scottmadden
MANAGEMENT CONSULTANTS

Smart. Focused. Done Right.®

ScottMadden's Energy Industry Update: Running Up That Hill

Webinar

November 19, 2020

scottmadden
MANAGEMENT CONSULTANTS

Smart. Focused. Done Right.®

Cristin Lyons

Partner

Cristin Lyons is a partner with ScottMadden and leads the firm's energy practice. Since joining the firm in 1999, Cristin has consulted with myriad clients on issues ranging from process and organizational redesign to merger integration to project and program management. Cristin led the firm's grid transformation practice for three years before becoming the energy practice lead. She is a frequent speaker and panelist at conferences across the country. Cristin earned a B.A. in political science and Spanish from Gettysburg College and an M.B.A. from the Cox School of Business at Southern Methodist University. She is also a member of Phi Beta Kappa.

Energy Is Who We Are

ScottMadden is a management consulting firm with more than 35 years of deep, hands-on experience. We deliver a broad array of consulting services—from strategic planning through implementation—across the energy utility ecosystem.

Our energy practice covers the following areas:

GENERATION

ENERGY MARKETS

TRANSMISSION & DISTRIBUTION

RATES & REGULATION

GRID EDGE

ENTERPRISE SUSTAINABILITY

scottmadden
MANAGEMENT CONSULTANTS

scottmadden
MANAGEMENT CONSULTANTS

Smart. Focused. Done Right.®

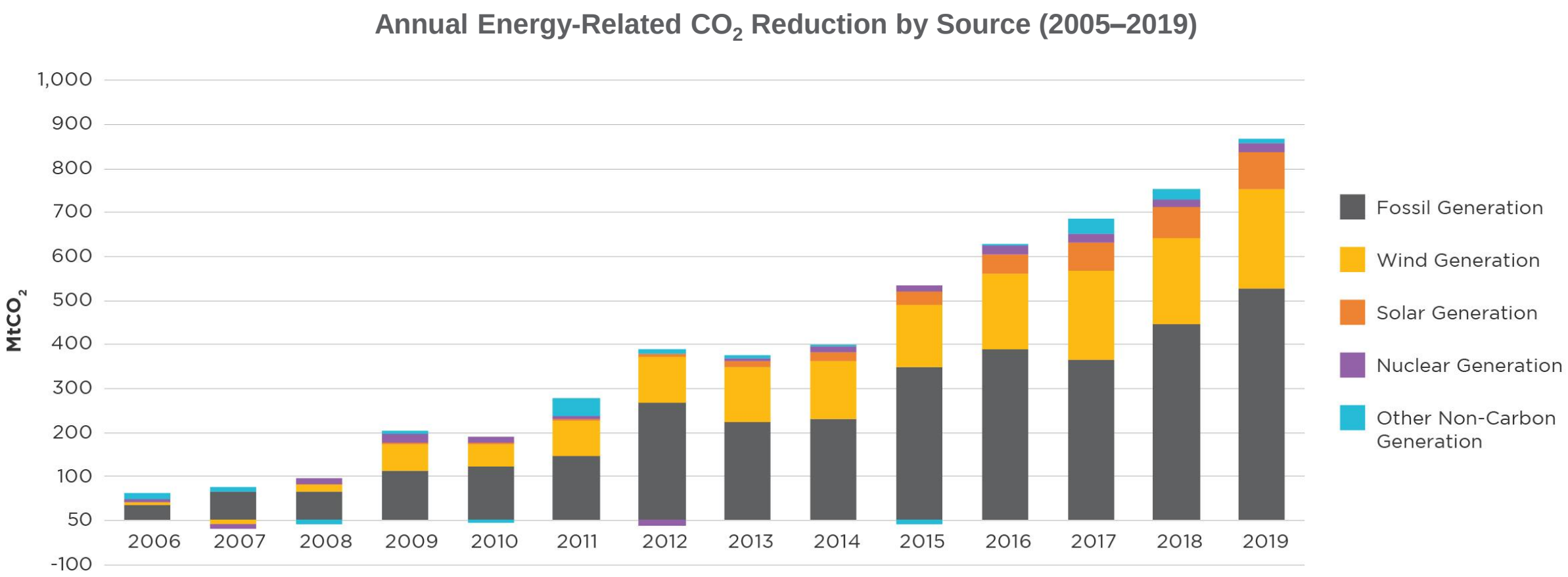
Tina Jeffress

Sr. Associate

Tina Jeffress joined ScottMadden as an associate in 2018 after receiving an M.B.A., with concentrations in energy and sustainable enterprise, from the University of North Carolina Kenan-Flagler Business School. In addition to her project work, she leads the firm's internal sustainability reporting and strategy. Tina interned with ScottMadden in the summer of 2017, working on the final stages of a multi-year operational excellence project within the nuclear division of a major utility. Prior to business school, Tina spent five years in the nonprofit sector, most recently leading research and corporate partnership initiatives at an international affairs think tank. Prior to this, she managed education and community development programs in the Dominican Republic. Tina earned a B.A. in international development studies and Spanish from the University of California, Los Angeles.

100% Clean Energy

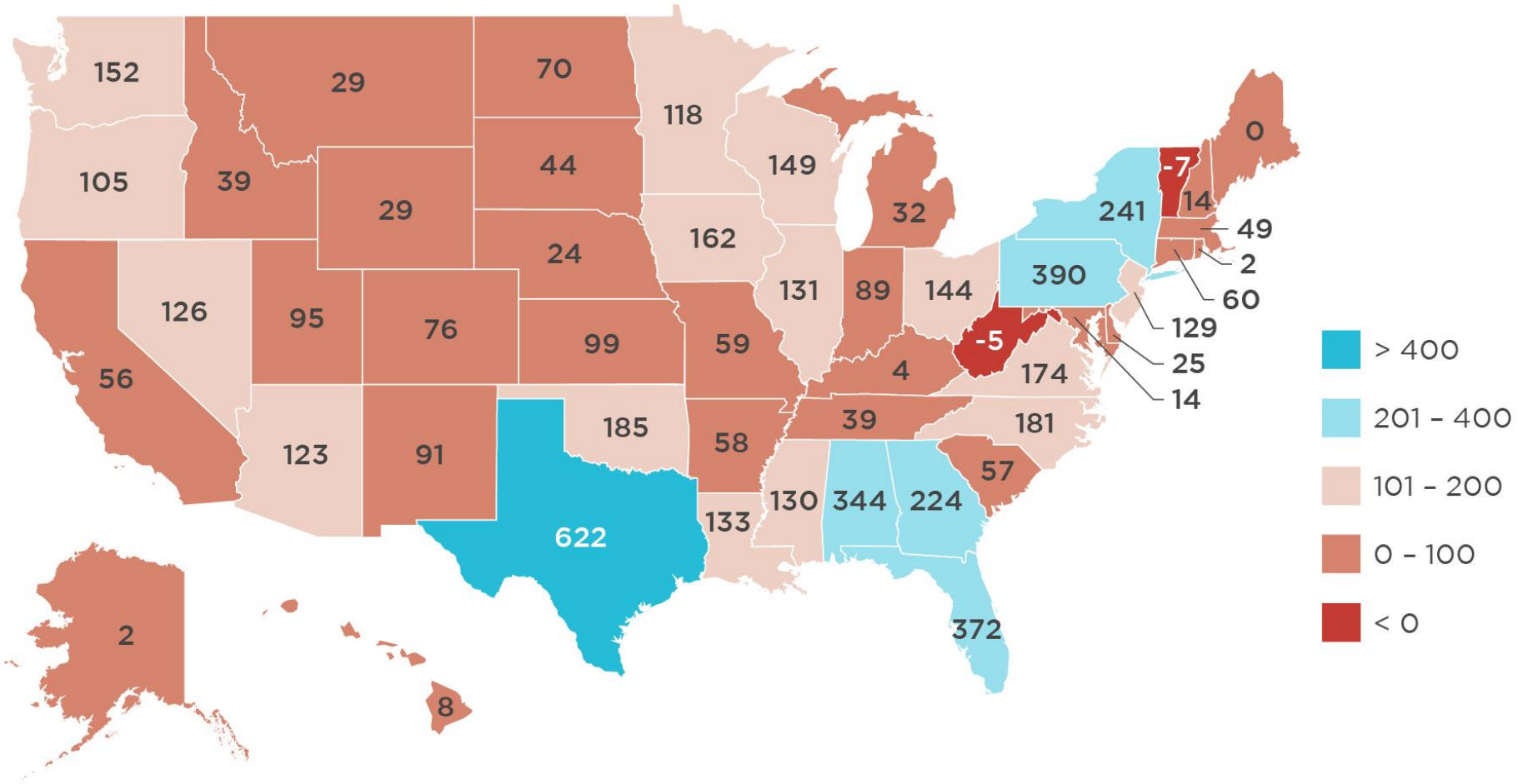
Natural Gas: A Major Source of Carbon Reductions



Sources: EIA; ScottMadden analysis

States Leading the Charge: Not Who You Would Think

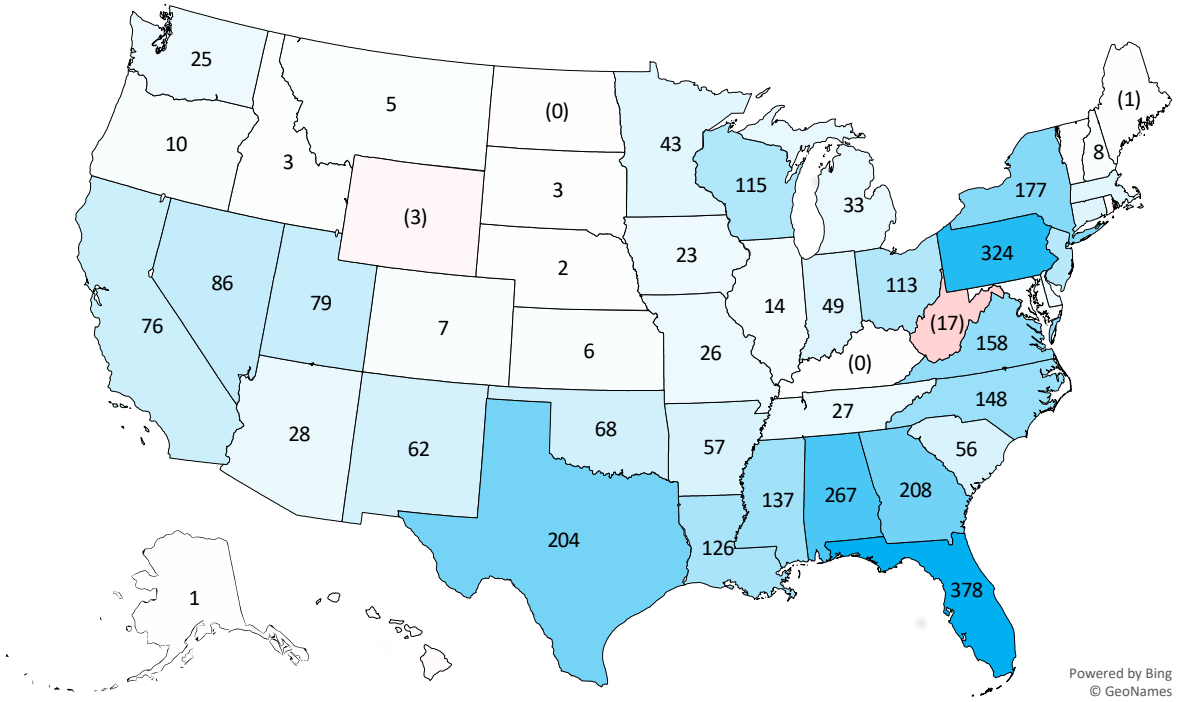
Cumulative Energy-Related CO_2 Emission Reductions by State (in $MtCO_2$) (2005–2019)



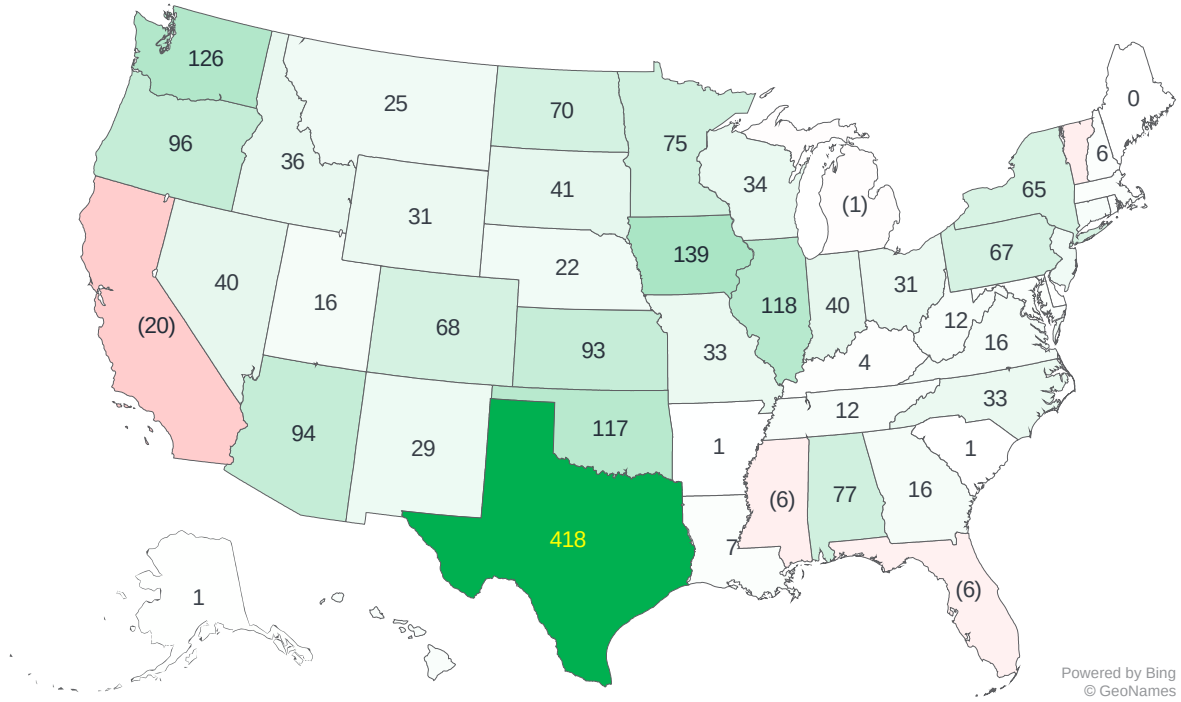
Sources: EIA; ScottMadden analysis

But How? Southeast Replaces Coal and Texas Builds Wind

Fossil Generation CO_2 Emission Reductions, 2005–2019 (in million metric tons)



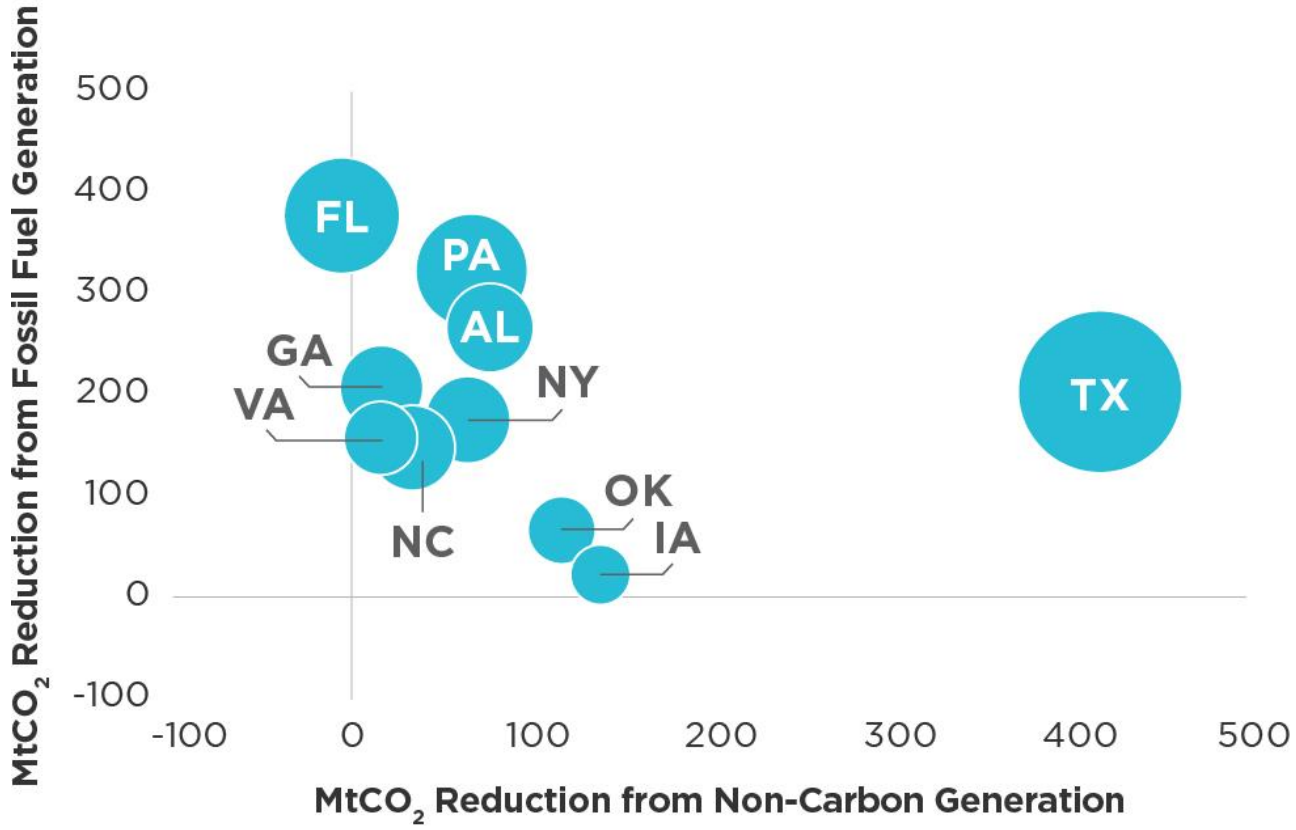
Non-Carbon Generation CO_2 Emission Reductions, 2005–2019 (in million metric tons)



Sources: EIA; ScottMadden analysis

Large States Drive Reductions; Natural Gas More Impactful Than RPS Policies

Top 10 States for Energy-Related CO_2 Reductions by Source (2005–2019)

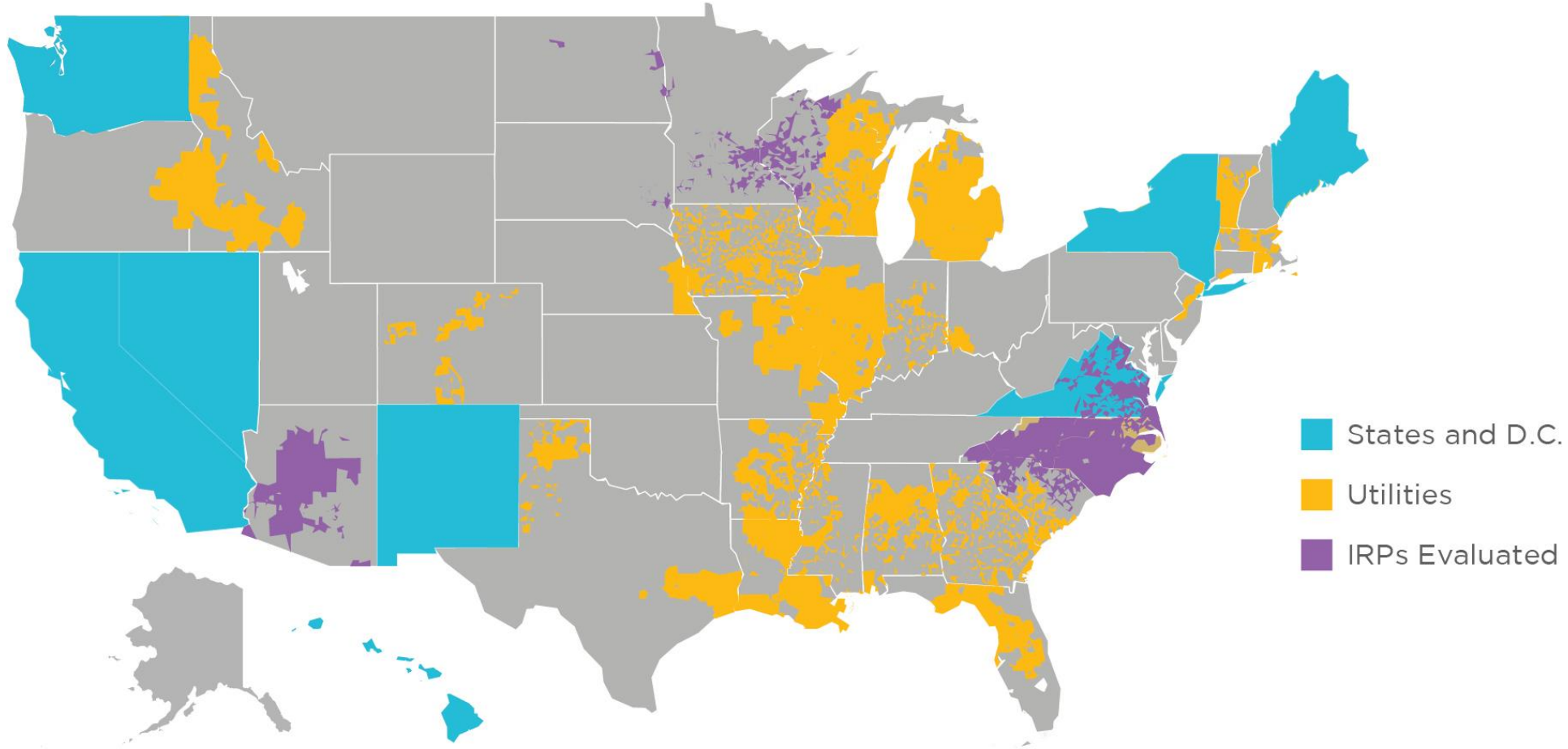


Note: Size of bubble reflects electric retail sales.

Sources: EIA; ScottMadden analysis

Our Approach

States and Electric Utility Service Territories with 100% Clean Energy Commitments



Sources: EIA; SEPA; Center for American Progress; Sierra Club; ScottMadden analysis; S&P Global

Key Findings: Results From Least-Cost Decarbonization Scenarios

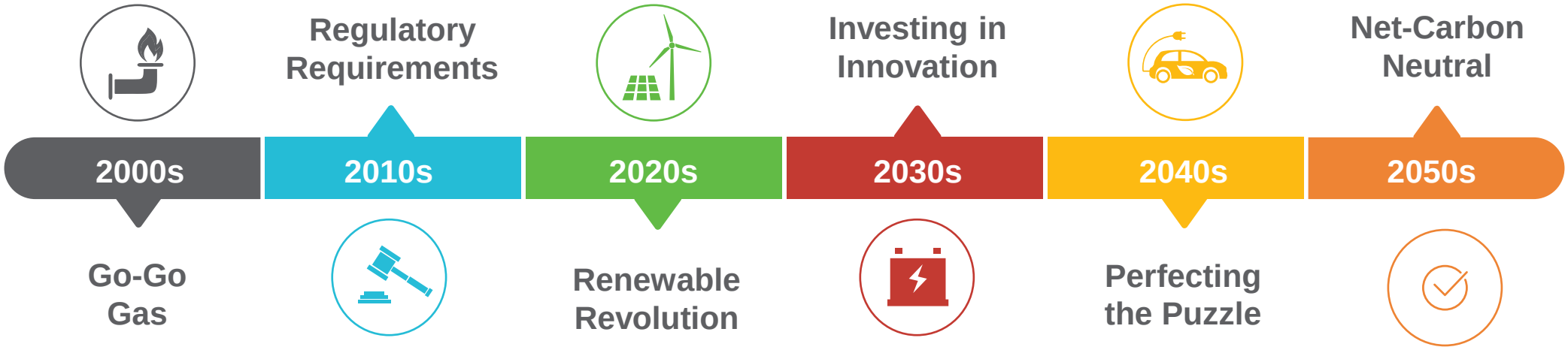
Planning for a Renewable Revolution

Natural Gas Remains Critical to Reliability

Decarbonization Costs Are Generally Lower Than Inflation

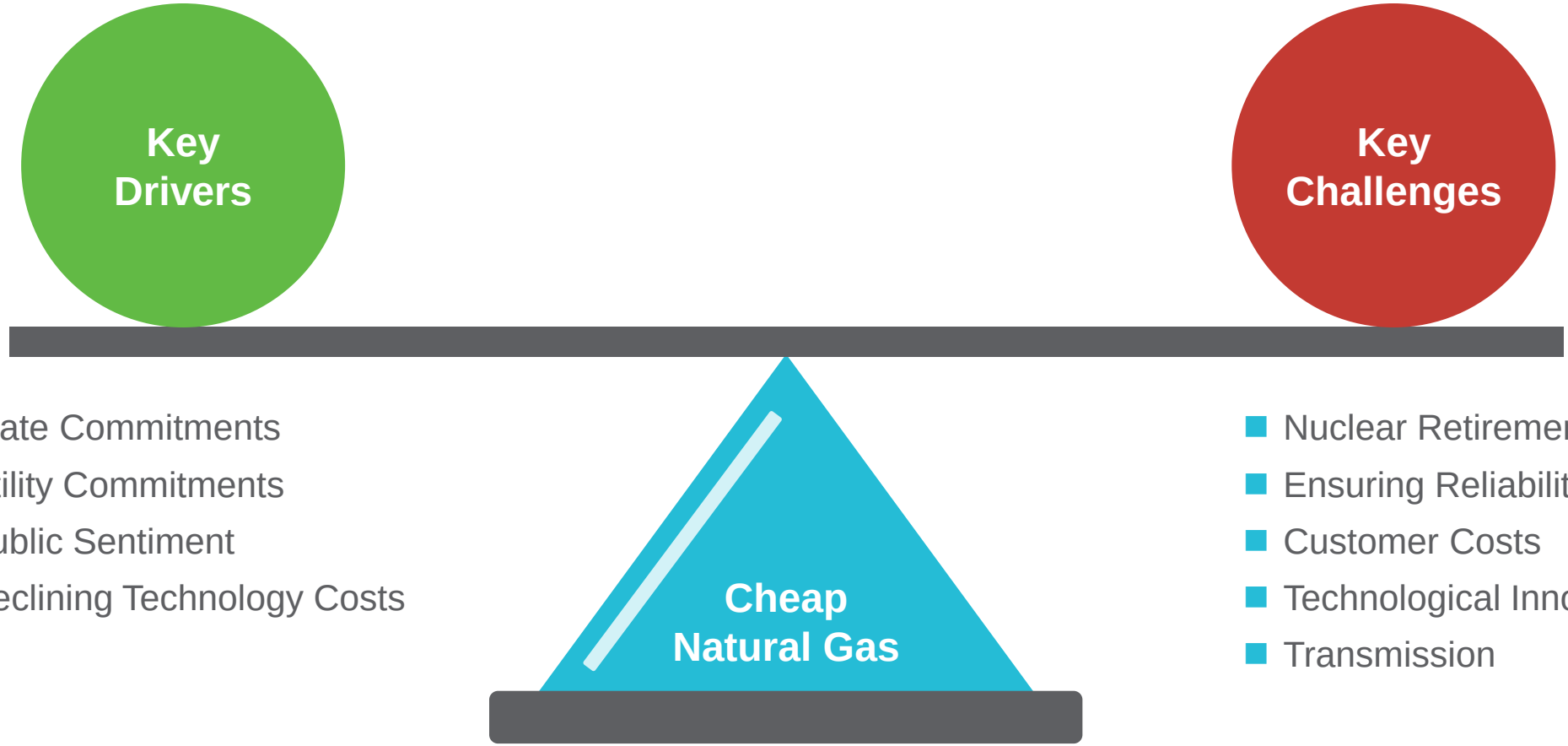
scottmadden
MANAGEMENT CONSULTANTS

Half a Century: The Long Journey to Net-Carbon Neutral



scottmadden
MANAGEMENT CONSULTANTS

Looking Forward: Key Drivers and Challenges



- State Commitments
- Utility Commitments
- Public Sentiment
- Declining Technology Costs

- Nuclear Retirements
- Ensuring Reliability
- Customer Costs
- Technological Innovation
- Transmission

scottmadden
MANAGEMENT CONSULTANTS

Key Takeaways

Carbon Emission: Where Have We Been and Where Are We Going?

Coal-to-Gas Shift

Since 2005, the shift from coal to natural gas drove the majority of energy-related CO_2 emissions reductions in the United States.

Scaling Up

Recent integrated resource plans from electric utilities pursuing 100% clean energy indicate the next step is to significantly scale up the deployment of renewable energy and battery storage capacity.

Technologies

Natural gas will remain an important resource ensuring reliability. This transition period will also require the development of new cost-effective technologies (e.g., long-duration storage, carbon capture, and sequestration) to ensure continued progress in the following decade.

scottmadden
MANAGEMENT CONSULTANTS

scottmadden
MANAGEMENT CONSULTANTS

Smart. Focused. Done Right.®

Steve Courtney

Manager

Steve Courtney joined ScottMadden in 2018. He has worked in the energy and utilities industry as a consultant and in corporate leadership roles for more than 25 years. His primary areas of expertise include competitive and regulated energy markets, electric transmission, power generation, and financial analysis and valuation. Steve earned an M.S. in management from Georgia Tech and a B.S. in mechanical engineering from North Carolina State University. He is a registered professional engineer and holds the chartered financial analyst designation.

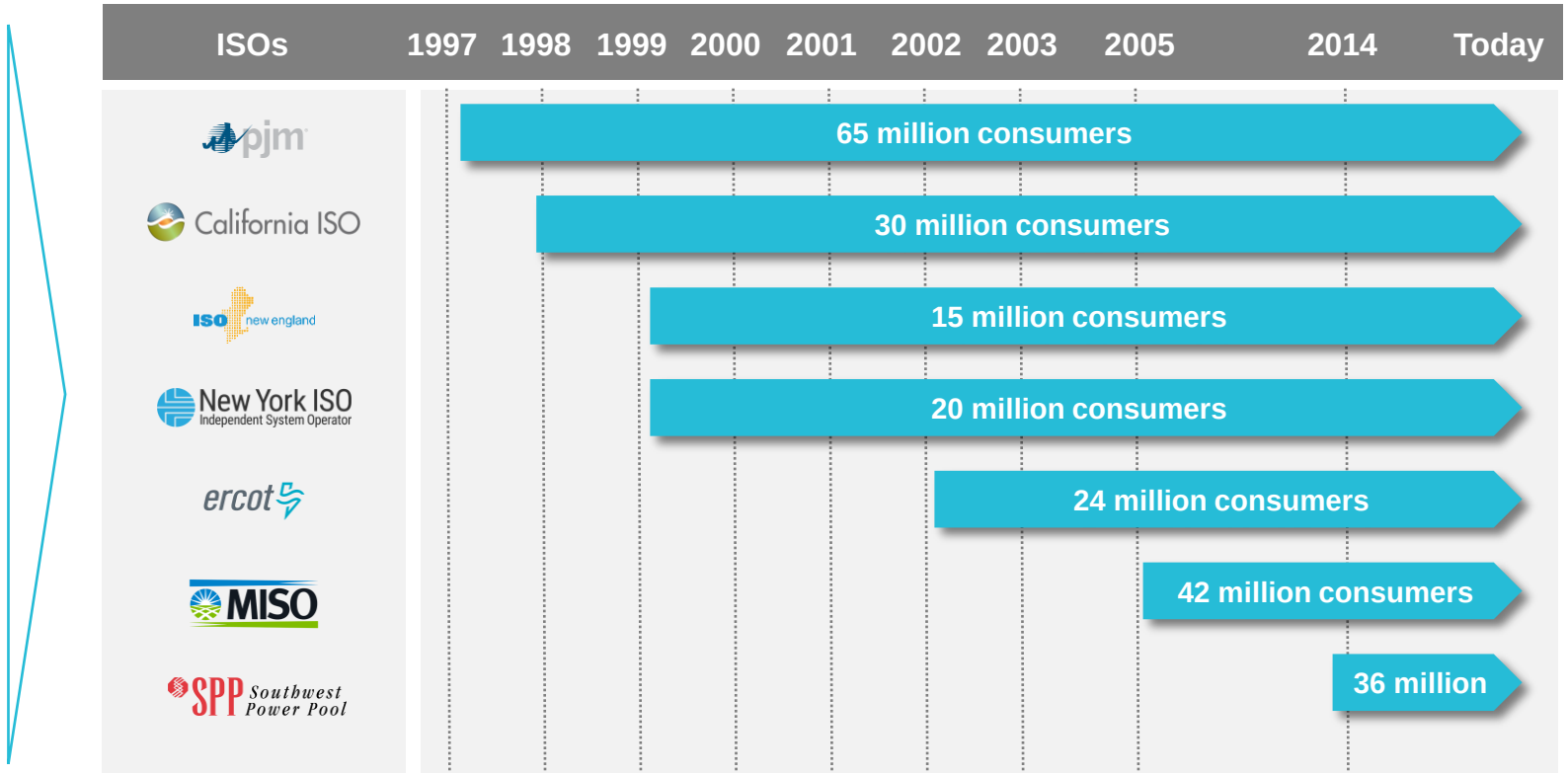
Electricity Markets

A Lasting Transition

In a remarkable period of transition beginning in 1997, generation in regions throughout the United States was deregulated and moved into bid-based electricity markets.

Legislative and Regulatory Developments

- **Order 2000 – Establishing RTOs** — 2000
- **Order 888/889 – Open Access** — 1997
- **California – Electric Utility Restructuring Act** — 1996
- **Order 636 – Natural Gas Unbundling** — 1992

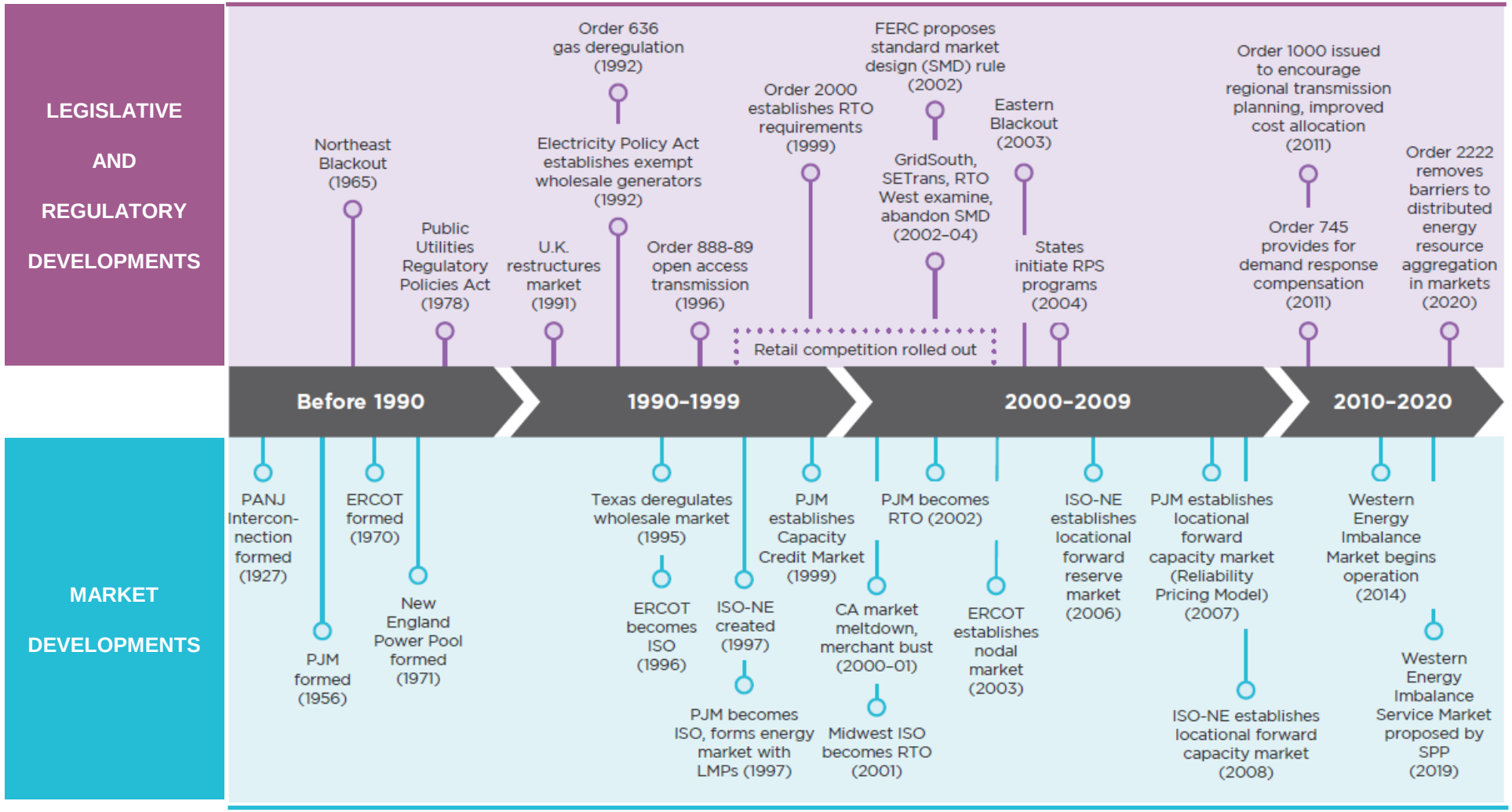


Today, the ISO electricity markets serve 232 million consumers and are valued annually at nearly $100B.

scottmadden
MANAGEMENT CONSULTANTS

Selected Electricity Market Developments

More recent developments—including capacity markets and energy imbalance markets—demonstrate the evolving nature of the ISOs.



scottmadden
MANAGEMENT CONSULTANTS

Today's Electricity Markets

Every day of the year, 24 hours a day, on day-ahead, hourly, and real-time intervals, electricity in these bid-based markets is bought and sold by thousands of participants.

ISO Operated Electricity Markets

Energy Markets
- Delivery of electricity
- Daily and hourly markets
- Real-time balancing

Ancillary Services Markets
- System balancing
- Standby resources
- Voltage support services
- Black start services

Capacity Markets
- Resource adequacy
- Capacity compensation

Capacity Market Approach

	Considerations	ISOs
Annual: 3 Years Ahead	■ Economic certainty for owners and developers ■ Volatility and adequacy of prices	■ PJM ■ NE-ISO
Annual: Intra Year	■ Price signaling for owners ■ Better alignment to seasonal reliability needs	■ MISO ■ NYISO
Do Not Operate	■ Scarcity pricing principles ■ Increasingly relying on renewables	■ CAISO ■ ERCOT ■ SPP

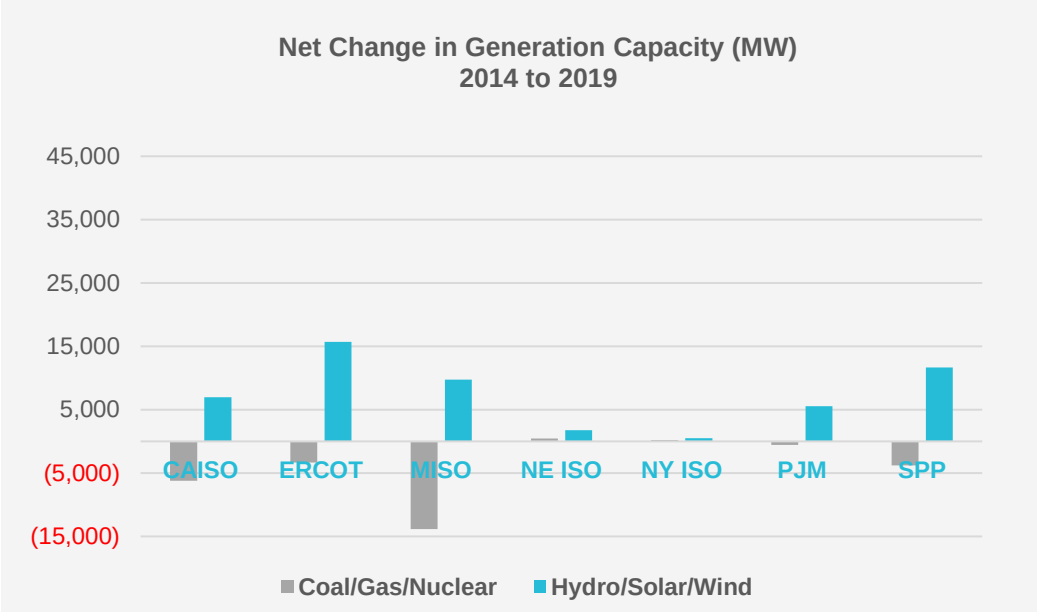
ISO markets differ significantly in approach to ensuring sufficient generation to serve future load.

scottmadden
MANAGEMENT CONSULTANTS

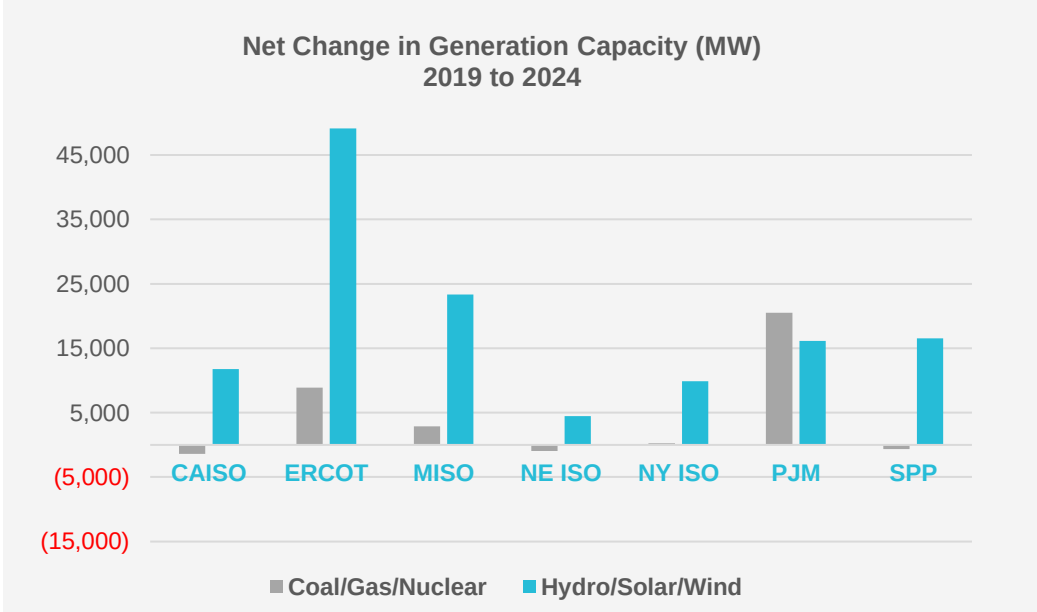
The Changing Generation Fleet

The generation fleet is changing rapidly as vast amounts of wind and solar come online. These are displacing more traditional forms of generation, including coal, natural gas, and nuclear.

The Transition from Traditional Generation to Solar and Wind …



Is Forecast to Accelerate Dramatically in Coming Years As Renewable Zero-Marginal Cost Economics Dominate



Net additions of solar and wind capacity over the next five years are forecast to exceed coal, natural gas, and nuclear generation by four times.

Source: S&P Global – October 2020

Mounting Challenges

The original objective for electricity markets was relatively simple—apply principles of deregulation and competition to drive down prices while ensuring reliability. Today's ISOs are facing a new set of challenges:

Supporting State Clean Energy Goals

- ISOs face growing expectations that they support state clean energy goals.
- PJM has been at the forefront of this issue with FERC for more than three years.

Attracting Capital Investment

- Proliferation of renewables and low-cost natural gas generation is challenging the economics of traditional generation resources.
- Transmission investments can also be impeded, especially by permitting delays.

Managing a Decentralized Fleet

- The assets that make up a generation fleet are smaller and controlled by a broader range of owner types.
- Electric customers are similarly choosing among numerous options.

scottmadden
MANAGEMENT CONSULTANTS

Where Do We Go From Here?

As these challenges grow, we see ISOs responding with a new era of innovation. Solutions are being developed and implemented across multiple fronts:

Facilitate Climate Solutions

- While there are barriers to ISO leadership, potential solutions are emerging.
- These include energy imbalance markets and carbon-pricing structures.

Enhance Market Policy

- Changing technologies and customer dynamics require continual reassessment of market policy.
- As the generation fleet evolves, ensuring markets properly compensate system reliability is key.

Expand the Digital Platform

- ISOs may start with foundational improvements like communications infrastructure and operator visualization.
- Advanced enhancements include integrated system modeling and data analytics.

scottmadden
MANAGEMENT CONSULTANTS

Key Takeaways

Electricity Markets: Looking Back—and Ahead

Industry Advancement

Recognize the critical gateway ISOs have provided for electric industry advancements in price efficiency, operating reliability, and customer choice.

Next Evolution

Changing dynamics of the industry—many a result of the ISOs themselves—are demanding a next evolution of policy and technological advancement.

ISOs Prepare to Lead

Based on the record of the ISOs, perhaps no area of the electric industry is more prepared to lead such change.

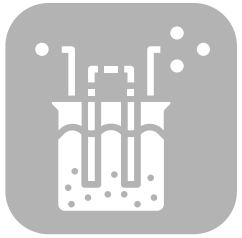
scottmadden
MANAGEMENT CONSULTANTS

Smart. Focused. Done Right.®

Steve Sanders

Director

Steve Sanders has more than15 years of management consulting and financial planning experience in the global business environment. His areas of industry expertise include energy utilities, energy trading and marketing, and industrial gases. Prior to joining ScottMadden, he held a variety of marketing and financial analysis roles, including leading the investment analysis group for a $1 billion industrial gas distribution business. Steve holds an M.B.A. from the Wharton School at the University of Pennsylvania, a B.S. in business administration from the University of Missouri, summa cum laude, and a B.A. in psychology from the University of Missouri, Phi Beta Kappa.



Hydrogen Economy

Some Recent H_2 Project Announcements

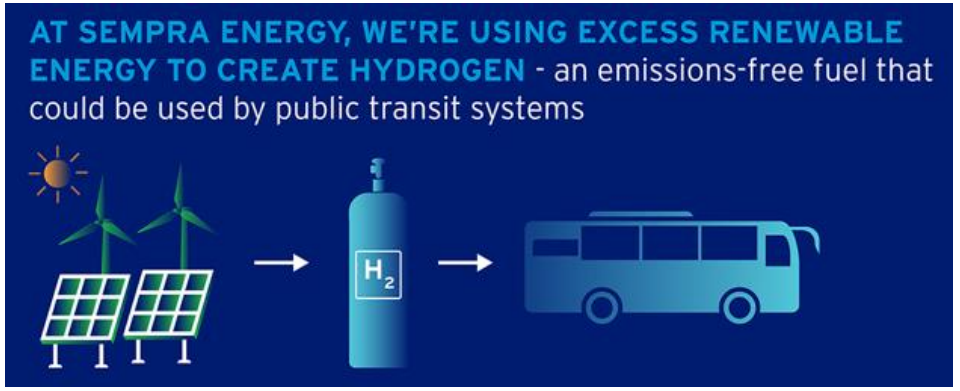
Just a sample of some recent H_2 projects in the news:

- **LADWP** | Intermountain project in Utah to replace natural gas with H_2
- **Sempra** | Green H_2 powered by excess renewable generation to supplement natural gas and use in transportation sector
- **NextEra** | Florida CCGT to be partially fueled by green H_2 from electrolyzers powered by excess solar
- **EmberClear** | CCGT in Ohio planned with H_2 production and geological storage
- **Balico** | CCGT in Virginia planned with future conversion to H_2
- **Danskammer** | NY Peaker plant conversion to 30% green H_2 by 2030

Why the sudden interest?

DOE has been publishing papers about the H_2 economy since 2002.

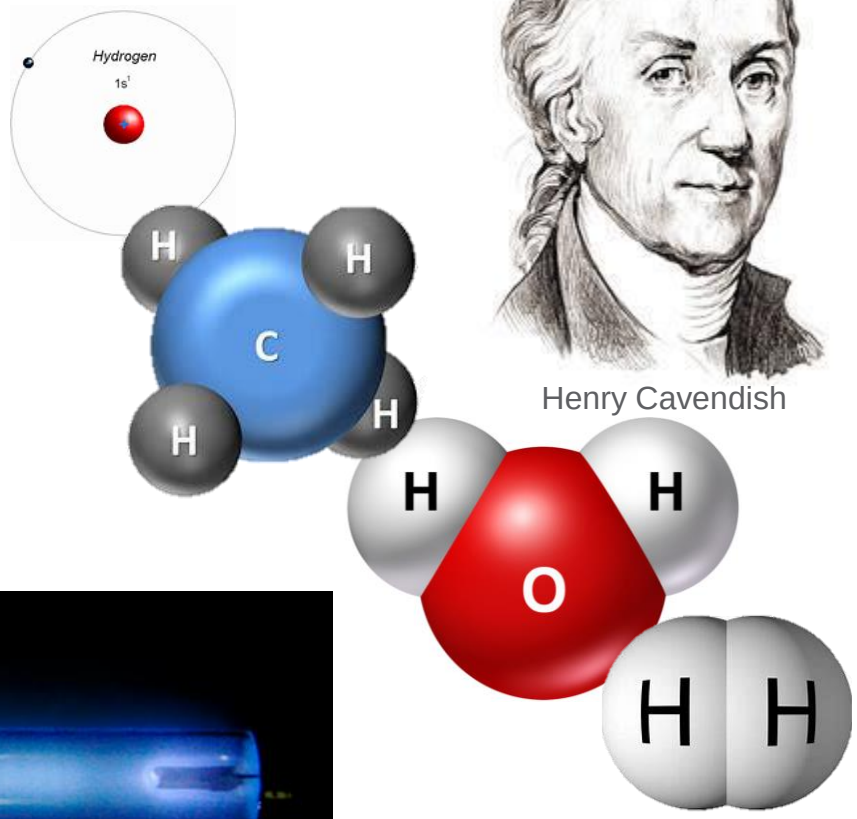
Will it happen this time?



scottmadden
MANAGEMENT CONSULTANTS

Hydrogen – Some Key Physical Properties

- First isolated in late 1700s by Henry Cavendish
- Comprises about 75% of the known mass of the universe
- Burns without a visible flame in daylight
  - One kg of H_2 has about the same energy as 3.2 kg of gasoline (~120,000 Btus)
- Boils into a gas at -423 degrees Fahrenheit
- Commonly used as a coolant in generation turbines
- Combusts in air concentrations of 4%–74% (much wider range than gasoline)
- Odorless, colorless, and normally only found combined in other molecules (e.g., water, methane)



Henry Cavendish

As a plasma, hydrogen glows purple.

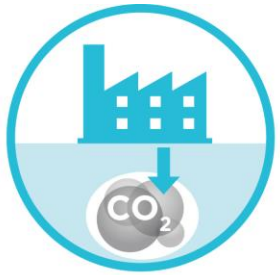
scottmadden
MANAGEMENT CONSULTANTS

Sources of H_2

H_2 Lingo: Types of Hydrogen Production

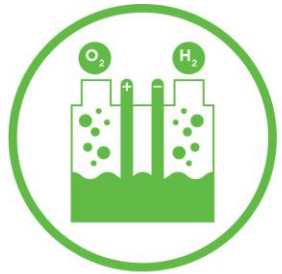
GREY HYDROGEN

- Production from **natural gas** or **coal** in a reformer
- **Emits CO_2**



BLUE HYDROGEN

- Production from **natural gas (typically)** in a reformer
- **CO_2 emissions captured** (typically 90%) and stored or used



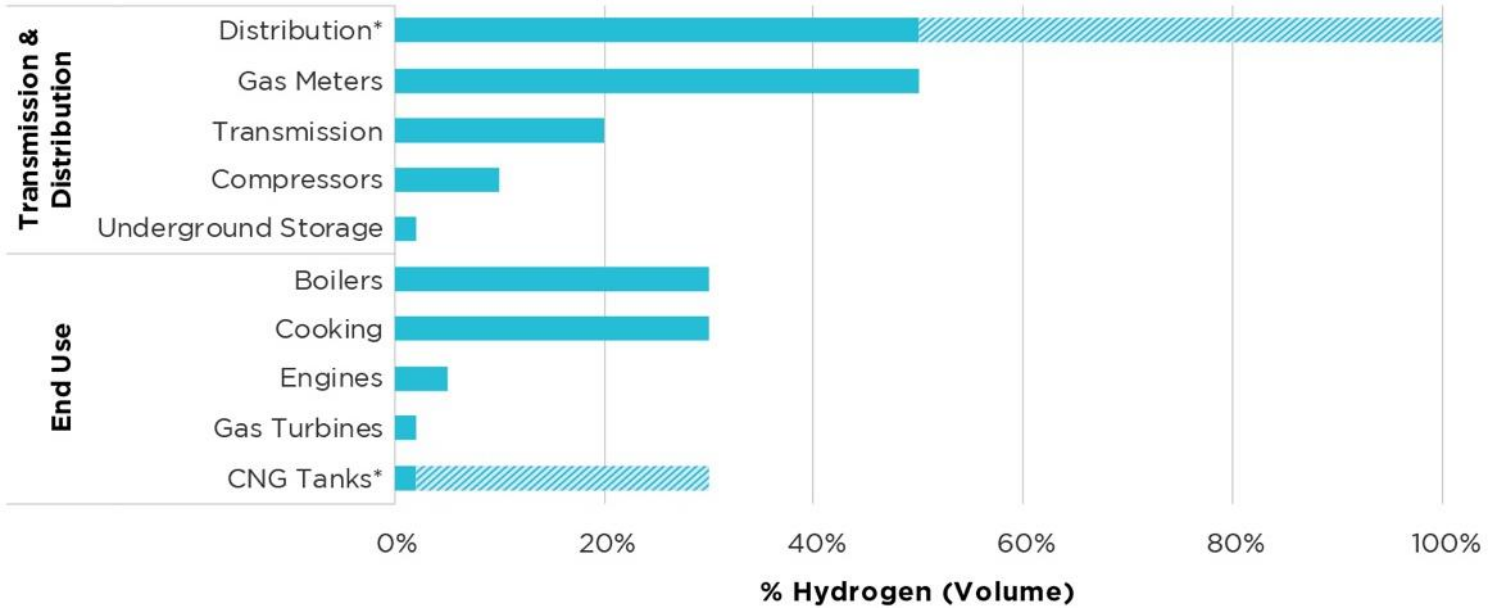
GREEN HYDROGEN

- Production from **water** and **green electricity** in an electrolyzer
- **Carbon neutral**

Source: SNAM

Storing and Moving H_2

Tolerance of Selected Existing Elements of the Natural Gas Network to Hydrogen Blend Shares by Volume



CNG tanks, turbines and engines have the lowest hydrogen tolerance. Minor adaptations could increase the grid's tolerance and exploit its transport capacity.

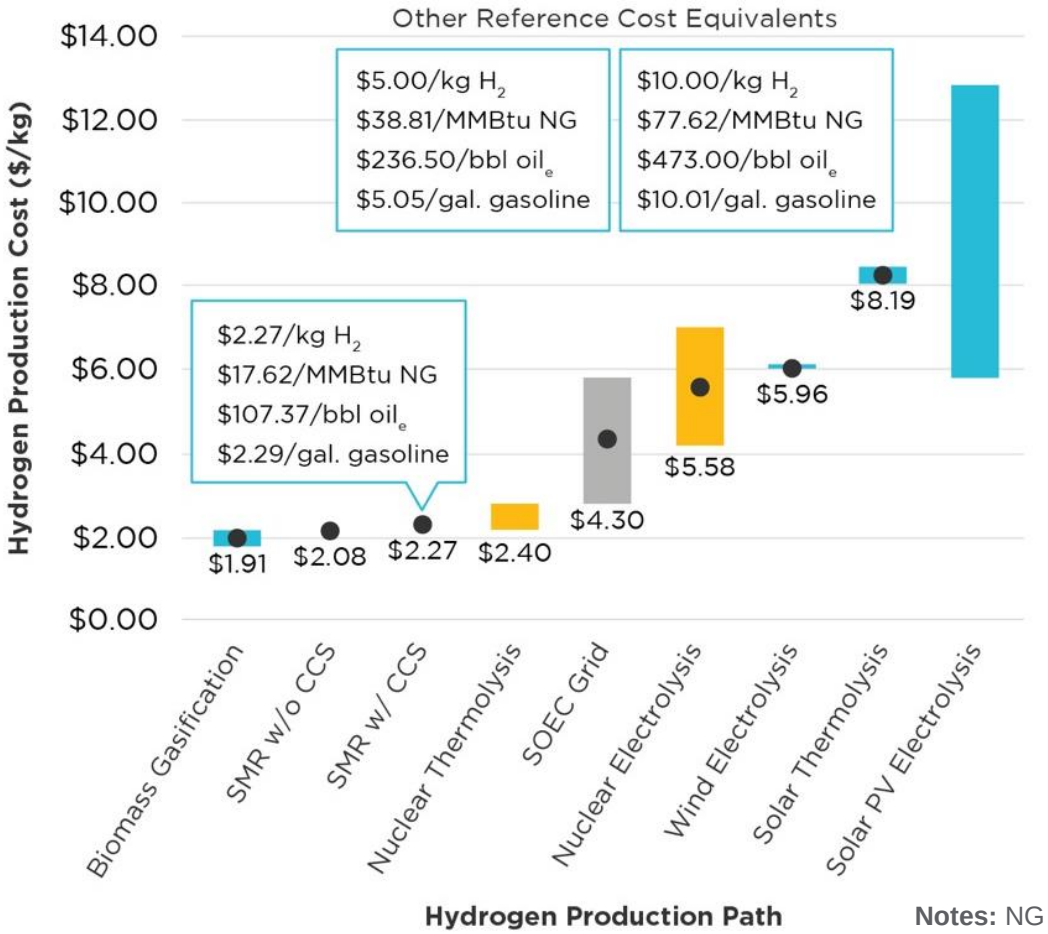
–IEA

Notes: *The higher tolerance for distribution would require specific safety assessments; the higher tolerance of CNG tanks is for Type IV tanks (although the tolerance for CNG tanks may be as low as 0.1% depending on the humidity of the natural gas (United Nations, 2014). **Higher limit for Germany applies if there are no CNG filling stations connected to the network; higher limit for Lithuania applies when pipeline pressure is greater than 16 bar pressure; higher limit for the Netherlands applies to high-calorific gas.

Source: IEA

At What Cost?

Current Hydrogen Production Cost Ranges and Averages by Technology and Equivalent Prices for Fossil Sources with CO_2 Capture and Storage



Notes: NG means natural gas; oile means oil equivalent; SOEC means solid oxide electrolyzer cell.

Source: DOE Hydrogen Strategy

scottmadden MANAGEMENT CONSULTANTS

What Would It Take for Hydrogen to “Go Big” This Time?

Ultimately, it will need to be green:

- Blue and grey hydrogen while addressing storage and transportation challenges
- Competitive with natural gas prices
- Sustained excess renewable generation
- Substantial tax incentives and grants (similar to wind and solar)

scottmadden
MANAGEMENT CONSULTANTS

Key Takeaways

Hydrogen Economy

Role for Hydrogen

Because the energy industry must continue to consider low- to no-carbon emissions generation, hydrogen will likely have a part to play.

Key Dependencies

Size of role for hydrogen depends upon three key factors:

- Its cost relative to natural gas
- Technical advancements in its production, storage, and distribution
- Safety

scottmadden
MANAGEMENT CONSULTANTS

YOUR WEBINAR PRESENTERS

Cristin Lyons
Partner and
Energy Practice Leader

Tina Jeffress
Sr. Associate

Steve Courtney
Manager

Steve Sanders
Director

See the link below for the latest Energy Industry Update

https://www.scottmadden.com/energy-industry-update/

scottmadden
MANAGEMENT CONSULTANTS

ScottMadden's Energy Industry Update – Running Up That Hill

See the link below for the latest Energy Industry Update
https://www.scottmadden.com/energy-industry-update/

scottmadden
MANAGEMENT CONSULTANTS