Modernizing the Power Grid: How Can We Meet 21st Century Energy Needs Within a 20th Century Footprint?

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Lenox, Massachusetts
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American Superconductor

American Superconductor™

Presentation Overview

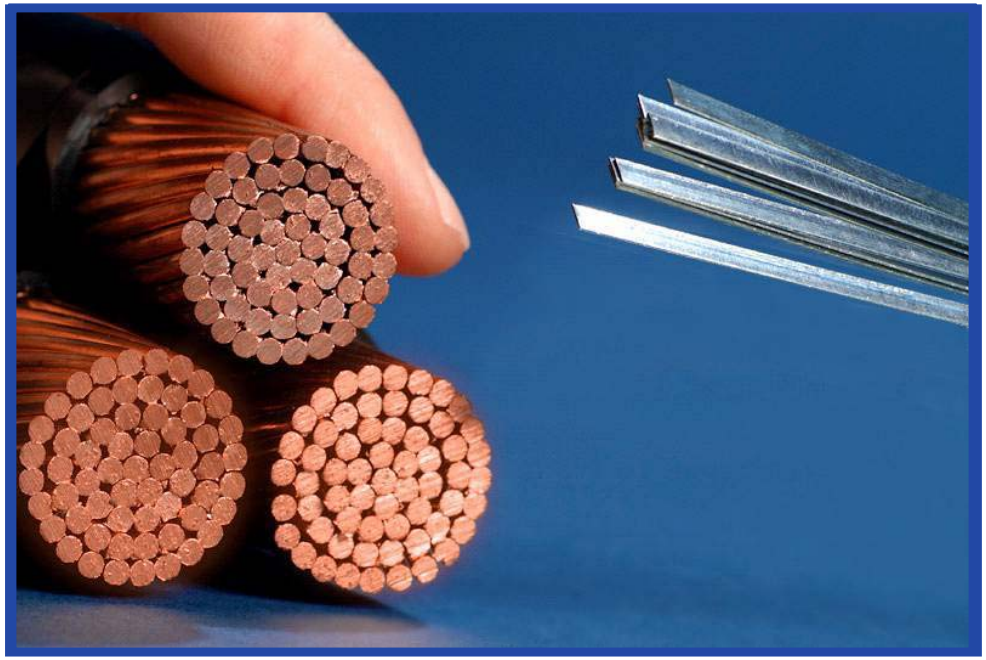
- Introduction to AMSC
- Needs of the future: fundamental social drivers
- Power flows are subject to unchanging physical laws
- Planning for growth: more capacity required
- Planning for uncertainty: more flexible tools required
- Conclusion

American Superconductor Overview

Market/Ticker:	NASDAQ/AMSC
Founded:	1987
Headquarters:	Westborough, MA
Other Locations:	Devens, MA
	Middleton, WI
	New Berlin, WI
Employees:	263
Patents owned/licensed:	700+

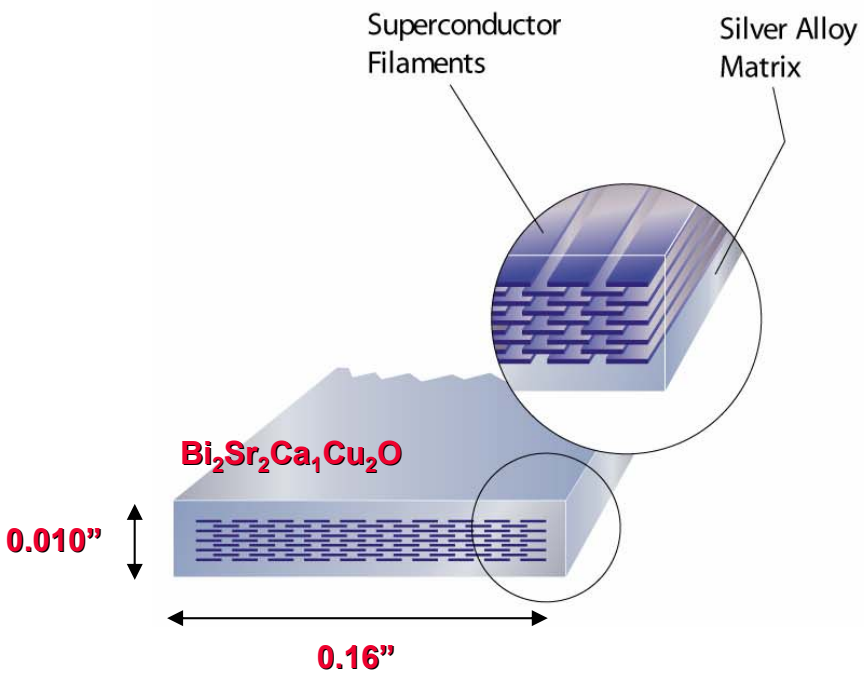
Products for electric power, transportation, industrial, medical and defense markets

HTS Wire: 150x Increase in Power Capacity

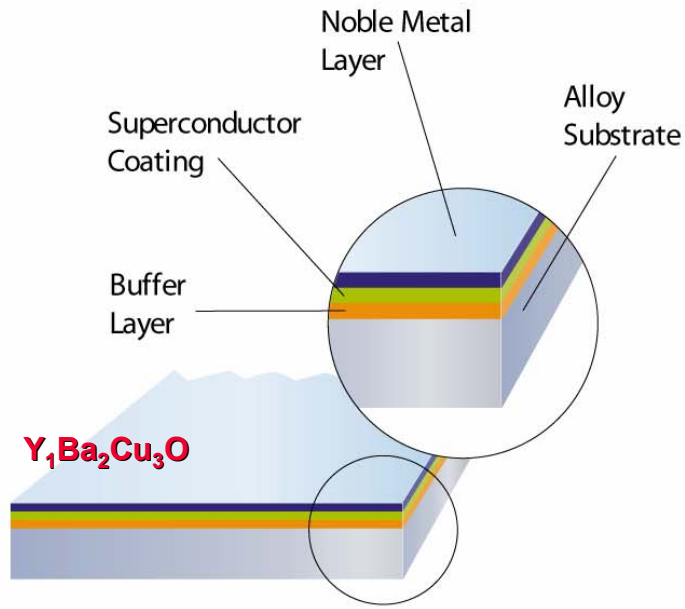


Power density drives system economics

HTS Wire: Inside the Enabling Technology



First generation (1G) HTS wire
(Available for sale)



Second generation (2G) HTS wire - 344 Superconductors
(Available for sale)

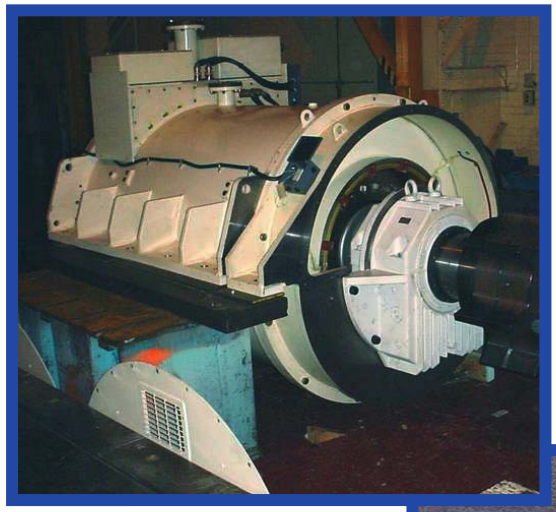
344 superconductors are designed to be a low cost, form-fit-function replacement for 1G wire

AMSC's Addressable Market Segments

A leading electricity solutions company addressing large-scale power applications

Demonstrated Applications of HTS

Power Cables



Motors, Generators

Synchronous Condensers

Fault Current Limiters

Maglev

HTS Wire – the Foundation of an Industry

Factors in Today's Power Gridlock

Demographics

Population Growth

Economic Growth

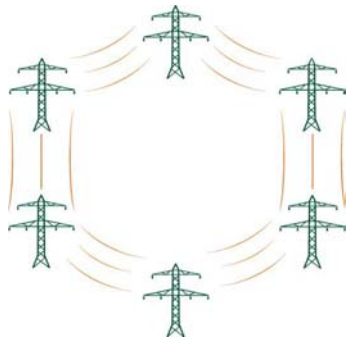
Urbanization

Business Pressures

Competitive Markets

Raising Asset Utilization

Extending Asset Life



Customer Needs

Electrification

Power Quality

Reliability

Siting

Right-of-Way

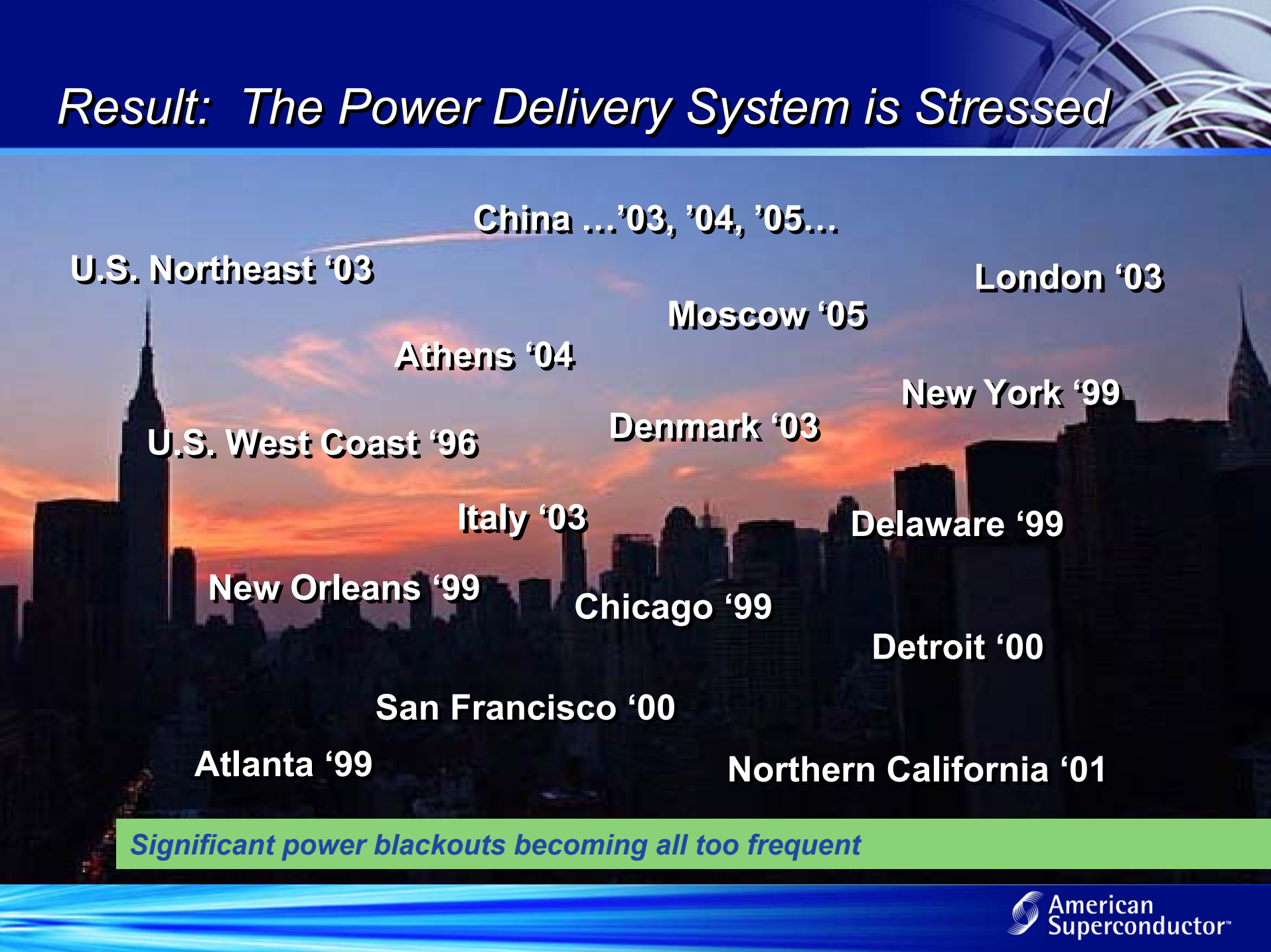
Property Owners

Environmentalists

State & Local Concerns

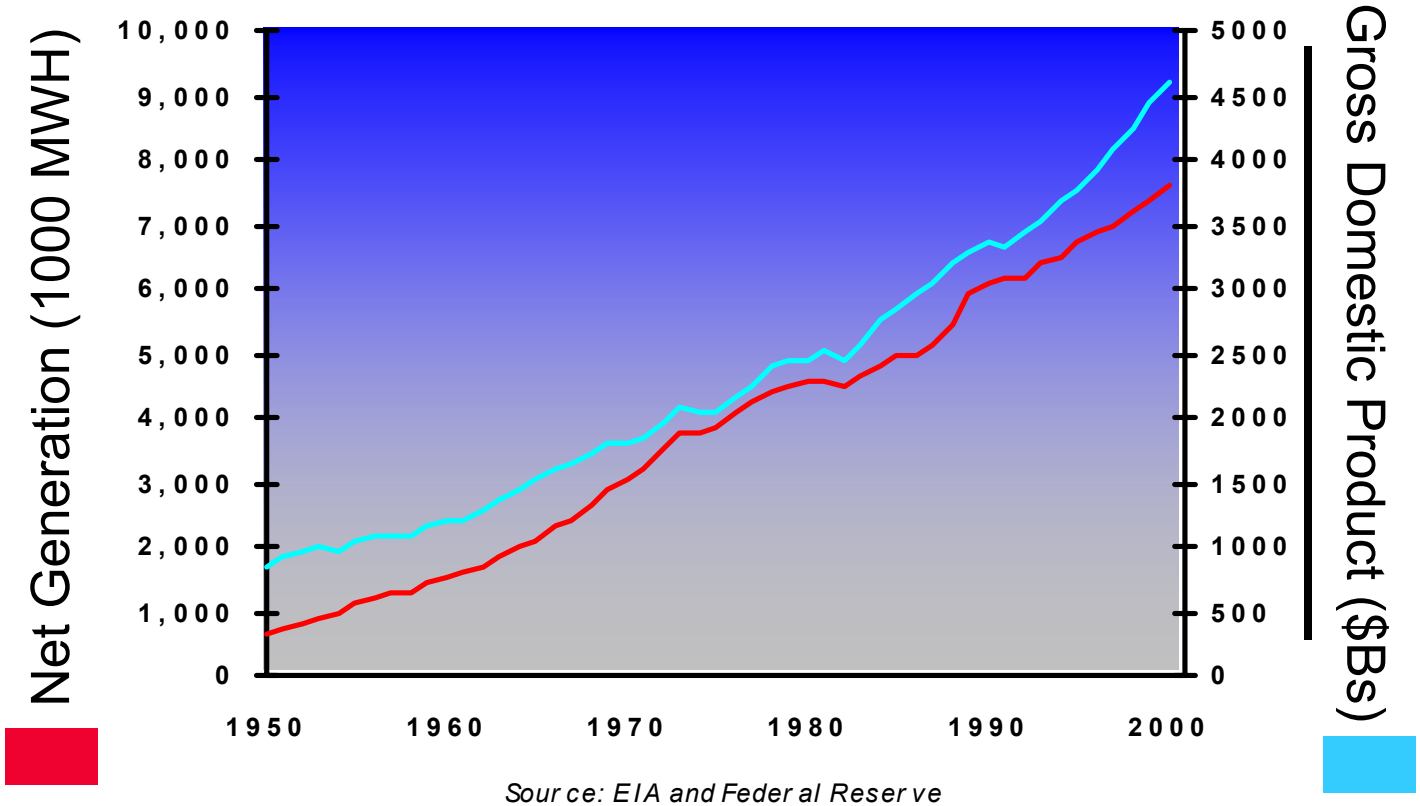
Converging social, economic pressures drive a need for new technology solutions

Result: The Power Delivery System is Stressed



Significant power blackouts becoming all too frequent

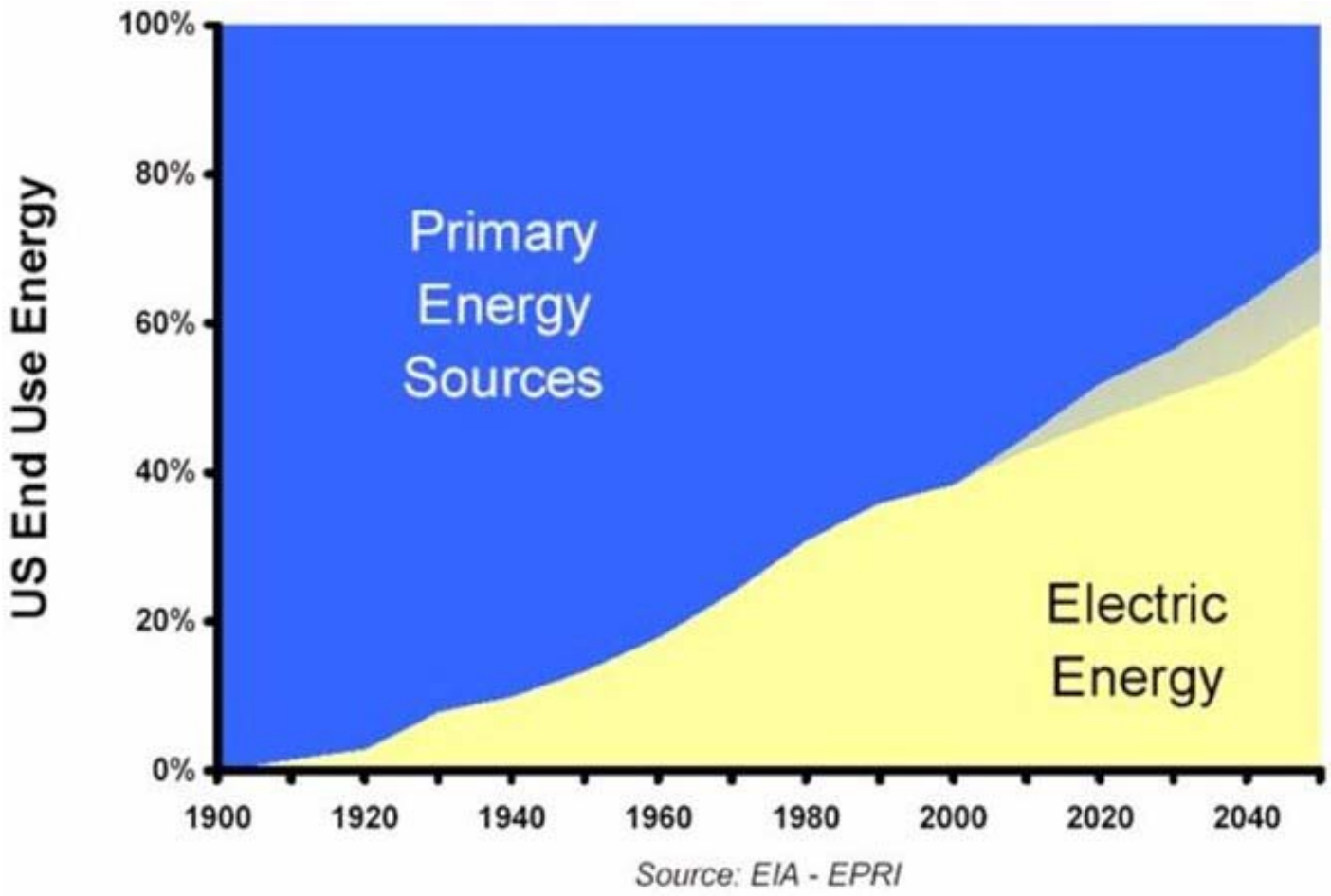
Power Consumption and GDP



Source: EIA and Federal Reserve

Electricity consumption is consistently the best predictor of overall GDP growth

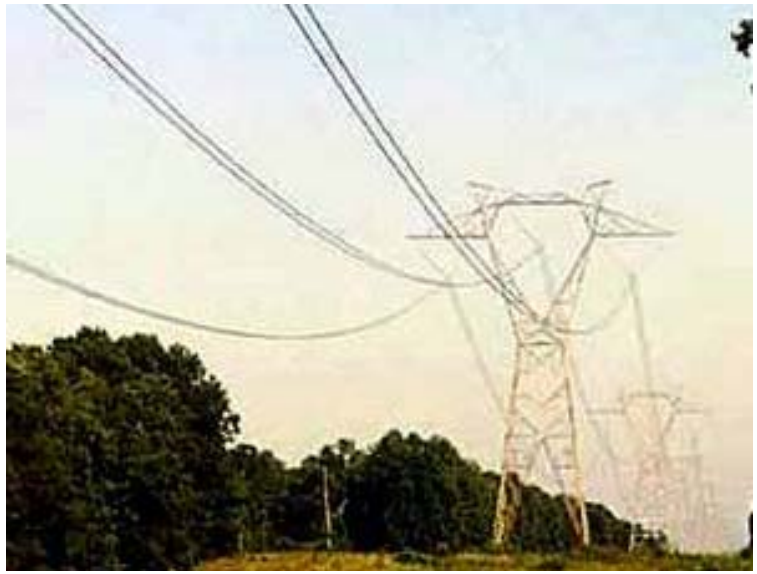
Electrification of End Use Energy Consumption



EPRI: Electricity consumption will surpass direct use of energy by 2020

Reducing U.S. Energy Import Dependence is a…

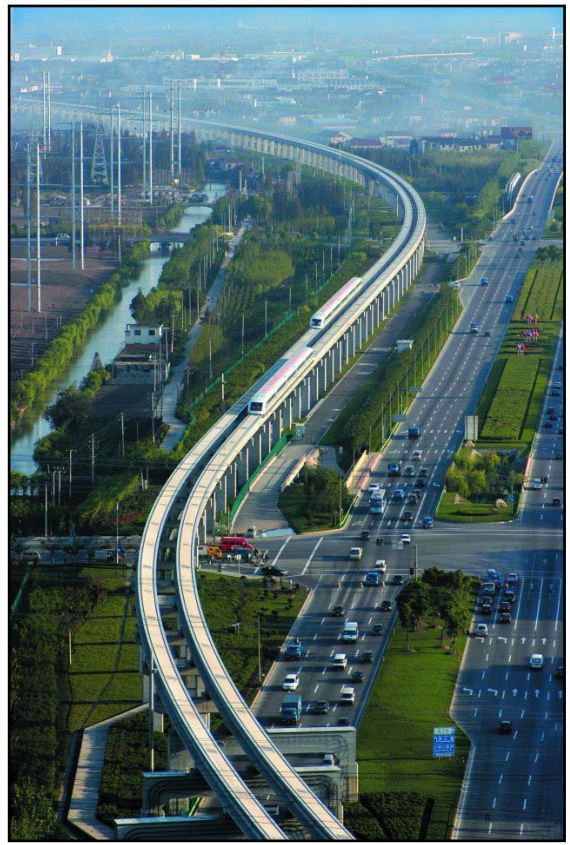
Transportation Issue?



Transmission Issue?

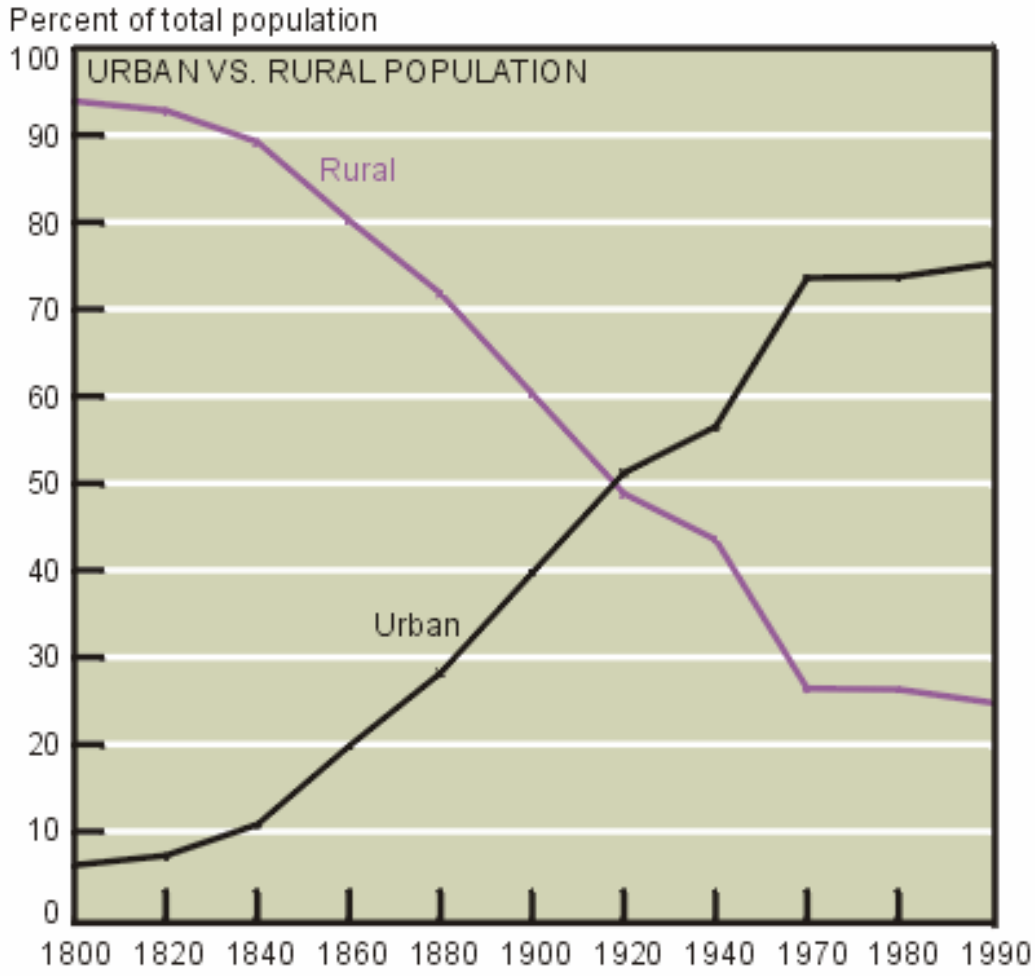
Changing patterns of energy use bring new risks and opportunities

The Next Wave: Electrification of Transportation?

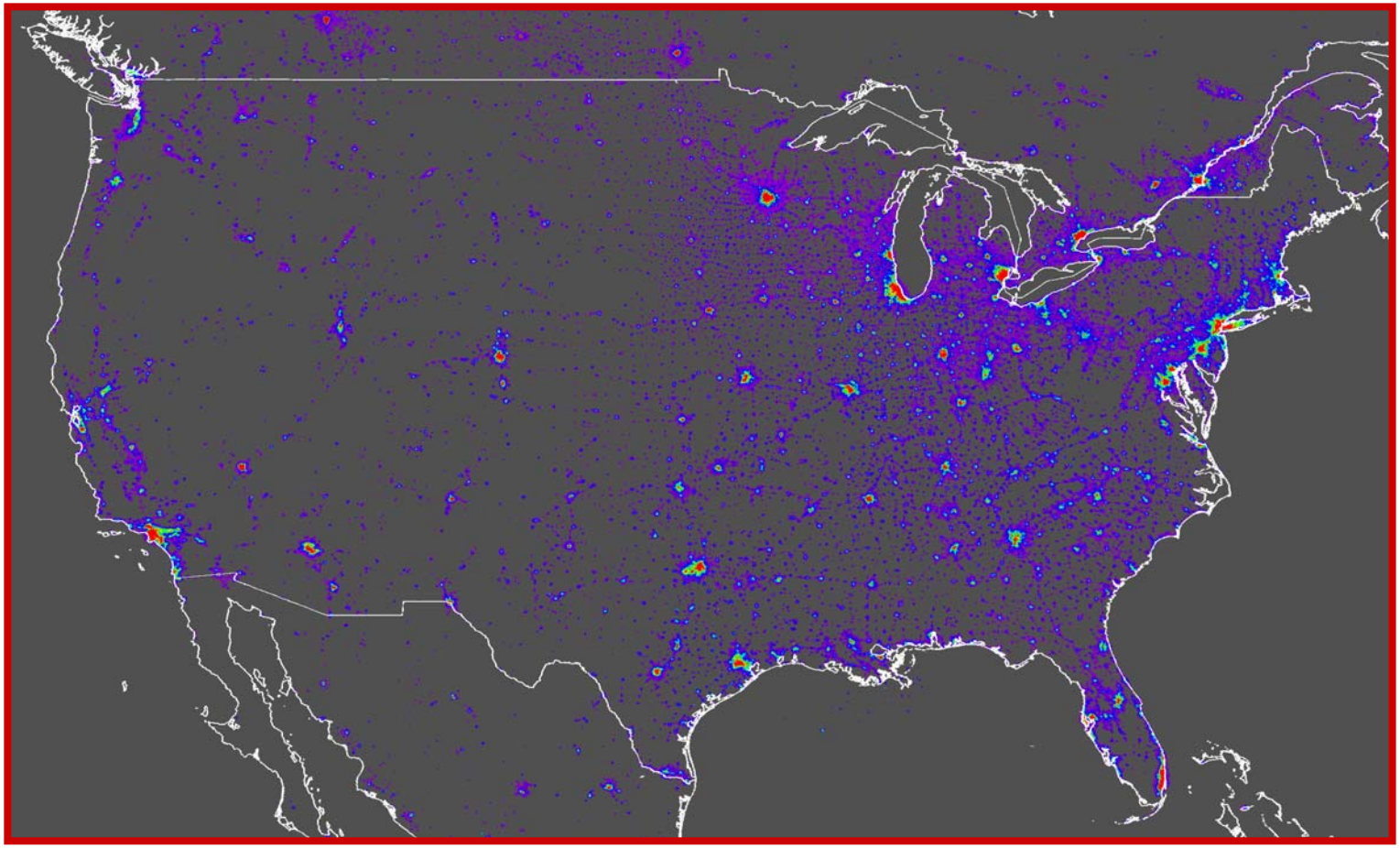


New solutions needed for convenient, high-speed mobility in the post-petroleum era

Urbanization of U.S. Population

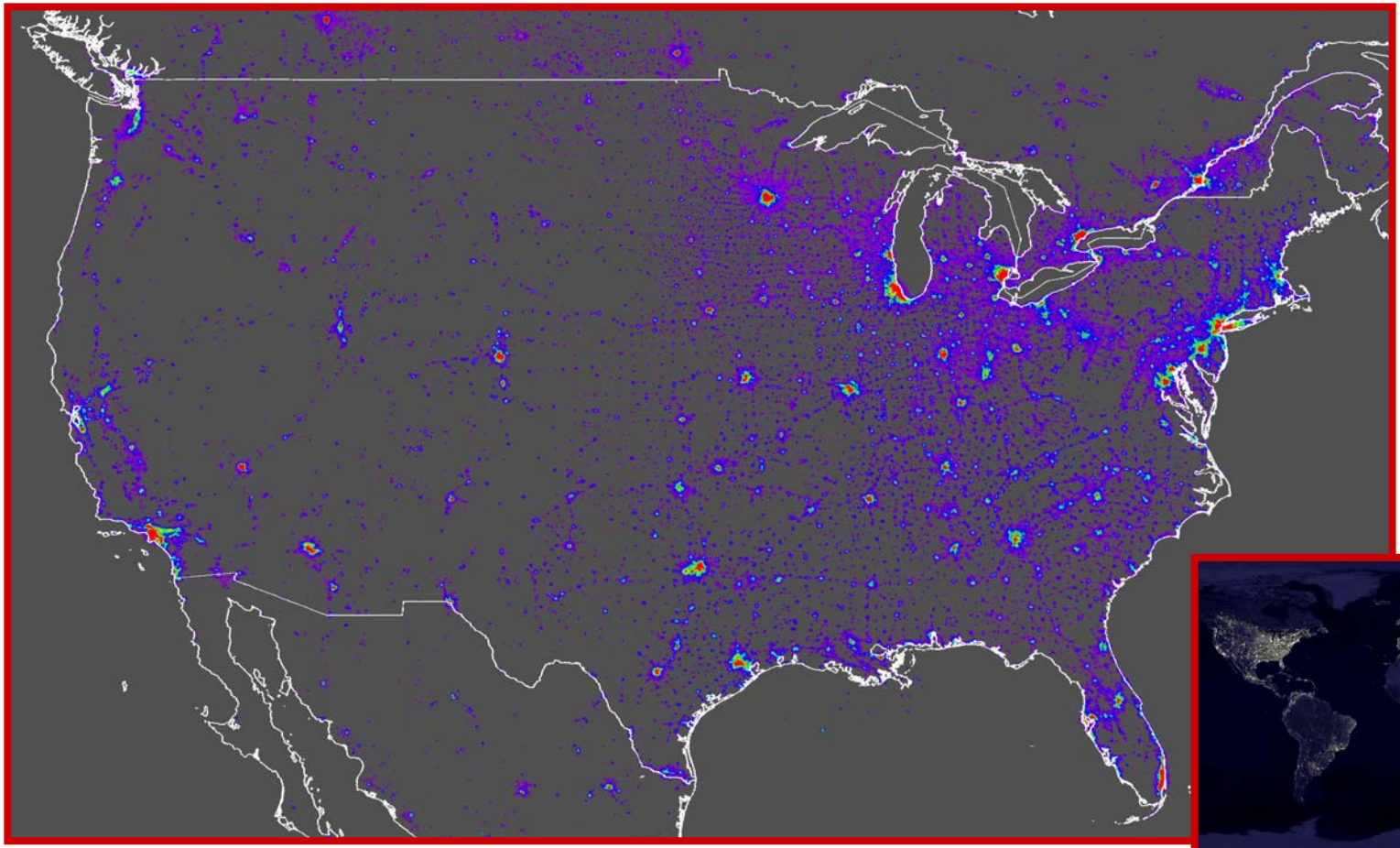


Power Demand is Geographically Concentrated



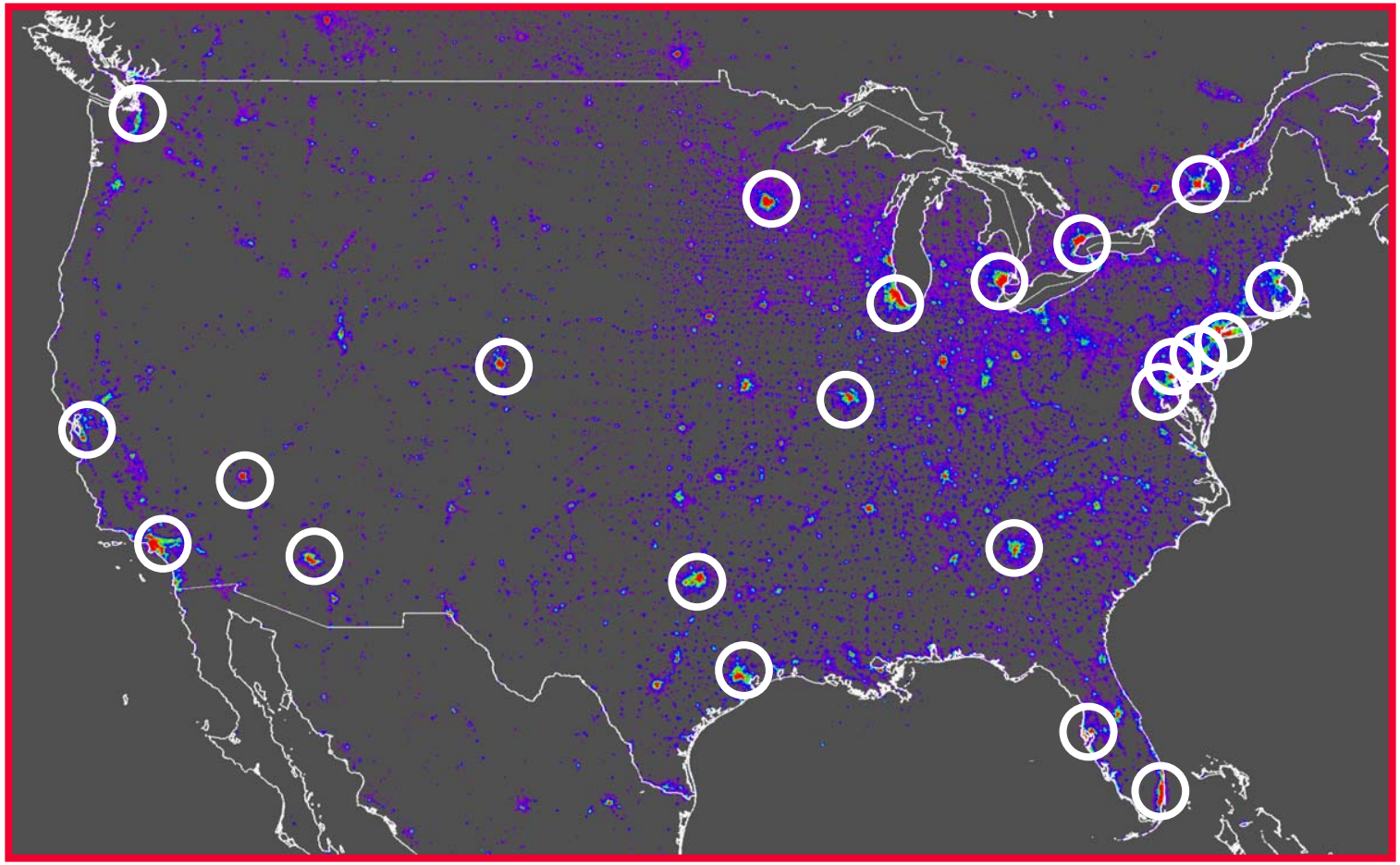
Worldwide, emerging "megacities" face unprecedented power delivery challenges

Power Demand is Geographically Concentrated

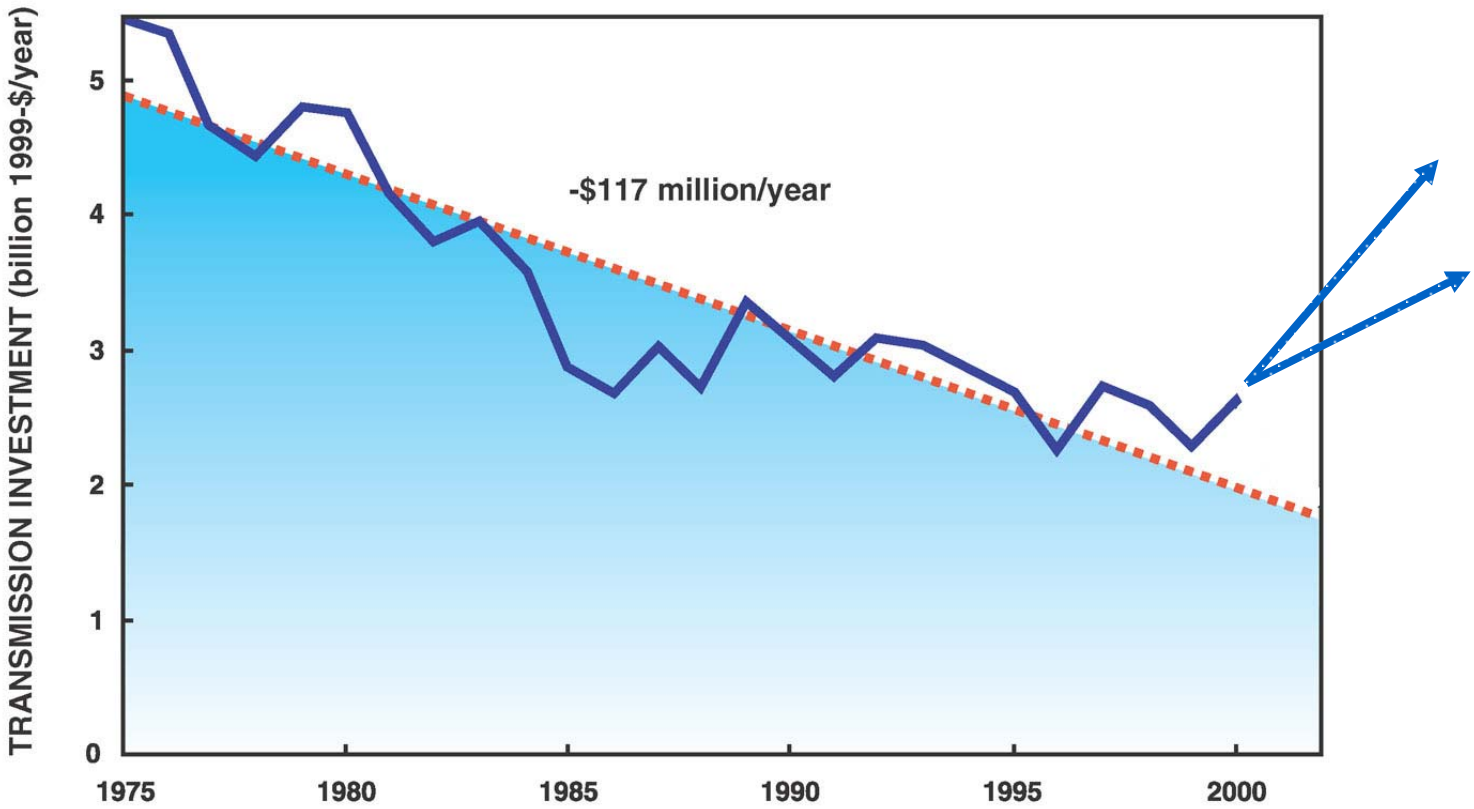


Worldwide, emerging "megacities" face unprecedented power delivery challenges

Metropolitan "Hot Spots" – 1/3 of U.S. Power Use



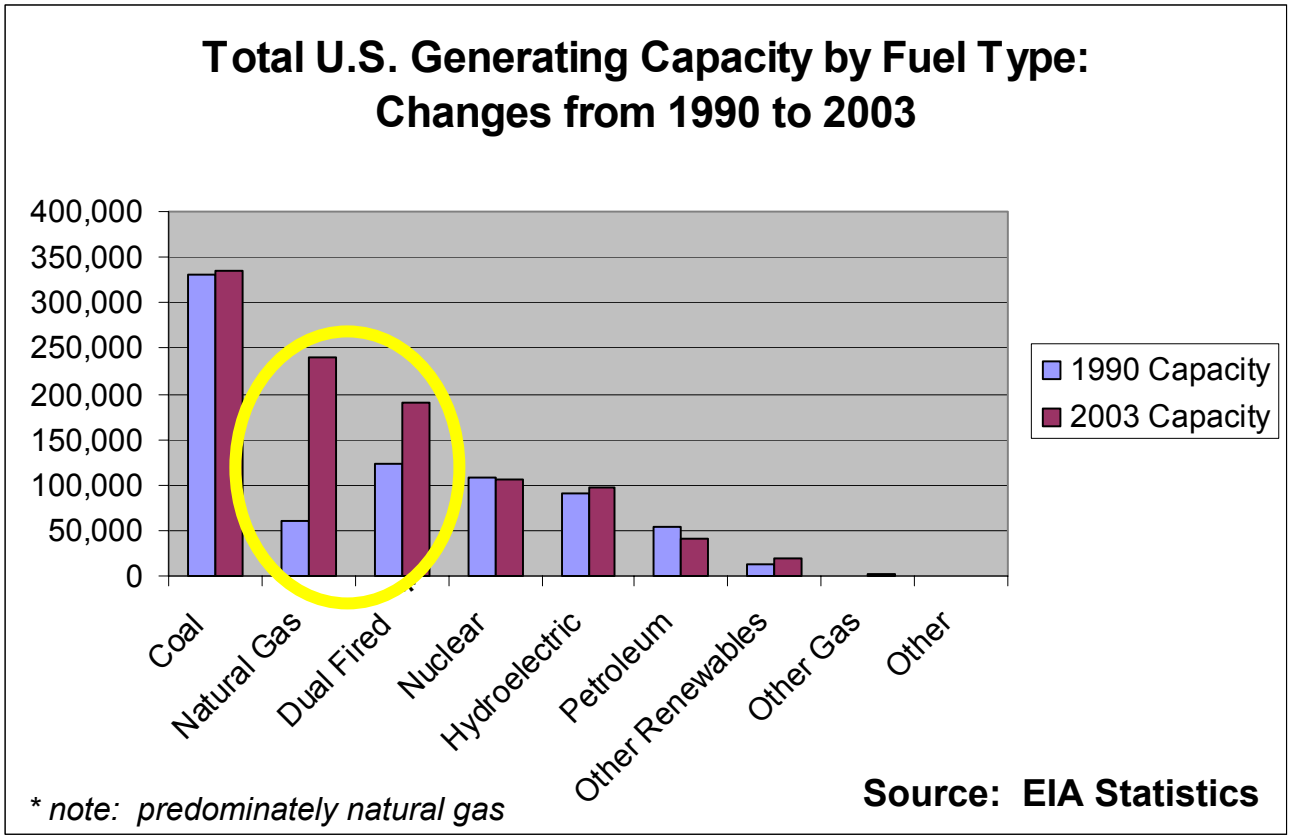
Investments in the Grid Have Fallen Behind



Source: *Transmission Planning for a Restructuring U.S. Electricity Industry*, Edison Electric Institute

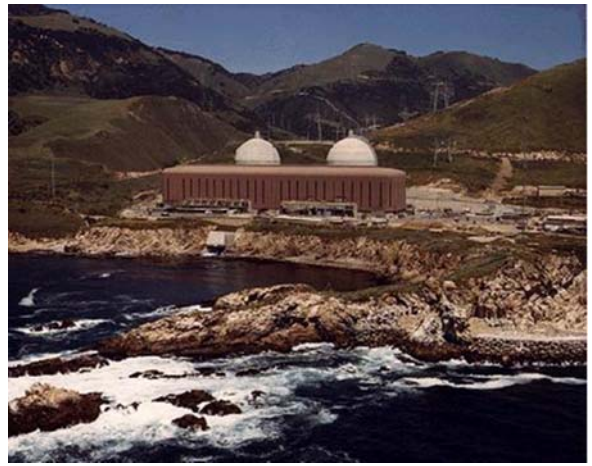
Result: the grid has been under mounting stress in recent years

The Recent Sharp Rise in Gas-Fired Generation: U.S. Strategy to "Fill the Gap" is Unsustainable



Gas dependence "at the margin" (especially in CA, NY, NE) drives high prices and exposes today's customers to very costly price spikes during peak hours

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

Time to Move Past Transmission Gridlock

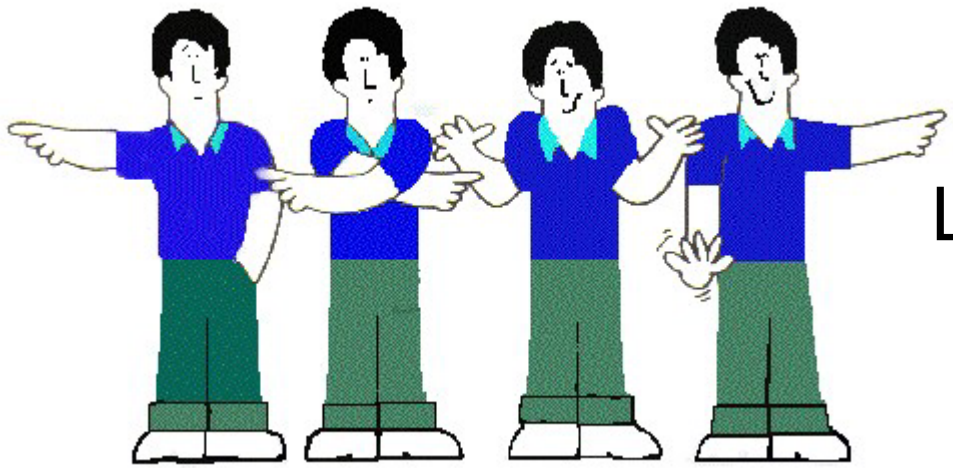
Congress

FERC

Governors

PUCs

Regional Interests



Land Owners

ISOs/RTOs

Consumer Advocates

Utilities

Generators

Local Communities

Marketers

Environmentalists

Future Vision for the Grid: Superhighway – or Gated Community?

FERC's View?

The State PUCs' View?

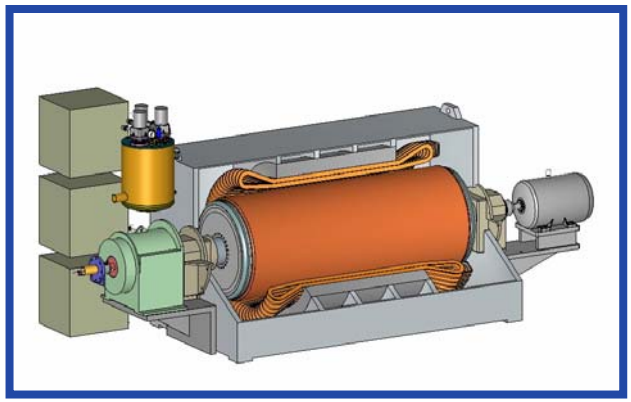
Industry stakeholders hold sharply conflicting views on the basic purpose of the grid

Physical Factors Limiting Grid Operation

- *Voltage (Stability) Ratings*
  - Constrained by “Prudent Operating Practice”
  - Many lines must run well below thermal limit
  - Overload puts system at risk of fast collapse during a contingency (line outage, plant trip)
- *Ampacity (Thermal) Ratings*
  - Inherent (material) limits of conventional conductors
  - Overload leads to sag / degradation / failure
- *Controllability*
  - Conventional AC power systems are free-flowing
  - DC lines require expensive conversion equipment

Principal AMSC Technologies For the Power Grid

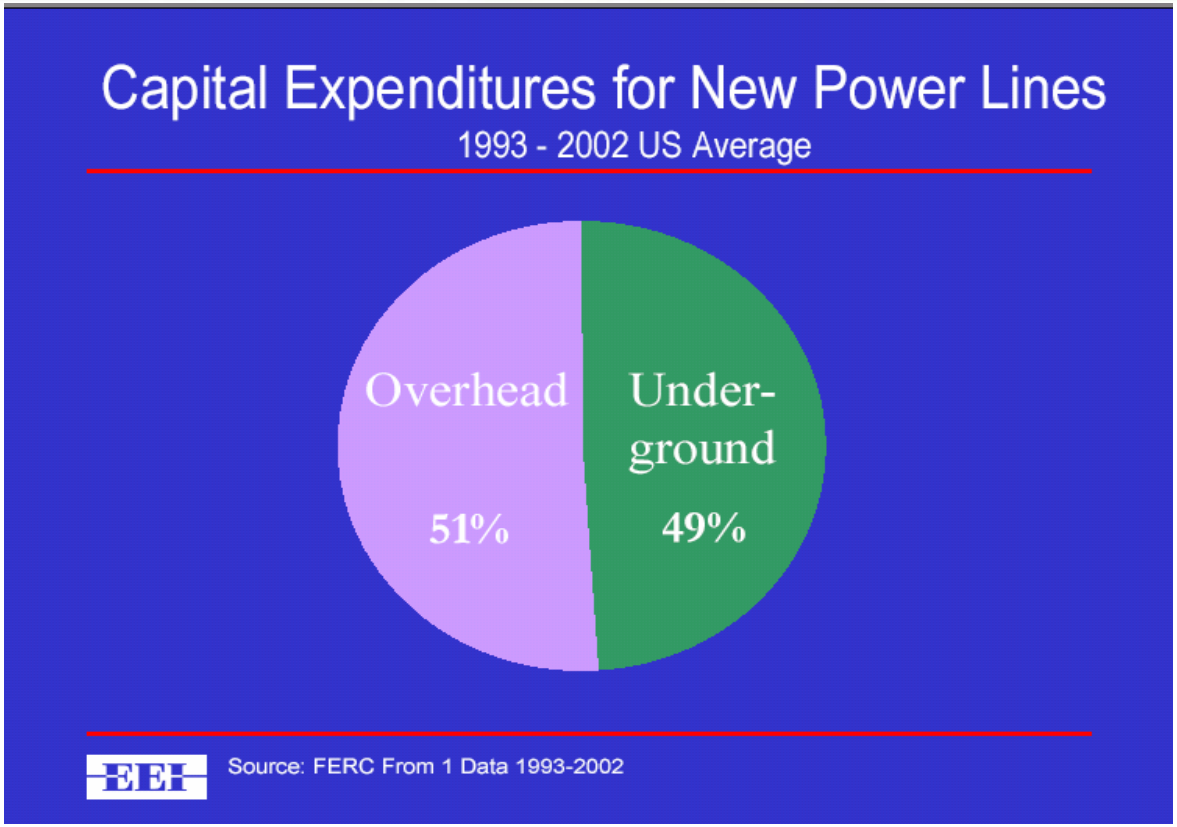
Power Electronics-Based “D-VAR” Voltage Booster



“SuperVAR” Dynamic Synchronous Condenser

High Capacity, Very Low Impedance “VLI” Superconductor Cable

To Avoid Siting Battles, Utilities Are Increasing Investment in Underground Solutions



Source: EEI

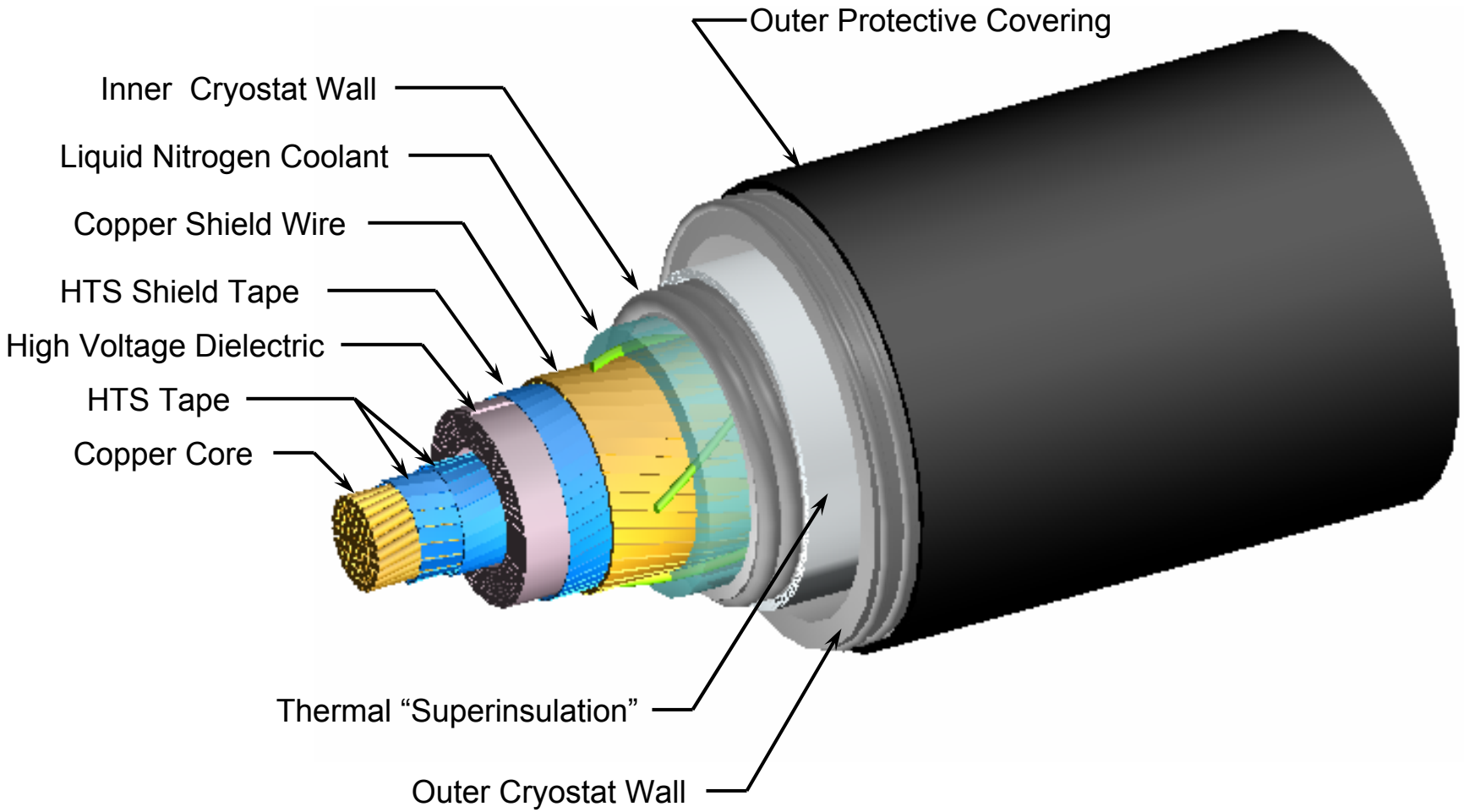
Growing pressure to put power infrastructure underground results in special physical and technical challenges for high-voltage, high-capacity transmission

Urban Power Systems – Then and Now

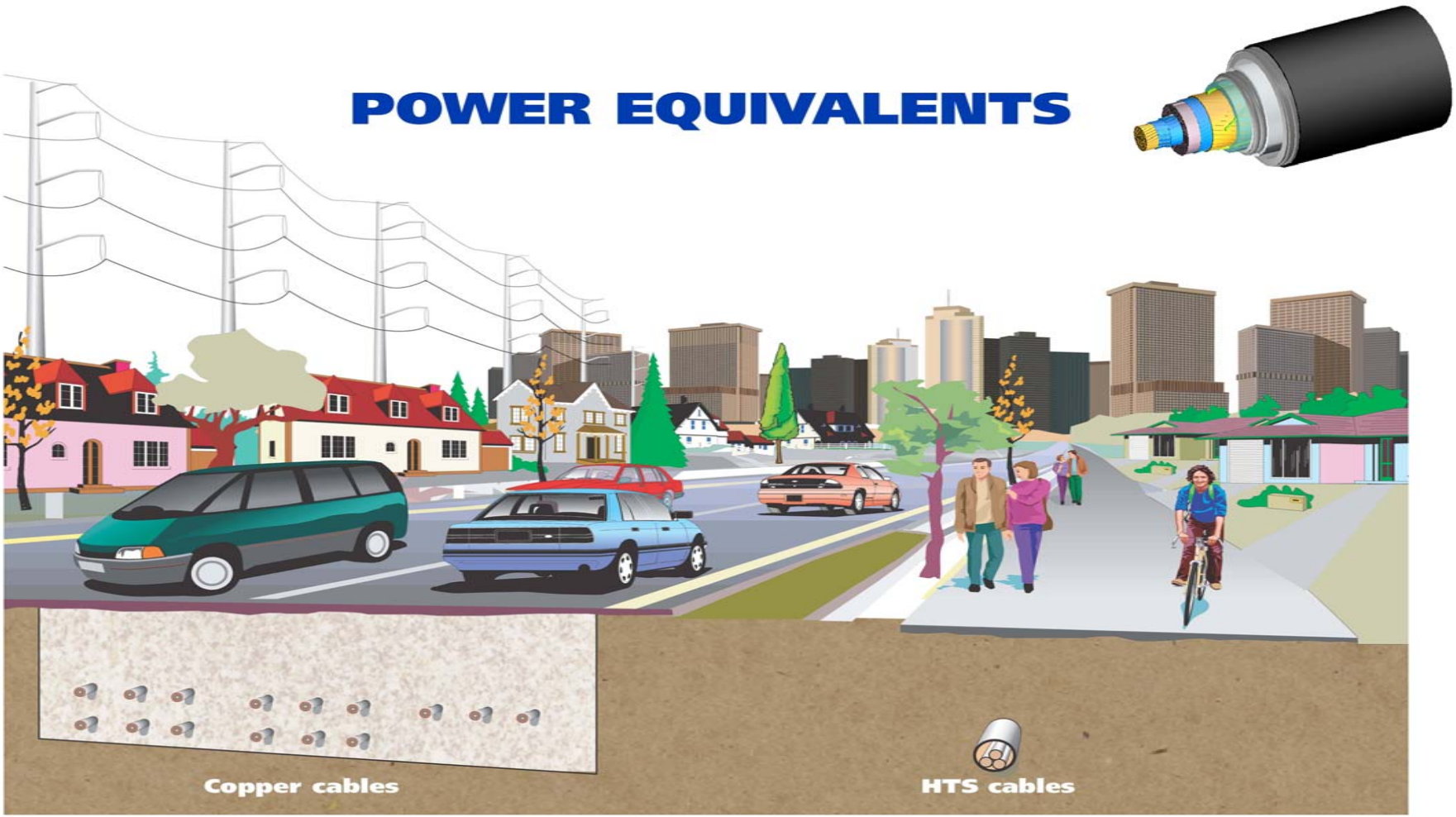
Wall Street & William Street
(early 1900s)

William Street & Fulton Street
(2003)

Typical VLI Cable Cross Section

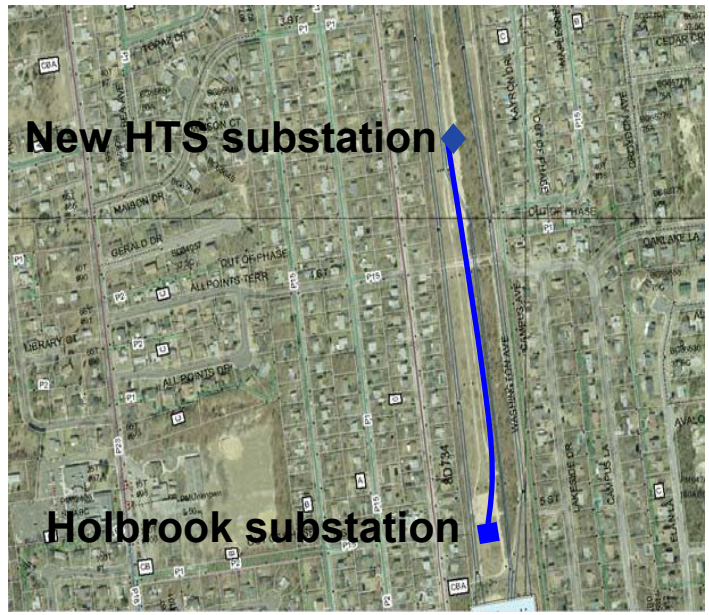


HTS Cable Offers a High-Performance Solution for Power-Dense, Costly Urban Areas



DOE SPI: LIPA Cable Project Overview

- Long Island Power Authority – Holbrook Substation
- Electrical Characteristics
  - Design Voltage/Current – 138kV/2400A ~ 574MVA
  - Design Fault Current – 69,000A @ 12 line cycles (200ms)
- Physical Characteristics
  - Length ~ 610m
  - HTS Conductor Length ~155km
  - Cold Dielectric Design
- Hardware Deliverables
  - Three ~610 m Long Phase Conductors
  - Six 161kV Outdoor Terminations
  - One 161kV Splice (Laboratory Test)
    - No splices for grid installation required
  - One Refrigeration System + Laboratory Pulse Tube System
- Installation/Commissioning – Fall 2006



Brookhaven, Long Island

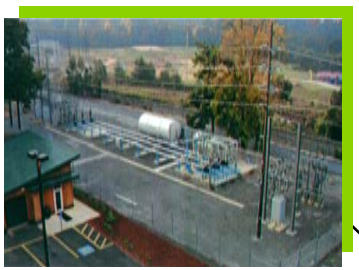
World's First Installation of a Transmission Voltage HTS Cable

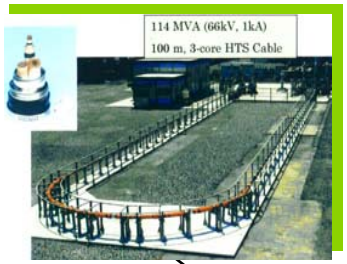
Long Island Power Authority

AIR LIQUIDE

Nexans

HTS Cable Demonstrations Moving to Commercialization





KEPRI/SEI
22.9 kV/50 MVA/100 m

Changtong/IEE
10.5 kV/29 MVA/75 m — In Operation

Innopower/Yunnan
35 kV/121 MVA/33.5 m — In Operation

LG/KERI/DAPAS
29 kV/50 MVA/30 m — Test

Southwire/AEP
14.5 kV/63 MVA/300 m

SuperPower/SEI/NiMo
34.5 kV/115 MVA/400 m

AMSC/Nexans/LIPA
138 kV/600 MVA/610 m

Furukawa
66 kV/230 MVA/300 m — Test

NKT
30 kV/104 MVA/30 m — In Operation

SEI/TEPCO
66 kV/115 MVA/100 m — Test

Southwire
12.4 kV/27 MVA/30 m — In Operation

Pirelli/EPRI
115 kV/400 MVA/50 m

1998 1999 2000 2001 2002 2003 2004

Uncertainty of New Supply Resources Drives Need for More Local Dynamic Reactive Power Support

- Growth of remote resources (e.g., windpower) will drive need for support to avoid hitting transmission & voltage constraints
- Pressures to retire older urban generators will drive need for in-city voltage support
- Competitive pressures will drive sudden, large-scale shifts in power flows
- Uncertainties will drive a need for rapidly-deployed, small-scale, modular dynamic voltage solutions

Distributed, dynamic VAR technologies: a low-cost strategy to plug gaps, boost reliability

Supplying Dynamic VARs with Power Electronics

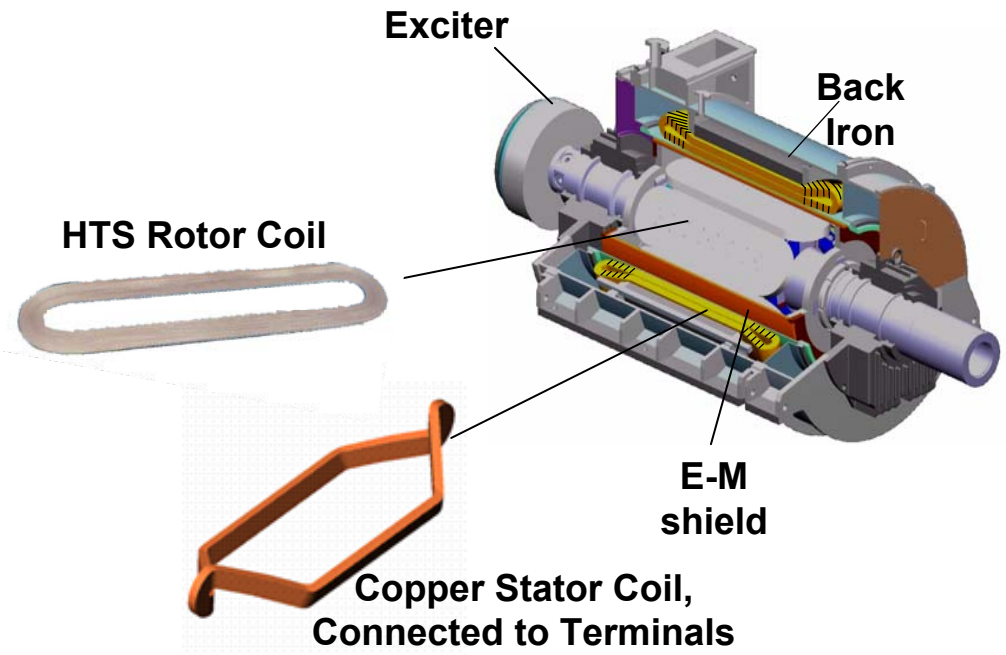
D-VAR (Dynamic Volt Ampere Reactive)

- High power inverters (STATCOM) providing 10s to 100s of MVARs
- Low cost, quick installation, no environmental permits required
- Co-located at distribution substations
- No on-site operator control (remotely monitored 24x7 by AMSC)
- Highly reliable (99.7+% availability)
- “Just-in-time grid capacity” enables a wide range of applications

Supplying Dynamic VARs with Rotating Machines

- Synchronous condenser: a rotating machine - generator without a prime mover
  - A powerful solution for injecting either capacitive or inductive VARs into grid for
    - Power factor correction
    - Instantaneous mitigation of voltage disturbances for grid stabilization

- HTS system solves key limitations of conventional copper-based synchronous condenser
  - Compact rotor coils enable high VAR output in small frame: lowers $/kVAR
  - Compact system, easily sited
  - Superconductors eliminate thermal fatigue from cycling rotor coil current – main source of failure of conventional systems



HTS Rotating Machinery – Progress Towards Commercialization

Rockwell/Reliance Motor
0.7 MW, 1800 rpm

Siemens Motor
0.45 MW, 1500 rpm

AMSC Motor
3.5 MW, 1800 rpm

AMSC Ship Motor
5 MW, 230 rpm
Test

GE Generator
1.8 MVA, 3600 rpm

AMSC Synchronous Condenser
8 MVA, 1800 rpm
Test

AMSC Ship Motor
36.5 MW, 120 rpm
Test

Siemens Generator
4 MW, 3000 rpm

GE Generator
100 MVA, 3600 rpm

Doosan/KERI
1MW, 1800 rpm

IHI/SEI Ship Motor
400 kW, 220 rpm

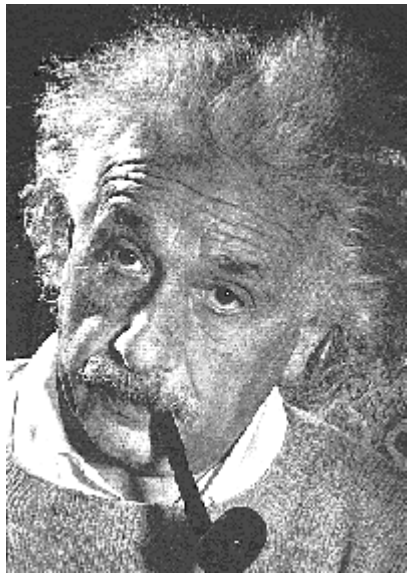
1999 2000 2001 2002 2003 2004

Just-in-Time Dynamic Voltage Support Applications

- Increase transfer capacity into, through and out of congested areas of the grid
- Provide VAR support to compensate for load growth, scheduled / unexpected retirements
- Reduce reliance on costly reliability-must-run generation, other sources of congestion/high LMPs
- Reliable, low-cost integration of wind generation and other forms of renewable energy

D-VAR offers a fast, low-cost way to extract more capacity from existing lines

The Goal: A 21st Century Grid That Is...



Smart…

Strong…

and Flexible

The Modern Grid needs all three traits to support our 21st century economy

Thank You!
Questions?

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