

CONNECTIONS

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The Slow Pace of Fast Change

Imagining the Futures of Energy Systems

- Garry Golden



The Future

Regulator

Disruptor

Public Utility

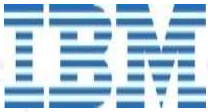
Vendor

Futurist

C H A N C E

A row of six light-colored wooden blocks, each with a single letter of the word "CHANGE" printed in bold black capital letters. The blocks are arranged in a slightly staggered line on a light wooden surface. The background is a plain, light grey wall.

Foresight 101: Four Futures Thinking



**Continued
Growth**

**Disciplined
Constrained**

Transformed

**Decline
Collapse**

Being Able to Describe Our Four Futures



**Continued
Growth**



**Disciplined
Constrained**



Transformed



**Decline
Collapse**

Start

End



**Surfacing
Uncertainties**



**Imagining
Transitions**



**Next
Steps**

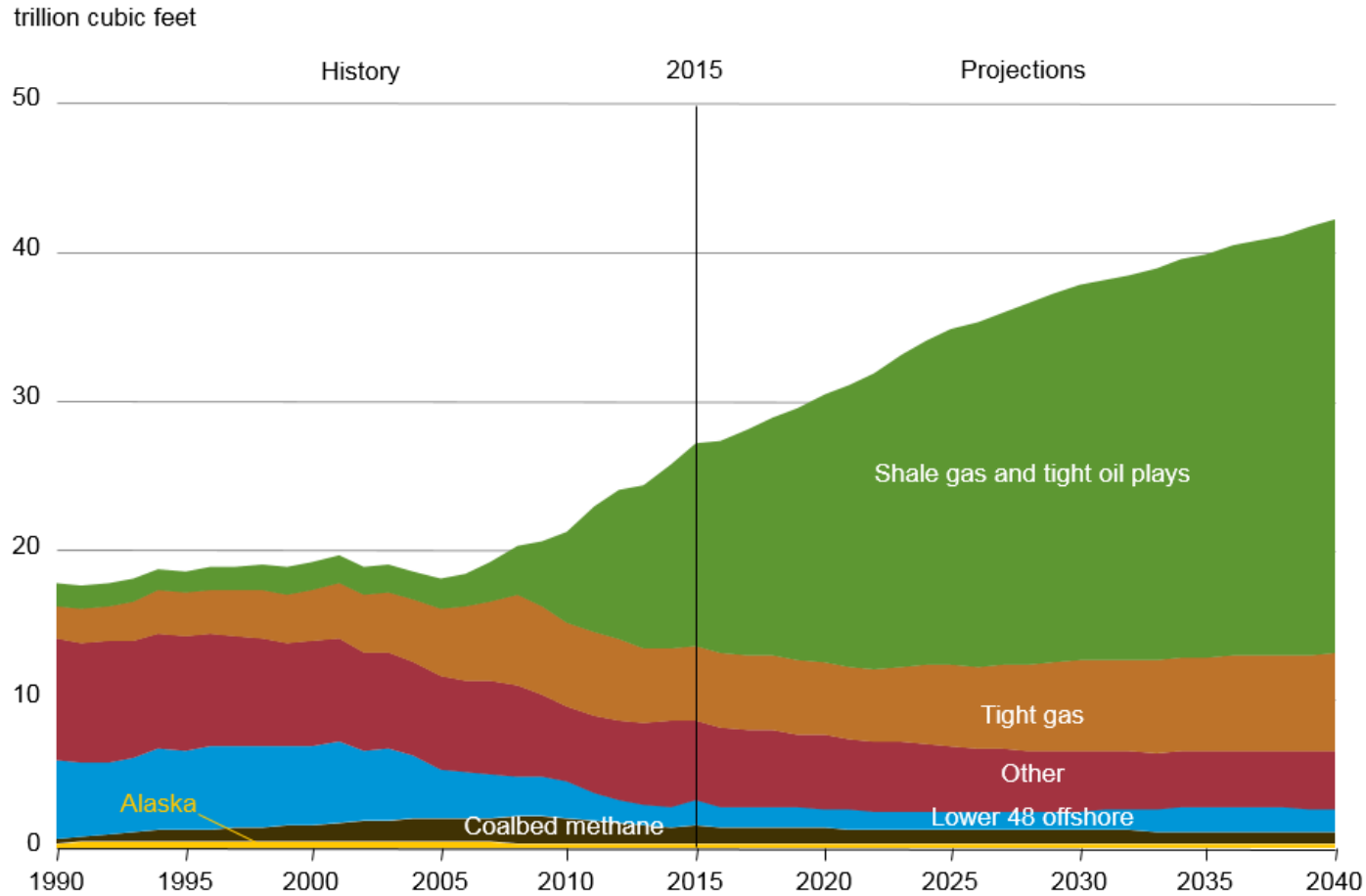


Foresight Helps Us Anticipate & Lead Change



10 Years: Uncertainties in Fuel Dynamics

Figure MT-46. U.S. dry natural gas production by source in the Reference case, 1990–2040



EIA_AEO 2016

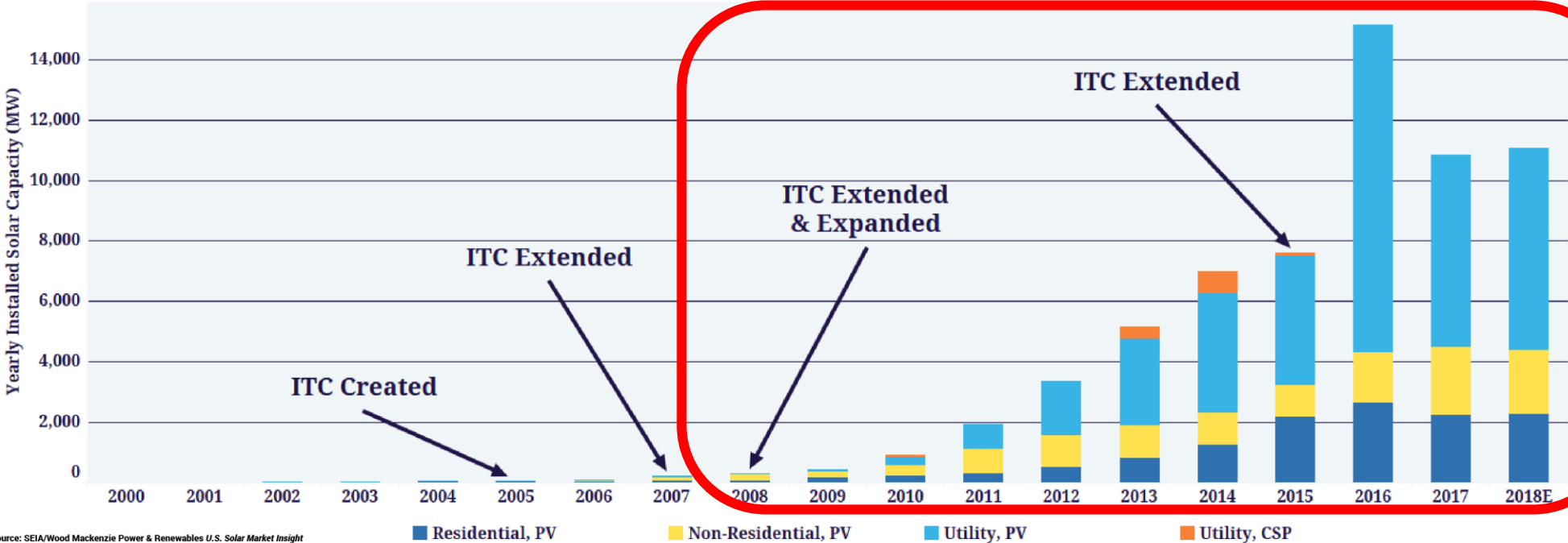


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10 Years: Uncertainties in Policy (2020 – 2030)



Annual U.S. Solar Installations



Source: SEIA/Wood Mackenzie Power & Renewables U.S. Solar Market Insight

Wood Mackenzie
POWER & RENEWABLES

SEIA Solar Energy Industries Association®

©2018

10 Years: Uncertainties in Players, Partners & Business Models



TESLA

amazon

Alphabet



Oil Giant Shell Wants to Sell You Electricity

Big Oil pivots to electricity,
Total leads the way

**Microsoft Is Getting Hungry
for Fuel Cells**

By Anna Hirtenstein
October 31, 2017, 1:00 AM EDT

Amazon and Google Are Plotting to Power Your Home

Amazon acquires right to buy stake in
fuel cell maker Plug Power

Amazon Invests \$700M in Rivian Electric Trucks, SUVs | ENS

Amazon wants to help make it easier to lower your power bill



10 Years: Uncertainties in Technology Deployment (2020 – 2030)

Coal comeback? Cleaner Natgas?

Transforming Generation Asset Utilization & Longevity?

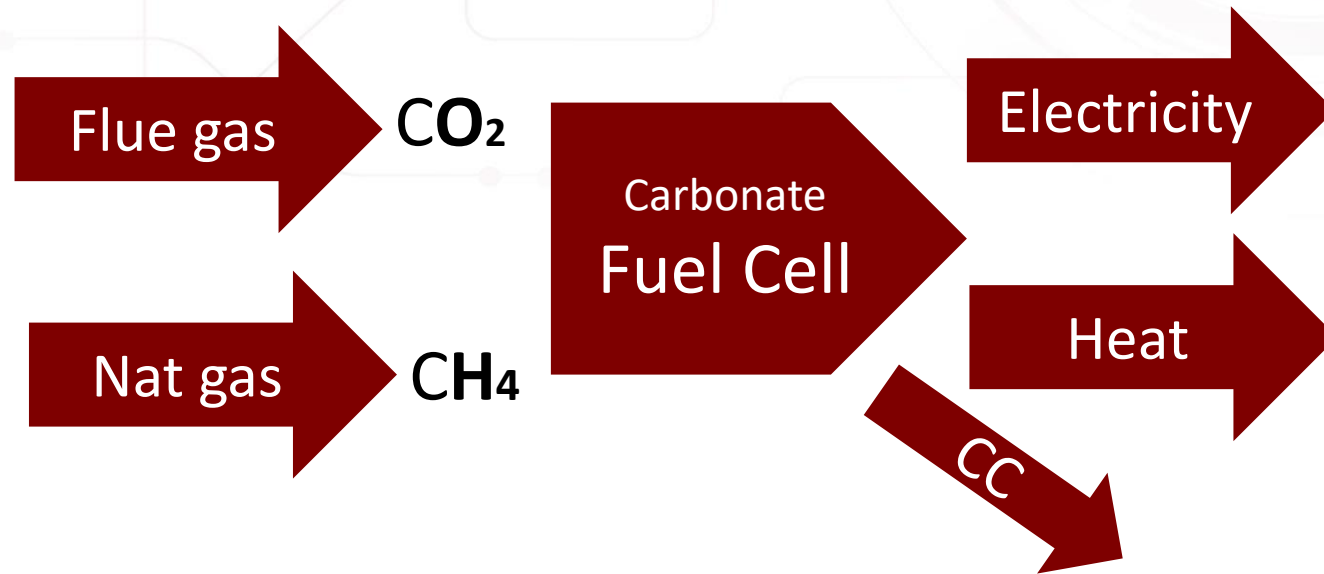
Coal plant – no CO ₂ capture	500 MW	.06 (\$/kWh)
90% amine capture	400 MW	.11 (\$/kWh)
90% CO₂ capture w/ fuel cell	900 MW	.08 (\$/kWh)
5% CO ₂ capture with fuel cell	522 MW	.06 (\$/kWh)

(Source: Fuelcell Energy & ExxonMobil)

ExxonMobil
fuelcellenergy



Carbonate Fuel Cells



10 Years: Uncertainties of Radical Ideas (2020 – 2030)



STOR·H
by AAQIUS



**Public Utilities as Thought Leaders:
Starting conversations
on themes we do not yet understand**



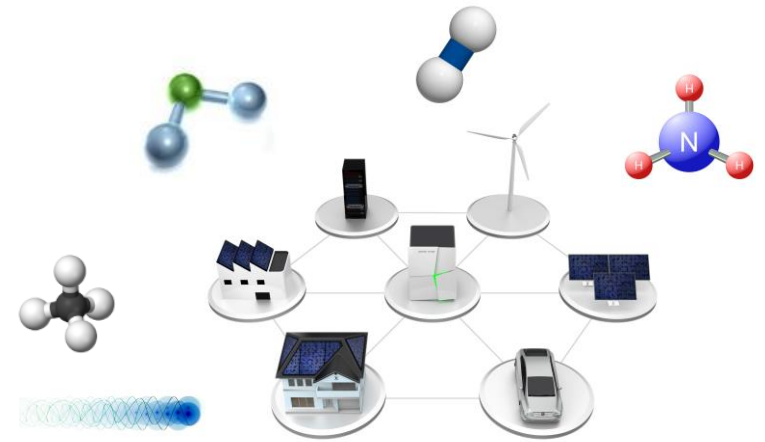
Imagining the Futures of Energy Systems



***Data-Driven
Innovations***



**Spectrum of
'Electric' Vehicles**

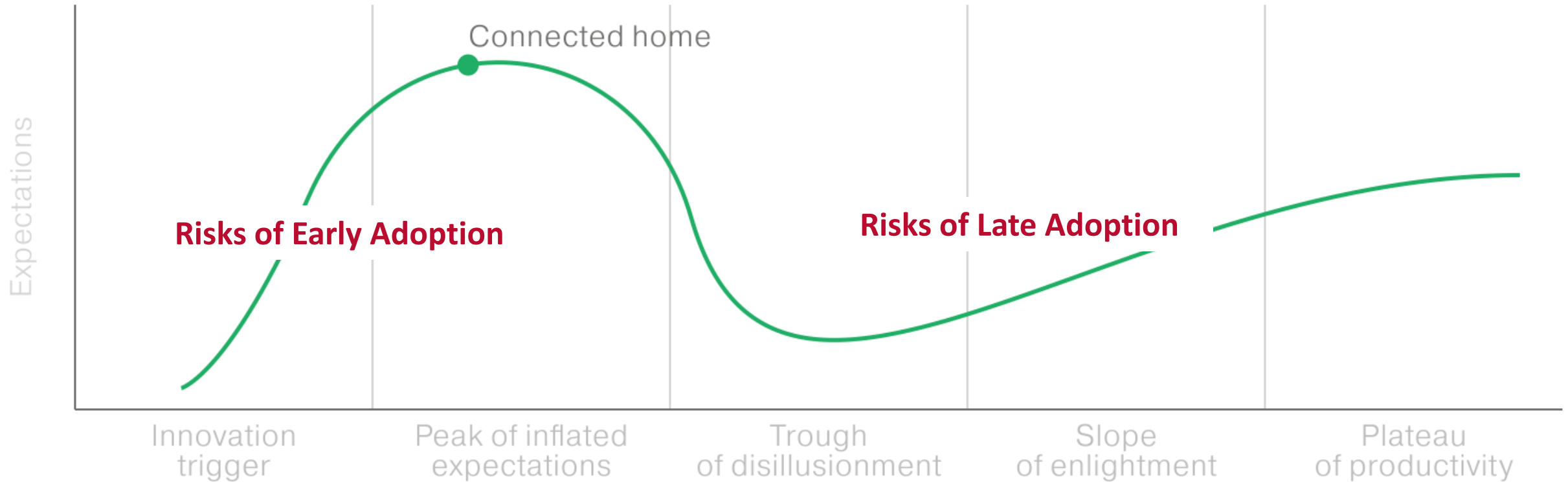


**(Not so) Radical Scenario:
Grid + Grid Convergence**

Hype vs Hope: Data Driven Innovations



Gartner Hype Cycle for Emerging Technologies, 2017



● Plateau will be reached in 5 to 10 years

itransition

Comscore: U.S. smart speaker penetration reached 20% of households with WiFi.
A 50% increase over the previous quarter, representing 18.7 million homes. (Q2, 2018)

***Preparing a People
Strategy for this
Data-Driven Future***



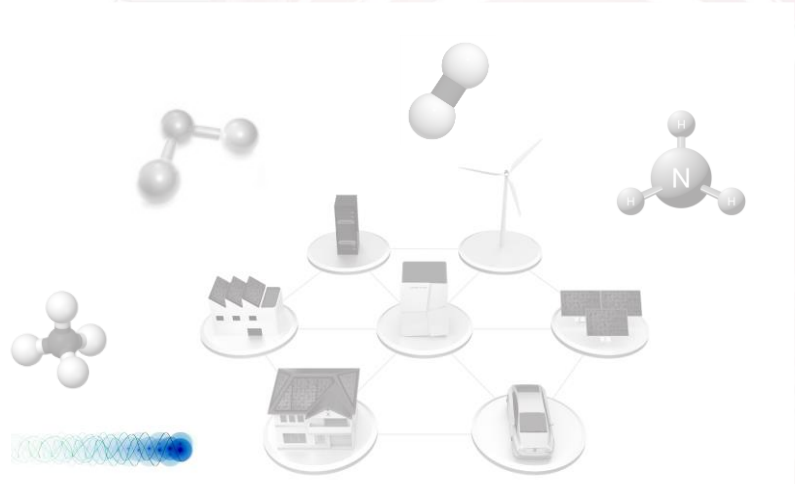
Imagining the Futures of Energy Systems



Data-Driven Innovations



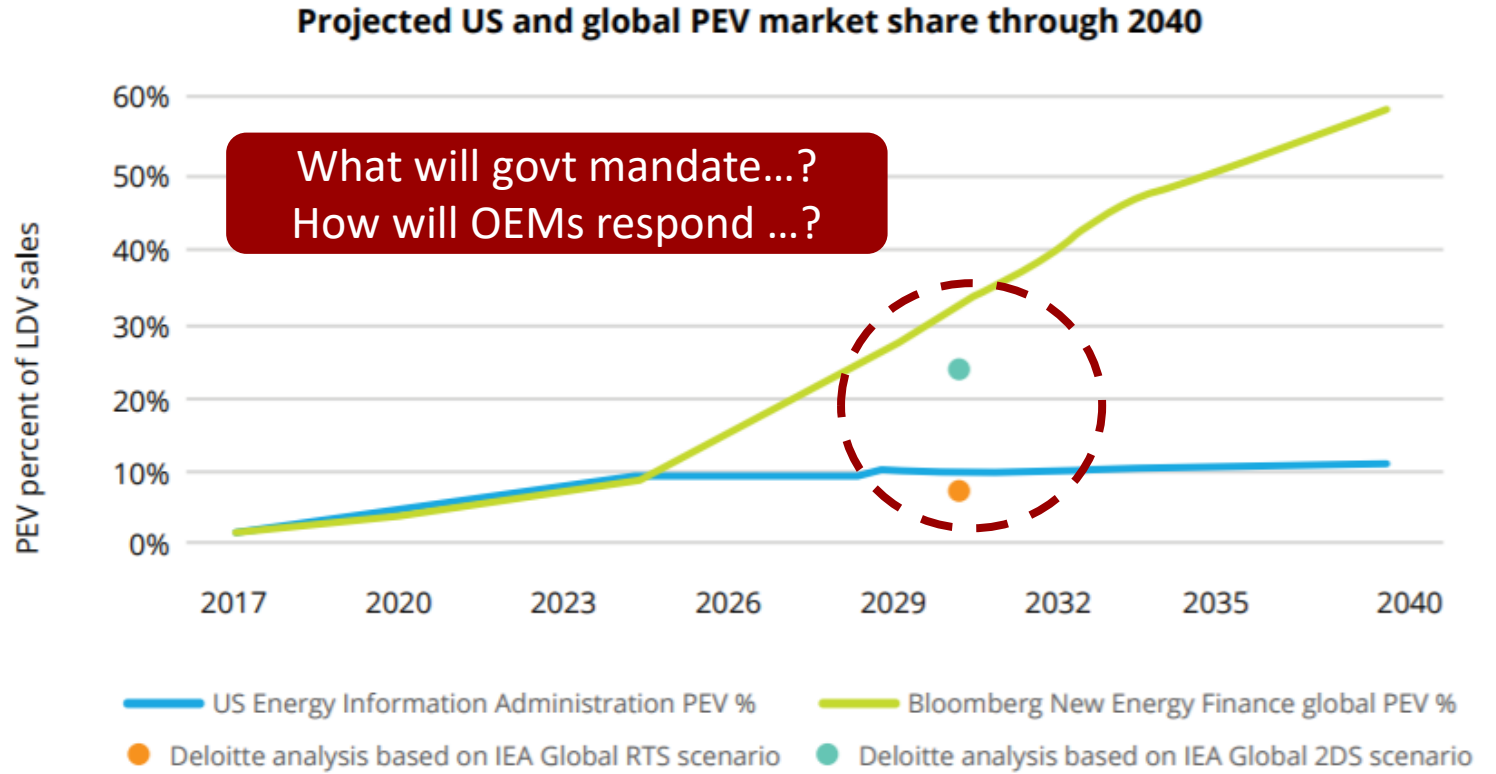
Spectrum of 'Electric' Vehicles



(Not so) Radical Scenario: Grid + Grid Convergence



Figure 2. Projected PEV share of total light-duty vehicle sales



Forecast Uncertainties

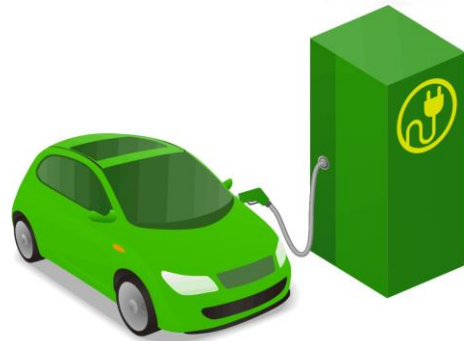
The IEA's Reference Technology Scenario (RTS), projecting 56 million electric cars in circulation by 2030, reflects projections that respond to policies on energy efficiency, energy diversification, air quality, and de-carbonization that have been announced or are under consideration. The IEA's 2DS scenario, projecting 160 million EVs in circulation by 2030, occurs in a context consistent with a 50% probability to limit the expected global average temperature increase to 2°C. We estimated annual sales required to meet IEA's EV stock projections for 2030 and then calculated the EV share of sales as a percent of total light-duty vehicle sales projected by Bloomberg New Energy Finance for 2030.

Source: Deloitte analysis.

'Electrification' Race is a Marathon not a Sprint



Hybrid ICEs



*Plug-in EVs
BEVs*



*Fuel-based
FCEVs*

Thinking Beyond
Passenger Vehicles:

Rail
Marine
Trucking
Aviation/UAVs

Autonomous
Last Mile / Micro Transit
Robotics



'Electrification' Debate: BEVs, FCEVs or Both



*... Elon Says
Game-Over
Batteries Won!*

More than three-quarters of executives (78% Global; 82% China; 85% U.S.) say fuel-cell electric mobility will be the real break-through for electric mobility.

KPMG

*... but Industry (and China) betting
on integration & fuel-based EVs*

BEVs 'Have Won' vs Limitations of All Electric Pathway

Battery pack = 400 miles
Daily Need = 40 miles



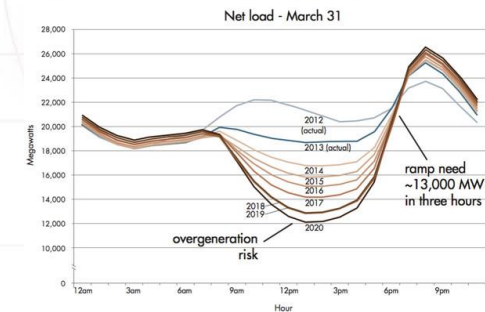
OEM Cost-to-X
vs Daily Use Demand



Fleet Uptime &
Recharging for
Urban Markets

'Duck Curve' to 'Dragon Curve'

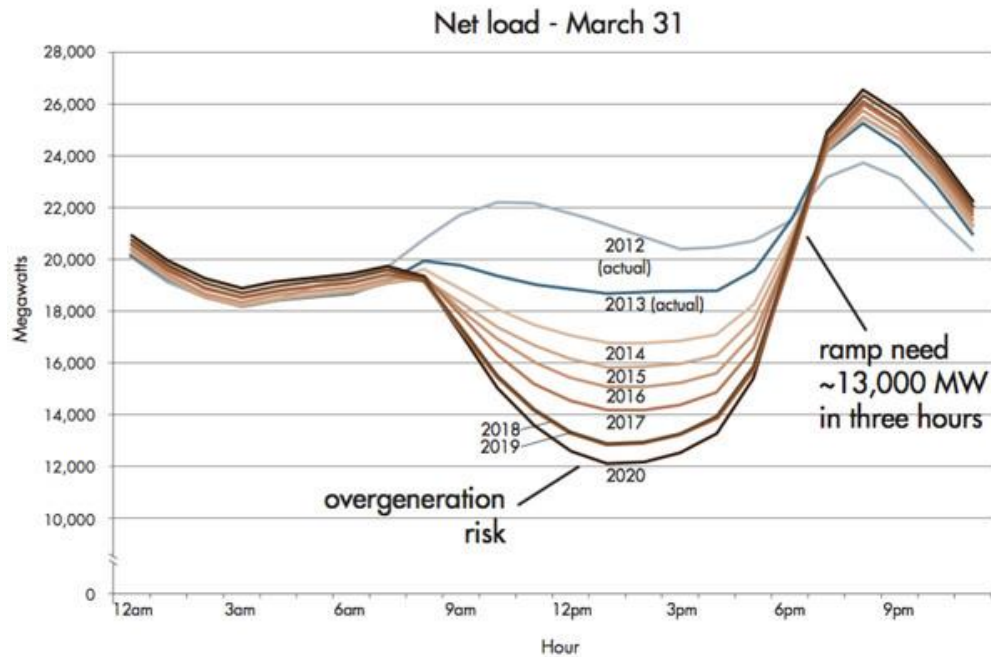
Figure 2: The duck curve shows steep ramping needs and overgeneration risk



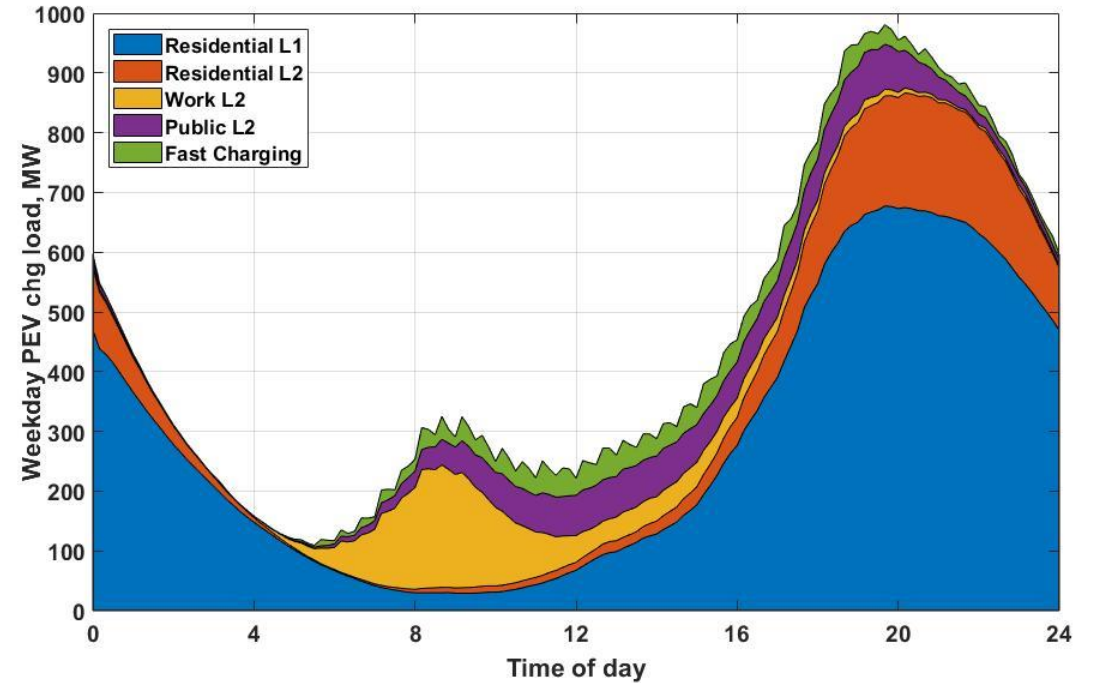
Full Costs of
Grid Management

Total Grid Management Costs 'Duck Curve' to 'Dragon Curve'

Figure 2: The duck curve shows steep ramping needs and overgeneration risk



'Duck Curve'

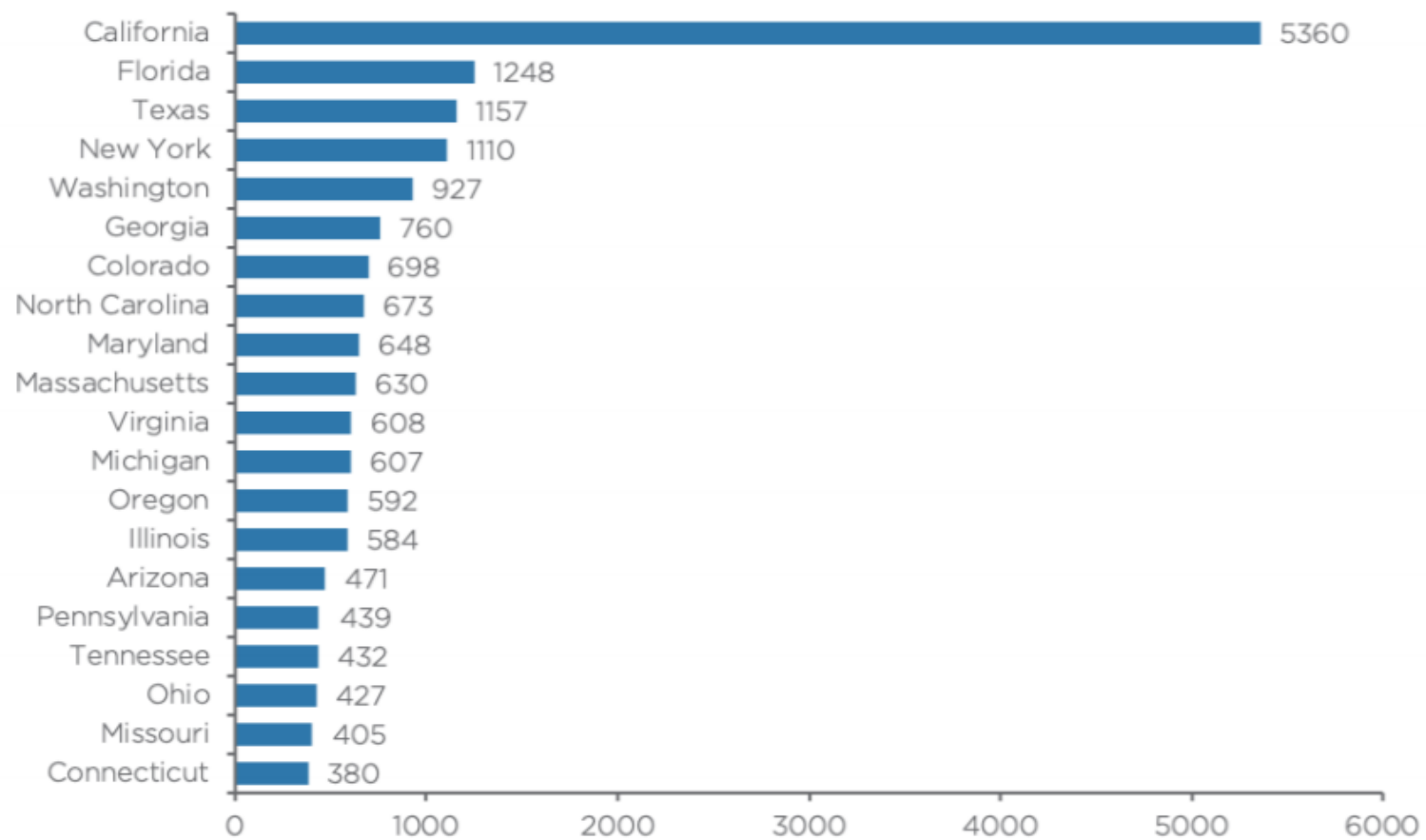


'Dragon Curve'

Planning for BEVs

- Fleet / Workplace Charging Networks
- Business Models + Rate Design
- Policies for Controlled Charging
- Incentive Models

Figure 10: U.S. non-residential charging stations by state, January 2019

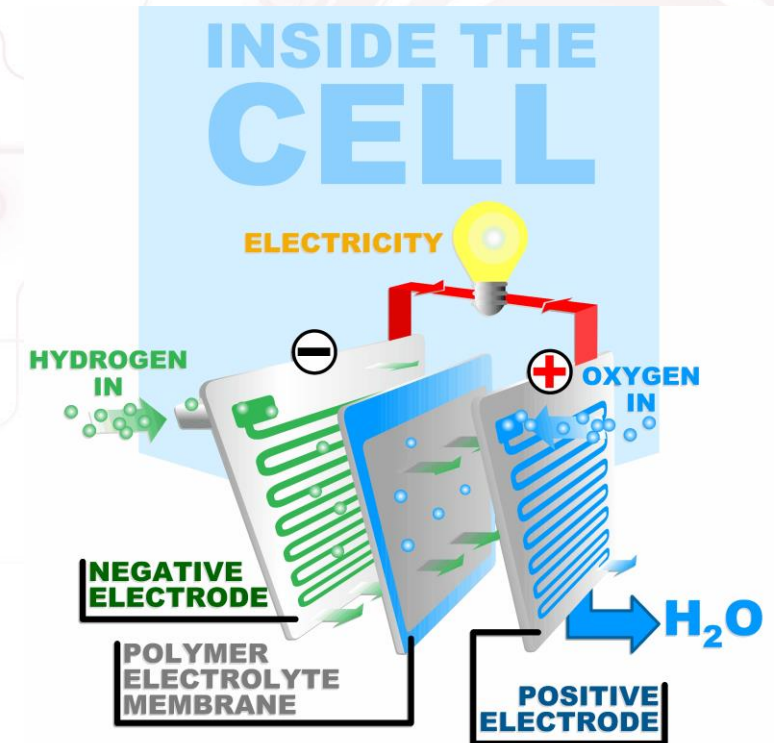


Source: Alternative Fuels Data Center, US Department of Energy, January 2019

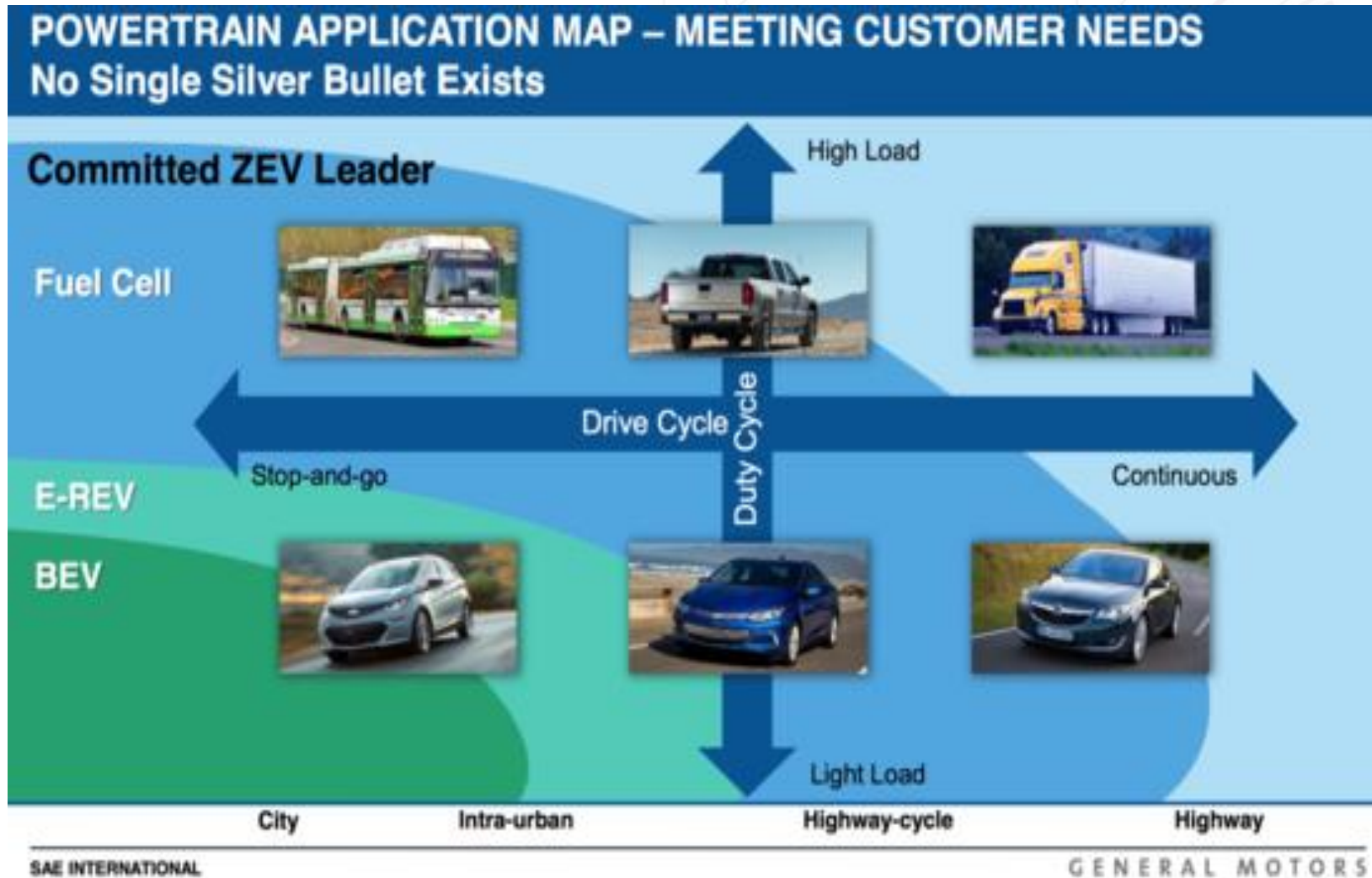


The Case for Fuel Cell + Battery Integration

- **Long-term Cost Curve (kW)**
Battery \$80-100 kW (at volume)
Fuel Cells \$20-30 kW (at volume)
- Total Cost of Ownership plus
Total Cost of System Management
- Lower Infrastructure Costs at Scale
(Julich Study, 2017)
- Market Incentives for Existing Incumbents



Caveat: We Could See Global (China) Push for Fuel-based EVs



Caveat: We Could See Global (China) Push for Fuel-based EVs



NIKOLA ONE™

Trucking



POWERCELL
BOSCH



Royal Caribbean INTERNATIONAL VIKING YANMAR ABB

Maritime



Hydrail

ALSTOM



Ultra Electronics USSI Protonex® a Ballard® company flyH2 AIRSPACE

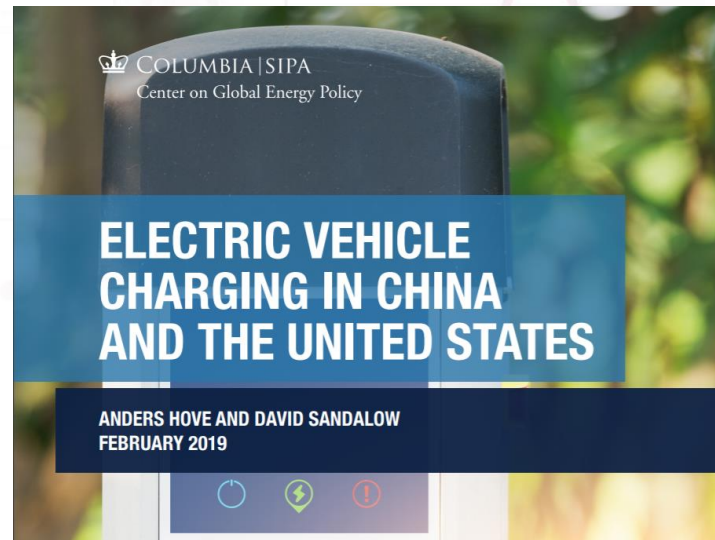


Aviation / UAVs

BEV Infrastructure – 2020 – 2030

Necessary and Not Sufficient

Preparing for Bifurcated ‘Electric’ Vehicle Market



Report

Electric Vehicle Sales Forecast and the Charging Infrastructure Required Through 2030

November 2018

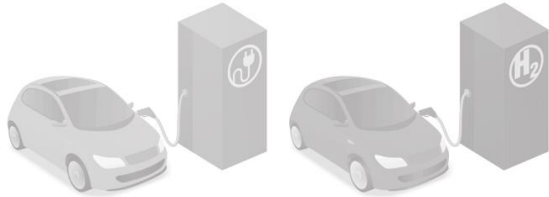
Prepared by:
Adam Cooper (IEI) and Kellen Schefter (EEI)

BEVs 18.7 million (2030)
9.6 million charge ports

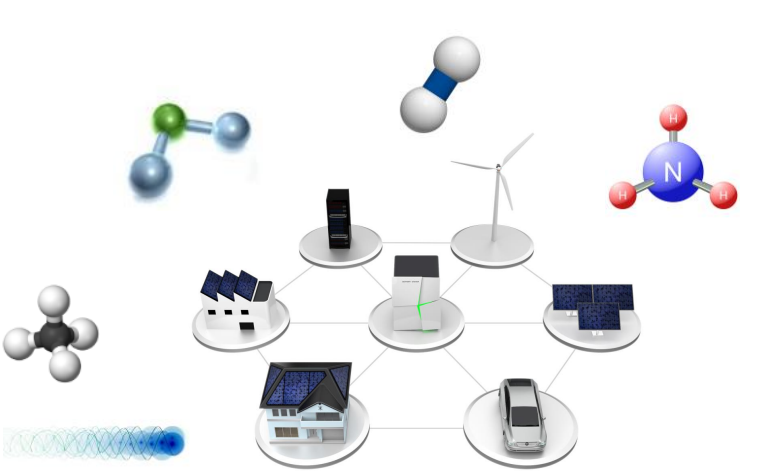
Imagining the Futures of Energy Systems



Data-Driven Innovations



Spectrum of 'Electric' Vehicles



(Not so) Radical Scenario: Grid + Grid Convergence

Should we be talking about Grid + Grid Coupling?



Two Scenarios: Electrification vs Decarbonization

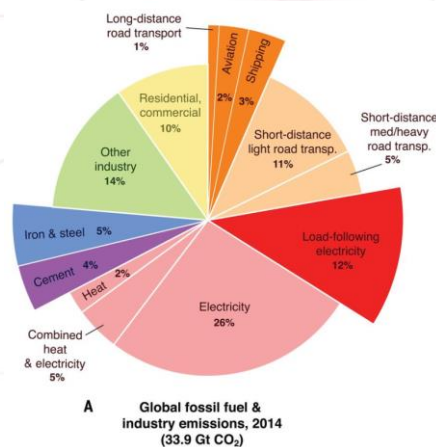
'Electrification' Pathway



Renewables

Battery Storage
& V2G Integration

Molecules-led Pathway



Decarbonization

Scale & Versatility



Incumbents

PtG Pathway
for Oil & Gas

Electrification: Battery Storage, Capacity Markets & ‘Virtual Power Plant’

First US wind-solar-storage site unveiled

14 February 2019 by David Weston

US developer NextEra and utility Portland General Electric will build a 380MW wind-solar-storage hybrid project in eastern Oregon, north-west US.

Sunrun Wins Big in New England Capacity Auction With Home Solar and Batteries

The 20-megawatt contract is small by power plant standards, but marks a crucial proof point for the theory that clean, decentralized energy devices can deliver reliable power to the grid.

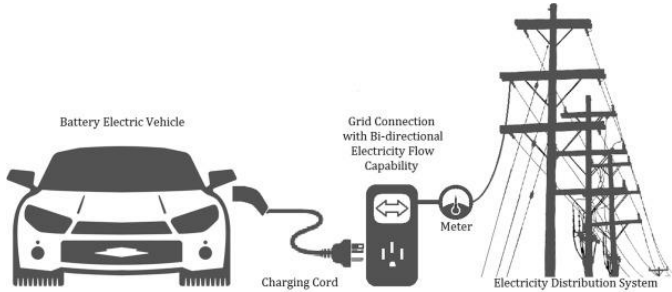
JULIAN SPECTOR | FEBRUARY 07, 2019

NV energy plan to add 100 MW storage, 1 GW renewables gets PUC approval

Why HECO Drew Such Low Solar-Plus-Storage Prices

 January 14, 2019 By [Peter Maloney](#) 

Electrification: Testing Viability of Vehicle to Grid (V2G)

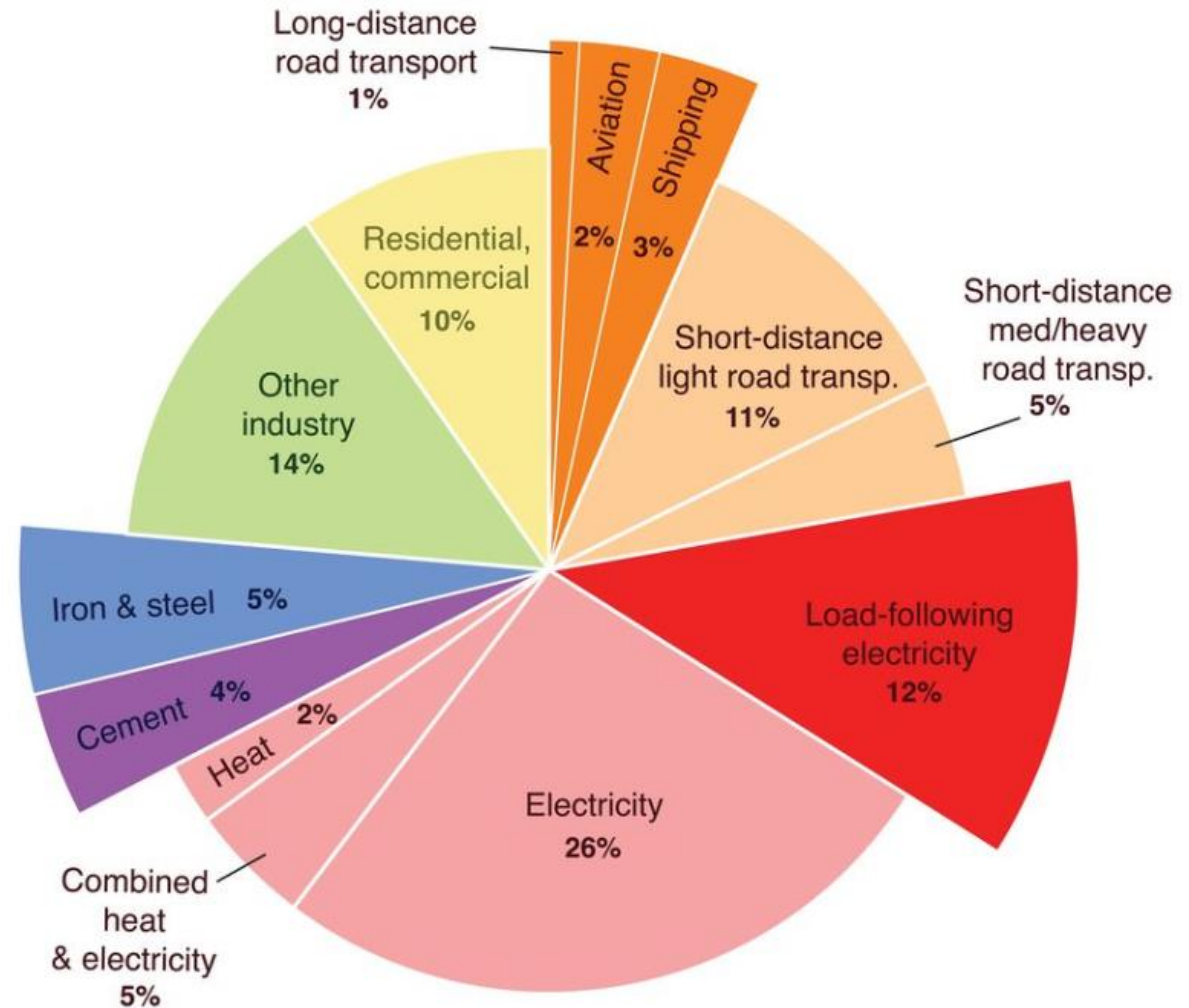


V2G Vision = EVs as Dispatchable Energy

Austin Sustainable and Holistic Integration of Energy Storage and Solar Photovoltaics (SHINES)



Limitations of 'Electrification' Policies



A Global fossil fuel & industry emissions, 2014
(33.9 Gt CO₂)

Molecules-led Pathway



2020 – 2030

**Rethinking Role of Molecules:
Distributed Energy Resources**



Distributed & Direct Use of Natural Gas, Propane and Biogas MicroCHP Fuel Cells



PEOPLES

100-home pilot program



BlueGEN

EU Passes 1,000 Installs;
US Dealerships
Factory Investments (20K/yr)



sunfire

THE POWER PLANT
FOR YOUR HOME



CONNECTIONS SUMMIT

Customers Discover Fuel Cells in RVs & Construction Sites



Propane-fed RV & #Vanlife Generators



 Intelligent Energy



Construction Site Diesel Generator Alternatives

Utilities Sector Debates: Gas vs Power? Gas + Power?

2020 - 2040

How might we navigate a DER Scenario that integrates public power + gas solutions for an era of energy appliances (MicroCHP) and utility-scale alternatives?

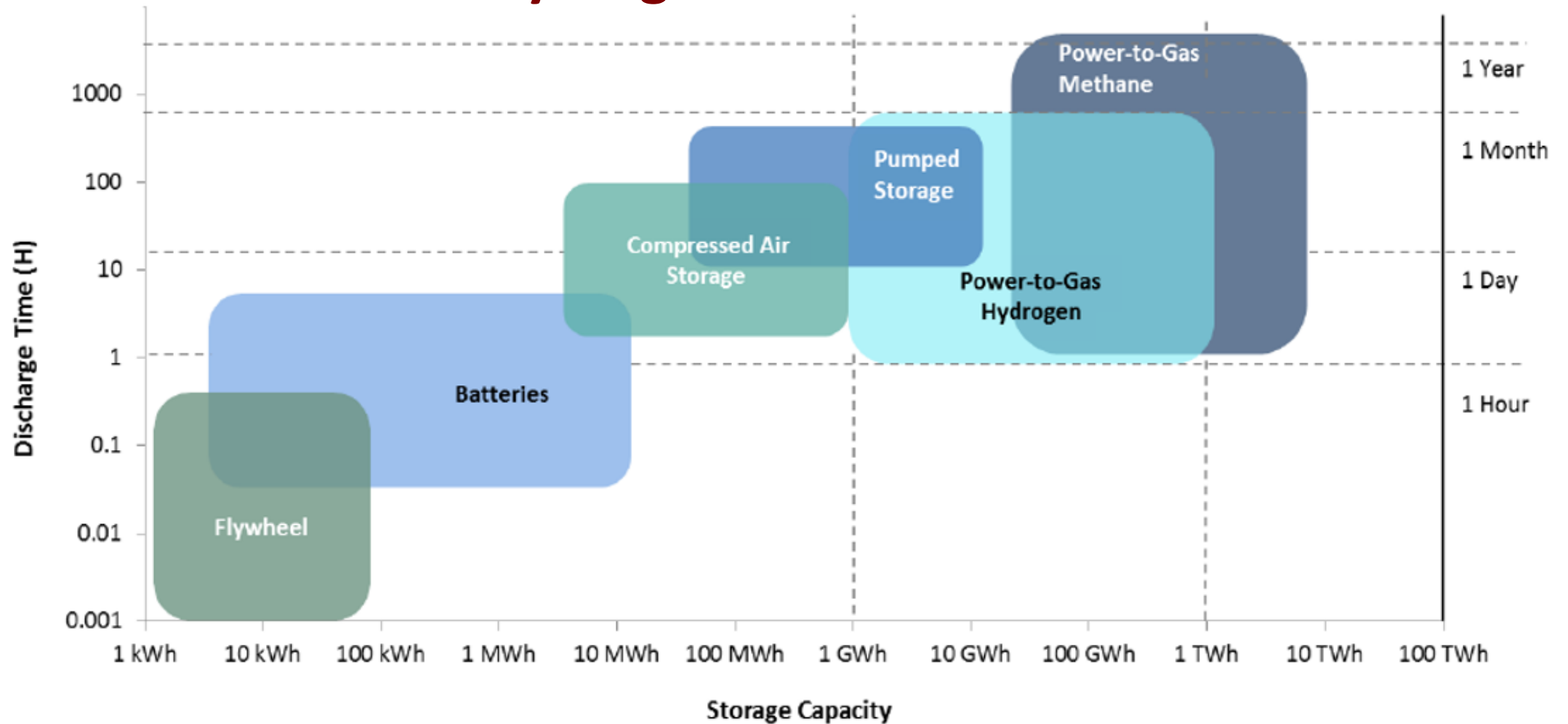


Power Parks
63 MW Beacon Falls



Energy Storage – Beyond Batteries & Pumped Hydro

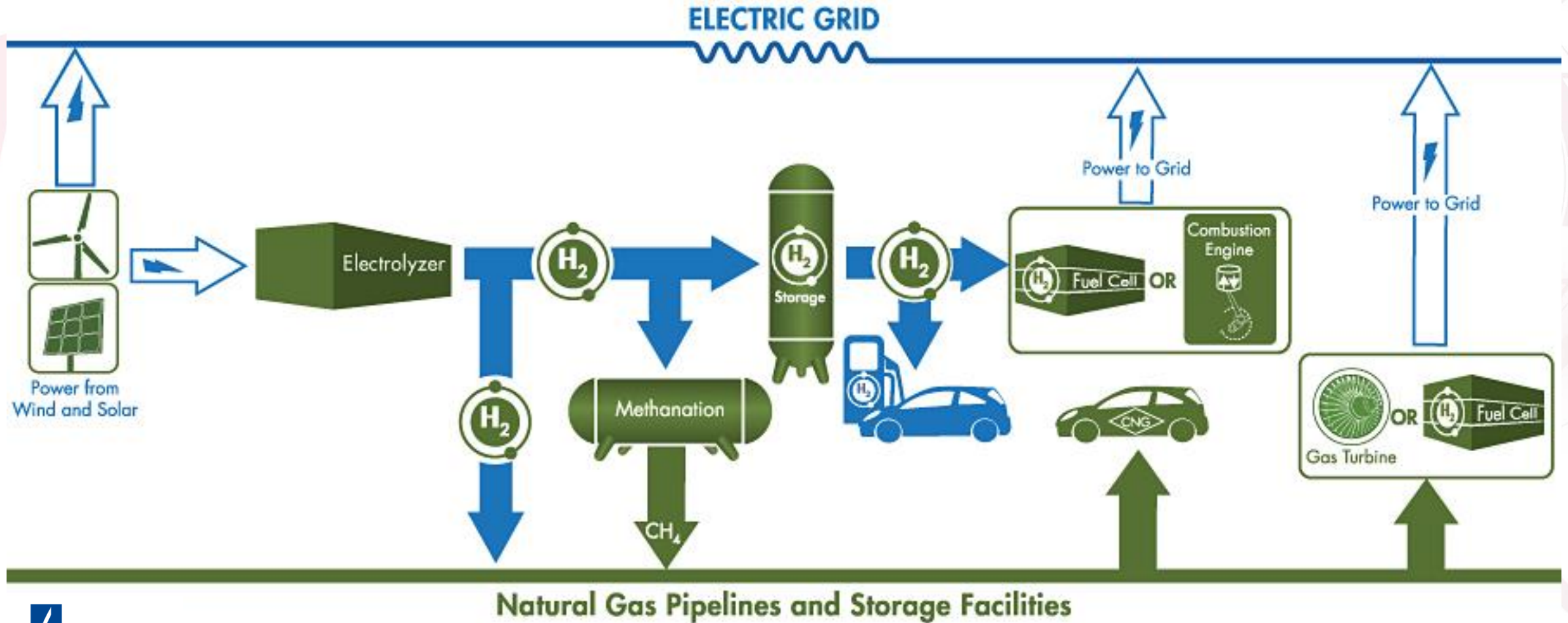
The Case for PtG: Hydrogen and ‘Renewable Gas’



After Fraunhofer ISE, 2015



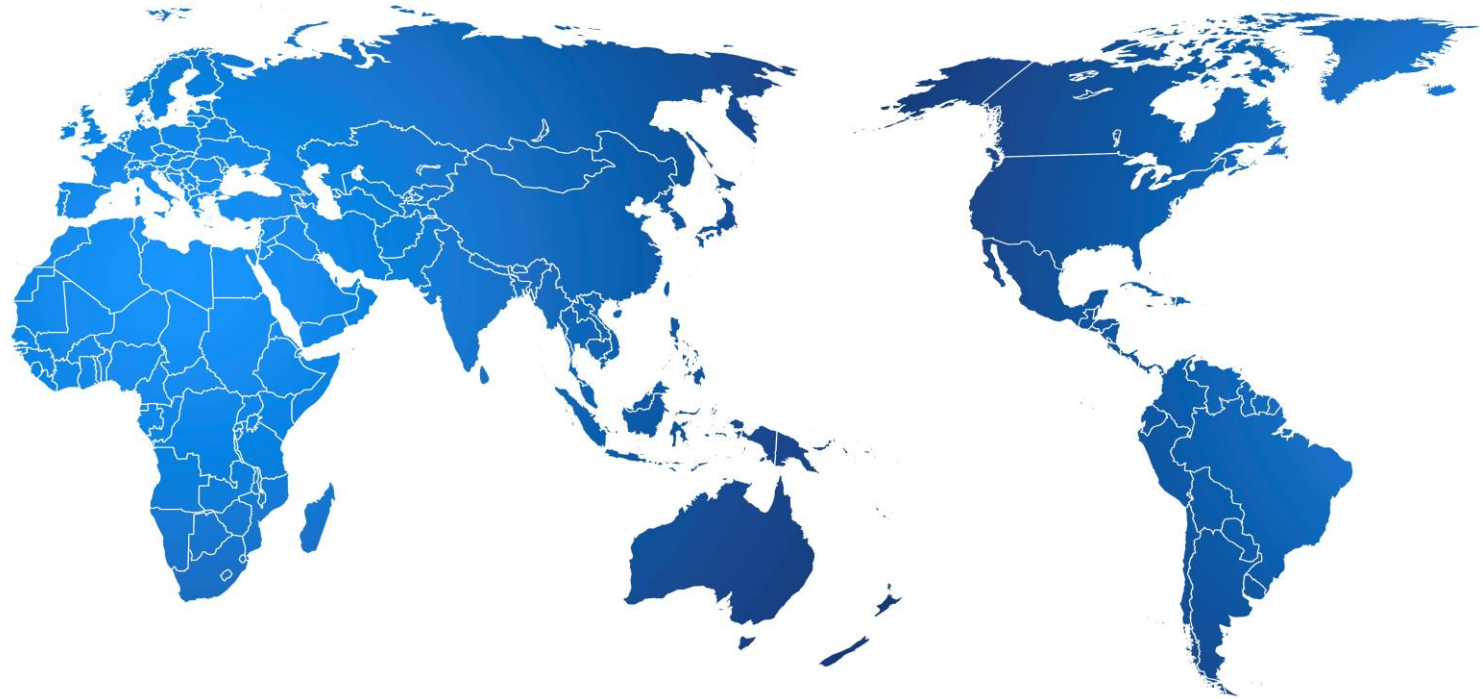
Power to Gas (PtG) Value Creation via Scale & Versatility



A Sempra Energy utility

The National Fuel Cell Research Center's Research and Development on "Power-to-Gas"

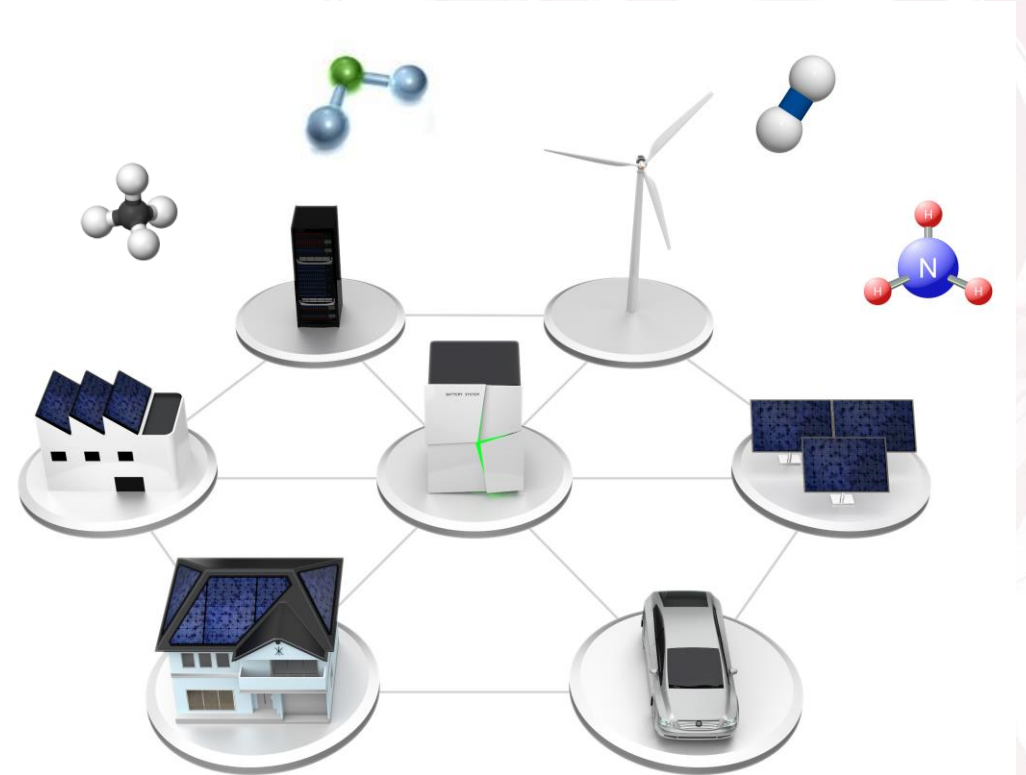
Current State Power to Gas Plans



Public Power Explores Integration Upside of PtG

Scenario: Public Power + Public Gas

- Grid Management + Balancing
- Scaling Renewables**
(Duck Curves; Seasonal Storage; Curtailment)
- Storage (Volume/Duration)
- Decarbonize Heat,
Broad Transportation & Industries**
- Regional Renewable/Bio Gas





*Surfacing
Uncertainties*



Imagining
Transitions



**Next
Steps**



Step # 1: Create a Sense of Urgency to Unlearn Old Ways

On the Plateau 'Managing the Decline'

- Incumbent mindset
- Incremental Improvement
- Fear, Uncertainty, Doubt & Denial

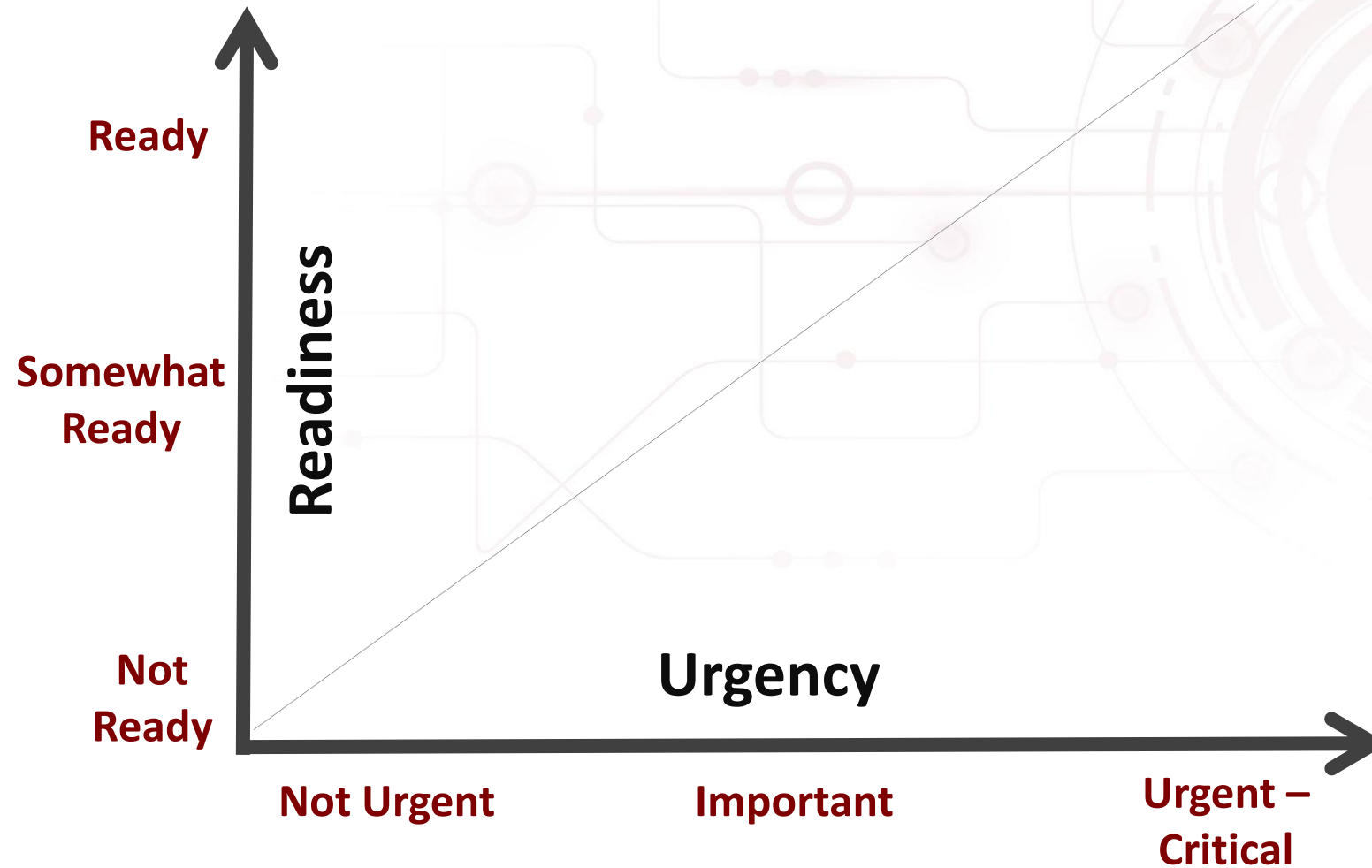
Big Bets, Small Steps

- Entrepreneurial mindset
- *Prototyping*
Transformative Change
- *Failing Forward*



Step # 2:

Pulse Check on Emerging Trends vs Organization Readiness



Step # 3: Create a Culture of T-Shaped Individuals & Teams

Broad set of Skill Sets & Mindsets

Depth of Subject Expertise

Depth of Subject Expertise

Step # 3: Create a Culture of T-Shaped Individuals & Teams

Broad set of Skill Sets & Mindsets

What are T-Shaped Skill sets & mindsets do we need..?

- Service/Experience Design
- Data Science
- Design Thinking
- Visual Communication
- Ethnography
- Artificial Intelligence
- IoT / Blockchain
- Leadership
- Values / Ethics
- Storytelling
- Entrepreneurship
- Behavioral Economics
- Sociology / Demographics
- Foresight

Depth of Subject Expertise



Thank You!!
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PDF & Resources:
garrygolden.com/Feb22