

Understanding the Smart Grid: Features, Benefits and Costs

Illinois Smart Grid Initiative

Joe Miller - Modern Grid Strategy Team

July 8, 2008



Funded by the U.S. Department of Energy
Office of Electricity Delivery and Energy Reliability



Conducted by the National Energy
Technology Laboratory

- **Why modernize the grid?**
- **What is the Smart Grid?**
- **What is the value proposition?**
- **Questions**



Why modernize the grid?



- **Economy now based on electricity**
 - Computers, networks, phone system, devices, robotic manufacturing, stock markets
- **Lifestyle now based on electricity**
 - Medical devices, appliances, air conditioners, computers
- **Must have infrastructure that facilitates growth**
 - The digital economy is vulnerable
 - 20 years ago semi-conductor load negligible. 10 years ago 10%. Today, past 20% and climbing (EPRI, 2006)
- **Key to global competitiveness**
 - Other regions upgrading to create competitive advantage

Running today's digital society through yesterday's grid is like running the Internet through an old telephone switchboard.

Reid Detchon, Energy Future Coalition



Office of Electricity
Delivery and Energy
Reliability

■ Aging

- 70% of transmission lines are 25 years or older
- 70% of transformers are 25 years or older
- 60% of circuit breakers are 30 years or older

■ Outmoded

- Designed in the 50s and installed in the 60s and 70s, before the era of the microprocessor.

■ Stressed

- Never designed for bulk power shipments
- Wholesale power transactions jumped 300% from 2000 to 2005. *Insight Magazine, Oct. 2005*

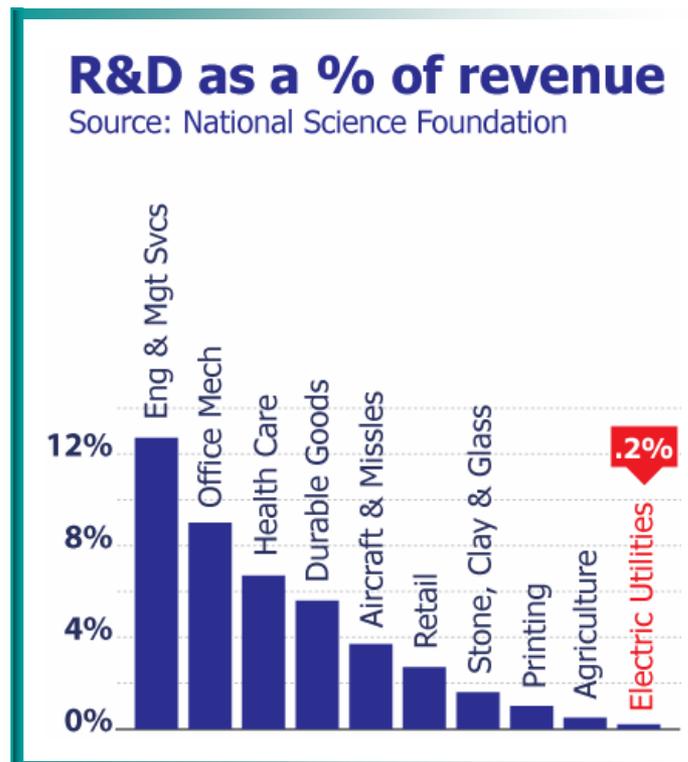
Much of the equipment that makes up the North American grid is reaching the end of its design life.

EnergyBiz Magazine, Sept. 2005



Office of Electricity
Delivery and Energy
Reliability

- **Living off the investments of the 60s and 70s**
 - “Trust fund” is out of money
- **Less Utility R&D than almost any other industry**
 - 0.2% of net revenues
 - 1/20th the average of all U.S. industries



- **Losing billions per year**
 - From disturbances, interruptions and grid congestion
- **Other regions are gaining on us**
 - China, Europe, Middle East
- **Missing the chance to lead a new industry**
 - Distribution automation, smart meters, advanced monitoring and control

Some major power corridors are at maximum capacity more than 80% of the time... equivalent to rush hour from 5am to midnight.

National Transmission Grid Study, 2003



Office of Electricity
Delivery and Energy
Reliability

We lose billions every year to blackouts, interruptions and congestion

- As much as \$135M per year in consumer losses
(Primen, 2004)
- In the NY ISO, 23% of the wholesale price is congestion costs, which are passed along to consumers. *(PNNL, 2006)*
- August 2003 blackout: \$4-6B, 50M people affected

It is not the cost of electricity that drives our decisions. It is the cost of NOT having electricity.

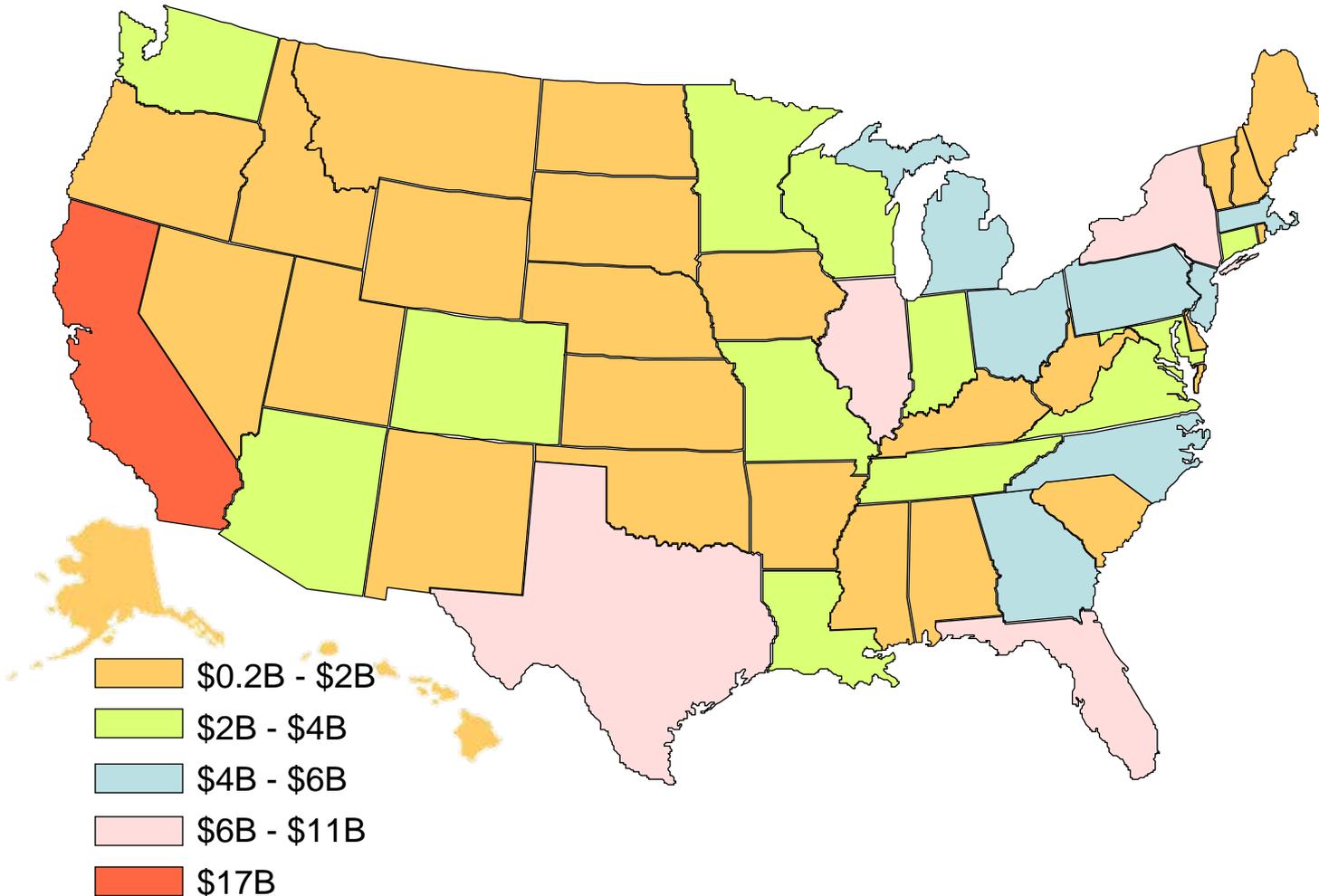
Energy Director, Oracle Corporation, 2004



Office of Electricity
Delivery and Energy
Reliability

Annual Business Loss from Grid Problems

Primen Study: Up to \$135B annually for power interruptions



Office of Electricity
Delivery and Energy
Reliability

- **Missing a once-a-century opportunity to lead a new industry**
 - At stake: jobs and export revenues
 - Other regions -- France, Germany, China, Canada -
- already taking a leadership role
- **We cannot be a world-class superpower without a world-class grid**

If I were running for president, I would say we need a new energy economy and we're going to create a million jobs with it. There is a trillion dollar untapped market for clean energy and energy conservation technologies already developed around the world.

Former President Bill Clinton, 2003



Office of Electricity
Delivery and Energy
Reliability

Forward Market Prices Continue to Climb

Midwest ISO (Cinergy)
\$112.12/MWh +62%

Massachusetts Hub
\$ 141.25/MWh +94 %

Northwest (Mid C)
\$ 105.66/MWh +70 %

New York City
\$ 208.51/MWh +123 %

**Southern California
(SP-15)**
\$ 139.41/MWh +88 %

PJM Western Hub
\$ 144.38/MWh +79 %

Palo Verde
\$ 132.95/MWh +76 %

Henry Hub (Gas)
\$ 12.99/MMBtu +108 %

Sources: Summer electric forwards data is July-August 2008 data from ICE as of 6/16/08. Actual on-peak data for 2007 are from Platts Megawatt Daily. The Henry Hub data is July-August Clearport data from Bloomberg as of 6/16/08.



Office of Electricity
Delivery and Energy
Reliability

What is the Smart Grid?



Imagine a World with 200 million electric vehicles that:

- Connect anywhere
- Provide transportation and act as storage and generators for the grid

And are powered by:

- Clean central station generation
- Renewables and other distributed generation

A shift from gasoline to PHEVs could reduce U.S. petroleum imports by 52% (PNNL – Impact assessment of PHEV's)



Resulting in:

- **Dramatic reduction in tailpipe emissions**
- **Reduction in petroleum imports of >50%**
- **Reduction in peak loads – lowering prices for consumers**
- **Improved grid reliability – decreasing today’s consumer losses of >\$125 Billion annually**
- **Increased grid security – the “Fort Knox” model**

The Smart Grid can make this “world” real!



The Smart Grid 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



It will “Enable active participation by consumers”

- **Consumers have access to new information, control and options to engage in electricity markets**
 - Energy management
 - Investment in DER and PHEV
 - Offer resources to market
- **Grid operators have new resource options**
 - Reduce peak load and prices
 - Improve grid reliability
- **E-bay level of activity**

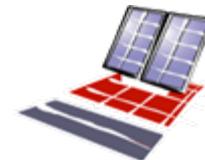
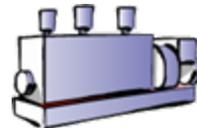
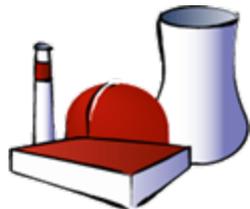
Involving the consumer is win – win!



Office of Electricity
Delivery and Energy
Reliability

It will “Accommodate all generation and storage options”

- **Seamlessly integrates all types and sizes of electrical generation and storage systems**
- **“Plug-and-play” convenience**
 - Simplified interconnection processes
 - Universal interoperability standards
- **Number of smaller, distributed sources will increase – shift to a more decentralized model**
- **Large central power plants will continue to play a major role.**



It will “Enable new products, services and markets”

- **Links buyers and sellers**
- **Consumer to RTO**
- **Supports the creation of new electricity markets**
 - PHEV and vehicle to grid
 - Brokers, integrators, aggregators, etc.
 - New commercial goods and services
- **Provides for consistent market operation across regions**

Markets motivate behavior and get results!



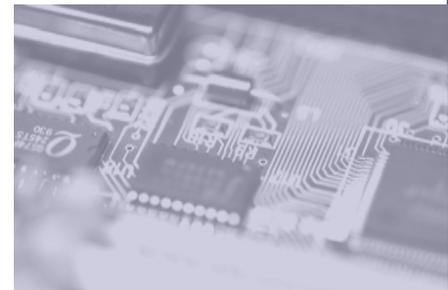
Office of Electricity
Delivery and Energy
Reliability

It will "Provide power quality for the digital economy"

- **Monitors, diagnoses and responds to PQ issues**
- **Supplies various grades of power quality at different pricing levels**
- **Greatly reduces consumer losses due to PQ (~\$25B/year)**
- **Quality Control for the grid**

Voltage dips that last less than 100 milliseconds can have the same effect on an industrial process as an outage that lasts several minutes or more

Primen, 2002



Office of Electricity
Delivery and Energy
Reliability

- **Operational improvements**
 - Improved load factors and lower system losses
 - Integrated outage management
 - Risk assessment
- **Asset Management improvements**
 - The knowledge to build only what we need
 - Improved maintenance processes
 - Improved resource management processes
 - More power through existing assets
- **Reduction in utility costs (O&M and Capital)**

Convergence of operating information with asset management processes will dramatically improve grid efficiency



Office of Electricity
Delivery and Energy
Reliability

It will “Anticipate & respond to system disturbances”

- **Performs continuous self-assessments**
- **Detects, analyzes, responds to, and restores grid components or network sections**
- **Handles problems too large or too fast-moving for human intervention**
- **Self heals - acts as the grid’s “immune system”**
- **Supports grid reliability, security, and power quality**

The blackout of August 2003 took hours to build up. Once it breached the original service territory, it took 9 seconds to blackout 50M people.

PNNL, June 2006



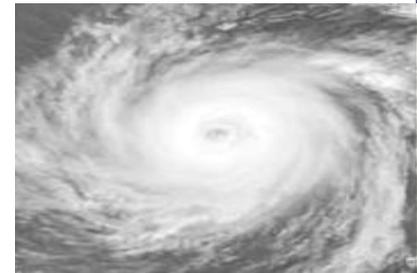
Office of Electricity
Delivery and Energy
Reliability

It will "Operate resiliently against attack and natural disaster"

- **System-wide solution to physical and cyber security**
- **Reduces threat, vulnerability, consequences**
- **Deters, detects, mitigates, responds, and restores**
- **"Fort Knox" image**
- **Decentralization and self-healing enabled**

The lack of a concerted, deliberate technical approach risks serious consequences from security threats to the power delivery system infrastructure.

Erich Gunther, Power & Energy Continuity, 2002



Office of Electricity
Delivery and Energy
Reliability

The Smart Grid Gap

<i>Characteristic</i>	<i>Today's Grid</i>	<i>Smart Grid</i>
Enables Consumer Participation	Consumers are uninformed and non-participative with the power system	Informed, involved and active consumers – DR and DER
Accommodates Generation/Storage	Dominated by central generation – many obstacles exist for DER interconnection	Many distributed energy resources with “plug and play” convenience – focus on renewables
Enables New Markets	Limited wholesale markets, not well integrated – limited opportunities for consumers	Mature, well-integrated wholesale markets, growth of new electricity markets
Meets PQ Needs for 21 st Century	Focus on outages – slow response to PQ issues	PQ a priority with a variety of quality/price options – rapid resolution of issues



The Smart Grid Gap

<i>Characteristic</i>	<i>Today's Grid</i>	<i>Smart Grid</i>
Optimizes Assets & Operates Efficiently	Little integration of operational data with asset management – business process silos	Greatly expanded data acquisition of grid parameters – deeply integrated with asset management processes
Self Heals	Responds to prevent further damage – focus is on protecting assets following fault	Automatically detects and responds to problems – focus on prevention, minimizing impact to consumer
Resists Attack	Vulnerable to malicious acts of terror and natural disasters	Resilient to attack and natural disasters with rapid restoration capabilities



What is the value proposition?



Cost to Modernize

- **\$165B over 20 years**
 - \$127B for Distribution
 - \$38B for Transmission
- **~\$8.3B per year** (incremental to business-as-usual)
- **Current annual investment - \$18B**

Benefit of Modernization

- **\$638B - \$802B over 20 years**
- **Overall benefit to cost ratio is 4:1 to 5:1**

Thus, based on the underlying assumptions, this comparison shows that the benefits of the envisioned Future Power Delivery System significantly outweigh the costs.

(EPRI, 2004)



Office of Electricity
Delivery and Energy
Reliability

- **Utility**
- **Consumer**
- **Societal**
- **Others?**



Operational efficiencies

- Metering and billing
- Outage management
- Process improvement
- Work force management
- Reduced losses (energy)
- Asset utilization

Asset Management improvements

- System planning
- Maintenance practices
- Engineering

These benefits are expected to improve customer satisfaction and reduce O&M and capital costs.



- **Access to information**
- **Ability to manage energy consumption**
- **Option to participate in demand response**
- **Convenient interconnection of distributed generation**
- **Option to bid (sell) into electricity markets**
- **Reduction in outages (number and duration)**
 - Fewer losses
 - Fewer inconveniences
- **Improved overall level of service**

Consumers receive information, control and options



Office of Electricity
Delivery and Energy
Reliability

- Improved operating and marketing efficiencies leading to downward pressure on electricity prices
- Improved reliability leading to reduction in consumer losses (~\$135B)
- Increased grid robustness improving grid security
- Integration of renewables and reduction in energy losses leading to a reduction of emissions
- Improved public and worker safety
- Job and GDP growth
- Opportunity to revolutionize the transportation sector

Achieving the Smart Grid Vision depends on consumer involvement – and the benefits are significant!



Office of Electricity
Delivery and Energy
Reliability

Is the SG Value Proposition Compelling?

- **Would you wash your clothes at 9pm to save 10 cents?**
- **Would you drive an extra quarter mile for 10% cheaper gas (that's 40 cents less)?**
- **Would you rather fill your vehicle with less carbon, while you sleep, work, shop for 75% less per gallon?**
- **Would you like it if your car had the intelligence to sell that power back during a peak and pay for your driving all week long?**
- **What value do you place on societal benefits?**



- [The Modern Grid Strategy](#)
- [Smart Grid Newsletter](#)
- [EPRI Intelligrid](#)
- [Galvin Electricity Initiative](#)
- [GridWise Alliance](#)
- [GridWise Architecture Council](#)
- [European SmartGrid Technology Platform](#)

Presenter's contact information:

Joe Miller

Sr. Vice President – Horizon Energy Group

jmiller@horizonenergygroup.com



Office of Electricity
Delivery and Energy
Reliability

Questions?



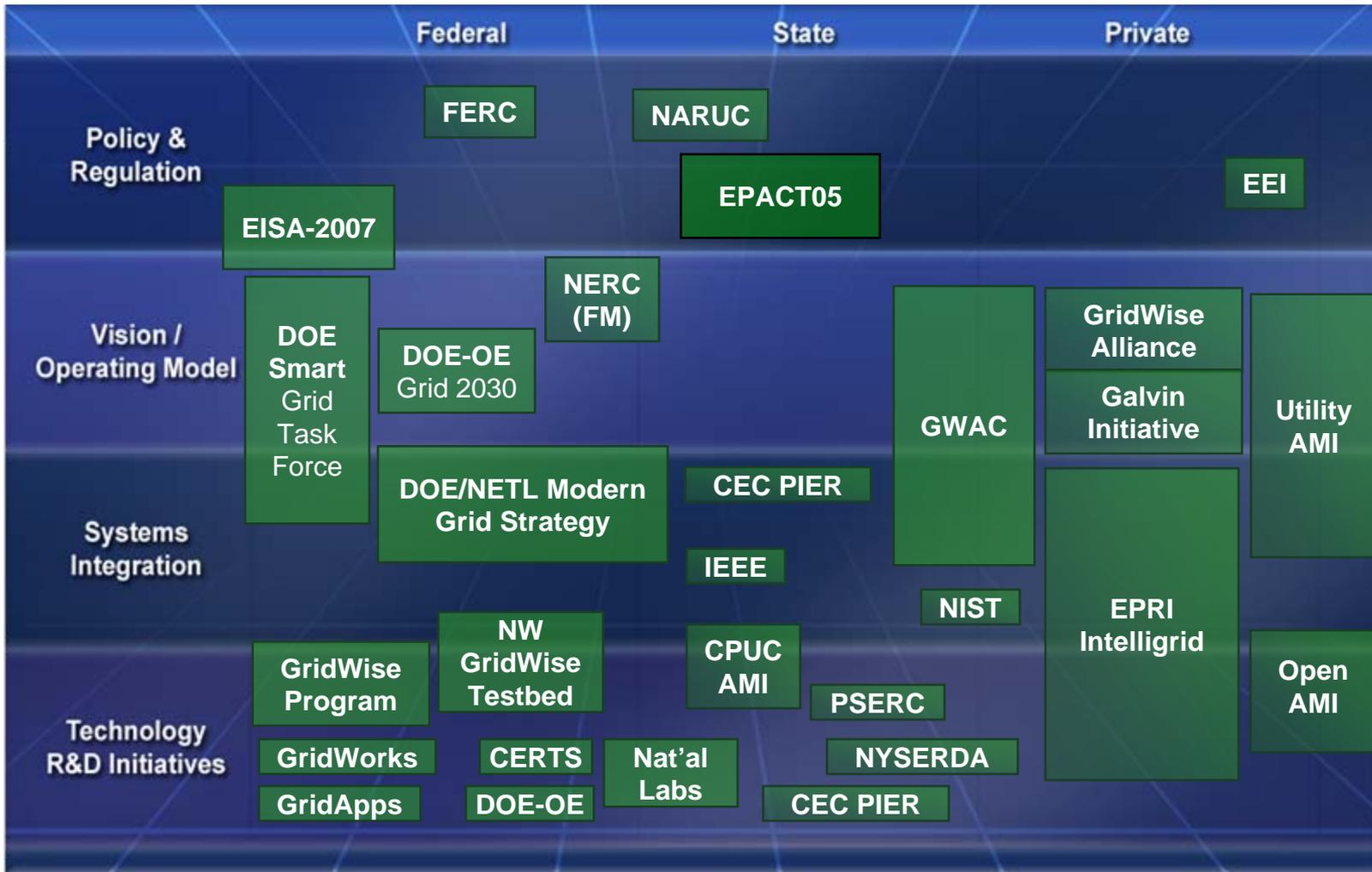
Office of Electricity
Delivery and Energy
Reliability

MODERN GRID STRATEGY

Backup Slides



Many aligned with the Smart Grid Vision



Office of Electricity
Delivery and Energy
Reliability