The Power of Networks in an Age of Gas

2013 EIA Energy Conference

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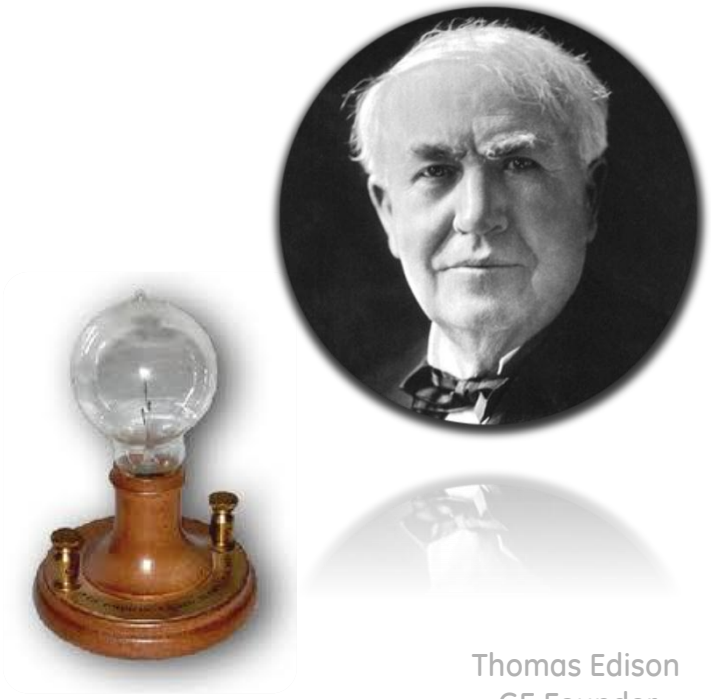
Sources of competitive advantage

Natural endowments

Creative endowments



Thomas Edison
- GE Founder

The U.S. is rich in both

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Advantage of networks

Physical and digital infrastructure

Power grid network

- More than 200,000 miles of high-voltage transmission lines (230 Kilovolts and greater)
- More than 3,700 TWh of power transmitted

U.S. natural gas pipeline network

- Over 306,000 miles of transmission pipelines
- More than 69 Billion Cubic feet per day transmitted (~25 Tcf per year)

Freight rail network

- Consists of over 140,000 miles of tracks
- 28,000 locomotives

Long haul trucking network

- National Highway System (NHS) 200,000 miles
- About 11 million trucks

Digital network

- Millions of miles of fiber optic cable
- 76% wireless broadband penetration

Benefits

✓ National competitiveness

✓ Environmental sustainability

✓ Resilience

Sources: EEI, DOT, EIA

The U.S. is also rich in mature networks

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Gas network technology

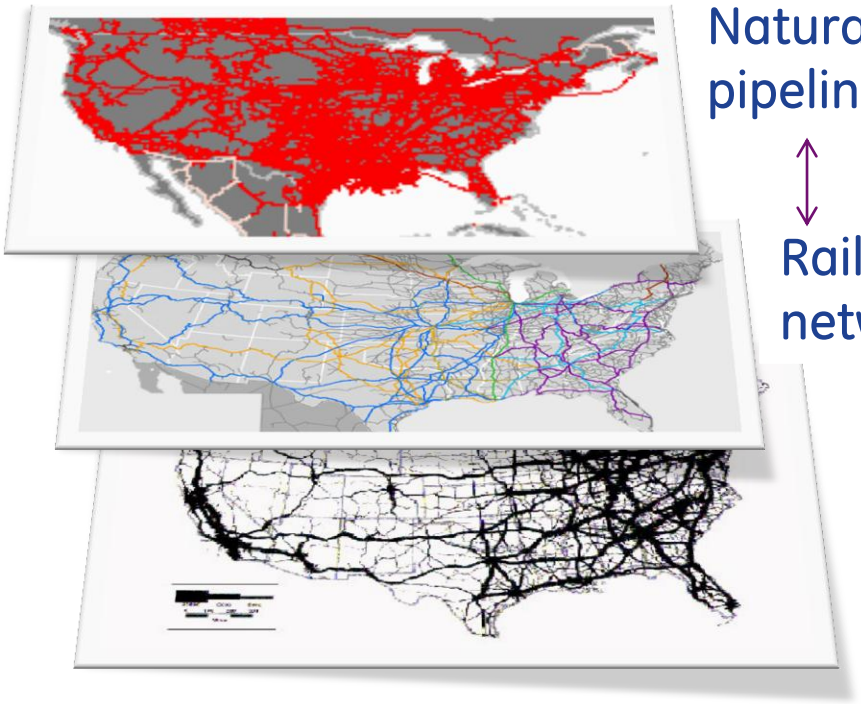
Gas supply

Network Type	Enabling technologies: Compression	Transport	Regas/ Storage
Land-based pipelines			
Ocean-based LNG ships			
Public roads — Micro LNG			
Public roads — CNG			

Linking across networks in new ways

Natural gas + transportation networks

New network connections emerging



Natural gas pipelines

Railroad network

Truck network

~6% of US energy is consumed in diesel transport

Strategic capital investments are required for transportation companies to capture the fuel price spread between natural gas and diesel

Rail and truck operators are evaluating the economics and will test technologies as they become available

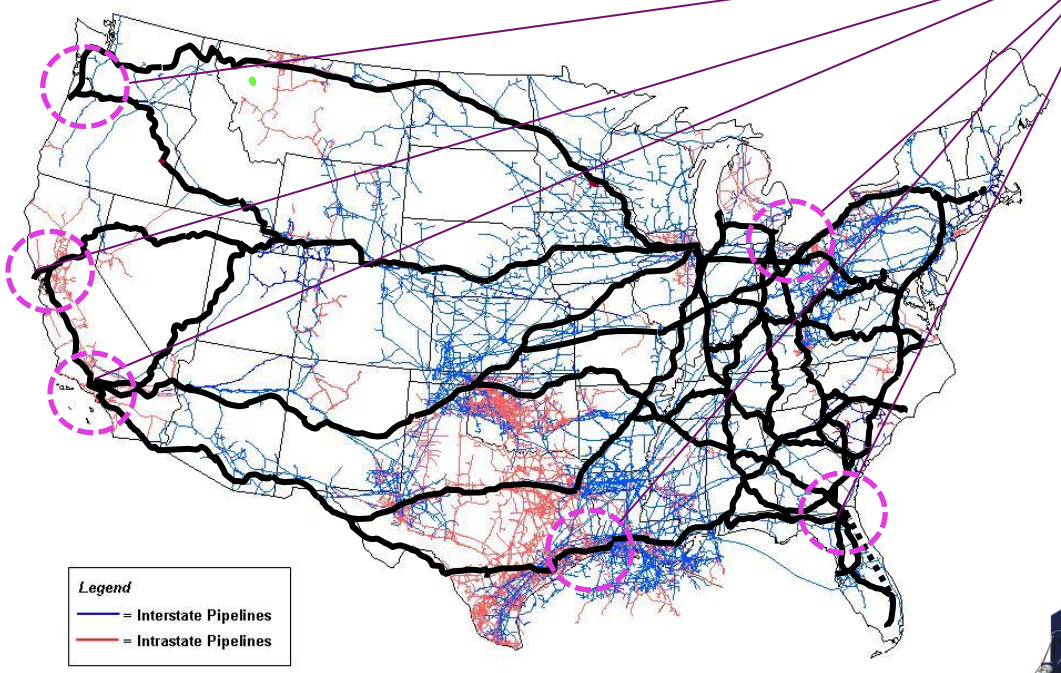
Growing potential for gas/ heavy transport network synergies

Linking physical networks

Rail + natural gas + trucking

Micro-LNG plant

Natural gas liquefaction plant producing up to 250,000 gallons per day



Sources: EIA, Office of Oil & Gas and CSX, 2013

Strategically located liquefaction plant investment of $15 to $20 billion could displace up to 30% of transport diesel

Fueling infrastructure a key to linking networks

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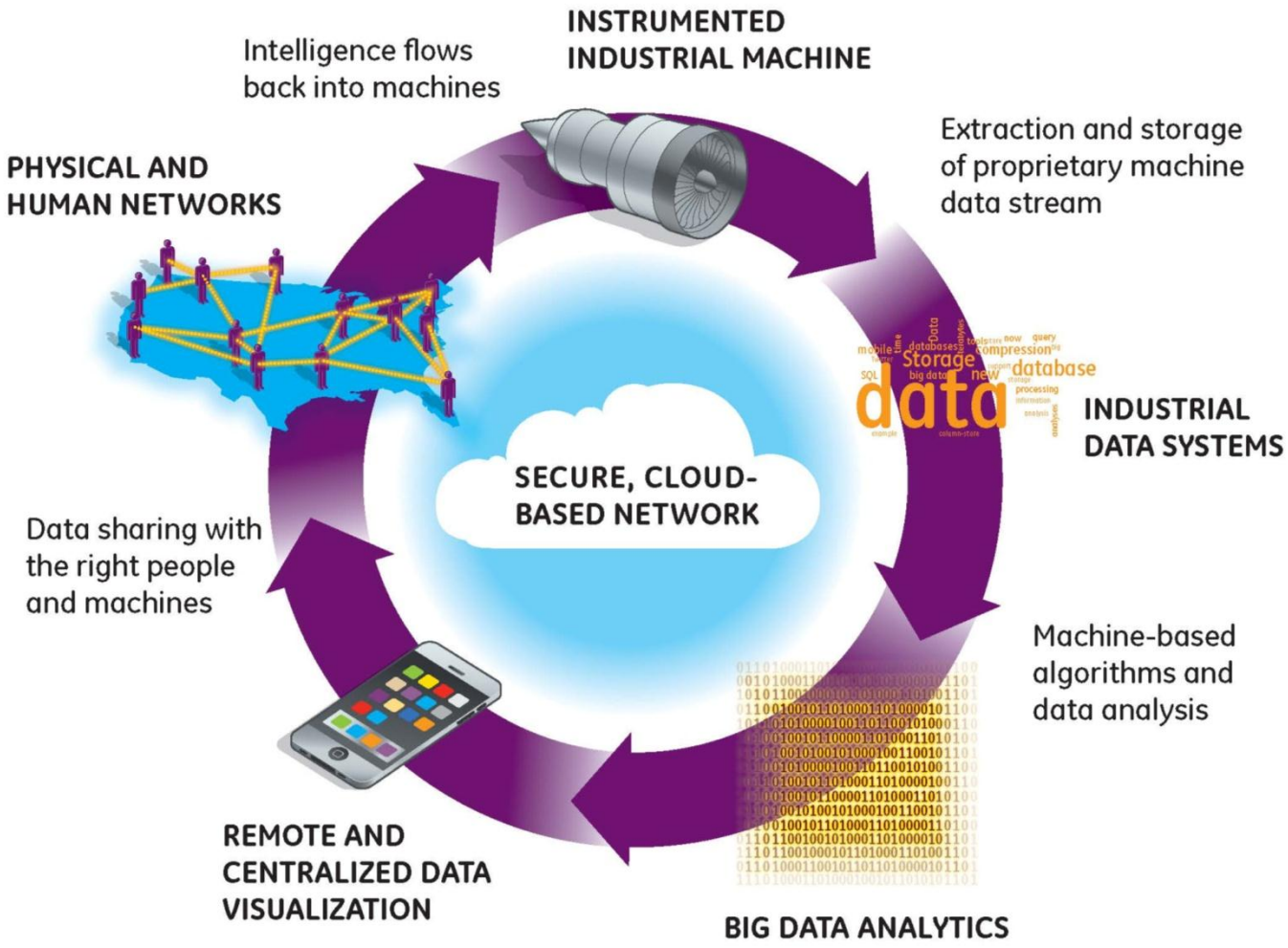
Digital networks

Expand and harness the Industrial Internet



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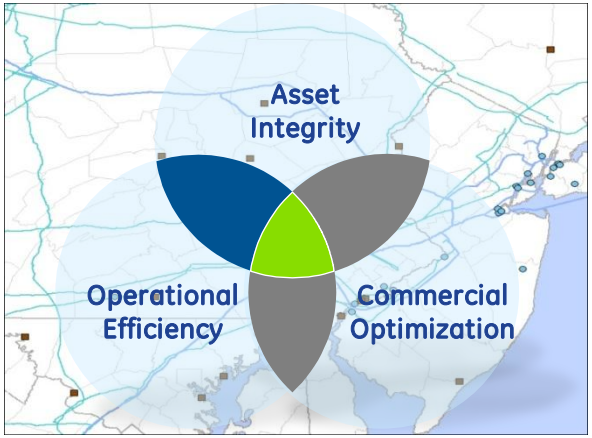
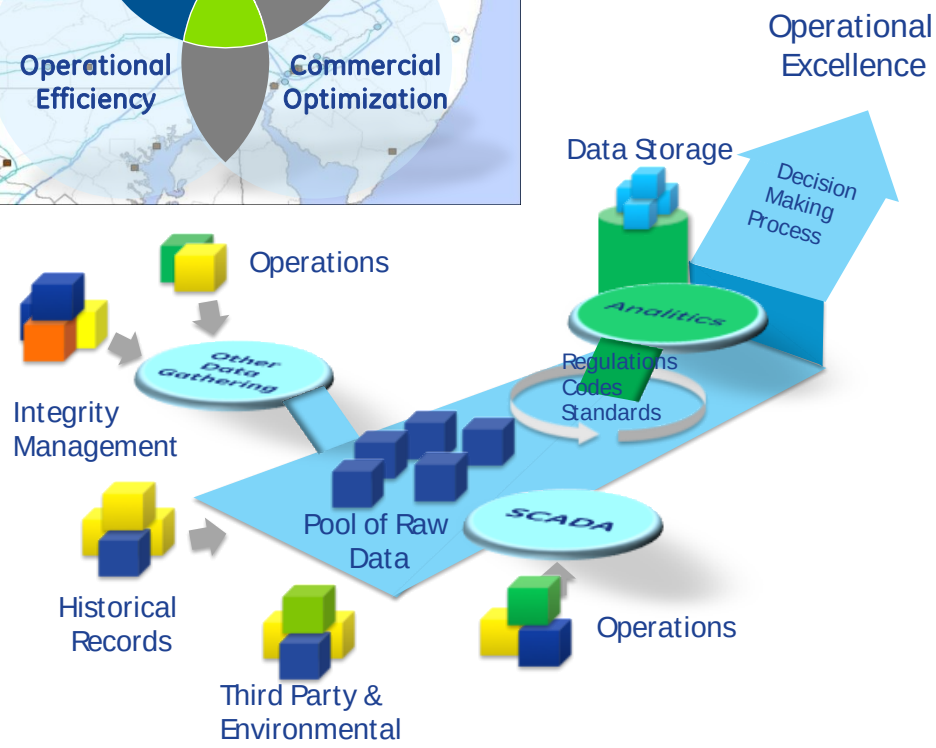
Intelligent pipelines

Digital integration with gas networks





Benefits

- ✓ Integration of operations, integrity, and commercial data streams
- ✓ Enhance opportunities for predictive maintenance
- ✓ Situational awareness and rapid response to incidents
- ✓ Monitoring, diagnostics and prognostics

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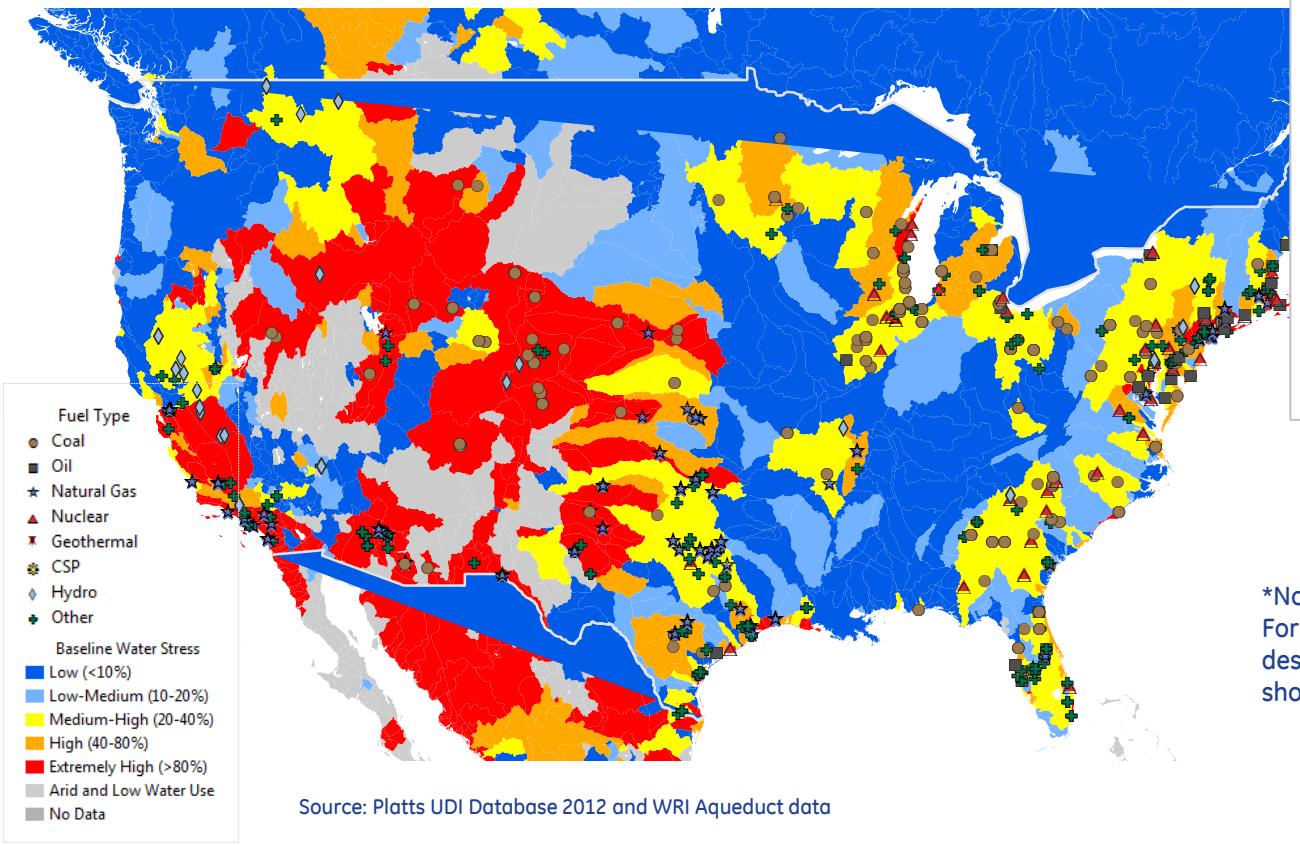
Energy-water stress nexus

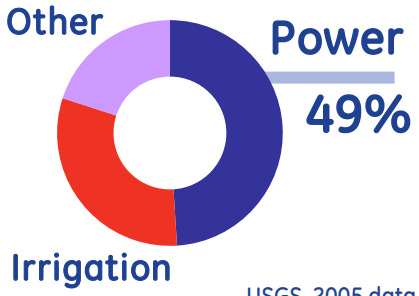
US water-dependent power generation units in regions of medium to extremely-high stress



Source: Platts UDI Database 2012 and WRI Aqueduct data

US Water Withdraws

410 BGD



USGS, 2005 data

*Notes: Includes thermal and hydro plants. For visualization purposes, plants with design capacity less than 100 MW are not shown.

~4,000 units are in areas of medium to extremely-high water stress

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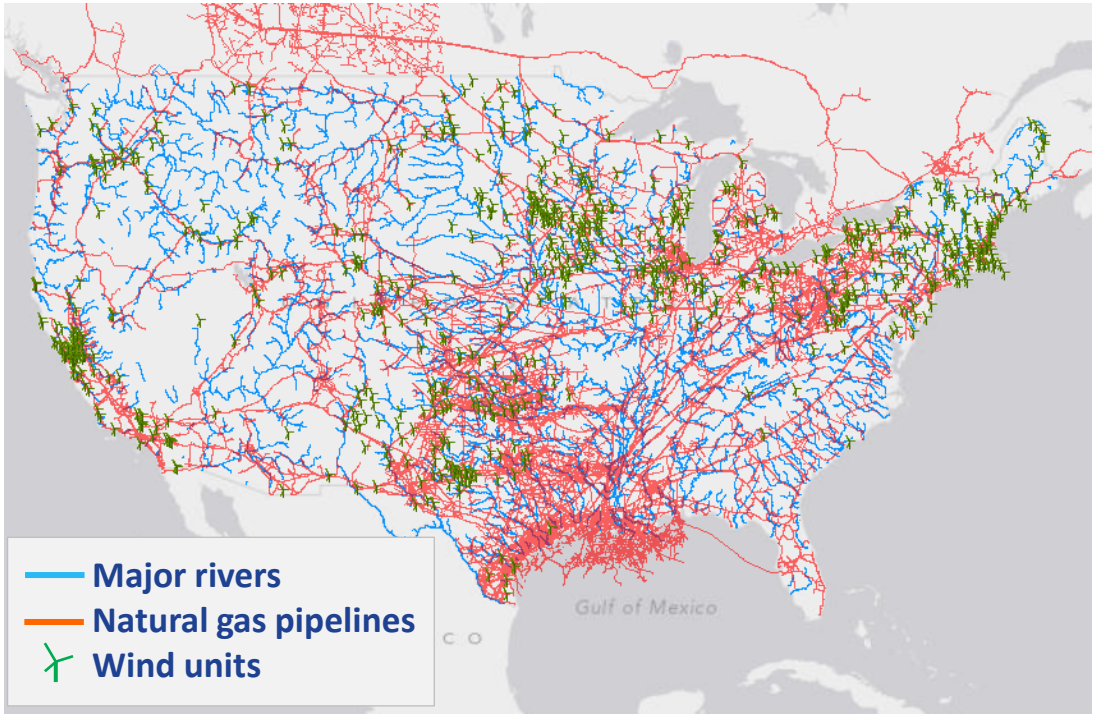
Linking networks for sustainability

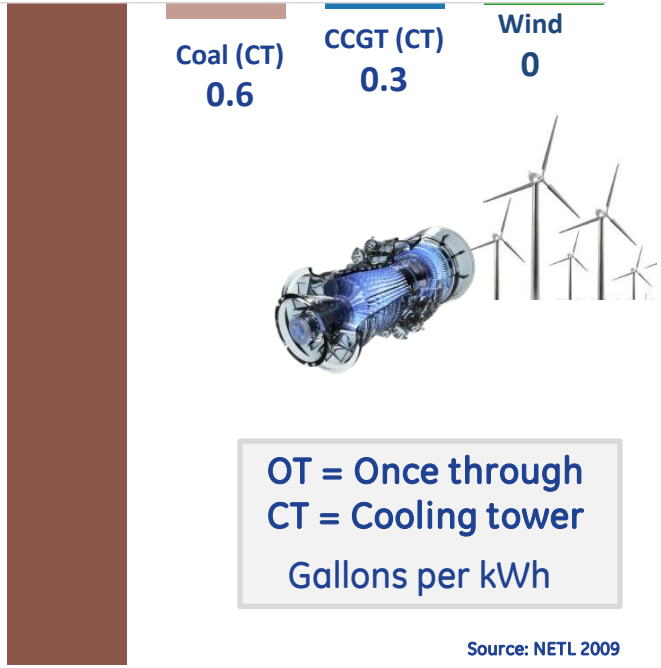
Benefits of gas and wind complementarity

River networks/ Gas Pipelines / Wind



Source: USGS, IHS Midstream, Platts UDI 2012

Power Gen Water Cooling Requirements



OT = Once through
CT = Cooling tower

Gallons per kWh

Source: NETL 2009

Smart gas + wind network deployment can reduce stress

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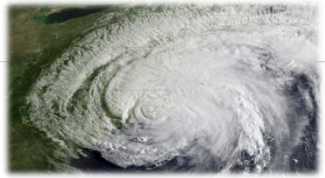
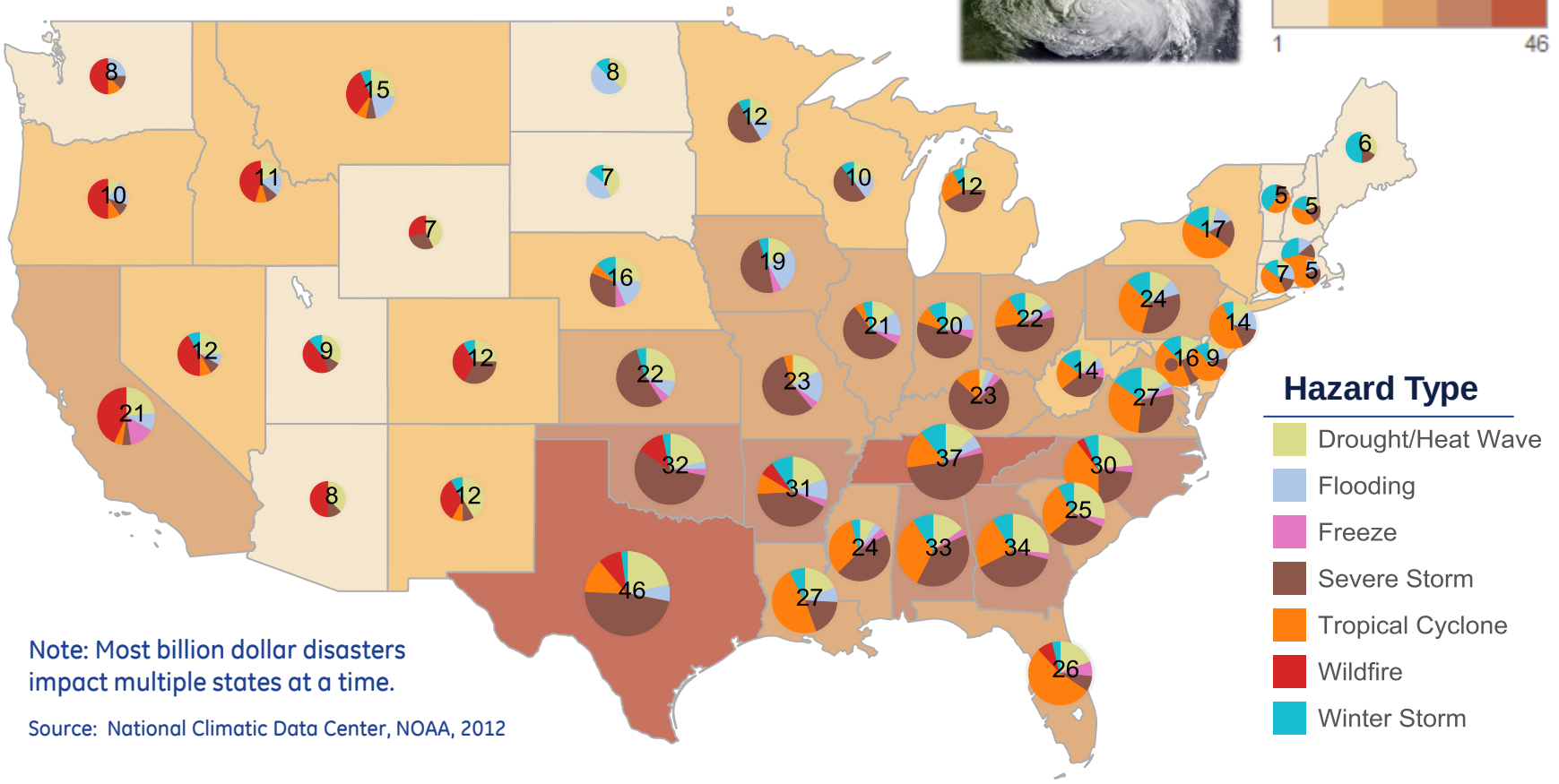
US billion dollar weather disasters

Number and type by state, 1980-2012





Note: Most billion dollar disasters impact multiple states at a time.

Source: National Climatic Data Center, NOAA, 2012

Total number = 144; total cost to US economy = $1 trillion

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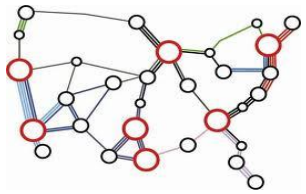
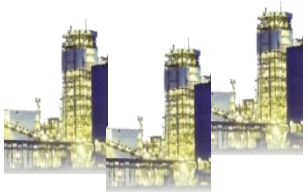
Building energy system resilience

How to **minimize disruption** + quickly **restore** basic functions

1. Diversification
2. Intelligence
3. Couple / decouple
4. Pooling/ coordination
5. Redundancy



Networks



Fleets

Facilities

Machines

Gas technology + gas network

Maintaining reliable operations at JFK airport; over 9 million passengers per year/ 31,000 flights

Combined Heat and Power (CHP)

2 x GE LM 6000s

74 MW plant

7,000 tons water

- ✓ Environmental friendly gas turbine or gas engine technology during normal operations (70-80% efficient)
- ✓ Ability to decouple ("island") from the grid during disruptions and to continue providing heat & power

Resilient sustainable infrastructure

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Harnessing the power of networks

Natural resource endowments + network endowments

National competitive advantage

- Policy should recognize that the US is rich in physical and digital networks
- The surge in gas production opens up new opportunities to further integrate networks to support new levels of national economic competitiveness

Environmental sustainability

- Harnessing network synergies can lower environmental externalities
- In addition to reducing emissions, harnessing the complementary relationship between gas and wind can reduce energy-water stresses

Resilience

- The cost and frequency of natural disasters are on the rise
- Investing technologies like CHP can advance regional and national resilience

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