & Control

Microgrids

- Japan
- Denmark cell control
- Kythnos Island
- CERTS, AEP, University of Wisconsin 100KW pilot at Dolan
- Significant action worldwide in multi-agent communities

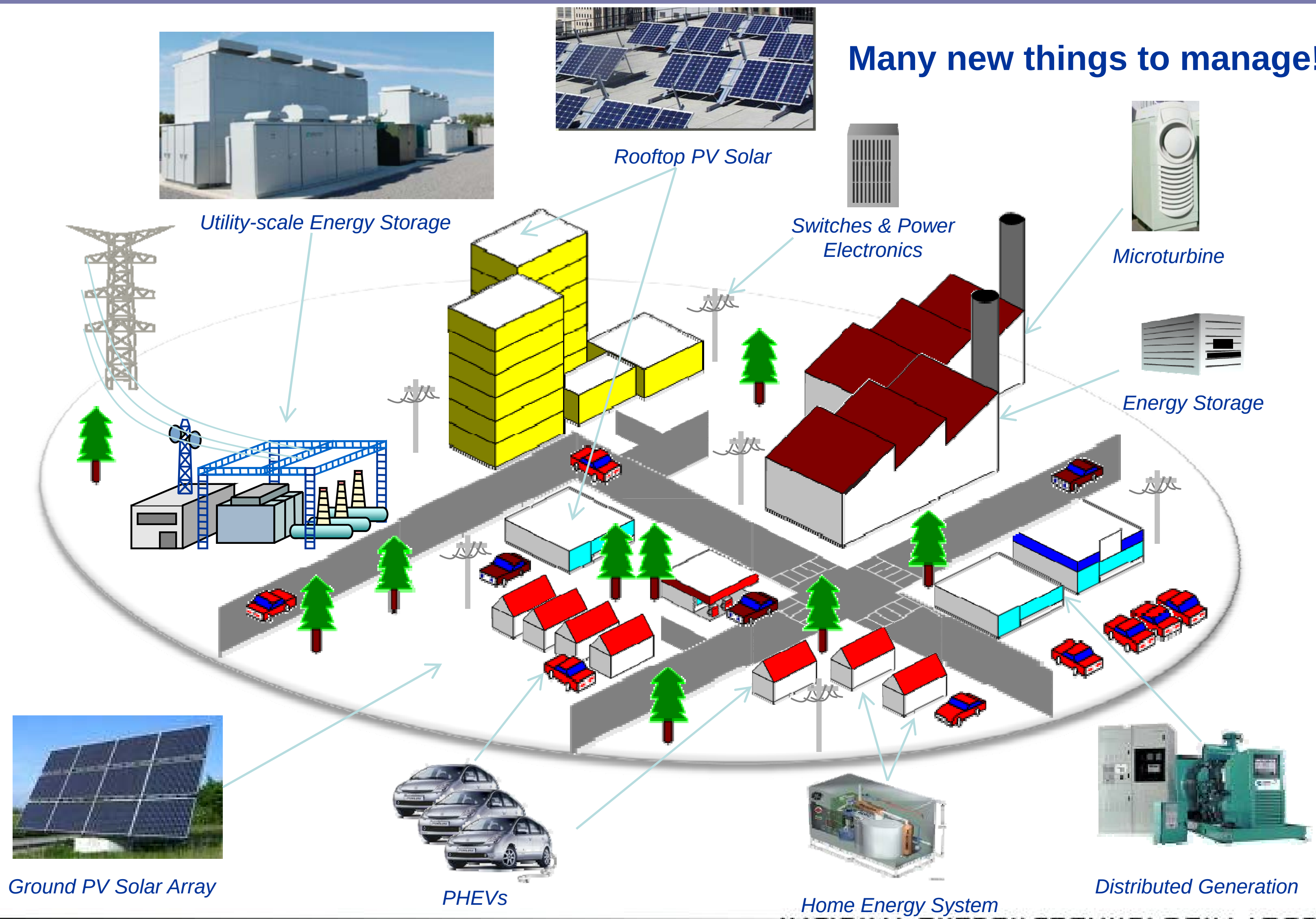
- DOE RDSI
  - San Diego Microgrid ($16M)
  - Fort Collins Mixed Distributed Resources ($11M)
  - WV Super Circuit ($10M)
  - ATK Rocky Mountain Power ($4M)
  - Santa Rita Jail Chevron, PG&E, et al ($14M)
  - conEd Consumer Enablement ($13M)
  - IIT Galvin Microgrid ($12M)
  - Hawaii Management of Distribution Resources ($15M)
  - Pulte Homes UNLV GE ($21M)

Three Key Lessons

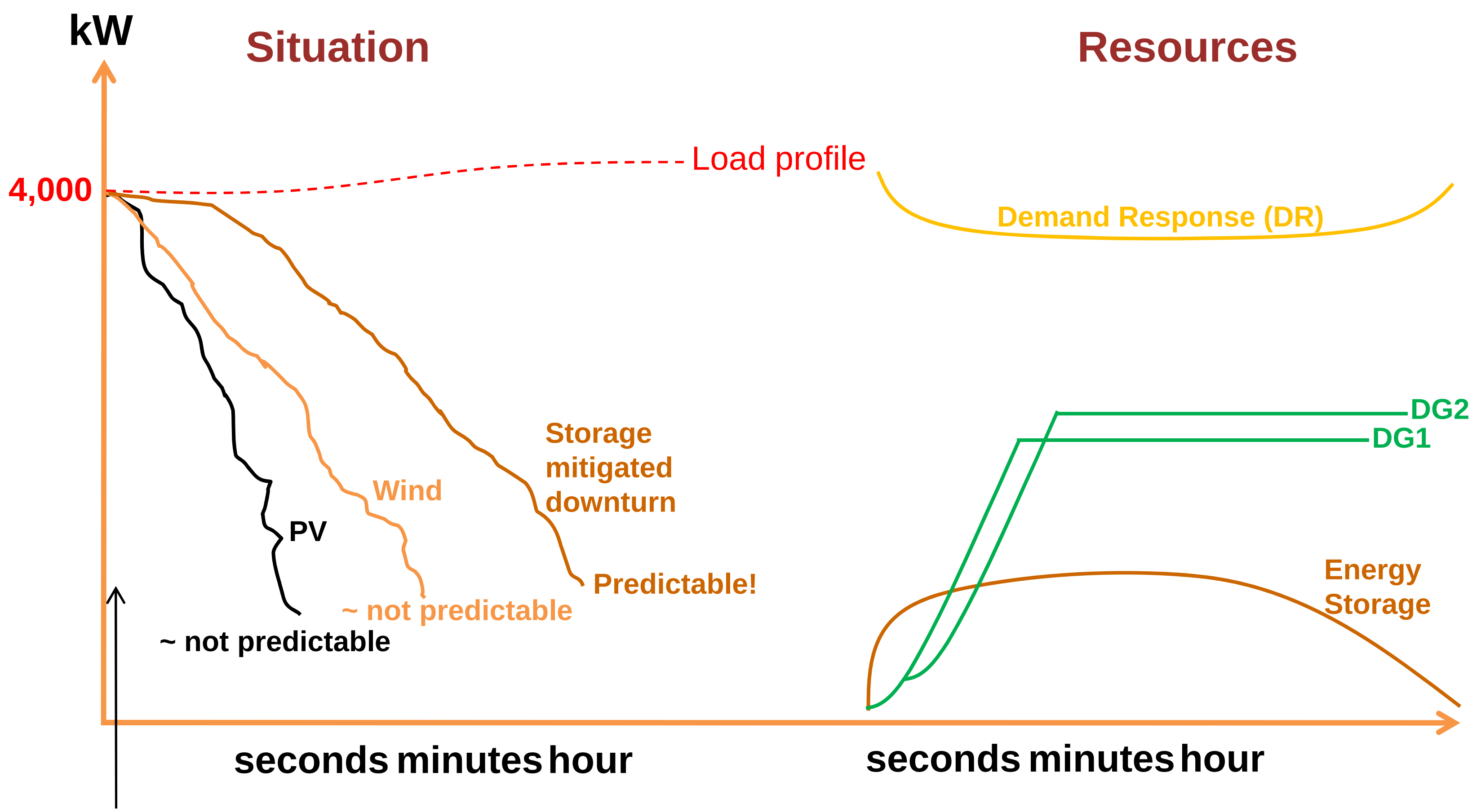
- Variability can be addressed by distributing the resources and control
- Energy storage is an essential element of control and energy efficiency
- Distributed generators can supply part-time needs effectively

Community Microgrid

Many new things to manage!



Address Variability with DER / Microgrid



Solar PV – clouds roll in

Wind turbine – wind stops blowing

Update 02/25/2008

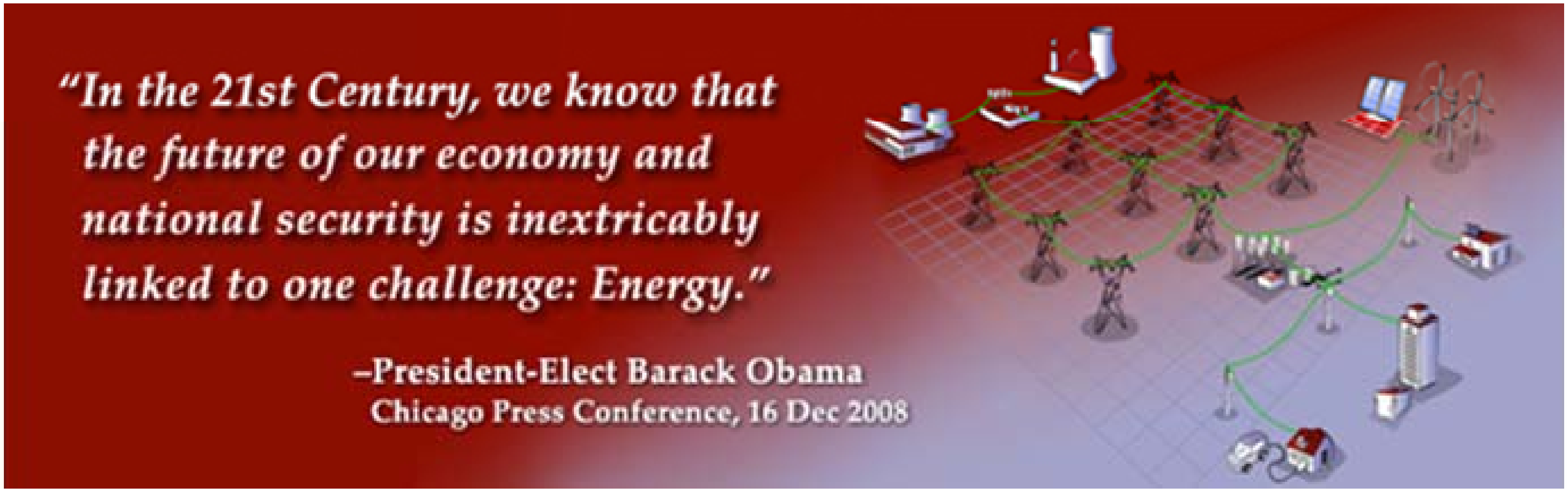
Conclusions

New Distribution Paradigm

- Control will be more like transmission than distribution
  - – Model-based, predictive, market-influenced
- Most of same transmission system tools apply
- Objectives are more local – “think global, act local”

  Solving peak issues with local solutions proves more efficient and emissions-friendly
- Recognize paradigm of active control
- Distributed Generation, especially BUGS, are primary solution for part-time grid needs

NETL Smart Grid Implementation Strategy



http://www.netl.doe.gov/smartgrid/

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