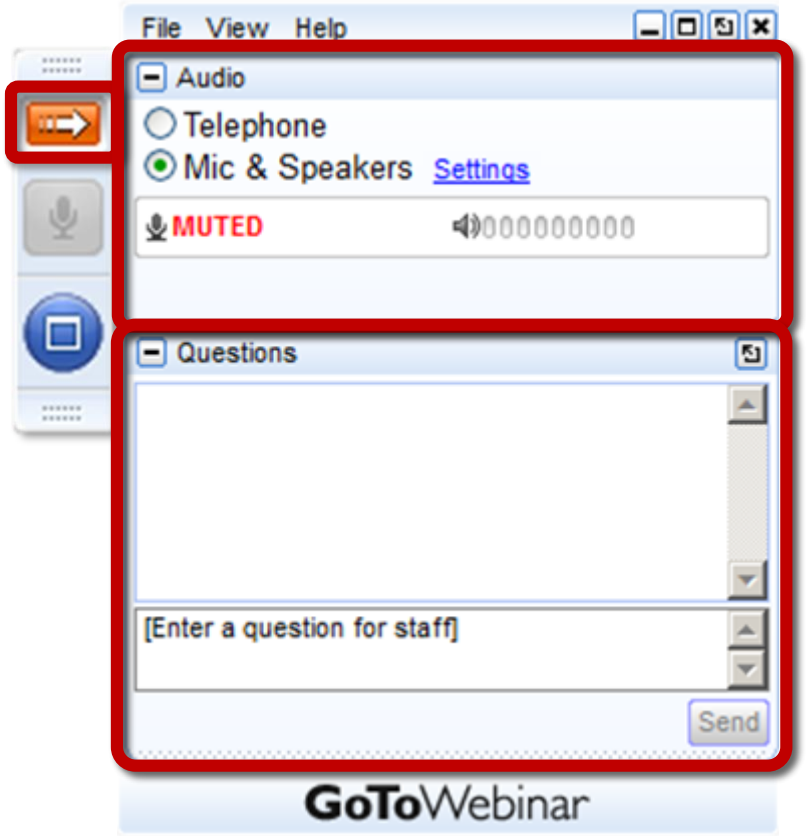
100% Clean Energy Collaborative Webinar

Power After Carbon: Findings and Insights for State Policymakers

September 9, 2020

CleanEnergy States Alliance

Webinar Logistics



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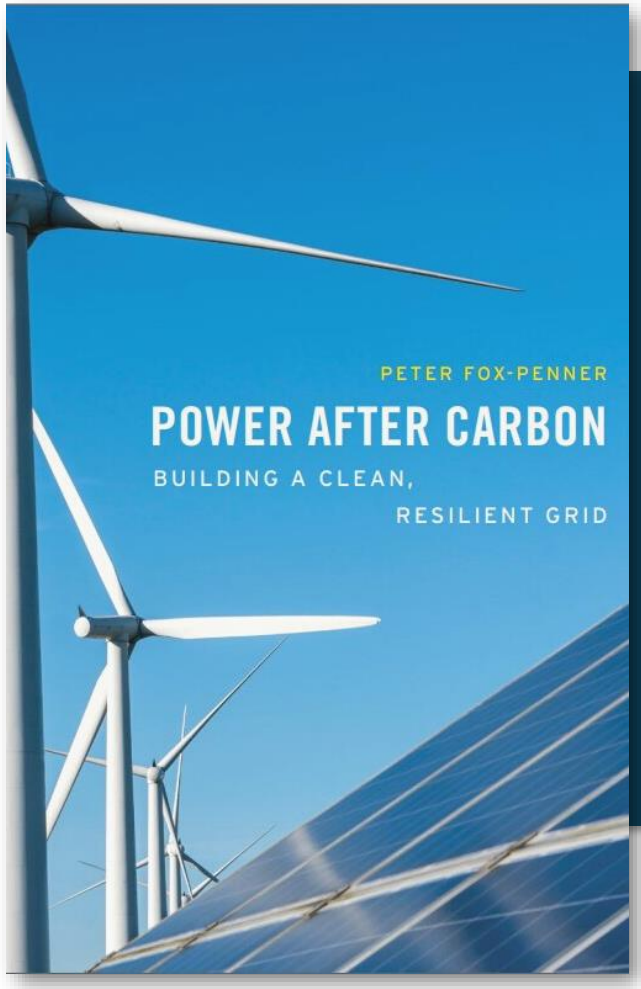
Webinar Speakers

Peter Fox-Penner
Founder and Director, Boston University's Institute for Sustainable Energy and Professor at the BU Questrom School of Business

BOSTON UNIVERSITY
Institute for Sustainable Energy

Warren Leon
Executive Director, Clean Energy States Alliance (moderator)

CleanEnergy States Alliance



PETER FOX-PENNER

POWER AFTER CARBON

Building a Smart, Clean and Resilient Power Industry

Presented to:

Clean Energy States Alliance Webinar

September 9, 2020

BU
Boston University Institute for Sustainable Energy
THE Brattle GROUP

Part I

Electricity’s Role in Climate Solutions

The Climate Crisis

At the current rate of warming of 0.2°C per decade, the planet will likely reach the lower target of 1.5°C by as early as 2030

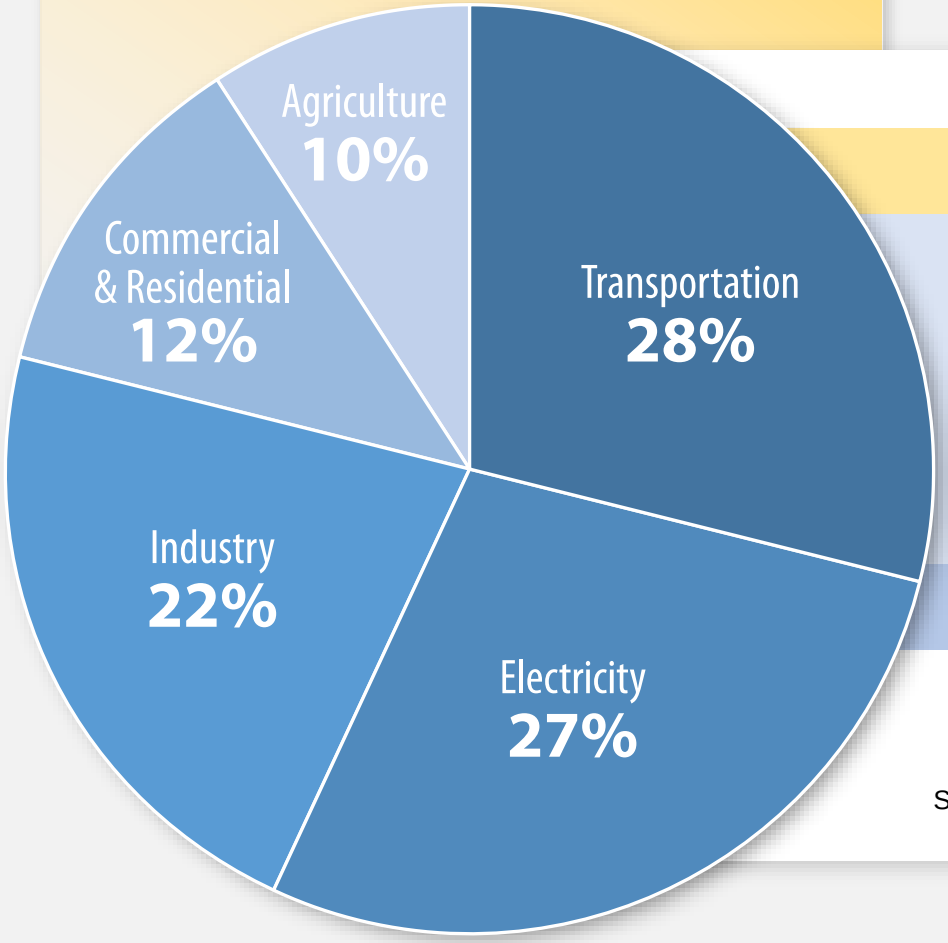
Arctic warming 2-3x faster than global average;
its sea ice is declining at a rate of 12.8% per decade

US CO_2 emissions from fossil fuel combustion rose 2.7% in 2018, fell 1.9% in 2019

Power sector emissions are down 29% from 2005 levels

Sources of Greenhouse Gases By Sector - US

Total U.S. Greenhouse Gas Emissions
By Economic Sector in 2018



In millions of metric tons of CO2e:

- Transportation: **1,869.5**
- Electricity: **1,803**
- Industry: **1,469**
- Agriculture: **667.7**
- Commercial & Residential: **801.2**

- **Total Emissions in 2018: 6,677**

*Percentages may not add up to 100% due to independent rounding.

Source: EPA https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

Energy-Climate Strategy for the Developed World: Efficiency + Clean Electricity + Clean Fuels

Accelerate energy efficiency

Electrify most transportation

Electrify most building heat

Electrify some industrial processes

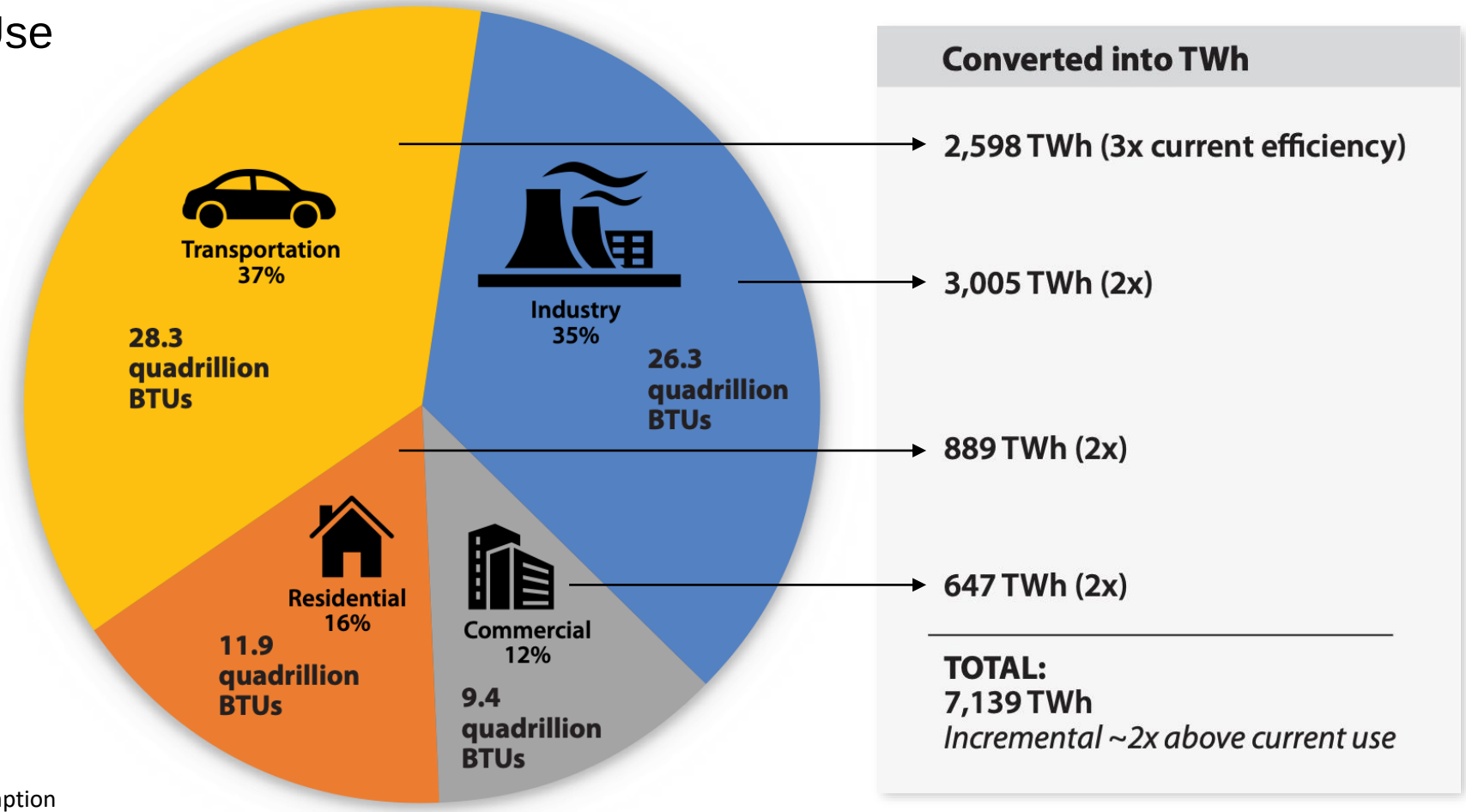
And the key:

A large enough power system
-- and clean gas/liquid fuels

- ✓No carbon
- ✓High resilience and reliability
- ✓Affordable and financially feasible

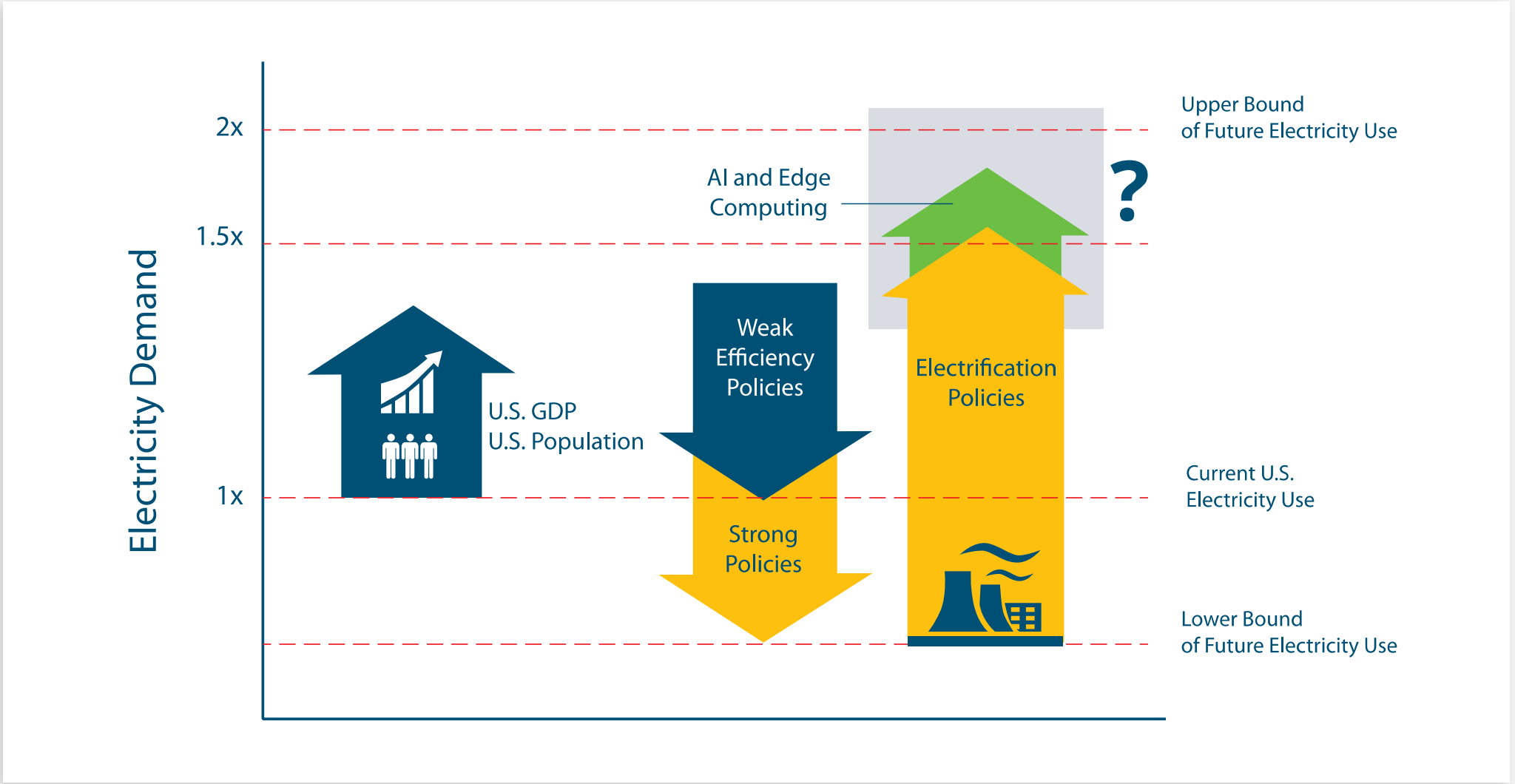
The Upper Regions of “Electrifying Everything”

U.S. Energy Use 2018

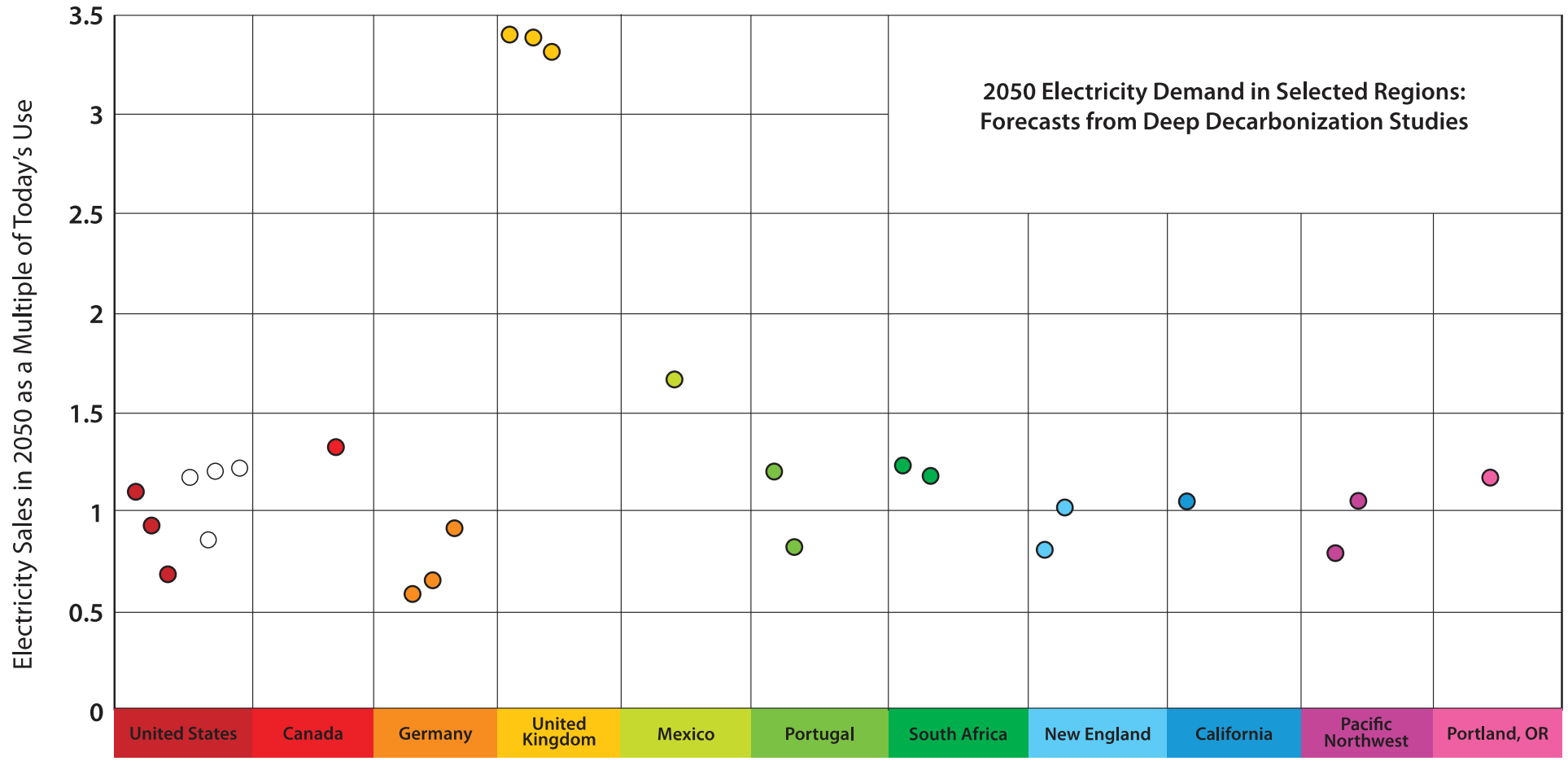


Source: EIA, U.S. energy consumption by source and sector, 2018.

How Much Power Will We *Really* Need?

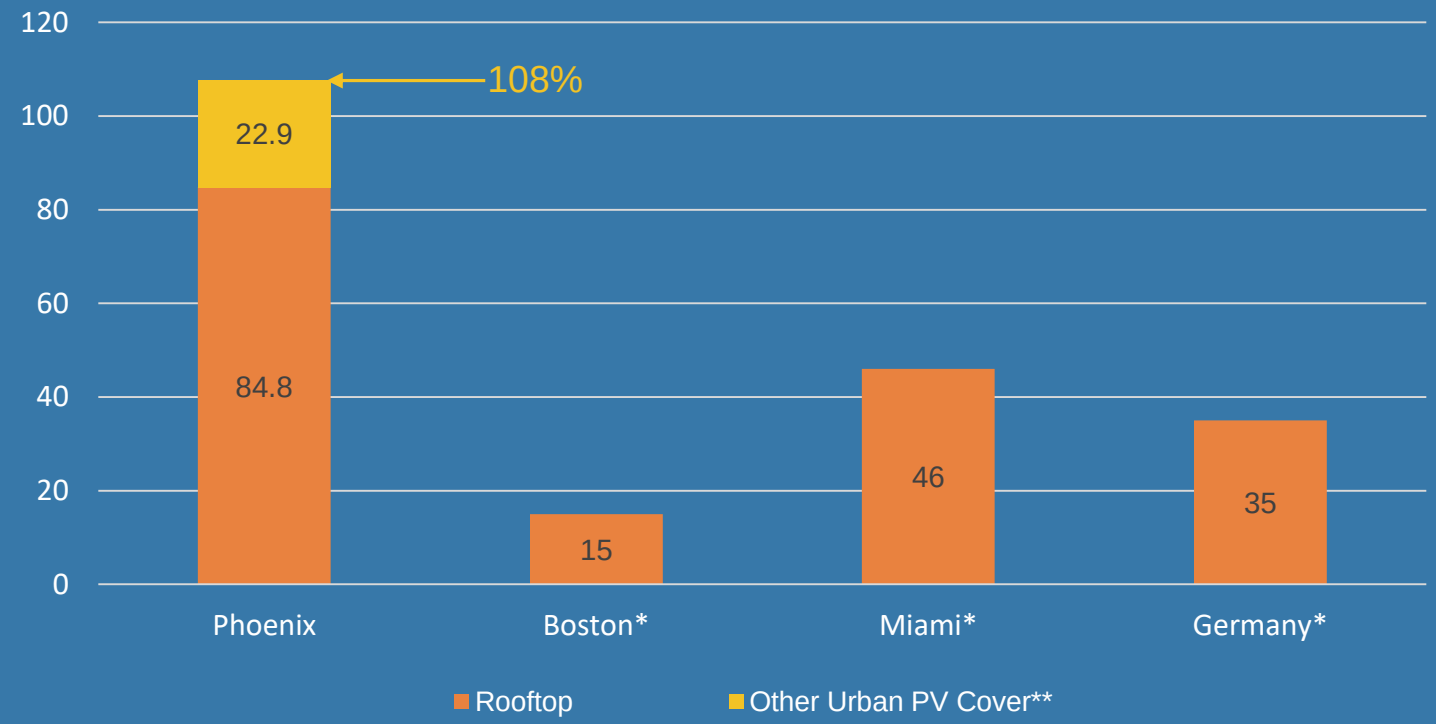


Power Increases in Deep Decarbonization Studies



How Much Electricity Can Distributed Sources Contribute?

% of city power use available from rooftops



23%

To power an all-solar Phoenix, current storage would need to occupy 23% of the city's land

Source for Germany: Mainzer et al, Solar Energy 105:715-731, p. 726.

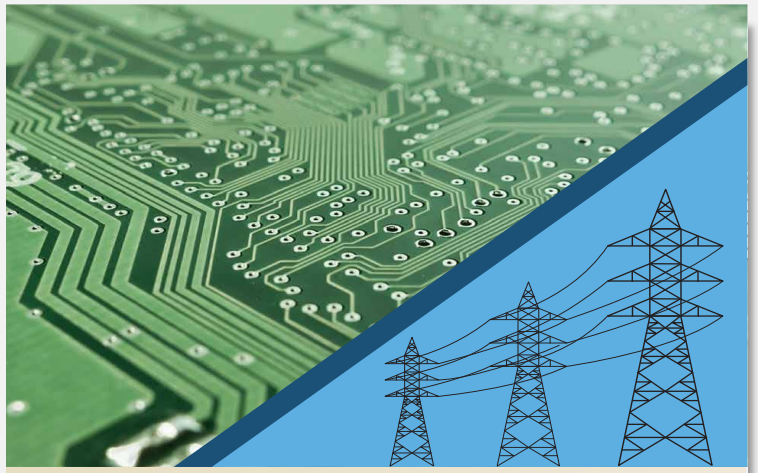
Part II

The Big Grid

How Large Power Grids Enable Cheaper Decarbonization

- Scale effects in power production and delivery
- Aggregated loads are “smoother” -- cheaper to serve
- Natural geographic diversity of wind & solar;
- Benefits of trading power
- Lower costs of preventing/repairing large blackouts

The Big Grid Faces Big Challenges



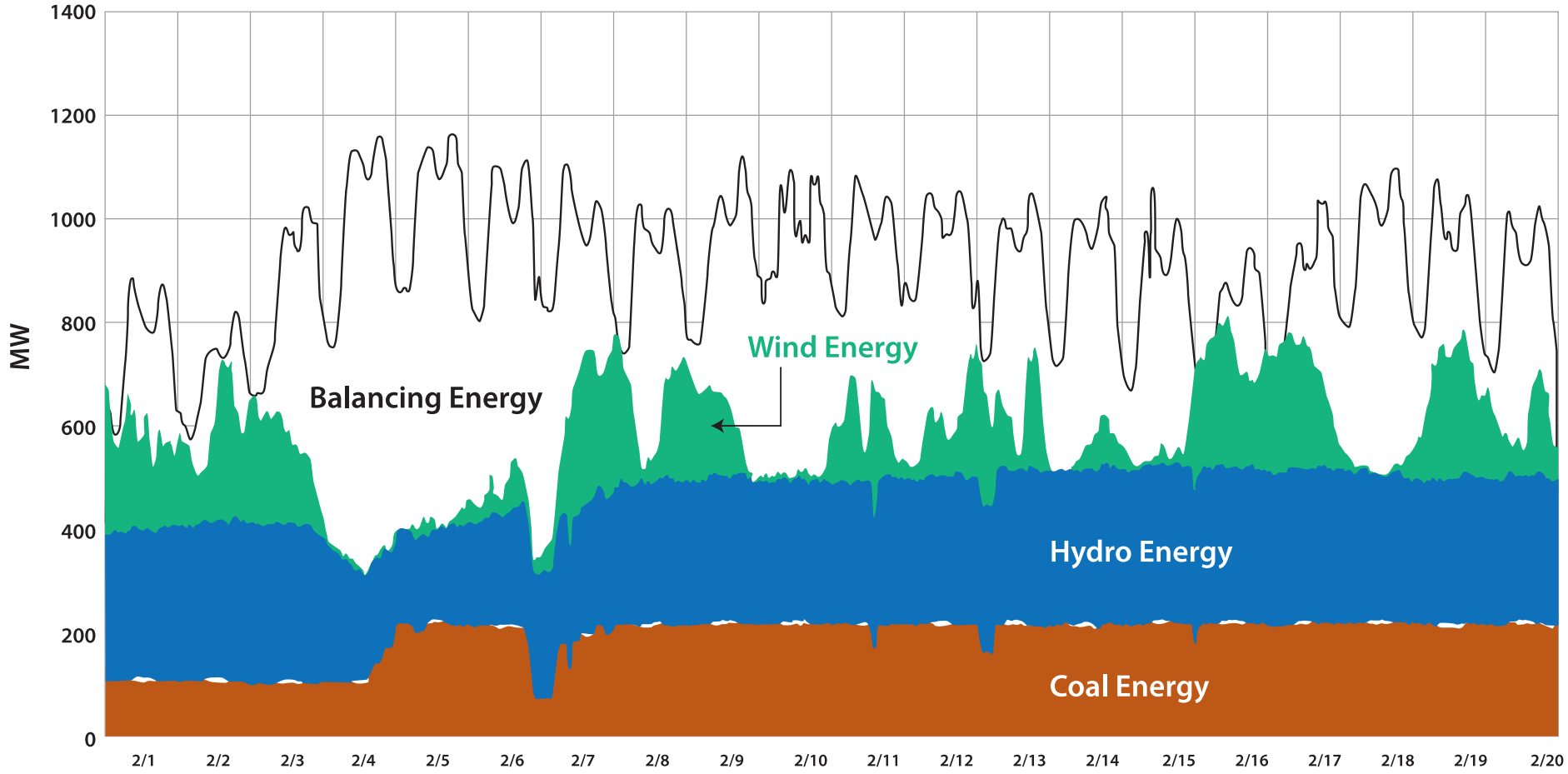
Large Grids Will Be Vulnerable to Strong Political Localization and DG Breakthroughs

Large Grids Must be Resilient to Climate and Other Disruptions (ex: PG&E) – Key Industry Priority

Large Grids Must be Built to Minimize Environmental Damage and Maximize Shared Benefits

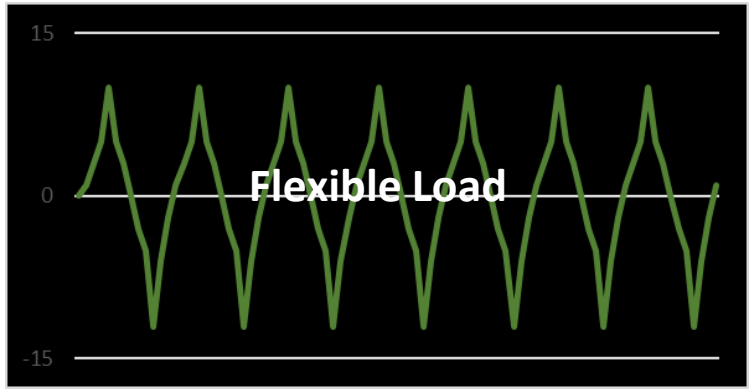
And the Biggest: Large-Scale Energy Balancing

Hourly Generation and Load for NorthWestern Energy – Feb. 2019



Source: NorthWestern Energy (2019), used by permission

Supply Side of A Carbon-Free Big Grid



What's Not Working Well Enough on the Big Grid?

- **More Large Storage Needed.** Hydroelectricity challenged; Battery and hydrogen storage too expensive → Continue R&D and diversify options
- **Demand response** potential is huge but highly variable and mechanics are complex → Market and regulatory reforms
- **Transmission** is underplanned and underbuilt → Regional energy planning
- **The financial mechanisms** for getting Big Grid facilities built aren't working well enough to meet carbon targets → Reform power markets

The Power Market Reform Debate in One Slide

The Four Schools of Thought on Reconciling Strong Climate Policies and Capacity Markets

Carbon Pricing is Essential

All-of-the-Above
Price carbon and make better capacity markets, but allow contracts and other climate policies

Maximize Markets
Capacity markets, carbon pricing and energy reforms should all be pursued in an integrated way.

Don't rely only on capacity markets

Prioritize capacity market prices to induce new plant

Policies Plus Markets
Allow bilateral contracts and enforce climate policies through measures such as RPS, electrification mandates, etc.

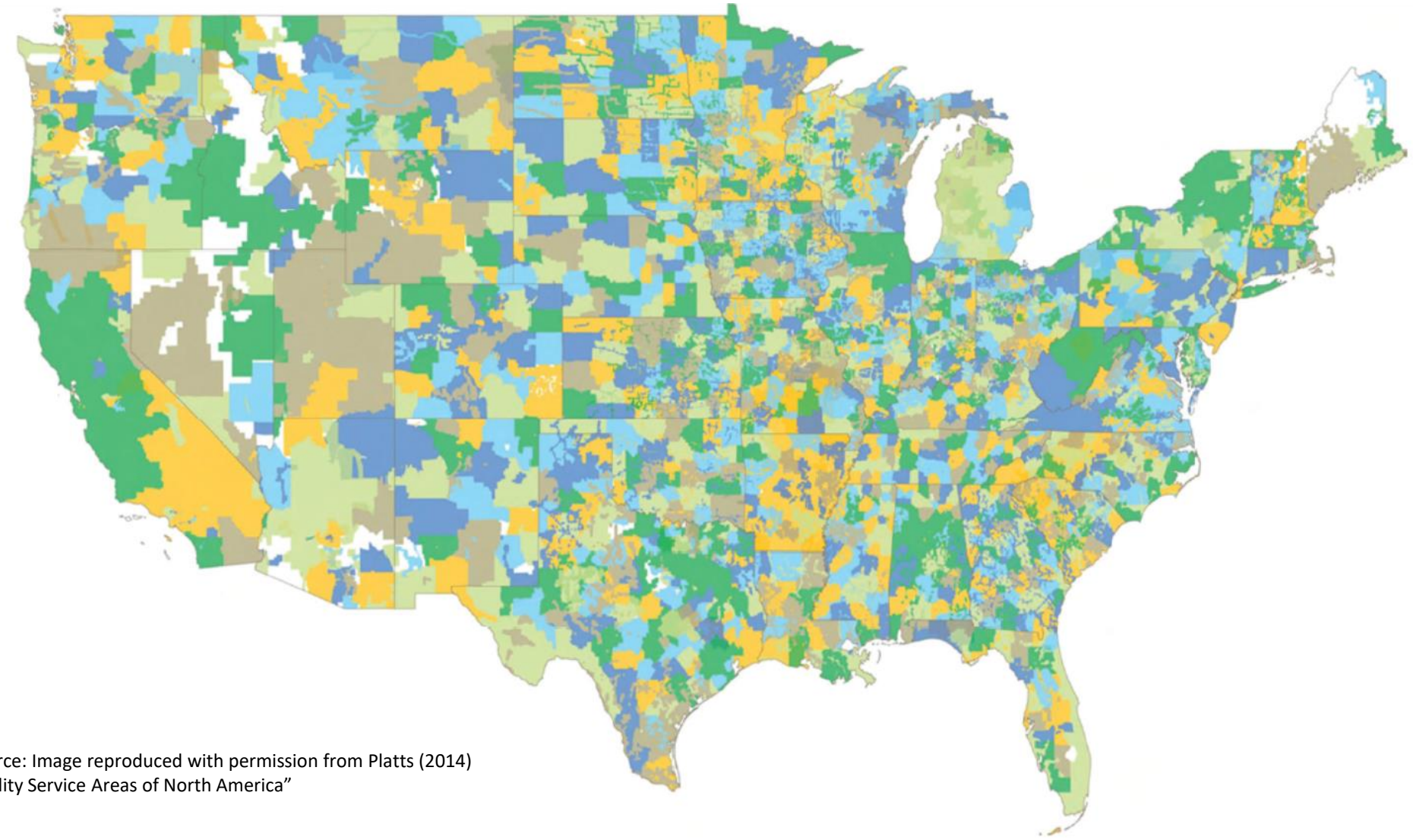
Better Capacity Markets
Capacity markets should be disaggregated into attribute markets even if carbon pricing isn't part of them

Carbon Pricing isn't adequate (or not likely)

Part III

The Retail Sector and the Utility of the Future

Distribution Utilities in the United States



Source: Image reproduced with permission from Platts (2014)
"Utility Service Areas of North America"

Business Pressure on Distribution Utilities

Low-to-Negative kWh Deliveries (Short Run)

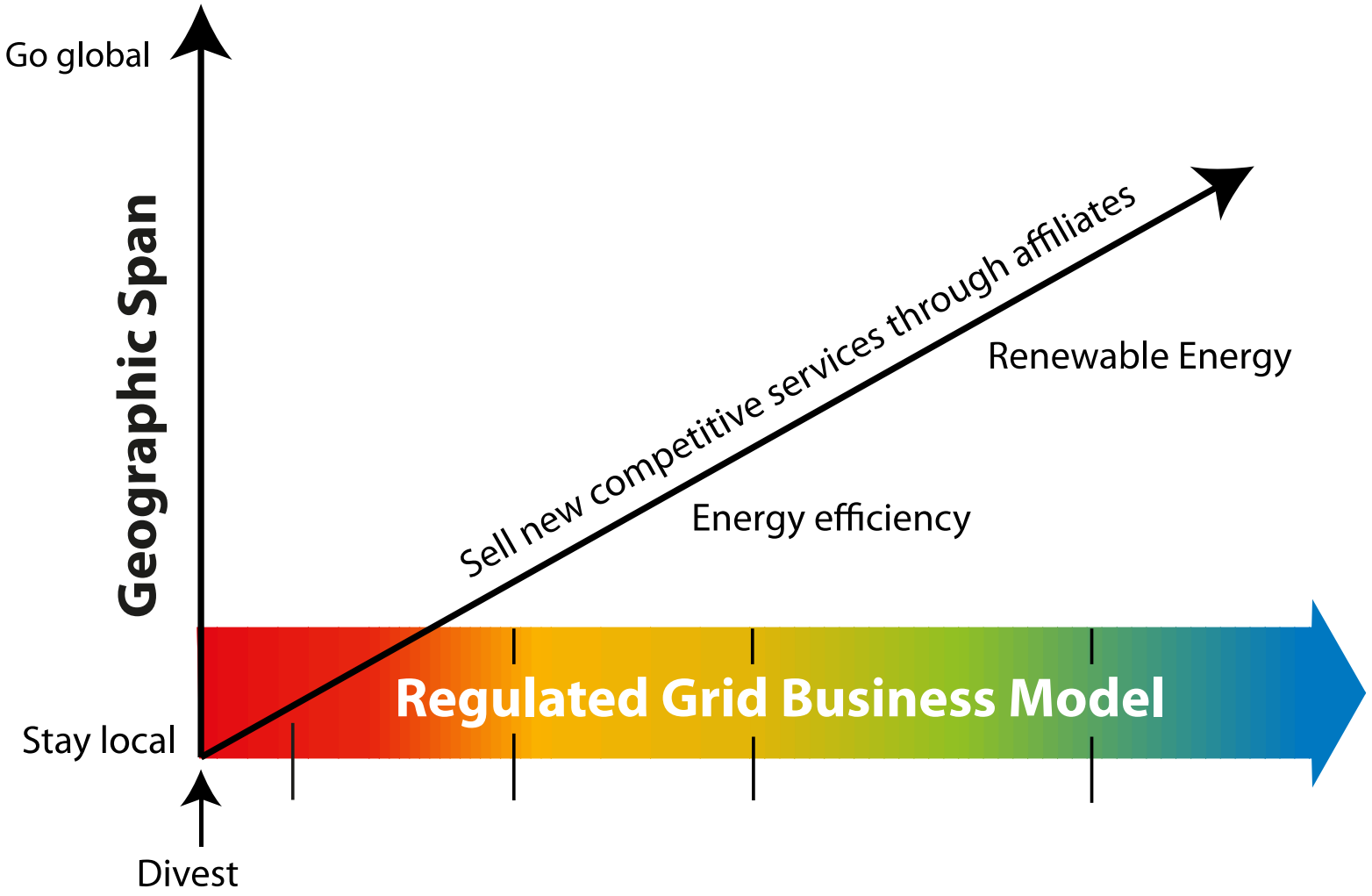
Increased Capex to Build Smart, Resilient Grid

Far More Complex and Demanding Operating Environment

- Severe Weather Events
- Accommodate DG/DR
- Customer service expectations

Risk of Fragmenting into Microgrids and Other Defections

Dimensions of Distribution Utility Strategy



The Regulated Grid Business Model Spectrum

Rare thus far and not recommended

Exit the distribution business entirely

Passive Distribution

Distribution utility owns but does not operate its own system—instead operated by independent DSO

Smart Integrators

Utilities that continue to serve as platforms and network orchestrators, but have stepped back from being the primary branded transactor with customers

Hybrid Business Models

Not the primary provider of services, but an integral, engaged partner in delivering energy services from other providers

Energy Service Utilities

Sell the full range of energy services to customers, mainly from closely-associated partner companies

Electrification: An Essential Frontier

- Transportation electrification: Strong market support
- Building Thermal Decarbonization: Public and private capital and strong policies
- Industry – specific RD&D collaboratives

Summary

Energy efficiency should be maximized, but this takes real work

A completely clean power industry ~ 50% larger is necessary and achievable

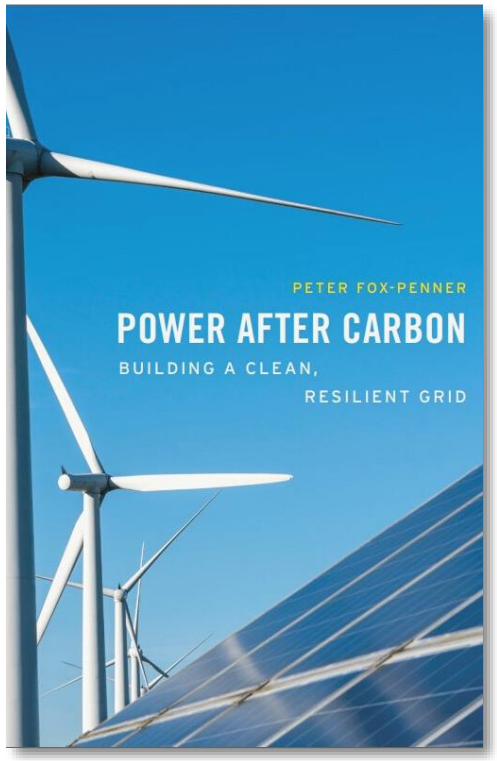
Decarbonized Big Grids need storage, regional planning and reformed markets

The downstream sector needs PBR, new business models and dynamic pricing

Cost-effective electrification of transport, heat, and industry needs action NOW

This is a 20-year project. Full speed ahead!

Thank You!



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Please buy at bookshop.org

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CONFLICT OF INTEREST DISCLOSURE

Dr. Fox-Penner holds equity in Energy Impact Partners, a utility-backed energy investment and innovation firm, and consults for Energy Impact Partners and The Brattle Group on energy technologies. Dr. Fox-Penner also conducts research in areas of interest similar to the business interests of Energy Impact Partners and The Brattle Group. The terms of this arrangement have been reviewed by Boston University in accordance with its financial conflicts of interest in research policies.

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Thank you for attending our webinar

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https://www.cesa.org/projects/100-clean-energy-collaborative/

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Innovative Pathways to Developing Solar+Storage in Low-Income Communities: Norfolk Solar's Qualified Opportunity Zone Fund
September 10, 1-2pm ET

An Introduction to Virtual Power Plants
September 28, 1-2pm ET

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