Governor's Energy Summit
West Virginia

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STRATEGY

Smart Grid: Enabling the 21st Century Economy

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Changing World

- Cost of new generation and delivery infrastructure is climbing sharply
- Changing prices in electricity and natural gas are challenging the basic utility model
- A changing consumer (political) base is reshaping the interaction at the meter
- A changing society is generating new priorities for the entire energy sector

Changing Grid Complexity

- **More, smaller generators (e.g. DG)**
  - Average size decreasing
  - 20K nodes (1994), 30K (2004), >200K (2014)
- **More variable resources (wind and solar)**
- **More incentives and drivers for alternatives (supply and demand)**
  - Top 4 renewables technologies have growth rate > 20% per year
  - Worldwide annual investment topped $70B in 2007
- **More customer interaction (AMI, DR, DG)**

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Changing Realities

- **Energy independence has emerged as a partner to economic strength and environmental stewardship**
- **WV Energy Opportunities Document: "*Energy and environmental policies are uniquely intertwined. The opportunities identified in this document are consistent with an appreciation that preserving the quality of our environment is fundamental to our health and well-being. We firmly believe that enhanced energy development can be accomplished consistent with environmental stewardship*."**

US Renewables Potential

- **Today's grid-connected electric capacity is 960 MW**
- **Today's average daily capacity used is 440 MW**
- **If we include reserve margin, the US needs a daily average of 530 MW**

- **NREL assessment of near-term practical potential by 2020 for electricity production:**
  - Biomass – 130 GW
  - Geothermal – 22 GW
  - Solar – 68 GW
  - Wind – 114 GW
- **Total = 334 GW**

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National Consensus on the Future of the Electric Grid

Federal, state, industry, academia, and research…

Does a Smart Grid Really Matter?

Without a Smart Grid	With a Smart Grid
<13% variable renewables penetration	>30% variable renewables penetration
5% demand response	15% demand response
<1% consumer generation used on the grid	10% consumer generation used on the grid
47% generation asset utilization	90% generation asset utilization
50% transmission asset utilization	80% transmission asset utilization
30% distribution asset utilization	80% distribution asset utilization

Smart Grid Characteristics

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

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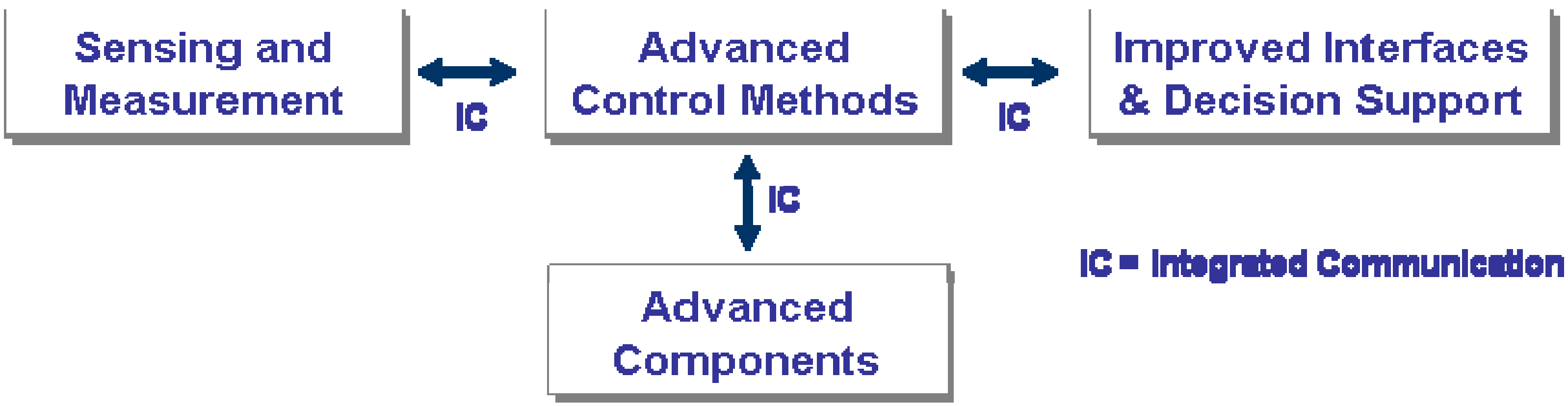
New Thoughts About Technology

- Integration is key
- Need flexibility and scalability because we don't have a straight-line future
- Markets are expanding in size and offerings – complexity



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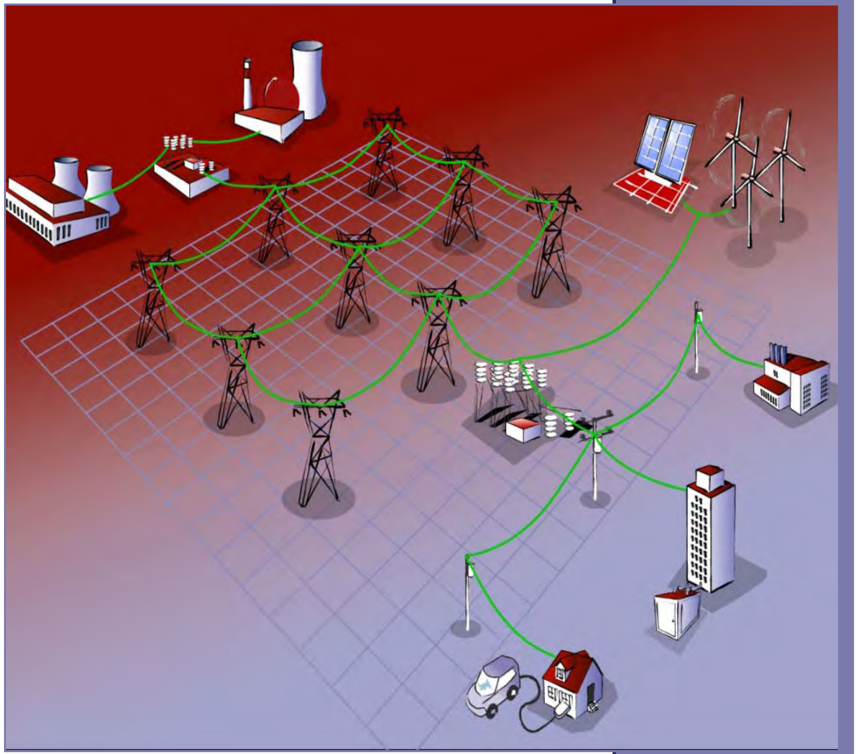
Benefits of a Smart Grid

West Virginia Smart Grid Implementation Project



- $525K project jointly funded through Attachment H process by NETL, RDS, Allegheny Power, AEP, State of West Virginia, WVU, and DOE OE
- Results will describe approach and value proposition of implementing Smart Grid in West Virginia
- Cost & benefit analysis comparing the state of current electricity grid and future Smart Grid in West Virginia
- Address the role of coal in Smart Grid
- Support economic development in State of West Virginia
- Only state-wide Smart Grid implementation plan
- Establishes West Virginia and NETL as leader in Smart Grid
- Only second Smart Grid study to be published

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Benefits of Transforming (San Diego Example)

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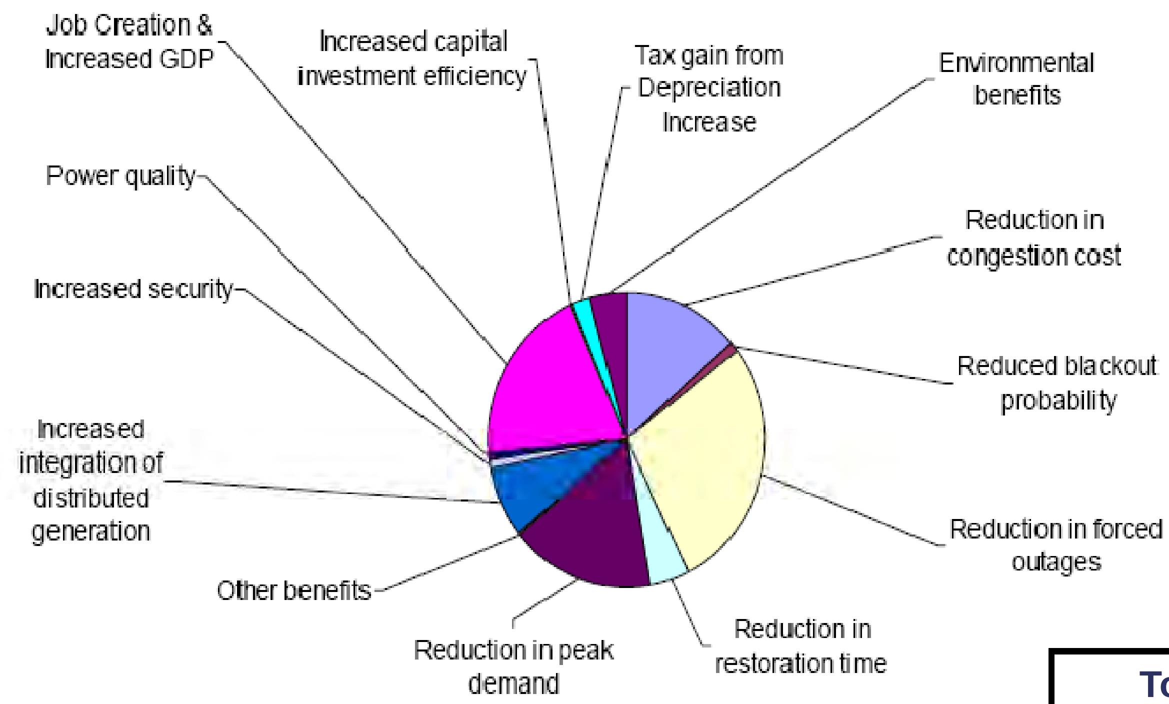

Source: San Diego Smart Grid Study, Energy Policy Initiatives Center, USD, October 2006

Regional
"IRR" >26%

Total Annual Benefits	**$141M**
System Benefits (20-years)	**$1,433M**
Societal Benefits (20-years)	**$1,396M**
Total Capital Cost	**$490M**
Annual O&M Cost	**$24M**

"Based on the cost-benefit analysis conducted for this study, there appear to be sufficient benefits to the utility system, to the broader region (societal), and in total, to justify a movement of the San Diego regional grid to a Smart Grid architecture." *- Bottom Line from San Diego Smart Grid Study, October 2006*

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Direct Benefits

Utility

- **Operational (outage management, improved processes, workforce efficiency, reduced losses, etc.)**
- **Asset Management (system planning, better capital asset utilization, etc.)**

Consumer

- **Reduced business loss (improved reliability, power quality, alternatives to outages, etc.)**
- **Better energy efficiency (less energy consumption, sell DG power to grid, reduced transportation costs – PHEV, etc.)**

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

Societal Benefits

- **Downward pressure on electricity prices** *through improved operating and market efficiencies, consumer involvement*
- **Improved reliability** *leading to reduction in consumer losses (~$135B)*
- **Increased grid robustness** *improving grid security*
- **Reduced losses and emissions** *through integration of renewables*
- **New jobs and growth in GDP**
- **Opportunity to revolutionize the transportation sector** *through integration of electric vehicles as generation and storage devices*

Societal Benefits – an example

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)

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**

(Source: EPRI, 2004)

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)***

NETL

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Additional information on the Smart Grid is available:

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

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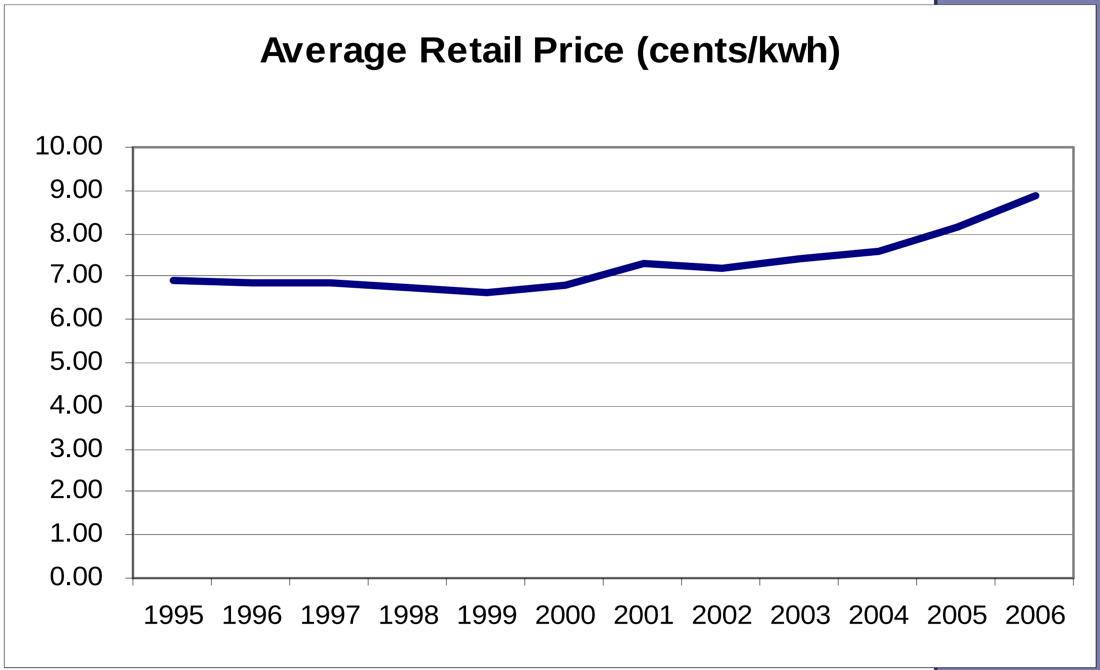
Background Information

Slides for additional explanation

A Changing Price

- **Electricity prices will increase 50% over the next 7 years.**
- **Rate caps phasing out in US**
- **Natural gas prices increased 251% from 1998 to 2007 and have increased more than 60% since 1 January 2008**



30% increase over last decade

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Energy Independence and Security Act of 2007

Title XIII – Smart Grids

Energy Independence and Security Act of 2007

- **US policy is to support grid modernization**
- **Smart Grid System Report**
  - Status and prospects of development
  - Regulatory or government barriers
  - Technology Penetration
  - Communications network capabilities, costs, obstacles
  - Recommendations for state and federal policies
- **Smart Grid Advisory Committee (thru 2020)**
- **Smart Grid Task Force (thru 2020)**
- **Smart Grid Interoperability Framework (NIST)**

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Energy Independence and Security Act of 2007

- **Smart Grid Technology RD&D**
- **Smart Grid Regional Demonstration Initiative**
  - 50% Cost Share
  - $100M per year – 2008-2012
- **Federal Matching Funds**
  - 20% reimbursement for qualifying Smart Grid investments
- **States shall consider:**
  - Requiring utilities to consider Smart Grid solutions including societal benefits
  - Allowing utilities to recover capital, O&M and other costs
  - Allowing recovery of book value of technologically obsolete assets

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Modern Grid Strategy Team

Introduction to the MGS Team

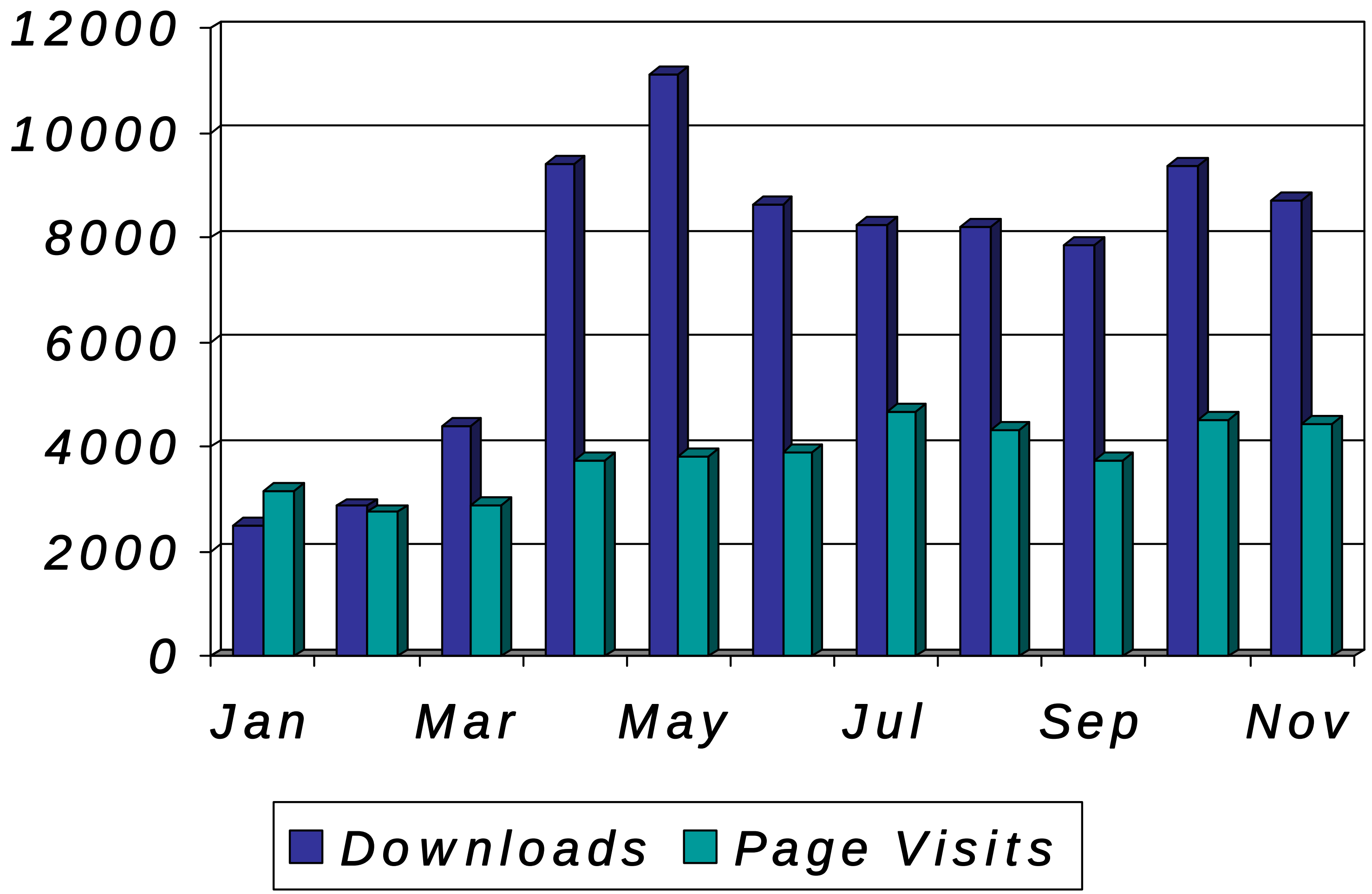
- **25 Industry Professionals with more than 500 yrs of energy experience (Illinois Power, Progress Energy, AEP, Wisconsin Electric, PJM, Istanbul Electric, TVA, Air Force, DTE Energy, GPU, Duquesne Light, etc) - senior management, engineering, operations, T&D, generation, fuels, R&D, asset management, regulatory, etc.**
- **Recognized internationally – previous and current work in Asia, North America, Europe, and Middle East**
- **Active relationships in >100 utilities, 6 RTO/ISO's, EEI, NARUC, 13 regulatory commissions, >25 industry (public and private) organizations, 10 energy investment organizations, >100 vendors, 6 consumer groups, and 39 "Smart Grid" groups**

2008 Stakeholder Involvement

- **Regulatory and Grid Groups supported: 8**
- **Industry Presentations / Workshops: 22**
- **Smart Grid Articles: 19 (+ 2 by the end of 2008)**
- **MGS Website Document Downloads: >63,000 through September**

Modern Grid Strategy – Industry Resource!

More than 81,000 downloads of our documents this year so far.



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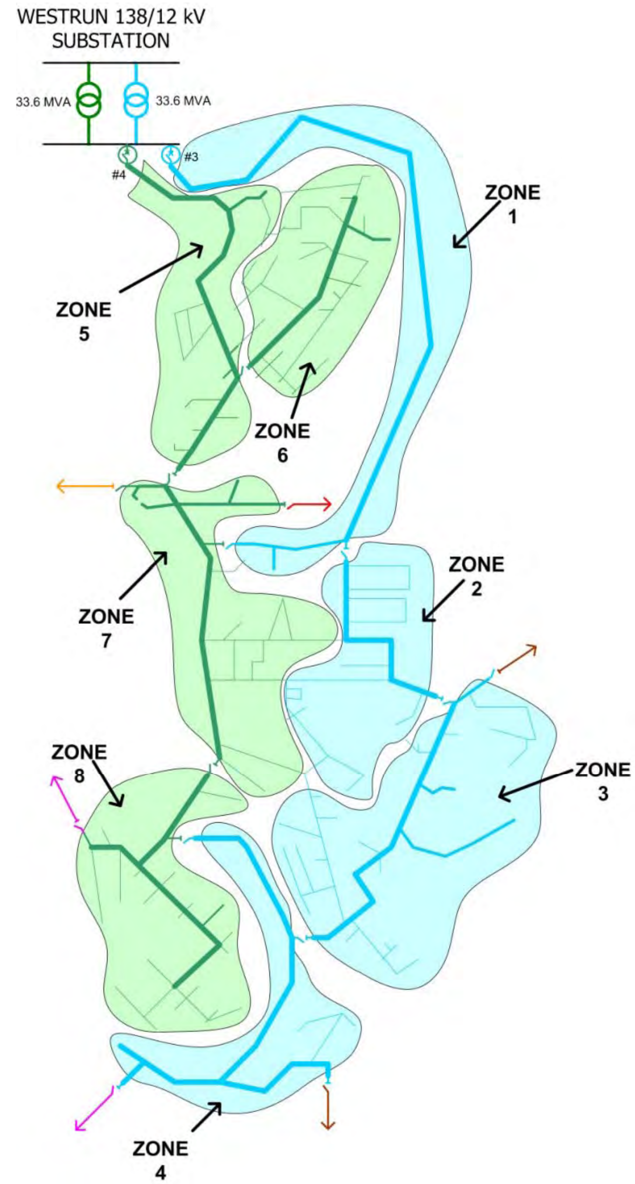
Morgantown DFT Project

- **Dynamic Feeder Reconfiguration System**
  - **Locate the feeder fault,**
  - **Isolate the fault**
  - **Restore service from adjacent feeders**
- **Automated switches**
  - **Optimal number/placement**
  - **3 switches @ each circuit**
  - **8 switches @ N/O ties w/adjacent circuits**
  - **Remotely controllable**
  - **Analogs measured**
  - **Human Machine Interface (HMI)**
- **Wi-Fi mesh-networked communications network**



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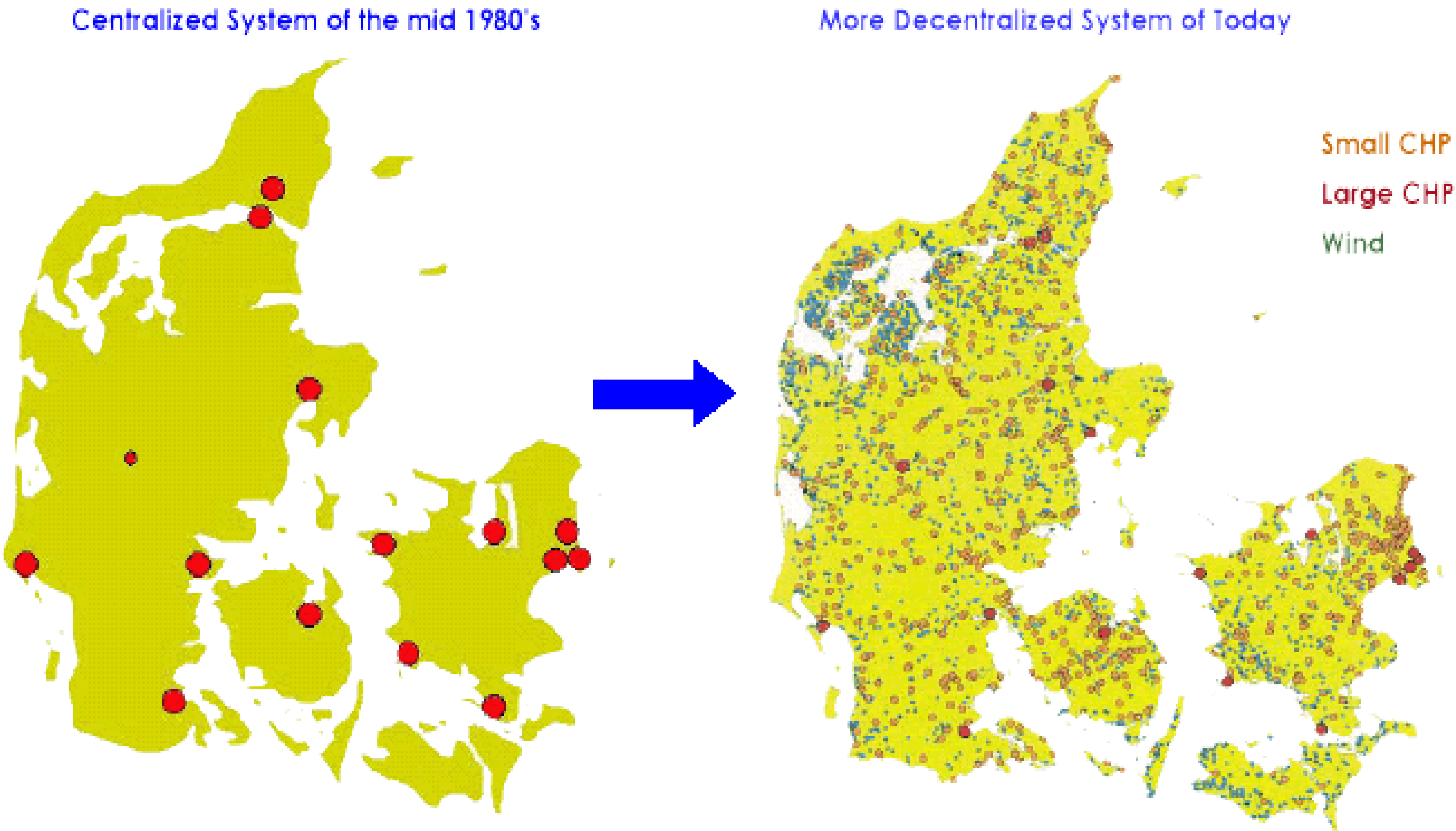
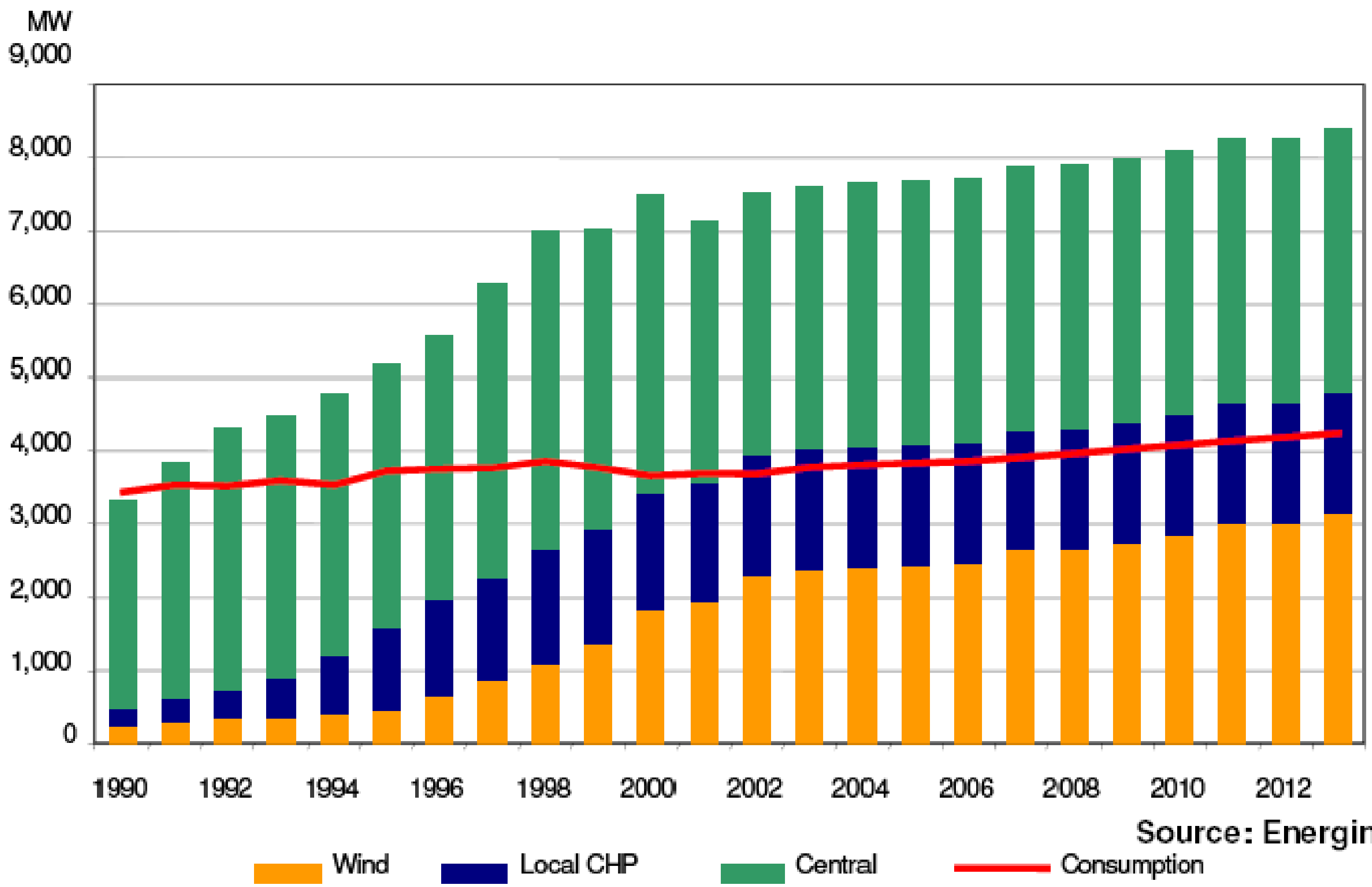
Denmark Smart Grid Example

Denmark Changed in Two Decades



Source: Danish Energy Center

Denmark Energy Contribution



Source: Energinet.dk

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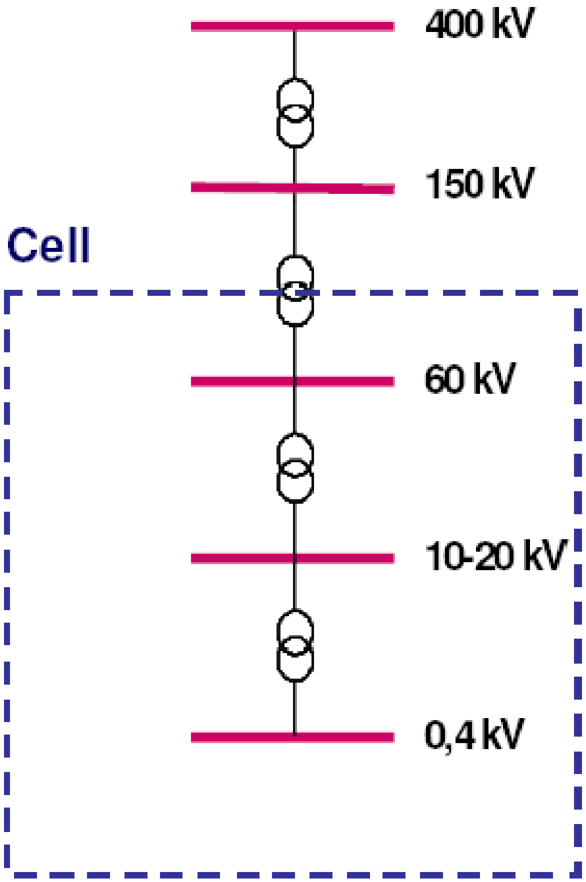
Denmark DG Penetration and Cell Structure



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)

Collaboration of public and private generation, transmission, and distribution co.'s

Clean Coal as the CHP Partner?

- **Smaller, clean coal plants play the CHP role? After all, it is a domestic resource!**
- **Closing the gap between capacity and energy use could increase the importance of coal as a baseload resource**
- **Closing the gap frees up capital investment needed to finance clean coal technology and carbon management solutions**

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Description of the Characteristics

It will "Enable active participation by consumers"

- **Consumers have access to new information, control and options to engage in electricity markets**
  - See what they use, when they use it, and what it costs
  - Manage energy costs
  - Investment in new devices
  - Sell resources for revenue or environmental stewardship
- **Grid operators have new resource options**
  - Reduce peak load and prices
  - Improve grid reliability

Today	***Tomorrow***
Little price visibility, time-of-use pricing rare, few choices	**Full price info, choose from many plans, prices and options, buy and sell, "E-Bay"**

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.**

Today	***Tomorrow***
Dominated by central generation. Little DG, DR, storage or renewables	**Many "plug and play" distributed energy resources complement central generation**

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**

Today	*Tomorrow*
Limited wholesale markets, not well integrated	**Mature, well-integrated wholesale markets, growth of new electricity markets**

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**

Today	*Tomorrow*
Focus on outages not power quality	**PQ a priority with variety of price/quality options based on needs**

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It will "Optimize asset utilization and operate efficiently"

- **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)**

Today	*Tomorrow*
Limited grid information & minimal integration with asset management	**Deep integration of grid intelligence with asset management applications**

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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**

Today	***Tomorrow***
Protects assets following disruption (e.g. trip relay)	**Prevents disruptions, minimizes impact, restores rapidly**

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

Today	Tomorrow
Vulnerable to terrorists and natural disasters	Deters, detects, mitigates, and restores rapidly and efficiently