
PaloVerde™
GENERATING STATION

Scenario Planning: A Study of Our Future to Make Better Decisions Today

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BIO

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Energy Policy & Business Strategy Executive Advisor

Palo Verde Generating Station

- Expert strategist
  - Experience in both nuclear & broader utility strategic foresight
  - National Renewable Energy Laboratory (NREL) working group nuclear member focused on sustainability design practices
  - Co-presented with Dr. Cynthia Selin (Arizona State University/University of Oxford) at the 7th Annual Conference on Governance of Emerging Technologies & Science, Sandra Day O'Connor College of Law
  - Guest lecturer and speaker at Arizona State University & University of New Mexico
  - U.S. Host and Consultancy Member of International Atomic Energy Agency (IAEA) Economics of Flexible Operations Technical Meeting (TM)
- Former nuclear instrumentation & controls design engineer

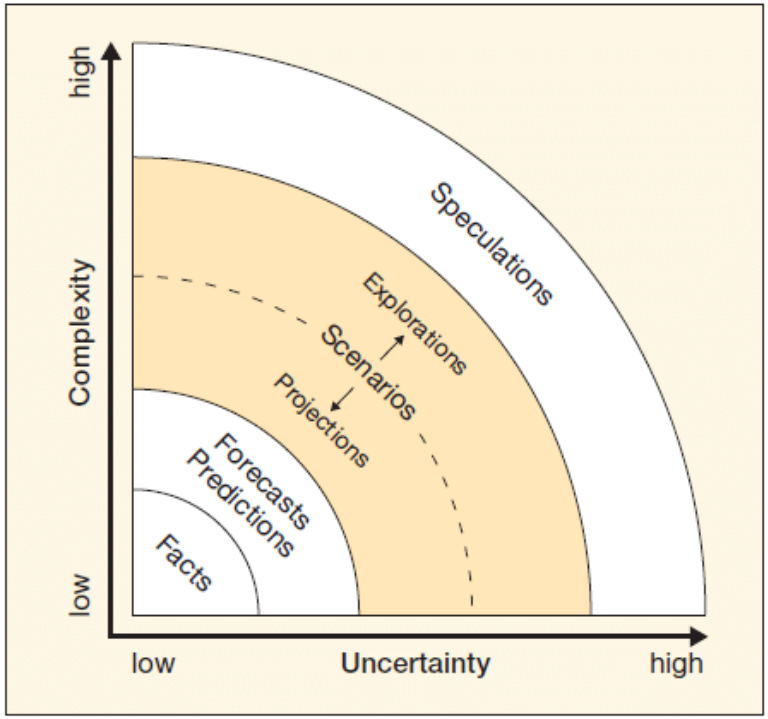
SESSION AGENDA

- A CHANGING WORLD
- SCENARIO PLANNING PROCESS
- QUESTIONING ASSUMPTIONS
- TRENDS AFFECTING OUR INDUSTRY
- A DIFFERENT APPROACH TO INNOVATION

A CHANGING WORLD

CHANGE & SENSE MAKING

- The energy industry is rapidly changing across social, technical, economic, environmental, and political spheres
- Due to the inherent level of uncertainty and complexity, focus must shift from **probability** to **plausibility**
  - Widen a company's lens to the changing world
  - Go beyond straight line future projections
  - Acknowledge and design for complex disruption ahead



Source: Zurek and Henrichs, 2007

SIGNALS OF A CHANGING WORLD:

↑ COMPLEXITY

&

↑ UNCERTAINTY

GRID DECENTRALIZATION: RURAL ELECTRIC CO-OPS SEEK MORE LOCAL CONTROL

- Traditional transmission and distribution networks are increasingly vulnerable to storms, floods, and wildfires
- Customers want:
  - locally produced electricity
  - Dynamic minute-by-minute pricing
- Over 900 electric cooperatives exist nationwide

Source: Renewable Energy World

PREPARING NEW YORKERS FOR FUTURE FLOODING

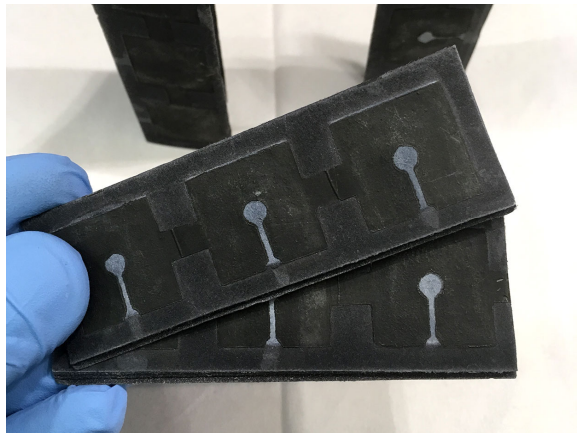
- The Federal Emergency Management Agency (FEMA) revised NYC's flood maps
- Flood maps indicate both current risk and, using a new methodology, ***future climate conditions***

- Homeowners in the highest flood risk areas must purchase flood insurance if they have a mortgage

Source: FloodHelpNY

PAPER BATTERIES CHARGED WITH BACTERIA COULD POWER THE INTERNET OF THINGS

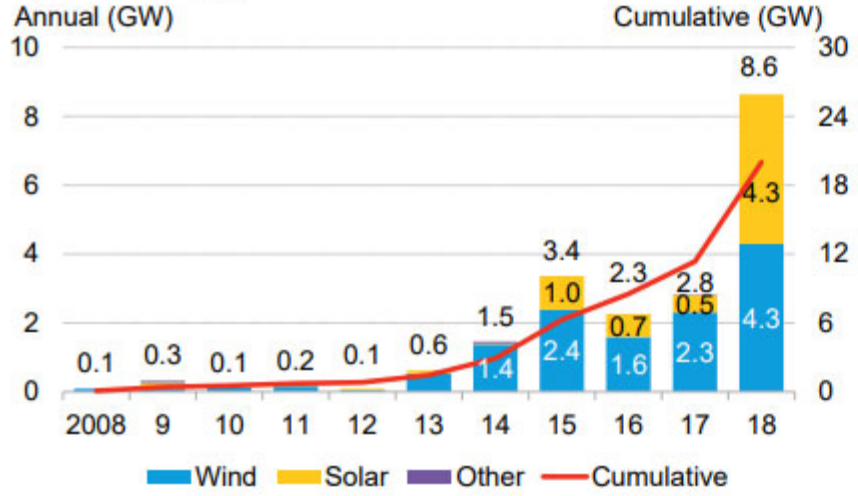
- Creation of a cheap, sustainable, single-use battery to power billions of sensors and devices
- Bacteria will both generate an electric current and devour the battery at the end of its useful life
- More than 50 billion electronic devices to be deployed during the next 5 years



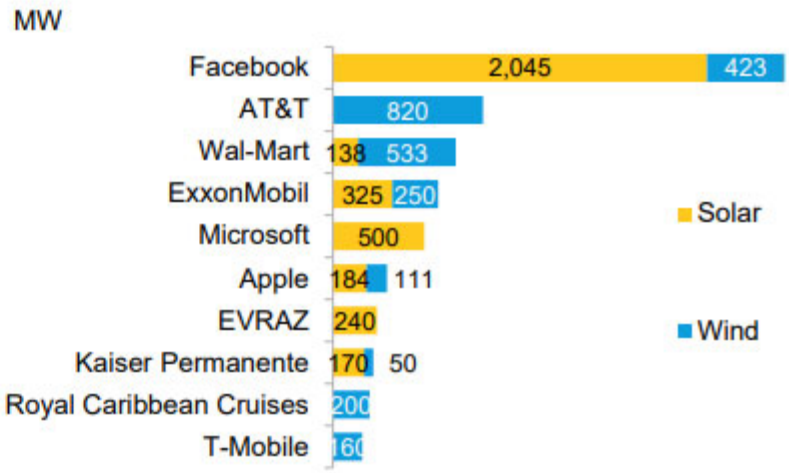
Source: IEEE Spectrum

INVESTOR PRESSURE TO DECREASE EMISSIONS

Renewable capacity contracted by corporations, by technology



Largest corporate offtakers, 2018



Source: BloombergNEF, 2019

- Power purchase agreements (PPAs) signed between buyers and generators spiked in 2018
- Facebook is working with regulated utilities to limit their exposure to plummeting wholesale power prices
- ExxonMobil is the first oil and gas major to lock into long-term clean energy contracts
- 4.5 GW of corporate PPAs signed since 2014 have been through smaller companies aggregating loads

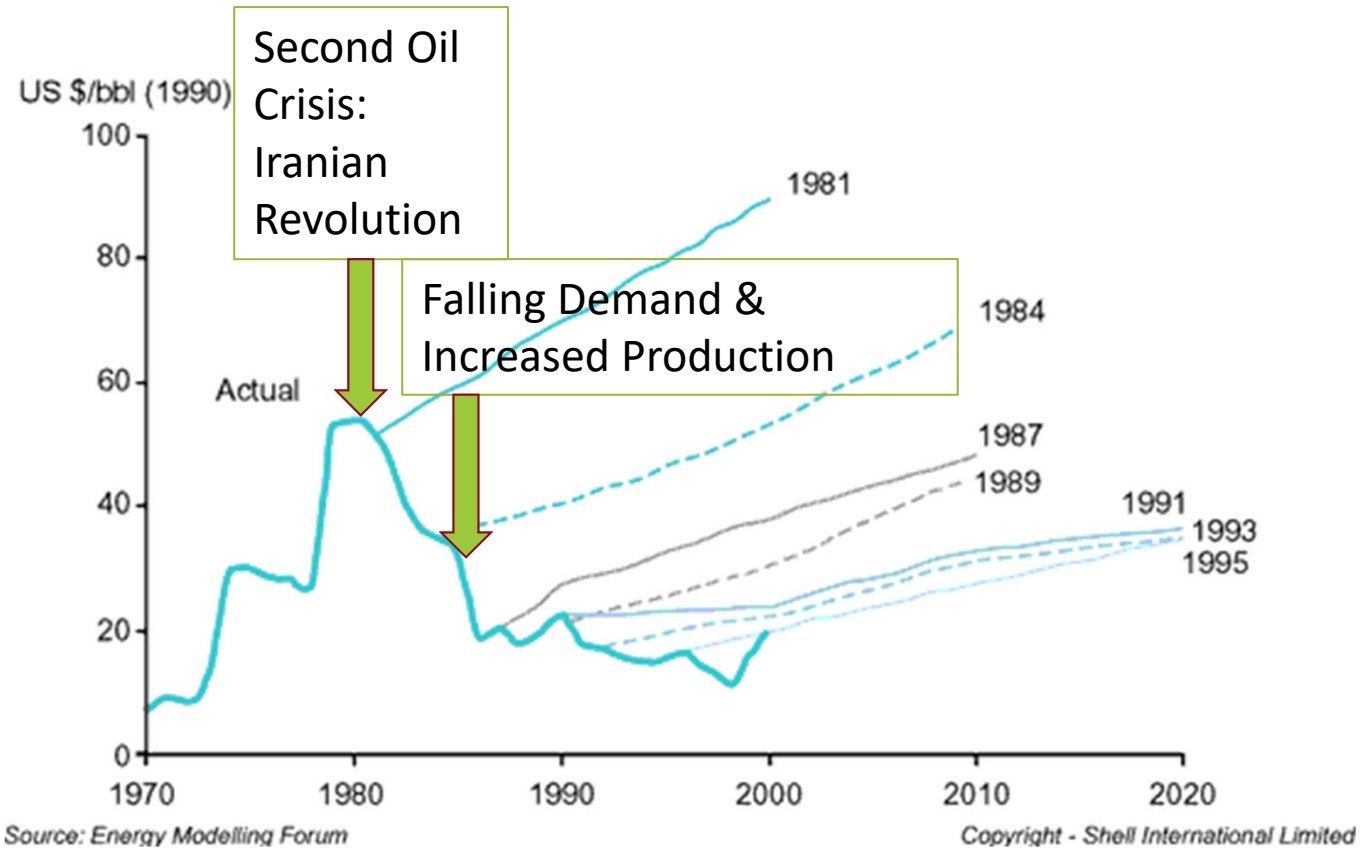
BIG QUESTIONS ABOUT DISRUPTIVE CHANGE

- What new opportunities and new threats are emerging?
- What do these trends mean for us?
- How can nuclear power best prepare for a changing energy landscape?

Source: Selin, 2018

SCENARIO PLANNING PROCESS

THE FUTURE WILL BE DIFFERENT FROM THE PAST



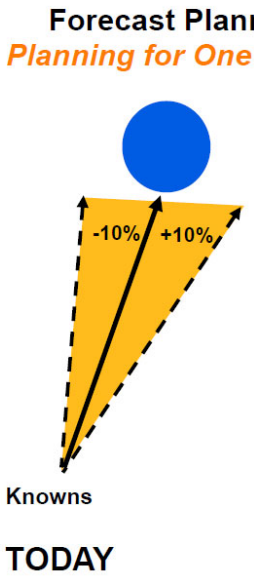
SCENARIOS

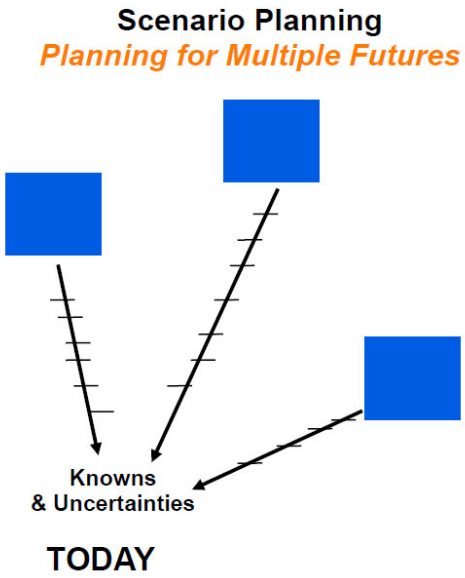
Scenario planning is a structured process for thinking systematically about the evolution of drivers of change.

SCENARIOS

- Portray alternative future pathways facing an industry in order to boost preparedness
- Help inform strategic decisions in the present by assessing the implications of possible futures

Common forecasting methods often fail in times of great uncertainty and complexity

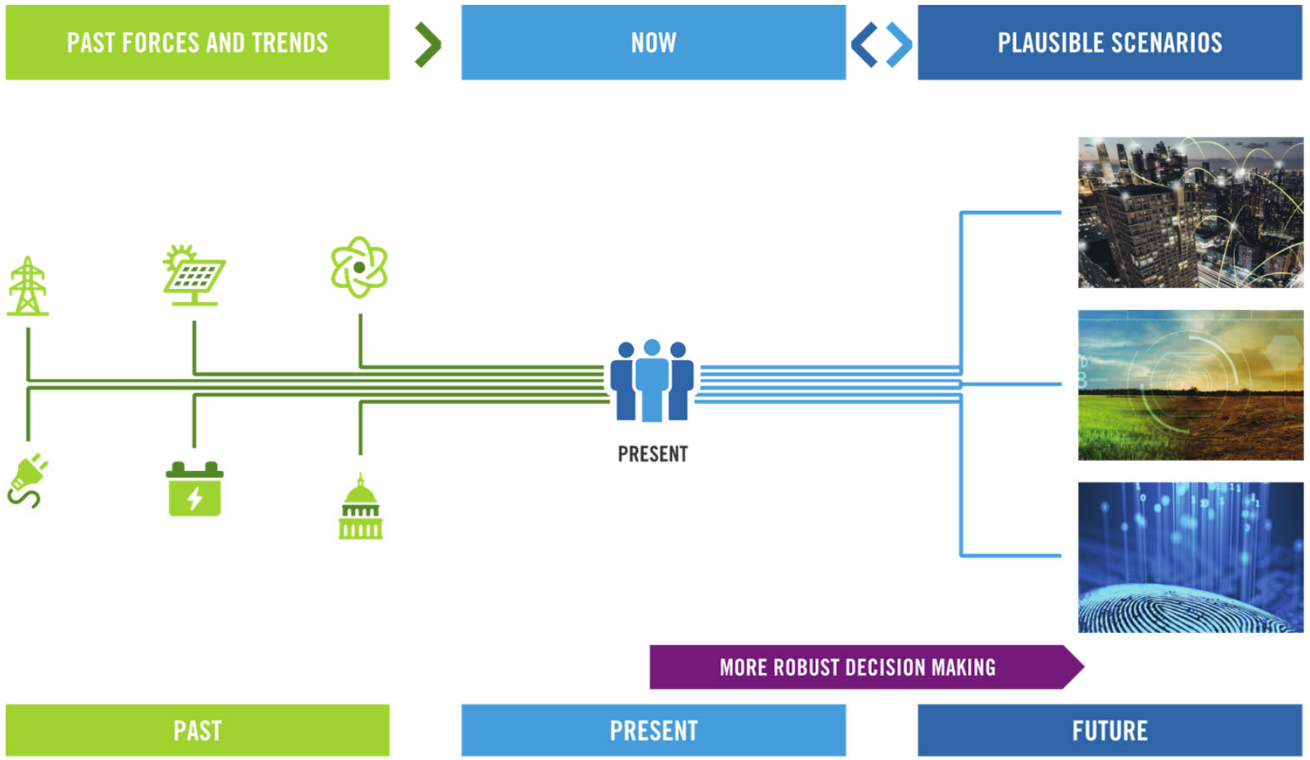




Source: Selin, 2006. *Futures*.

Source: Jay Ogilvy, 2015. Forbes.

THE SCENARIO
PLANNING PROCESS



ASSESSING IMPLICATIONS TO GENERATE NEW OPTIONS

How will our current way of working fly in the future?

How will our existing strategies perform in each of the scenarios?

What are the pros and cons of each world?

Where are we vulnerable?

What are the new opportunities?

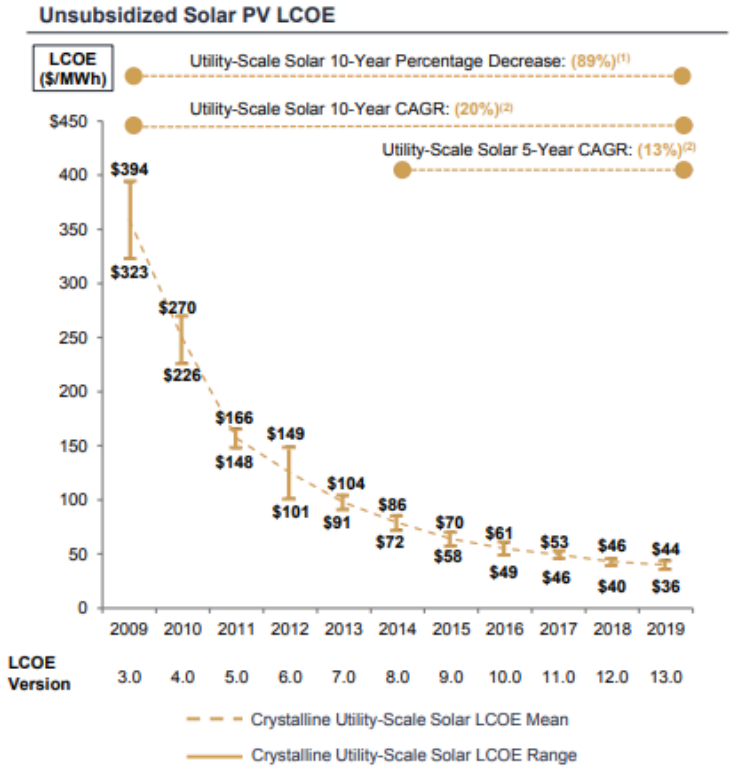
Source: Selin 2017 | *Scenaric*

QUESTIONING ASSUMPTIONS

SOLAR

Illustration of utility scale solar levelized cost of energy (LCOE):

- System component declines due to material costs
- Improvements in efficiency
- *"As industries mature, rates of decline diminish"*

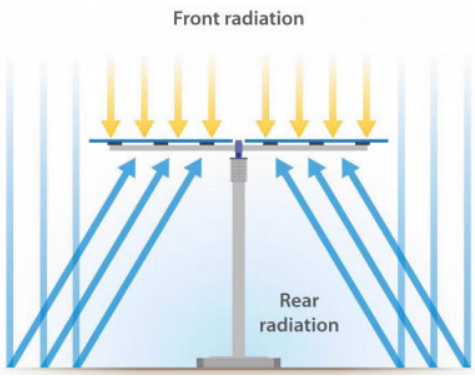


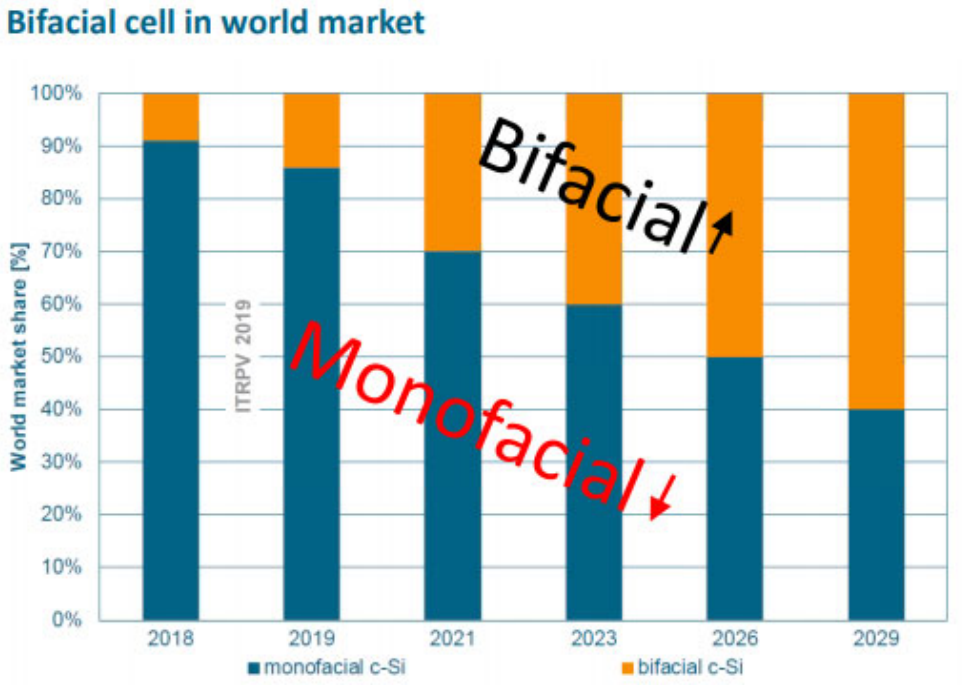
Source: Lazard Levelized Cost of Energy (LCOE) Ver. 13, 2019

SOLAR TECHNOLOGY DISRUPTION

Bi-Facial Solar:

- LCOE of bifacial systems is competitive with monofacial systems
  - 25% tariff exemption rescinded
- NREL: Energy gains of 6% to 9%





Source: National Renewable Energy Laboratory, 2019

DEMAND FOR HYDROGEN

Weak market signals, but near-future potential

World Energy Council (WEC):

- Technologies ready
- Cost decrease: scaling up, automating processes and production, & use of existing supply chains (e.g. ammonia)
- "**Green**" → "**Clean**" hydrogen
  - *Inclusive of nuclear*
- Deeper consumer engagement = emergence of niche markets:
  - green fertilizer for Coffee Hy!
  - green steel
- Other: Heavy-duty mobility, home heating, long-term storage

Collaboration: WEC Hydrogen Global platform

Source: Marzia Zafar, WEC Director of Insights, 2019

Commercial News:

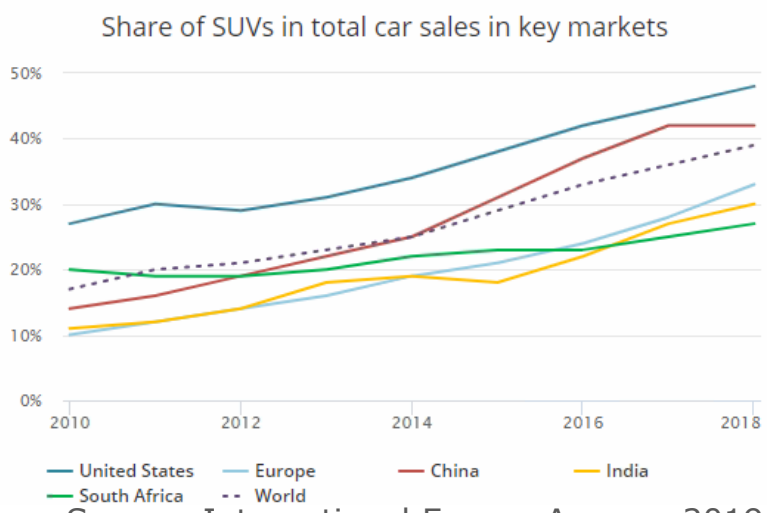
- Amazon: hydrogen drones
- Nikola Motor: heavy-duty hydrogen semi-trucks

Source: Nikola Motor, 2019

ELECTRIC VEHICLE ADOPTION

Charging patterns are based on individual use

- **Disruption:**
  - Hydrogen vehicles
  - Adoption of Sport Utility Vehicles (SUV)
    - Difficult to electrify due to size
  - Adoption of autonomous vehicles
  - Rideshare growth
  - Vehicle-sharing platforms



Source: International Energy Agency, 2019

Regional Trends:

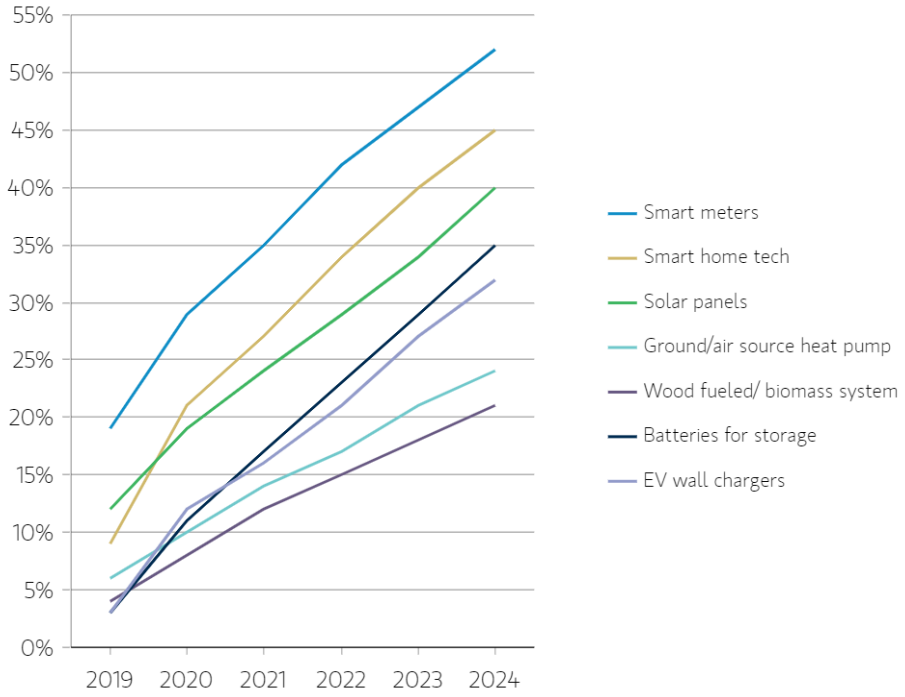
- Locally, the city of Chandler debuted the first autonomous vehicle rideshare pickup zone

CONSUMER TRENDS

Many predictions show stagnant or low consumer demand growth for utilities

- It is possible that the demand a utility sees may go down
- **United States:** Over 900+ electricity co-operations exist

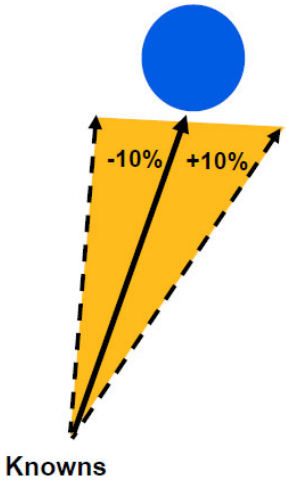
- **Morgan Stanley Research:**
  - 1 in 3 homeowners worldwide interested in generating their own electricity in the next 5 years
  - Consumers well aware of new energy technology, battery storage, smart meters & home technology
  - Role of changing demographics



Source: Alphawise, Morgan Stanley Research

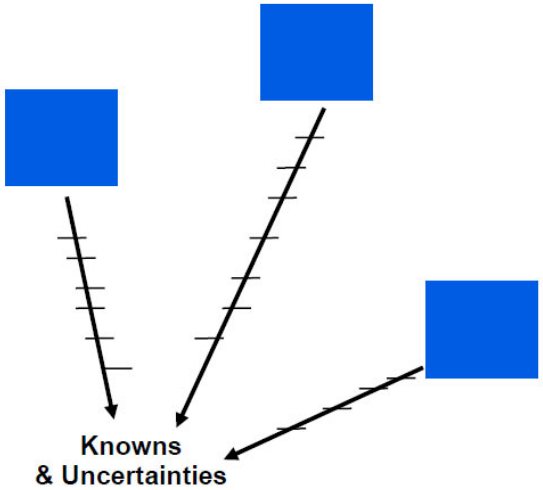
PLANNING

Forecast Planning
Planning for One Future



TODAY

Scenario Planning
Planning for Multiple Futures



TODAY

Source: Jay Ogilvy, 2015. Forbes.

TRENDS AFFECTING OUR INDUSTRY

ENERGY STORAGE TECHNOLOGIES

DIGITIZATION

TRANSFORMATION
OF THE GRID

AUTOMATION, ARTIFICIAL INTELLIGENCE, & MACHINE LEARNING

SYSTEMATIC RESEARCH

COMMUNICATION
INFORMATION MEDIA

CLIMATE CHANGE

ENERGY POLICY

ELECTRIFICATION

MARKET VALUES

NATURE OF RISK & RETURN

ECONOMIC OUTLOOK

DRIVING **FORCES**

Broad shifts occurring outside the industry that have the potential to influence industry trends

Derived according to "**STEEP**" framework:

- **S**OCIAL
- **T**ECHNOLOGICAL
- **E**NVIRONMENTAL
- **E**CONOMIC
- **P**OLITICAL

What are the main external factors that will shape the future of nuclear power in 2040?

What are the big picture changes that may influence the energy landscape?

Source: Selin | *Scenaric*

MAPPING THE
CONTEXTUAL ENVIRONMENT

SOCIAL

Polarization of Thought/Echo Chambers
Changing Demographics
Public Understanding of Different Generating Sources
Increased Cyber Security Threats
Social Impact of Climate Change
Consumer Demand for Energy Autonomy
Drive to Electrification
Energy Demand and Population Growth
Local Employment Trends
Public Attention on Nuclear Weapons Scare
Volatility in Skilled Labor Demand

MAPPING THE
CONTEXTUAL ENVIRONMENT

TECHNOLOGICAL

Abundance of Data Access
Growth in Consumer Energy Storage
Drive to Energy Efficiency
Advances in Energy Storage
Developments in Grid Stability Technology
Challenges in New Nuclear Construction
Production Efficiencies due to Technology
Evolution of Small Modular Reactors
Innovations in Accident Tolerant Fuel

MAPPING THE
CONTEXTUAL ENVIRONMENT

ENVIRONMENTAL

Air Pollution Impacts

Environmental Implications of Climate Change

Energy-Water Nexus

Grassroots Environmental Focus

Integration of New Technologies

Demand for Plug-in EV

Growing Resource Scarcity

Rooftop Solar Penetration

Electricity Generation Variability

Physical Plant Vulnerability

MAPPING THE
CONTEXTUAL ENVIRONMENT

ECONOMIC

Aging Grid and Infrastructure

Aging Nuclear Fleet

Global Economic Outlook

Rising Inequalities

Life Cycle Costs for All Generating Sources

Natural Gas Price

New Build Duration

Economic Viability of Nuclear Power

Regional Economic Outlook

Subsidized Renewables

Willingness to Pay

Technological Efficiencies

MAPPING THE
CONTEXTUAL ENVIRONMENT

POLITICAL

Changing Fuel Demands

Political Drive to Address Climate Change

Globalization

Instability Worldwide

National Energy Policies

Nuclear Waste Resolution

Geopolitics of Oil

Political Support of Nuclear Power

Fragmentation of Energy Policy

Demand Side Management (Load Shifting)

WORKING WITH **TRENDS**

Broad shifts occurring outside the industry that have the potential to influence industry trends

SOCIAL

TECHNOLOGICAL

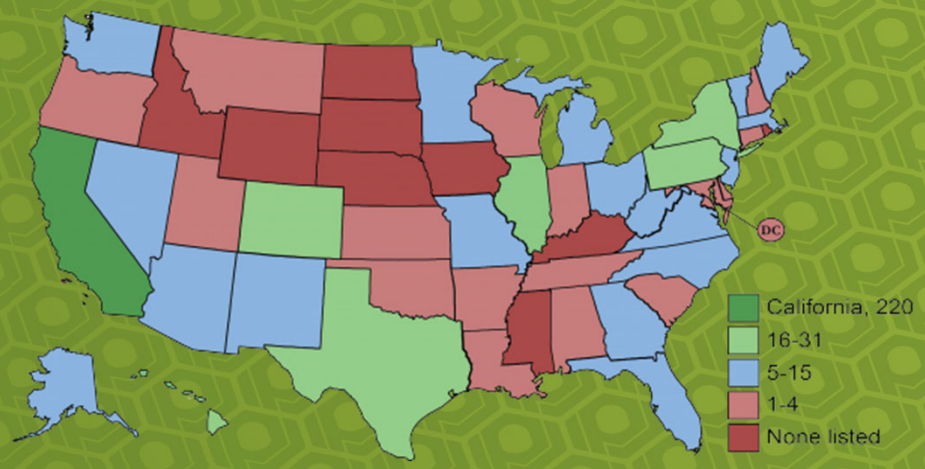
ENVIRONMENTAL

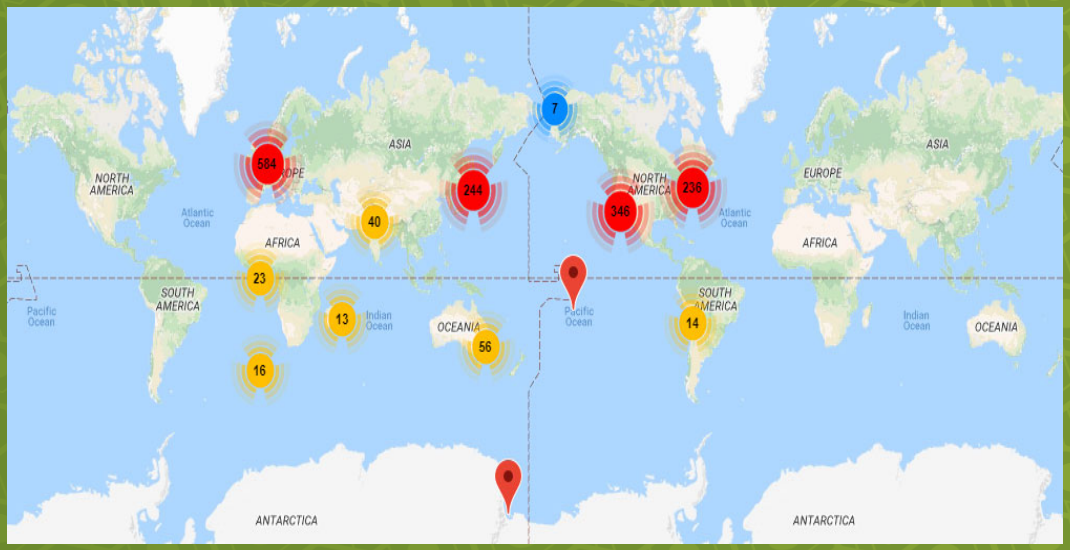
ECONOMIC

POLITICAL

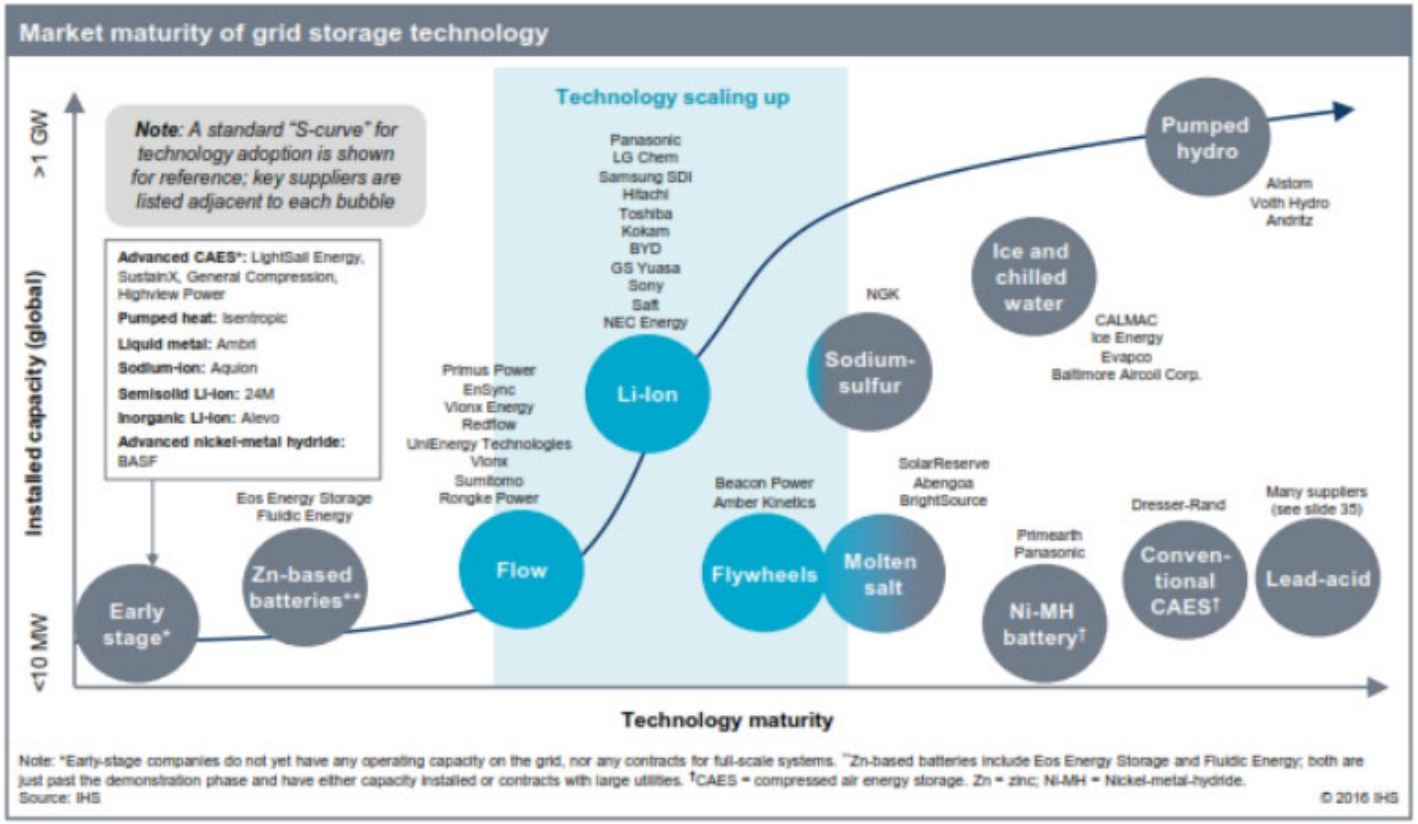
Exploration of several trends

Innovations and Cost Savings in Grid Scale Electrical Energy Storage (EES)



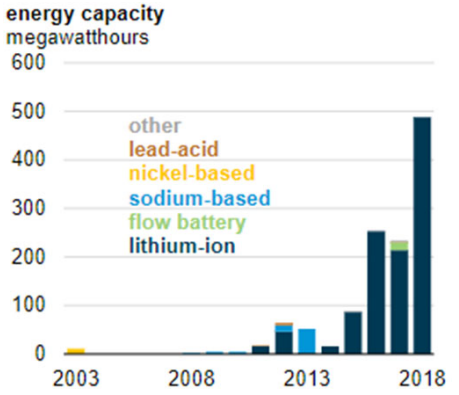


U.S. DOE “Global Energy Storage Database Projects”



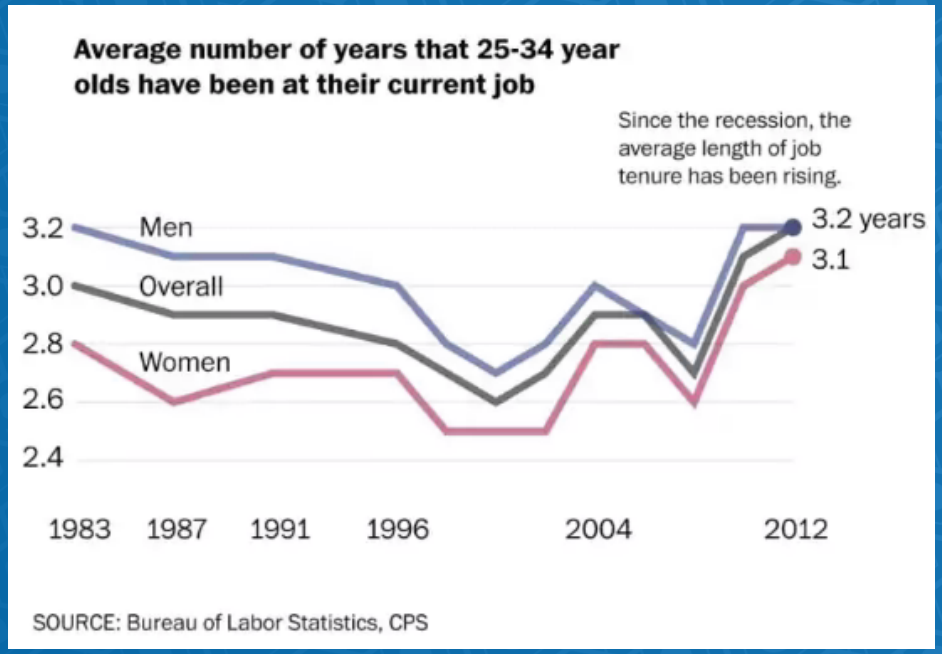
Tech Spotlight:

- Researchers at the universities of Michigan and Utah have found a way to devise a flow battery anolyte that is 1,000 times more stable than existing compounds, potentially leading to longer-lived, more efficient batteries.



Source: U.S. Energy Information Agency, 2020

Societal Value of Long-term Employment with a Single Employer

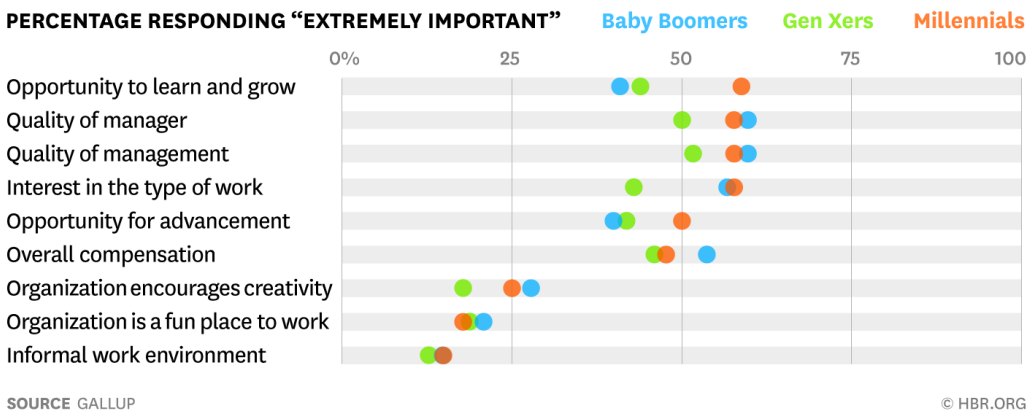


Though millennials are not job hopping more than past generations, their reasons for staying or leaving are changing.

More and more people are having to join companies via outside contract agencies – many with limited, if any, benefits plan (e.g. 401k, pension, merit increases/bonuses, PTO.)

What Different Generations Look for When Applying for a Job

According to a survey of 1,700 U.S. workers.



According to Forbes, some key reasons for changing jobs in today's day and age are the following:

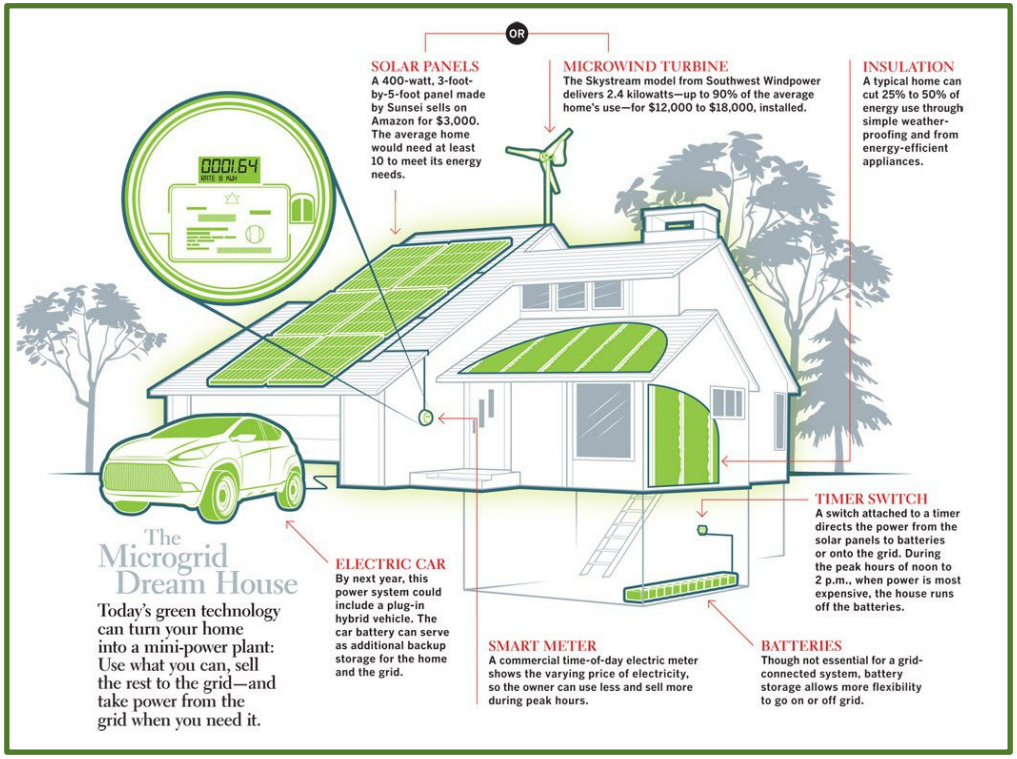
- **Globalization:** A position at the hottest start-up in the Bay Area can be filled by an expert based in Beijing.
- **New Loyalties:** Instead of being loyal to a particular company, many are now loyal to specific people they work with. When these people leave, they typically bring their friends with them.
- **Mindset:** New employees expect to be at an organization for a few years before moving onto the next big thing. Changing jobs, while getting promotions in the process, allows employees to avoid the "dues paying" that can trap workers in a painfully slow ascent up the corporate ladder. There is also reduced negative stigma around job hopping today.
- **Job Fulfillment:** New workers more than any other previous generation consider "positive culture" and "interesting work" very important or essential to their dream job. Less focus is placed on "stability" because it is rare to find post-recession.

Increasing Demand for Energy Autonomy

The guiding concept of energy autonomy means that the goal must be to make energy available in a way that is self-determined, not heteronomous; energy must be free and independent of external constraints . . . used according to decision-making of one's own.

Herman Scheer, "Energy Autonomy: the economic, social and technological case for renewable energy"

Driven in part by improving technical capability and by ambitious carbon emissions reduction targets, there has been the beginning of a shift towards a more distributed energy generation model, capable of delivering a range of potential benefits, but also presenting a number of social and technical challenges.



Microgrids:
A microgrid not only provides backup for the grid in case of emergencies, but can also be used to cut costs, or connect to a local resource that is too small or unreliable for traditional grid use; allows communities to be more energy independent and, in some cases, more environmentally friendly.

Further Aging of the Grid and Increasing Cost of Upkeep and Enhancements

Aging and Unstable, The Nation's Electrical Grid is 'The Weakest Link'

From the 1950s to the '80s, significant power outages averaged fewer than five per year. But that's changed. In 2007, there were 76, in 2011, more than 300.

NPR

Grid Modernization

- Until recently, grids transmitted power in only one direction: from large-scale power plants to customers.
- New technology, such as rooftop solar, have paved the way for customers to also sell back power. Modernization of the grid to support this comes at a cost.
- Companies are likely to invest hundreds of millions of dollars in advanced grid technology.

Much of the U.S. energy system predates the turn of the 20th century. Most electric transmission and distribution lines were constructed in the 1950s and 1960s with a 50-year life expectancy, and the more then 640,000 miles of high-voltage transmission lines in the 'lower 48 states' power grids are at full capacity.
Without greater attention to aging equipment, capacity bottlenecks, and increased demand, as well as increasing storm and climate impacts, Americans will likely experience longer and more frequent power interruptions.
American Society of Civil Engineers

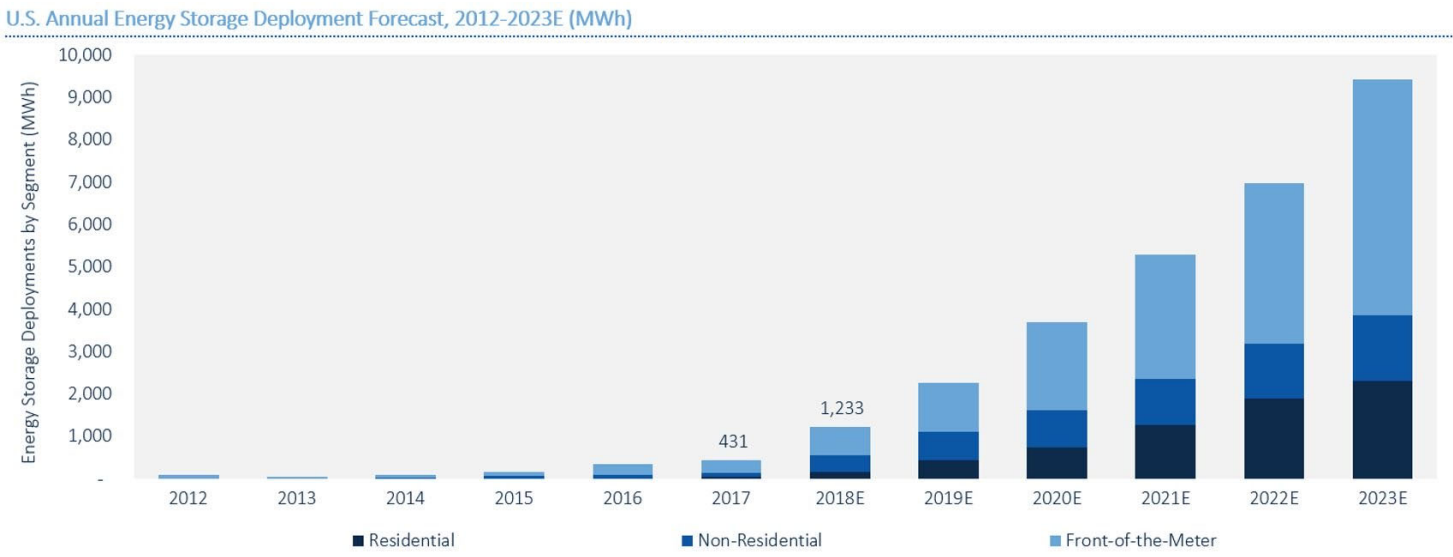
Advances in Consumer Energy Storage

Compact, stackable and with a built-in inverter, Powerwall also comes ready to integrate seamlessly with Tesla solar, enabling you to self-power your home and even go off-grid, if you like. No need to wait for the upcoming Solar Roof to buy one.

Tesla

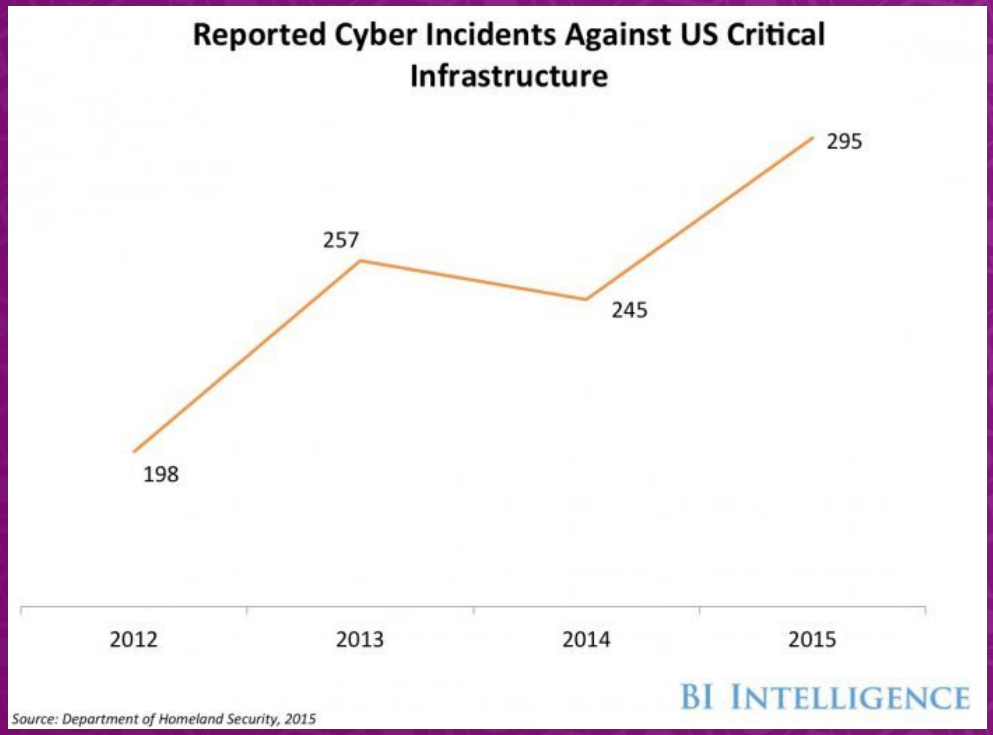
Customer Side Storage Options

- Charging a Plug-in Electric Vehicle's battery
- Storage Heaters – an electric heater that stores thermal energy during the evening and releases it during the day
- Ice Storage - standard chiller runs at night to produce an ice pile; water then circulates through the pile during the day to produce chilled water that would normally be the chiller's daytime output
- House batteries used to store surplus electricity



Source: GTM Research/ESA U.S. Energy Storage Monitor, 2020

Increased Frequency of Cyber Security Events



- According to the U.S. Department of Homeland Security, cybersecurity attacks are more frequent and sophisticated across numerous industries
- Number of attacks on industrial control systems on the rise

Hacker Spotlight:
Symantec uncovered evidence of North Korea attacking banks in Bangladesh, Vietnam, Ecuador and Poland, stealing at least US $94 million

Hacker Spotlight:
In December of 2016, hackers caused a blackout in the Ukraine by hacking into a power grid's connected control system

Why is the frequency rising?

- **Ransom Money**: Hackers can cripple business/plant operations through ransomware and demand to be paid to release their grip
- **Political Disruption**: Country-sponsored attacks used to leak stolen information or alter databases
- **Stealing Virtual Money**: Online bank heists are in the multi-million dollar realm

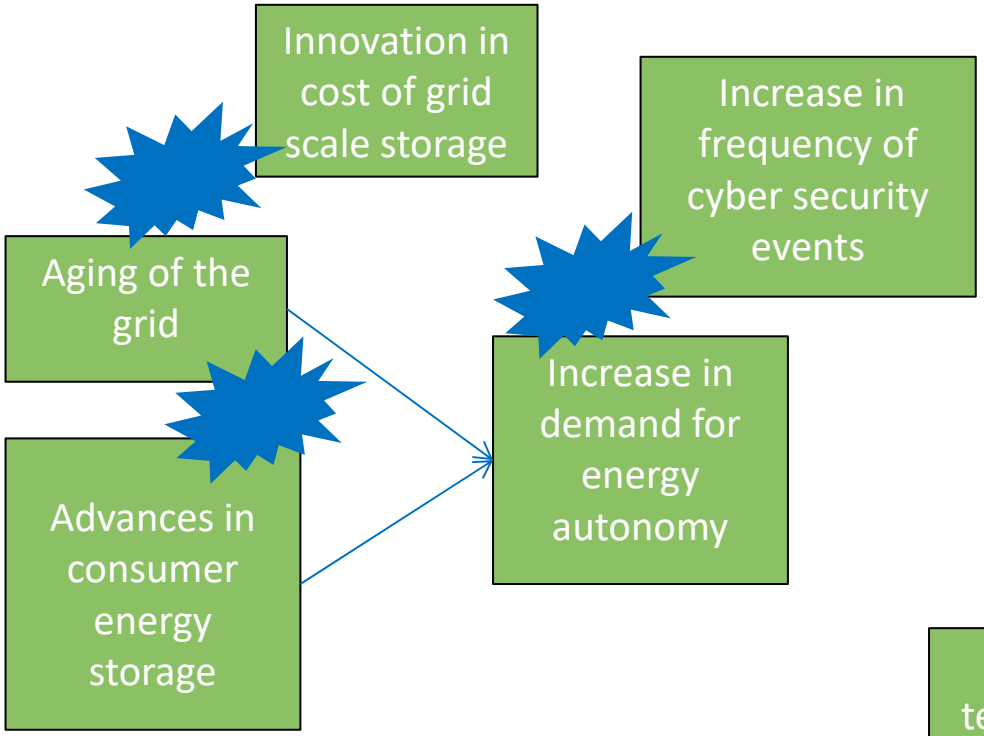
WORKING WITH **TRENDS**

Broad shifts occurring outside the industry that have the potential to influence industry trends

- **S**OCIAL
- **T**ECHNOLOGICAL
- **E**NVIRONMENTAL
- **E**CONOMIC
- **P**OLITICAL

Combination of 2 or more factors to explore the implications

EXAMPLE: TREND **CRASHING**



Decreasing long term employment with a single employer

New Insights? What surprising discovery did you make?

New Questions? What would you now like to know more about?

Building larger eco-systems of potential futures

SWOT analysis to reveal options and analyze trade-offs

A DIFFERENT APPROACH TO INNOVATION

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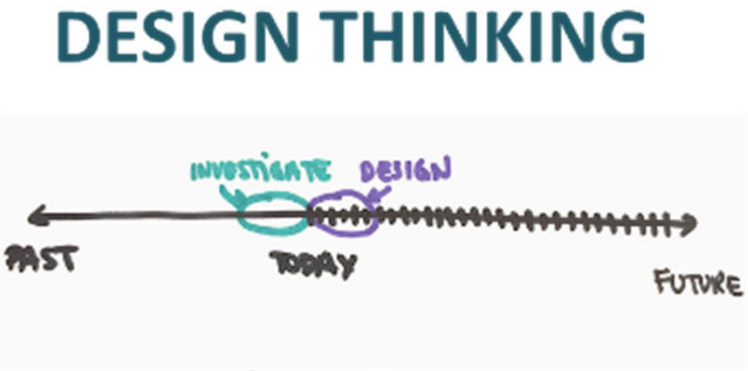
Traditional Design Approach

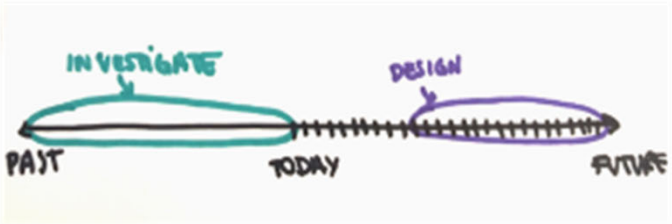
- Designs for today and the immediate future

Futures Thinking Approach

- Design for today and the far reaching future (e.g. 30 years)



Short-Term

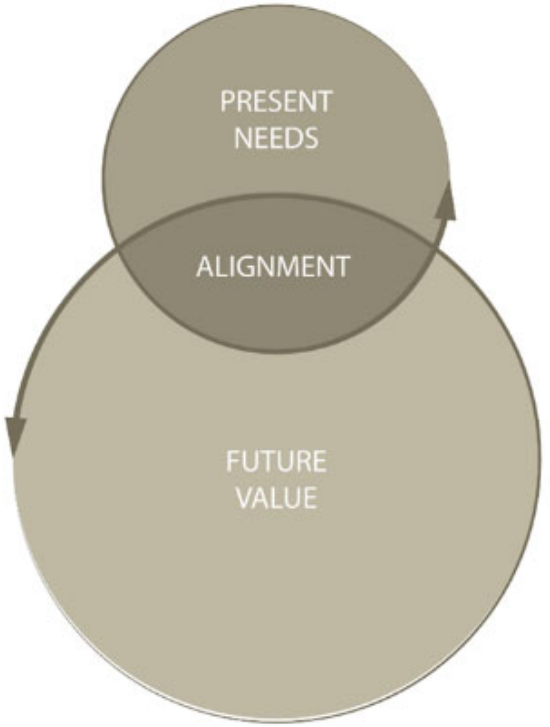


Long-Term

Source: Roumiantseva, 2016

A DIFFERENT APPROACH TO INNOVATION

Visually depicted another way…

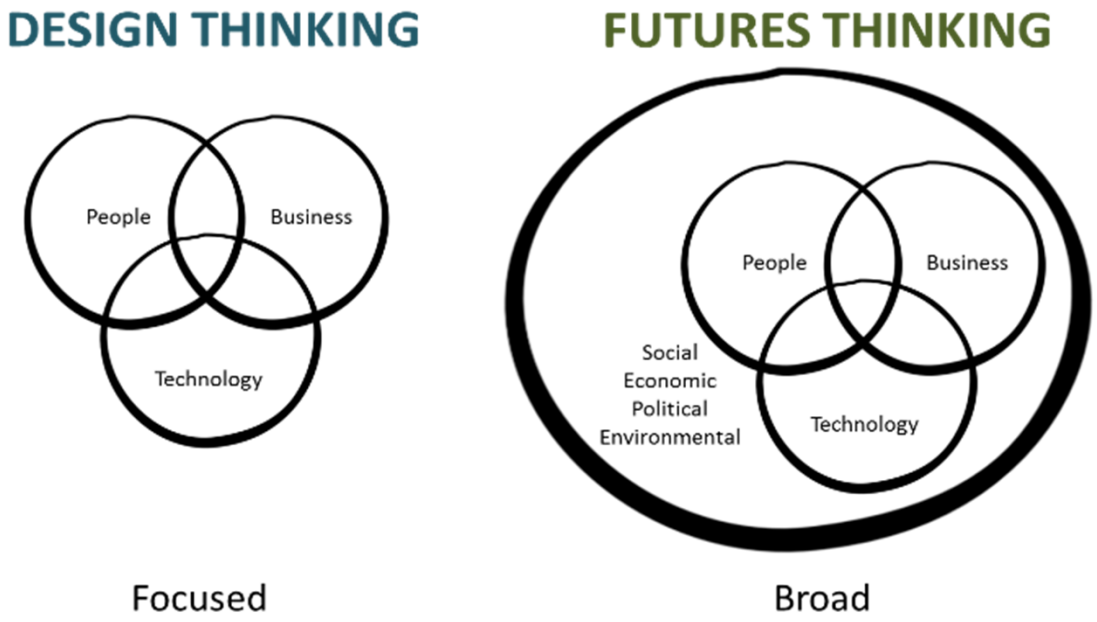


Source: Roumiantseva, 2016

A DIFFERENT APPROACH TO INNOVATION

Utility companies have frequently **focused** on how to solve today's problems

Today's environment demands a **broader** approach



Source: Roumiantseva, 2016

A DIFFERENT APPROACH TO INNOVATION

- Companies have been surprised when outside influences (e.g. technology trends) upend their business approach
- Netflix approached Blockbuster with a partnership proposal
- Blockbuster:
  - Maintain status quo
  - Focus on physical stores and inventory
  - Ignored weak signals of change

Source: NBC News, 2020

A DIFFERENT APPROACH TO INNOVATION

- Dubai used to be a small fishing village of 50,000
- Diversification started in 1970
- By 2000, there's a stock exchange

Source: World Economic Forum, 2020

- Today, less than 1% of Dubai's GDP is from oil – *at one time it was over half*
- Population now 3M+

Future Strategy

- Goal of 50% renewables by 2050
- Need to avoid over-dependence on oil

NEW APPROACH TO INNOVATION

- Allows an industry to go from **reactive** to **proactive**
- Identify new partnerships
- Inspire technical collaboration in untraditional spaces
- Learn from other industries/competitors
- Understand the larger conversations, such as circular economy design
- Go beyond engineering and economic solutions

Big lever changes will greatly impact pathway analyses

Distribution of demand is not equal across all generation sources

EXAMPLE OPTION: CEMENT PARTNERSHIP

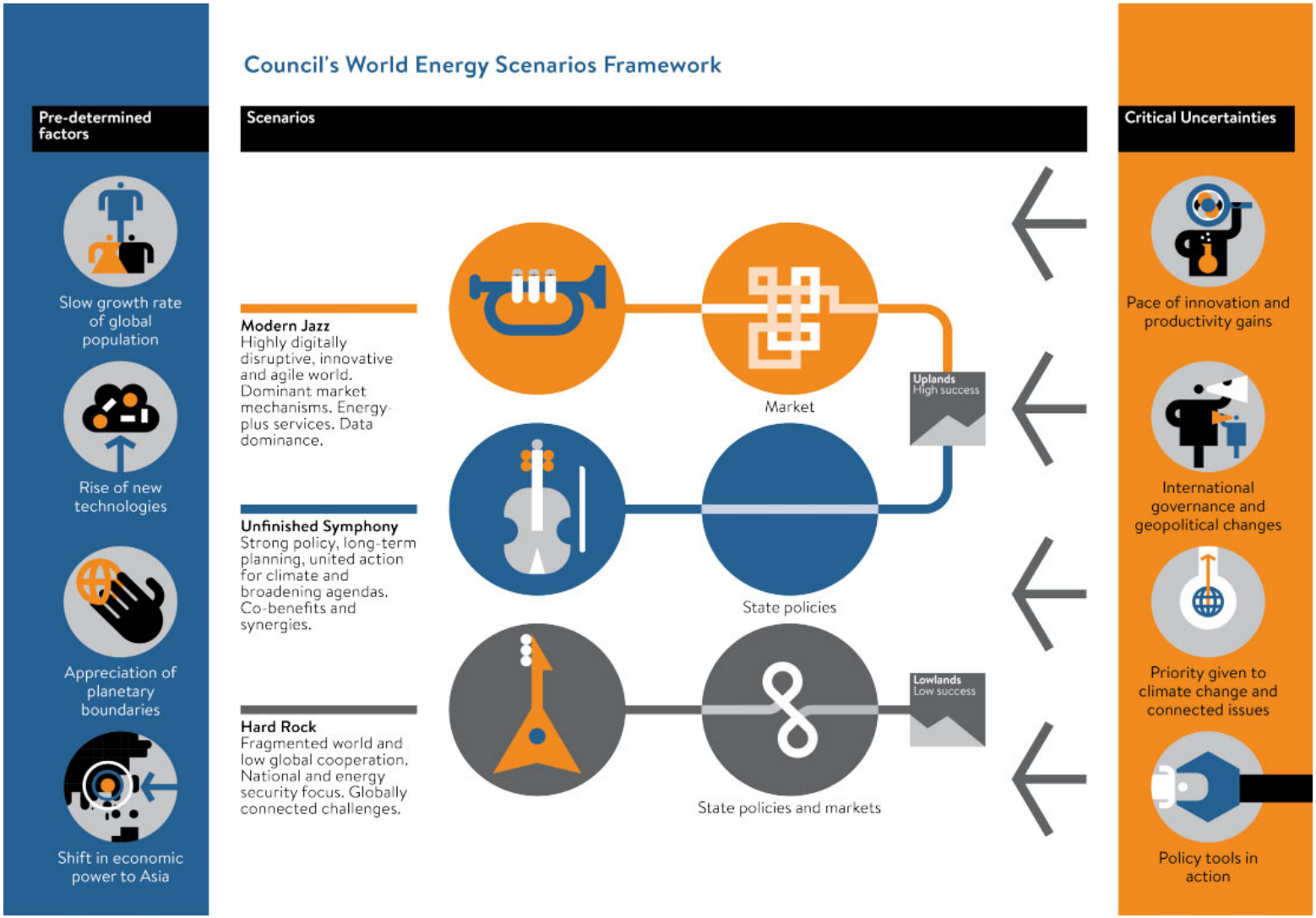
- Cement production accounts for 8% of carbon emissions globally
  - If the industry was a country, it would be the third largest emitter behind the U.S. and China
- Traditional production CO2 emissions:
  - 50% from calcination (chemical)
  - 40% from heating the kiln (burning fossil fuels)
  - 10% from electricity (e.g. machinery)

- The **Global Cement and Concrete Association (GCCA)** has a focus on sustainable development
  - Represents 50% of the production capacity
- Emergence of "**green**" cement solutions
  - Many focused on use of renewables only
  - ***Could nuclear power form a partnership?***

GLOBAL SCENARIO PLANNING USE

Scenario planning is used by over half of Fortune 500 companies, the largest United States corporations by total revenue, representing many successful industries.

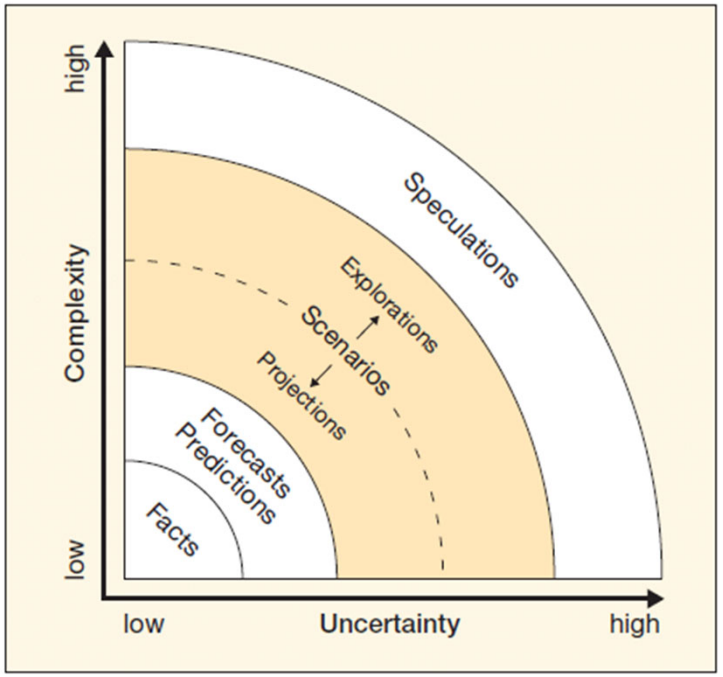
WORLD ENERGY COUNCIL



Source: World Energy Council, 2020

We need sense making tools

We need a rigorous methodology for organizing ideas



Source: Zurek and Henrichs, 2007

"**OPERATIONAL EFFECTIVENESS** is not **STRATEGY**."

Michael Porter,
Harvard Business Review

TODAY'S DESIRED OUTCOMES:

- ✓ Inspire you to think about the future differently
- ✓ Heighten your awareness about industry uncertainties
- ✓ Introduce you to scenario planning as a sense making tool

Thank you!

Please do not hesitate to connect and contact me:

Zainub Dungarwalla

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