The Transforming Energy Industry:

Technology Innovation

Anda Ray
SVP, External Relations and Technical Resources
EPRI

Task Force on Innovation:
NARUC Annual Meeting Conference

November 12, 2017

Today's Topics -

- Introduction to an Integrated Energy Network
- Innovation in an Electrified and Integrated World
- Growth in Electrification
- Technology Innovation increases Consumer Value

Integrated Energy Network

Integration Essential to Improve:

Reliability, Resiliency, Efficiency, Productivity, Create New Opportunities, and Expand Customer Choice

The Customer

5 C's = Convenience, Comfort, Choice, Control and Cost-effective

Energy Resources

Cleaner, Resilient, Interdependent and Flexible

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WHY Technology Innovation for a "Digital Utility"?

Enabling Responsiveness and Commercial Operation

Enabling Protection of Privacy and Data

Enabling Efficient Asset Performance

Integrating Advances in Information Communications Technologies

Enabling and Protecting the Workforce

Enabling Customer and Delivery Services

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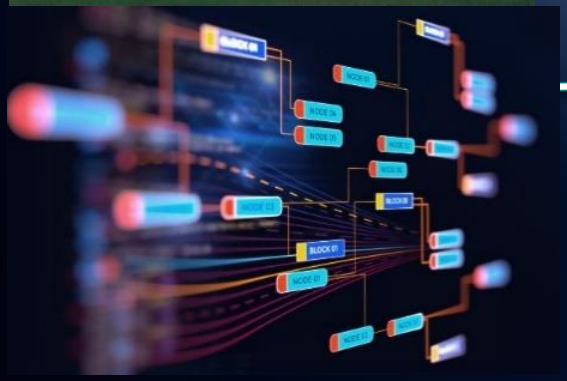
Integrated Grid



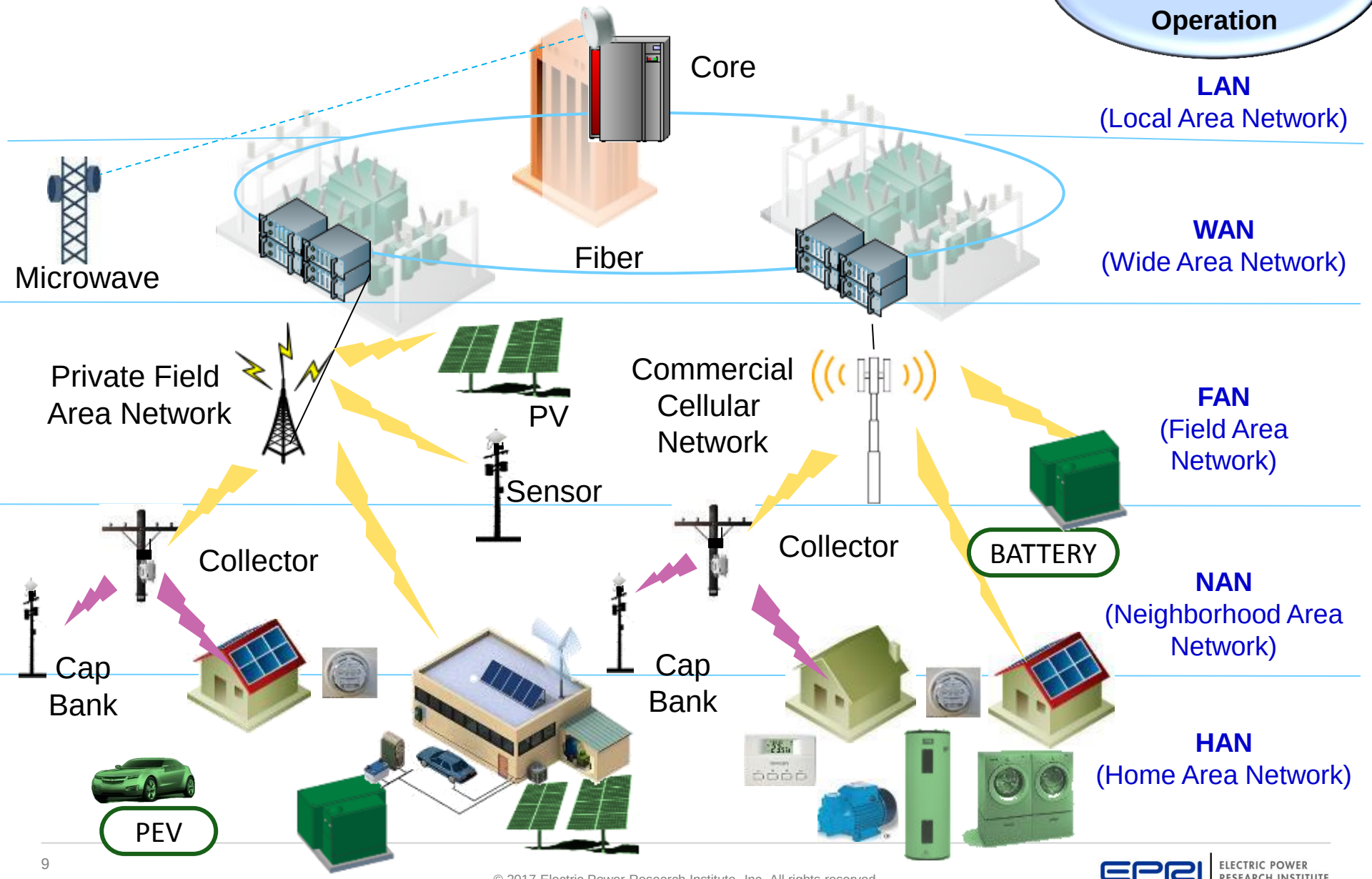
Enabling the Full Value of both Central and Distributed Energy Resources

Digitally Connected and Interactive

Sensors, Information, Communication, Analytics + Artificial Intelligence – To Improve Reliability, Resiliency, Restoration … and Consumer Value

Ubiquitous Communication Network Needed

Enabling Responsiveness and Commercial Operation



LAN
(Local Area Network)

WAN
(Wide Area Network)

FAN
(Field Area Network)

NAN
(Neighborhood Area Network)

HAN
(Home Area Network)

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Simply Put: The Objective of a Digitized System

"See" –

To see what is happening on the system, acquire data, increase "*Transparency*"

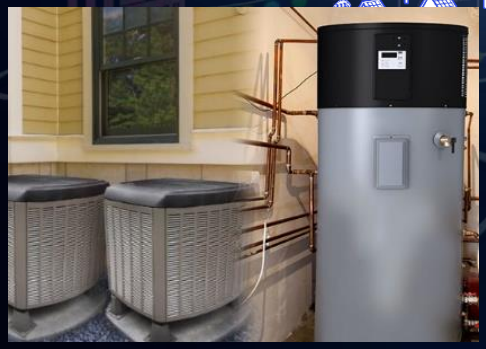
"Plan" –

To anticipate, forecast and plan how to respond to what is happening on the system. More *"Knowledge"*

"Act" –

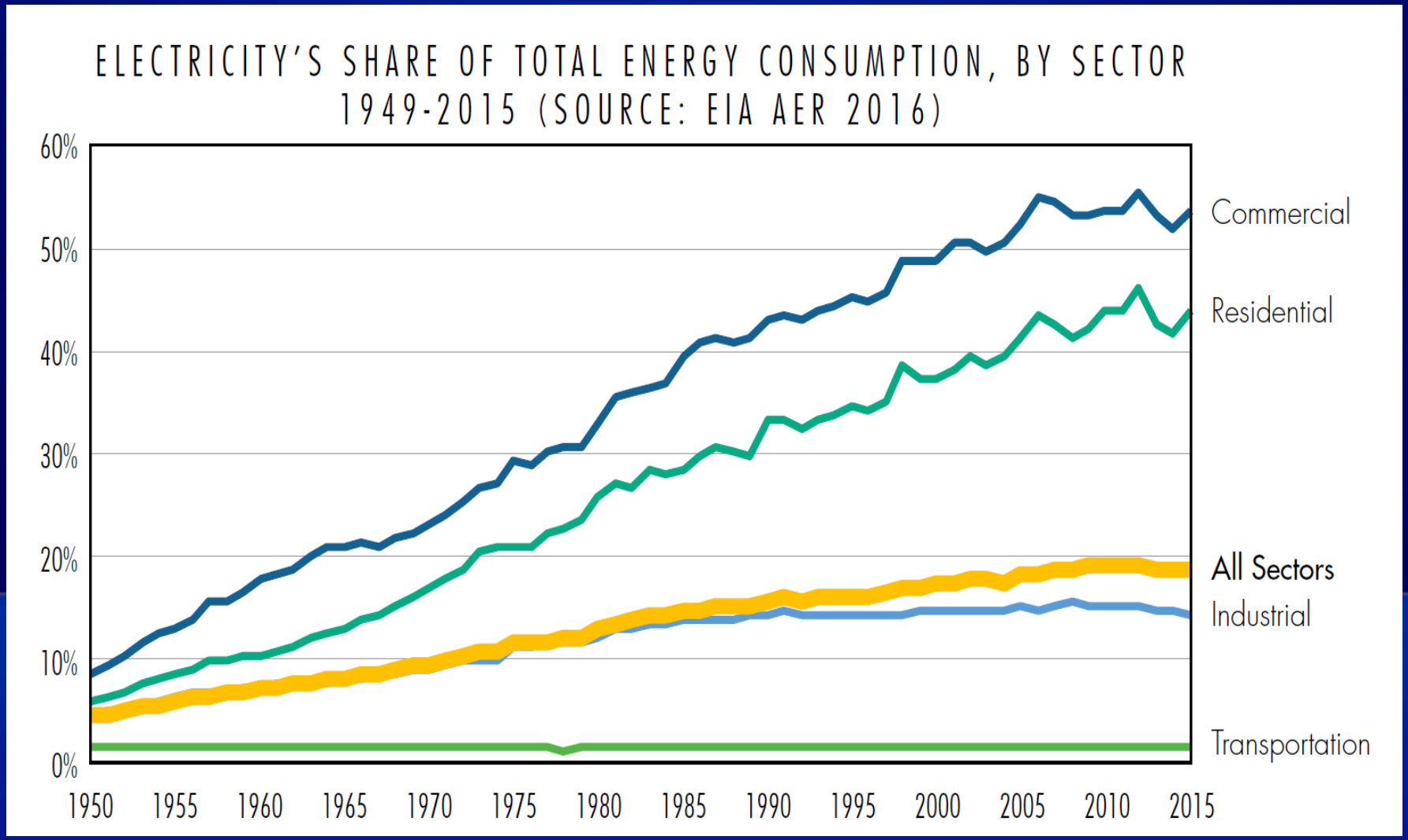
Act to *"Enable"* meeting the needs of the customer and keep the system flexible, reliable, connected, protected and safe

Efficient Electrification



Improve Productivity, Reduce Emissions, Reduce Cost and Is More Controllable

Using Cleaner Energy: Electricity Growing Faster than Total Energy



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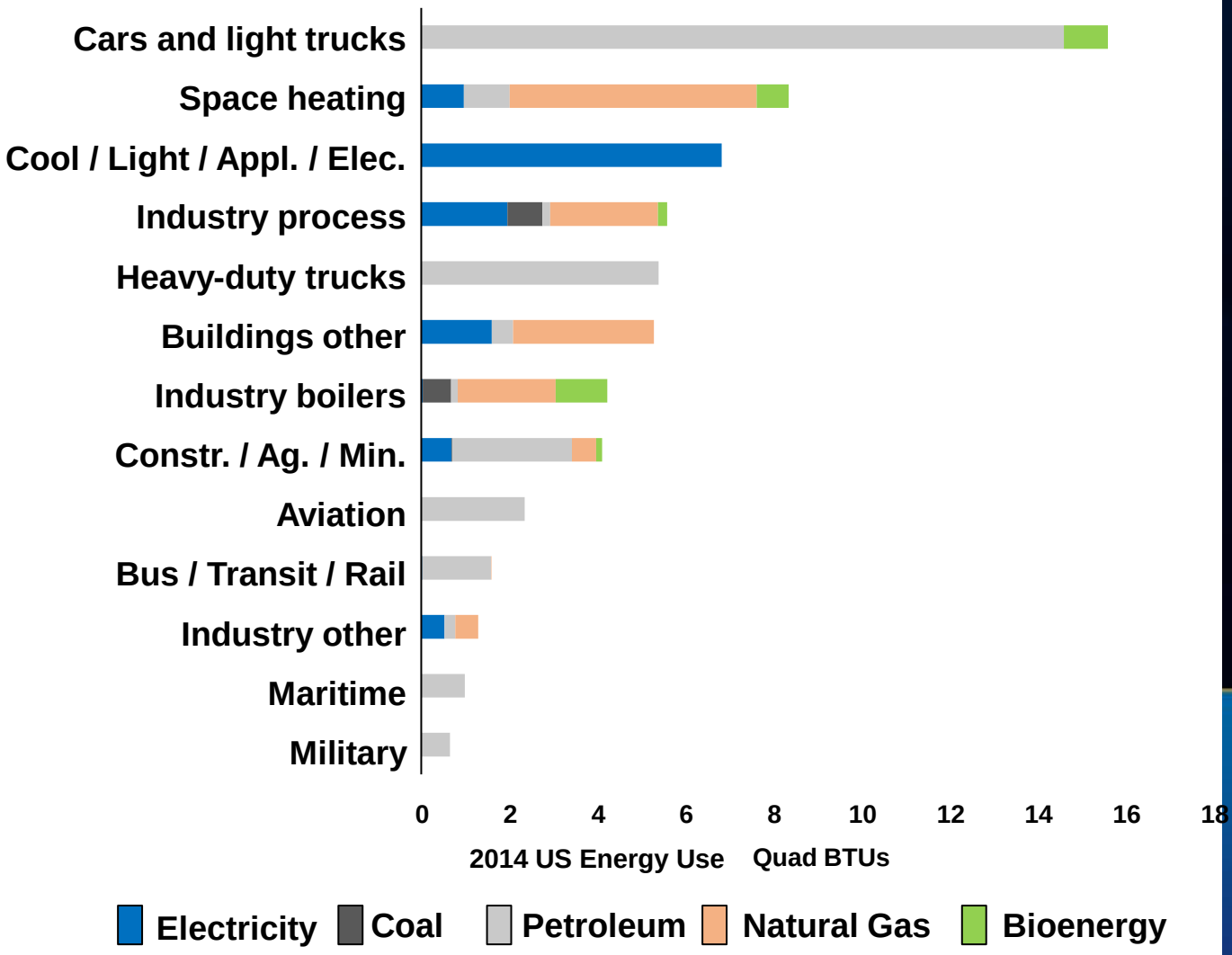
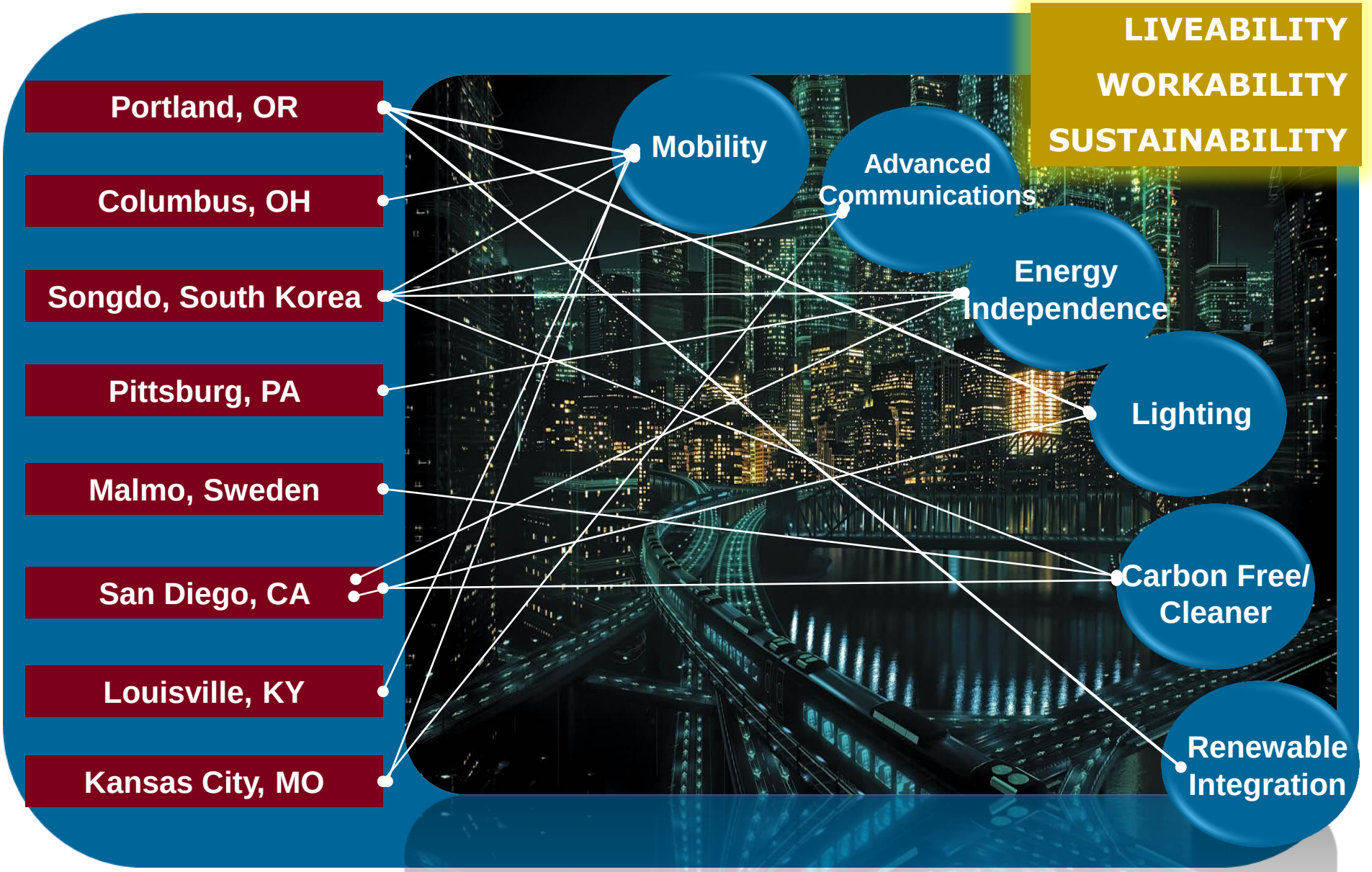
Final Energy Use



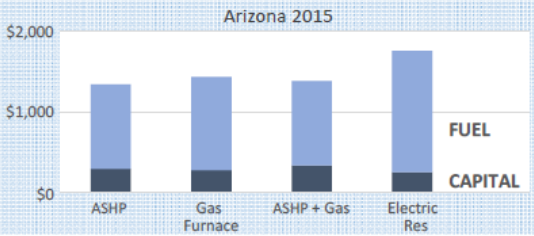
Today Smart Cities Need Digitization and Electrification



What are the Costs and Benefits of Electrification?

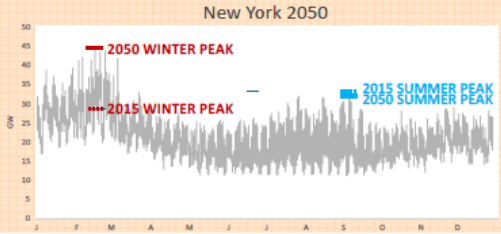
End-user costs/benefits

- Capital vs. operating costs
- Service/product quality and productivity



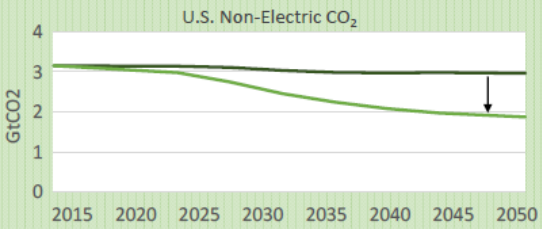
System costs/benefits

- Generation, T&D capacity requirements
- Grid flexibility



Environmental costs/benefits

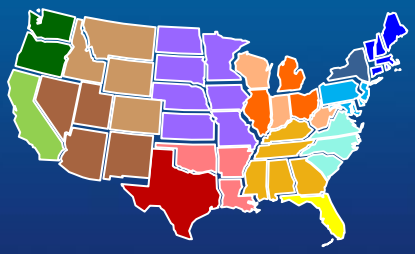
- CO_2, criteria pollutant emissions
- Water resources, quality



FOLLOW-ON STUDY 2018:
STATE-LEVEL ASSESSMENT

EPRI STUDY UNDERWAY:

US National Assessment from 2015-2050



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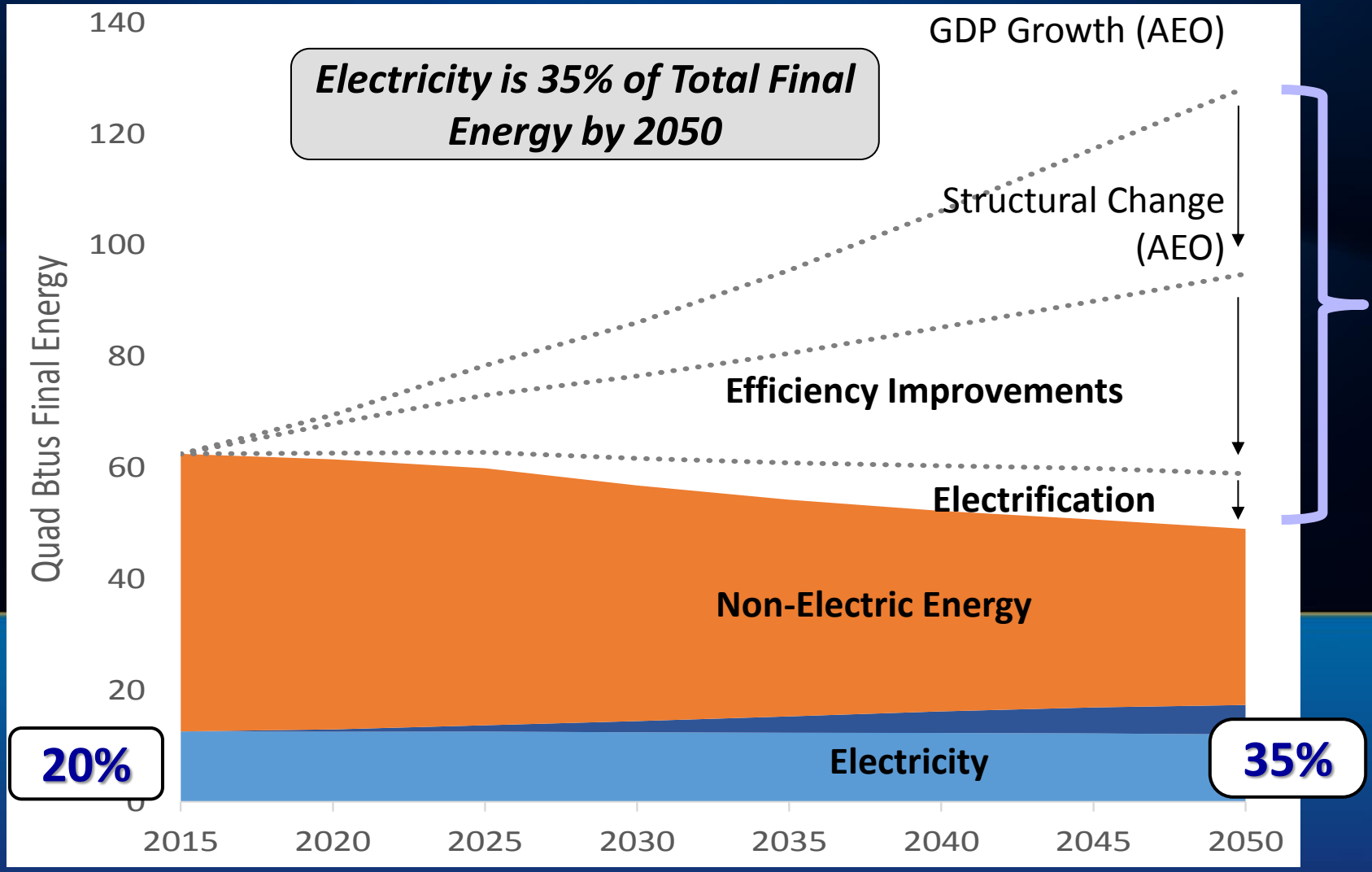
Electricity Increases as a Percentage of Total Final Energy (2015-2050)



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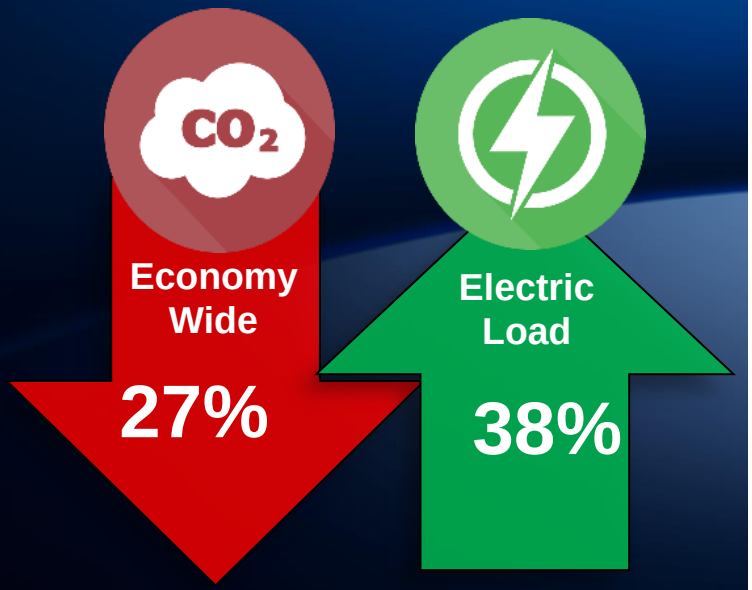
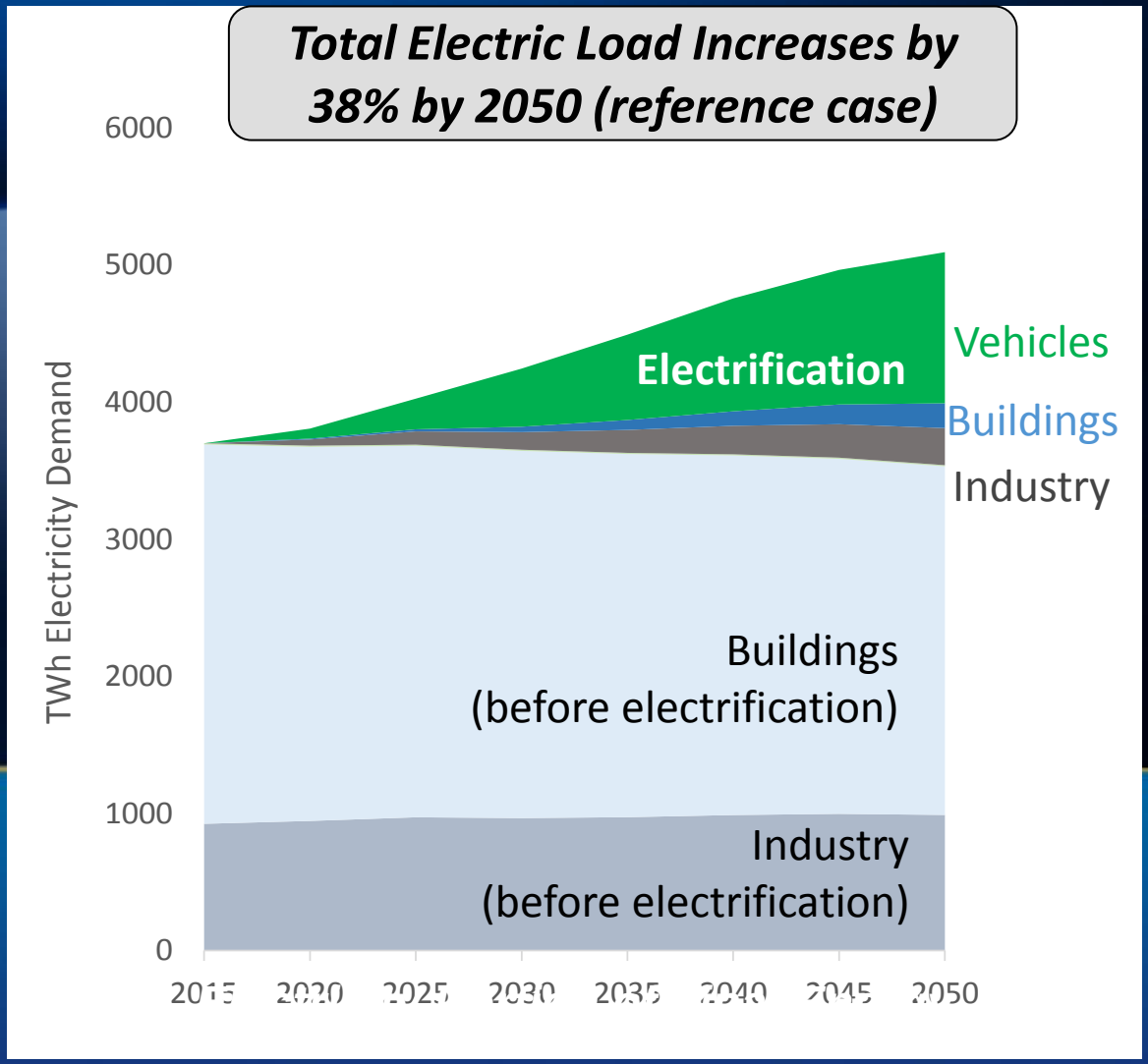
Total Electric Final Energy Increases (2015-2050)

Work in Progress – DRAFT NOT FINAL





Source: DRAFT 2017 EPRI/REGEN Reference Case of US Final Energy

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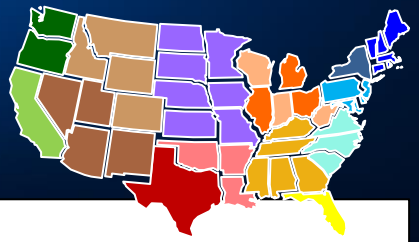
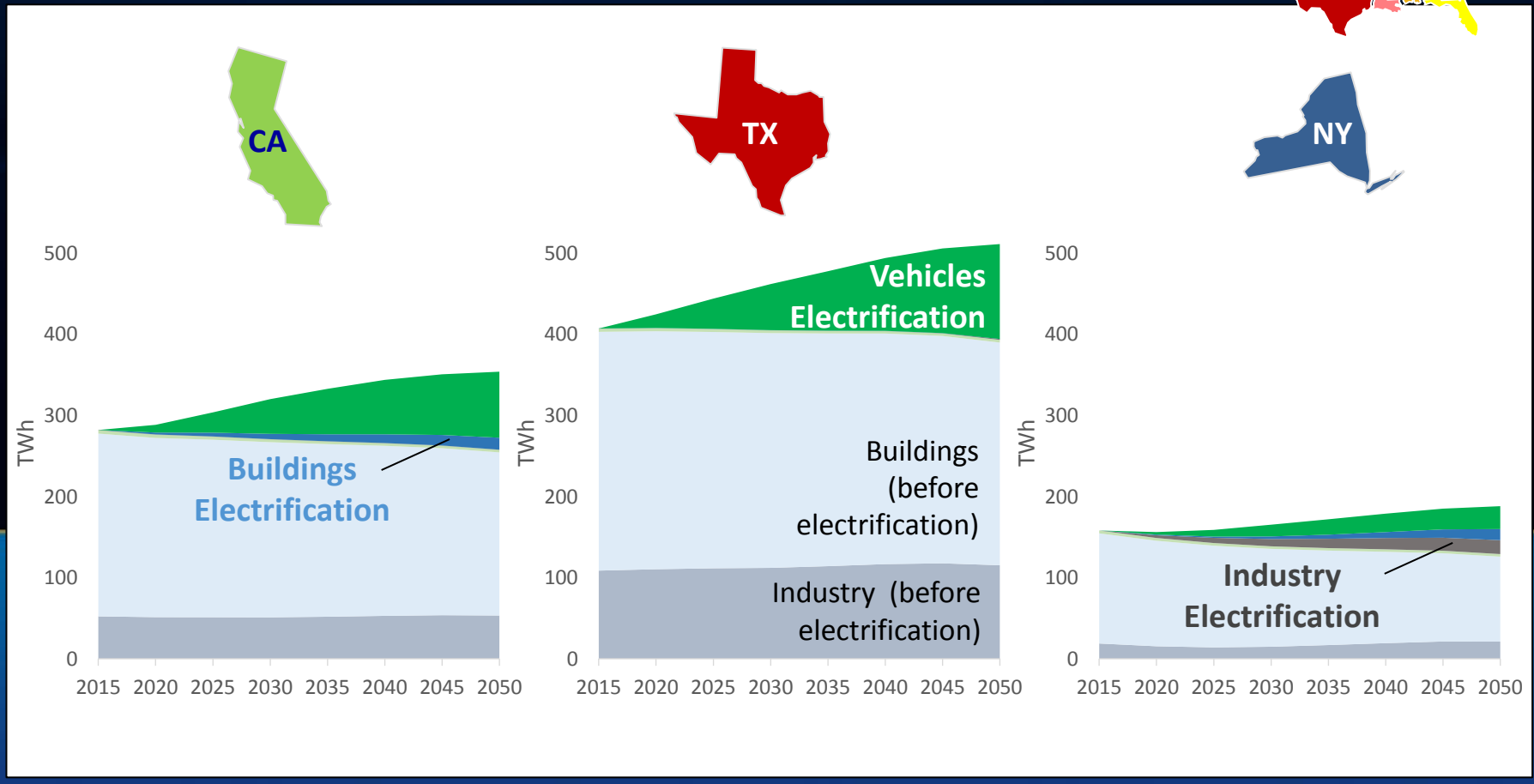
State Assessments Differ

FOLLOW-ON STUDY 2018:
STATE-LEVEL ASSESSMENT





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ELECTRIFICATION 2018

INTERNATIONAL CONFERENCE & EXPOSITION

SAVE THE DATE:

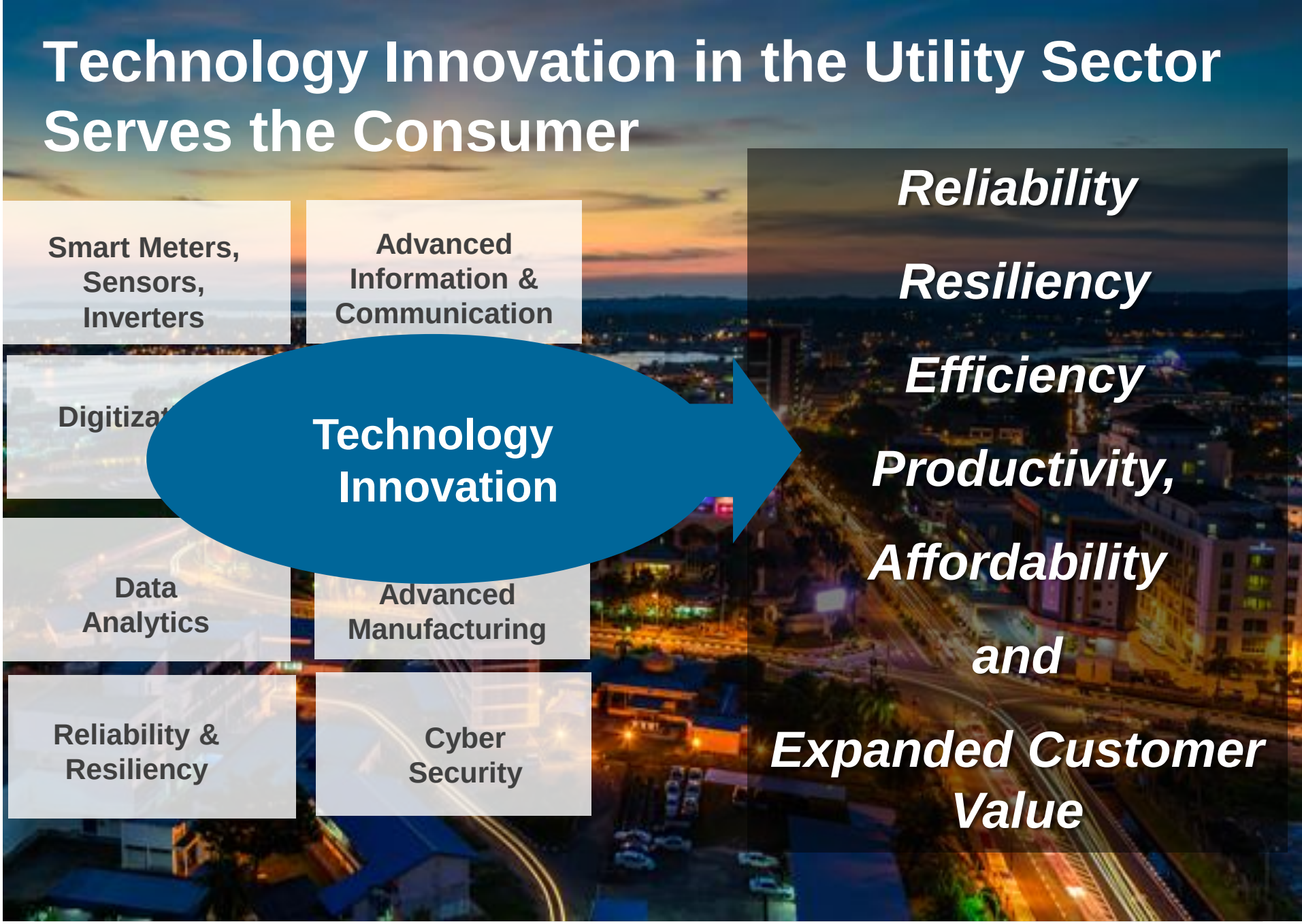
AUGUST 20-23, 2018 LONG BEACH, CALIFORNIA

- To gain an understanding of the quantifiable customer and environmental benefits of efficient electrification
- To learn about best practices for implementing efficient electrification programs to maximize customer benefit
- To experience the latest electrification-related technologies in action
- To collaborate with industry, government, and academic leaders

For more information, contact Info@Electrification2018.com or visit http://www.electrification2018.com/

Scan here for the latest EPRI Efficient Electrification newsletter

Technology Innovation in the Utility Sector Serves the Consumer



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Integrated Energy Network…

…Serves The Customer

Defines a pathway to the future which provides customers with the flexibility to use, produce and manage energy the way they want - while ensuring universal access to reliable, safe, affordable, cleaner energy.

Task Force on Innovation: NARUC Annual Meeting Nov. 12, 2017

David Kolata, Executive Director
Citizens Utility Board

Innovation in the Utility Sector

- Great opportunity
- Necessary for least-cost future
- Regulatory, business model challenges

Likely Requires a Performance-Based Approach

- "Gold-plating" risk
- Incentive problems

EVs as Illustration

- Transportation Electrification Accord
- TheEvAccord.com
- Must optimize to:
  - Improve load shape
  - Reduce peaks
  - Facilitate integration of renewables
  - Maximize grid value

Consumer Confidence?

- Compensation tied to performance
- Effective use of pilots
- Appropriate balance of risk/reward

Importance of Data

- The “easy” problem
- Experience so far not encouraging
- Illinois as model

BigEnergyData.info

Finding the ways that work

WYOMING PUBLIC SERVICE COMMISSION

Kara Brighton Fornstrom, Deputy Chair

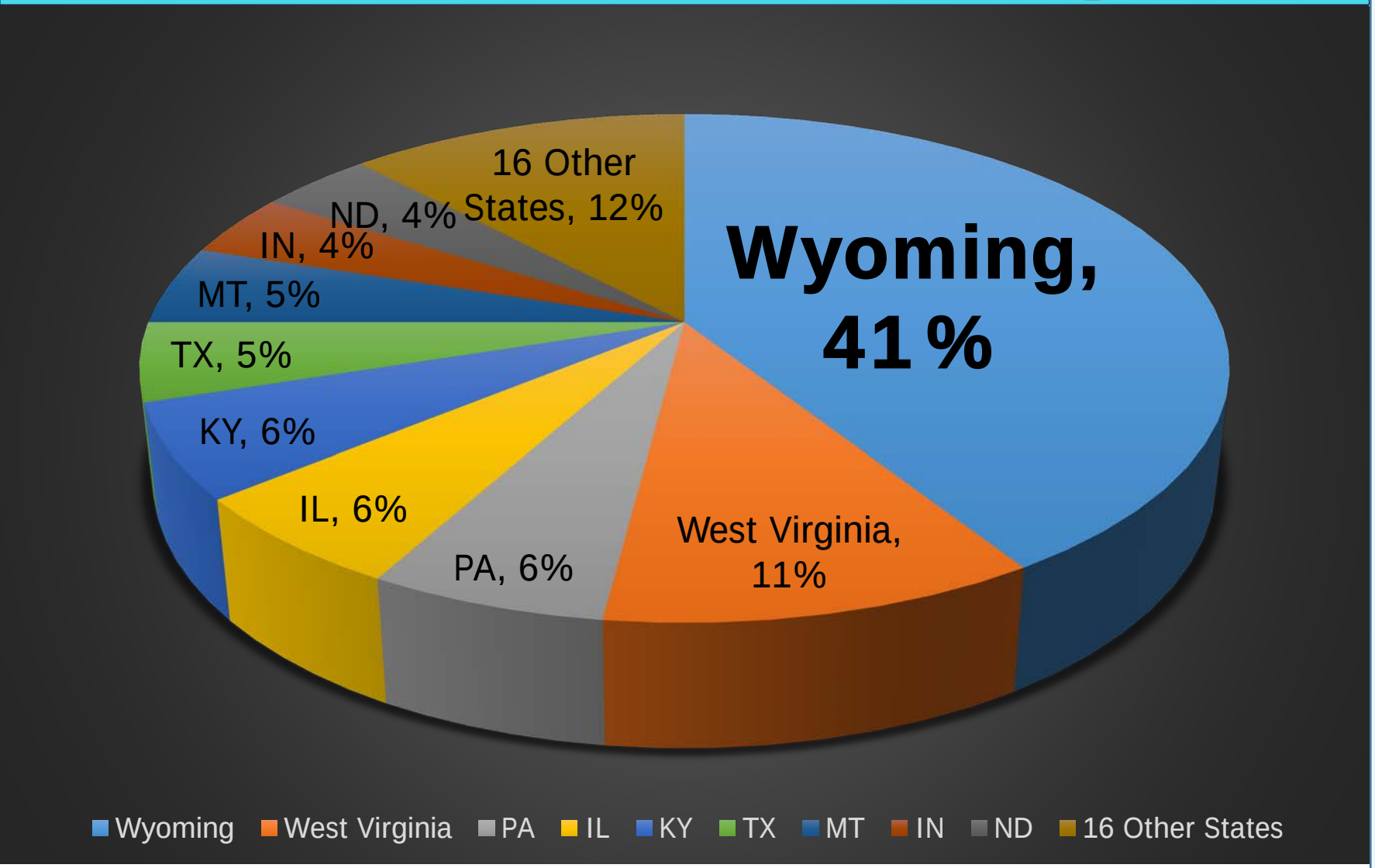
Innovation Panel

November 12, 2017

WYOMING PUBLIC SERVICE COMMISSION

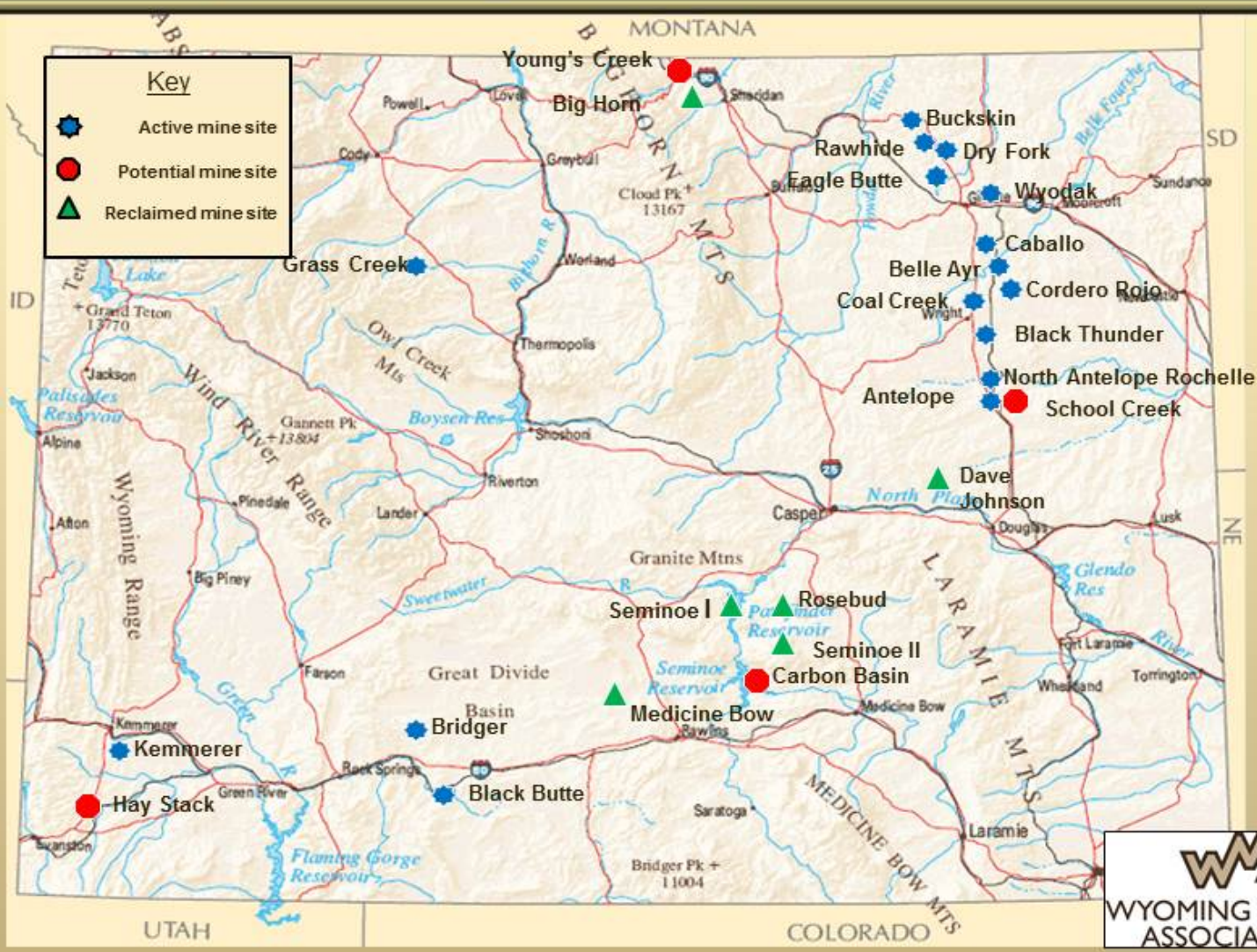
Innovation is NOT Exclusive to New Industries

2016 U.S. Coal Production by State



Source: 2017 Wyoming State Geological Survey

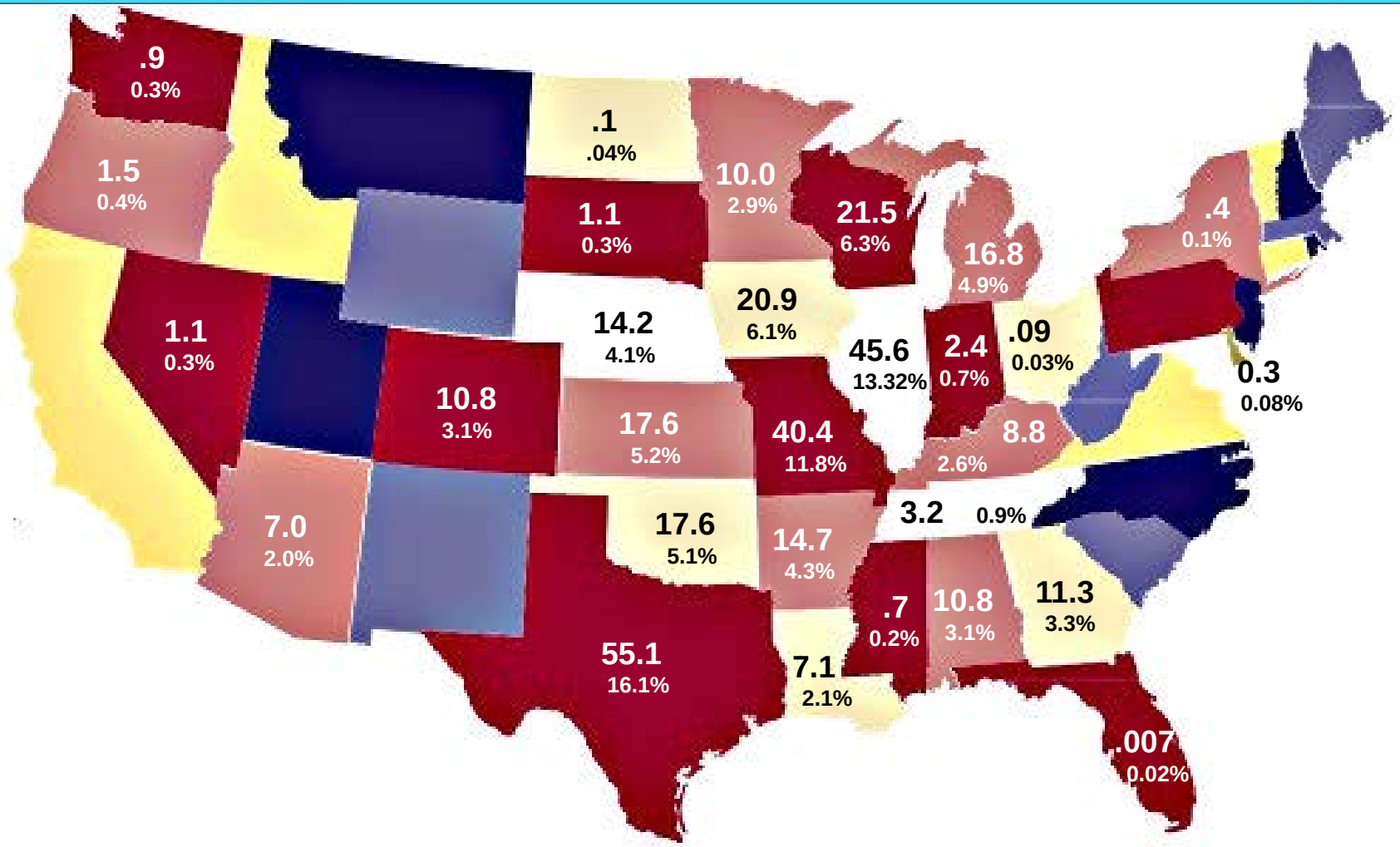
Wyoming's Coal Mines



WYOMING MINING ASSOCIATION

WYOMING PUBLIC SERVICE COMMISSION

Coal Shipments from Wyoming to Other States in 2015



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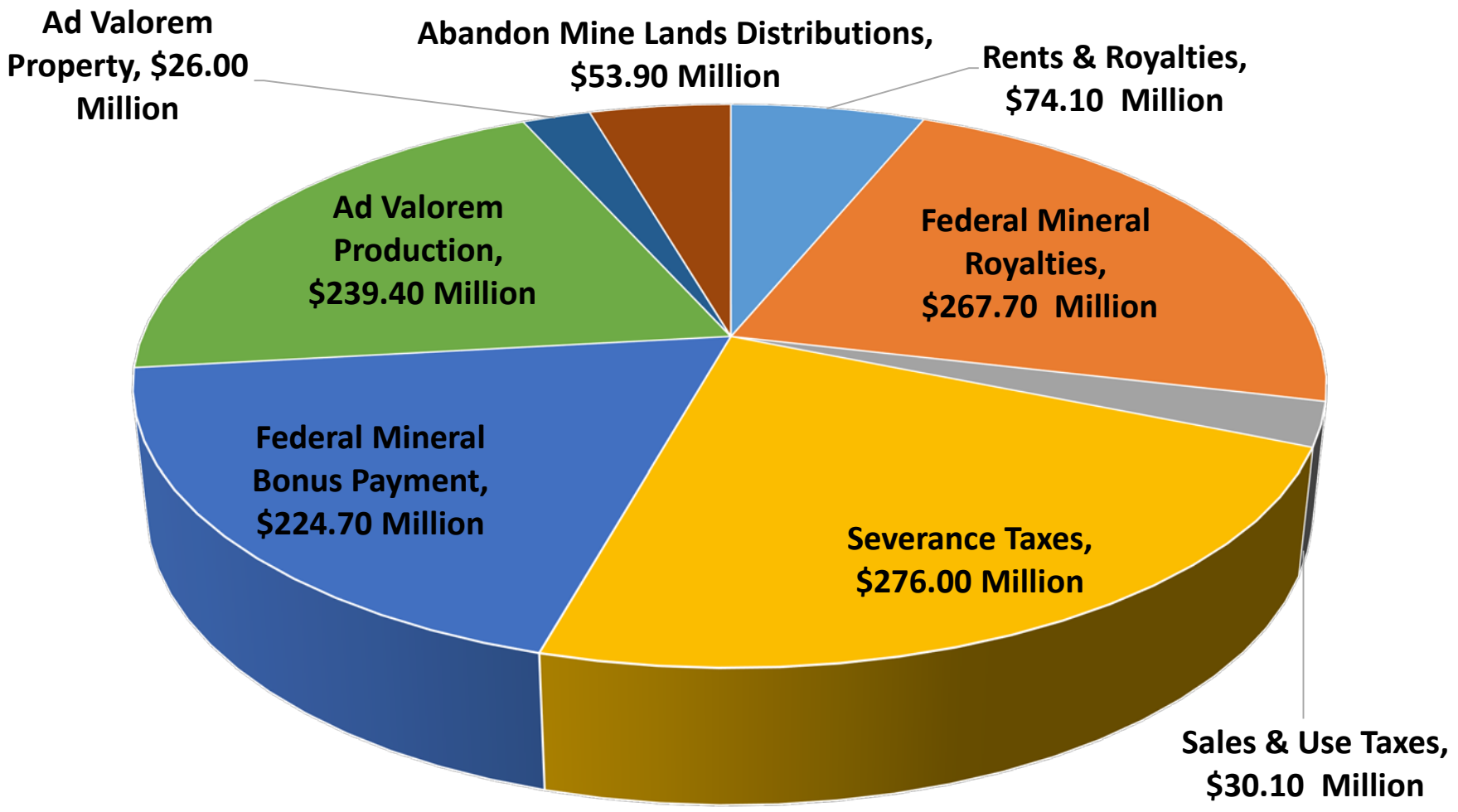
Coal Contribution to Wyoming in 2015

$1.2 Billion



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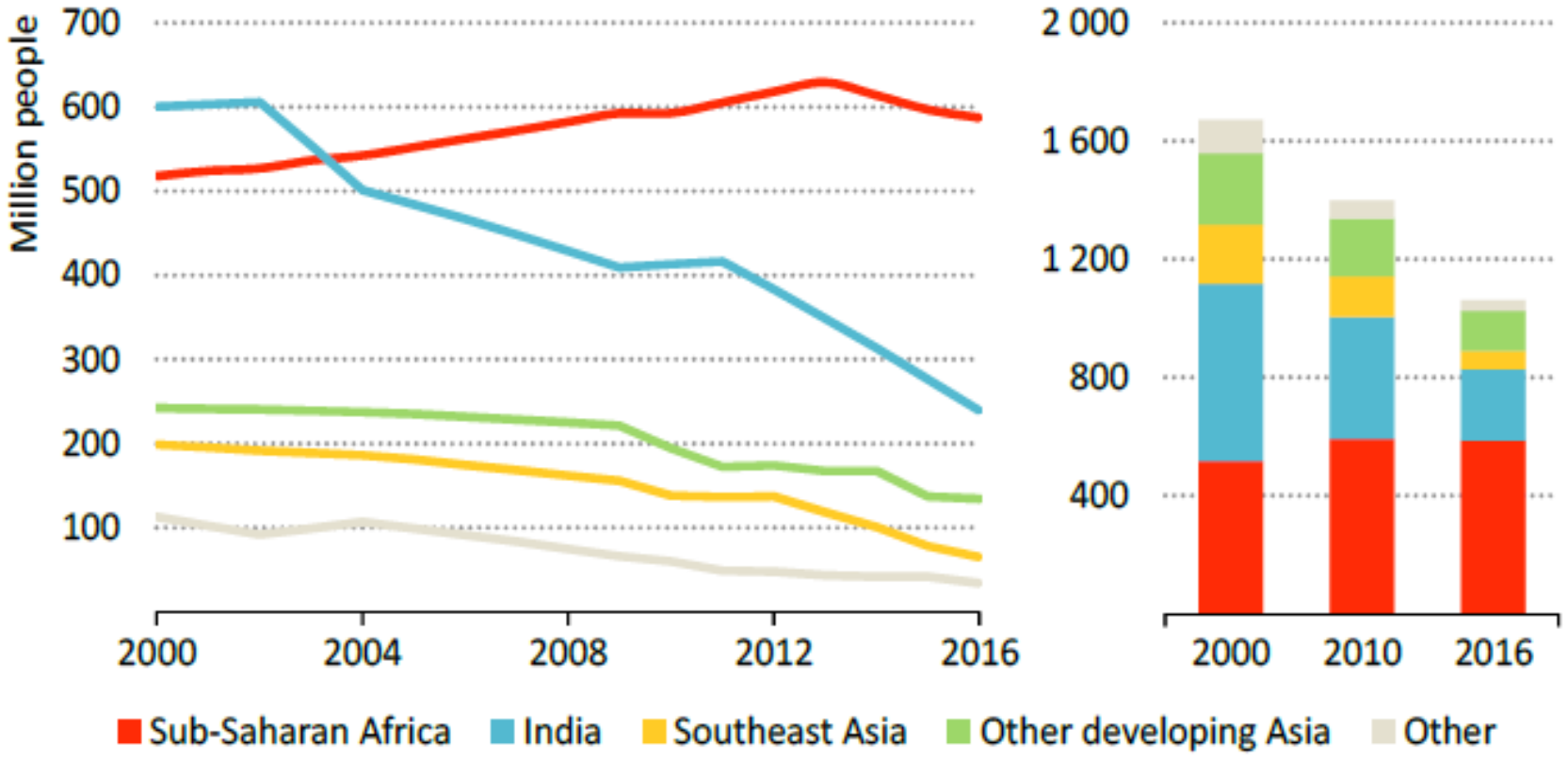
Coal Mine Employment in Wyoming

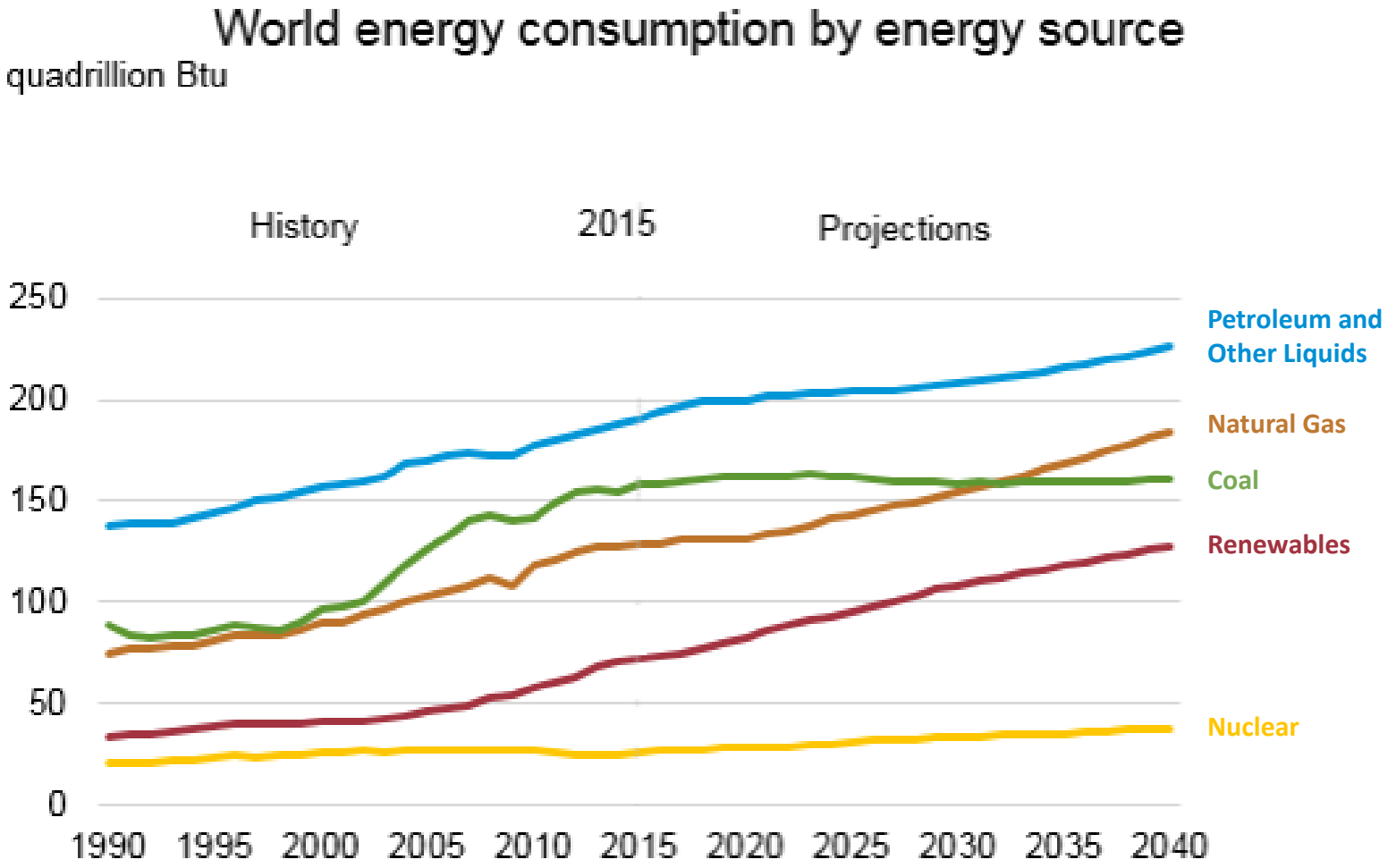
- As of December 2016, Wyoming coal mines employed 5,627 miners and mine operations personnel
- Coal industry jobs are among the best paying in the state
  - Wyoming coal miners take home an average of $82,000 before benefits—almost twice the statewide average
- Estimates indicate that each coal industry position drives the need for three additional jobs in the state
  - Coal industry accounts for approximately 10% of the jobs in Wyoming

1.1 Billion People Without Access to Electricity



Source: Energy Access Outlook: from Poverty to Prosperity, part of the *World Energy Outlook-2017*

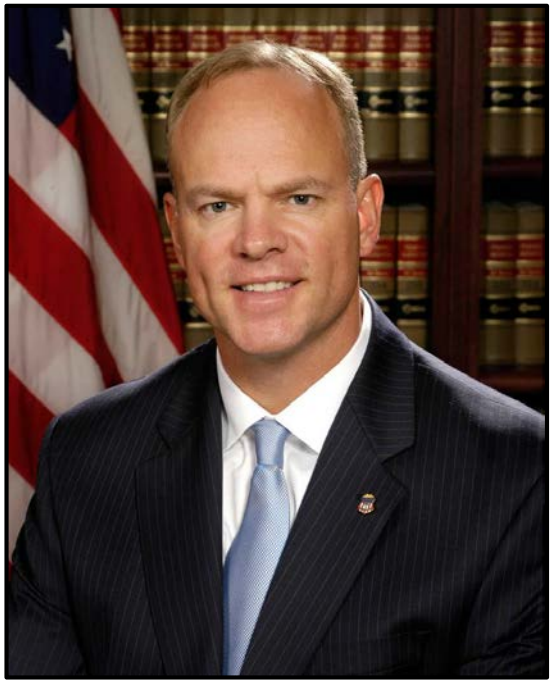
World Coal Dependency Outlook: Significant Through 2040



Governor Mead's Vision

CO_2

Environmental Liability → Asset



Revenue Stream

Next Generation Technology for Today's Energy

ITC
WYOMING
INTEGRATED
TEST CENTER

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PUBLIC
SERVICE
COMMISSION

The ITC

- One of the world's largest CO_2 demonstration scale test facilities
- 20+ MW of coal derived flue gas from the Dry Fork Power Station
- Simple design minimizes costs, provides flexibility & quick turnaround times
- Designed for maximum flexibility and scalability for testing

ITC
WYOMING
INTEGRATED
TEST CENTER

Credit: Basin Electric Cooperative

Who is Invested in the ITC?

- State of Wyoming - $15 million
- Basin Electric – Host at Dry Fork Station
- Tri-State G&T - $5 million
- National Rural Electric Cooperatives Association - $1 million
- Wyoming Infrastructure Authority – Managing Entity
- Black Hills Corp. and Rocky Mountain Power providing technical expertise and in-kind contributions
- XPRIZE Foundation – First tenant

ITC WYOMING INTEGRATED TEST CENTER

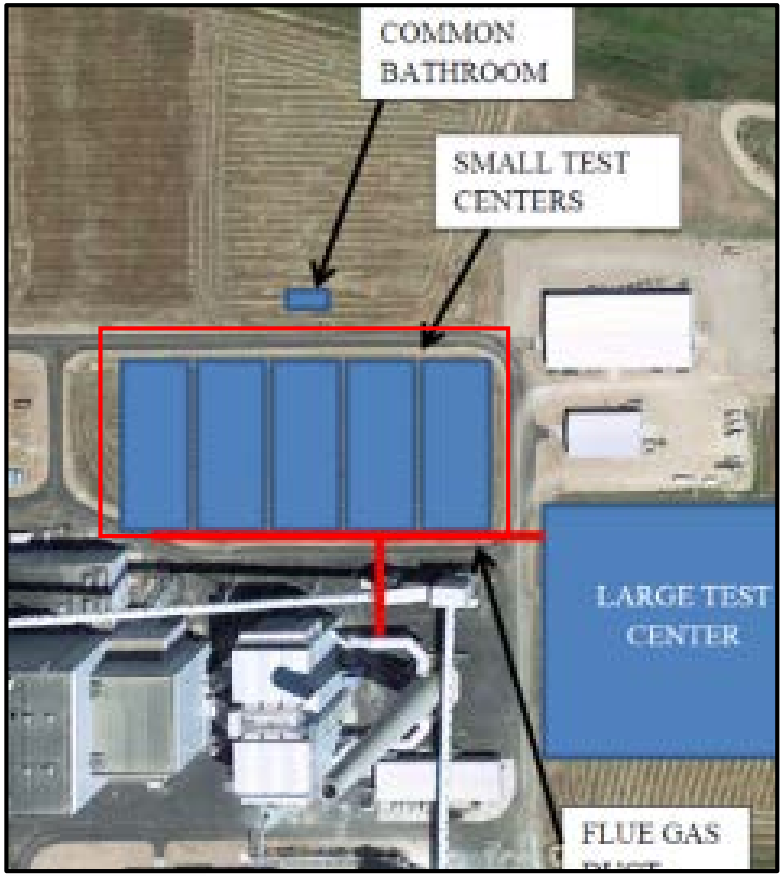
BASIN ELECTRIC POWER COOPERATIVE
A Touchstone Energy® Cooperative

TRI-STATE G&T
A Touchstone Energy® Cooperative

National Rural Electric Cooperative Association
A Touchstone Energy® Cooperative

nrg | cosia CARBON XPRIZE

Site of XPRIZE Competition-Small Test Bays



ITC WYOMING INTEGRATED TEST CENTER

XPRIZE is a temporary tenant of the ITC and at the completion of the competition, the space will be available to new testers.

Photo Credit: Basin Electric Cooperative

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Impact Statement

The Carbon XPRIZE will prove to the world that energy innovation can enable solutions to climate change.

By demonstrating breakthrough technologies that turn CO_2 emissions into valuable products the Carbon XPRIZE will catalyze the development of markets for CO_2 mitigation technologies, and inspire other industries, governments, and educational institutions to take concrete positive action to combat climate change. In success, the competition will help shift the public sentiment to be more optimistic about climate change.

Competition Goals and Intent

1. Support and incentivize development and demonstration of breakthrough technologies

2. Encourage a diversity of CO_2 conversion technologies and end products while incentivizing solutions that, when commercialized, can have meaningful impact on massive scale of global CO_2 emissions

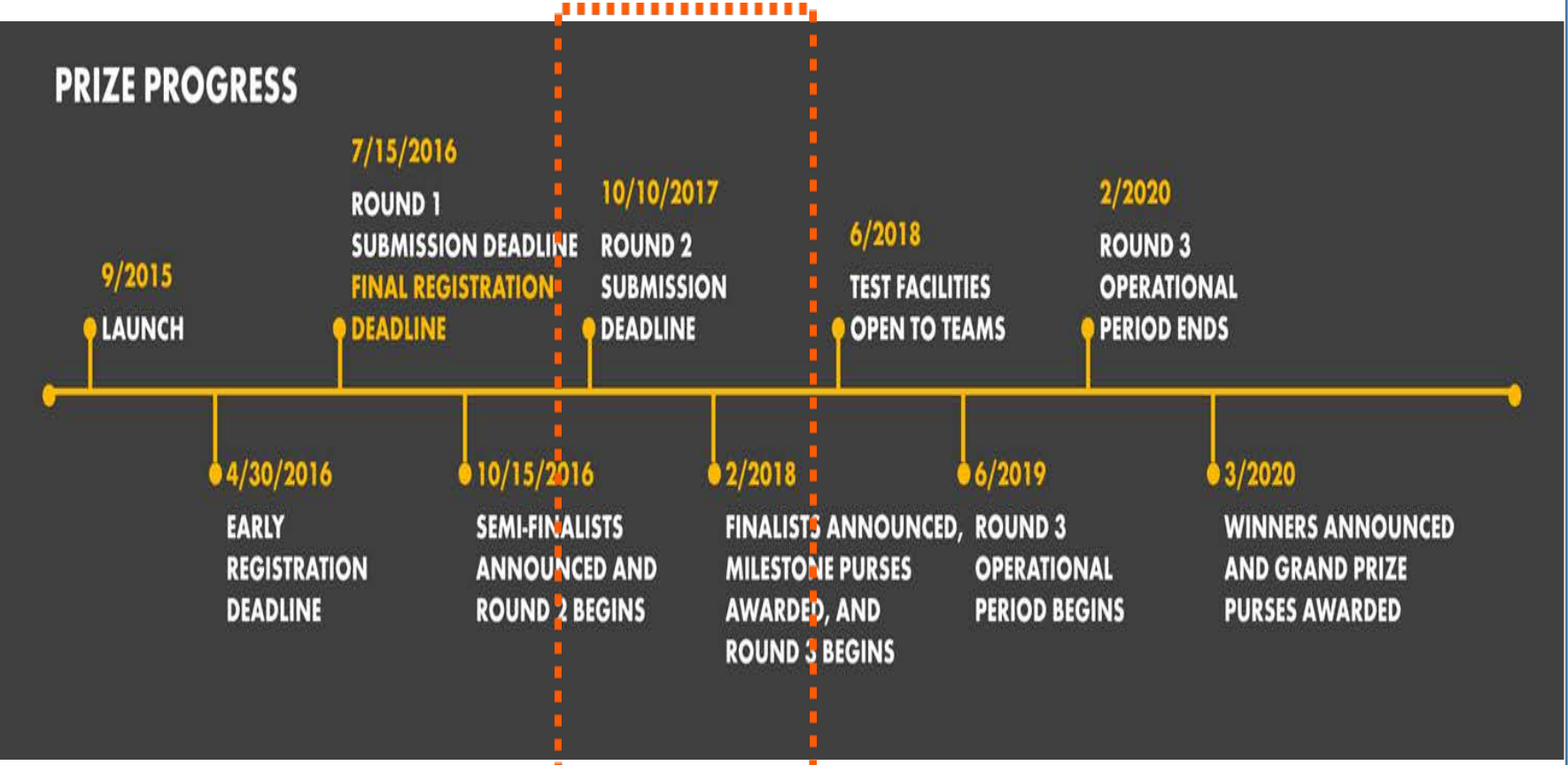
3. Facilitate meaningful industrial testing, 3rd party validation, and demonstration of conversion solutions

4. Support and build collaborative ecosystem of technology developers, scientists, funders, and other stakeholders around the theme of CO_2-conversion and CO_2-based products

Snapshot of the Carbon XPRIZE

THE WINNING TEAM WILL…	Convert the most CO_2 into one or more products with the highest net value
PRIZE PURSE	• $2.5M milestone prize purse for each track • $7.5M grand prize purse for each track
TIMELINE	4.5 years: September 2015 – March 2020
STRUCTURE	Teams register for one of two tracks: • 1 track tested on coal ("Track A") • 1 track tested on natural gas ("Track B") Teams compete in three rounds: • Round 1: Technical and Business Viability Assessment • Round 2: Pilot Scale Competition • Round 3: Demonstration Scale Competition
JUDGING CRITERIA	**Scoring Criteria:** • Amount of CO_2 converted into products • Net value of products **Minimum Thresholds:** • Maximum volume of fresh water consumed • Maximum land footprint in Round 3 demonstration

Competition Timeline

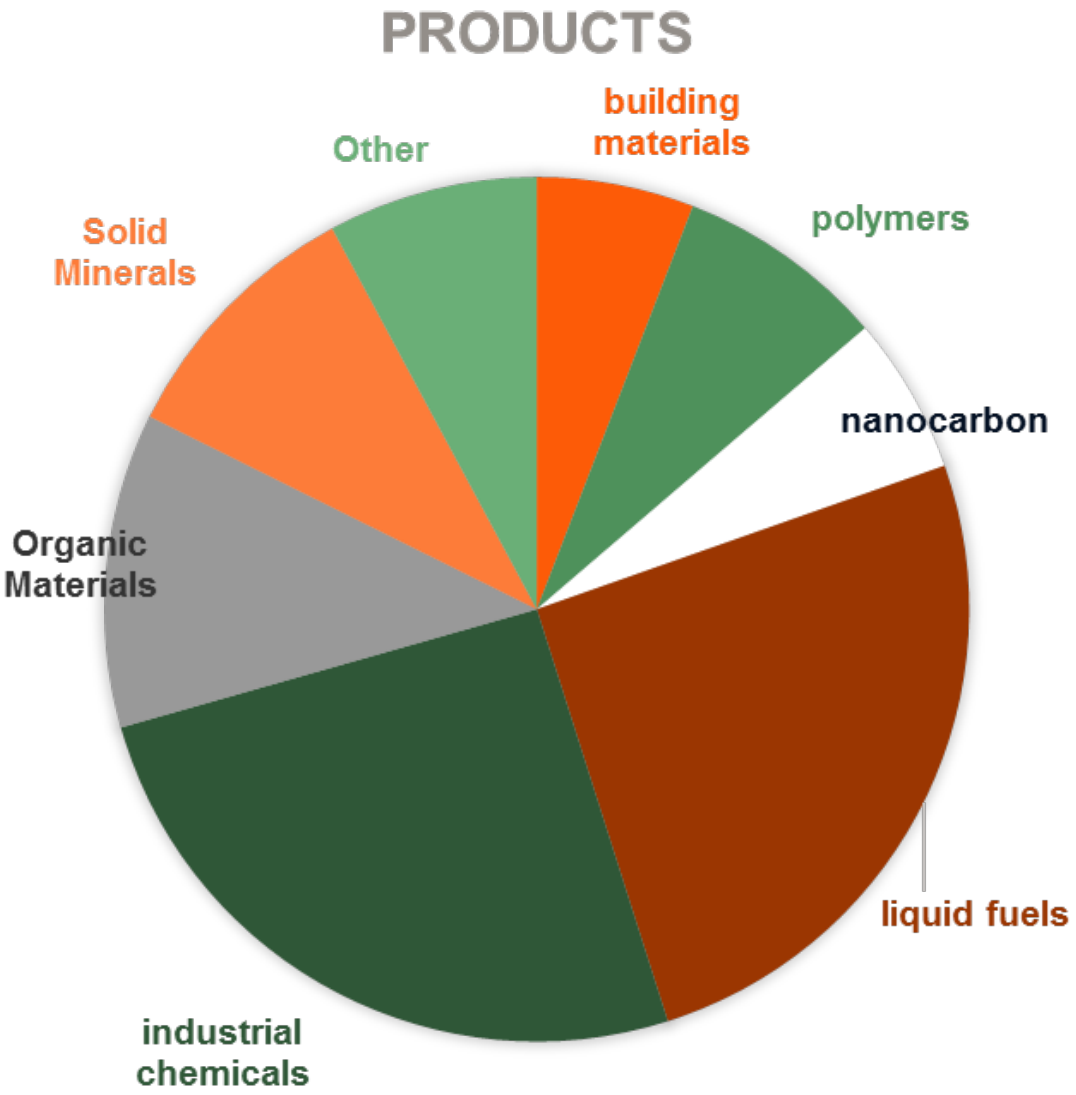


Carbon XPRIZE Competitors

GEOGRAPHIC BREAKDOWN

	Round 1	Round 2 Start	Round 2 Current
USA	21	14	10
Canada	12	9	8
China	1	1	1
India	1	1	1
Scotland	1	1	1
Switzerland	1	1	1
Finland	1	n/a	n/a
TOTALS	**38**	**27**	**22**

Team Products



Commission Discussion Points

- Should regulators support CO_2 research and development in utility rate cases?
- Who owns the CO_2?
- Who owns the pipeline?
- Who benefits from the revenue from the CO_2 sold?
- What are the risks and who shoulders the risk? (ratepayer, shareholders?)
  - Counter party risks?
  - Joint ventures?
- Market risks
  - How widespread will the CO_2 be utilized?
  - How will the market for the CO_2 use affect the utility with the increases as well as decreases in drilling?
  - What are the risks associated with the market for CO_2?
  - Negative market prices?
  - Could/Should there be a cost sharing relationship?

WYOMING PUBLIC SERVICE COMMISSION

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WYOMING PUBLIC SERVICE COMMISSION

NARUC Annual Conference

Integrated Distributed Energy Resources Planning

November 12, 2017

Lorraine H. Akiba, Commissioner

Hawaii Public Utilities Commission

November 12, 2017

State Commissions at the Forefront of Change

- Hawaii PUC issues orders in major dockets to outline the strategic road map for Hawaii's utilities of the future and provide directives to achieve the integrated grid of the future. Addresses DERs, community renewables, TOU and DR rates with energy storage options

- NY PSC initiates the NY REV proceeding to establish a market based energy system with utilities in new roles as distributed system platform providers to connect customers to distributed energy resource providers

- CPUC issues orders in major dockets to address NEM, TOU rates, and energy storage. Providing the impetus to create a competitive market for energy storage development to drive technology innovation and lower costs

- Minnesota PUC establishes the valuation of solar tariff and community solar programs to address the cost benefits of integrating distributed energy resources onto the grid

- Colorado PUC and Maine PUC address the regulatory framework for developing and encouraging community solar programs in their jurisdictions

- Illinois PUC issues orders regarding grid modernization and smart grid technology tools for the integrated grid of the future

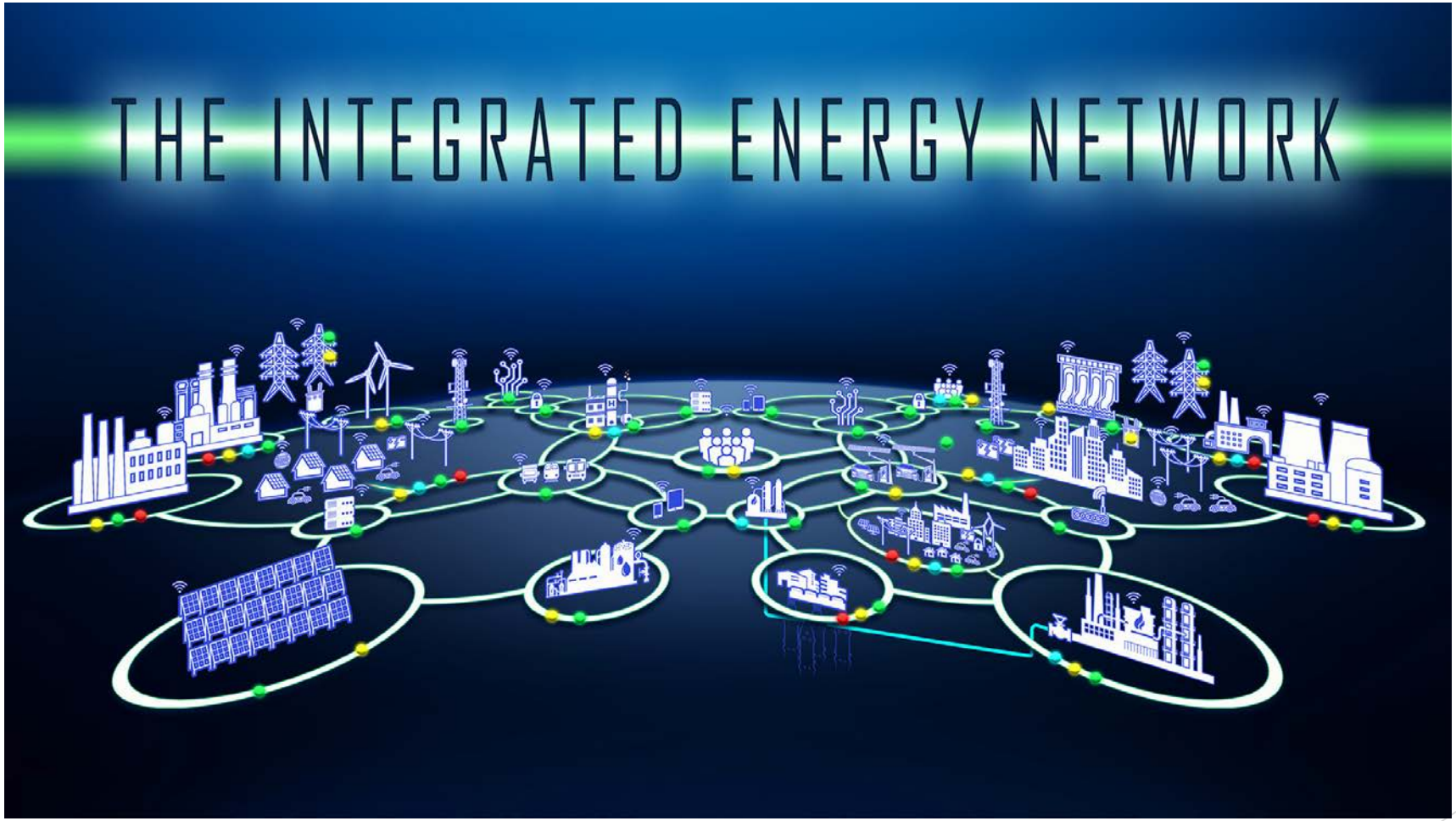
- Ohio PUC issues orders and initiates regulatory proceedings to review technology and regulatory innovations regarding grid modernization

Policy and Regulatory Reforms to Achieve Hawaii's Clean Energy Future

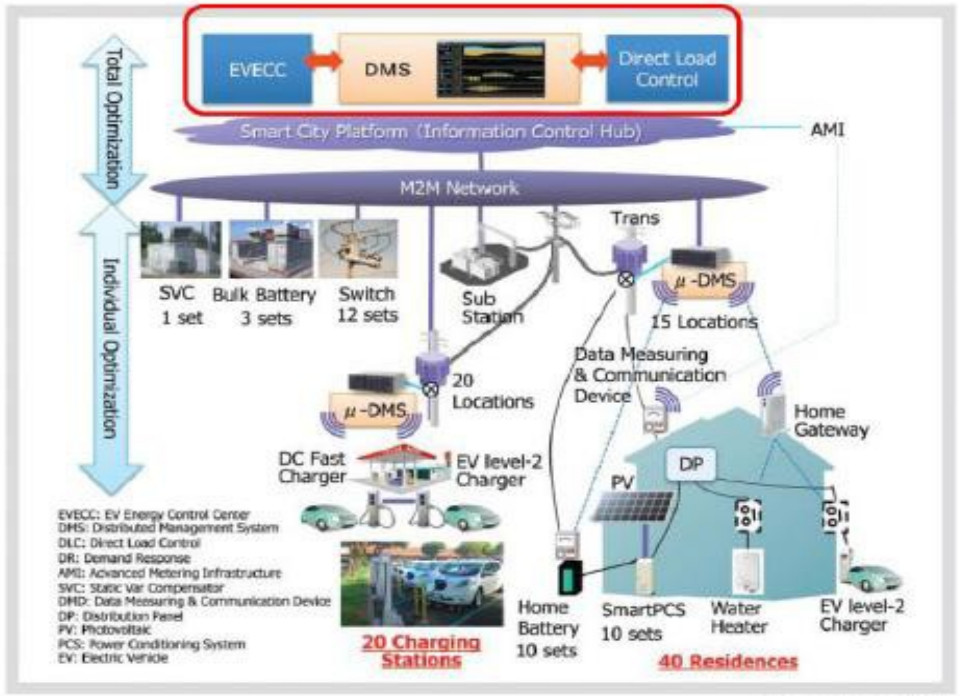
- Recent PUC directives and orders to Hawaii's utilities to implement new business models to become a world leading operator of a high renewable energy resource grid with affordable access for all customers
- Regulatory policies and pricing also need to reflect these new business models with new incentives to achieve Hawaii's clean energy future
- Review and revision of pricing of energy services to reflect new business and technical demands
- Recent legislation enacted into law effective July 1, 2015 adopting a renewable portfolio standard of 30% by 2020, 70% by 2040, and 100% by 2045

Envision the Integrated Grid of the Future

- Hawaii is the living laboratory for the integrated grid of the future to achieve the 100% renewable energy portfolio standard
- Implementing new programs like community renewables to give all customers access to renewable energy
- Implementing real time DER actions and combining the tools of both traditional central plant utility scale and decentralized distribution generation models


THE INTEGRATED ENERGY NETWORK

Overall View of System Configuration



PUC Orders Address DER Interconnection and New Customer Options

- Interconnection of Energy Storage Systems (Docket No. 2014-0130)
  - Storage systems will be reviewed for safety and reliability
  - Resolution of further technical issues moved to DER docket
- Distributed Energy Resources Policy Docket (Docket No. 2014-0192)
  - Established to investigate technical, economic, and policy issues
  - Opening order highlighted 3 key objectives:
    1) Clear interconnection backlog
    2) Enable DER market growth
    3) Create new DER market choices
- Included Staff Paper and Proposal
- Continues work started by stakeholders in the Reliability Standards Working Group (RSWG)

- October 2015 order approves two new rooftop PV programs for HECO customers to facilitate transition to long term technical and policy solutions that support continued distributed energy resources on the grid

- Customers given more choices and opportunities to utilize new energy storage technology on the customer side of the meter

- Grid supply option with bill credit at fixed rates based on wholesale rates for PV at approximately 15 cents per kwh on Oahu and Big Island, 17 cents per kwh on Maui, 24 cents per kwh on Molokai and 28 cents per kwh on Lanai.

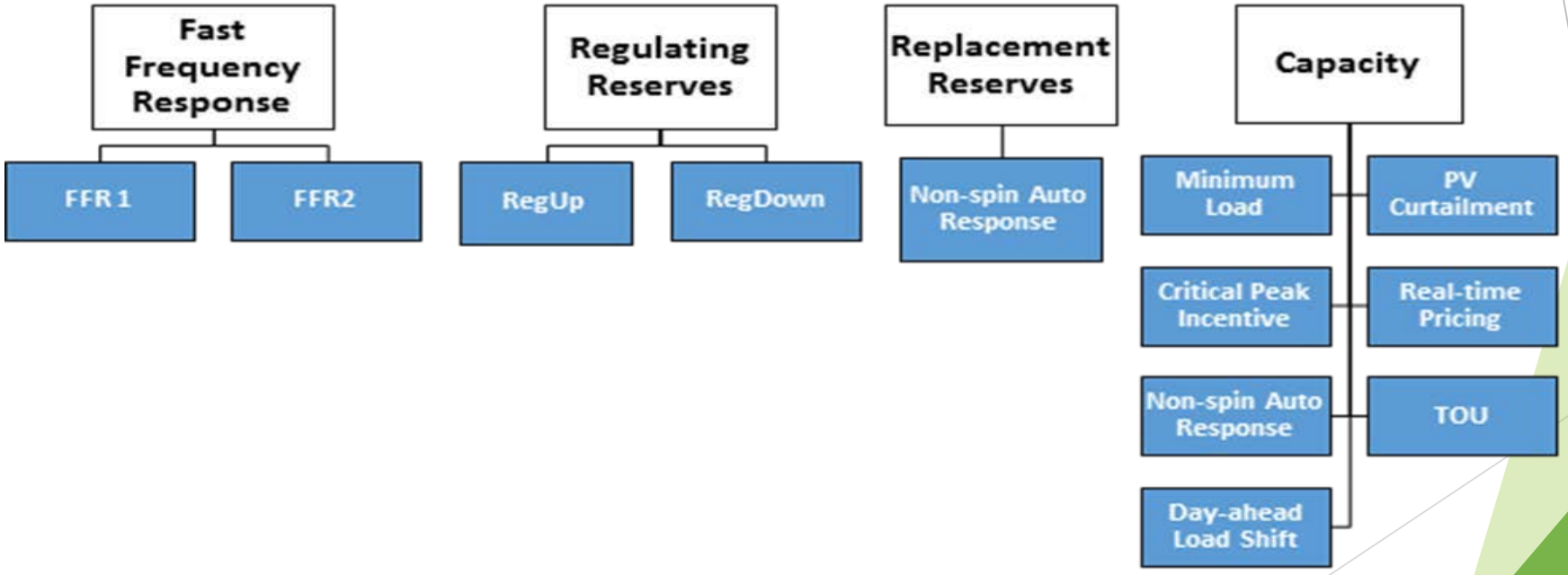
- Self supply option designed for customers with rooftop PV systems and energy storage; expedited review and approval for interconnection

- KIUC customers already on similar schedule Q rates for NEM

Demand Response - Docket No. 2015-0412

- The HECO Companies have filed first set of comprehensive DR Portfolio Plans
- Core efforts include:
- (a) identify system response requirements;
- (b) define grid service needs in technology-neutral terms;
- (c) model costs of requisite ancillary services (avoided cost basis);
- (d) determine DR potential to meet said ancillary services
- HECO identified 4 broad ancillary service tariff categories : Fast Frequency Response; Regulating Reserves; Replacement Reserves; and Capacity.

- Under each of these tariffs, more granular service riders can be included:
- FFR1 and FFR2
- RegUp/RegDown
- Non-spin Auto Response
- Capacity services including time-of-use and PV curtailment



Future Trends and Actions Transforming the Energy Industry

- Advances in technology lead to consumerization of energy and new wave of utility customer engagement solutions
- Advanced usage of data analytics for energy management services and operations of the grid
- With the internet of things (“IOT”), utilities become energy management service providers to customers and fill the role of advisor and facilitator of all things energy
- Utilities assume dynamic roles as conductors of the complex orchestra that makes up the integrated grid
- Energy is becoming more local. Community and utility engagement with community renewables, integrated energy districts, EE and DR

Roles of Digital Utilities of the Future

- The digital economy is being driven by technology developments including open cloud interoperable software platforms and grid control technology
- Big data analytics and technology tools allow for real time visualization and operation to help integrate more intermittent renewable energy resources and DER onto the grid
- We are moving from the digital economy to the virtual economy with development and usage of AI (artificial intelligence), sensors and machine to machine learning tools
- Blockchain technology and transactive energy transformation
- Utilities will need to leverage and facilitate usage of information and communications technologies across energy, water and transportation sectors

Grid Modernization - Docket No. 2017-0226

Hawaii PUC issues Order 34281 in Docket 2016-0087 which rejected w/out prejudice the HECO Smart Grid Foundation Project and outlined concerns regarding cost effectiveness, how the project would support renewable and DER integration, risks of technology obsolescence and stranded costs, and the pace of implementation of the “smart grid”.

The commission ordered the utility to develop a holistic grid modernization strategy including not just sound technology solutions and tools but also providing new business models, new regulatory approaches, and the emergence of new providers to facilitate increasingly innovative solutions

Grid modernization guidance in April 2014 when the Hawaii PUC issued the seminal white paper and strategic road map for the utilities, “Commission’s Inclinations on the Future of Hawaii’s Electric Utilities”

The Inclinations and the corresponding orders in 4 separate dockets initiated proceedings addressing:

1) Integrated resource planning;
2) Migrating from new metering to a grid services market;
3) Launching community renewables (community solar);
4) Growing demand response capabilities; and
5) Aligning cost recovery with performance incentive mechanisms and new performance metrics

- Grid Modernization as Part of the Regulatory Framework
- DER Investigation and Grid Mod
- Demand Response and Grid Mod
- Integrated Planning through PSIP and DGIP and Grid Mod

Mahalo!

For any questions, please contact:

Lorraine.H.Akiba@hawaii.gov
(808) 586-2020

Lorraine H. Akiba, Commissioner
Hawaii Public Utilities Commission

$15 To Move The Needle on Innovation

Dawn Lippert

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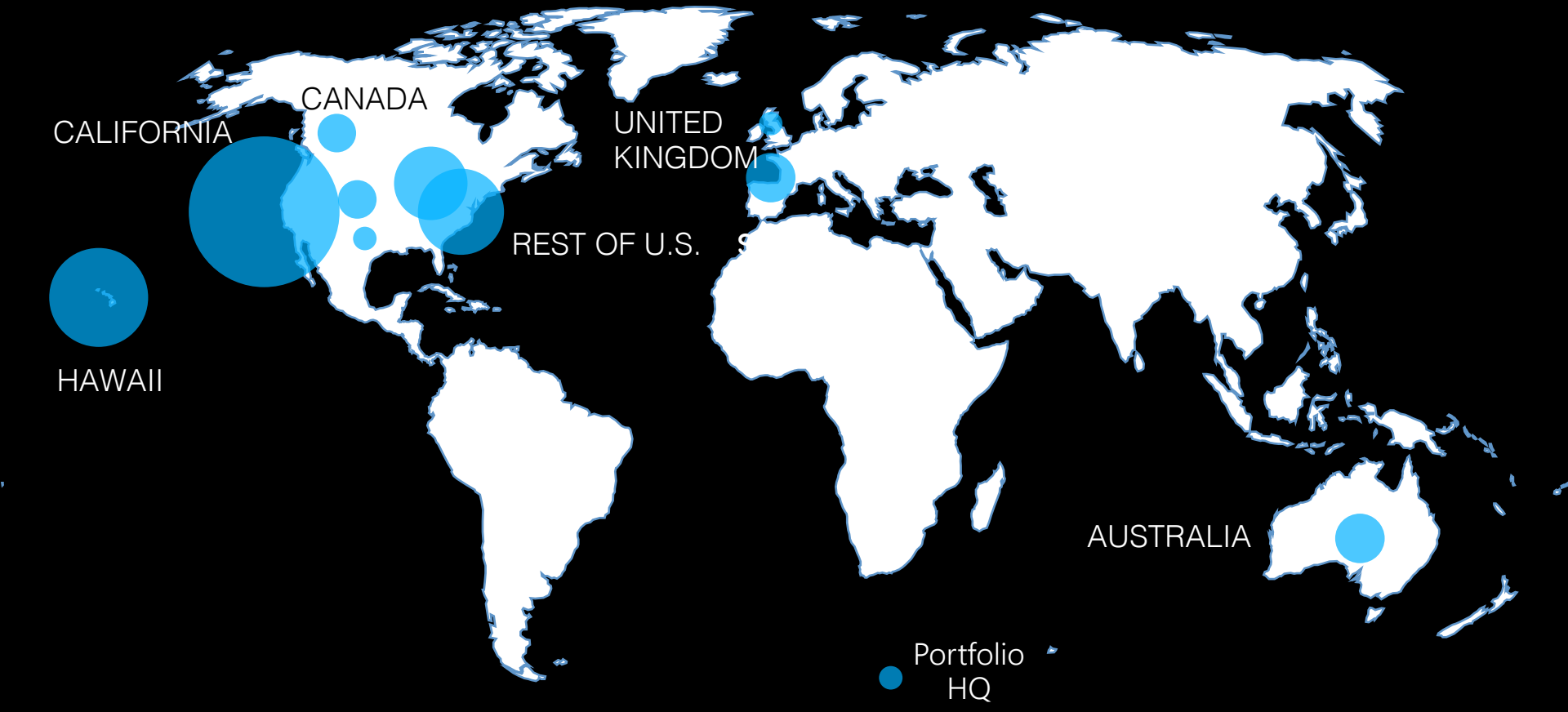
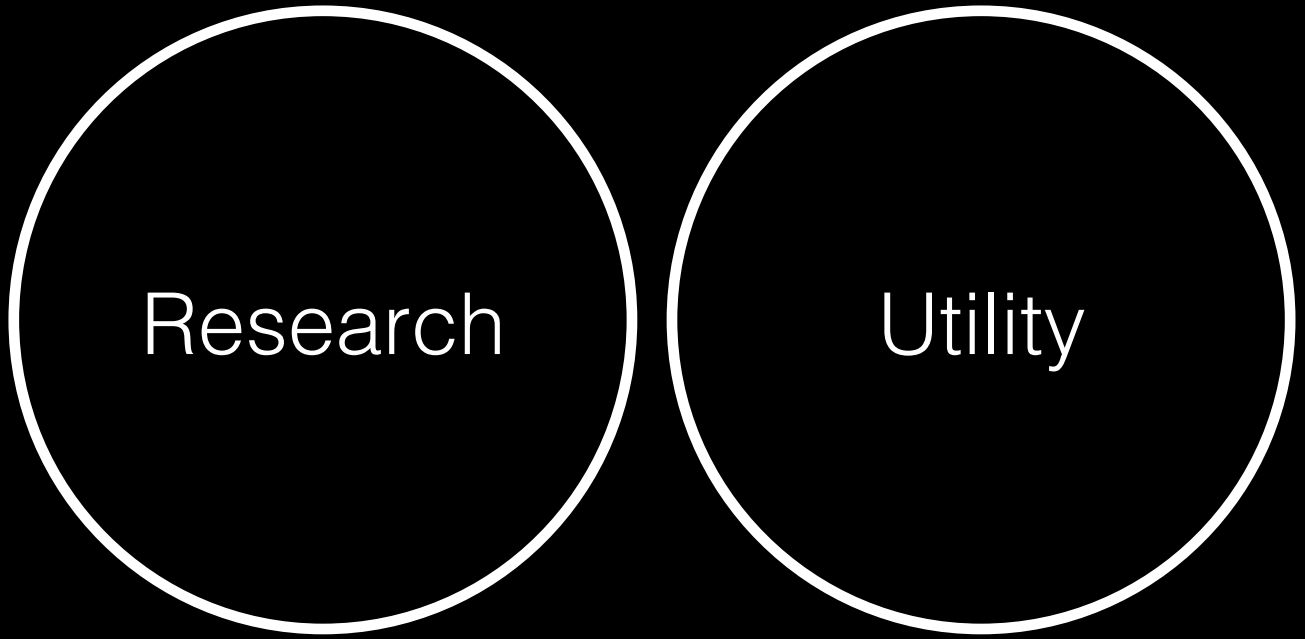
Elemental Excelerator

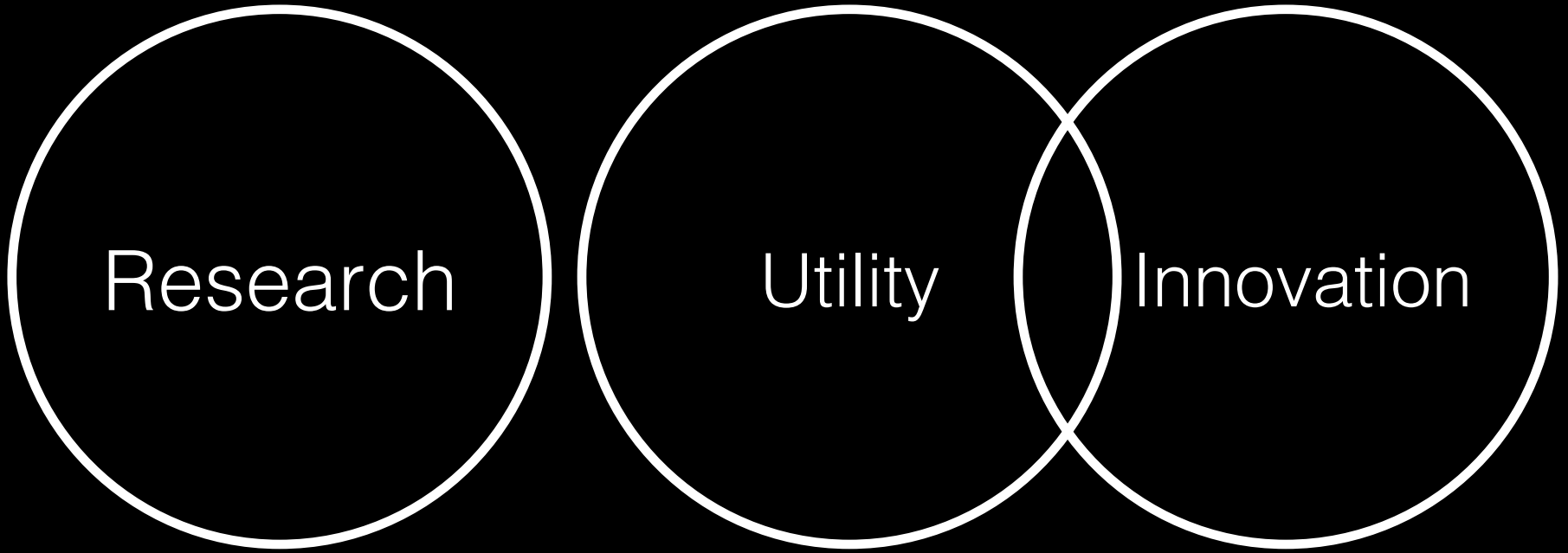
63 portfolio companies from around the world

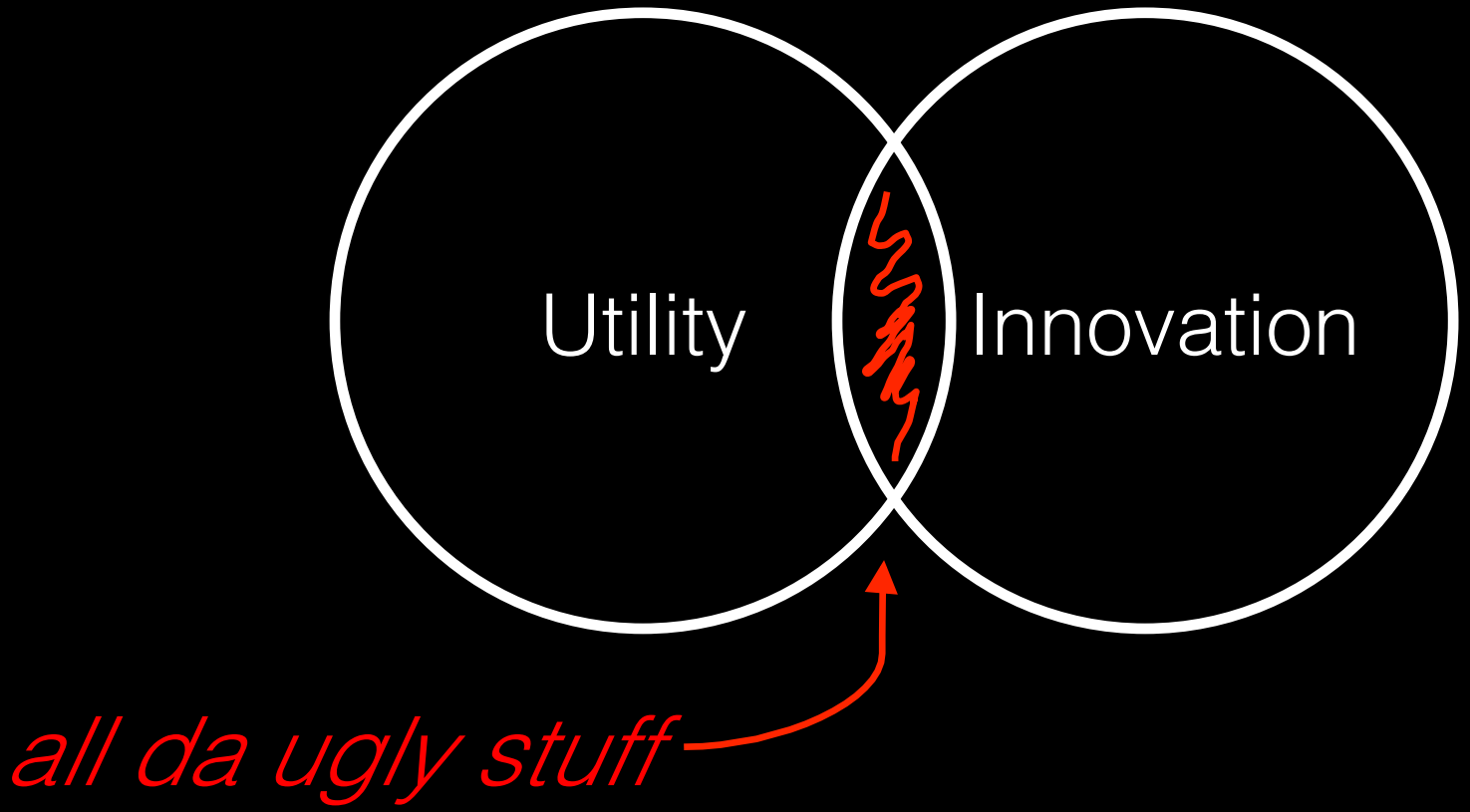


1. Open smartphone browser
2. Go to sift.ly
3. Enter participant code: ABLY

Research vs. Innovation


Research
Utility


Research
Utility
Innovation

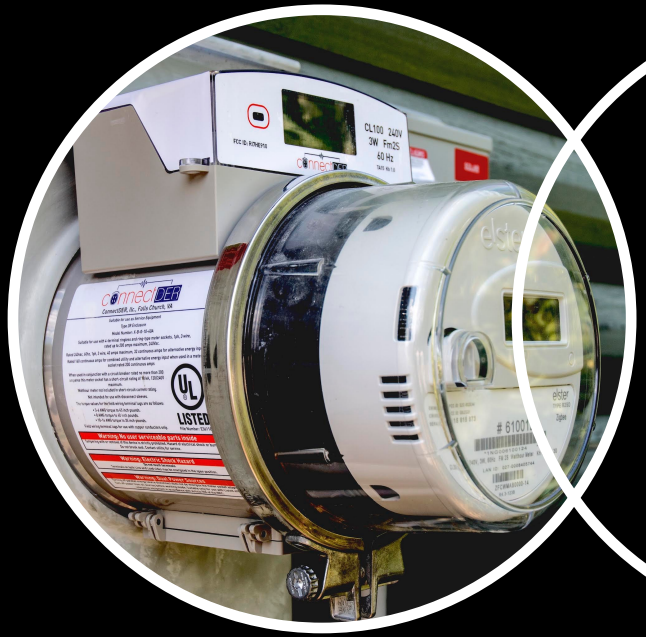

Utility
Innovation
all da ugly stuff

ConnectDER

6 units being tested

—

0 solar installers engaged



4+ units deployed

—

4 solar installers engaged

What We Gain From Innovation

Data

Team

Process

Developing Pathways to Scale

We asked 80 utilities and startups about their top ingredients for successful startup-utility partnerships.

Here are the results…

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Rank the top ingredients for a successful utility-startup project.

1 = most important
3 = least important

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Utilities say projects with startups work best when…

1. **Utility executive responsible for innovation**
2. Cross-cutting utility innovation team
3. Utility operations team engaged in pilot

Startups say utility projects work best when…

1. Clear process for collaboration
2. Clear articulation of utility pain points
3. **Utility executive responsible for innovation**

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What is the most important characteristic of a startup wanting to work with the utility?

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Utilities rank characteristics of startups to work with utilities

1. Road to a clear business case
2. Partnership with a larger entity for implementation
3. Nimble planning tools

Startups rank characteristics they need to work w/utilities

1. Road to a clear business case
2. Tested by other utilities
3. Partnership with a larger entity for implementation

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1) Ask utilities: how much $ goes to research vs. innovation?

2) Ask utilities: what happens when a pilot is successful?

3) Grab coffee with 3 entrepreneurs who work with utilities.

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1) Ask utilities: how much $ goes to research vs. innovation?

2) Ask utilities: what happens when a pilot is successful?

3) Grab coffee with 3 entrepreneurs who work with utilities.
   Cost: $15

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BRAEMAR
ENERGY VENTURES

Jiong Ma, Senior Partner

Infrastructure, Innovation and Investment

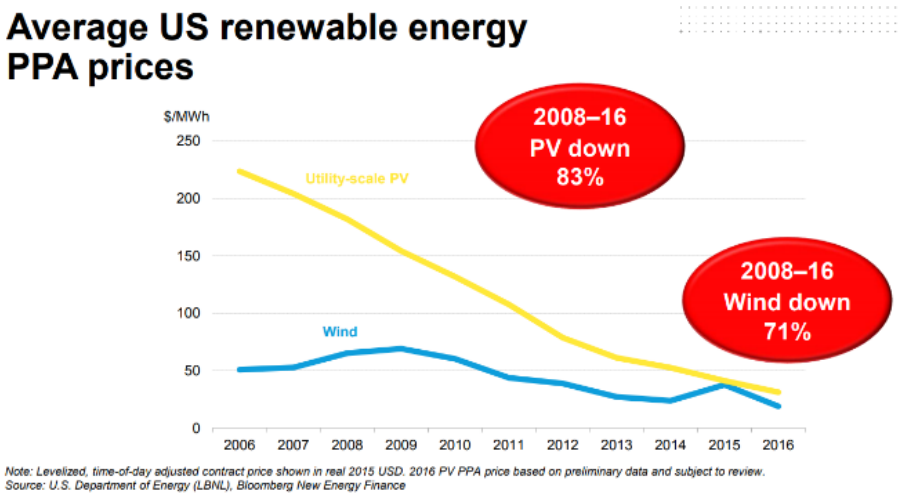
NARUC 129th Annual Meeting and Education Conference

Energy Infrastructure Market Experiencing a Paradigm Shift Across Multiple Fronts

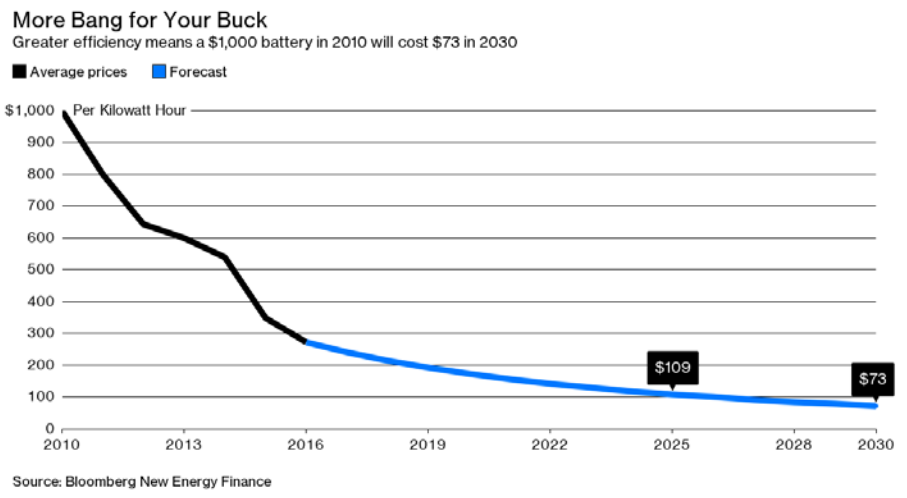
1 New Energy Technologies Continuing the Cost Decline

Cost of deploying new energy technologies – wind, solar, batteries – is declining at a faster rate than what many have predicted, thanks to both increased production scale and continued innovation

U.S. Avg Wind and PV PPA Prices



Li-ion Battery Pack Cost Predictions

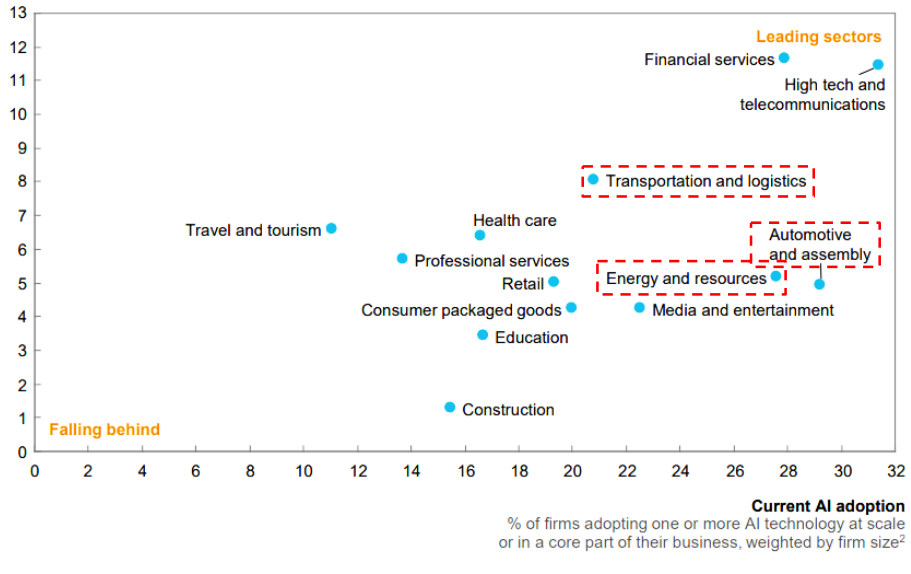


Source: Bloomberg New Energy Finance, 2017

2 Data Intelligence Has Potential to Further Improve Asset Value

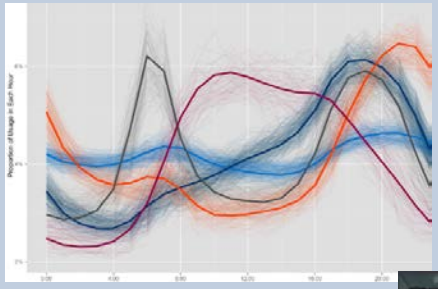
Energy, Auto, Industrial Sectors on AI Forefront

Future AI demand trajectory[1]
Average estimated % change in AI spending, next 3 years, weighted by firm size[2]



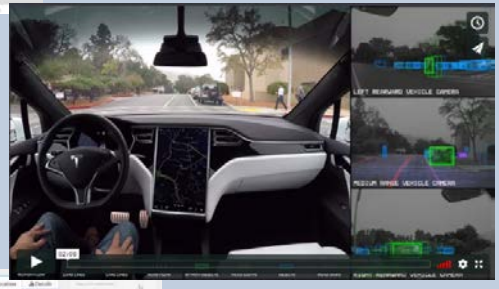
Current AI adoption
% of firms adopting one or more AI technology at scale or in a core part of their business, weighted by firm size[2]

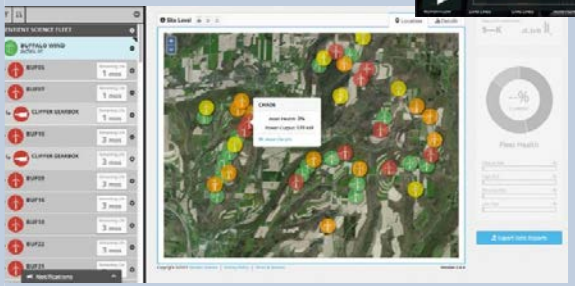
1 Based on midpoint of the range selected by survey respondent
2 Results weighted by firm size



Utilities use statistical clustering to identify customer archetypes

Auto companies use neural networks to push autonomous driving technologies





Asset operators use equipment life prediction and condition-based O&M algorithms

Source: McKinsey Global Institute, 2017

3 Shared Economy Dramatically Changing Asset Ownership and Utilization

Example in the Auto Sector

Shared

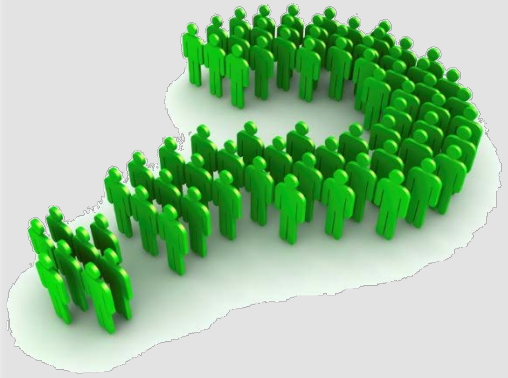
- Shared mobility goes beyond on-demand taxis
- … with emergence of **shared OEM-owned fleet**, **p2p car sharing** catering to longer trips

Connected

- On-demand mobility created the first layer of **location-based awareness**
- Spreading across **after-market segments** (remotely-controlled charging and servicing) and adjacent consumer segments

Fit-for-purpose

- **New transport solutions specializing** in long-haul vs. last-mile solo commute vs. group trip, roundtrip vs. pick-up/drop-off
- Innovation also taking place in transport of goods (autonomous delivery, last-mile consolidation centers)

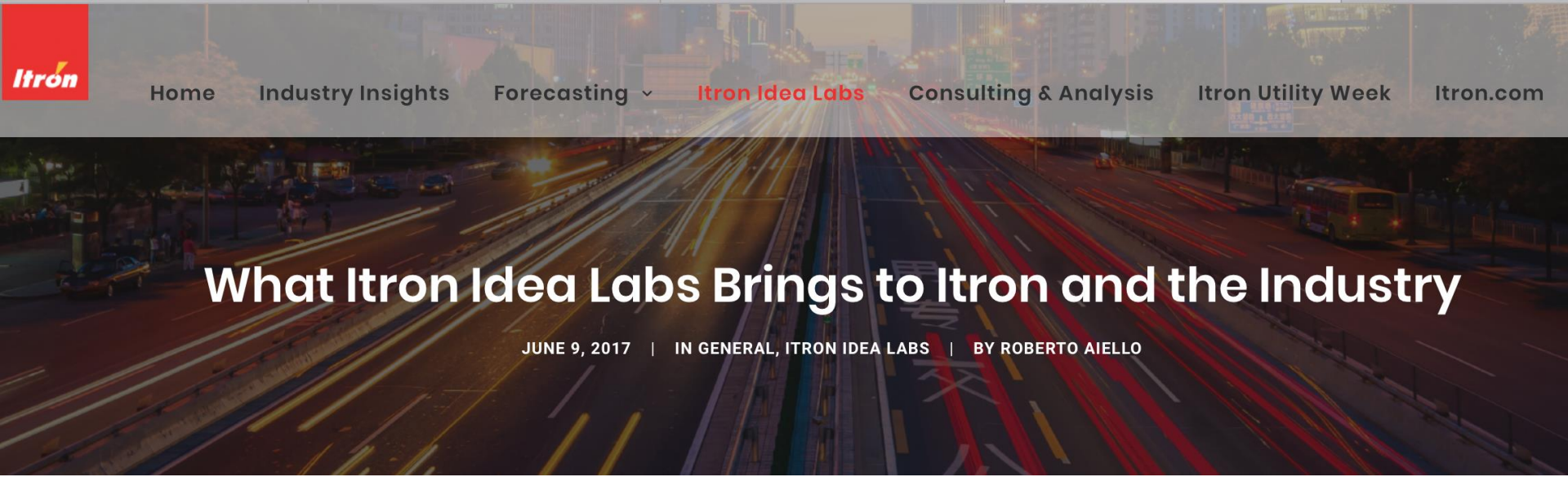


What should we take as learnings for the energy infrastructure sector?

Transformation Towards a More Connected and Consumer-Focused Energy Market

Elena Vasconi, Acting Director

» November 2017



What Itron Idea Labs Brings to Itron and the Industry

JUNE 9, 2017 | IN GENERAL, ITRON IDEA LABS | BY ROBERTO AIELLO

"Itron Idea Labs' main goal is to create **disruptive innovation**. We start with a **business idea**, **validate the business model with a customer**, validate the technology, transition it to a **business unit**."

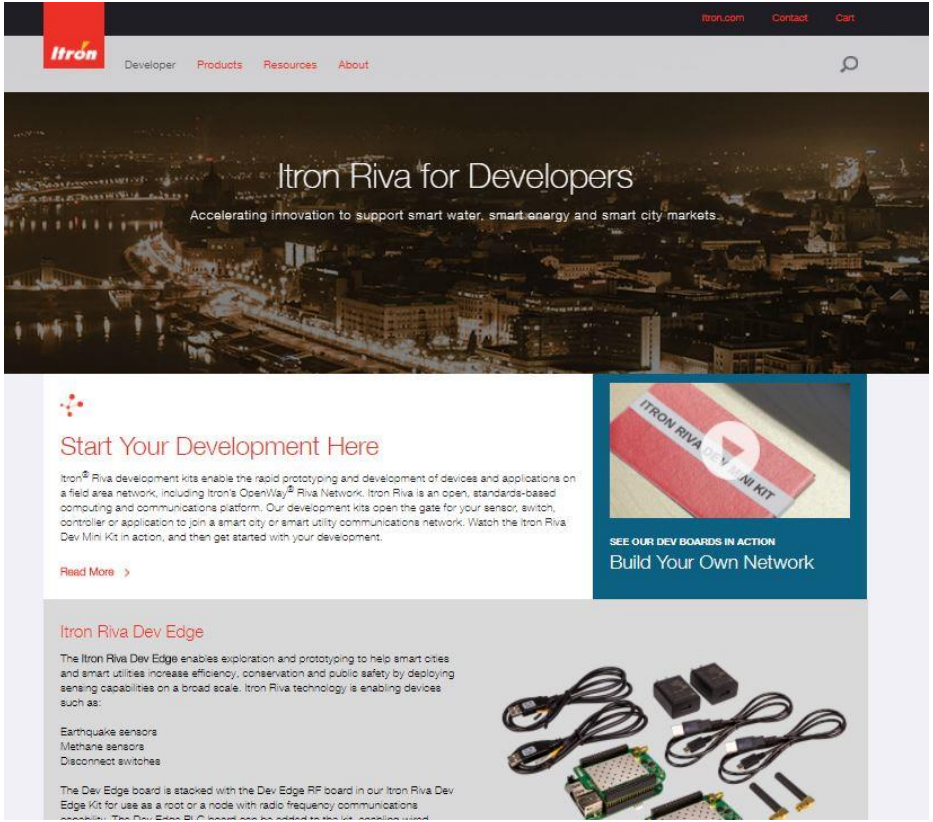
CROWD SOURCING IDEAS

- www.itronriva.com
- Developer kits, SDKs, videos, documentation etc
- Mains-powered RF & PLC, battery-powered RF dev kits

Riva LE

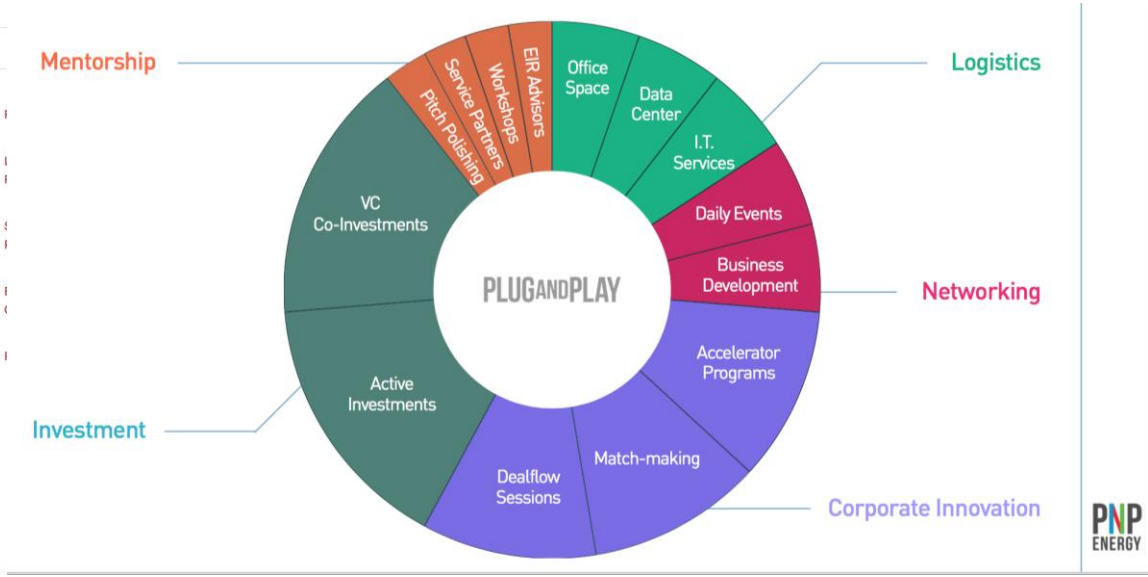
Riva Edge

Riva Mini



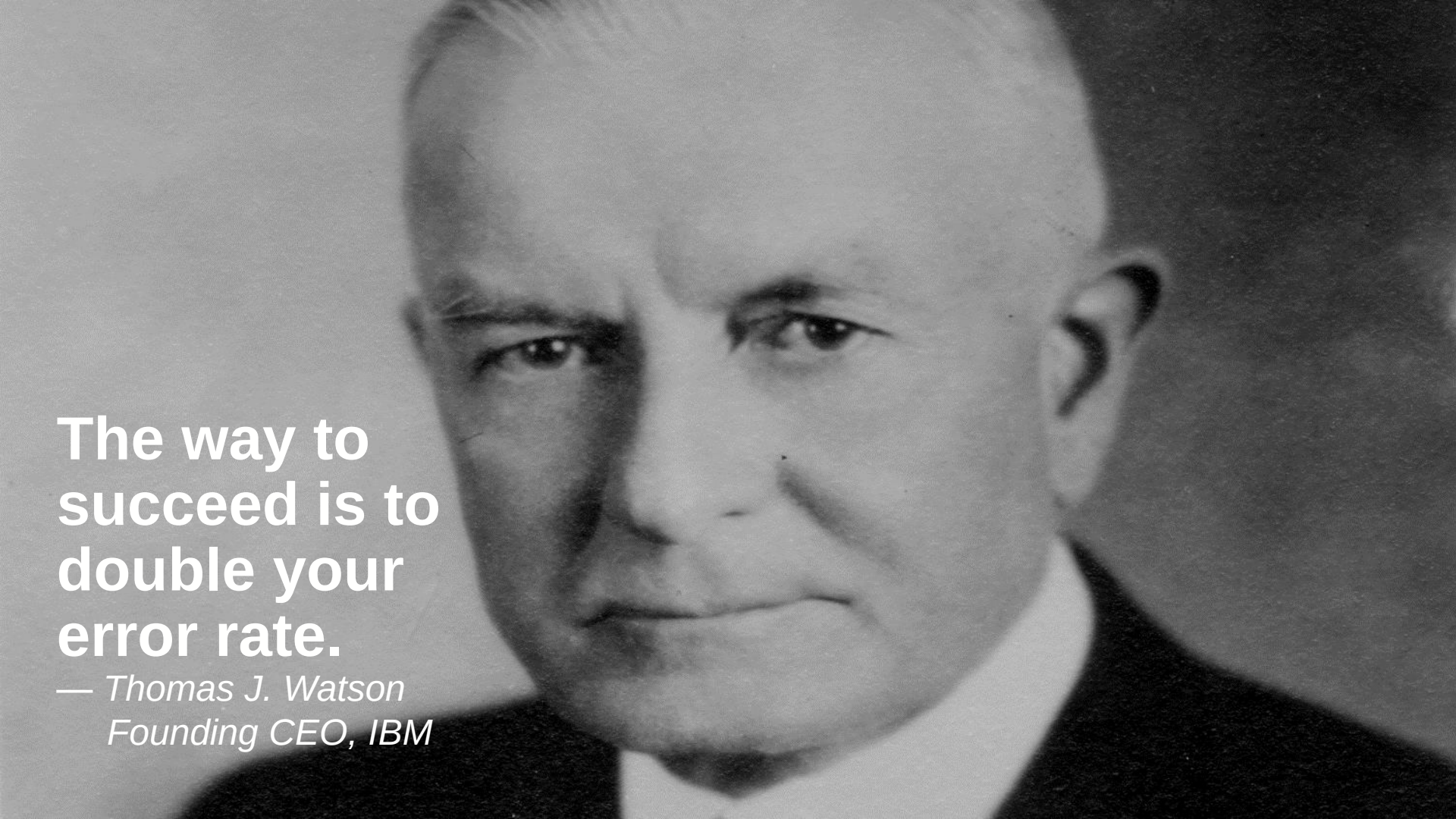
MINING THE START UP ECOSYSTEM

Investing in the Energy Vertical

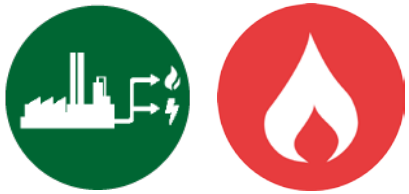
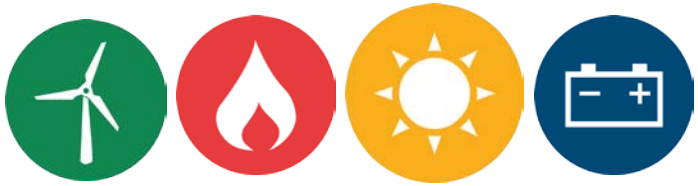


Itron idea labs

GETTING IDEAS TO MARKET


The way to succeed is to double your error rate.
— Thomas J. Watson
Founding CEO, IBM

Growth through Evolution

1976 - 1978	BECHTEL	
1980 - 1985	FLUOR®	
1985 - 1990	INDECK®	
1991 - 2001	skygen	
2001 - Today	Invenergy	

Early 1900s
Powering American Industry

1950s
Manhattan Project

1970s
Energy Crisis

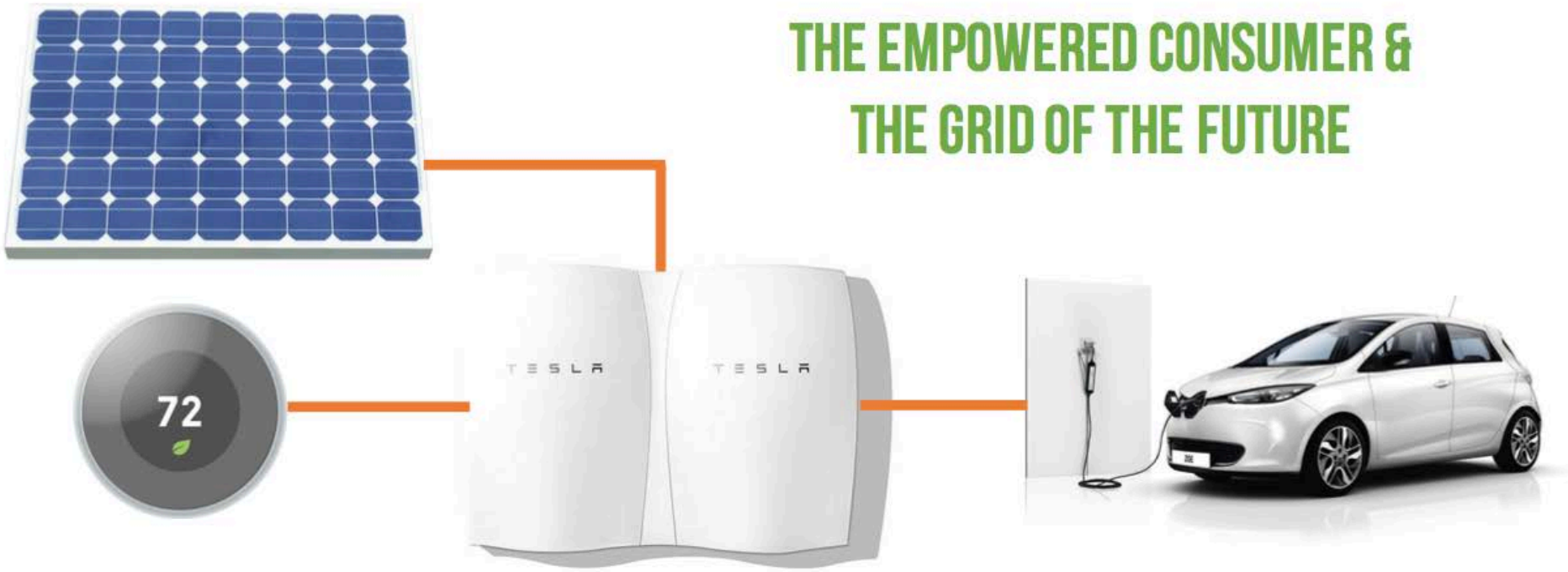

2000s
September 11th

PAST

FUTURE


Defending the Past

THE EMPOWERED CONSUMER & THE GRID OF THE FUTURE



Invenergy

The Future for Coal Power Is Very Limited

-AEP

Wind and solar represents nameplate MW capacity.

Source: Current Internal Integrated Resource Plans. Excludes impact of Wind Catcher. Reflects PSO's Integrated Resource Plan filed 11/1/17.

Actual additions depend on market conditions, regulatory approval, customer demand and other external factors.

AMERICAN ELECTRIC POWER

Towards A Forward-Looking Regulatory Culture