



A Grid that is Smart, Strong and Flexible

***How Can We Develop 21st Century Secure Power Networks –
Within the Footprint of the 20th Century Grid?***

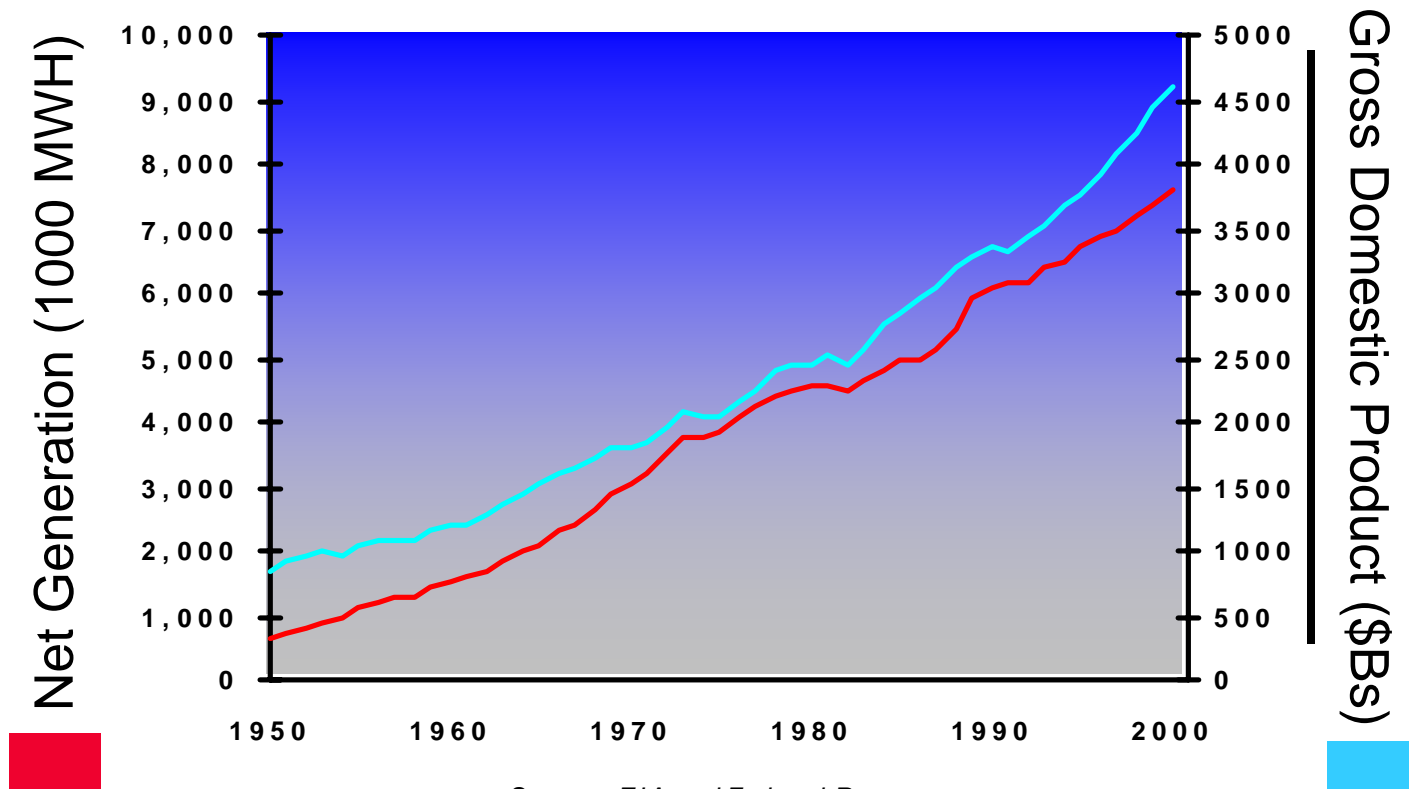
*Presented to the NARUC Energy Resources & Environment Committee
February, 14, 2005 – Washington, DC
John B. Howe, VP Electric Industry Affairs
American Superconductor*

Presentation Overview

- Addressing the nation's energy and power needs:
Why our 21st century economy requires high-capacity, reliable and secure power networks
- Technology is furnishing new solutions:
Late 20th century materials breakthroughs enable new grid upgrade strategies that combine high performance, zero/minimal siting impacts
- Recommendations to state regulators:
Policy initiatives to encourage broader and more rapid adoption of these approaches



Power Consumption and GDP: A Close Correlation



Source: EIA and Federal Reserve

Electricity consumption is consistently the best predictor of overall GDP growth

After the “Dash for Gas,” What’s Next? Tapping America’s Rich, Diverse Energy Base



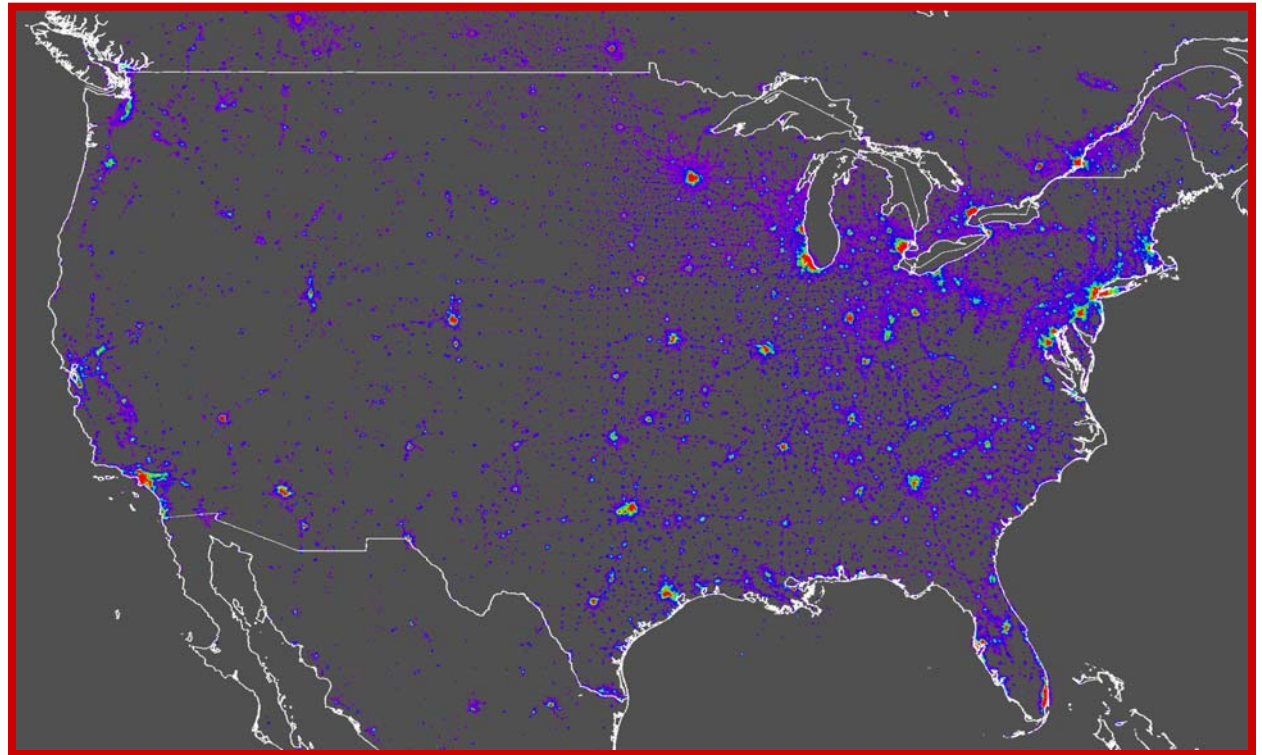
The challenge: The most abundant energy resources are far from urban centers

Power Demand in the World and the U.S.: Highly Concentrated in Urban Areas



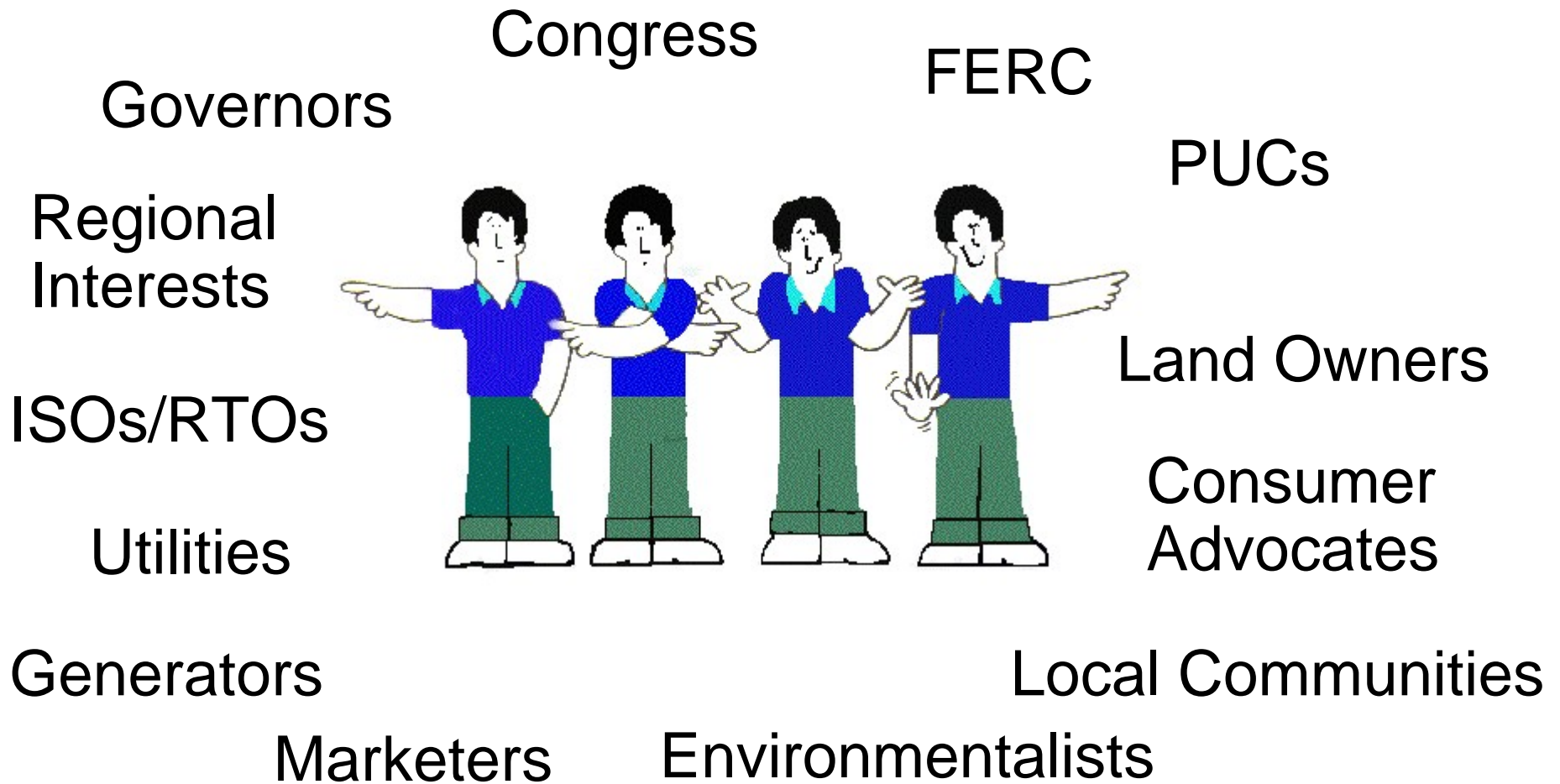
The World at Night

The U.S. at Night →



Worldwide, emerging “megacities” face unprecedented power delivery challenges

“You Can’t Get There From Here!” -- Stakeholder Conflict Feeds Policy Gridlock



Result: electric industry restructuring efforts have hit a dangerous stall

Power System Infrastructure Must Meet Demands Driven by Our Economy and Demographics

U.S. transmission “expansion plans” since late 1980s have been driven largely by “non-expansion” options, e.g.,

- Gas-fired IPPs close to load centers
- Distributed generation
- Renewable energy
- Demand response
- Locational pricing
- “Smart Grid” technologies

These strategies can effectively complement core system upgrades – but they are not “perfect substitutes”

Implementing Secure Power Networks: An Urgent National Priority

- The security and reliability of our nation's 20th century power networks is a significant concern
- A robust economy in the 21st century and the security of the nation require *secure power networks*
- Secure power networks are high capacity, smart, controllable, more easily protected and self-protecting if damaged or stressed
- Self-protecting networks adjust rapidly and automatically to disruptions in power network equipment caused by weather damage, willful destruction or other reasons

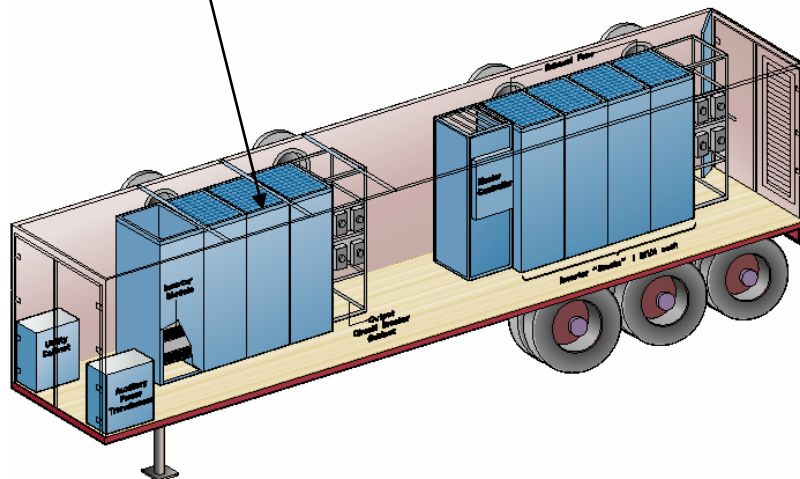
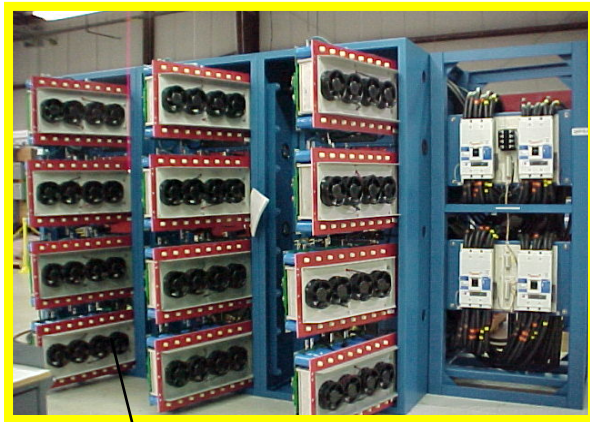
Power Grid Performance is Limited by Immutable Physical Laws

Two chief factors limit the capacity of power lines and cables:

- *Thermal Ratings*
 - Conventional conductors have inherent physical (material) limitations
 - Overload leads to excessive sag, degraded insulation, burnout and outright failure
- *Stability Ratings*
 - “Prudent Operating Practice” often dictates operation well below thermal rating limit
 - Overload puts system at risk of fast collapse during a contingency (line outage, plant trip)

VARs (“imaginary power”) – especially dynamic VARs – are critical to grid reliability

D-VAR[®] Voltage Boosters: Dynamic Voltage Support Through Fast Switching

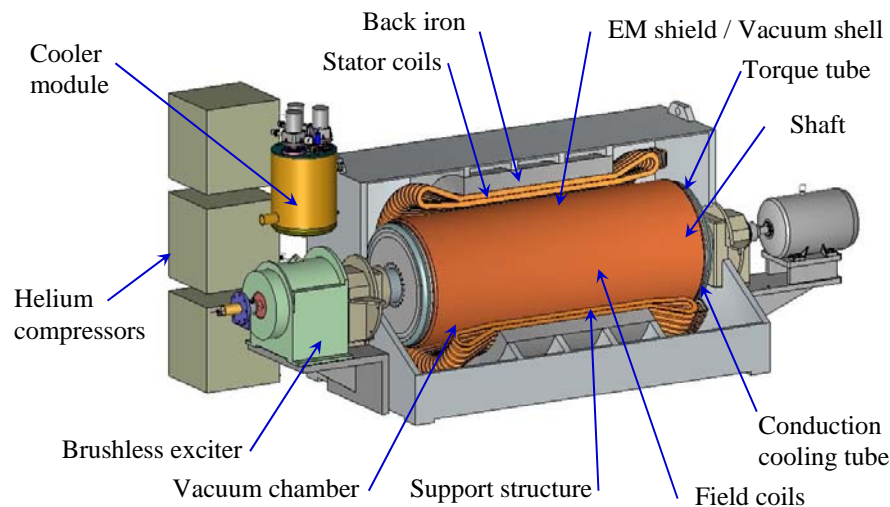


D-VAR Overview

- **D**ynamic **V**ARs... Fully Integrated Statcom with proprietary 3X overload (AMSC proprietary power electronics technology)
- Instantaneously injects precise amounts of reactive power into a network
- Can be seamlessly integrated with static shunt devices as part of a larger solution
- Modular, fast to deploy, easy to site in existing substations – and relocate as needs change
- Provides significant improvement in transmission reliability and capacity
- Environmentally benign

31 D-VAR systems presently operating on utility grids in the U.S. & Canada

SuperVAR™ Synchronous Condensers: Dynamic Voltage Support Through Rotating Mass

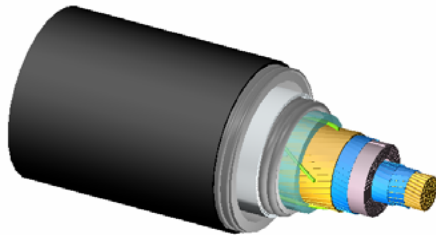


SuperVAR overview

- Established rotating machines platform
- Mobile, rapid siting and installation in substations with zero siting impacts
- World's first commercial product based on HTS technology
- TVA launch customer – ordered first five production units
- Successfully tested on the Ohio power grid
- Advanced prototype, now under demonstration at a steel mill on TVA system, has handled millions of events

Full-scale commercial introduction following successful demonstration

Very Low Impedance (VLI) Superconductor Cables: Smashing Grid Bottlenecks



VLI Cable *Feature Overview*

- **VLI** (Very Low Impedance) enables control of power flows with conventional PARs
- The result: a DC-like solution that can be integrated into existing AC grids without costly terminal stations
- Very high (3-5x) power flow enables solutions at lower voltages
- Environmentally compatible – underground installation, no dielectric oil
- Thermally independent – enables close placement in tight urban rights-of-way
- Coaxial design suppresses $\pm 100\%$ of EMF

A high capacity, controllable solution to multiply power flows in congested areas

Long Island Power Authority (LIPA) HTS Cable East Garden City, NY

- Electrical Operating Characteristics
 - Operating Voltage/Current – 138kV/2400A ~ 574MVA
 - Design Fault Current – 69,000A @ 15 line cycles (250ms)
- Physical Characteristics
 - Length ~660m
 - HTS Conductor Length – 159km
 - Cold Dielectric Design
- Hardware Deliverables
 - Three 660m long Phase Conductors
 - Six 161kV Outdoor Terminations
 - One 161kV Splice
 - One Refrigeration System + Pulse Tube System
- Installation/Commissioning – 2005/2006



World's First Installation of a Transmission Voltage HTS Cable

Clear Agreement on the Problem: The Grid Is Not Keeping Pace with New Challenges

“If SMD is ever to “work,” there must first be independent, regional transmission providers and robust transmission and generation infrastructure.”

-- NRECA, November 2002

“Without an adequate transmission network, the Commission’s objective of workable competitive wholesale electricity markets cannot be realized.”

--American Transmission Company, Nov. 2002

“Consumers and businesses need reliable supplies of energy to make our economy run -- so I urge you to pass legislation to modernize our electricity system...”

-- President Bush, January 2004

“There is growing evidence that the U.S. transmission system is in urgent need of modernization.”

-- DOE National Transmission Grid Study, May 2002

“Inadequate investment in transmission infrastructure is a significant and growing national problem.”

-- National Commission on Energy Policy
August 2003

“...the lack of a strong, nation-wide transmission system is limiting effective competition, raising costs to all electric customers, and risking reliability in many areas.”

-- FERC Chairman Wood, July 2002

Emerging Agreement on Solutions: New Grid Technology Offers a Pathway Forward

“The statute and/or regulations should encourage the use of new low-impact technologies and existing corridors ... subject to a simplified/expedited permitting process or in certain cases exempted ... Examples of "low-impact" transmission enhancement projects include:

- overhead projects that make more intensive use of existing electrical rights-of-way;
- certain underground projects that avoid long-term disruptive effects by making use of electrical or other existing corridors...; and
- projects that are located entirely within substations.”

-- NGA Task Force on Electricity Infrastructure,
“Interstate Strategies for Transmission Planning and Expansion”
July 2002

Emerging Agreement on Solutions: New Grid Technology Offers a Pathway Forward

“We are especially interested in encouraging investment in new technologies that can be installed relatively quickly (i.e., do not require the long siting process for procurement of new rights-of-way, have designs that accommodate modular and portable application, and may be environmentally benign). Such technologies... appear to offer significant promise to expand grid capacity, reduce congestion, improve reliability, and enhance wholesale competition without great cost or delay.”

-- Federal Energy Regulatory Commission
Proposed Transmission Pricing Policy Statement
January 2003

FERC Staff Report on Reactive Power (AD05-1): a critical renewed focus

Emerging Agreement on Solutions: New Grid Technology Offers a Pathway Forward

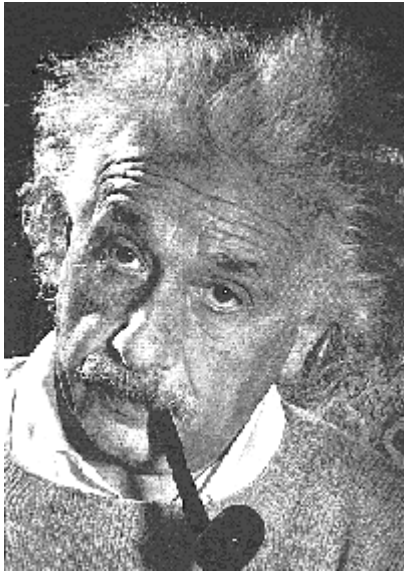
“(T)he Commission shall establish, by rule, incentive-based (including, but not limited to performance-based) rate treatments for the transmission of electric energy in interstate commerce (that)... encourage deployment of transmission technologies and other measures to increase the capacity and efficiency of existing transmission facilities and improve the operation of such facilities...”

- Electricity Title, Section 1241
Proposed Comprehensive National Energy Legislation

Encouraging Formation of Secure Power Networks: Recommendations for State Regulators

- Target voltage constraints to boost grid reliability and power transfer capacity – often quickly and at low cost
- Require planning consideration of all alternatives – DG, DR, Renewables, IT and low-impact grid upgrades
- Review rate treatment and incentives for utility spending on grid-related R&D (which has seen a sharp decline)
- Encourage in-state demonstration / pilot projects of next-generation grid technologies
- Reassess criteria for use of “clean energy funds” – for many emerging technologies, the “missing link” is a reliable pathway to market that can feasibly be sited!

What's Needed: Public Policies to Support Development of a 21st Century Grid That Is...



Smart...



Strong...



and Flexible

New grid technologies can play a key role in helping us “get there from here”

**Thank You!
Questions?**

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