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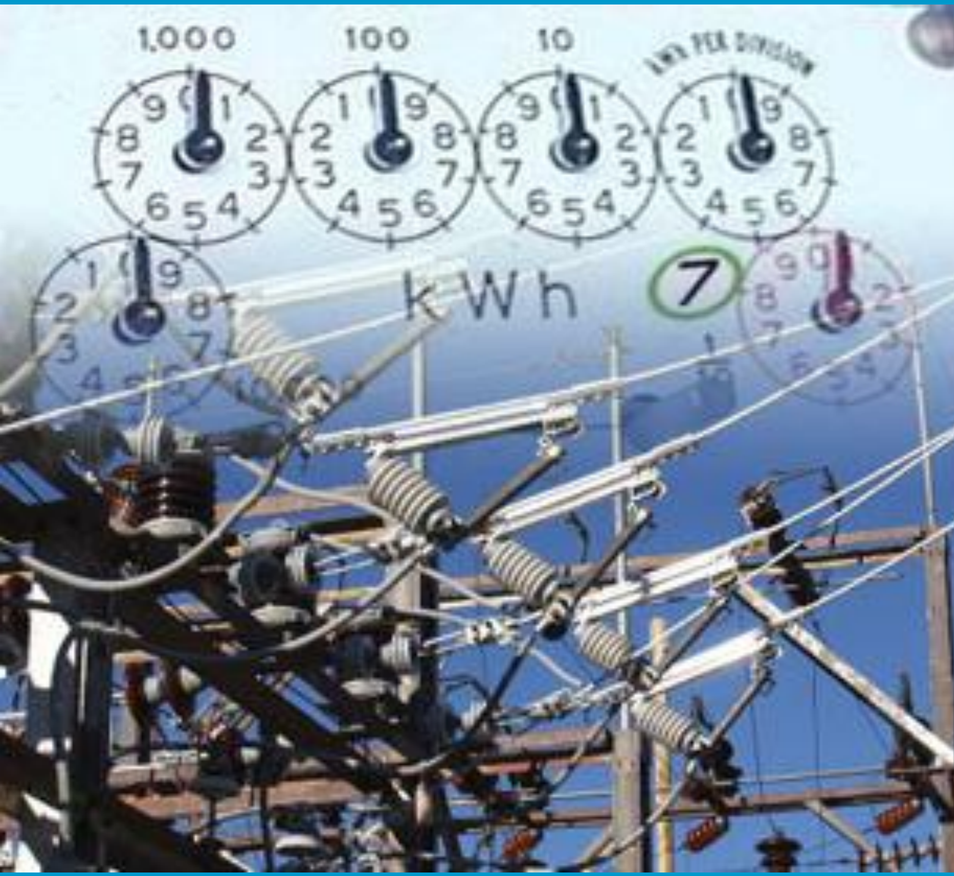


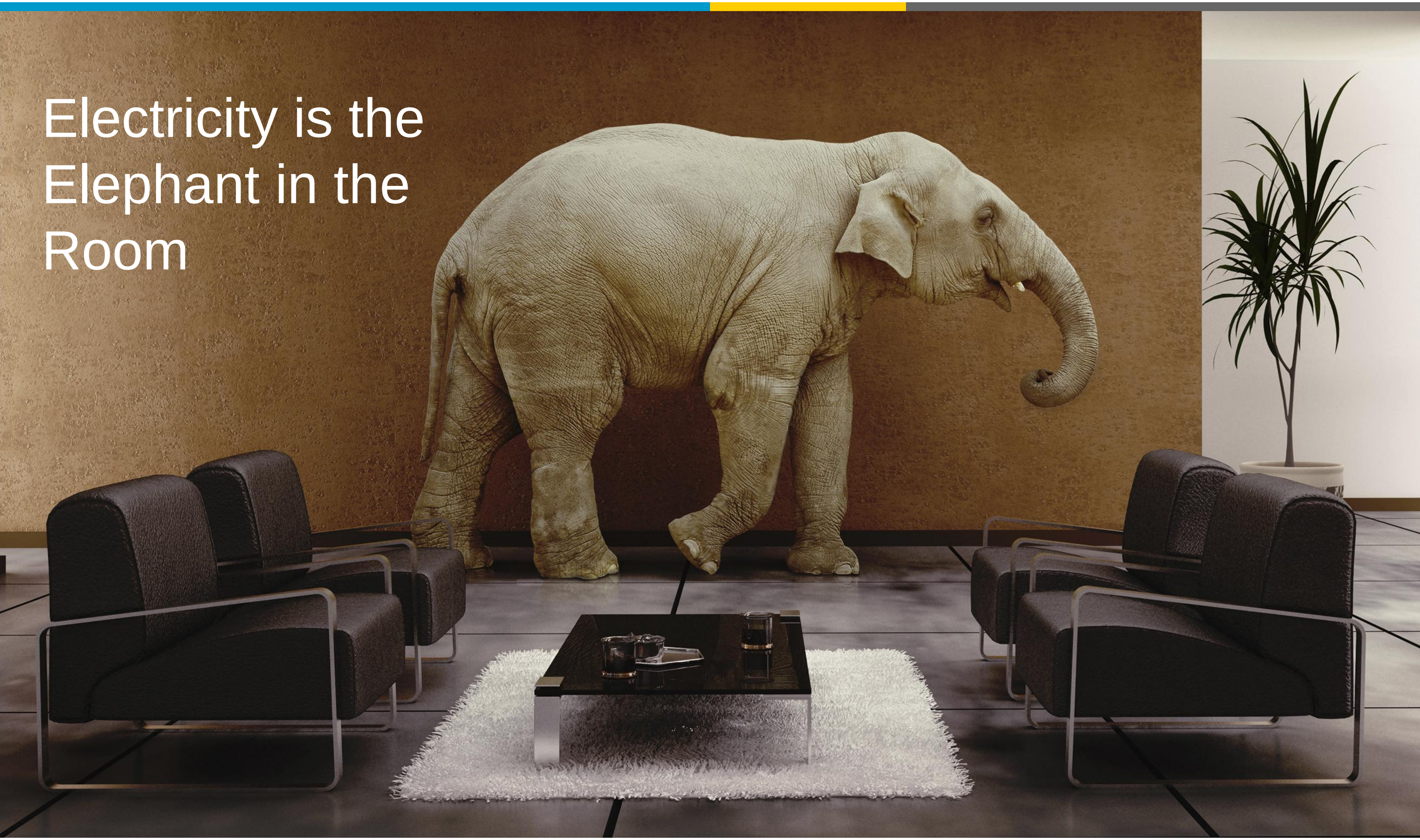
Smart Grid Strategies – Changing the Paradigm to Maximize Benefits and Address Challenges of Electric Power Delivery.

Scott Minos

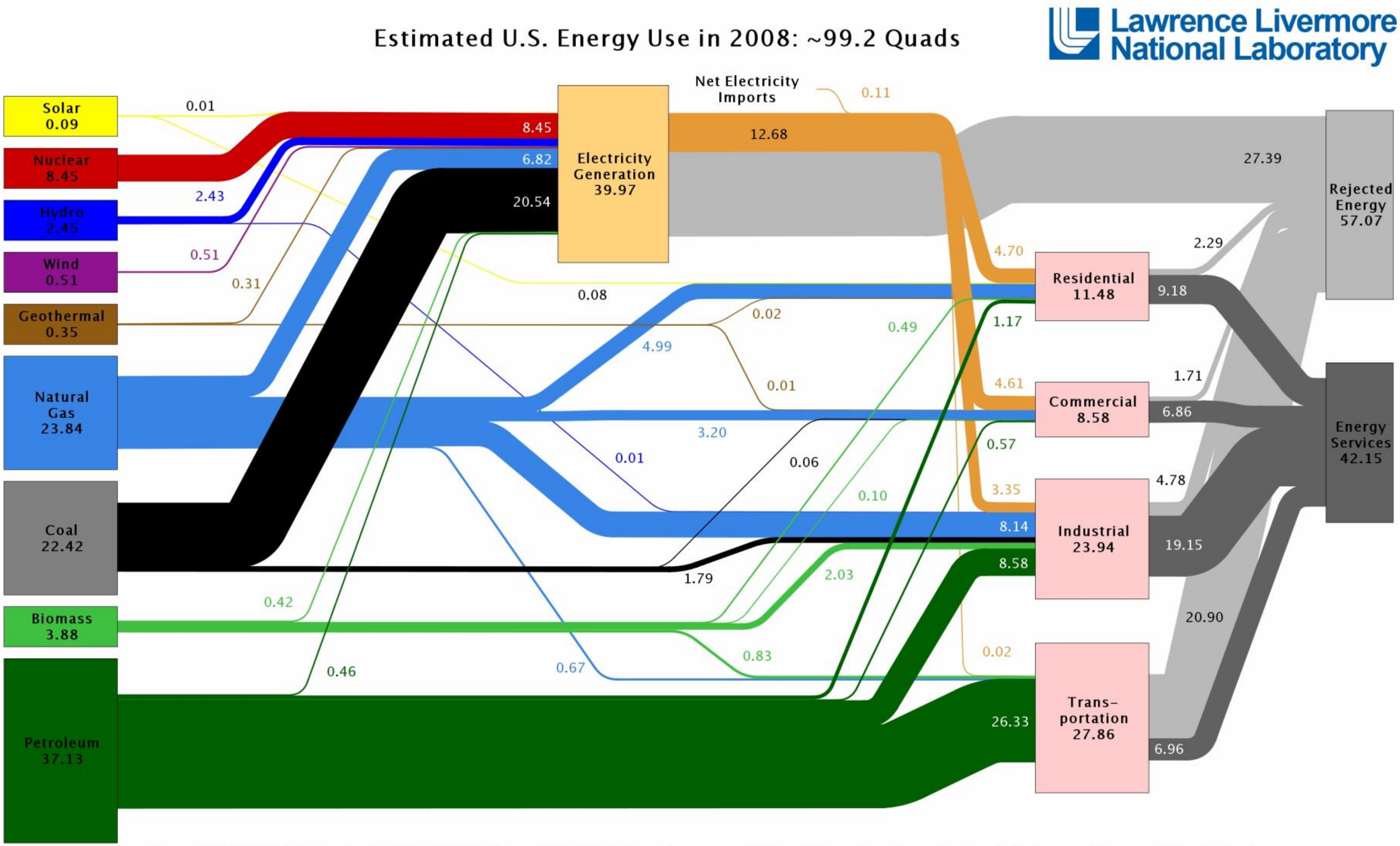
Senior Policy & Communications Specialist

Intercontinental Hotel
Jeddah, Kingdom of Saudi Arabia
October, 2012

But the News Is Not All Good



Energy Use and Waste 2008



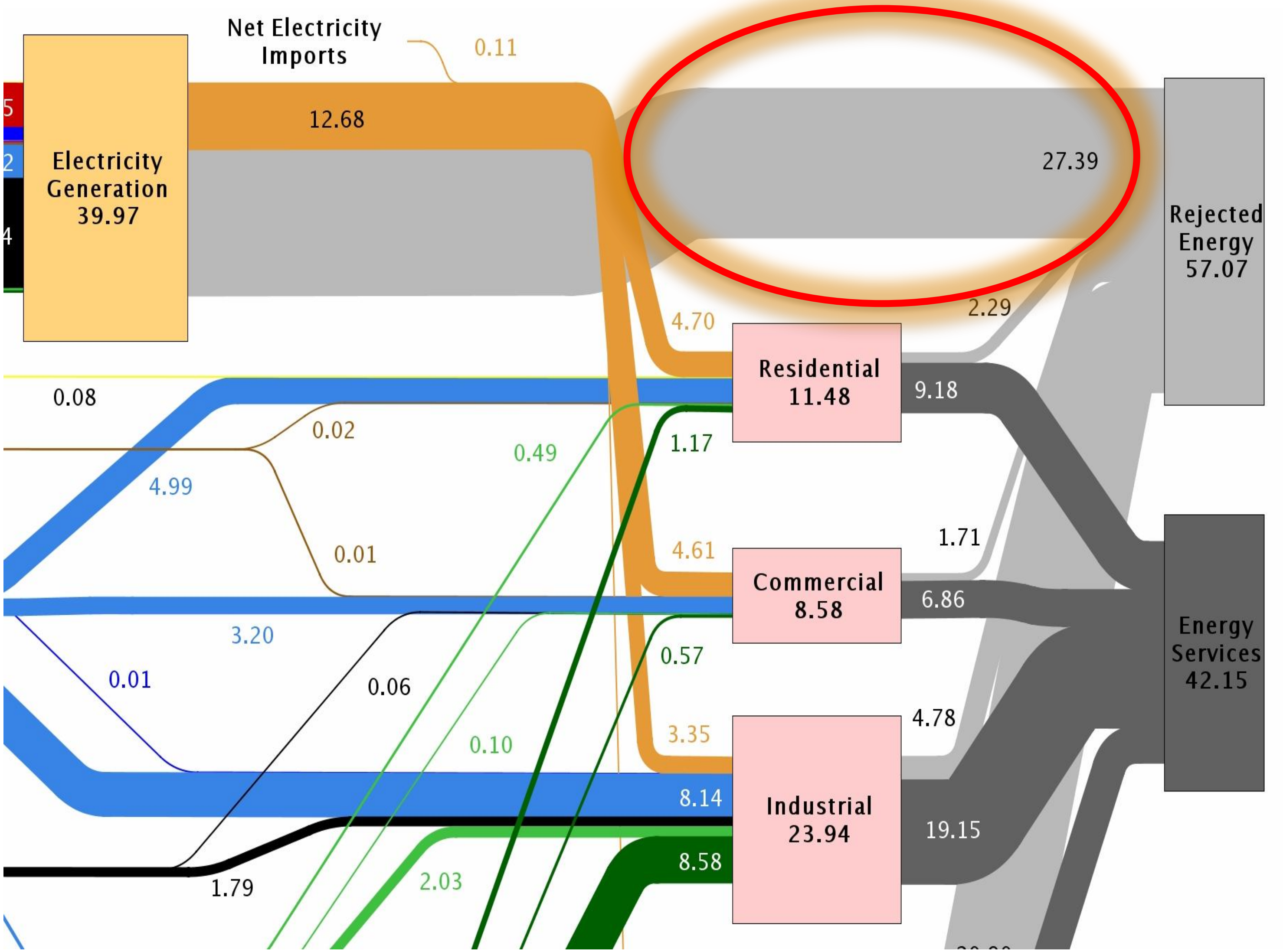
Source: LLNL 2009. Data is based on DOE/EIA-0384(2008), June 2009. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for non-thermal resources (i.e., hydro, wind and solar) in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

2/3 of Electric Generation is Lost Through Inefficiencies

39.97% of all fuel sources to go electric generation.

27.39 % of the fuel sources that go to electric generation is wasted. Another way to look at is nearly _75% of the power that goes to electric generation is wasted._ This is power that is never used!

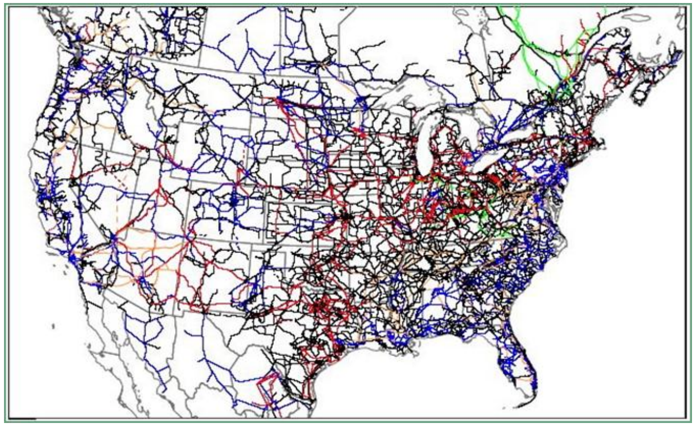
8.78 % of waste comes from buildings & industry combined – that is only a THIRD of what is wasted by unused electric power.



The Electric Grid - A Complex System

Not holistically designed, evolved incrementally. Today:

- 30,000 Transmission paths + 180,000 miles of transmission line
- 14,000 Transmission substations
- Distribution grid connects these substations with over 100 million loads—residential, industrial, and commercial customers
- 3,170 traditional electric utilities
- 239 investor-owned, 2,009 publicly owned, 912 consumer-owned rural cooperatives, and 10 federal electric utilities
- Electricity flows within three major interconnections along paths of lowest impedance (at the speed of light); yet grid is operated in a decentralized manner by over 140 control areas
- Demand is semi-uncontrolled.



“To meet the energy challenge and create a 21st century energy economy, we need a 21st century electric grid”

DOE Secretary Chu
September 2009

"We cannot solve 21st Century challenges with 19th and 20th Century solutions".

Scott Minos

Are We There Yet?

You have to know where you are going in the development of the Smart Grid. If you don't, how will you know when you get there?

Key Trends and Drivers for a 2030 Electric Grid

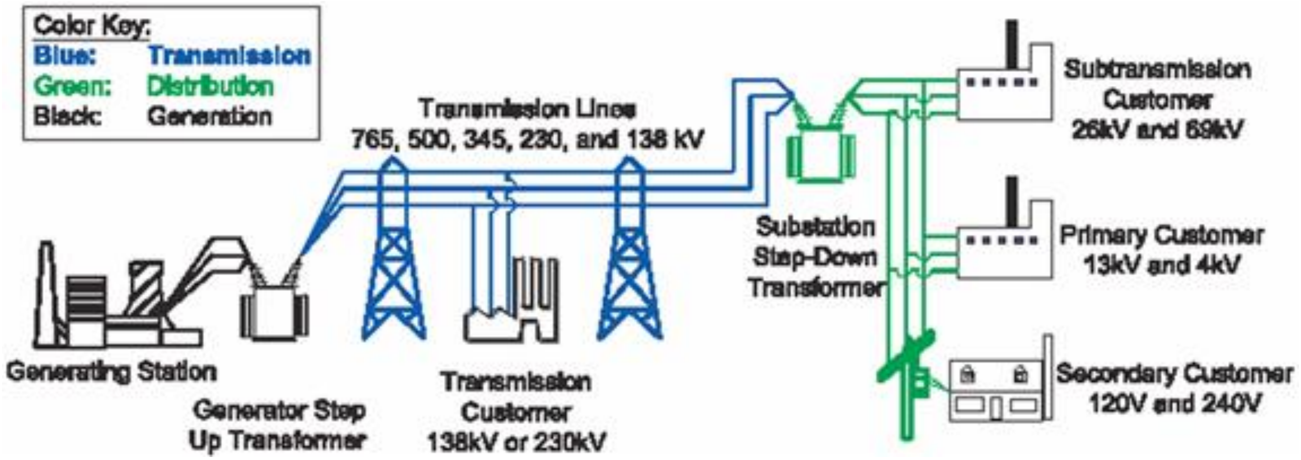
2008		2030
3.1% renewable (non-hydro) 6.0% hydro 19.6% nuclear 21.4% natural gas 48.2% coal 1.7% oil and other	Electricity Supply Mix	• More wind and solar power • More distributed generation and storage • Same or more natural gas-fired generation • Same or more nuclear power • Less coal
• 3,733 million MWh • 752,740 MW non-coincident peak demand	Demand Requirements	• 20% more electricity consumption • 25% higher peak demand • Adoption of plug-in electric vehicles • Widespread consumer participation in dynamic pricing
• 140 control areas • "Gridlocked" siting and permitting • Interoperability requirements	Complexity of the Grid	• Volumes of phasor and smart meter data to manage and use • $ billions investment in automated T&D systems • Interoperable and integrated power generation, delivery, and end-use
• Aging infrastructure and workforce • Cyber security awareness • Infrastructure interdependence	Vulnerabilities of Energy Infrastructure	• More digitalization and controls • Increased interdependencies • Built-in cyber security protections against mounting threats

- To move to the previous scenario by 2030 we need to develop and deploy a smart grid.
- We all have heard of a smart grid. But do any of us ***REALLY*** know what it is?
- The problem is there is no one definition agreed upon.

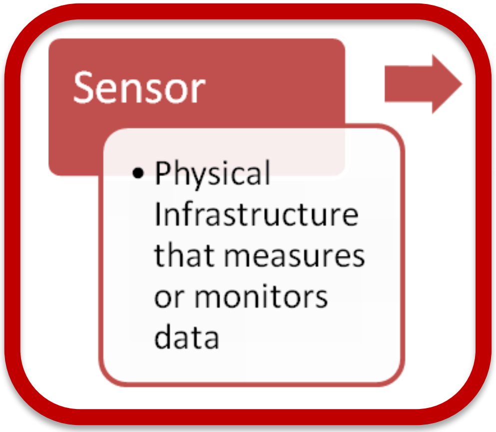
The Smart Grid is not so much of a "what" as it is a "how", meaning that it is an enabler, not an objective. It does things to get one to an end goal, but is not the goal itself.

Perhaps a good way to establish a working definition for the purposes of today's discussion is to first ask ourselves a more simplistic question…one that is often overlooked. "What is a DUMB grid?"


NO OUTLET
ONE WAY



So then, what is a smart grid?



Measuring is key, but simply measuring is not smart in and of itself.

The Smart Grid is all about management, therefore measuring is vital – because what gets measured gets managed.

Measuring energy is a key functionality and finds its place throughout the lifecycle of the grid such as generation, distribution and consumption of energy inside or outside of a building.

The efficiency and quality of energy generation and distribution relies completely on the ability of the systems to measure key components with high accuracy.

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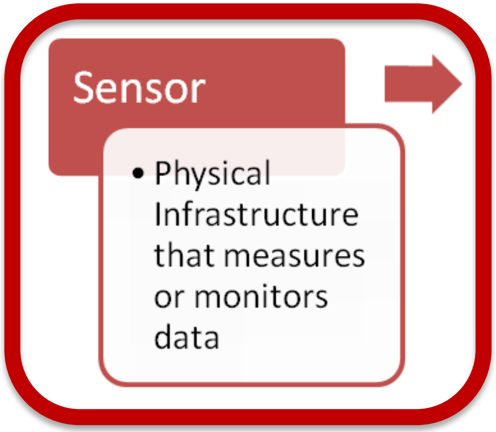

Sensor
Physical Infrastructure that measures or monitors data

17

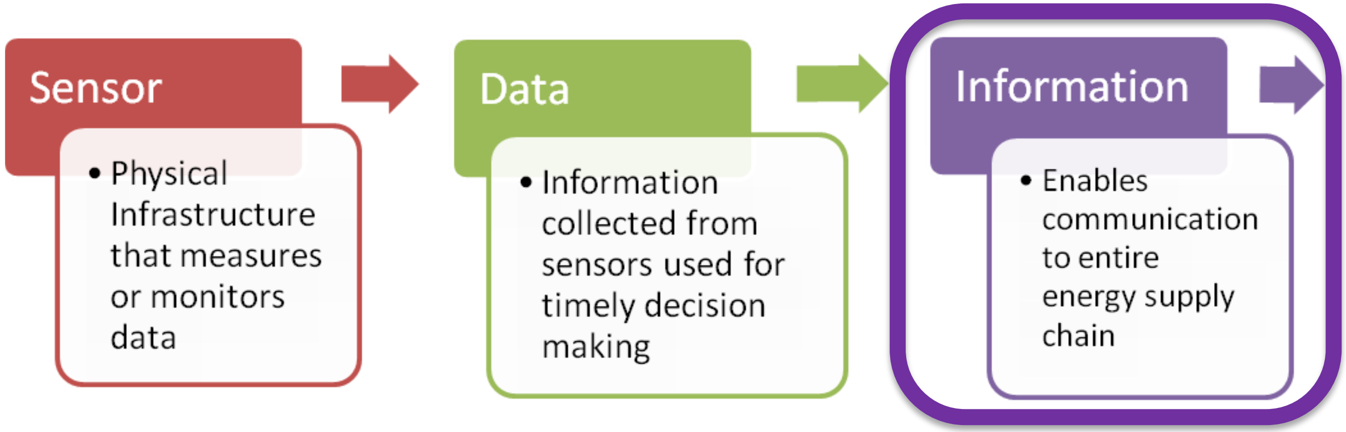
Sensor

- Physical Infrastructure that measures or monitors data

Data

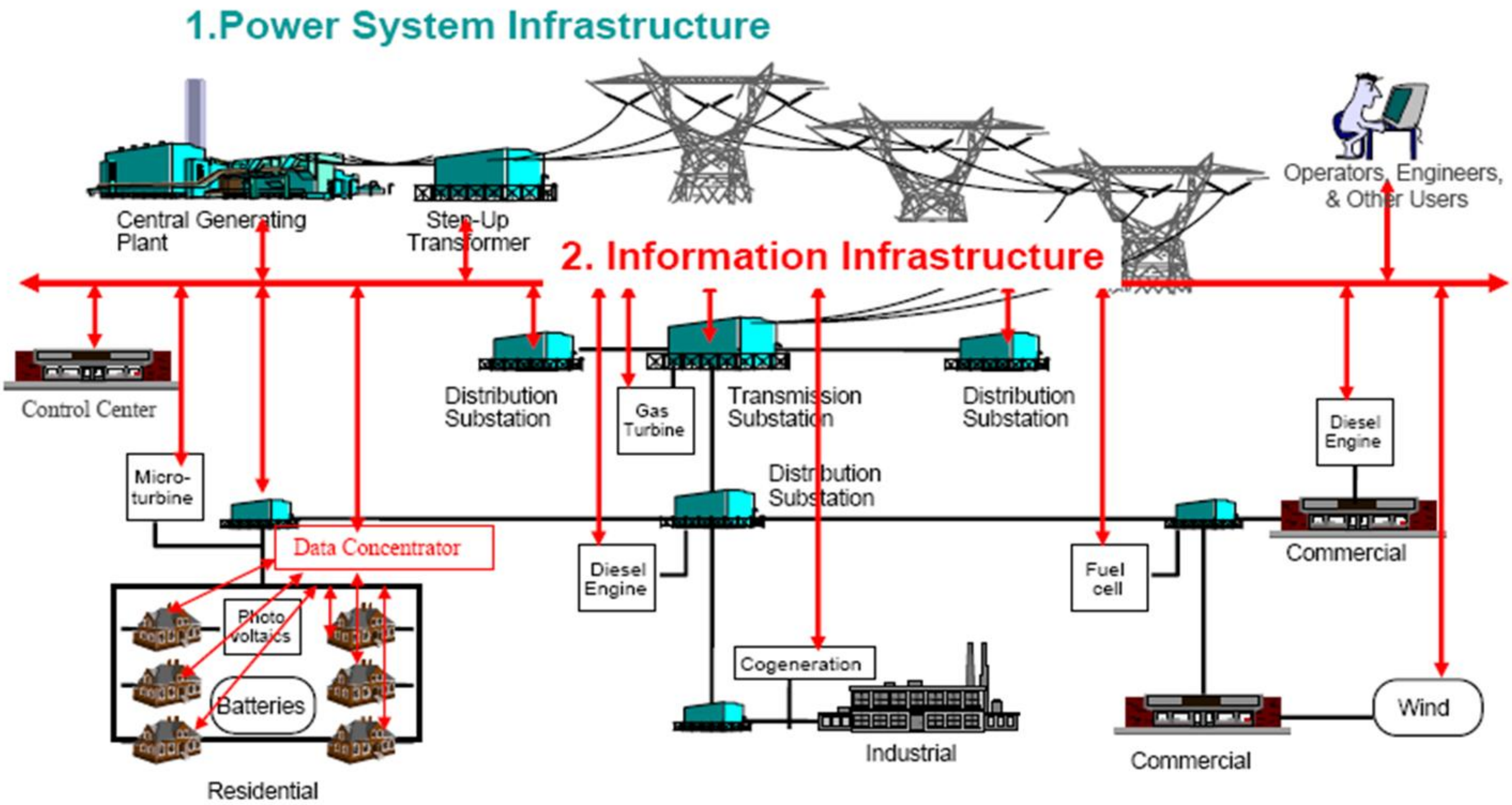
- Information collected from sensors used for timely decision making

18

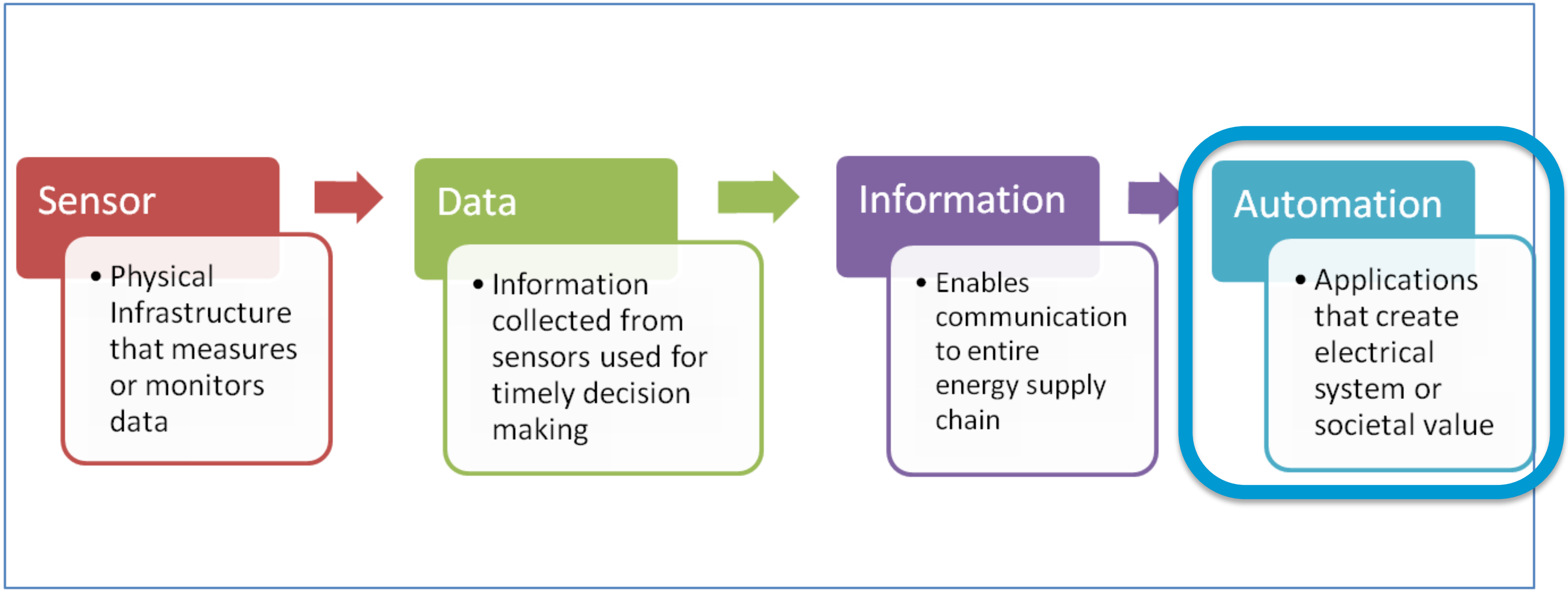

Sensor
Physical Infrastructure that measures or monitors data
Data
Information collected from sensors used for timely decision making
Information
Enables communication to entire energy supply chain

19

Electricity + Communication + Information



What is the Value of a Smart Grid?



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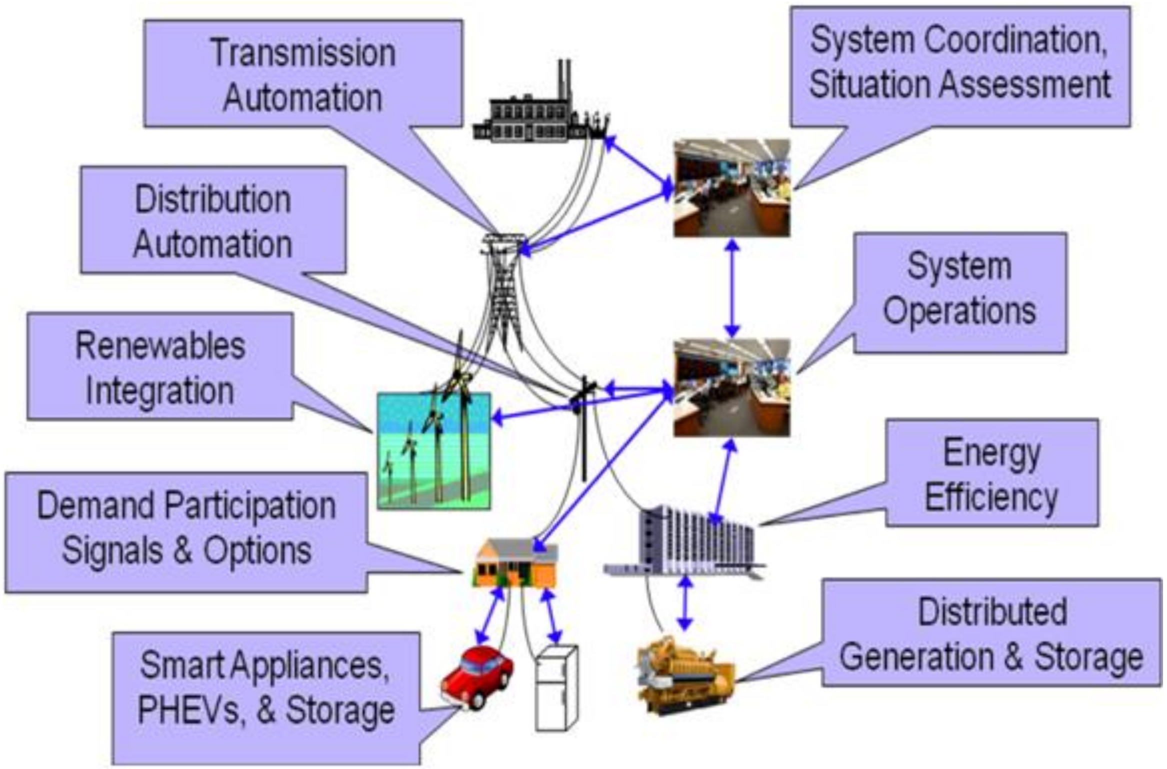
Each country and utility has its own reasons, strategy and understanding for a smart grid; therefore, different technologies are required to meet those needs.

These technologies would not exist without a semiconductor solution - analog components that attach to the line to condition the signals and digital components for analyzing, measuring, calculating and communicating data over a smart grid.

Smart Grid – Utilizing Digital Technologies to Enhance the Reliability, Security, and Efficiency of the Electric System



Smart Grid Characteristics

- 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
- Operate resiliently against attack and natural disaster

Yet, Another Part of the Definition

The Smart Grid is only as smart as the people who build it…

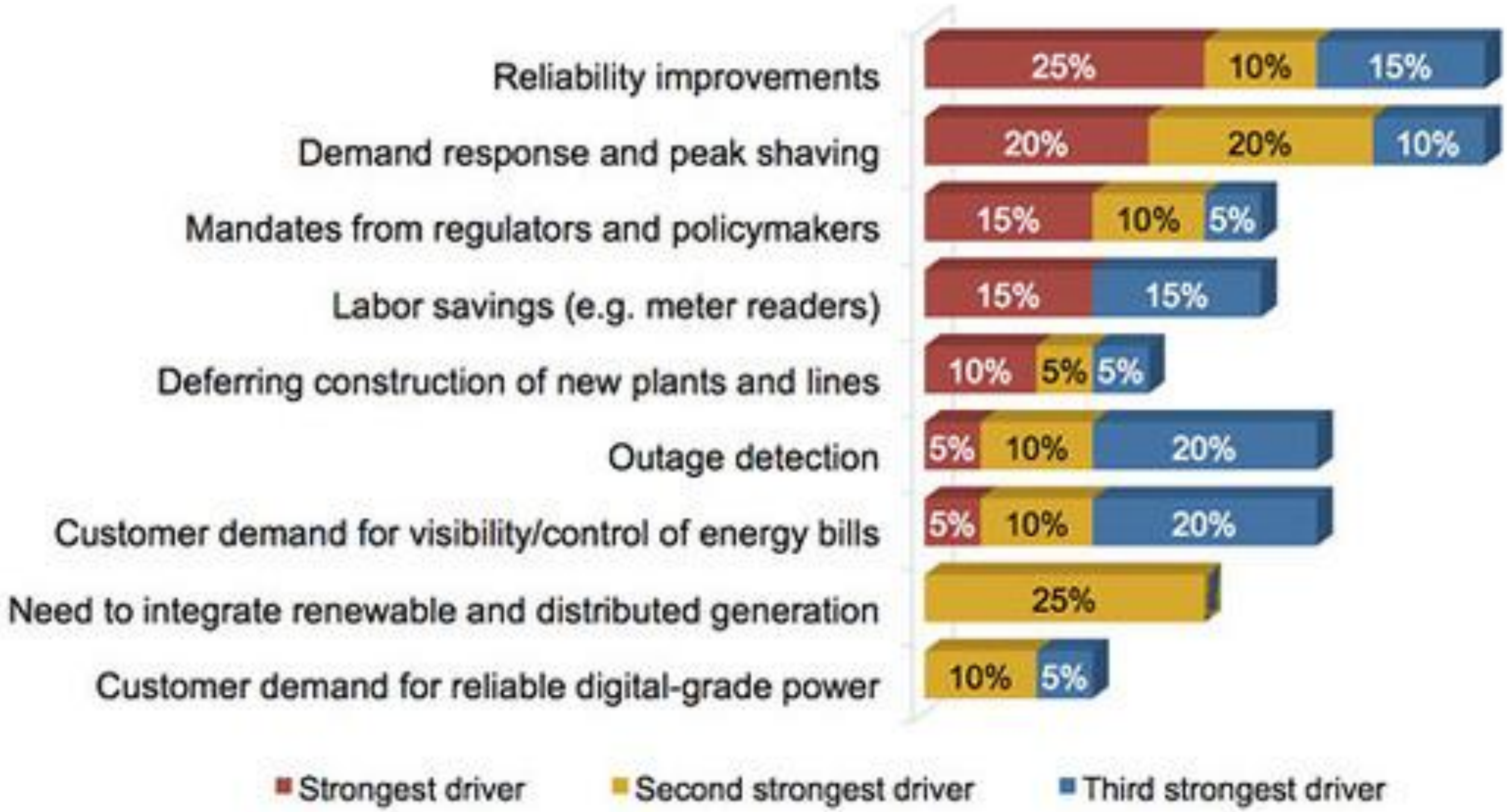
…as well as the people who use it.

The People Who Build It

Utilities are mostly concerned with adjusting to the public rather than having the public adjust to them.

Energy measurement during generation and distribution is much more complex than at consumption.

The People Who Build It



The People Who Build It

- While understanding some of the possibilities a Smart Grid may be able to provide, utilities also have many concerns about these technologies.
- Critics state that utilities simply do not want to invest capital into upgrades.
- But the reality is that their trepidation has many valid merits.

The People Who Build It

- For example, utilities are concerned over being forced to accept distributed power from customers.
- Utilities cannot vouch for the integrity of a customer's pv array, as an example, yet is being asked or required to accept power from it and to pay for that power.
- Once again, automation and other Smart Grid attributes are able to mitigate this, but not wholly, and certainly not to the level that would appease utilities.

The People Who Build It

Equally as complex, the Smart Grid allows the utility to have greater ability to manage the grid for their needs. But that is a double-edged sword. It also allows the consumer to manage the grid for their own needs. What ends up happening is that the grid is serving two masters, as it were. Automation helps, but is not the only answer.

With so many people having some control over the power, the utilities are concerned about losing control. They rightfully point out that if the grid goes down they will be the ones held accountable even though it may not be solely or even partially their fault.

Demand Response and Consumer Engagement

A revolution doesn't happen when society adopts new tools, it happens when society adopts new behaviors.

Clay Shirky, Digital Guru, and NYU Prof. of Telecommunications

- We must motivate consumers and condition them to participate as knowledgeable and engaged partners in an energy economy.
- Must run pilots
  - Time to Drawer – have to run a pilot long enough to determine point of consumer apathy with the technology (and throw it in the drawer, as it were)

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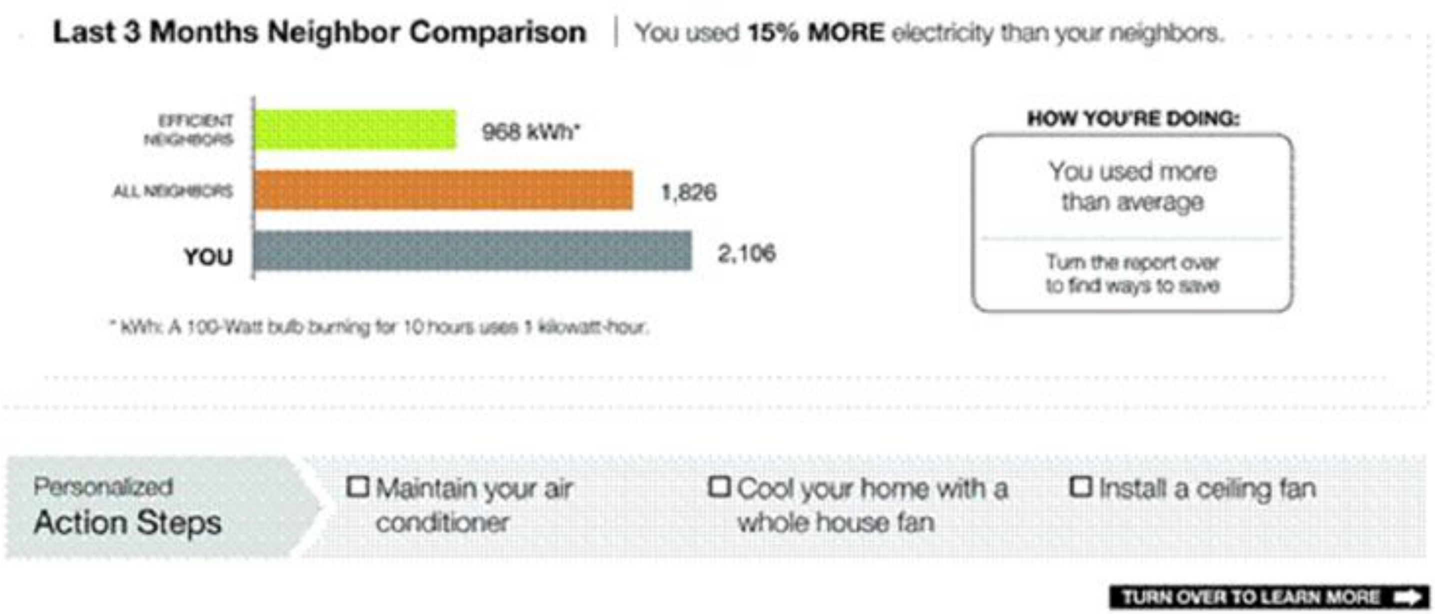
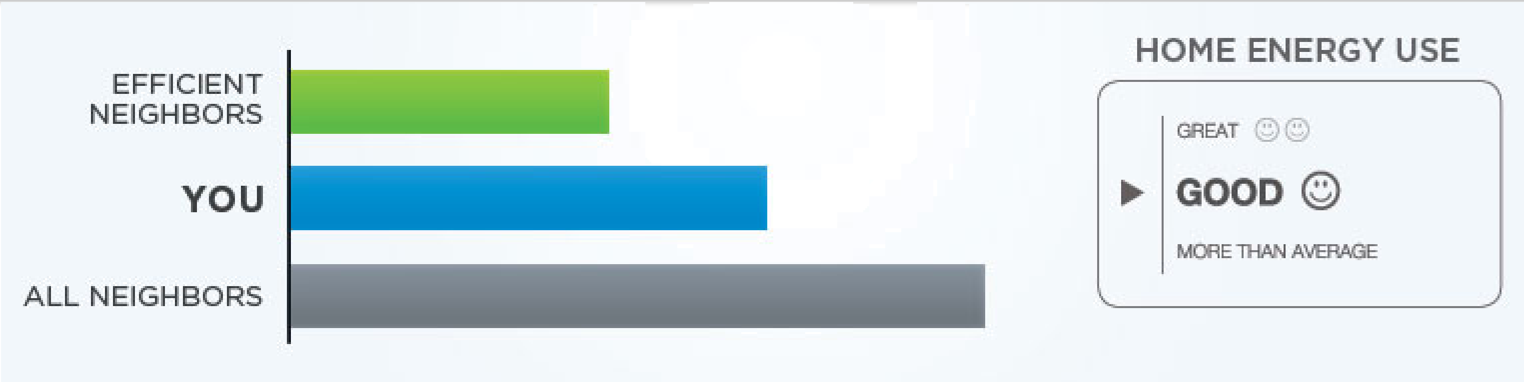
Without communication, the energy usage of appliances such as HVAC systems, dryers, heaters and plug-in electric vehicles (PEV) ***is unknown to utilities and energy customers. Communication enables the consumer and utility to gather and act on information in real-time*** and allows utilities to ease energy usage within the capacity of their power grid. This also permits data to be consolidated within residences, multi-dwelling structures or industrial facilities.

Communicating Social Norms



Market Appeal & Public Action

Consumer Info: Peer Comparisons & Time of Day



Average steady state savings = 2.5%

Energy Use (kWh)

12am 1pm 7pm 12am

Source: www.opower.com

Grid Modernization: The Social Factor

One of the main concerns regarding smart grid implementation is privacy, along with the need for policies assuring that data collected by utilities is protected and utilized properly.

Grid Modernization: The Social Factor

Individuals' electricity usage patterns describe their lifestyle, and that is why privacy is such an important topic for end-users. At the same time, is just that characteristic that makes the Smart Grid so valuable for the utilities.

There's a significant risk that user consumption data may be used for purposes ranging from targeted marketing to determining a household's habits.

Casual monitoring (Reactive)

Spying (Active)

Reliability and Self-Healing

Resilience **rather than** ***Resistance***

- It is very difficult and expensive to make the grid totally resistant.
- However, to make the grid self-healing to largely mitigate problems that may occur a very small percentage of the time it might well be more beneficial, effective, and affordable over than a system that may be resistant, but if made susceptible will be very damaged.
- For example, while cyber security is very important, there has never been a serious breach of the national grid.
- Still, diligence is important because as we move more toward digital technologies and microgrids that threat increases.

The Importance of Interoperability Standards

Interoperability standards are the foundation of whether a smart grid will be deployed and commercialized.

Consumer, commercial, and industry acceptance will largely depend on whether there is clear definition of the technologies and rules that will be established.

Without it, entities will sit on the sideline waiting to see who the winners and losers will be.

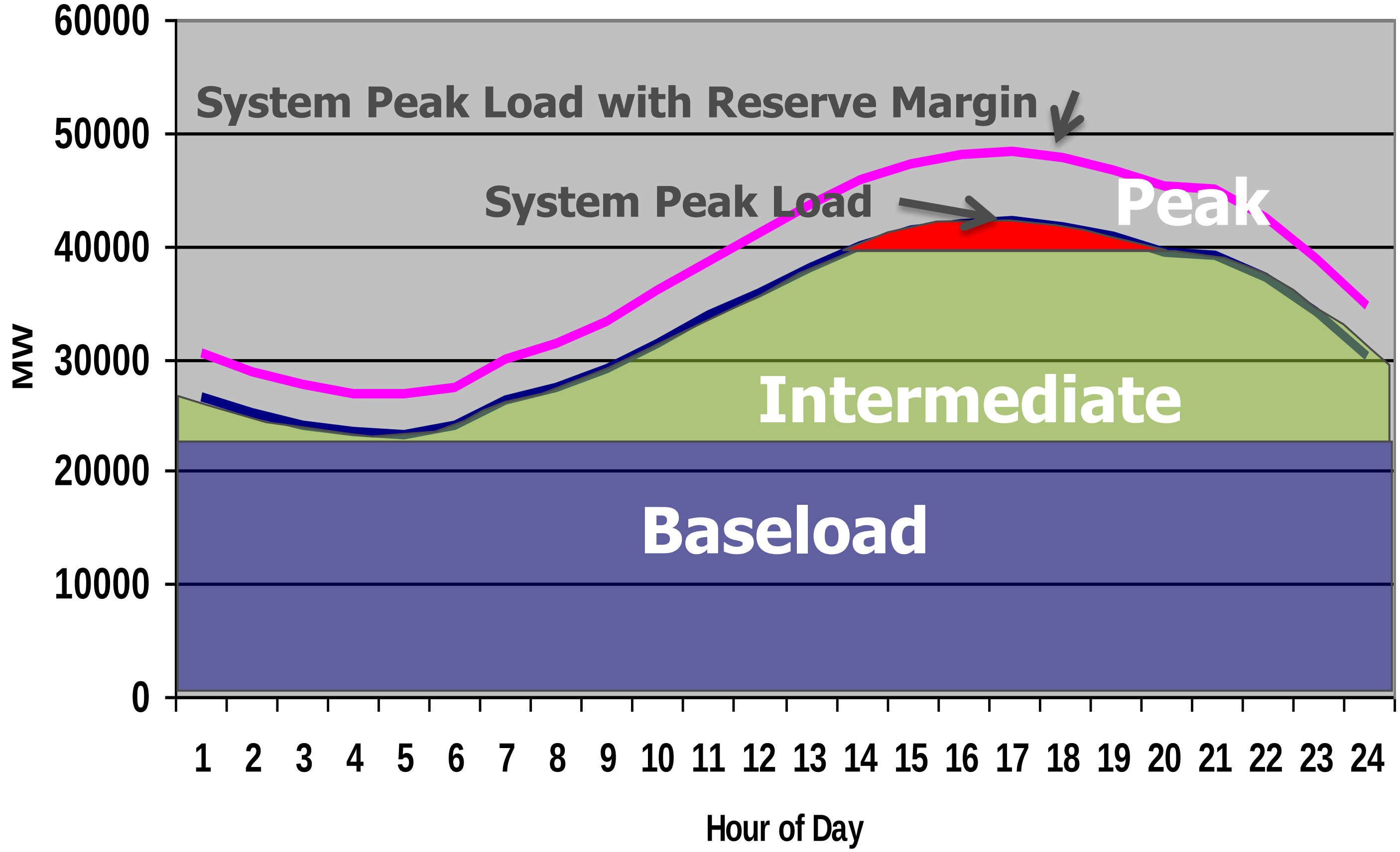
Beta vs. VHS, BluRay vs. HD, Apple vs. Android

This is too important of an issue to allow it to be decided by any factors other than best technologies.

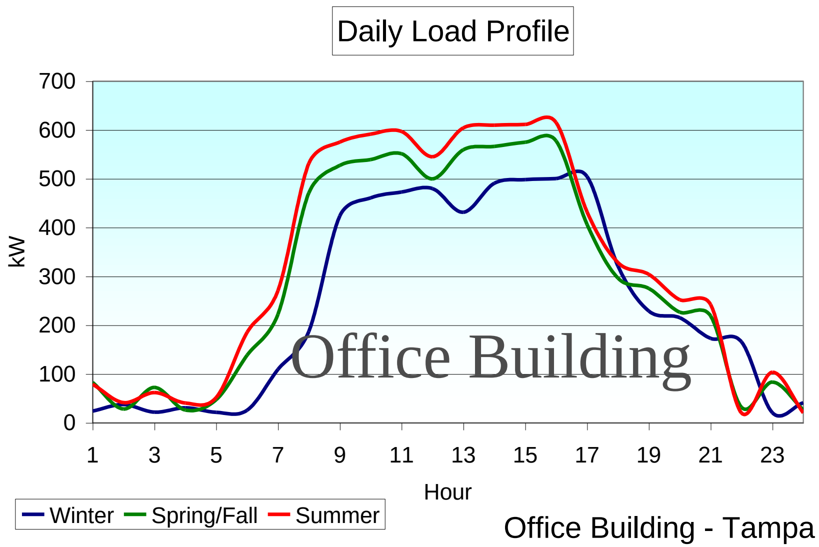
Demand Response and Distribution Grid Management

Load Shaving

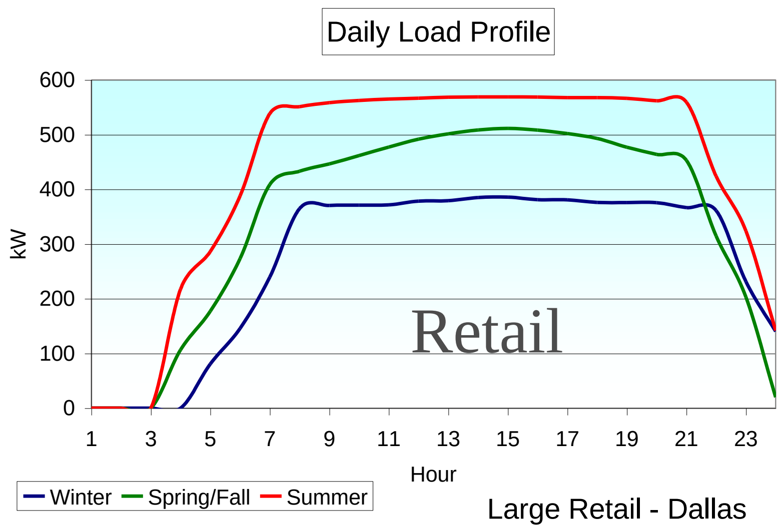
Daily System Load Curve- Goal is to Flatten



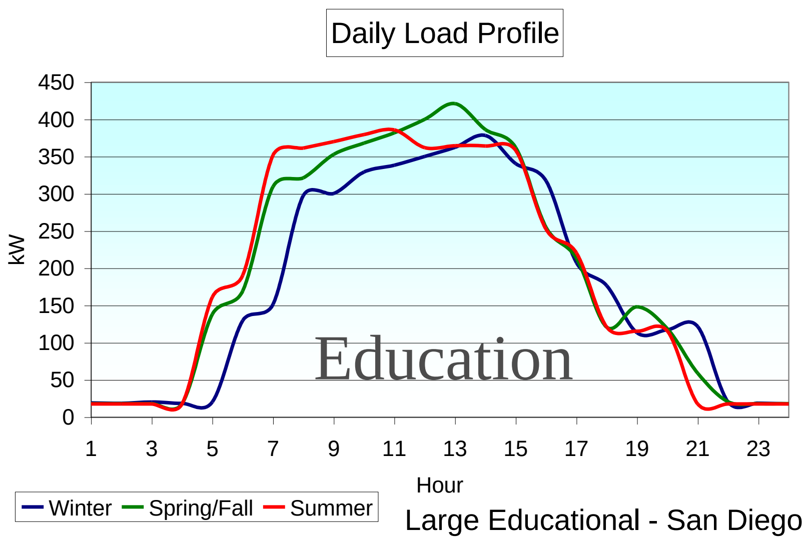
Other Load Profiles Showing High Variables Requiring a Very Flexible, Scalable, and Elastic Grid



Office Building - Tampa

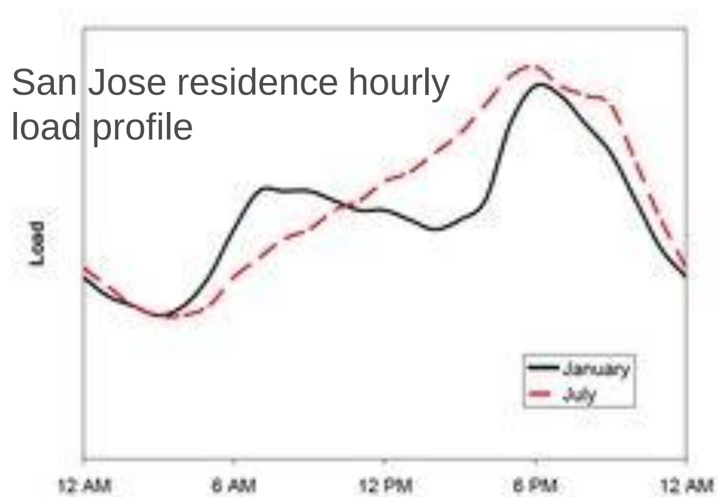


Large Retail - Dallas



Large Educational - San Diego

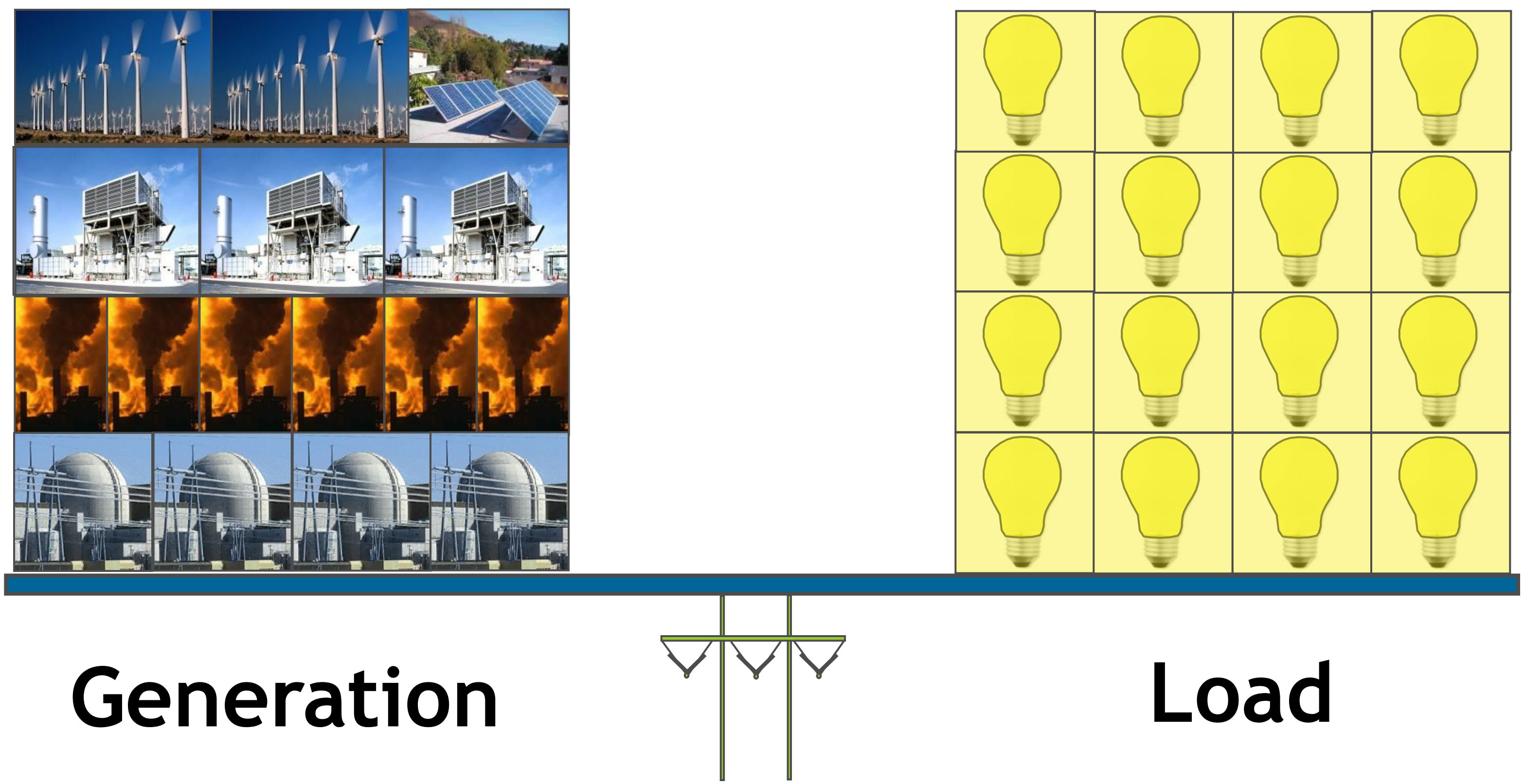
San Jose residence hourly load profile



Challenge - Balancing Generation and Load at the Same (Instantaneously)

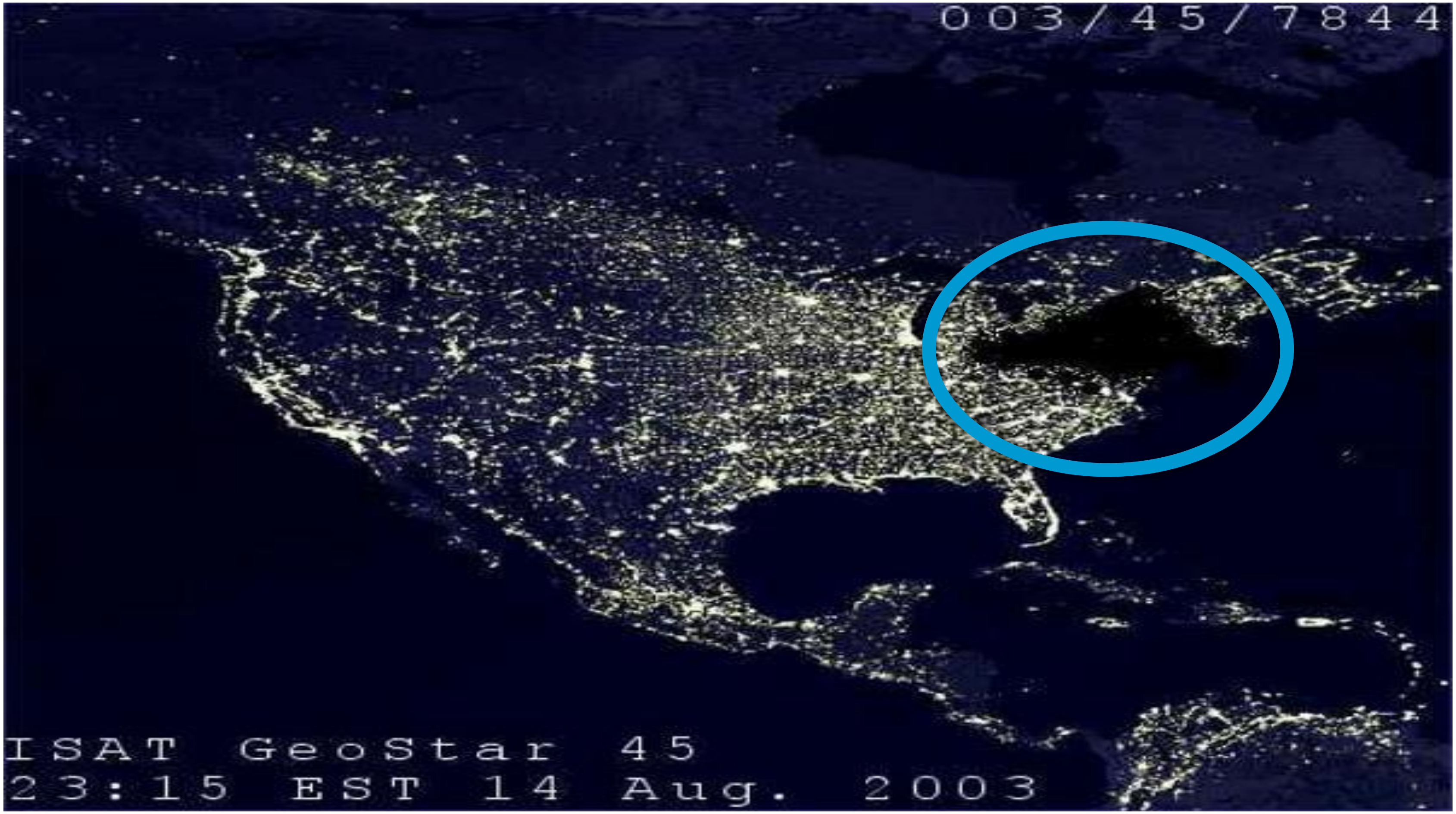
Objective

Less Variability - More Predictability

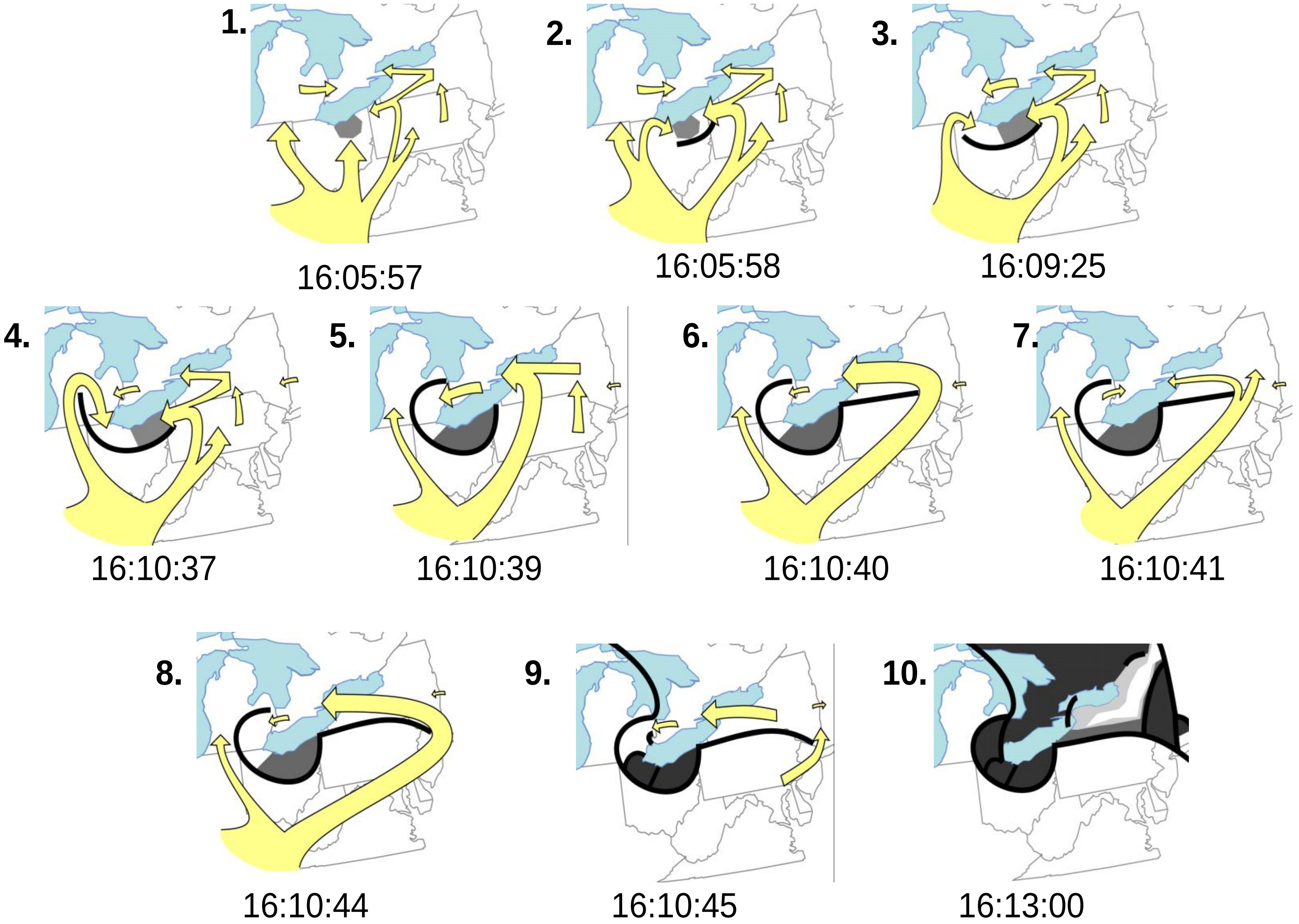


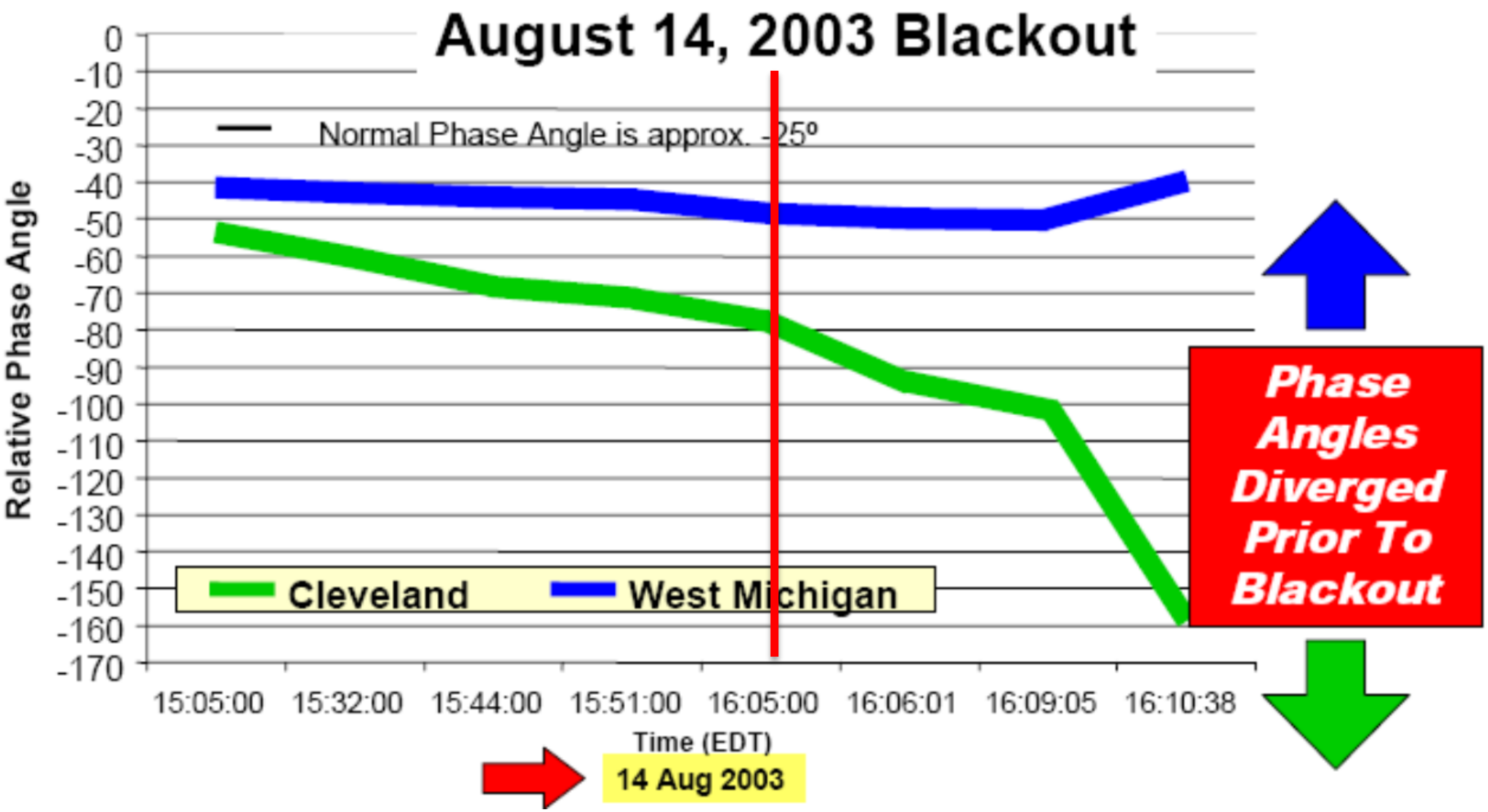
Wide-Area Situational Awareness

Lack of Wide Area Situational Awareness Contributed to 2003 Blackout

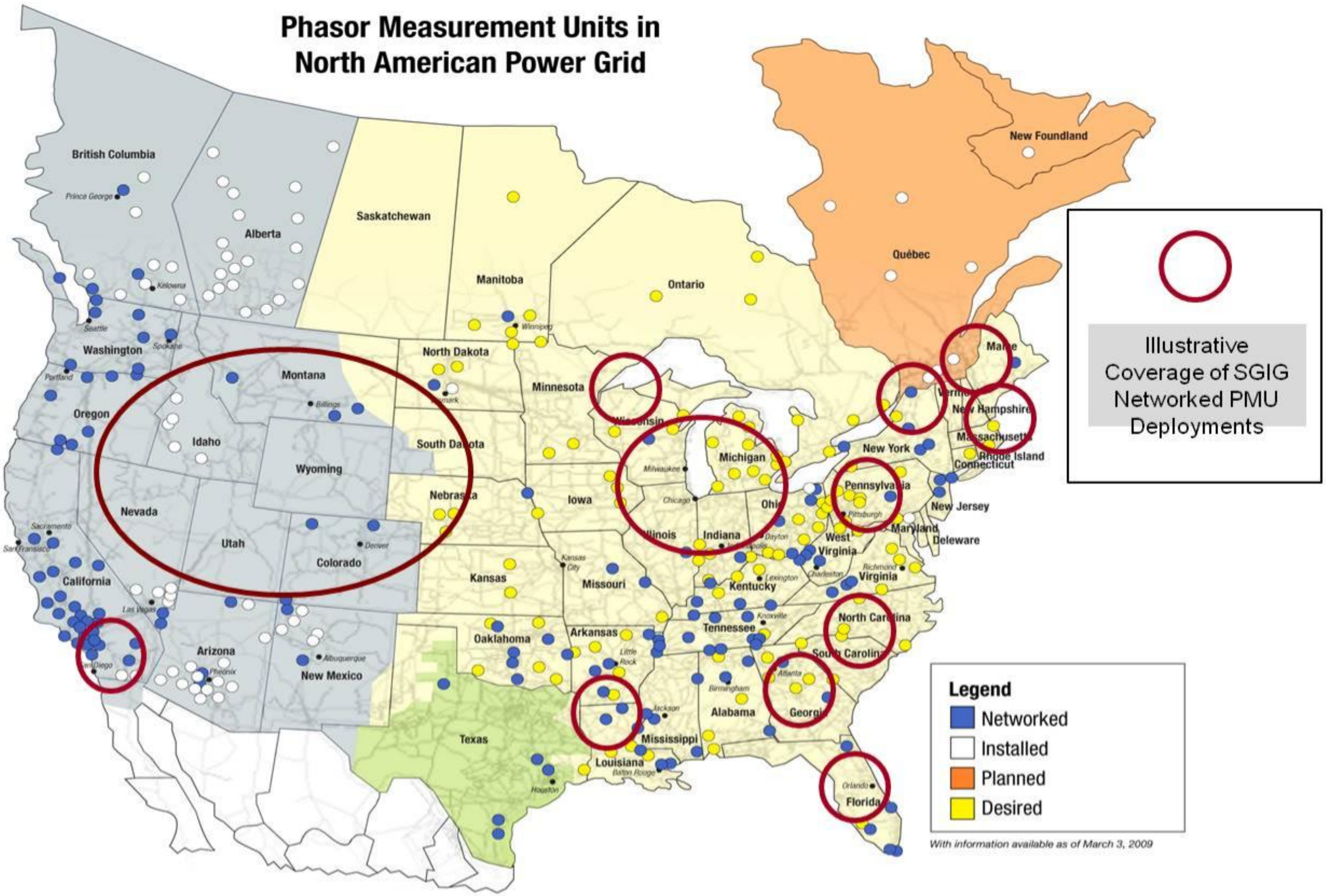


Timeline 2003 Blackout - 6 Minutes to Black



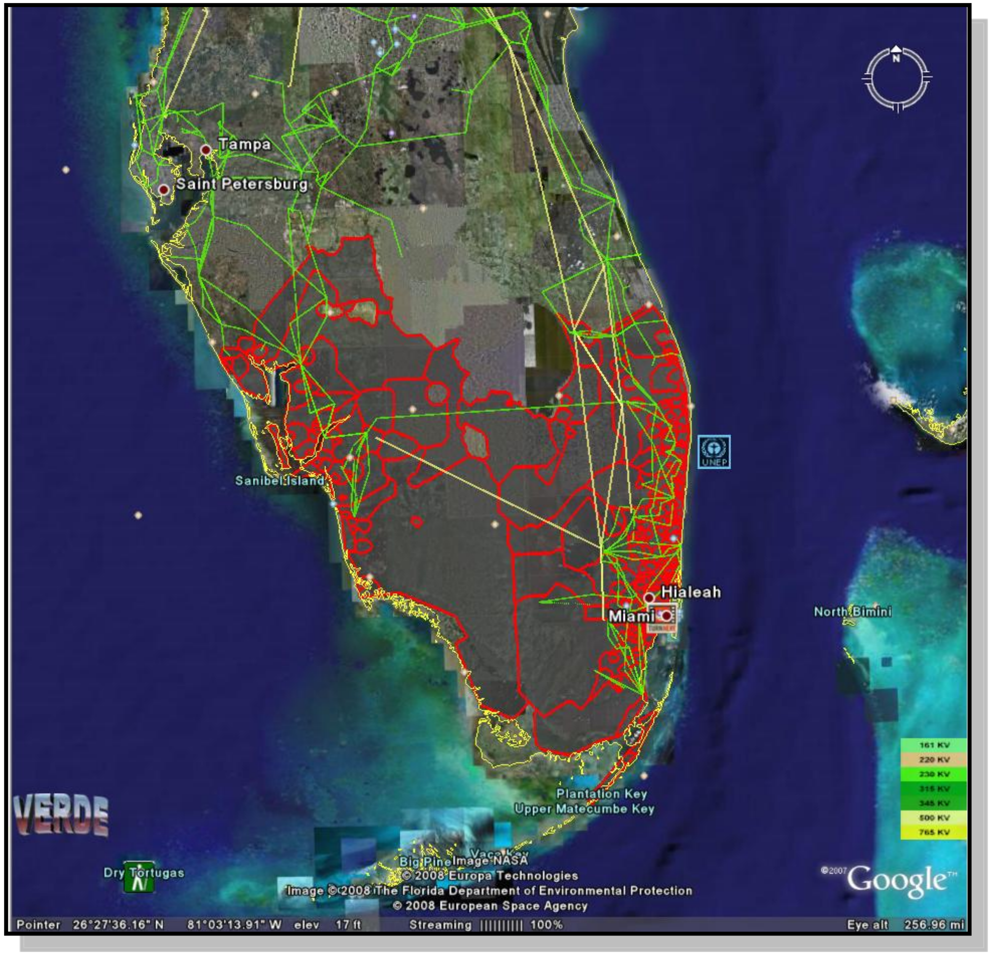

August 14, 2003 Blackout
Normal Phase Angle is approx. -25º
Relative Phase Angle
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
Cleveland
West Michigan
15:05:00
15:32:00
15:44:00
15:51:00
16:05:00
16:06:01
16:09:05
16:10:38
Time (EDT)
14 Aug 2003
Phase Angles Diverged Prior To Blackout

SGIG Networked PMU Deployments Fill Key Gaps for National Coverage



Florida Blackout - February 26, 2008

[YouTube - Florida Blackout]




ANOTHER BLACKOUT
Jammu & Kashmir
Punjab
Himachal Pradesh
Uttarakhand
Haryana
Delhi
Sikkim
Assam
Bihar
Rajasthan
Uttar Pradesh
West Bengal
Jharkhand
Odisha

Variable Power Source Integration

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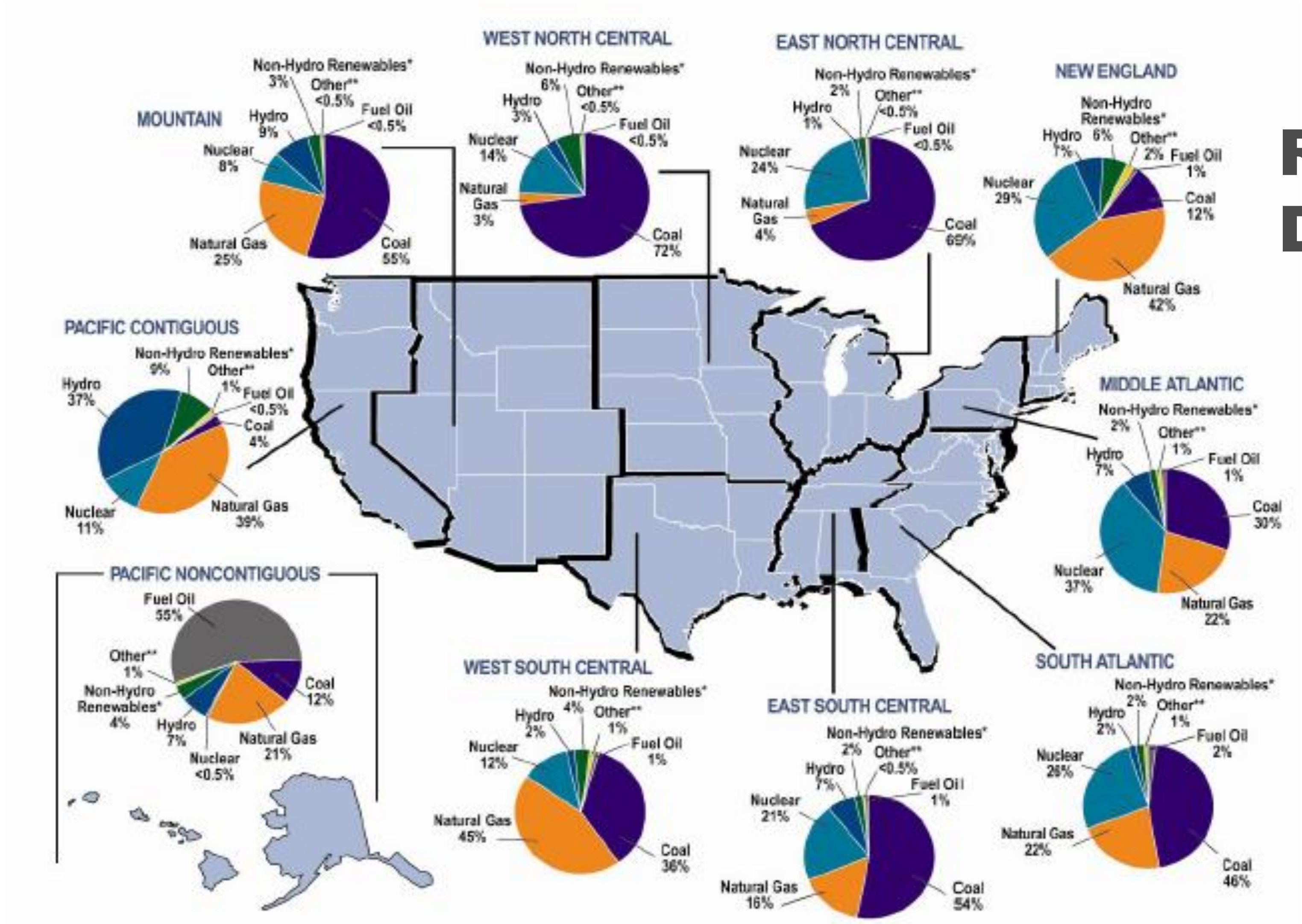
Different Regions of the Country Use Different Fuel Mixes to Generate Electricity



Regional Diversity

*Includes generation by agricultural waste, landfill gas recovery, municipal solid waste, wood, geothermal, non-wood waste, wind, and solar.

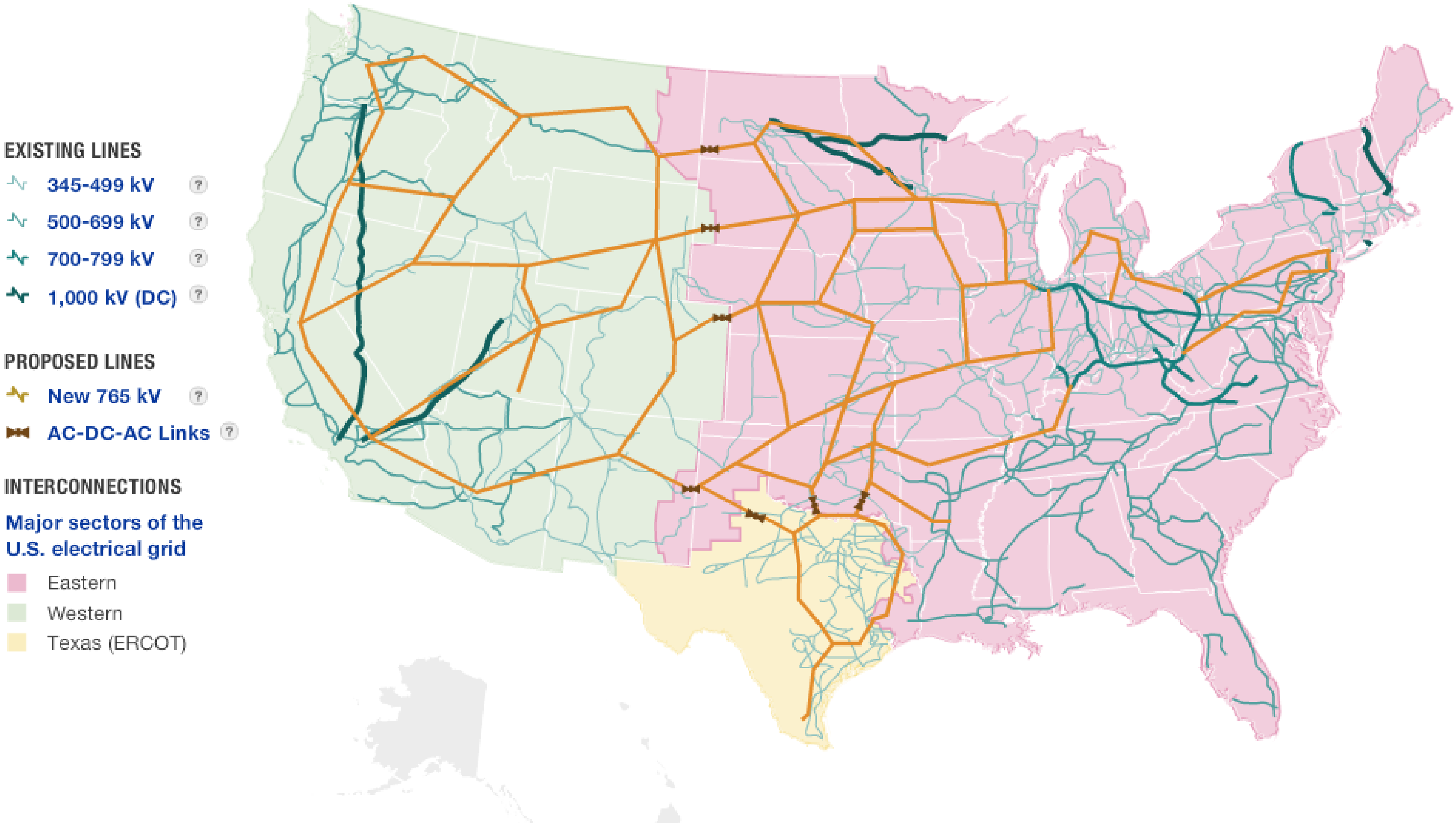
** Includes generation by tires, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, and miscellaneous technologies.

Sum of components may not add to 100% due to independent rounding.

Source: U.S. Department of Energy, Energy Information Administration, Power Plant Operations Report (EIA-923); 2009 preliminary generation data.

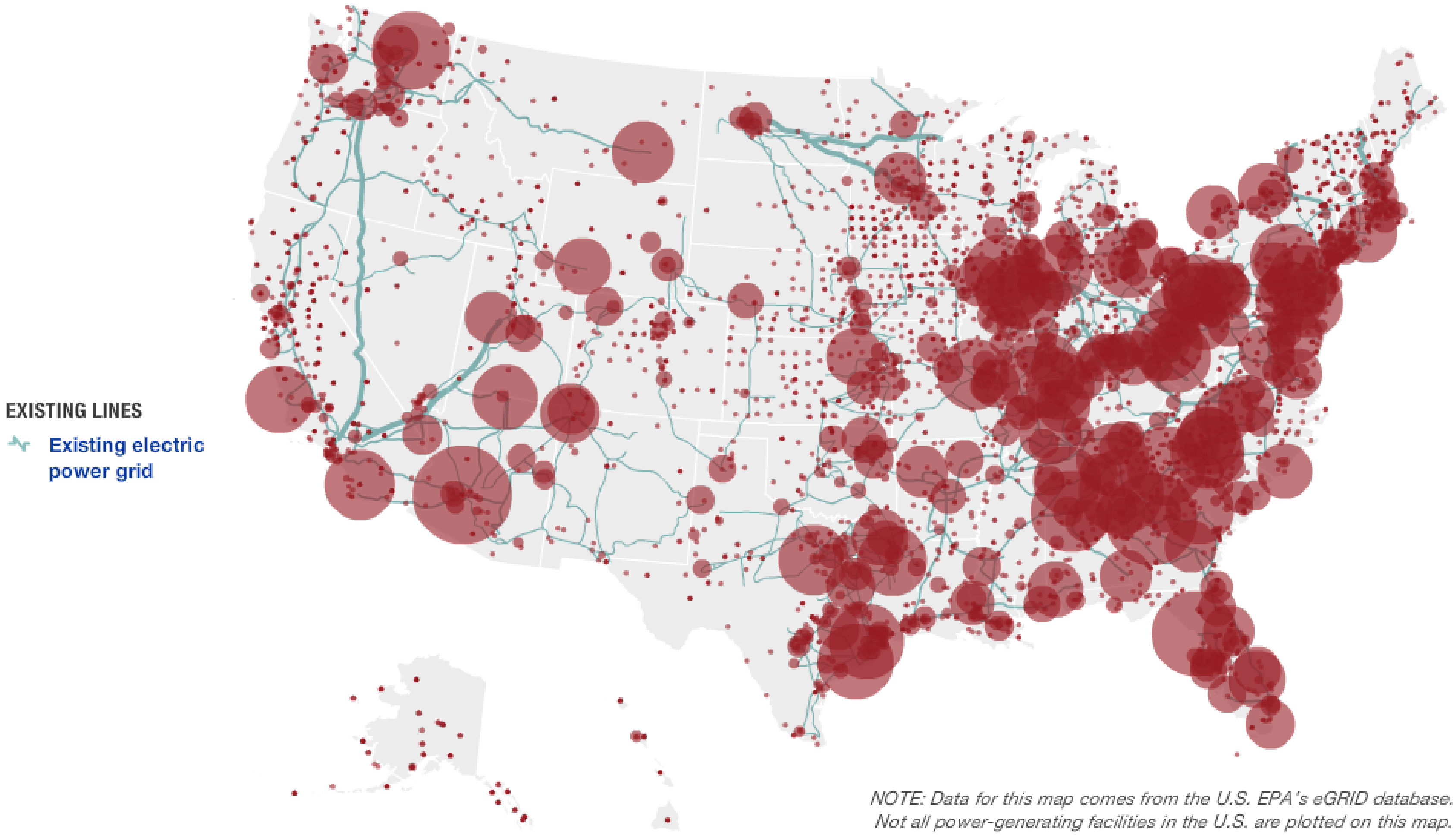
May 2010

The Power Grid System Does Not Tell the Whole Story



Source: American Electric Power, American Wind Energy Association, Center for American Progress, Department of Energy, Edison Electric Institute, Energy Information Administration, Electric Power Research Institute, Federal Energy Regulatory Commission, National Renewable Energy Laboratory, U.S. Environmental Protection Agency, Western Resource Advocates
Credit: Producer: Andrew Prince; Designer: Alyson Hurt; Editors: Avie Schneider and Vikki Valentine; Supervising Editors: Anne Gudenkauf and Quinn O'Toole; Additional Research: Jenny Gold; Database and GIS Analysis: Robert Benincasa

Current Power Plants and Main Power Arteries



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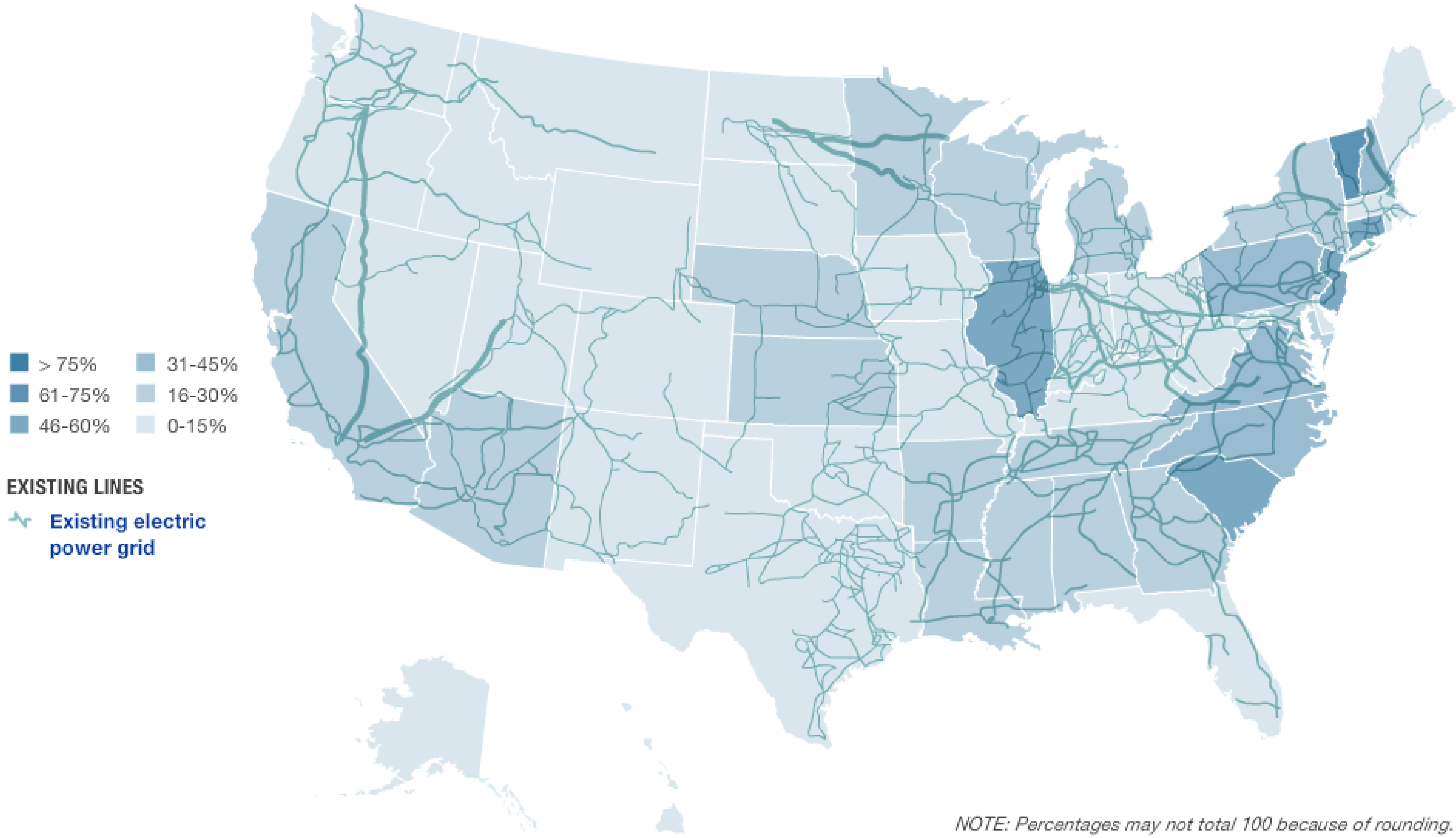
Current Nuclear Power Distribution



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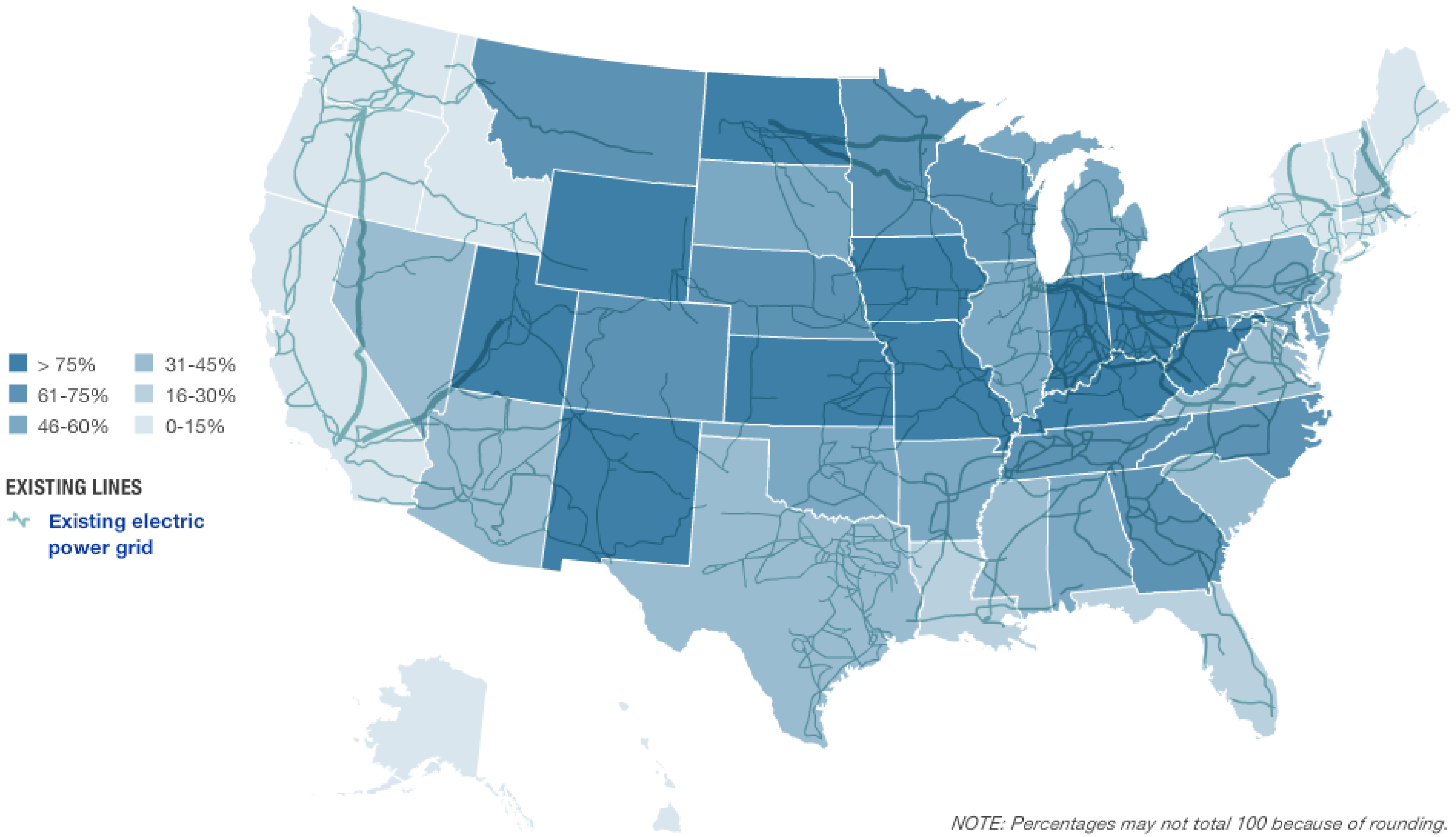
Current Coal Power Sources and Grid Delivery



NOTE: Percentages may not total 100 because of rounding.

Source: American Electric Power, American Wind Energy Association, Center for American Progress, Department of Energy, Edison Electric Institute, Energy Information Administration, Electric Power Research Institute, Federal Energy Regulatory Commission, National Renewable Energy Laboratory, U.S. Environmental Protection Agency, Western Resource Advocates
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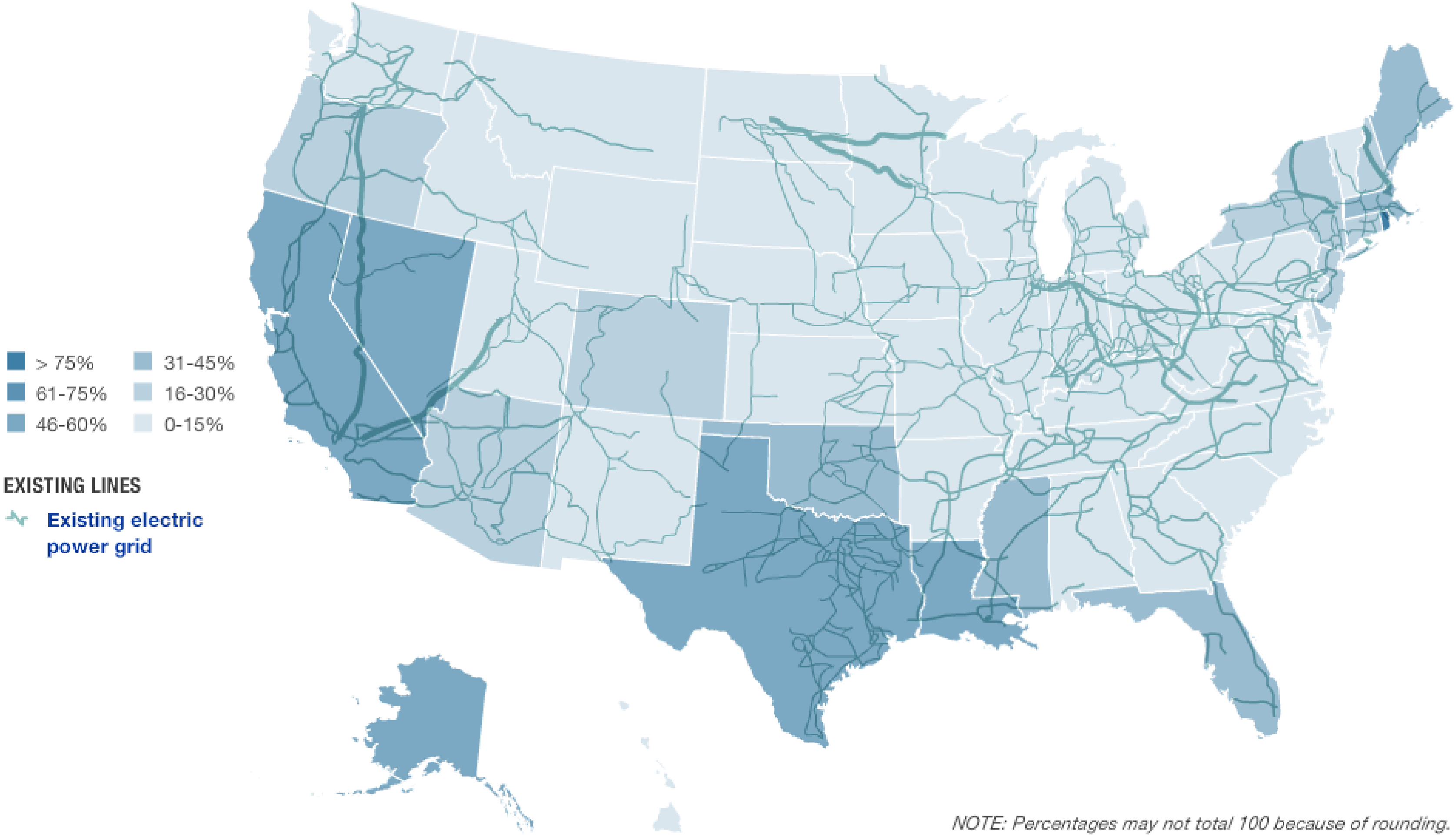
Current Natural Gas (Erd Gas) Power Sources and Grid Delivery



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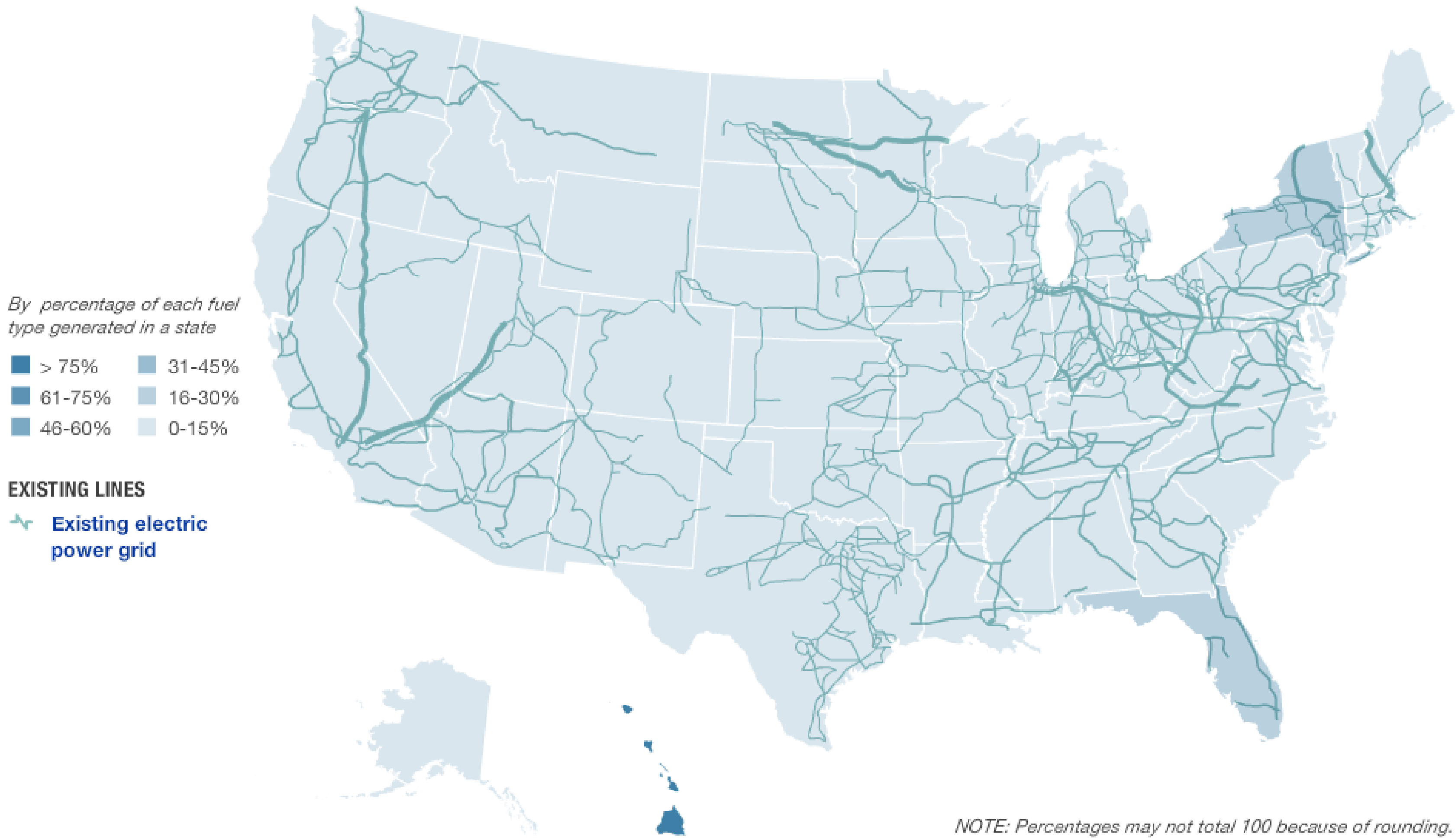
Current Oil (Bunker Fuel) Power Sources and Grid Delivery



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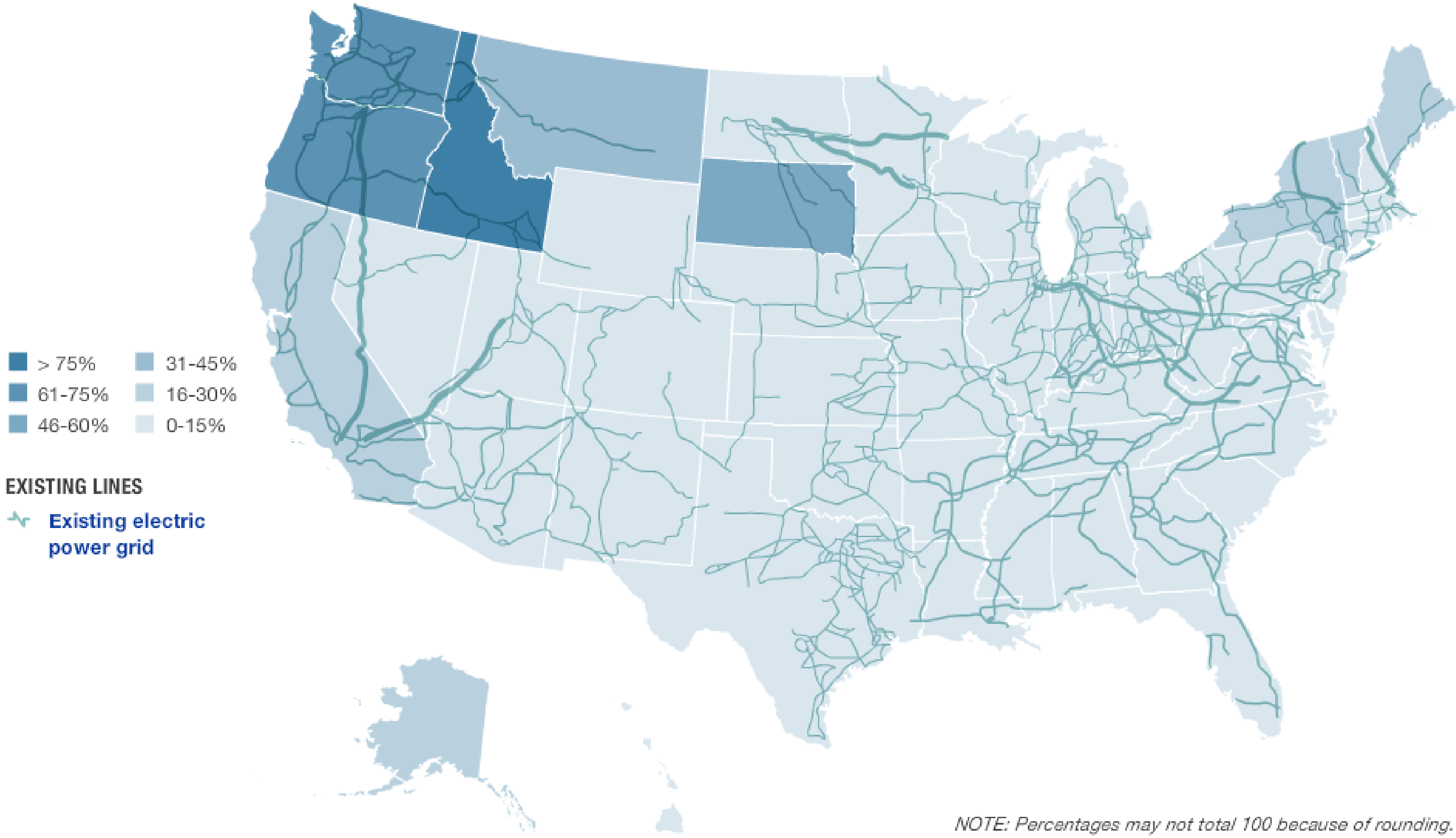
Current Hydroelectric Power Sources and Grid Delivery



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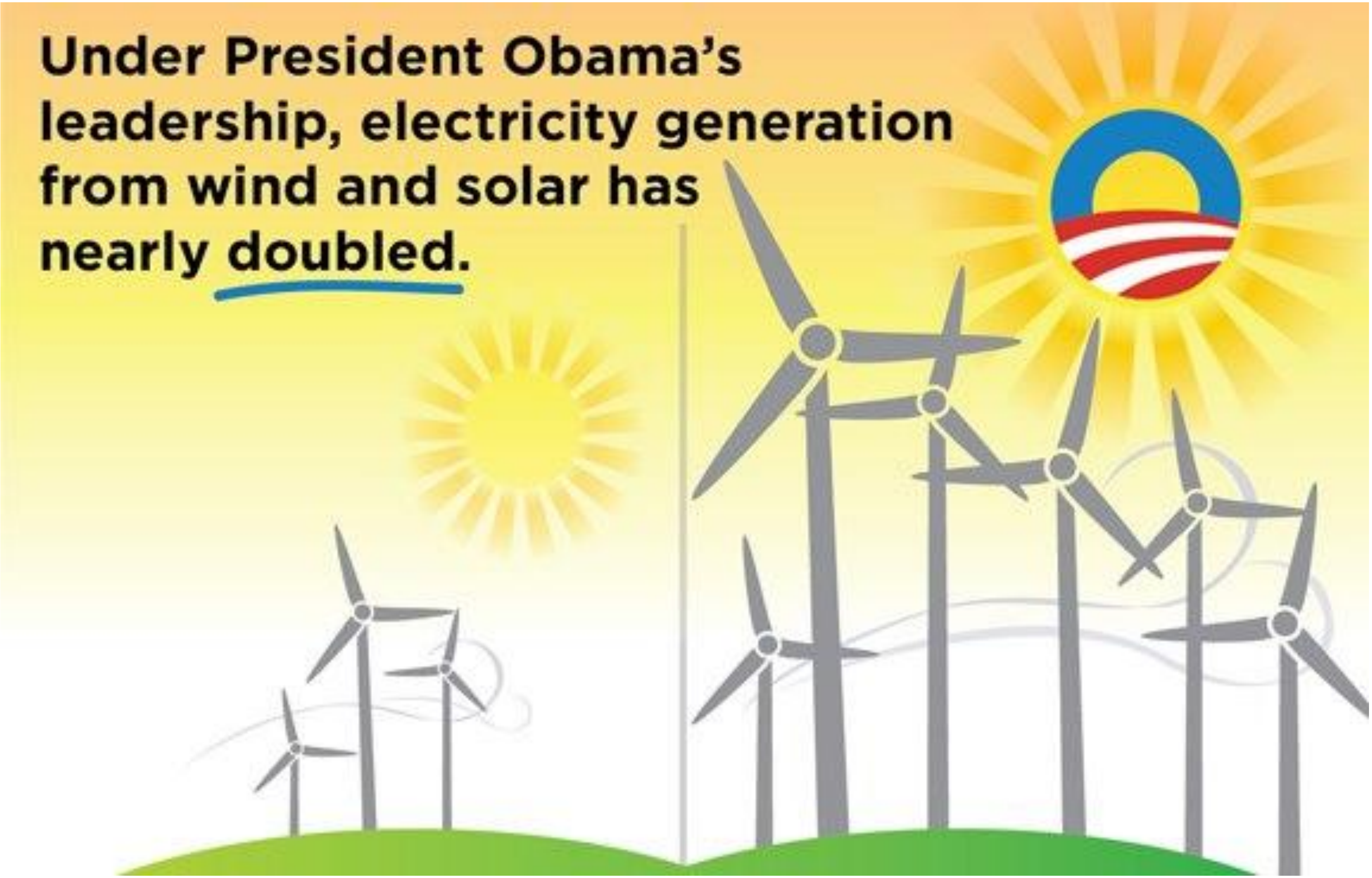

Under President Obama's leadership, electricity generation from wind and solar has nearly doubled.

Moving in the Right Direction, BUT…

…the current grid has difficulty accommodating variable sources of power like wind and solar energy, the fastest-growing sources of renewable power on the grid. As these resources begin to supply increasing percentages of power to the grid, integrating them into grid operations will become increasingly difficult.

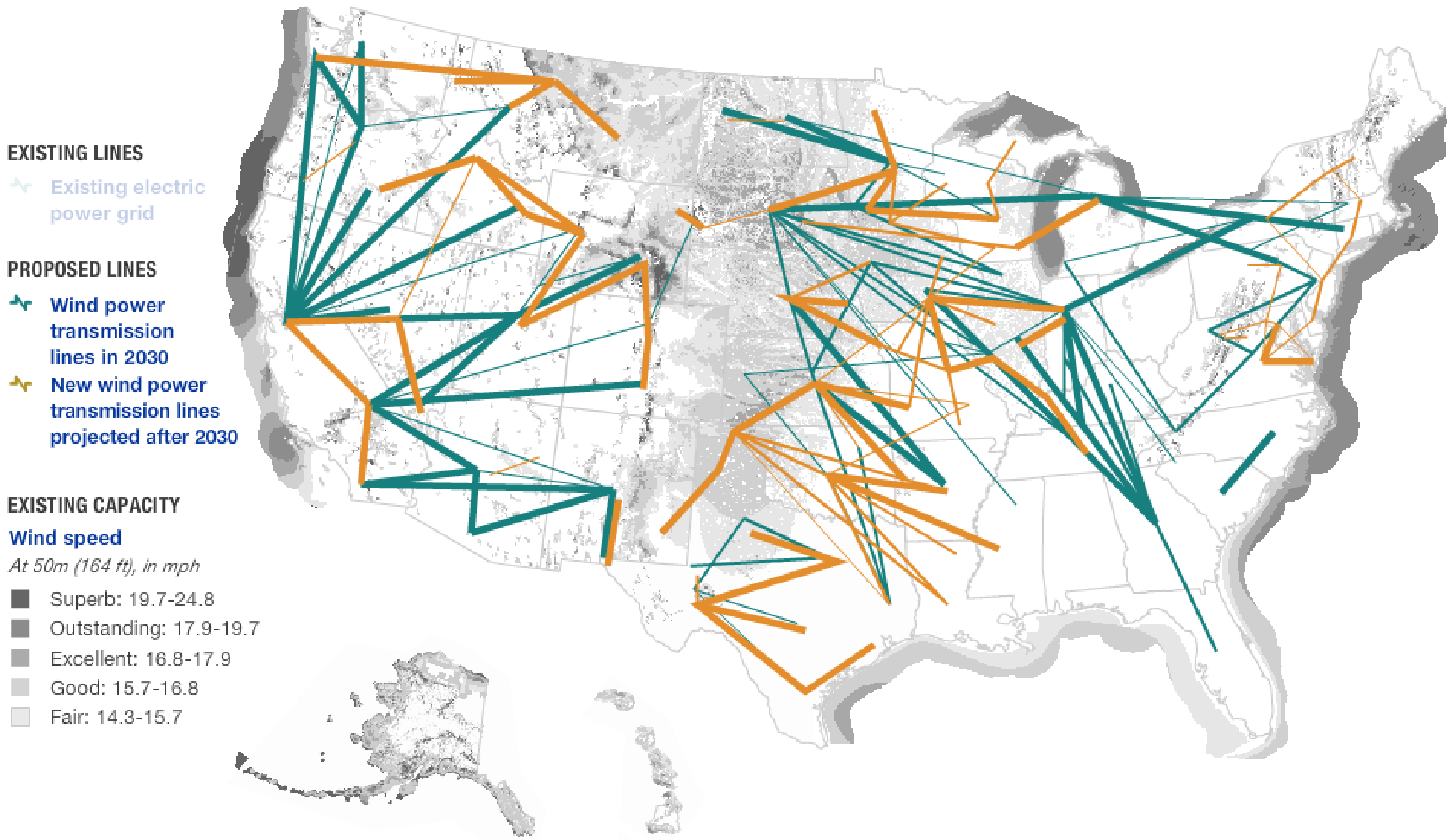
Regarding Renewables...

The physical reality is that geothermal, solar and wind, resources are usually located in remote places, while much of the power demand is in urban areas.

Furthermore, by 2030, 80 percent of the world's population will live in urban areas and will require even more energy.

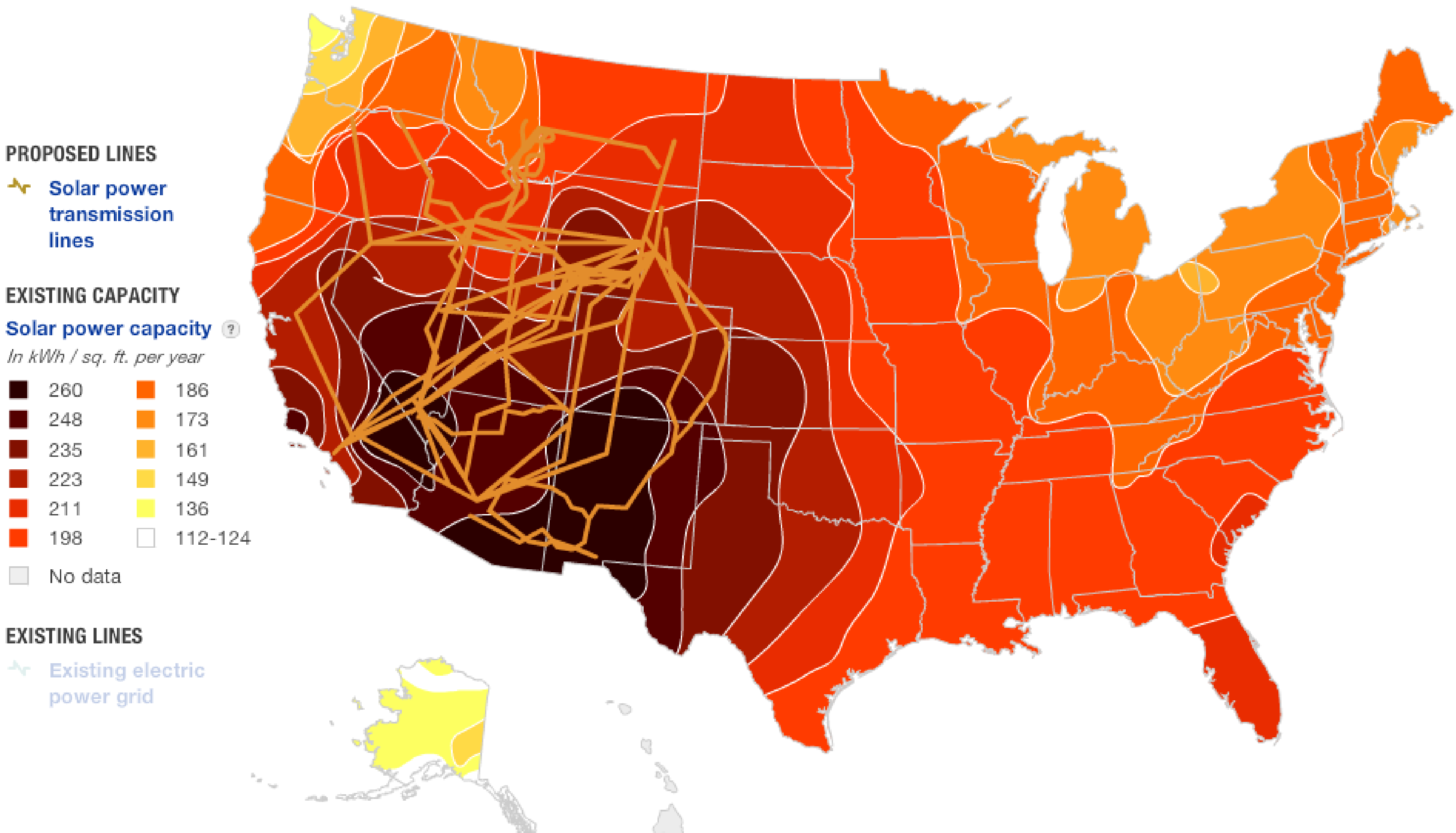
We cannot change where renewables are best captured or where they are naturally appearing, but we can impact this paradigm by investing in an advanced and larger power infrastructure for electricity to get from the interior to the coasts easily and efficiently.

Wind Power Transmission in 2030 and Beyond



Source: American Electric Power, American Wind Energy Association, Center for American Progress, Department of Energy, Edison Electric Institute, Energy Information Administration, Electric Power Research Institute, Federal Energy Regulatory Commission, National Renewable Energy Laboratory, U.S. Environmental Protection Agency, Western Resource Advocates
Credit: Producer: Andrew Prince; Designer: Alyson Hurt; Editors: Avie Schneider and Vikki Valentine; Supervising Editors: Anne Gudenkauf and Quinn O'Toole; Additional Research: Jenny Gold; Database and GIS Analysis: Robert Benincasa

Future Solar Power Distribution and Current Capacity



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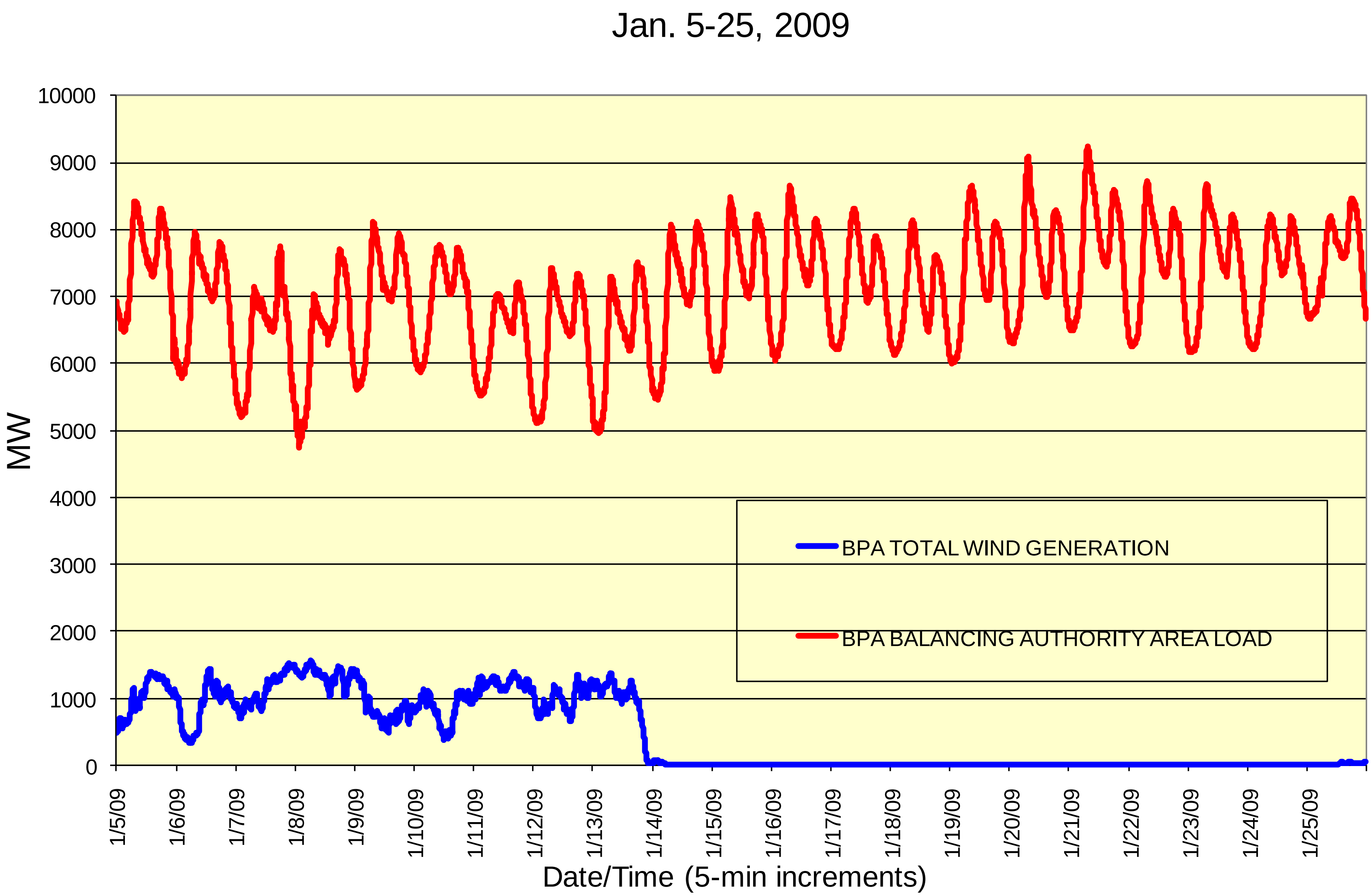
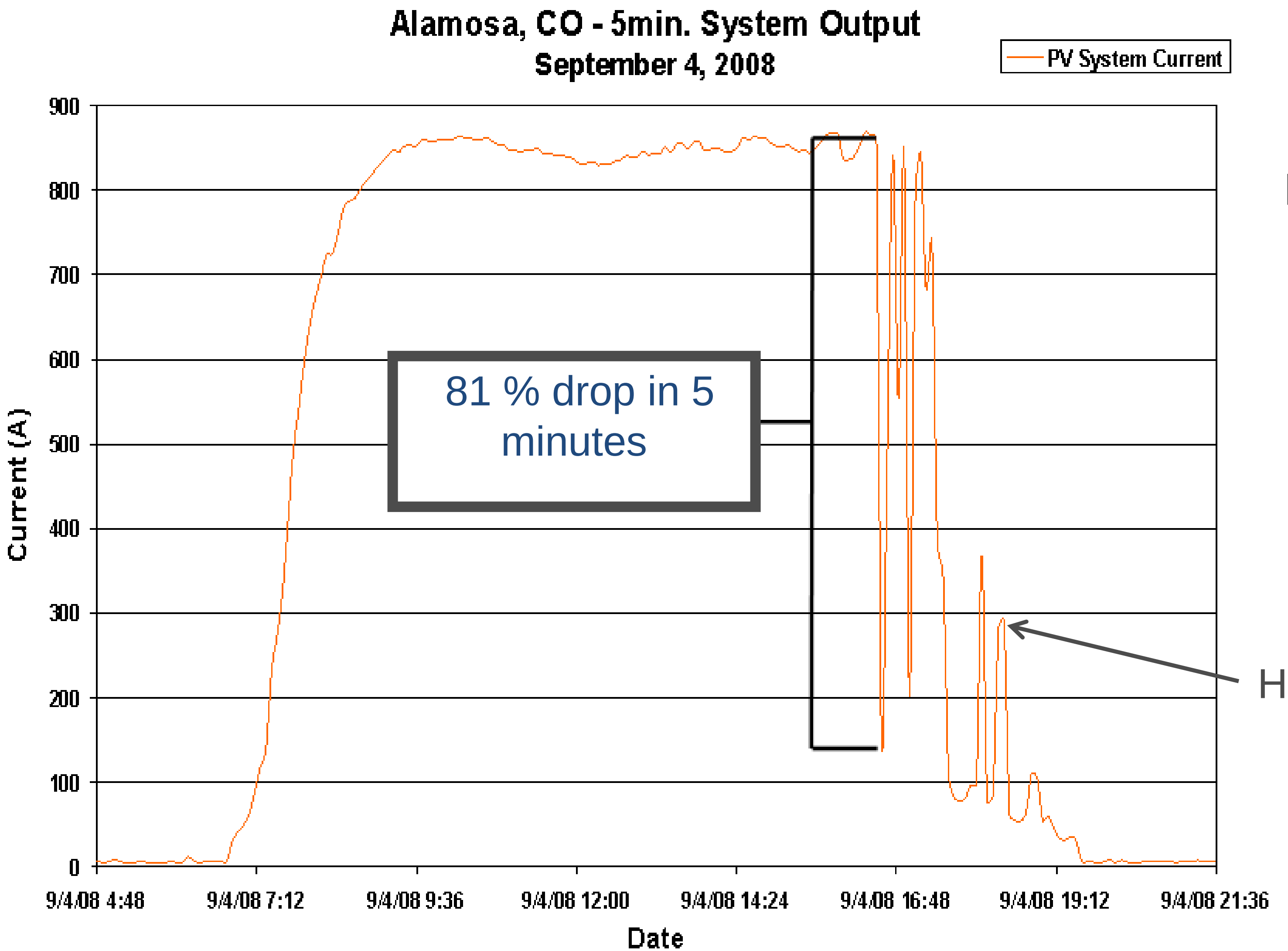
Challenge: Wind Requires Substantial Balancing Reserves



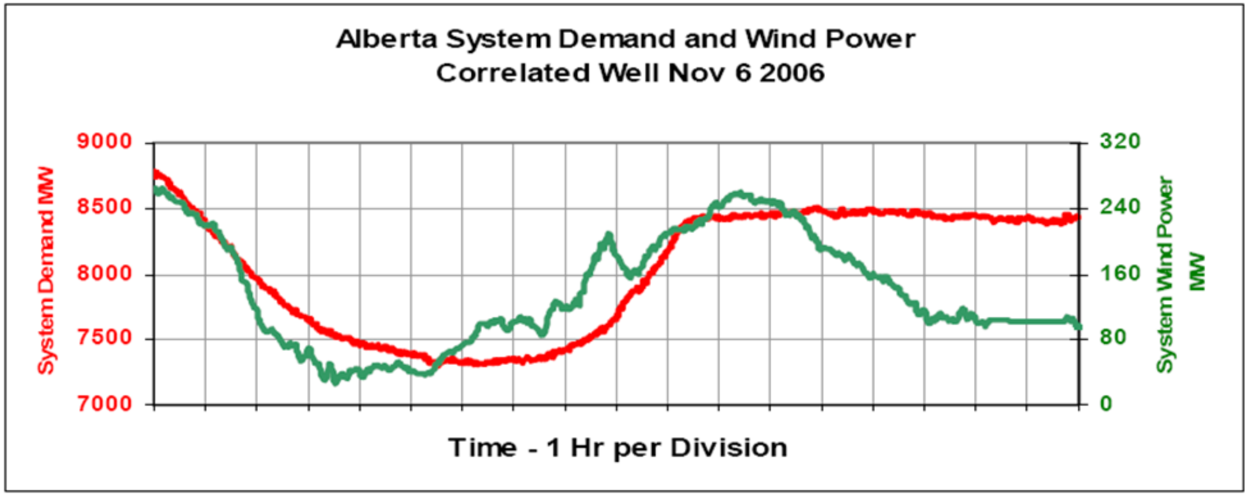
Challenge: Solar Energy Sources Are Highly Variable

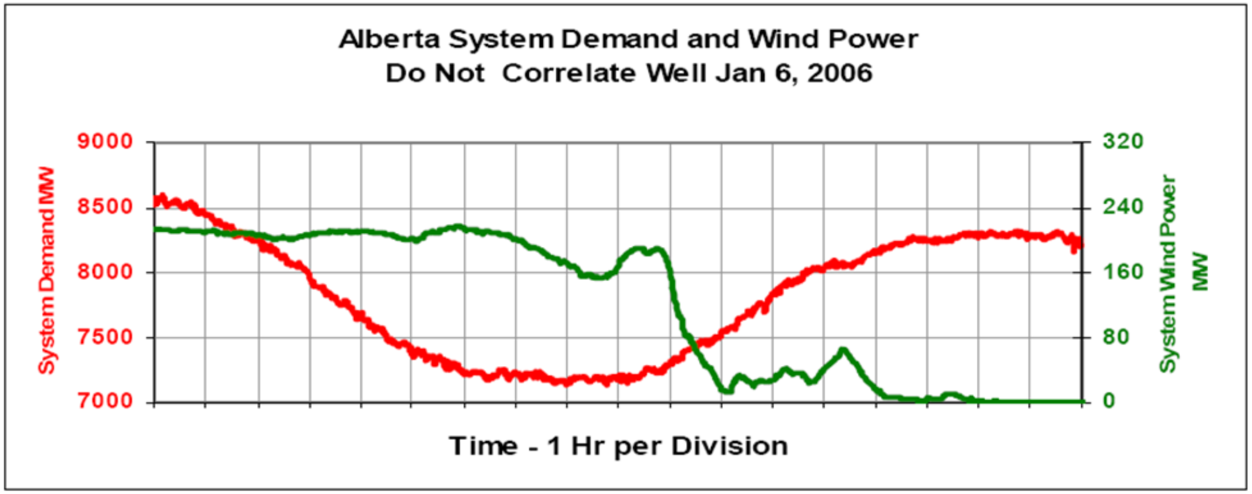


Output from an 8MW solar PV panel in Colorado on 9/4/08

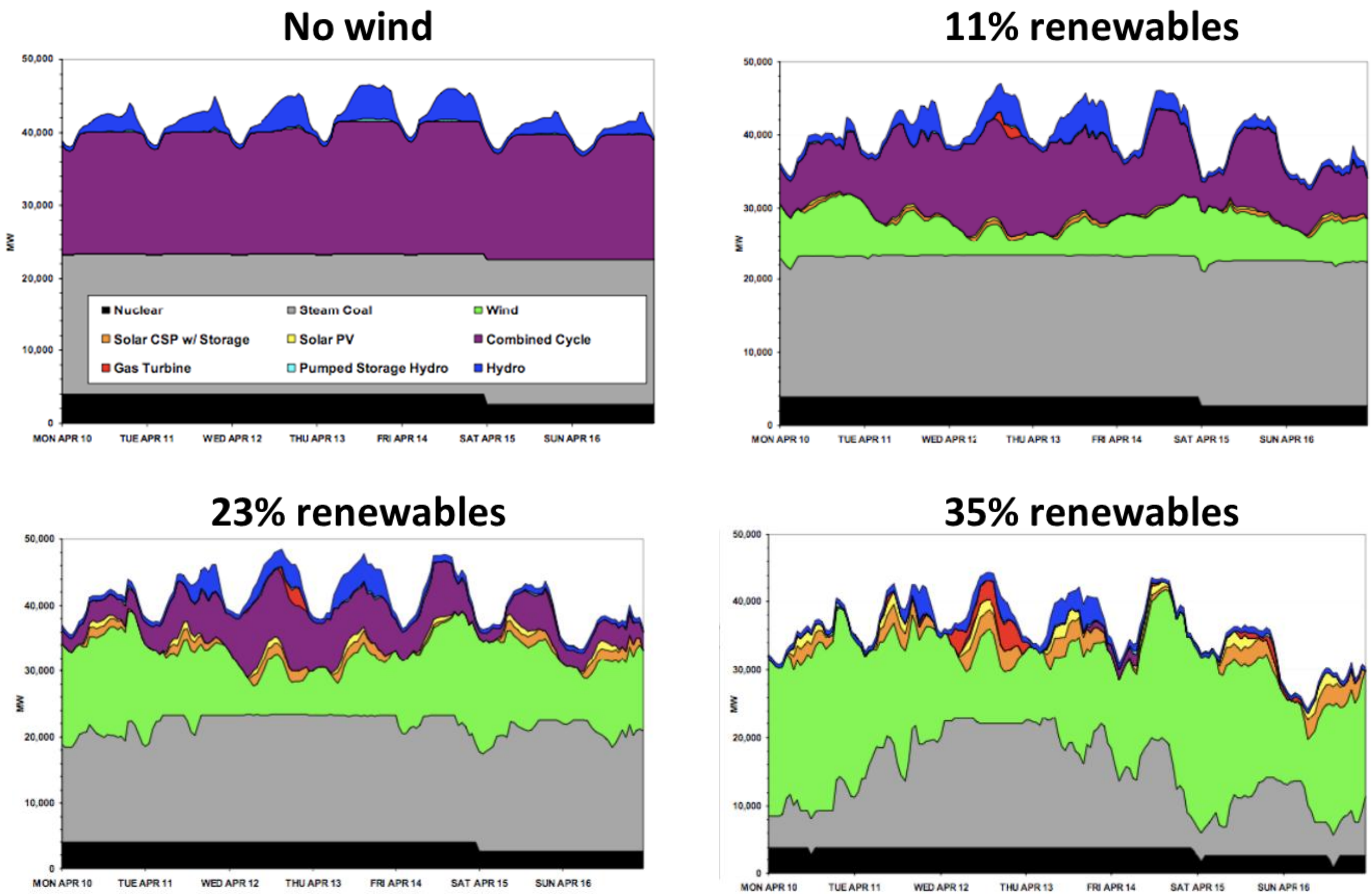
High variability due to clouds

Variable Generation Resources Can Create Challenges for Reliability





High Penetration of Variable Generation Can Create Operational Challenges



Electric Transportation

Enabling a Charging Infrastructure for EVs

One of the key factors for acceptance of EVs in the marketplace will be the availability of charging stations.

Charging stations are currently being installed in cities throughout the United States. For now, many municipalities and private companies are offering free recharges to EV owners as an incentive for these clean vehicles.

However, as EVs gain market share, this "free refueling" is likely to come to an end, and a convenient way to charge EV owners for their "fill-ups“ charging station owners will be required.

This is an Example When Automation Can Create Value!

Smart Grid technologies offer a potential solution to this problem, at least within the area served by the energy provider of the EV owner. With the Smart Grid, EVs can identify themselves to the charging station when they are plugged in, and the electricity used can be automatically billed to the owner's account without the need for cash or a credit card.

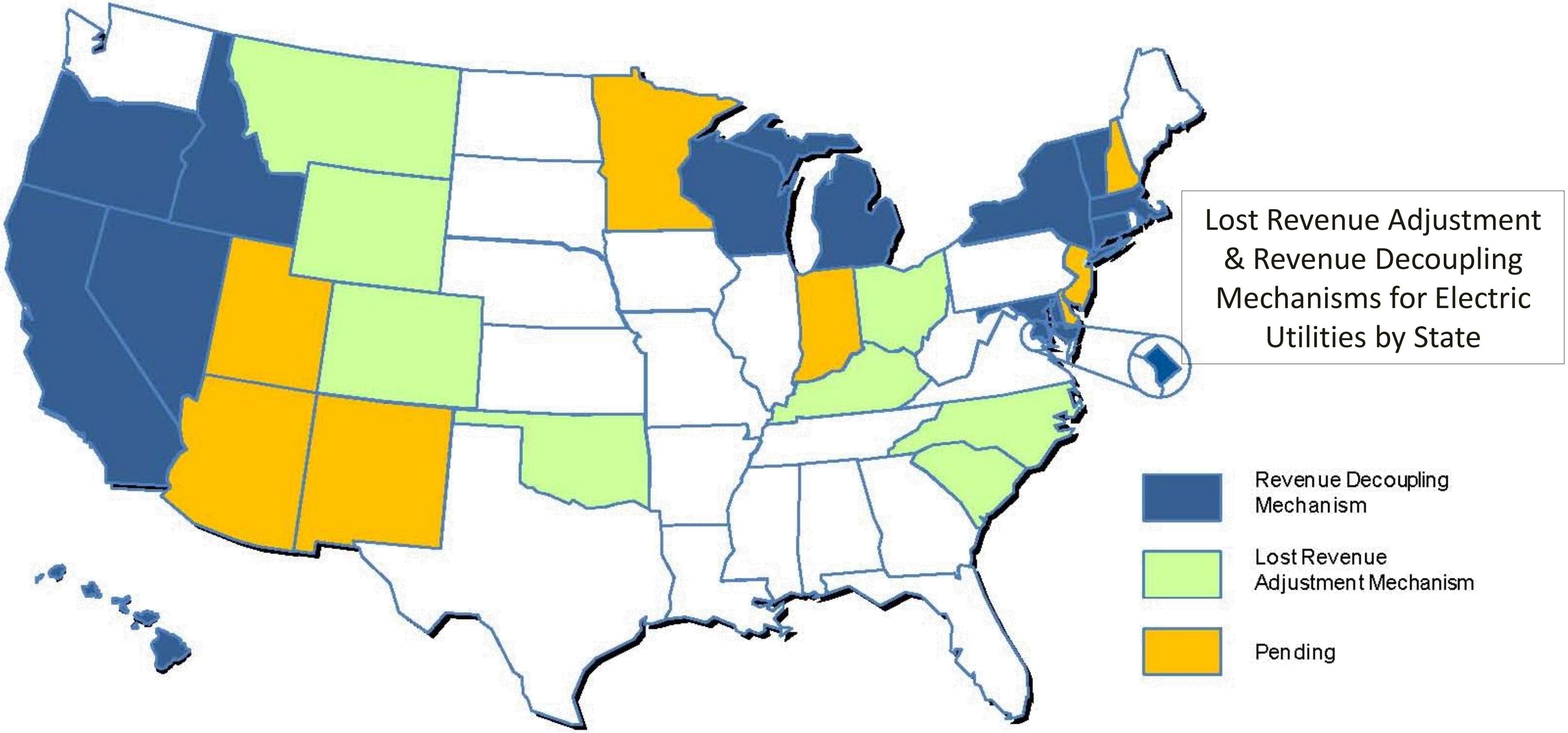
Policy and Regulation

The Challenge of Power Regulation

Some PUCs and utilities aggressively pursuing efficiency,

but it's not enough.

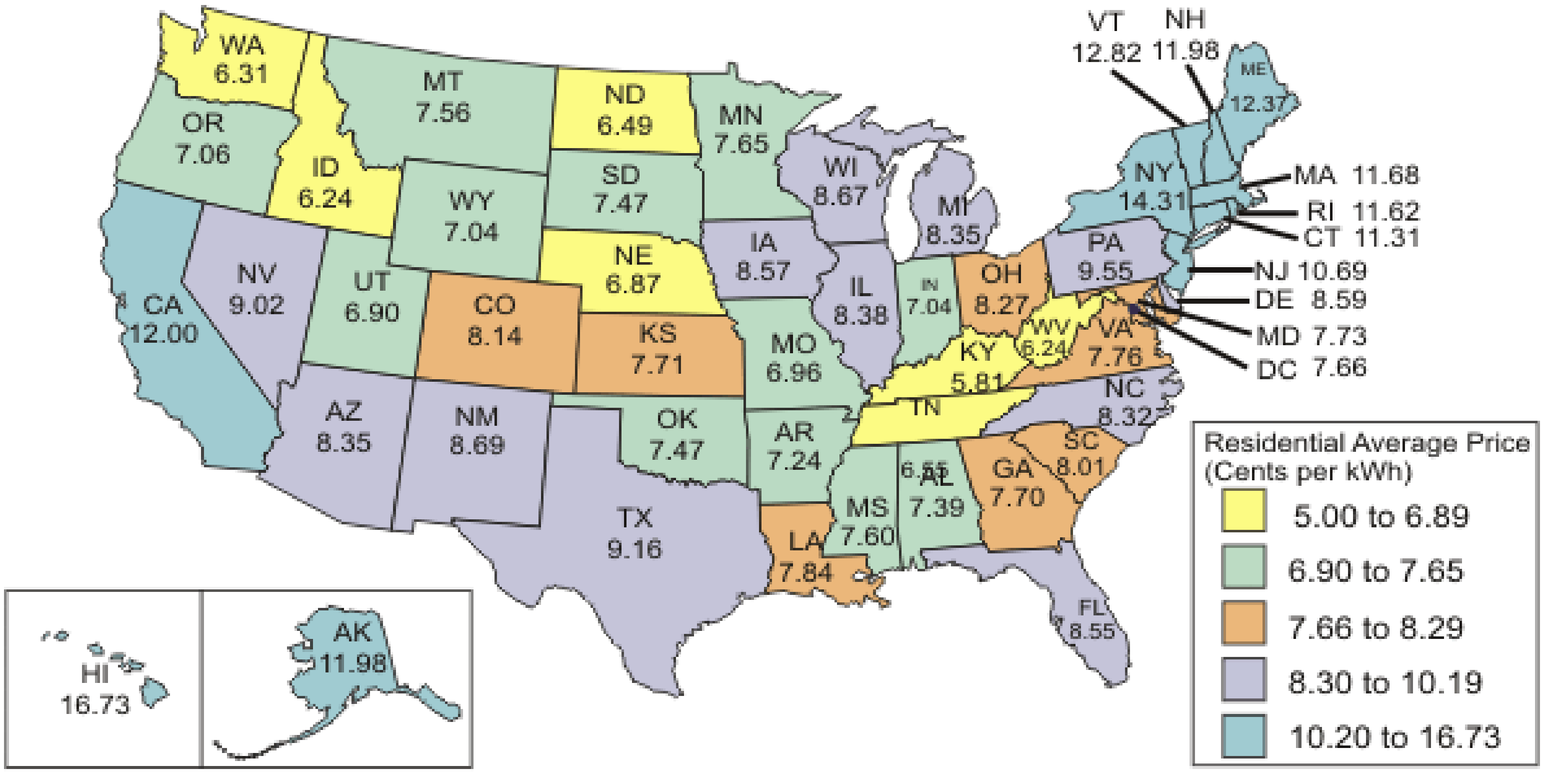
Need to break the link between utility sales and utility profits.



Source: IEE, *State Electric Efficiency Regulatory Frameworks*, July 2010

The Challenge of Power Regulation (continued)

Independent Statistics & Analysis
U.S. Energy Information Administration



Source: Energy Information Administration, Form EIA-861, "Annual Electric Power Industry Report."

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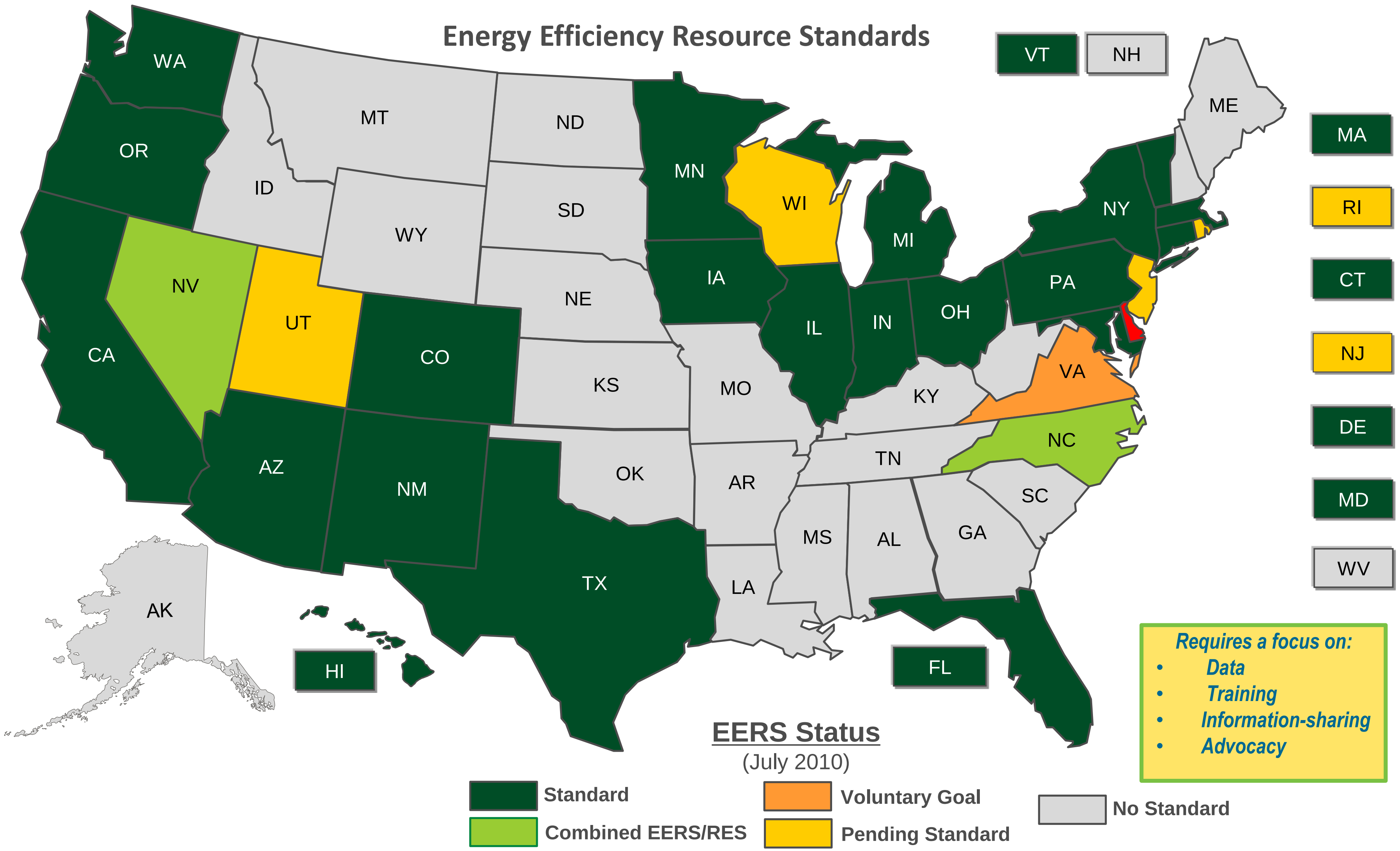
The Challenge of Power Regulation (continued)



Source: ACEEE

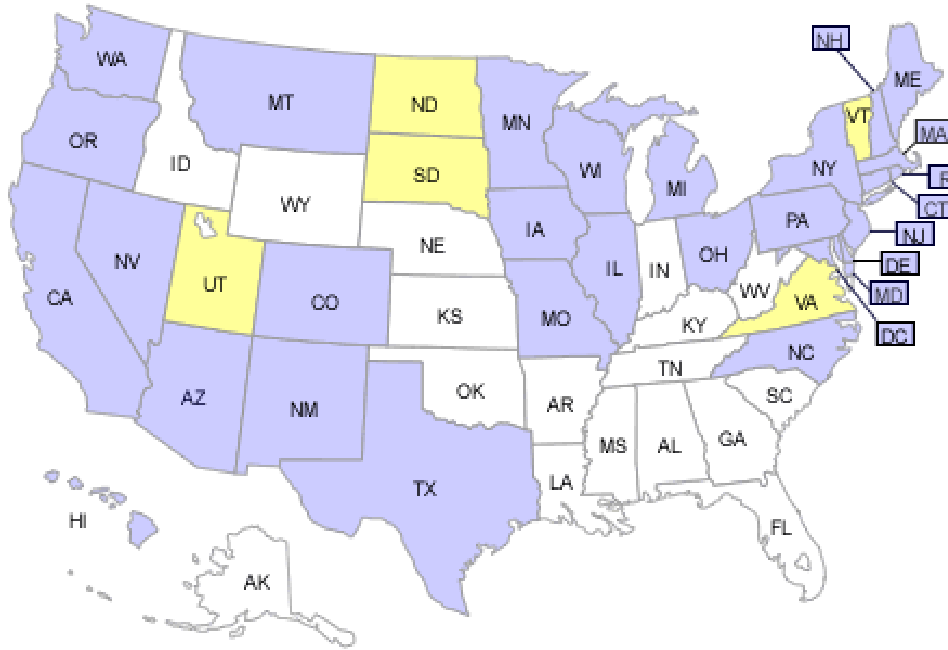
"Smart Grid"

There is no one definition

- Varies from state depending upon policy, market, or electricity prices
- There is not a "one size fits all"

Examples of variables that influence the development of the Smart Grid:

- Renewable Portfolio Standards
- Electric Vehicle goals
- Generation Mix
- High Peak (Peak Demand)-reliability issues
- Weather Events-reliability issues
- Customer/mile



States with RPS
States with RPS Goals

ECONOMIC POLICY

The Economic Imperative of Energy Efficiency

- Energy efficiency is the farthest reaching, least-polluting, and fastest growing energy success story of the last 40 years.
- For example, during this time United States' energy efficiency provided ~75 percent of the new demands for energy-related goods and services, while new energy supplies have met only 25 percent of those.

The Economic Imperative of Energy Efficiency

- However, ***to promote long-term sustainability, and to maintain a robust level of economic productivity and prosperity, we will have to more than double the historic rates of energy efficiency improvements so they are closer to 150 percent or more by 2050.***
- The reason? A nation's overall productivity is directly tied to the energy-efficiency of its economy.

Aiming for Zero

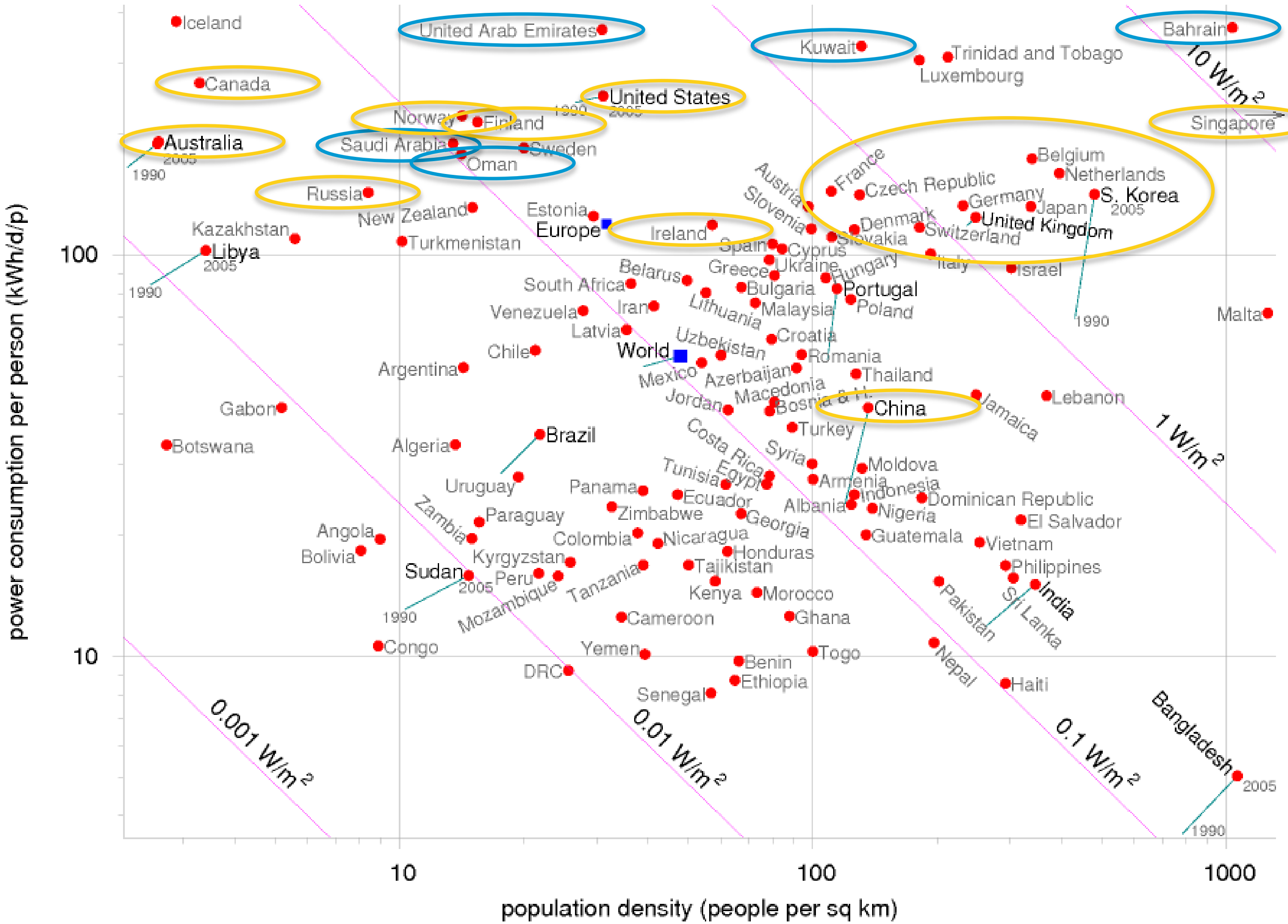
- Sustainability is NOT the same thing as Zero Energy. There is no such thing as zero energy. Energy does not exist in a vacuum – it always comes from somewhere and goes somewhere.

- Because there is always a cost to energy, trade-offs are inevitable in order to find a harmonious balance that offers the greatest efficiency and least impact on the environment.

- THIS IS THE ULIMATE GOAL – TO NOT USE ENERGY. ***THE MOST EFFICIENT ENERGY IS ENERGY WE DO NOT GENERATE!*** *This is not a technology, it is behavior modification, or learning to live in a new reality.*

Working Definition of Energy Investments

- The cost-effective investment in the energy we ***don't generate*** to produce our goods and services is investment in conservation.
- The cost-effective investment in the maximizing the energy we ***use*** to produce our goods and services is investment in efficiency.
- Negawatts or Gigawatts – both are good.



power consumption per person (kWh/d/p)
population density (people per sq km)
0.001 W/m²
0.01 W/m²
0.1 W/m²
1 W/m²
10 W/m²
Iceland
Canada
Australia
United Arab Emirates
United States
Norway
Finland
Saudi Arabia
Sweden
Oman
Russia
Kazakhstan
Libya
New Zealand
Turkmenistan
Estonia
Europe
Ireland
Kuwait
Trinidad and Tobago
Luxembourg
Bahrain
Singapore
France
Czech Republic
Belgium
Netherlands
S. Korea
Germany
Japan
United Kingdom
Denmark
Switzerland
Italy
Israel
Austria
Slovenia
Slovakia
Spain
Cyprus
Greece
Ukraine
Hungary
Belarus
Bulgaria
Portugal
Poland
South Africa
Iran
Lithuania
Malaysia
Venezuela
Latvia
Croatia
Uzbekistan
Chile
World
Romania
Argentina
Mexico
Azerbaijan
Thailand
Macedonia
Jordan
Bosnia & H.
China
Jamaica
Lebanon
Malta
Gabon
Turkey
Botswana
Algeria
Brazil
Costa Rica
Syria
Moldova
Tunisia
Egypt
Armenia
Indonesia
Uruguay
Panama
Ecuador
Albania
Dominican Republic
Zambia
Paraguay
Zimbabwe
Georgia
Nigeria
El Salvador
Angola
Colombia
Nicaragua
Guatemala
Vietnam
Bolivia
Kyrgyzstan
Honduras
Philippines
Sudan
Peru
Tajikistan
Tanzania
Mozambique
Kenya
Morocco
Pakistan
Sri Lanka
India
Cameroon
Ghana
Congo
Yemen
Togo
Nepal
Benin
Haiti
DRC
Ethiopia
Senegal
Bangladesh
1990
2005
10
100
1000

If you choose it, you use it or you lose it. (Waste vs. Use)

- We need efficiency because for our well being we need productivity, which requires energy. ***Energy becomes productive when it takes the form of sustainable development.***
- But there is a thin line between being productive (use it) and waste (lose it)
- There is also a thin line between sustainability (use it) and being unproductive (lose it, or worse - never had it.)

Energy Supply Is Not the Economic Imperative

- In globally integrated energy and capital markets ***the most independent nation is not the one with the highest national energy supply to demand ratio, but the one with the lowest energy use per GDP*** (at least when comparing broadly similar economies in terms of industrial capacity and development) ***combined with the smallest environmental footprint from the production and use of the energy.***

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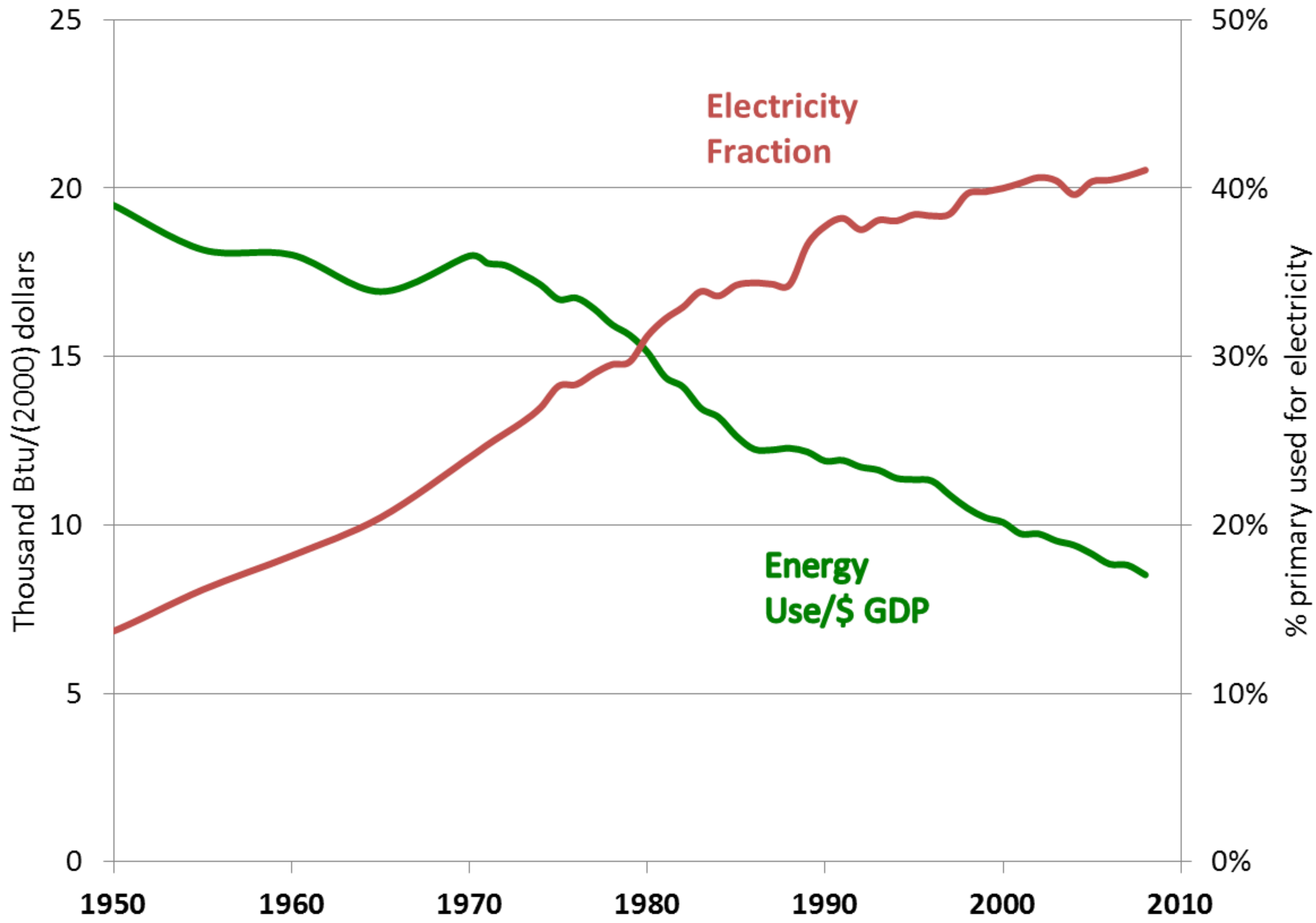
The Value of the Grid to the United States



Thank You For Your Time and Attention

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www.eere.energy.gov
www.oe.energy.gov
www.smartgrid.gov

The End

The End