

Leading Sustainable Energy Transformation in an Uncertain World

Experience-based Reflections

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Personal Opening Remarks

No “Sustainable Energy” definition ...however, we need to understand the “**WHY**” and under what condition “**WHAT**” will no longer work



Exponentially Increasing
Energy Industry Volatility,
Uncertainty, Complexity &
Ambiguity (VUCA)

“Different” Energy Industry Context

We all TALK mega trends and shocks

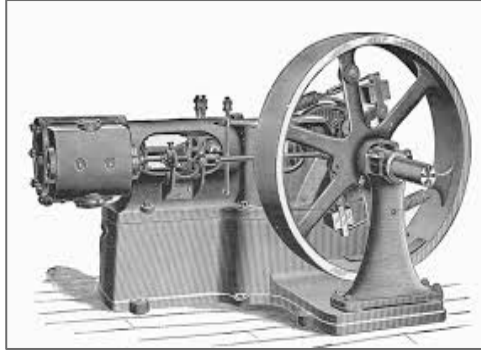
50%	Existing energy infrastructure reaching end of lifetime
20%	World without electricity
75%	Expected increase in electricity demand by 2030
80%	Primary energy consumption hydro-carbon based by 2025
65%	Population living in cities by 2040
12k	Total number of natural disasters world-wide likely by 2025
e.g. social/political unrest, financial/investment uncertainty, etc.	

but, we DO NOT fully understand transformative nature of changes



Why? Historical approaches insufficient to effectively address EXPONENTIAL (x-Time) changes (reactive, bottom-up, technology centric, etc.)

3rd Industrial Revolution-Resource Scarcity



- **Mechanization (1740 – 1840):** first industrial revolution triggered by the steam engine revolutionized labor productivity and offered potential for wealth creation while also killing off companies and industries that could not keep up
- 13% (≈130m) of the world's population industrialized (Western Europe)
- The UK needed 150 years for its GDP per capita to double
- Daily energy use per person (middle class) around 2000 calories (food)



- **Urbanization and Electrification (1880 – 1920):** second industrial revolution created equally large productivity opportunities as well as established global corporations and banks
- 16% of the world industrialized for the first time (the United States, Canada, Australia, Russia, and Japan)
- The USA needed 50 years for its GDP per capita to double

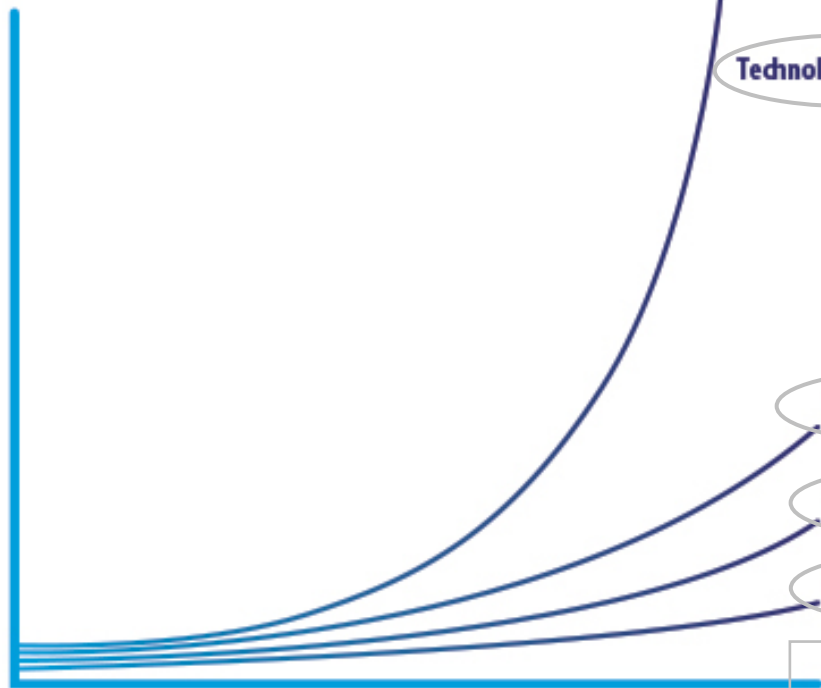


- **Resource Revolution (1990 – 2030):** combining information technology, nano-scale materials science, biology, with industrial technology. Zero-waste manufacturing, 3-D printing, hardware as software, etc.
- By 2030, 2.5B of new middle class will be industrialized for the first time (emerging economies)...+ 29 new mega cities (min. 10m population)
- Today, a member of the middle class uses more than 200,000 calories of energy a day, including gasoline, electricity, natural gas, etc. – 100x increase
- China needed less than 15 years for its GDP per capita to double

Four (4) Dimensional Changes with Uneven Speed

Speed of Change

CHANGE



Technology Change

- ✓ Conventional vs. Information technology
- ✓ Obsolescence (shorter ROI)
- ✓ Interoperability, Open-Standards & Seamless Adoption

Social Change

- ✓ “Behavior-based” Choice & socio-economic benefits
- ✓ Energy Broker (Transactive Energy)
- ✓ Seamless (“When and Where” needed)

Business Change

- ✓ Non-traditional competition
- ✓ OPEX vs. CAPEX (“cloud”)
- ✓ Organizational re-design & process agile
- ✓ Aging professional workforce

Political Change

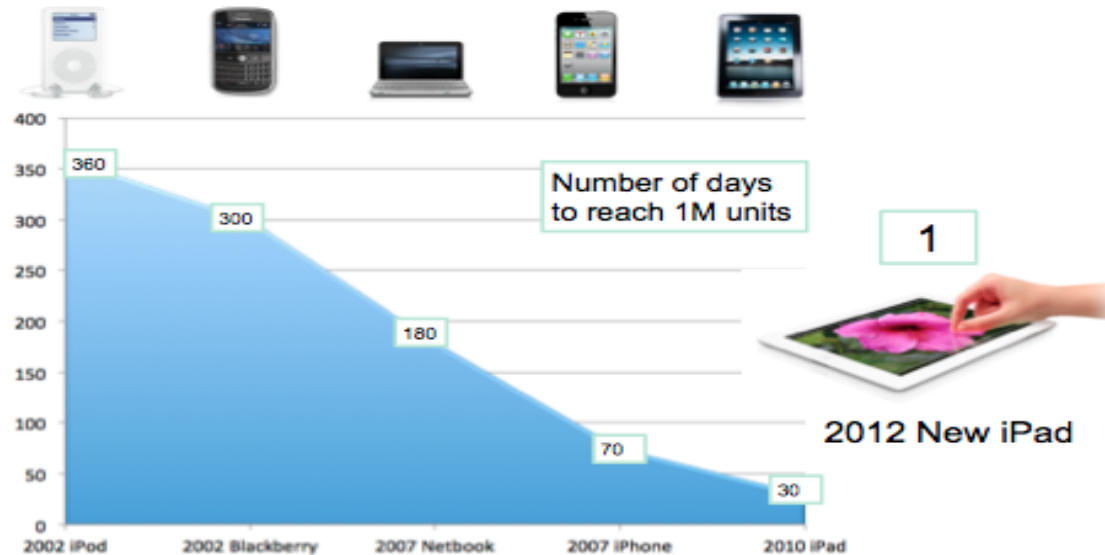
- ✓ Regulation and Policy: slow, reactive, tactical, etc.

TIME

“Mission Impossible”
...information technology vs. cognitive psychology vs. business culture vs. reactive regulation and policy...

Cross-industry Convergence...Cloud, Distributed Computing, Aviation, Banking, Social Media, etc.

Speed of Adoption



Evolution of Scale and Performance Requirements

Scale

Computing (Moore's Law):
2x every 18 months

Communication (Fiber Law):
2x every 9 months

Content (Community Law): 2^n
(n =number of connected people)

...around 50 Billion machines connected by 2020...



Twitter usage: 80 GB/day



Generation Turbine Data: 588 GB/day

- ✓ 500 gigabytes (10^9) of data from a single wind turbine blade
- ✓ In 2013, 2 ½ zettabyte (10^{21}) of data produced a day vs. all of 2008

...and yet, 99% of the world is still NOT connected...

TOTEX: $1 + 1 < 2$

VALUE: $1 + 1 > 2$

Nexus

Not About Technology Itself

Technology Investment: \$8.1B in 2015; approx. \$40B by 2020 *(Source: ABI Research)*

Max. Value Through Integrated Approach Across Value Chain



- Connected People, Processes, “Things”
- De-centralized and autonomous operations
- Integrated business models (e.g. microgrids, sustainable community, etc.) and customer services (e.g. “energy broker”, bitcoin of energy, eliminating poverty of energy, etc.)

Disrupt or Be Distributed (*examples*)

Distributive
“Players”



- **Automotive industry:** Software Car, Direct Sales, Free “Fuel”, #3 best selling EV cars in the world
- **Energy industry:** energy storage GW factory, Solar City, Fast Charging stations + Free electricity for customers

- Technology that will be capable of delivering power through wireless connection: anywhere, anyone, anytime (≈24 months to commercialization)
- Will make obsolete traditional utility business model



- **Generation:** agreements to fund \$1.5B in wind and solar projects
- **Retail:** \$3.2B investment in NEST (energy management)
- **Wholesale** (*130 FERC-61,107, effective February 23, 2010*): Google Energy authorized to be a power marketer, purchasing electricity and reselling it to wholesale customers



- **Today:** using 2.2B kWh of renewable electricity annually
- **Future:** by 2020 - produce or procure 7B kWh of renewable energy globally
- **Future:** by 2020 - reduce the energy intensity per square foot required to power all buildings around the world by 20%

How to Deal with VUCA Situation?

“Tomorrow”
of Energy
Industry

January 15, 2009, Captain Chesley Sullenberger and First Officer Jeffrey Skiles, made an unpowered water landing in the Hudson River ... **IN JUST 208 seconds**



*“The fact that we got **so much, so right, so quickly**, under those conditions is a testament to our **training, our preparation and years of experience**, and the **judgment** that we’d developed” Captain Ch. Sullenberger*

Informed/On-Demand Action in VUCA situation
INSIGHT + CONTEXT + EXPERIENCE

How to capture the biggest industry sustainable energy opportunity in a century ? (1/3)

Insight – Customer Centricity



- ✓ Behavioral psychology...customer choice / access to competitive choice
- ✓ Sustainable Outcome...It is not about price but it is about value/benefits vs. convenience vs. “share of valet” (affordability)
- ✓ Seamless experience (developed economies)...seamless and quality access at any time and anywhere (emerging economies)
- ✓ Socio-economic approach...customer is not energy unit (kWh/BTU), etc.
- ✓ Emerging trend...“energy broker”...transactive approach

How to capture the biggest industry sustainable energy opportunity in a century ? (2/3)

Context – Regional Diversity and Resource Scarcity



- ✓ Community, socio-economic & regional differences exist and will exist...not one size fits all
- ✓ Solutions and market design for de-centralized, autonomous, abnormal weather conditions
- ✓ Paradigm shift in resource utilization (“consumption”)
- ✓ Finding opportunities to substitute away from scarce resources
- ✓ Eliminating energy waste throughout the system – from production to end use
- ✓ Moving energy products, services and the processes that develop or deliver them from the “physical world” to the “virtual realm”

How to capture the biggest industry sustainable energy opportunity in a century ? (3/3)

Experience



- ✓ “X-ponential” changes require much less regulation (no regulation) and more disruptive innovation to deliver sustainable energy outcomes at scale for a fraction of TOTEX
- ✓ Open-market enabling competitive diversity and choice
- ✓ Grid obsolescence paradigm--the future is about: local flexible demand and supply markets, transactive energy and customer as a energy broker business model, de-centralized & autonomous operations...possibly enabled by non-energy companies



Thank You