The Slow Pace of Fast Change

Imagining the Futures of Energy Systems

- Garry Golden
The Future

Regulator  Disruptor
Public Utility  Vendor  Futurist
CHANGE
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
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

trillion cubic feet

History

2015

Projections

Shale gas and tight oil plays

Tight gas

Other

Lower 48 offshore

Coalbed methane

Alaska

EIA_AEO 2016
10 Years: Uncertainties in Policy (2020 – 2030)

Annual U.S. Solar Installations

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

©2018
10 Years: Uncertainties in Players, Partners & Business Models

Oil Giant Shell Wants to Sell You Electricity

Big Oil pivots to electricity, Total leads the way

Microsoft Is Getting Hungry for Fuel Cells

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
Coal comeback? Cleaner Natgas?

Transforming Generation Asset Utilization & Longevity?

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Capacity</th>
<th>Cost ($/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal plant – no CO2 capture</td>
<td>500 MW</td>
<td>.06</td>
</tr>
<tr>
<td>90% amine capture</td>
<td>400 MW</td>
<td>.11</td>
</tr>
<tr>
<td>90% CO2 capture w/ fuel cell</td>
<td>900 MW</td>
<td>.08</td>
</tr>
<tr>
<td>5% CO2 capture with fuel cell</td>
<td>522 MW</td>
<td>.06</td>
</tr>
</tbody>
</table>

(Source: Fuelcell Energy & ExxonMobil)

Carbonate Fuel Cells
10 Years: Uncertainties of Radical Ideas (2020 – 2030)
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
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
Forecast Uncertainties

What will Govt mandate...? How will OEMs respond ...?

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 2ºC. 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  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!

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

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.
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’

Full Costs of Grid Management
Total Grid Management Costs ‘Duck Curve’ to ‘Dragon Curve’

‘Duck Curve’

‘Dragon Curve’
Planning for BEVs

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

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**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 $80-100\ kW \text{ (at volume)}$
  - Fuel Cells $20-30\ kW \text{ (at volume)}$

- 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

- Trucking
- Maritime
- Hydrail
- Aviation / UAVs
BEV Infrastructure – 2020 – 2030

Necessary and Not Sufficient
Preparing for Bifurcated ‘Electric’ Vehicle Market

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

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.

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

Global fossil fuel & industry emissions, 2014 (33.9 Gt CO₂)
2020 – 2030

Rethinking Role of Molecules: Distributed Energy Resources
Distributed & Direct Use of Natural Gas, Propane and Biogas MicroCHP Fuel Cells

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

100-home pilot program

THE POWER PLANT FOR YOUR HOME
Customers Discover Fuel Cells in RVs & Construction Sites

Propane-fed RV & #Vanlife Generators

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

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
Imagining Transitions
Surfacing Uncertainties
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

- Depth of Subject Expertise
- Broad set of Skill Sets & Mindsets
Step # 3: Create a Culture of T-Shaped Individuals & Teams

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