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Disrupting Our Way to a Sustainable Energy Future

May 5, 2015

Council for Chemical Research

Alexandria, Virginia

U.S. DEPARTMENT OF ENERGY

PNNL-SA-109955

Hurricane Sandy, 2012

Today's energy system is largely one way

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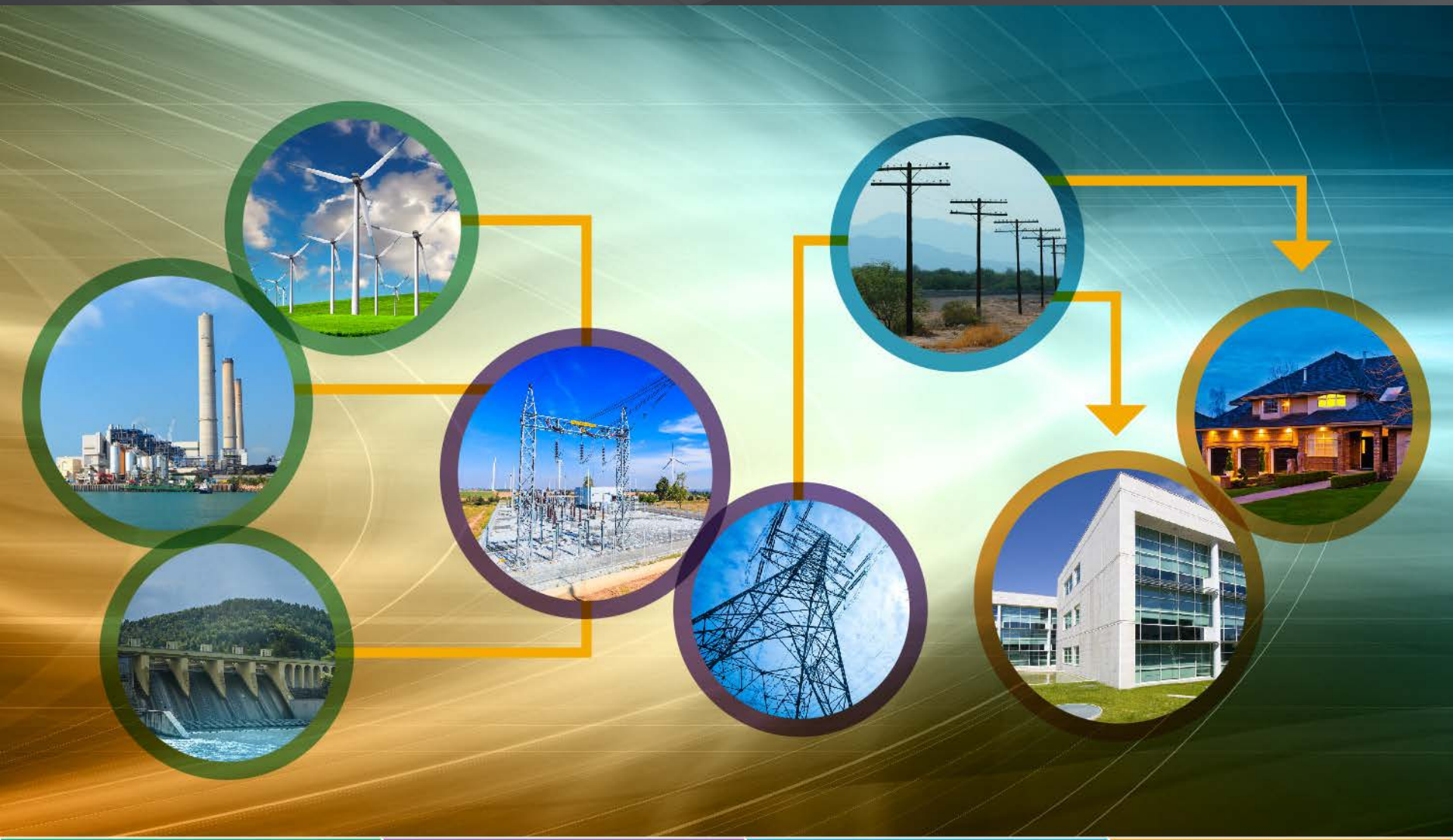

Generation | Transmission | Distribution | End use

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Generation has evolved

Base

Intermittent

Storage

With technology advances, U.S. is now the world's leading oil producer

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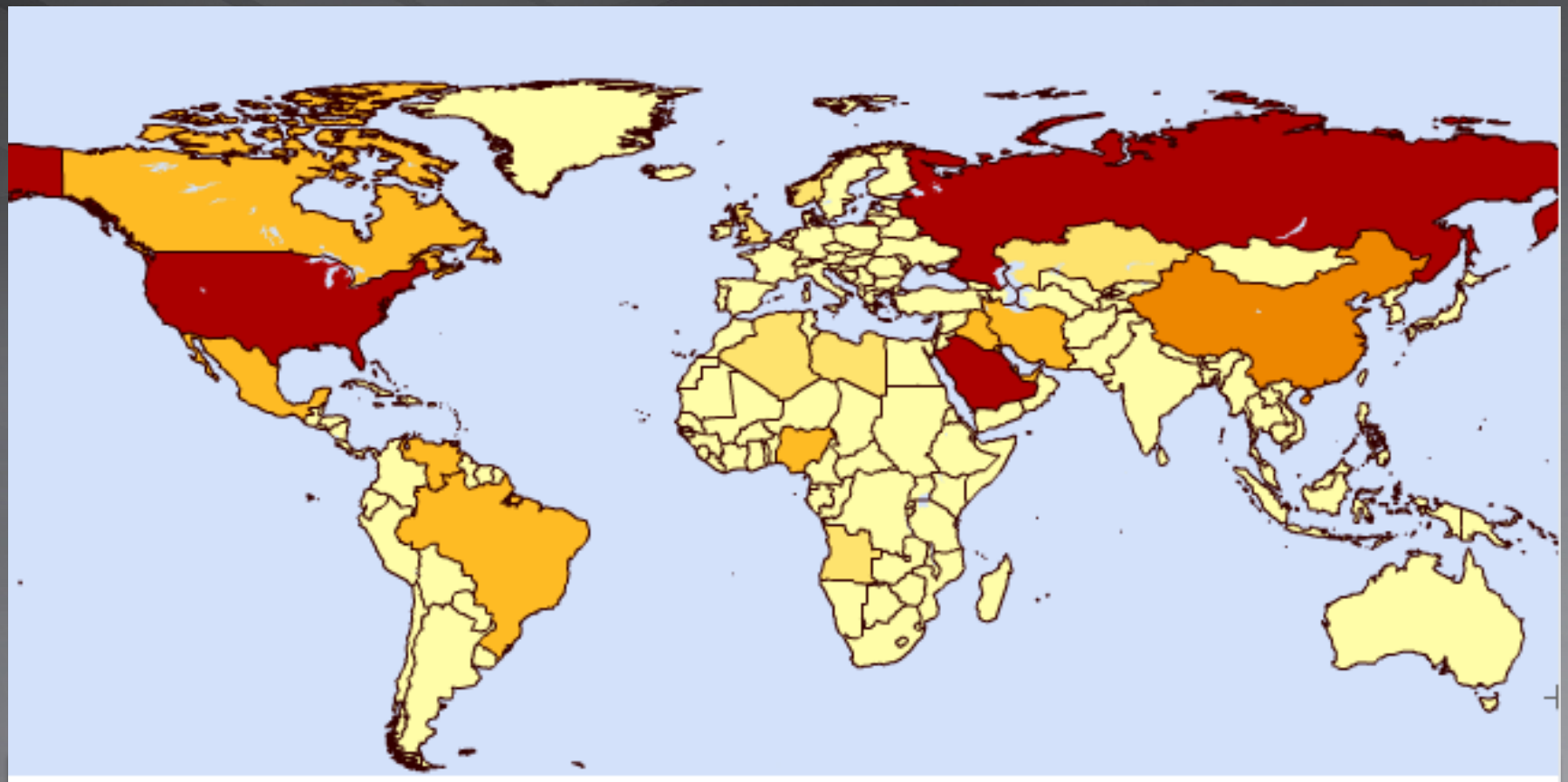

Top World Oil Producers (2013)

1 United States
2 Saudi Arabia
3 Russia
4 China
5 Canada
6 United Arab Emirates
7 Iran
8 Iraq
9 Mexico
10 Kuwait

Horizontal drilling: the key disruptive technology behind this change

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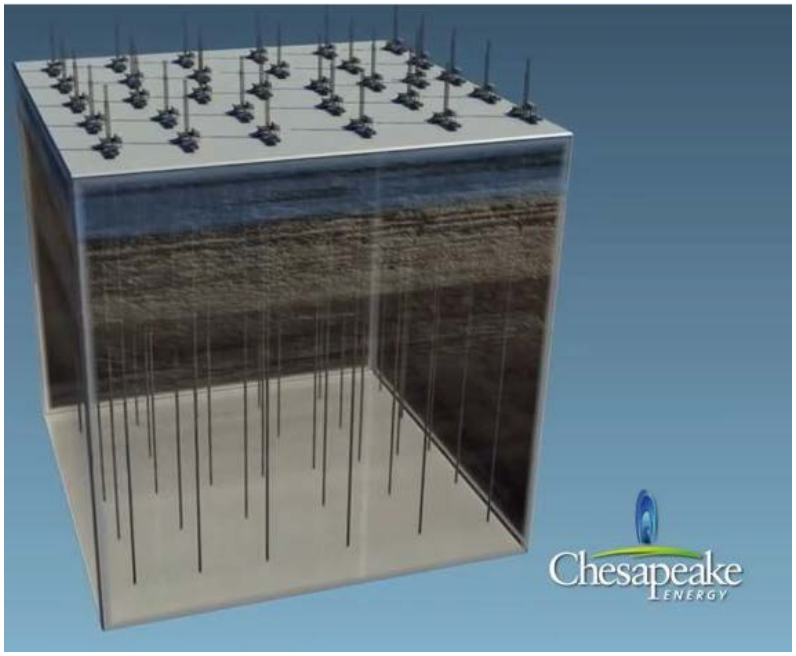
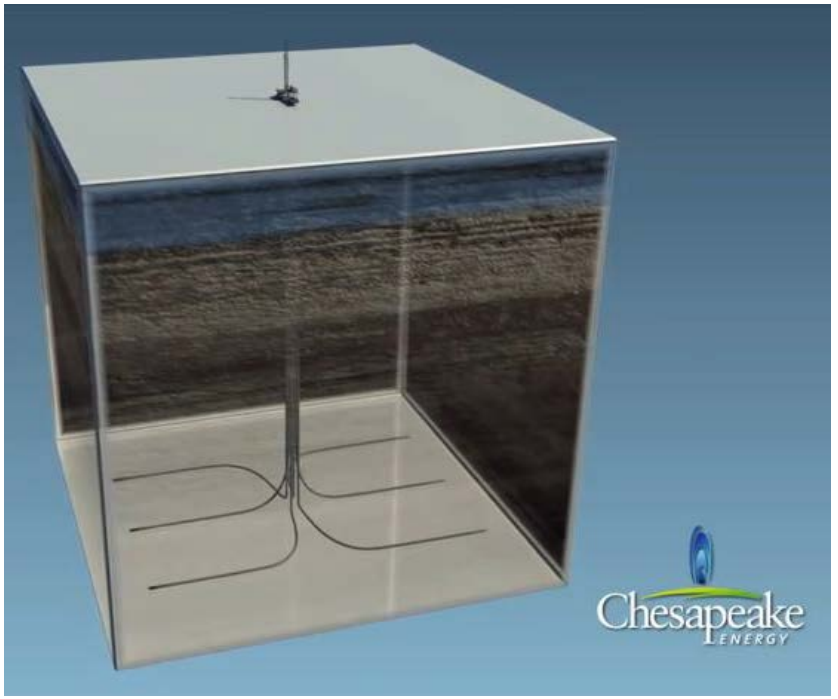


$100/barrel



$60/barrel

Image: Halliburton

Image: Schlumberger

Thin-film solar voltaics have disrupted solar energy

Solar farms

Conversion rate before 2008: 10%

Now: 22-24%

Image: Dow

Solar shingles

Not widely used before 2008

Conversion rate now: 19-20%

Images: Corning®, NREL, DOE SunShot Initiative

Finding energy in surprising places

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Image: Lucid Energy

New battery technologies provide grid-scale storage

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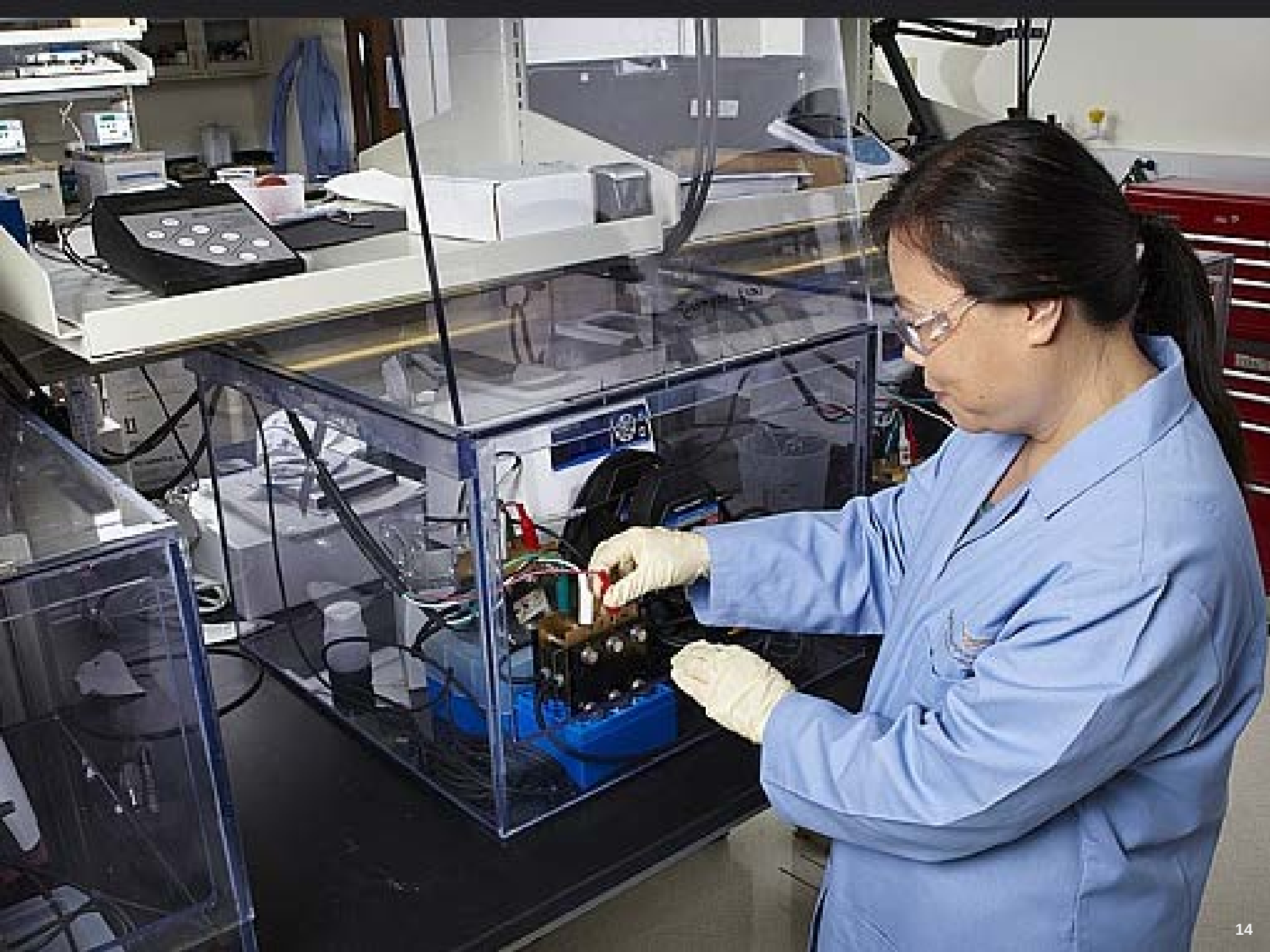
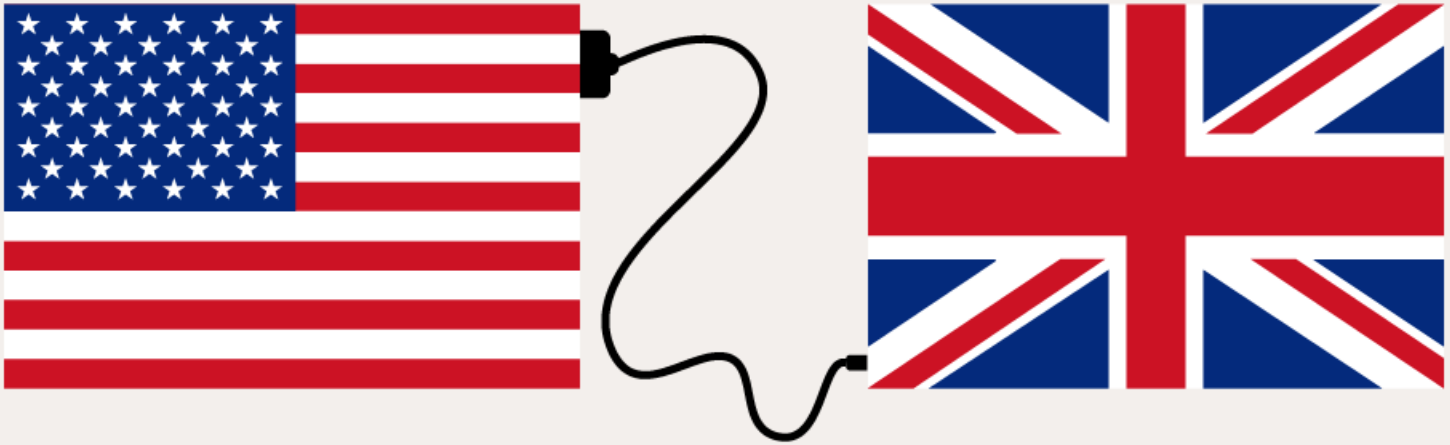
Image: UniEnergy Technologies, Inc.



The amount of energy wasted by the US economy in 2012...



could power the United Kingdom for 7 years.

Lighting technologies are dramatically increasing efficiency

Efficiency: 10%

Image: Philips North America

Efficiency: up to 50%

Gallium nitride crystal

What do all these disruptors have in common?

Challenging conventional business models

Creating “prosumers” via decentralization

Future energy system will be two-way

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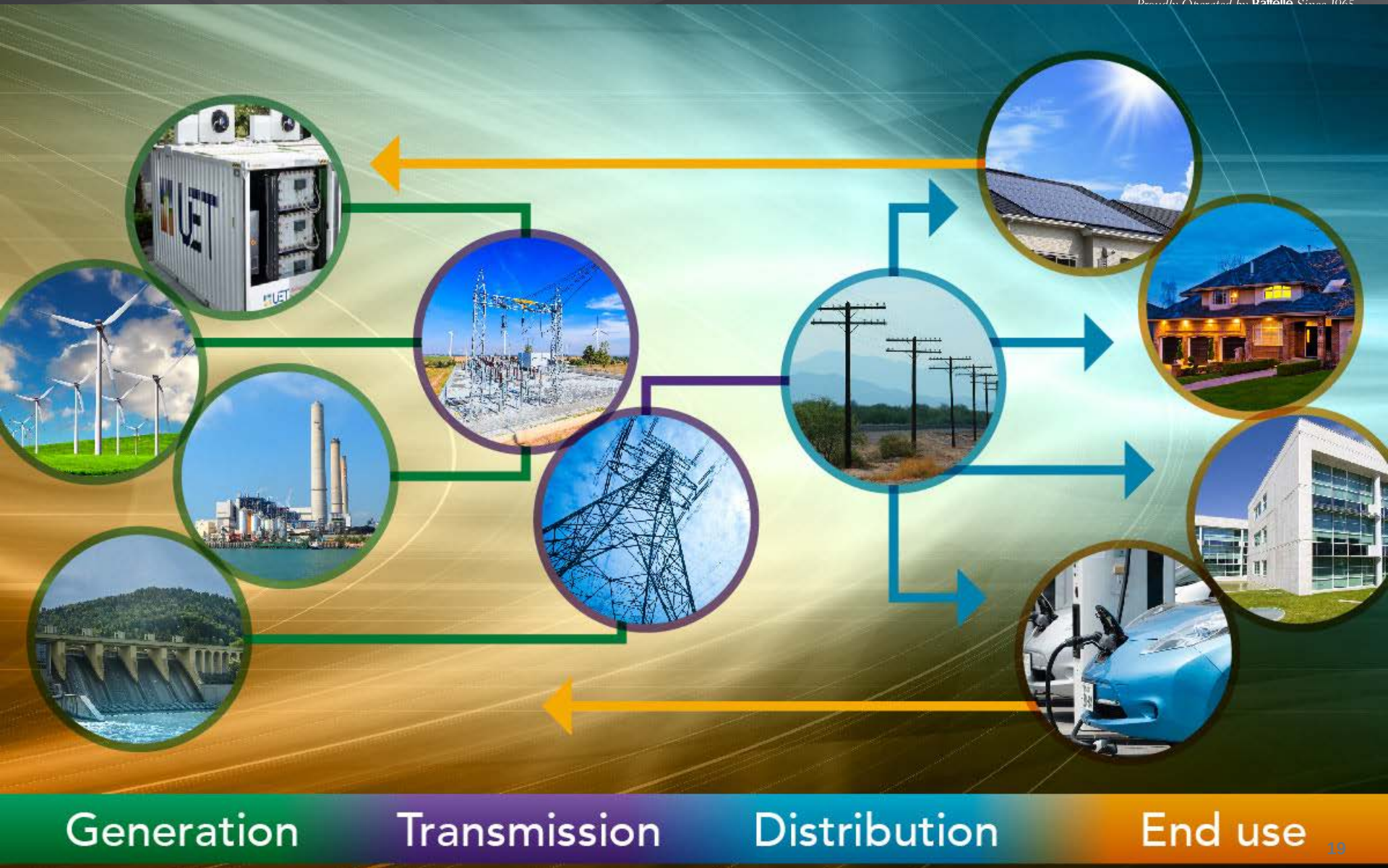

Characteristics of the future energy system

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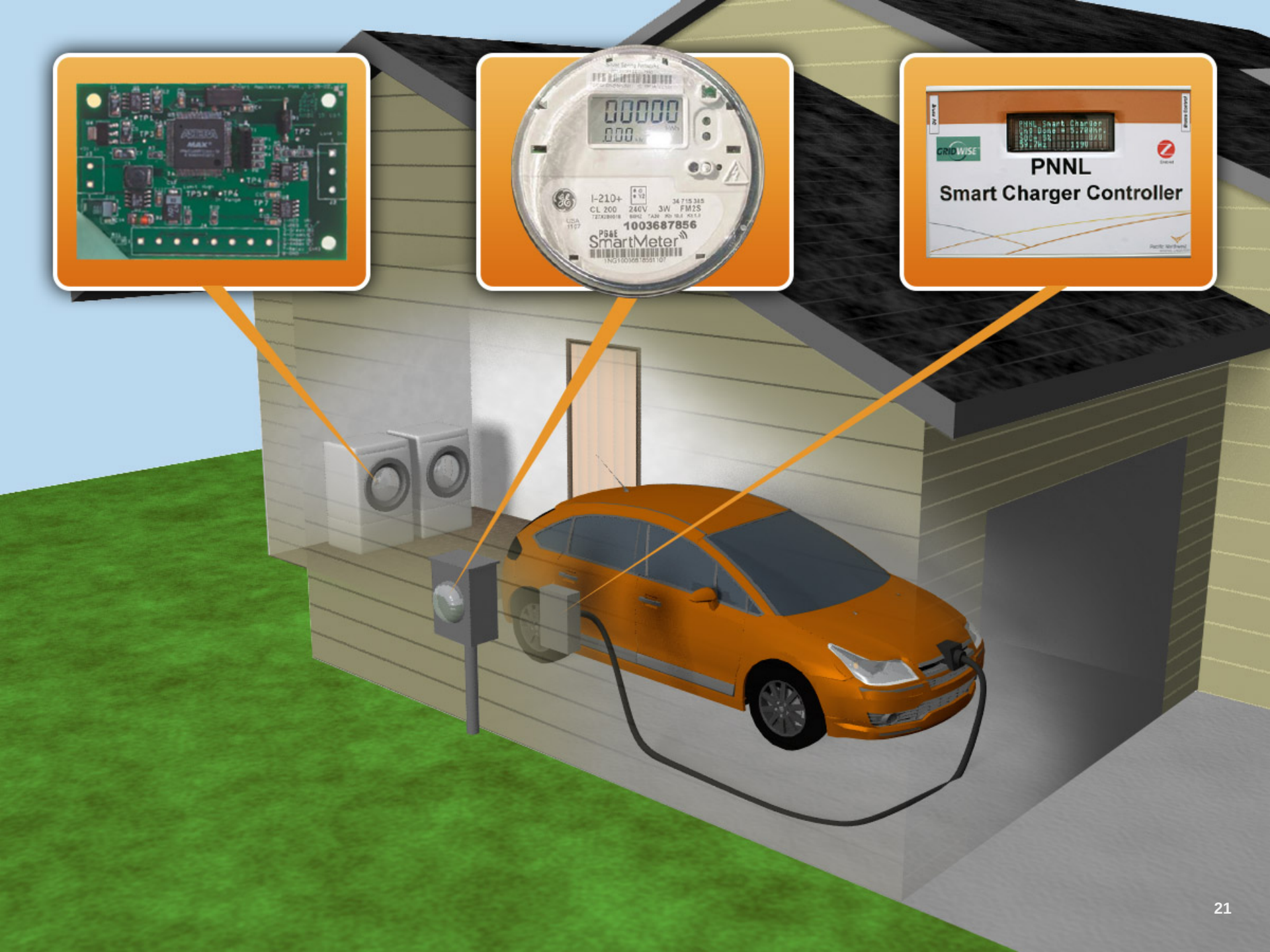
Growing Asset Stress

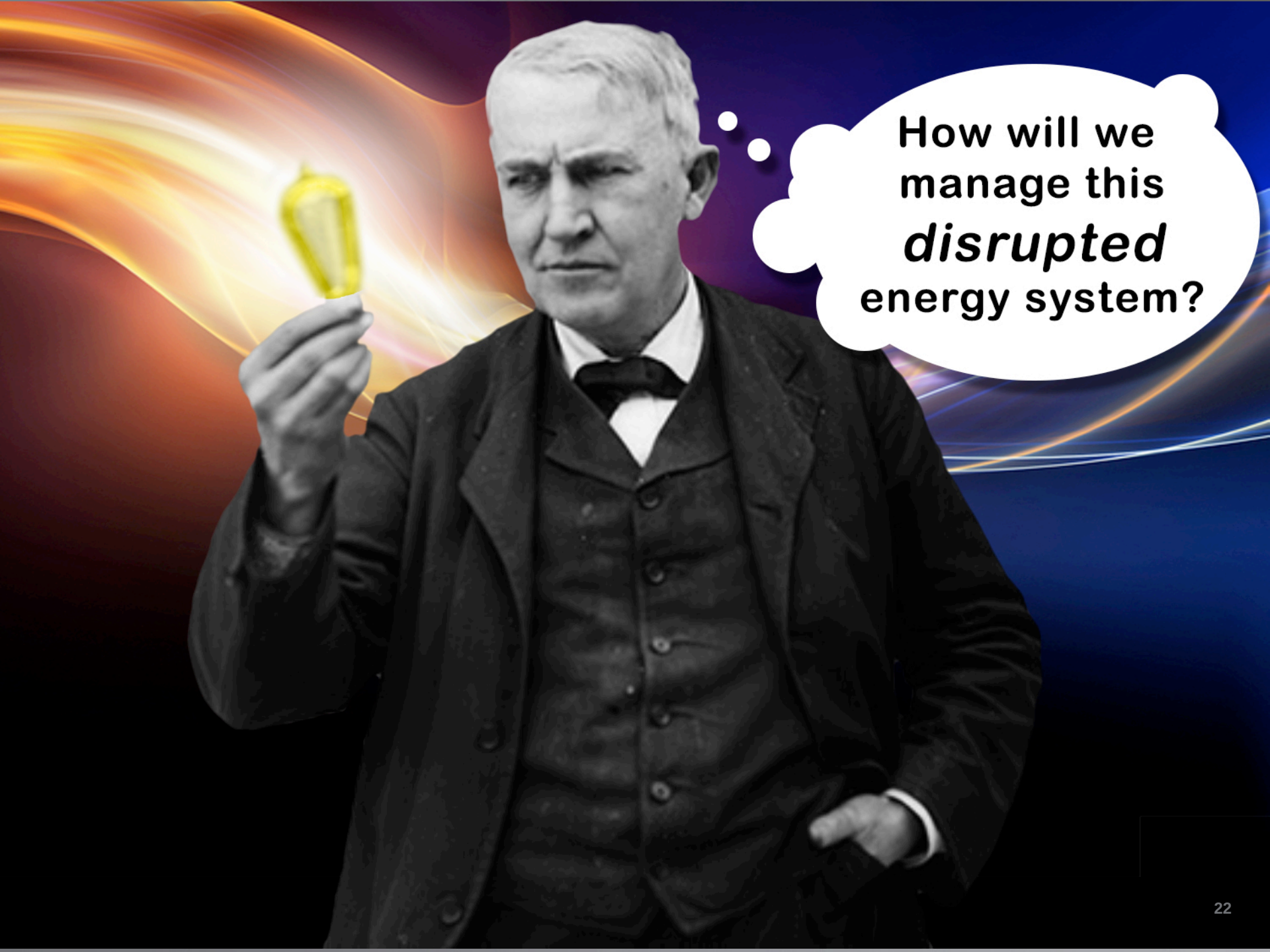
Increased Variable Generation

More Dynamic Market

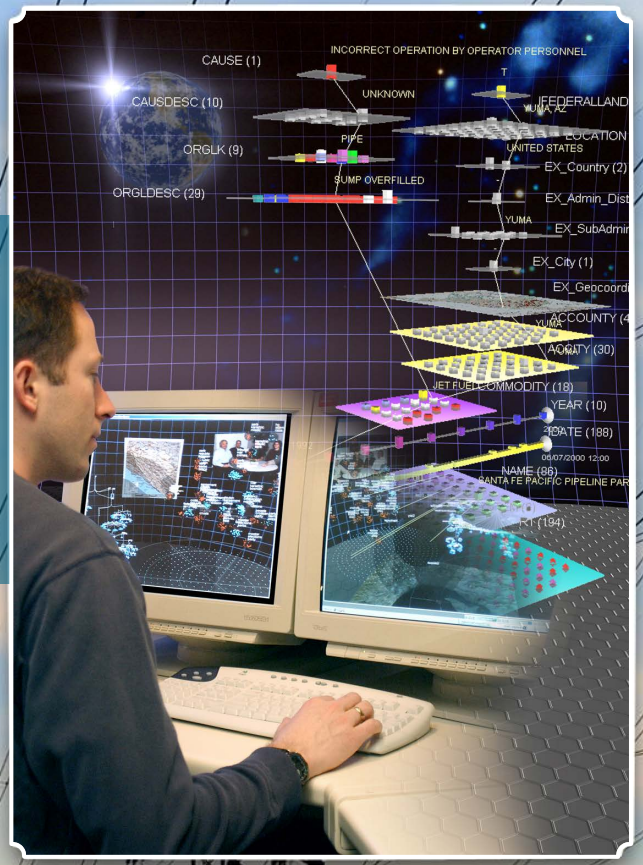
New Controllable Assets

Massive Data


PNNL
Smart Charger Controller
1003687856
SmartMeter


How will we manage this *disrupted* energy system?

Modernize the Grid



Future power grid must meet new expectations and technical challenges

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Historical Expectations

- Affordable Power
- Reliable Power
- Secure Power

Emerging Expectations

Integrate renewable generation

Increase grid-scale storage

Electrify transportation

Dynamic and responsive loads

IT meets ET: Key to realizing full potential of the future power grid

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Data

Situational awareness

Simulation

Operations and planning

Tools

Real-time decision support

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Deployment of a vast new sensor network is generating unprecedented real-time data

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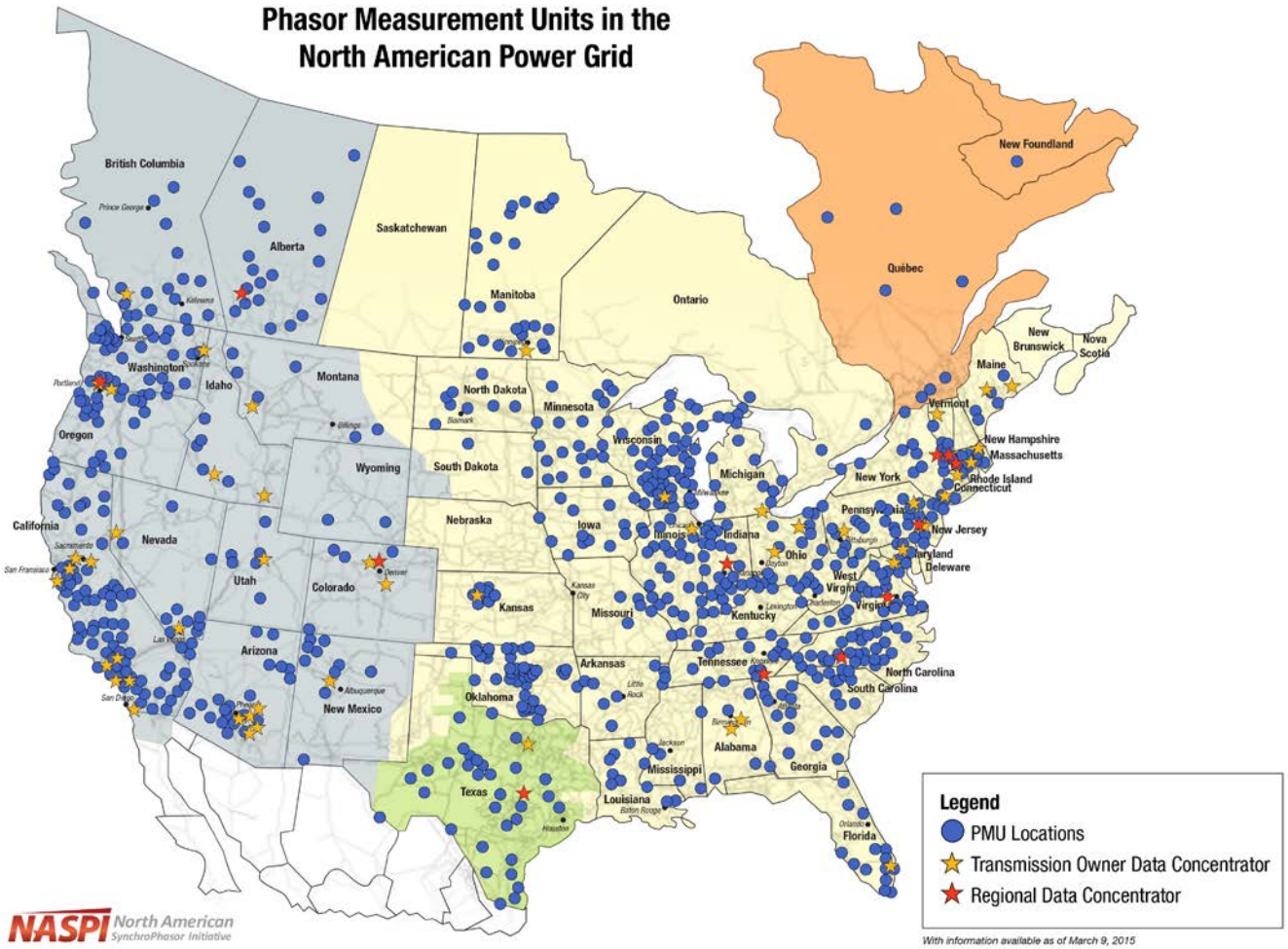
North American SyncroPhasor Initiative

- Power companies, utilities, vendors, DOE/labs, and universities
- High-resolution, time-stamped data



Rich new data streams are transforming grid management

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	Today – SCADA data	Tomorrow – Phasor data	Improvement
Variety	voltage + current	+ phase angle	more information
Velocity	1 sample / 4 seconds	30-120 samples / second	~200x faster
Volume	8 terabytes / year	1.5 petabytes / year	~200x more data*
Veracity	unseen ms-oscillations	oscillations seen at 10ms	greater accuracy

Real-time data ingestion from a distributed sensor network with myriad devices

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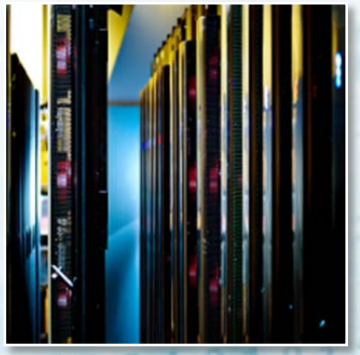
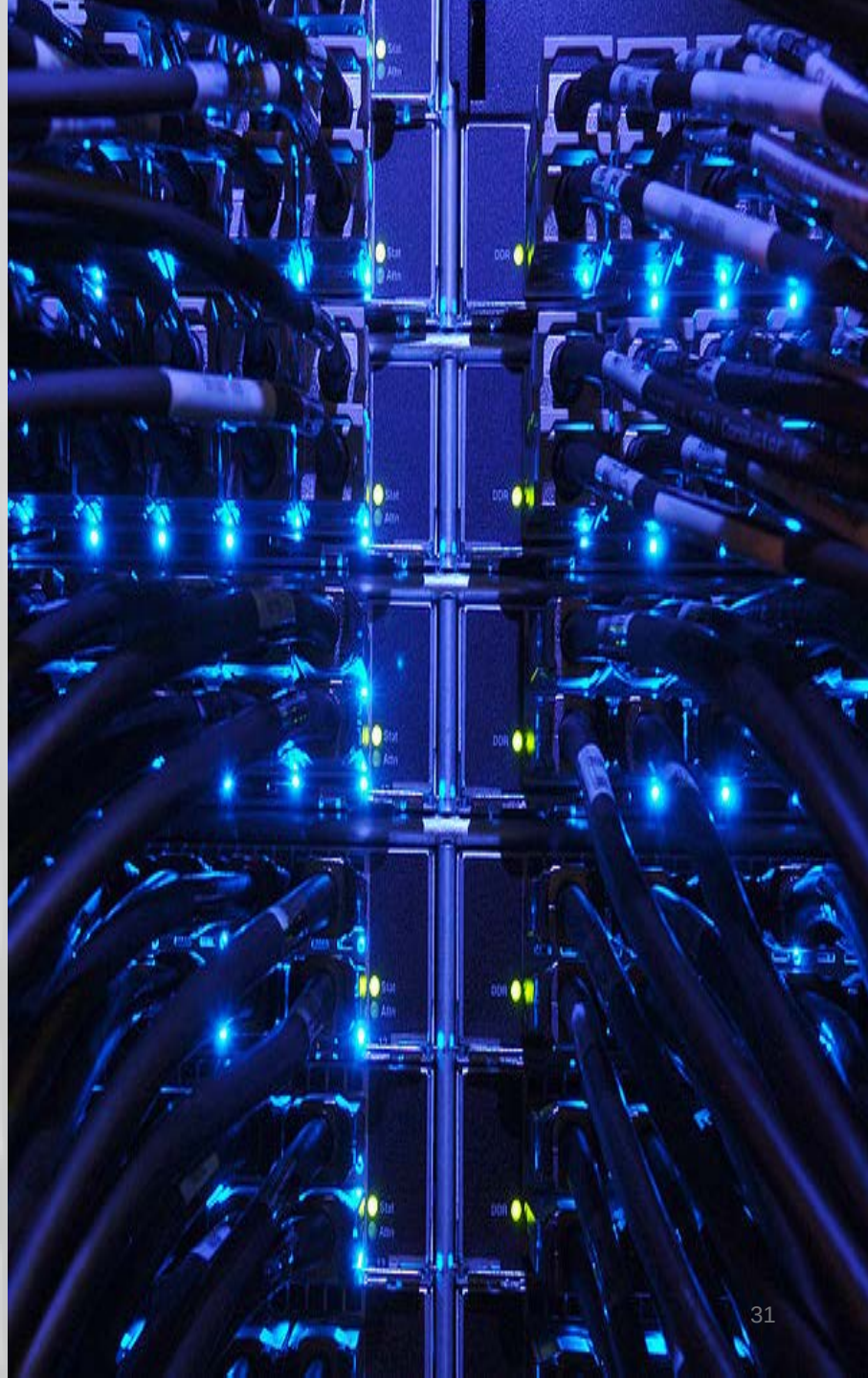
- Cyber-secure sensor network
- Data provenance and privacy
- Real-time ingestion & curation
- Actionable analysis




Simulation

Model complexity and time constraints drive use of high-performance computing

- State estimation
- Dynamic simulation
- Contingency analyses
- Stochastic optimization



Integrated model of transmission and distribution system requires 1B nodes

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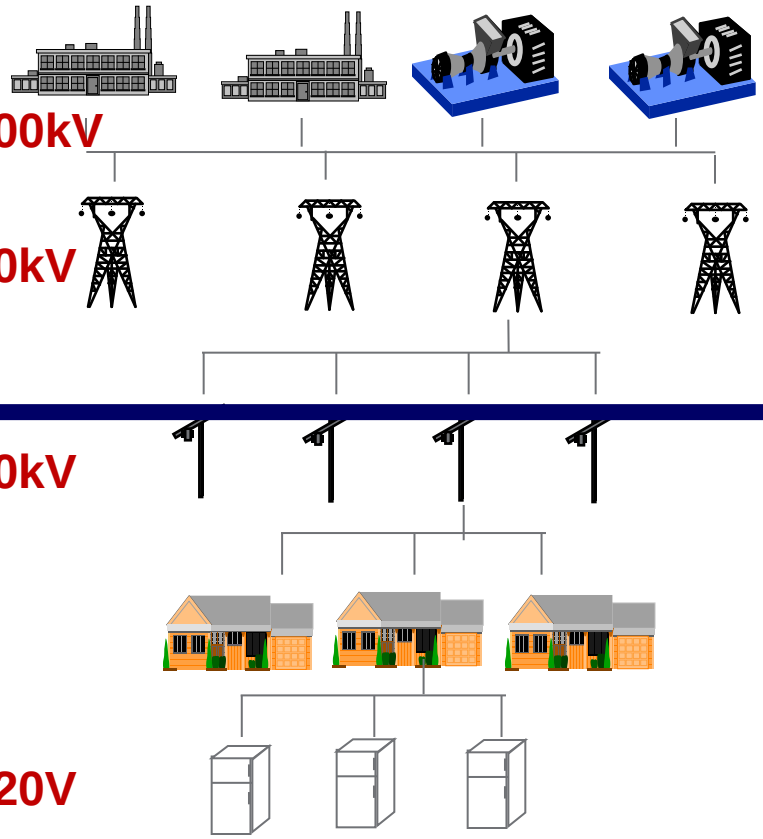
Element		Nodes in Western U.S.	
Generation	Transmission	~10^2	500kV
Transmission		~10^3	60kV
Substations		~10^4	
Distribution Feeders	Distribution	~10^5	10kV
Customer Meters		~10^7	
Appliances/Equipment		~10^9	120V



Faster simulations will improve operations and planning

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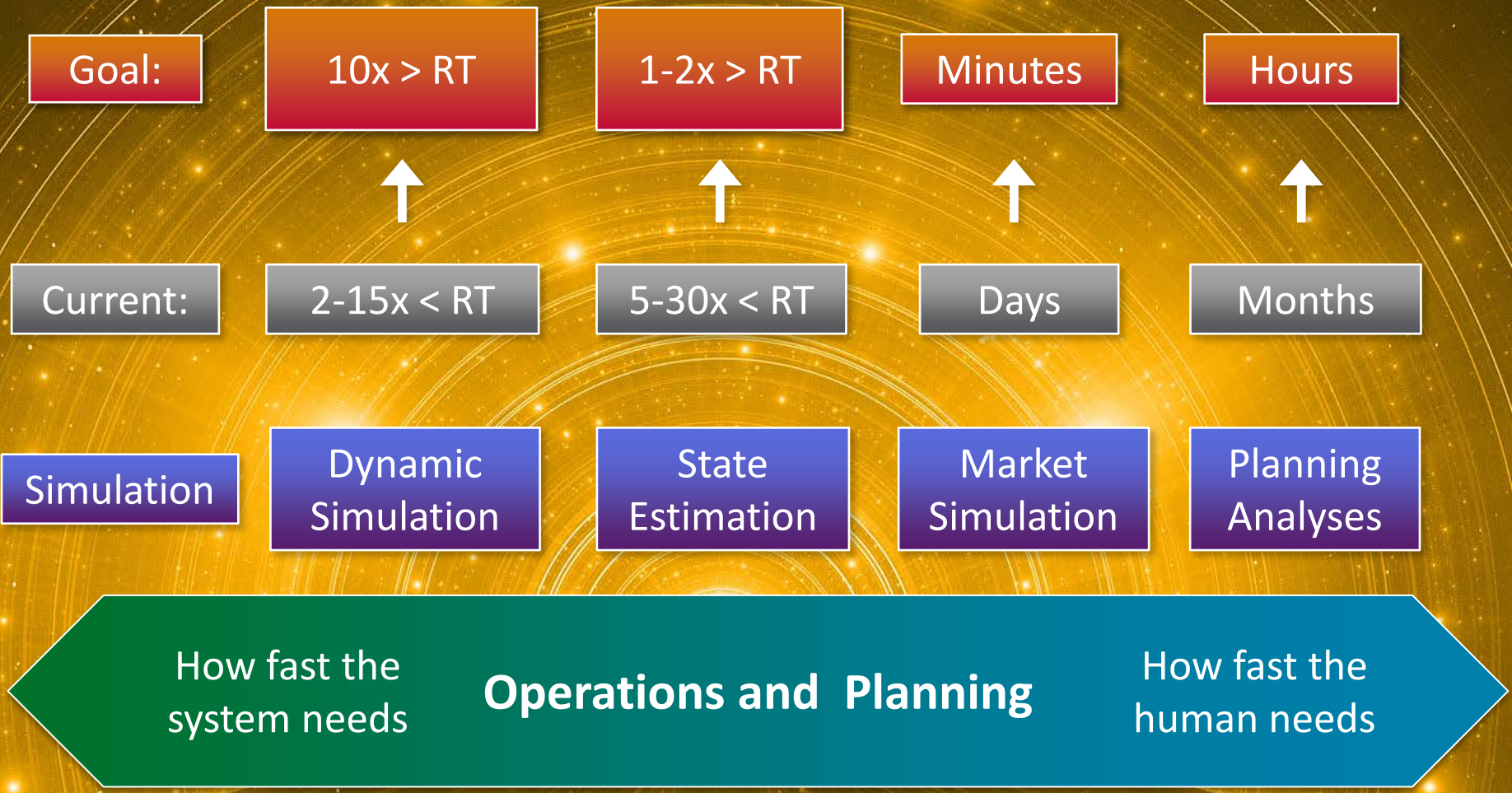

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Tools

GridLAB-D provides a unified model of the key elements of the smart grid

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Power Systems

Loads

Markets

GridLAB-D models:

- Power flow
- End-use load behavior in thousands of homes
- Double-auction markets

Information visualization and decision support tools enable situational awareness

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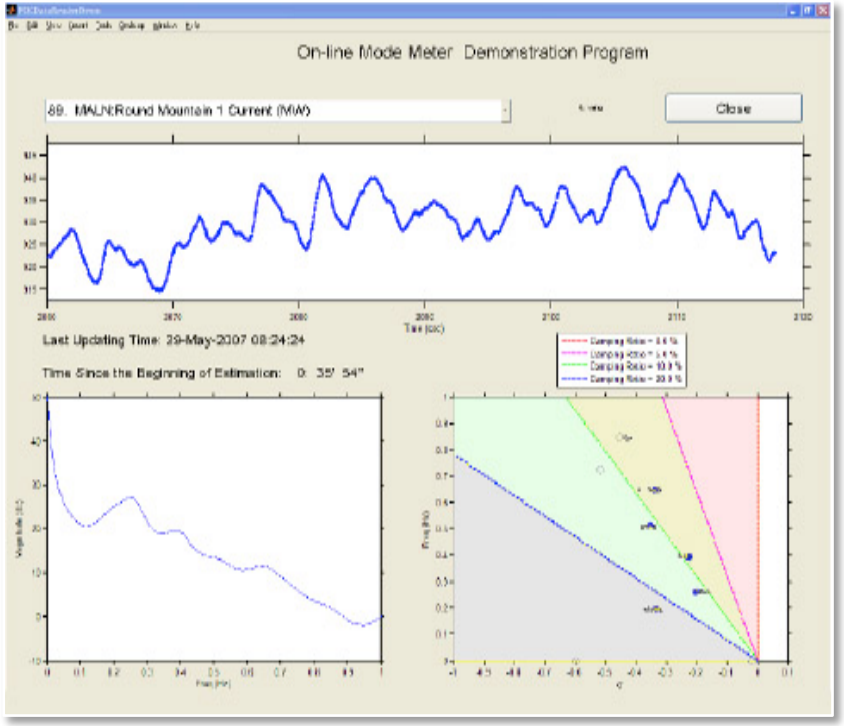
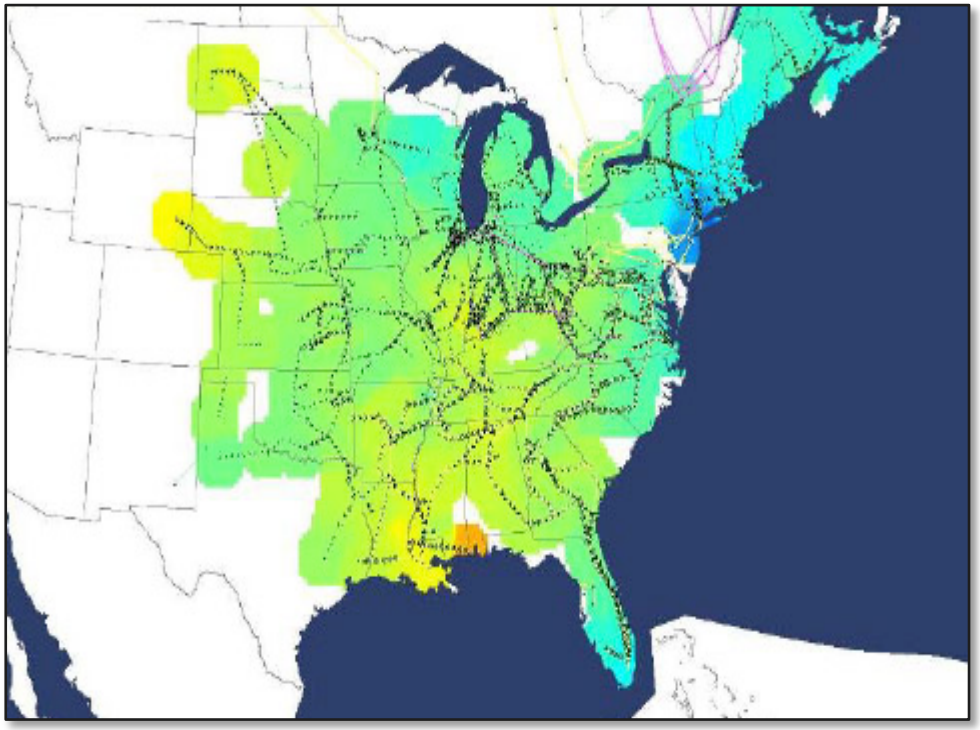


Small Signal Analysis Tool



Wide Area Hybrid Grid Health Tool


Transforming the U.S. Electrical System

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Opportunities in the chemical enterprise

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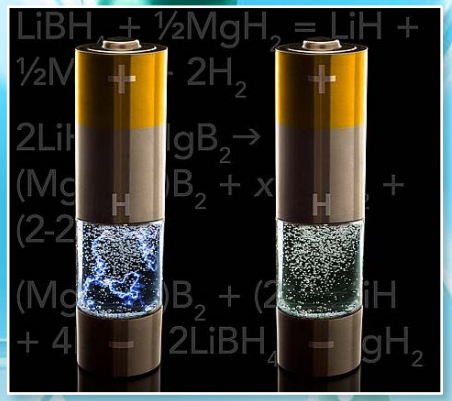
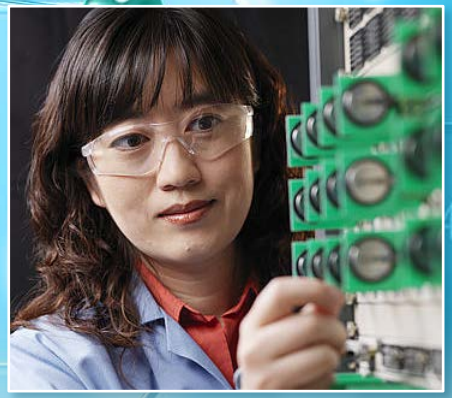
Renewables

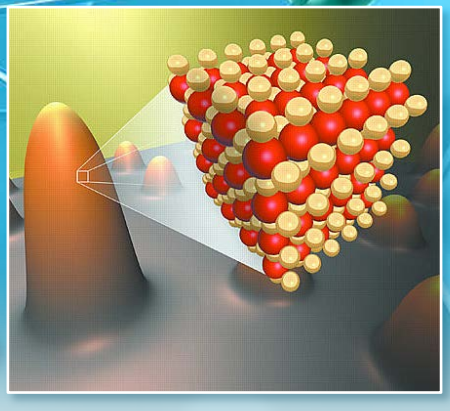


Hydrogen

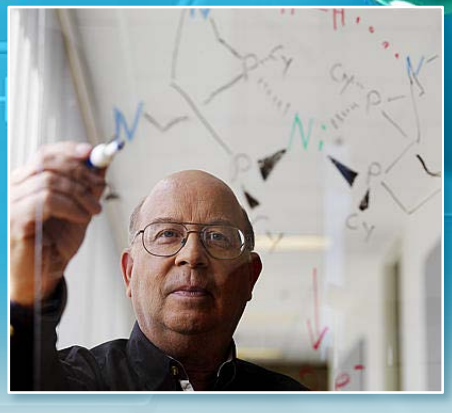


Storage

Catalysis



Materials



Electrochemistry

We invite you to collaborate with us

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