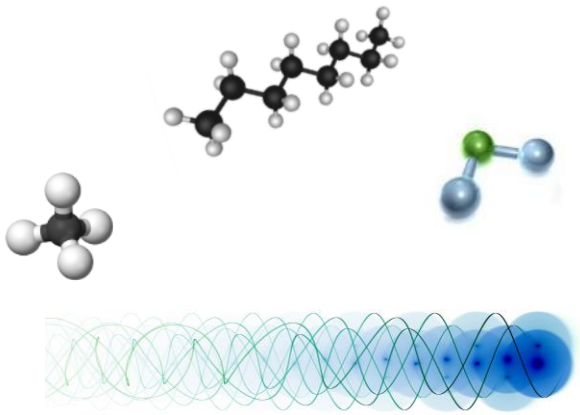


The Slow Pace of Fast Change

The Future of Energy Systems

Designed for

TEA
THE EnergyAuthority

Designed by

Garry Golden

Start

End

In the News

Transitions Ahead

Next Steps

The *Slow Pace* of Fast Change

Transactive Grid

?

? Distributed

Alternative Futures

? Design for Behavior Change

Baseline Future

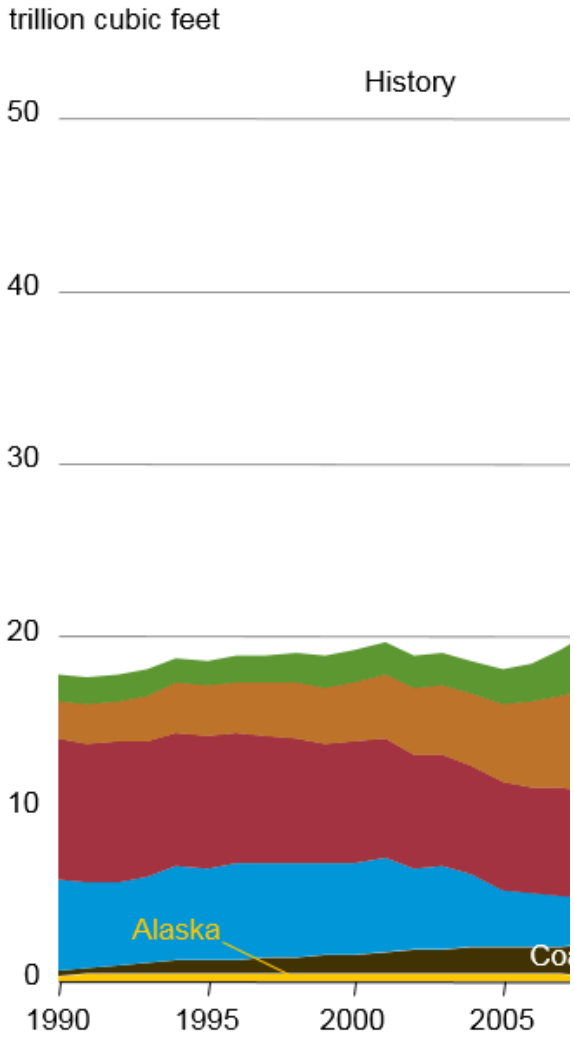
Maintenance, Preservation & Renewal

20th Century Dynamics

21st Century Dynamics

10 Years: Uncertainties in Fuel Dynamics

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



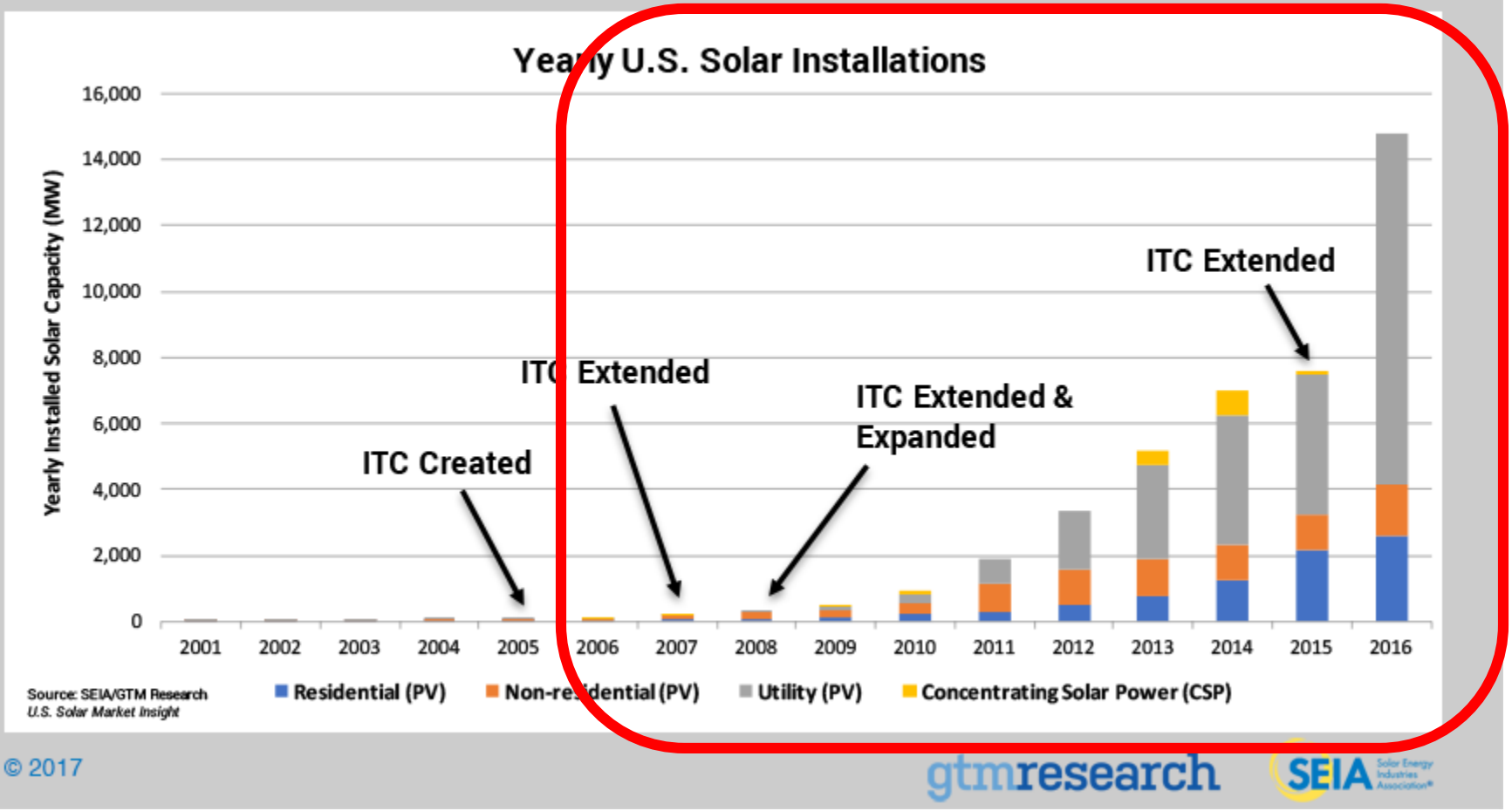
Shale Gas
Tight Gas

Onshore/Offshore Conventional

Coal bed Methane

EIA_AEO 2016

10 Years: Uncertainties in Policy



© 2017

gtmresearch SEIA Solar Energy Industries Association

10 Years: Uncertainties in ‘Players’ & Business Models

TESLA

JOHN DEERE

Alphabet

amazon

Microsoft Is Getting Hungry for Fuel Cells

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

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

Walmart takes a page from Amazon, invests in Plug Power

10 Years: Uncertainties in Technology Deployment

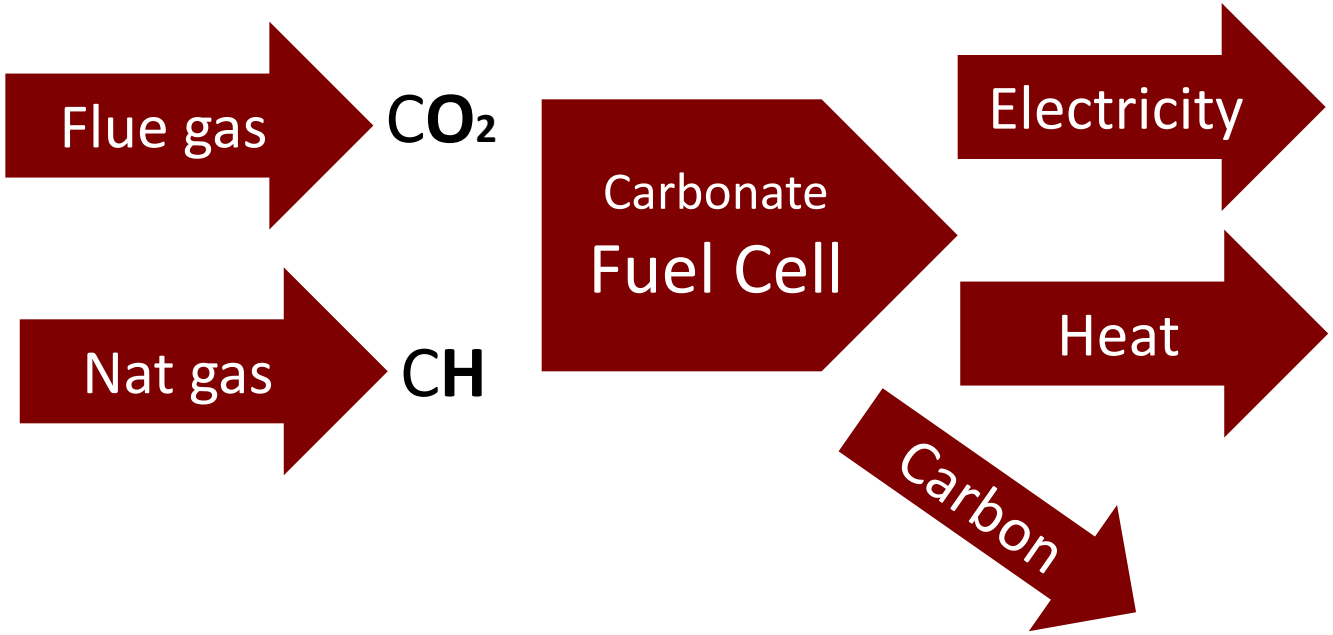
Coal comeback? Cleaner Natgas? Asset Utilization?

ExxonMobil

FuelCell Energy

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

(Source: Fuelcell Energy & ExxonMobil)



Every day I make an effort to move toward what I do not understand.

- Cellist, Yo-Yo Ma

Four Futures Thinking

?

Peabody ENERGY

Microsoft

IBM

BlackBerry

NOKIA

Continued Growth

Disciplined Constrained

Transformed

Decline Collapse

Describing the Four Futures for TEA and Your Public Utility…

Continued Growth

Disciplined Constrained

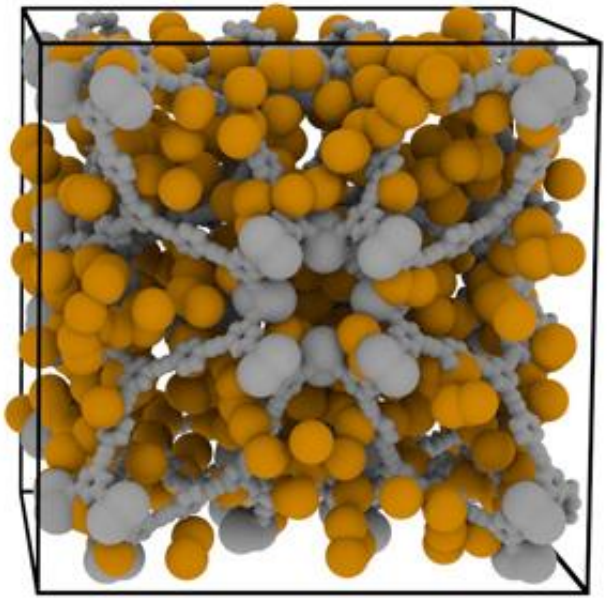
Transformed

Decline Collapse

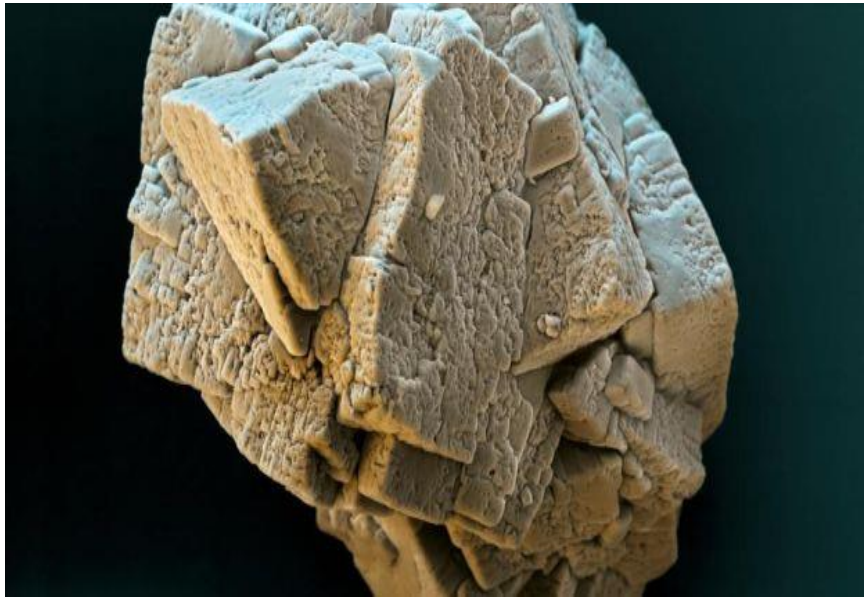
In the News

High Surface Area Crystal Sponges

MOFs – Metal Organic Frameworks



Northwestern
Image by Christopher Wilmer/NuMat Technologies)



Science Journal

BASF
We create chemistry

NuMat
TECHNOLOGIES

MOF Technologies™
Adsorbent Nanomaterials

In late 2018 Tokyo Gas will sell solid natural gas (MOFs) in 7-11 stores as fuel for portable micro fuel cells that recharge devices.

TOKYO GAS

ELEVEN

True

False

Dubai Testing Retail based Fuel Distribution for EV Scooters

STOR·H
by AAQIUS

Could fuel-based micro-power systems be at same developmental stage as cell phones in early 1990s?

kraftwerk

$49 (12 cartridges)
11 phone charges per cartridge

Disruptive Idea:
External Recharger vs Embedded Fuel Cell Power

Apple granted portable fuel cell power system patent

Apple has been granted a patent for an external portable fuel cell electricity generation unit designed to power portable computing devices.

By Leon Spencer | March 18, 2015 -- 05:55 GMT (22:55 PDT) | Topic: Apple

ZDNet

Apple files patent for MacBook fuel cell that could last weeks

APPLE / 04 SEPTEMBER 15 / by JAMES TEMPERTON

Disruptive Idea: Embedded Fuel cell Power

One week battery life on an iPhone 6? It's possible

POSTED 1:49 PM, AUGUST 28, 2015, BY CNN WIRE

Intelligent Energy

An Apple iPhone and a quadcopter, both retrofitted with hyrdogen fuel cell batteries, and a hydrogen fuel cell are displayed by Intelligent Energy at ShowStoppers. Photo by Ann Singer.

Better Battery = Energy consumer's 'faster horse' thinking?

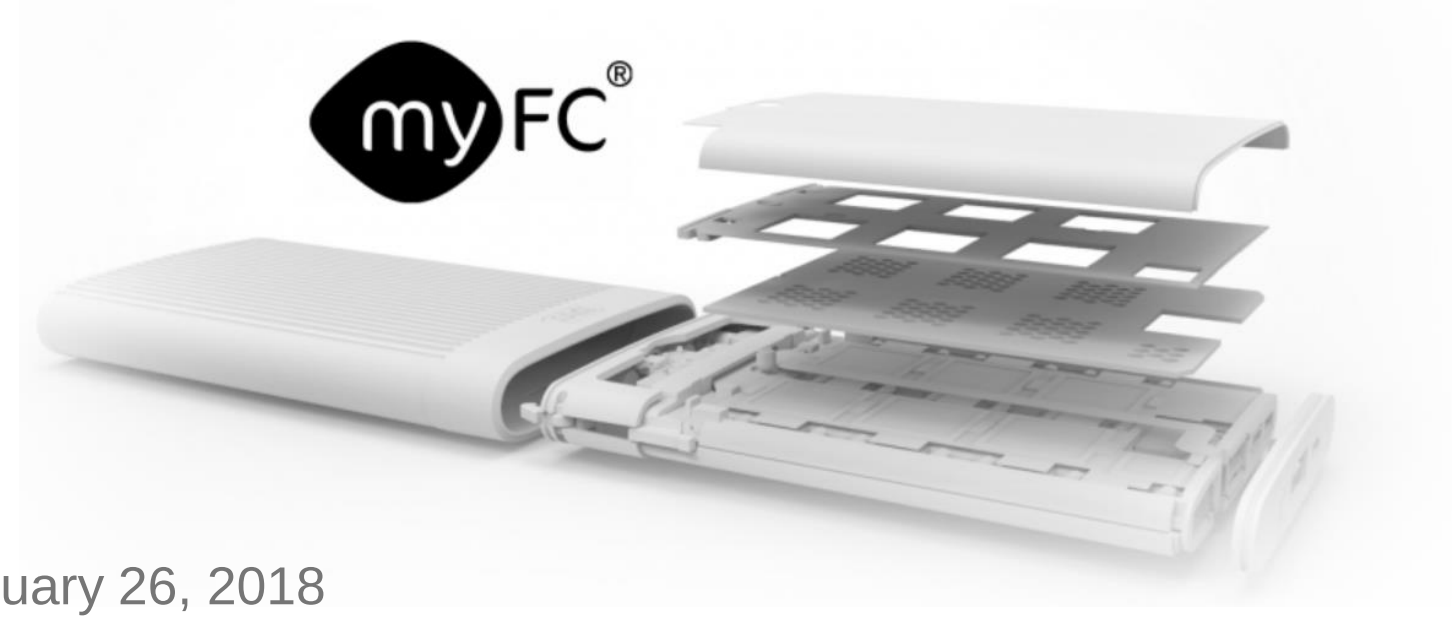
MyFC predicts that fuel cells will surpass batteries in energy density and cost efficiency in a few years

myFC

YOUR POWER SOURCE

MyFC initiates feasibility study with leading Chinese smartphone manufacturer

"Since we launched the world's smallest fuel cell LAMINA in early 2017, our intention has been to pursue the integration of our fuel cell technology in smartphones. This R&D project marks the start of that initiative, which we refer to as job #3," says Björn Westerholm, CEO of myFC.



February 26, 2018

The Indian Patent Office granted myFC a key patent application for JAQ Hybrid the world's smallest fuel cell charger, able to both produce and store energy thanks to the coexistence of battery and fuel cell. It can be charged using myFC's patented, green fuel, based on salt and water, as well as through a regular power outlet.

What could happen in 12 years…?

China Moving Beyond Battery

intel

myFC
YOUR POWER SOURCE

Microsoft

Intelligent Energy

Acquisitions in Portable Power

Unplugging at Burning Man

Houses without Electrical Sockets

amazon

Walmart

Vision: #1 Fuel Distributors

2022

2024

2028

2030

What if fuel-based innovations capture the head, heart & wallets of the our communities?

Retail-shelf energy becomes unexpected innovation of 2020s:

- ❑ Customers *cut the cord* and reduce grid-use
- ❑ New types of competition + coopetition emerge

- ❑ Do we get into the portable fuels business?
- ❑ Do we get into managed services of embedded systems?
- ❑ Do we support a range of fuel mixtures: traditional CH gases, hydrogen (renewable vs natgas derived) and synthetic gas?

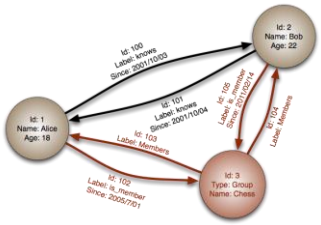
STOR·H by AAQIUS

End

Transitions Ahead

Next Steps

Anticipating Transitions & Shifting Expectations



Data-driven Work Experiences

DER Scenarios

EV or Not to EV

Blockchain + Energy

Changing Nature of Work: Data driven Experiences

AI ***Design for Behavior Change***

Why Software is Eating the World…

THE WALL STREET JOURNAL.

By MARC ANDREESSEN

August 20, 2011

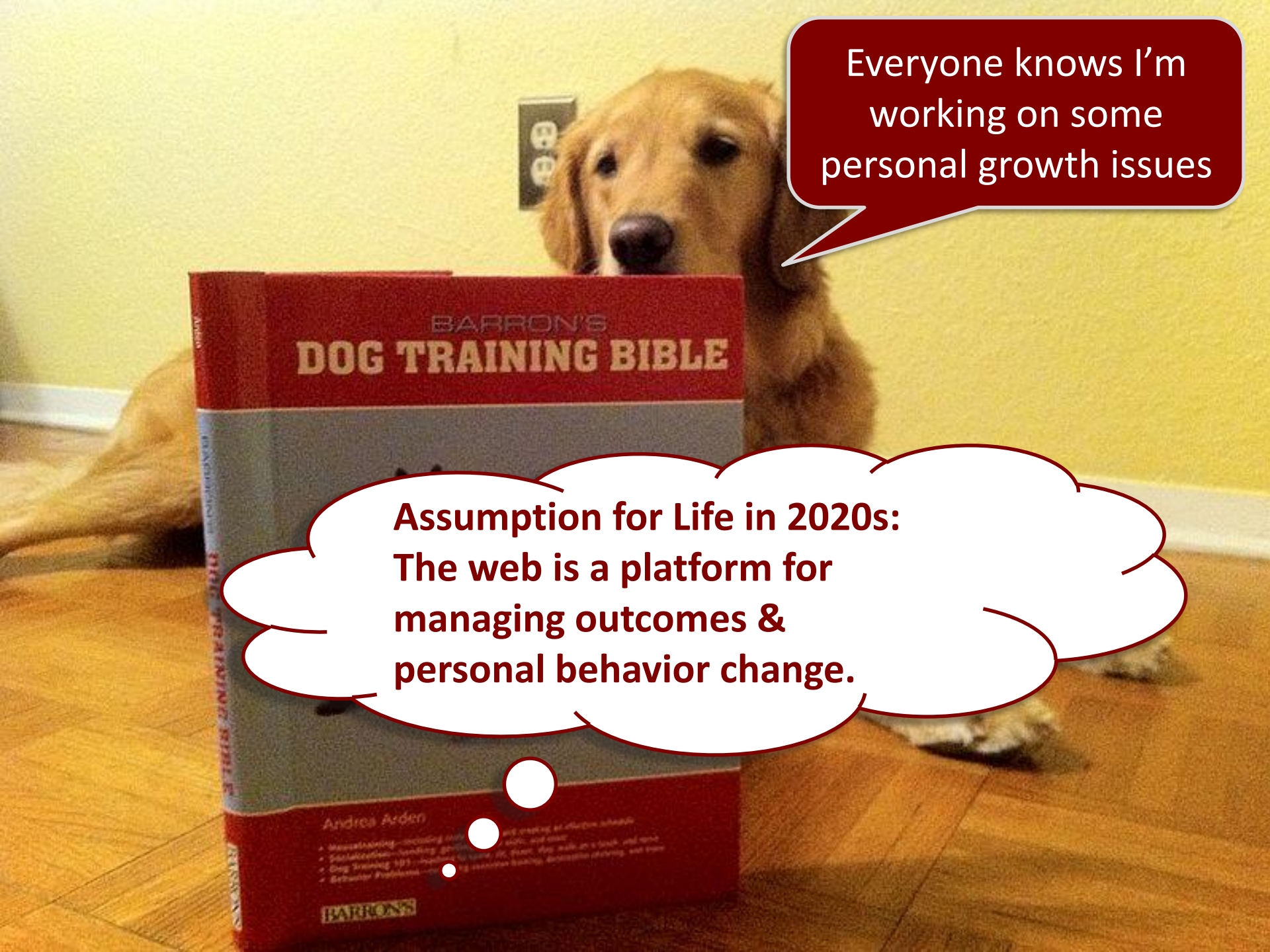
Social Norms for the Anonymous-Access Web

1993

"On the Internet, nobody knows you're a dog."

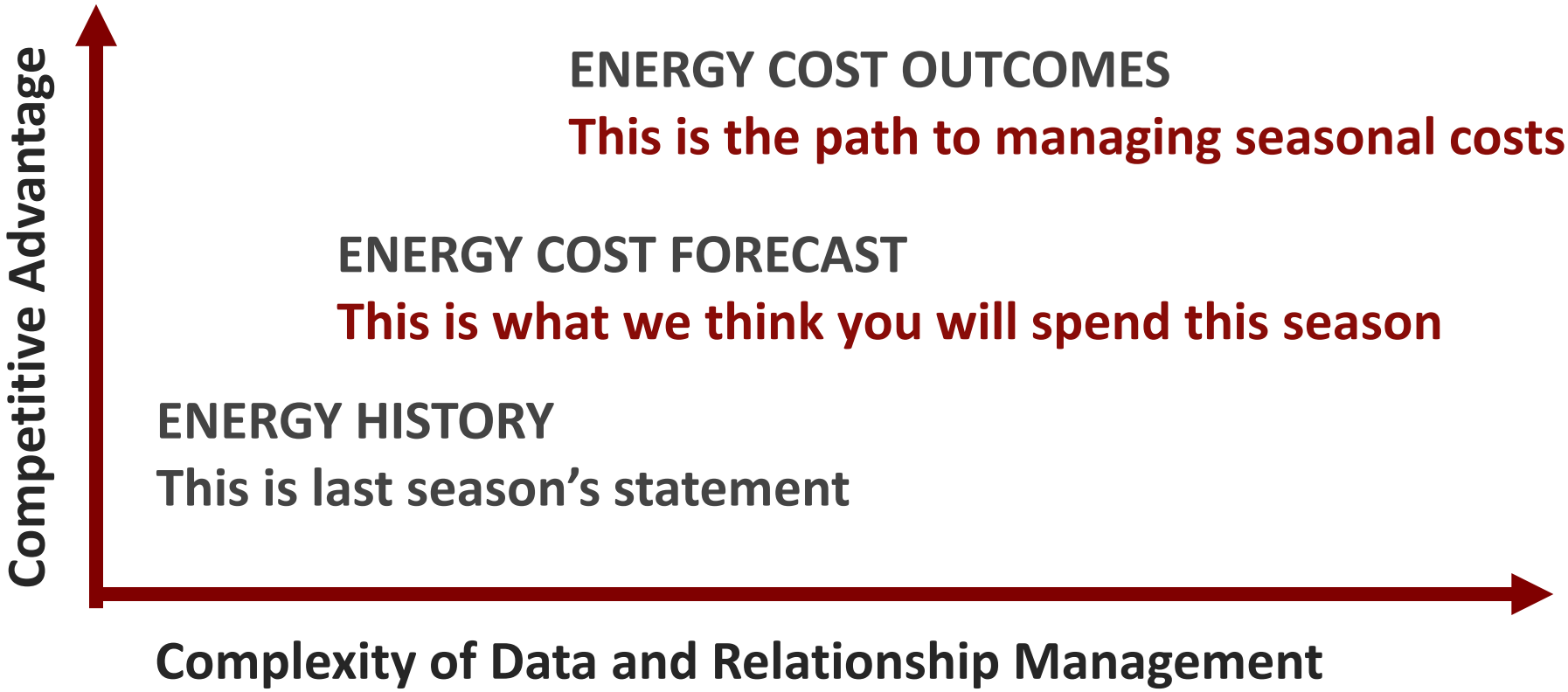
Social Norms & the Social Web

2008

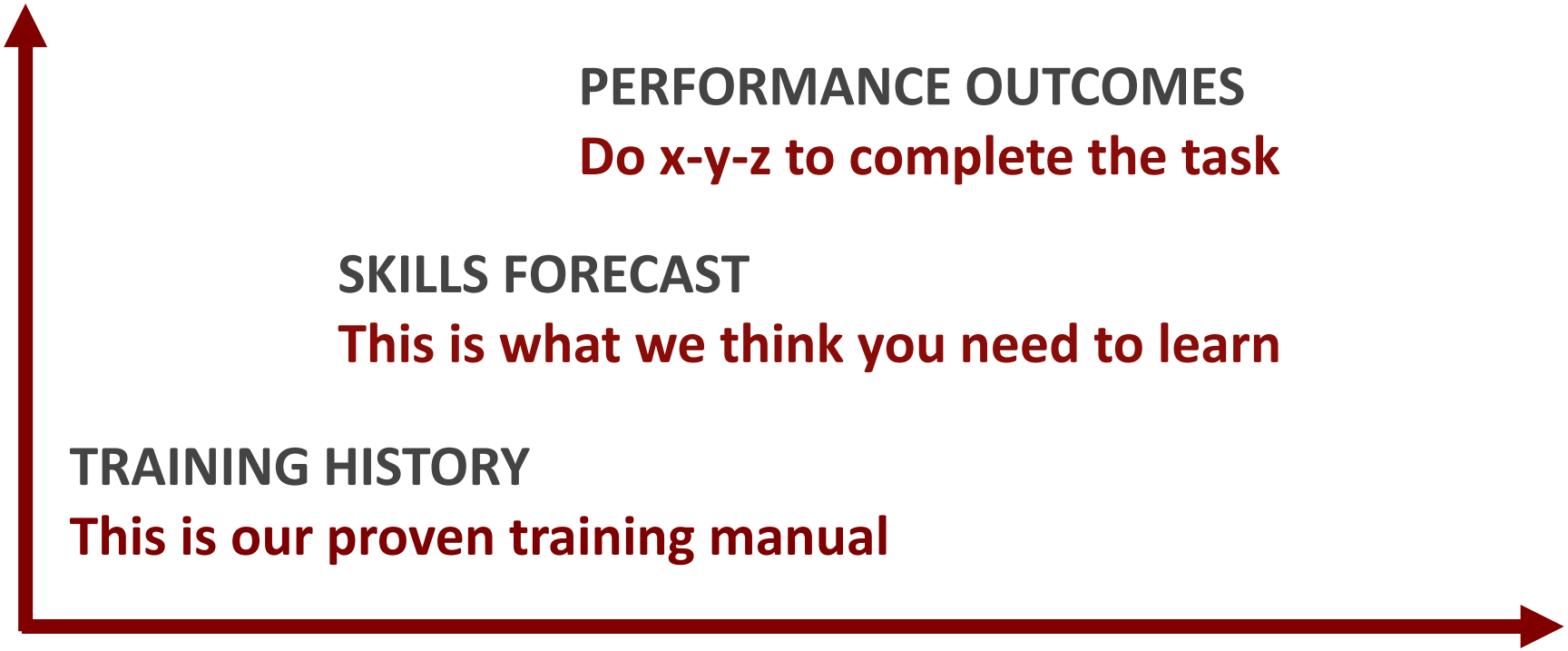

Everyone knows I'm working on some personal growth issues
BARRON'S
DOG TRAINING BIBLE
Andrea Arden
BARRON'S
Assumption for Life in 2020s:
The web is a platform for managing outcomes & personal behavior change.

Outcomes-based Value Creation Depends on…

Guided Energy Experiences



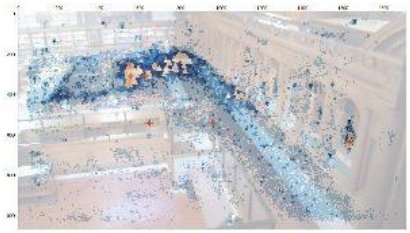
Guided Workplace Experiences



Hype: Data as New Oil … Data as the New Soil

Social Data

Health Data



MEASURE the FUTURE

Device + Place Data

EXPERIENCE API

"I did this…"

Learning & Work Experience Data

First Signal of Experience Analytics

Activity Streams

<Actor, Verb, Object>

“I did this”

Why xAPI?
Understand the Link Between Training, Care & Outcomes

Course

Outputs

EXPERIENCE API

“I did this…”

Statements

Seamless Integrated into
Software & Connected Devices

Real World

Outcomes

Scenario:
Professional Staff Embrace Experience Capture Analytics

- ❑ Lucy ***read*** an article on virtual reality for aging populations
- ❑ Lucy **opened** an Evernote folder on aging solutions
- ❑ Lucy ***watched*** *a* Youtube video on Social VR Experiences for Seniors
- ❑ Lucy ***interviewed*** *the Director of MIT's* Age Lab
- ❑ Lucy ***attended*** an MIT workshop on VR simulations
- ❑ Lucy ***wore*** an 'aging suit' at MIT Age Lab
- ❑ Lucy ***mentored*** with the Head of Innovation at AARP
- ❑ Lucy ***designed*** a new VR social space using Facebook Oculus dev kit
- ❑ Lucy **won** an Webbie award for Social VR platform
- ❑ Lucy ***taught*** a Coursera MOOC on Universal Design and VR experiences
- ❑ Lucy **was hired** as head of Social VR for Aging Populations at Facebook

"I did this…" Analytics

Assumption to Explore

By 2025, Experience Data Will Become Your Most Valuable Digital Asset

If we capture experience data…

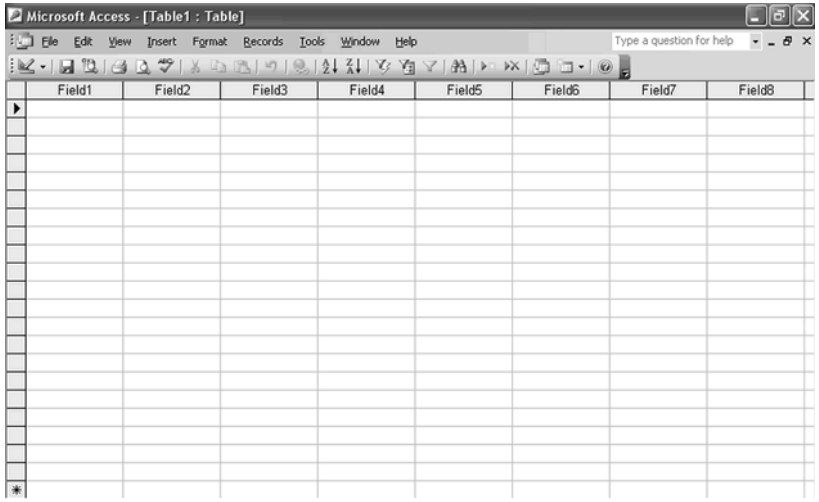
"I did this…"
Statements

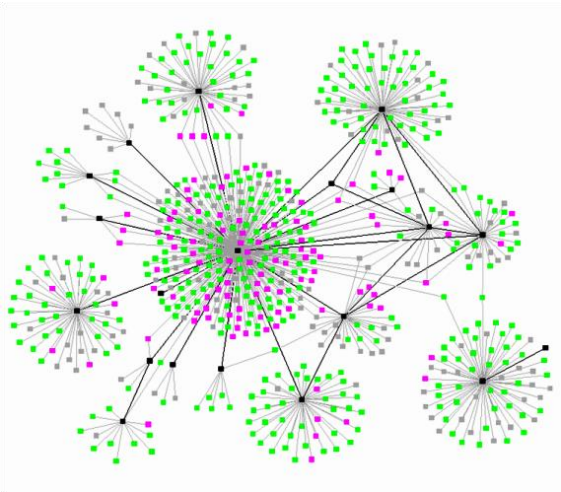
How do we approach regulations?

How do we avoid the creepy line?

How do we make sense of it?

Building a Connected Data Foundation for Outcomes-focused Performance Support



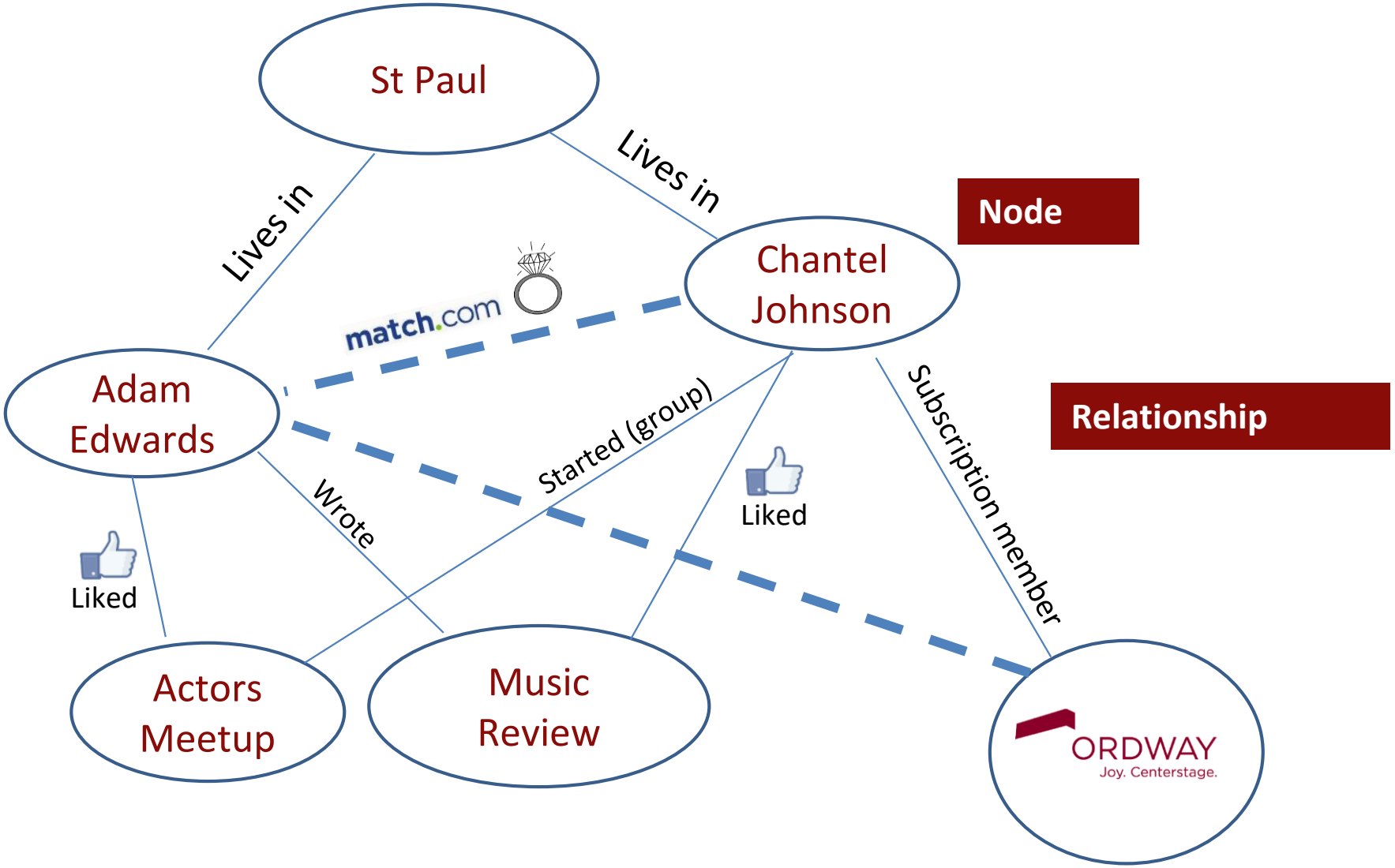


neo4j

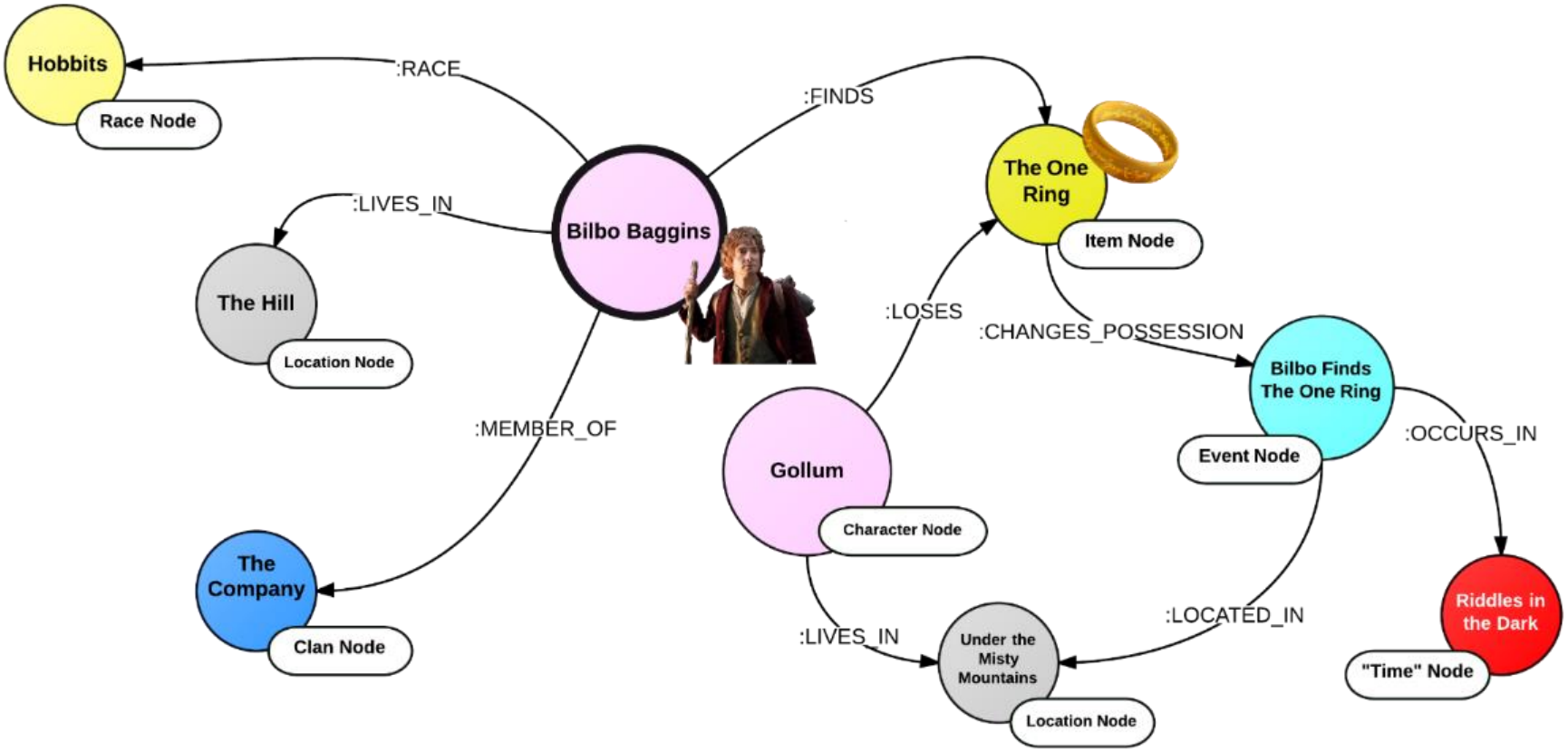
Tables = Past

Graph Thinking = Future

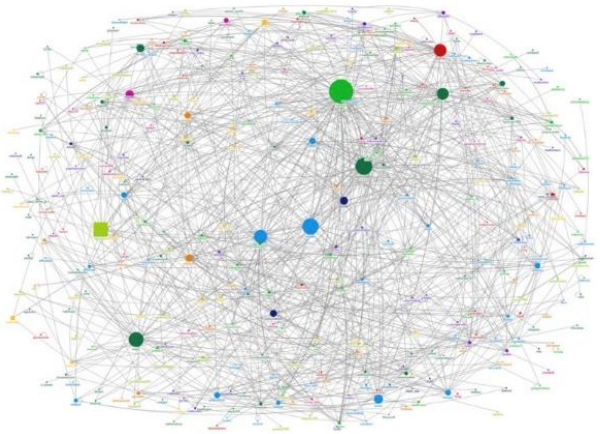
Graph Database =
Understanding Relationships + Connections



Graph Thinking to Understand Pathways & Outcomes



Assumption:
Connected Data & Graph Analytics Changing the World



Value of our Social Graph

Era of Knowledge & Experience Graphs?

Scenario 2028:
Experience Analytics & Knowledge Graphs for Utilities Sector

Technicians

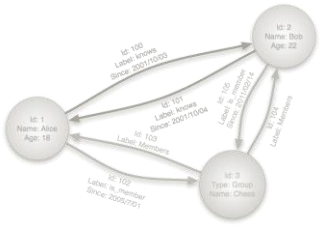
Customer Facing

Managers & Executives

Will the industry build a Shared *Energy* Graph?

Members – Companies – Jobs – Skills – Schools – Knowledge

Anticipating Transitions & Shifting Expectations



Data-driven Work Experiences

DER Scenarios

EV or Not to EV

Blockchain + Energy

2018 – 2030

Shifting Expectations for Distributed Energy Resources

Policy Hinting at Favorites: Community Solar & Batteries

Community Storage: Aggregated System level Solutions

"Community Storage" is an emerging term for programs that aggregate distributed energy storage resources that are located throughout a community, such as water heaters, electric vehicles, and interconnected storage batteries, to improve the operational efficiency of electric energy services to consumers.

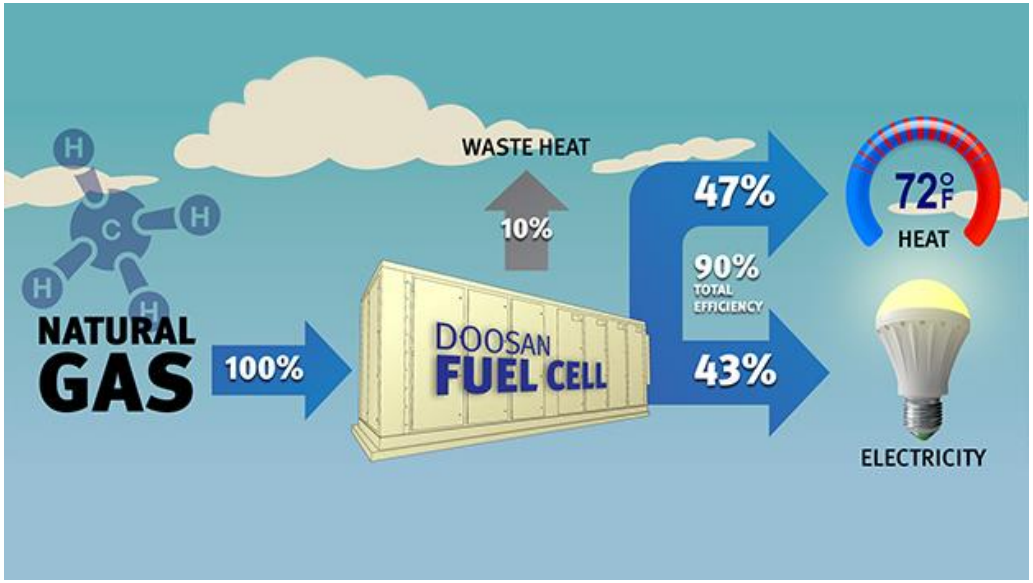
Strengthening Signals but Lingering Scars

NatGas Friendly Vision: Fuel Cells as DER base of Micro Grids & CHP

DOOSAN

Bloomenergy

fuelcellenergy



Nedstack
PEM FUEL CELLS

Fuel cell technology
elcogen

POWERCELL

Stumbling Into the Future..

Connecticut is California of East Coast

GOVERNMENT PRODUCT NEWS

Fuel cells: Local and state governments turn to them for resilient power generation

15MW Dominion
Bridgeport Fuel Cell Park

63MW Beacon Falls (Approved)

fuelcellenergy

Connecticut Municipal cmeec Electric Energy Cooperative

Asia & Europe Setting Policy to Attack the Cost Curve

Global Overview

Installed Systems	939	
Generated Electricity	20.094	GWh
Avoided CO_2	4094	Tonnes

Micro CHP

EU starts five-year project to make fuel-cell gensets

28 February 2018 | By Peter Judge

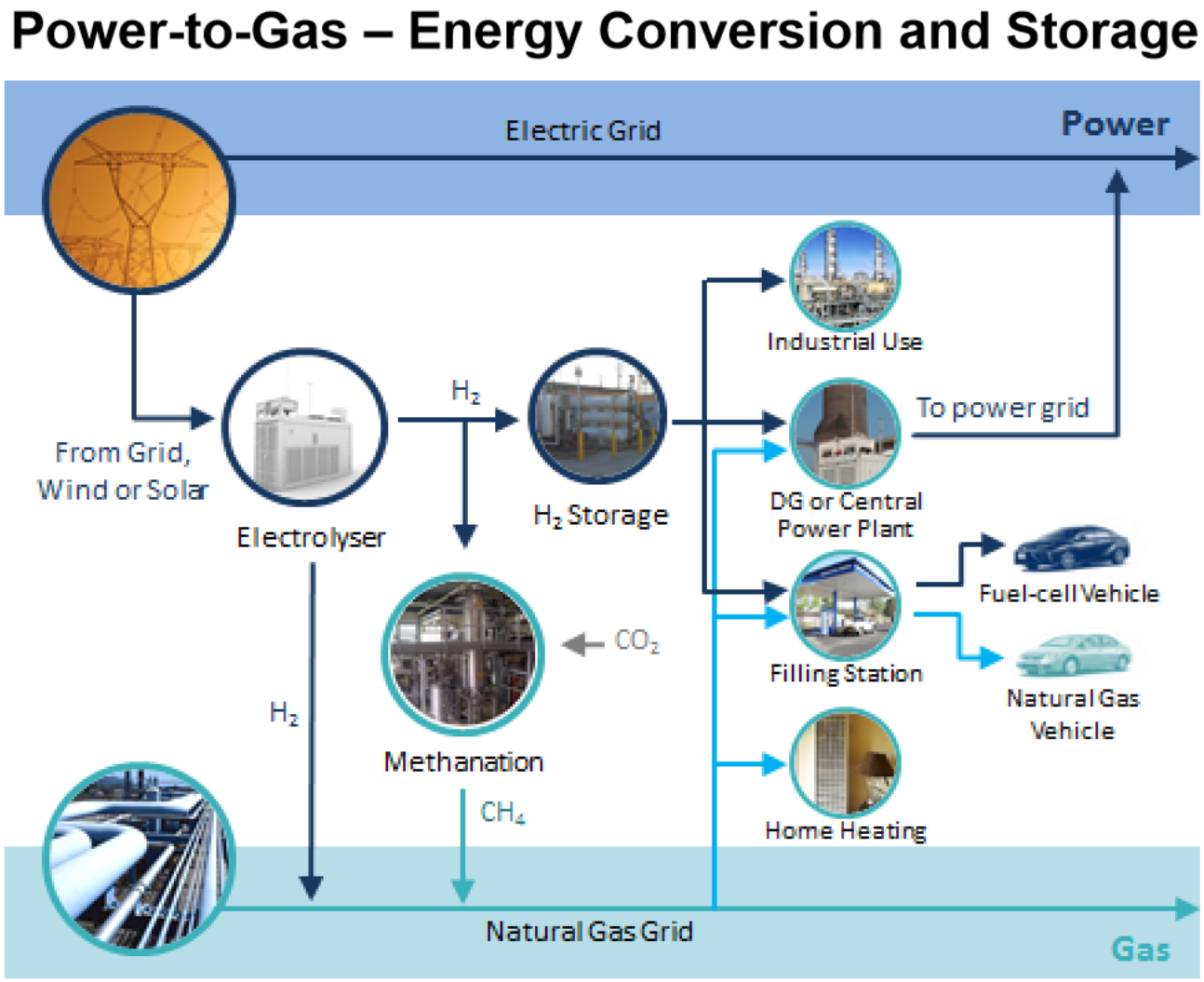
Generators

Incumbents are Starting to Show Interest

DER at Scale: Power to Gas

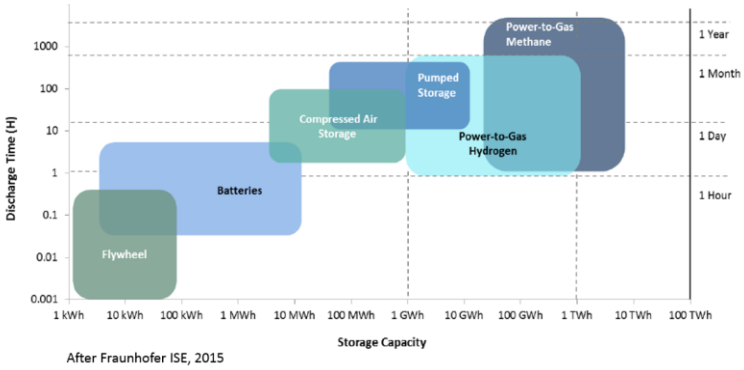
Power-to-Gas for Renewables Integration
ARPA-e REFUEL Kick-off Meting
August 18, 2017
Jeffrey G. Reed, PhD
Director Business Strategy
and Advanced Technology

SoCalGas
A Sempra Energy utility



The Case for PtG: Hydrogen and ‘Renewable Gas’

- ❑ Great PR Strategy for *Big Gas Growth of ‘Hydricity’*
- ❑ Storage (Volume/Duration)
- ❑ Scale at Incremental Cost
- ❑ Value Model
- ❑ Scaling Renewables
  (Duck Curves; Seasonal Storage; Curtailment)
- ❑ Integration of Gas + Grid
- ❑ Decarbonize
  Heat & Industrial Processes



After Fraunhofer ISE, 2015

Power to Gas (PtG) – Australia

Australian Gas Infrastructure Group

Tonsely Innovation District
Adelaide
1.25MW PEM electrolyser

thyssenkrupp

THE HYDROGEN UTILITY™ H2U

The Port Lincoln facility

10MW hydrogen-fired gas turbine, fuelled by local wind and solar power, and a 5MW hydrogen fuel cell.
The Port Lincoln facility will store 10 tonnes of hydrogen, equivalent to 200MWh; $117.5 million project

Power to Gas (PtG) – Europe Leading the Way

Distributed Energy Resources Beyond Solar + Batteries

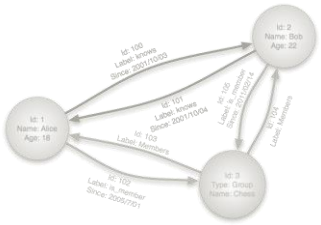
Opportunities

- ❑ Policies for PtG / ReP2G
- ❑ Resiliency & Community Spirit
- ❑ Expand Service Area
- ❑ Reduce Long-term Expenditures
- ❑ Empower Commercial Clients
- ❑ Decarbonize Industry

Challenges

- ❑ Balancing Motivation + ROI
- ❑ Understanding Grid + Gas Dynamics
- ❑ Public Power versus Public Gas
- ❑ Convincing Big Gas of the Natgas Burning Platform

Anticipating Transitions & Shifting Expectations



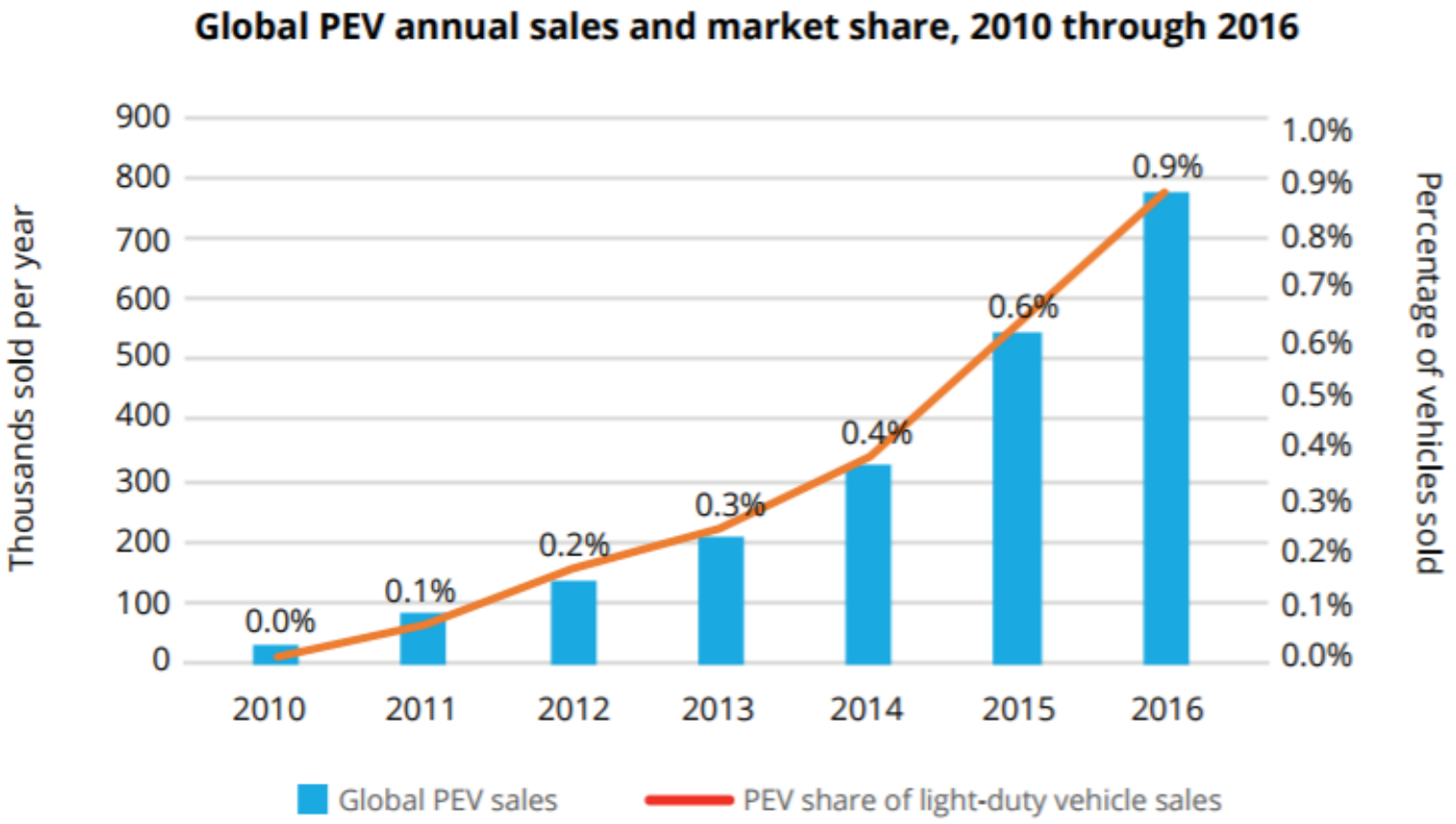
Data-driven Work Experiences

DER Scenarios

EV or Not to EV

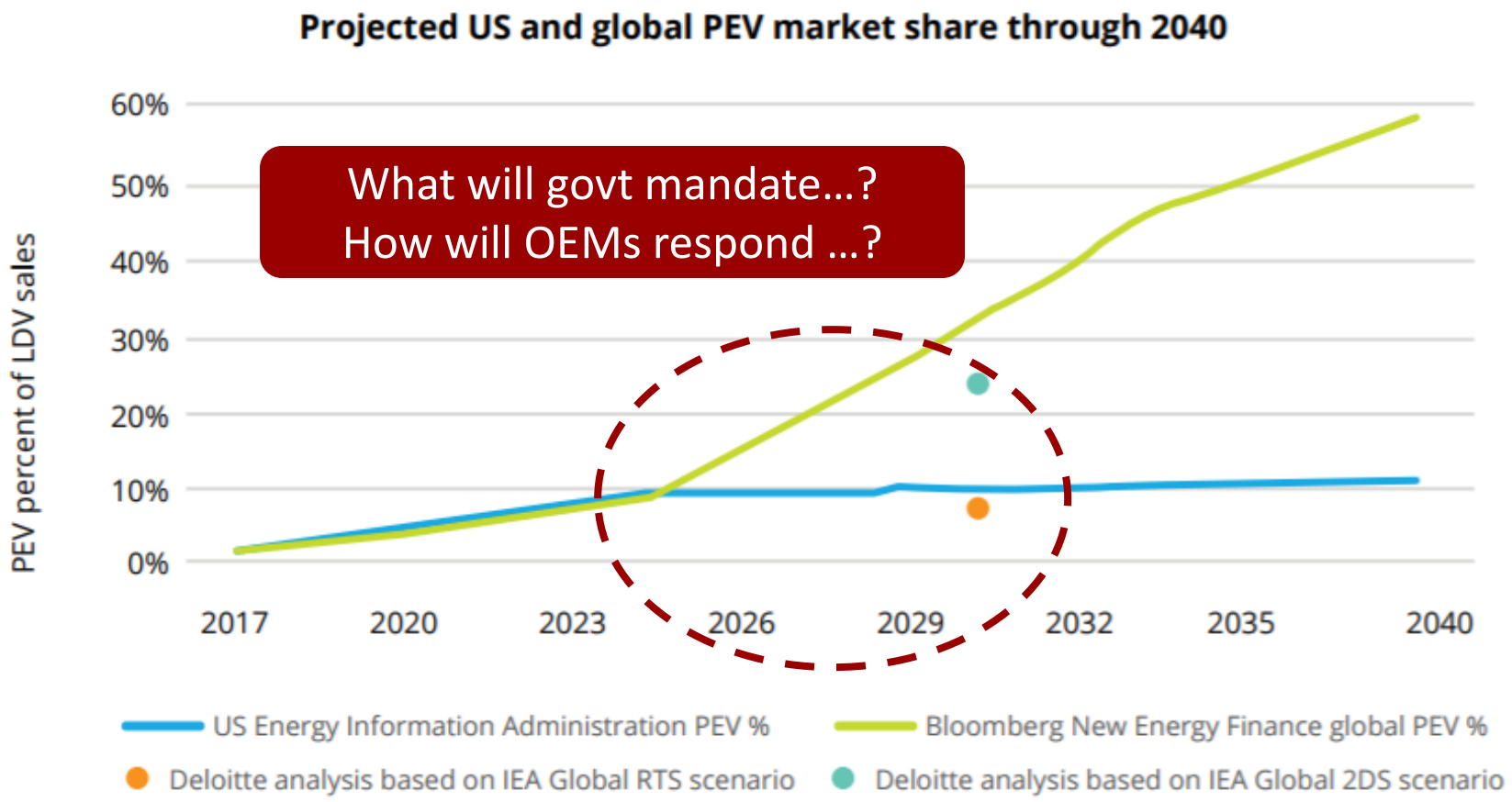
Blockchain + Energy

Electrification of Vehicle Fleet



Source: Electric Drive Transportation Association, "Electric drive sales dashboard," and Jeff Cobb, "Top ten plug-in vehicle adopting countries of 2016," HybridCars, January 17, 2017.

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



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 of Vehicle Fleet: The Long Game & Big Picture

Hybrid ICEs

Plug-in EVs

Fuel-based EVs

Hydrogen Rich Fuels

Marathon, Not a Sprint

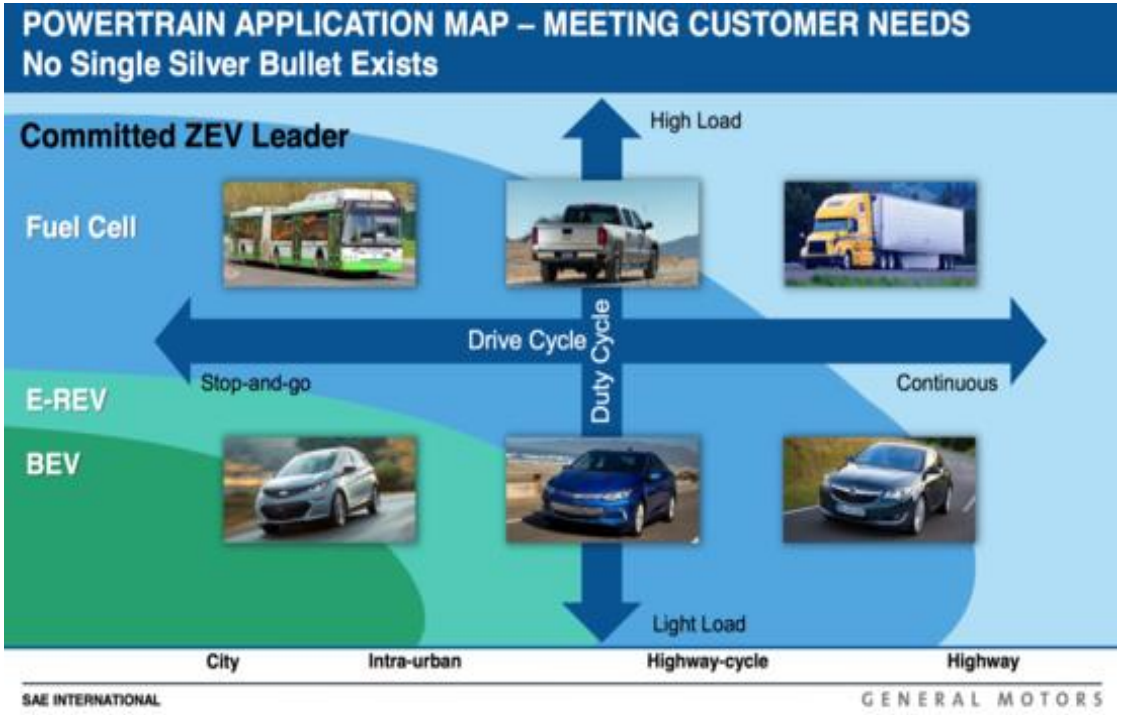
More than three-quarters of executives (77% global; 85% U.S.) say fuel-cell electric mobility will be the real break-through for electric mobility.

… Elon Says Game-Over Batteries Won!

… but Industry betting on integration & fuel-based EVs

Caution on Early Bets with Electric Vehicle Transition

- ❑ OEMs Prefer Cost to Weight
- ❑ Integration Gives Customer ROI
- ❑ Keeps Big Oil in Game
- ❑ Urban Market Infrastructure
- ❑ Fleets (Uptime)
- ❑ Autonomous Fleets (Power-Hungry)



Electrification of Vehicle Fleets

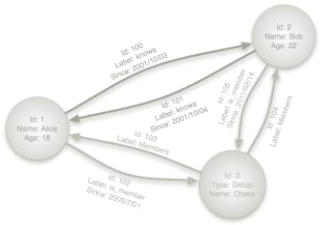
Opportunities

- ❑ Vehicle to Grid (V2G) Service Model
- ❑ Managed Services for Fleets
- ❑ Transform Excess Electrons to Higher Value H2 Fuel
- ❑ Hydrail (Rail Industry)
- ❑ Drones / UAVs

Challenges

- ❑ Elon's Twitter Account & Early Adopter Enthusiasm
- ❑ Viability & Sustainability
- ❑ Regulatory Certainty
- ❑ Business Model

Anticipating Transitions & Shifting Expectations



Data-driven Work Experiences

DER Scenarios

EV or Not to EV

Blockchain + Energy

World Economic Forum Survey Projects Blockchain 'Tipping Point' by 2023

“By 2025, 10% of Global GDP will be orchestrated by blockchain applications.”

Implications of the blockchain cannot be understood… yet

1994: "Today Show": "What is the Internet, Anyway?"

Evolution of the Web-based Capabilities & Solutions

Access to Digital Files

Access to Social Networks

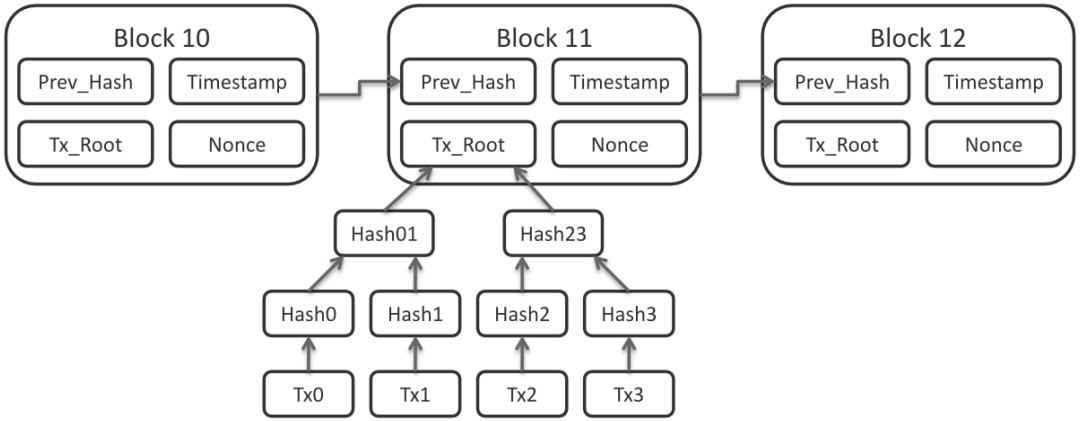
Access to Trusted Transactions

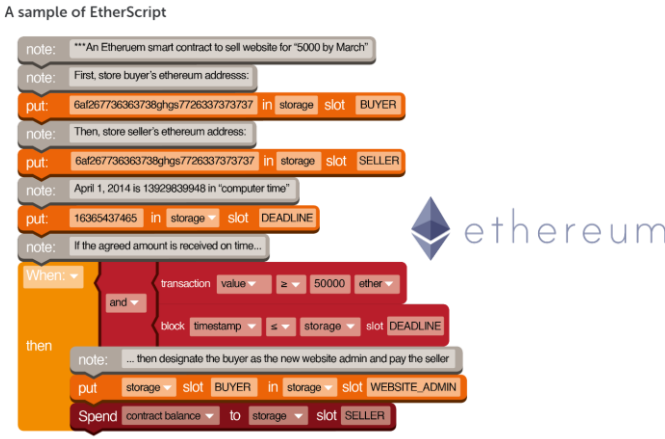
Low Cost + High Security

It's just Decentralized Databases + Process Automation!

Assets* get entered onto the ledger and generate keys** **+** ***Network Consensus on who did what…

***Smart Contracts* execute legal agreements + business processes**





***'Assets'* = Energy Usage Data, Bills, Appoints, Crew Field Notes, Identity, Credit Card Information, Equipment Repairs…**

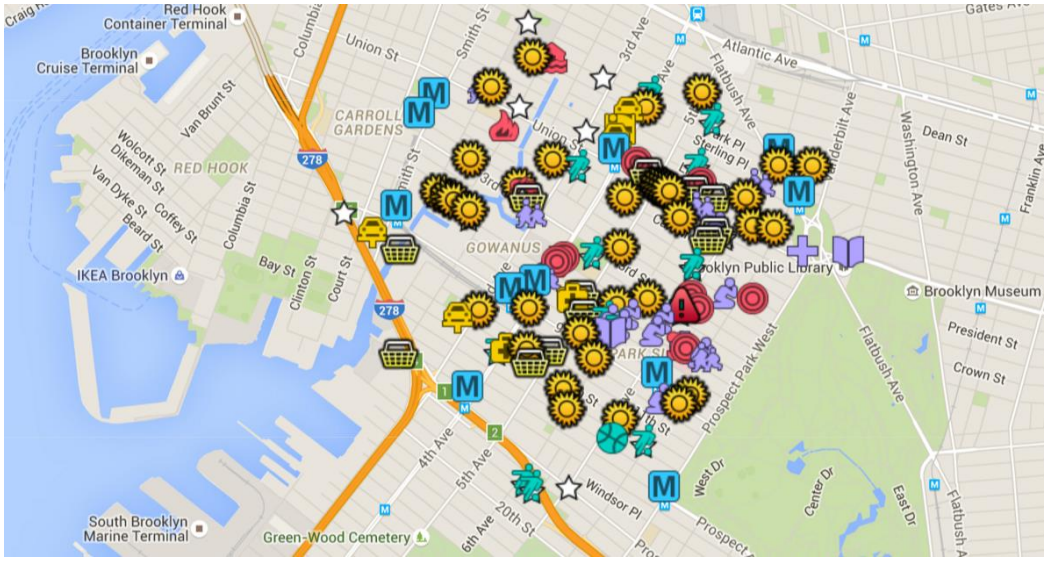
Authorization for Data use; Revenue Cycle Management; Front-end Compliance Walls; IoT Cyber Security; Wholesale Trading

Learning Curve: Development Platforms

Blockchain as Backbone for Microgrid?

BROOKLYN MICROGRID

LO3 ENERGY

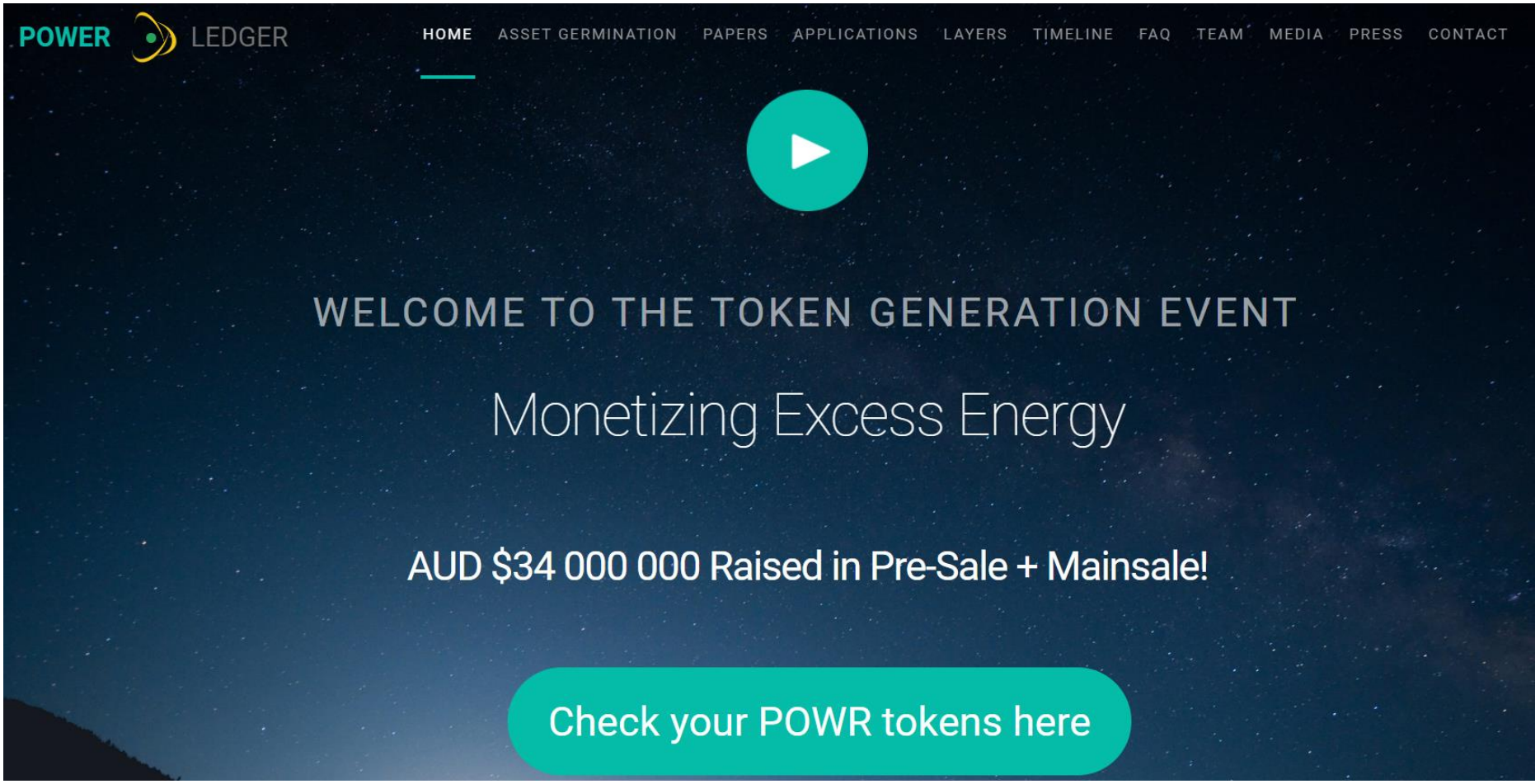


Neighbor-to-Neighbor Energy Sales

Crowd-funding Community Energy Assets

Economics for Behavior Change (Negawatts)

Hype Phase for Blockchain Energy Platforms



Hype Phase for Blockchain + AI Agents

GRID+

Meet your new agent

The Grid+ Smart-Energy Agent is an always-on device that pays for your electricity in real time and always finds the best price available.

RESPOND TO DEMAND

The intelligent agent can help balance load on the grid by controlling smart devices, such as a NEST thermostat or a Tesla Powerwall, to generate extra revenue.

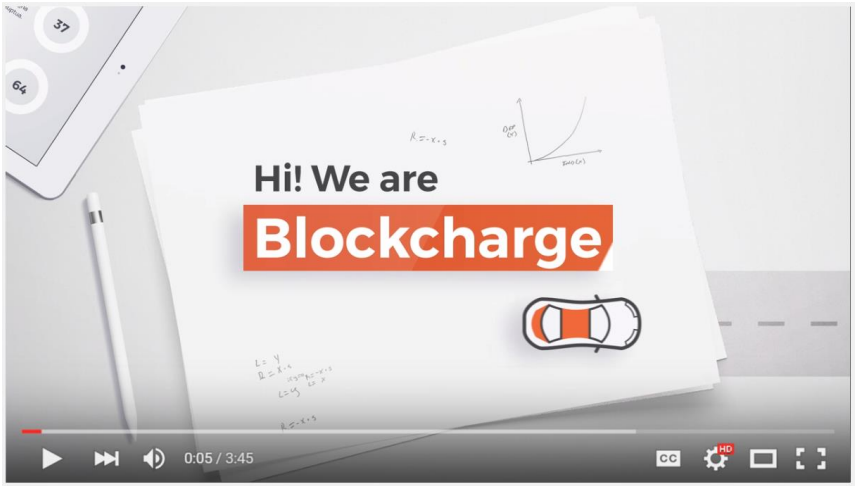
ARBITRAGE ENERGY

Your agent can leverage energy storage, such as the Tesla Powerwall, to purchase energy when it is cheap and sell it when prices peak.

Innovative Proof of Concepts… Shared Infrastructure

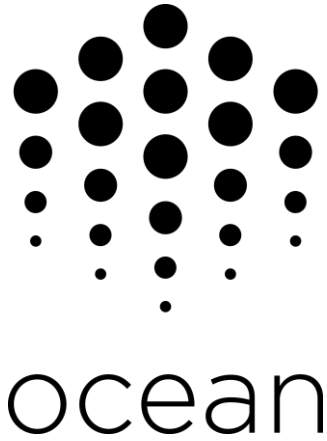
Innogy Charges New Electric Car Fleet Using Ethereum Blockchain

Innogy SE, a subsidiary of German energy conglomerate RWE, announced that it has launched hundreds of blockchain-powered charging stations for electric cars across Germany through its e-mobility startup venture Share&Charge.



BlockCharge - EV Charging via the Ethereum BlockChain (HQ)

Application: Energy Data Exchanges



Application: Liquidity & Financing Ecosystems

Sweetbridge

A blockchain-based protocol stack for global commerce and supply chains

Bridgecoin

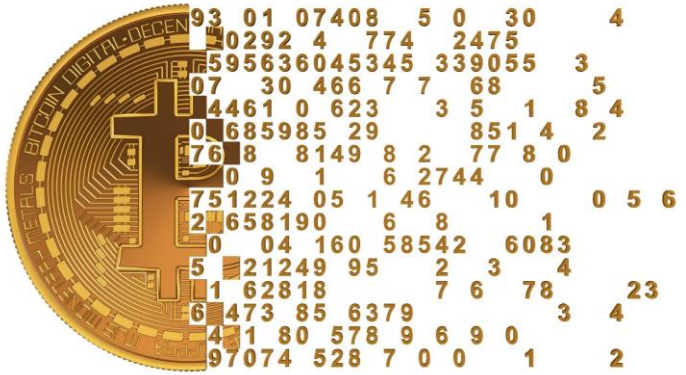
1. A stable currency
2. Pegged to fiat currency
3. Your key to using the Sweetbridge Fund liquidity application

Sweetcoin

1. Enables interest-free borrowing
2. A limited-supply currency
3. Your key to exchanging Bridgecoin for fiat & using the Settlement application at no fee

Radical Idea: Crypto Currencies Tied to Behavior Change

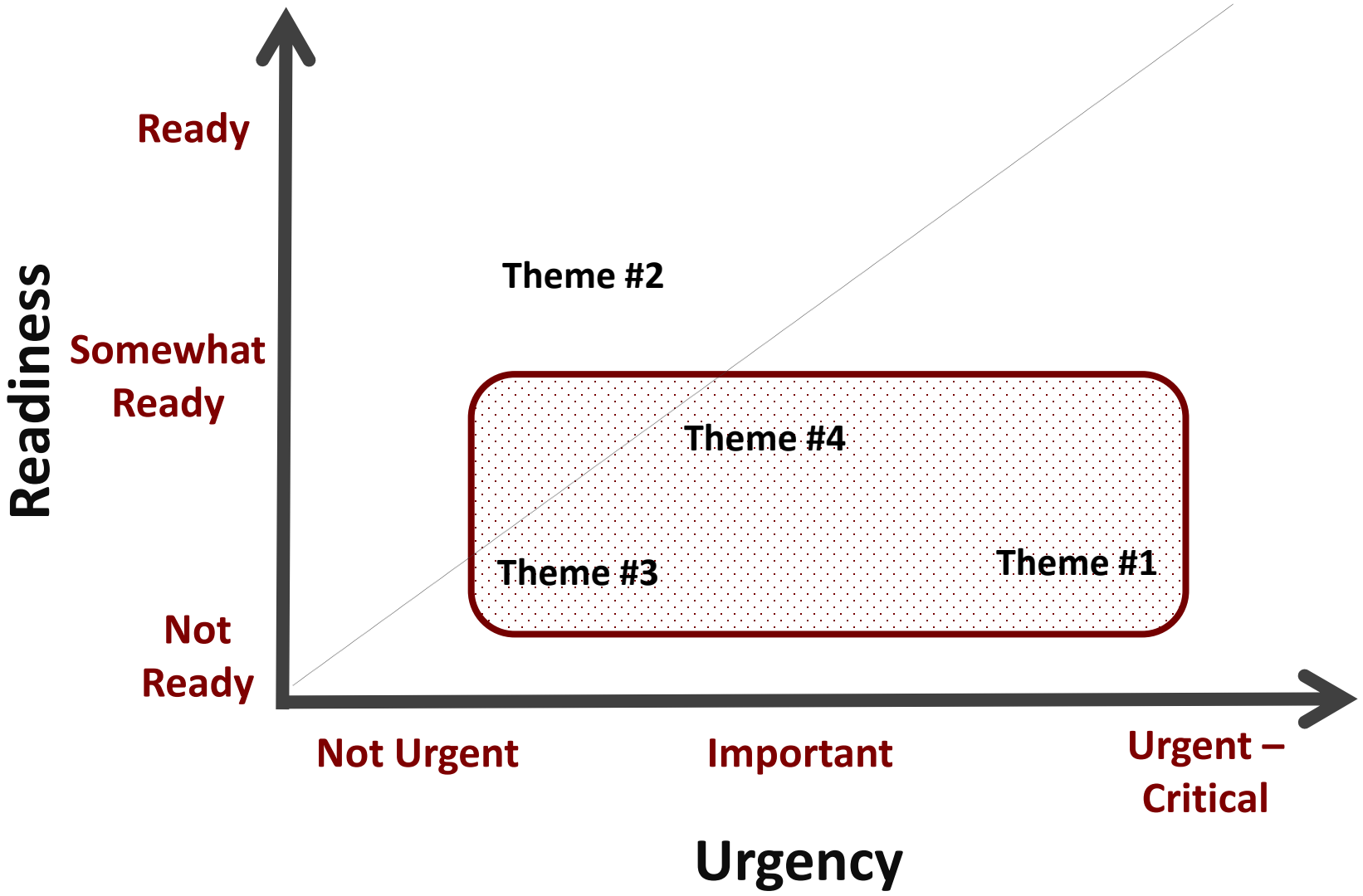
Crypto Currencies +
Smart Contracts automate incentives for energy demand management



Utilities Issue Negawatts

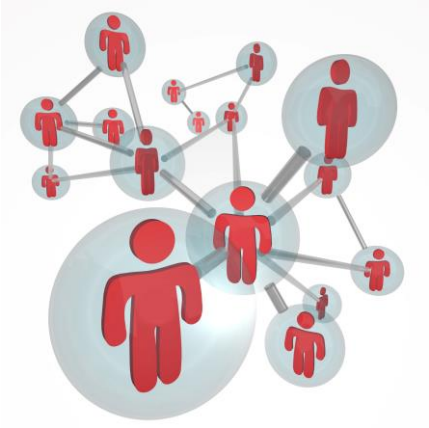
Images Removed

Step #1: Take a Pulse Check on Emerging Trends vs Organizational Appetite



Step #2
Start a Signals Team:
Follow Those Who Imagine Different Futures

Blockchain &
Smart Contracts



Graph Analytics
Connected Data

Industry Talent
Development

Step #3

Use ‘What’s Possible’ Questions’ to Brainstorm Ideas

Following the success of HP’s Chief Innovation Officer Phil McKinney, generate a weekly ‘Killer Question’ email message or ‘Twitter’ conversation that spurs conversation about future energy system experiences.

What is a need that does not exist today but in five years will be our most requested product/service from our communities?

What skills set will be most in demand in five years that we do not currently address in formal training programs?

What job title does not exist today but in five years will be on our most valued positions within the POU?

Thank You!!

PDF + Resources

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Two Rs