Reinventing the Electricity Sector

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Seattle City Light Utility of the Future Discussion, July 30th, 2015

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Rocky Mountain Institute works across industries on challenging energy issues to drive the efficient and restorative use of resources with market-based approaches

e-Lab
Electricity Innovation Lab
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e-Lab brings together leading electricity sector actors to solve regulatory, business, and economic barriers to the economic deployment of distributed resources

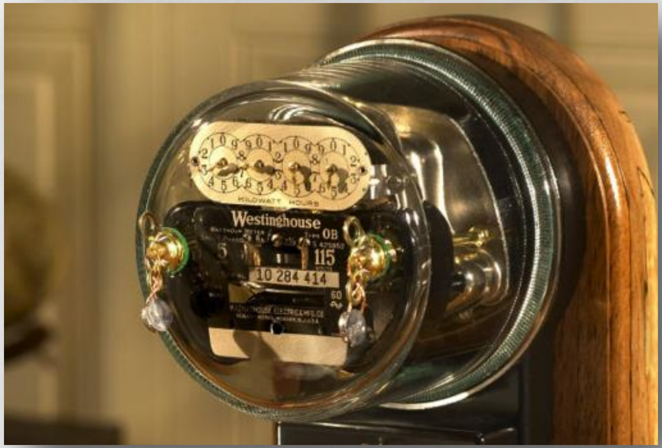
RMI transforms global energy use to create a clean, properous, and secure future.

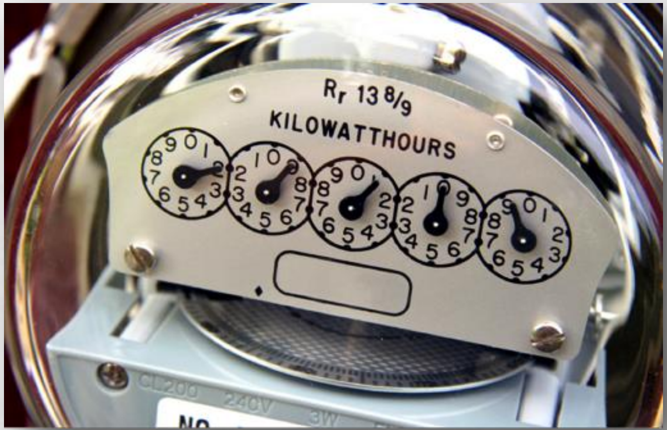
Agenda

1. There's been a lot of transformation lately
2. Trends to help us read the tea leaves
3. Transformation can happen fast
4. Reporting from the front lines
5. Navigating to the future is not simple

Technology has fundamentally transformed the way we live, work, and communicate

But it has not [yet] impacted the electricity sector as fully





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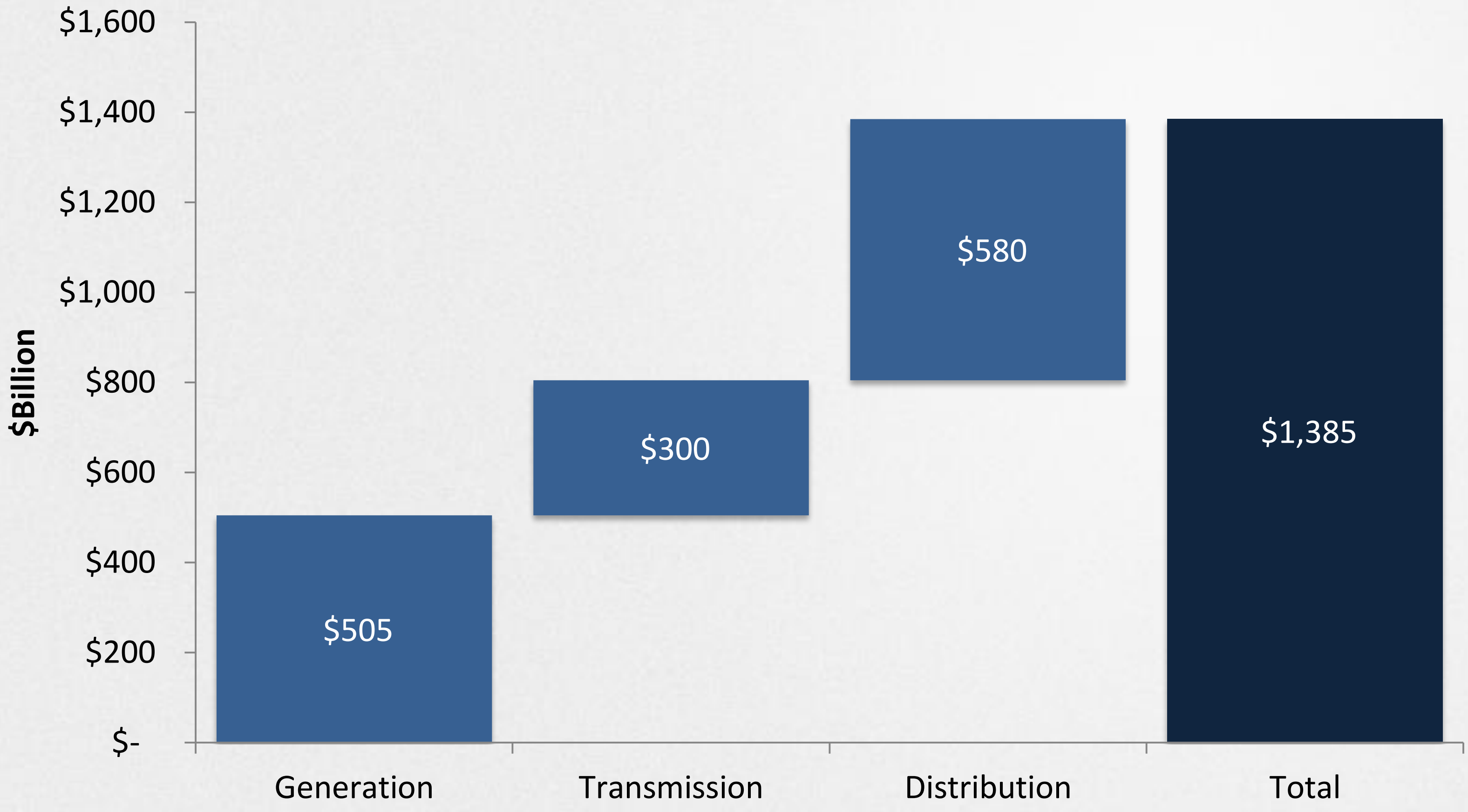
Trends to help us read the tea leaves

"Truths" of the historical electric system may no longer hold in their entirety…creating challenges but also opportunity

- ✓ CERTAINTY OF INCREASING DEMAND
- ✓ BIGGER IS BETTER: ECONOMIES OF SCALE
- ✓ UNI-DIRECTIONAL POWER & INFO
- ✓ NATURAL MONOPOLY
- ✓ DISENGAGED CUSTOMERS

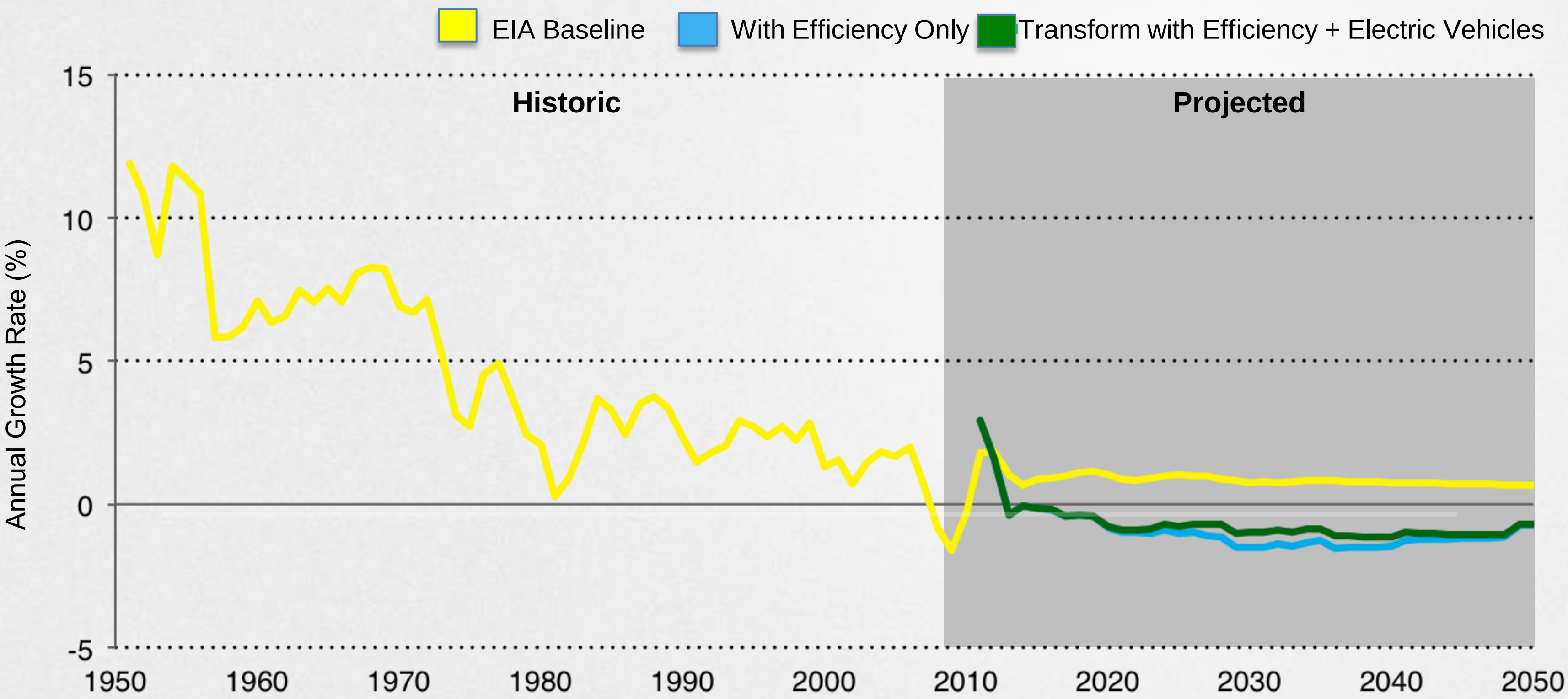
The U.S. may invest up to $1.4 trillion in the electricity sector in the next 15 years



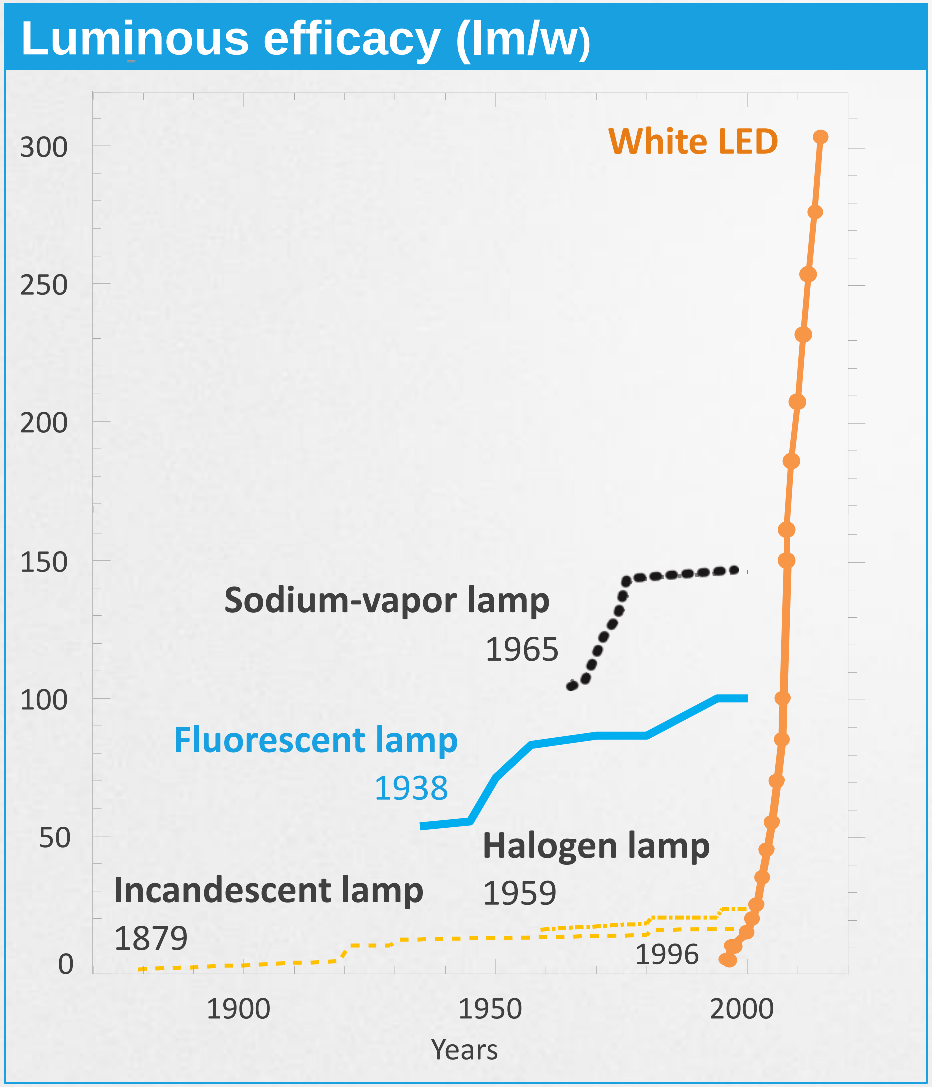
Source: DOE QER 2015; EEI

Demand may flatten or decline

Annual changes in U.S. electricity consumption, Reinventing Fire analysis



LEDs alone could shave up to 10% of US electricity use



U.S. buildings are becoming much more efficient

3-4x energy productivity worth 4x its cost

~277→173 (–38%)
2010 retrofit

284→85 (–70%)
2013 retrofit

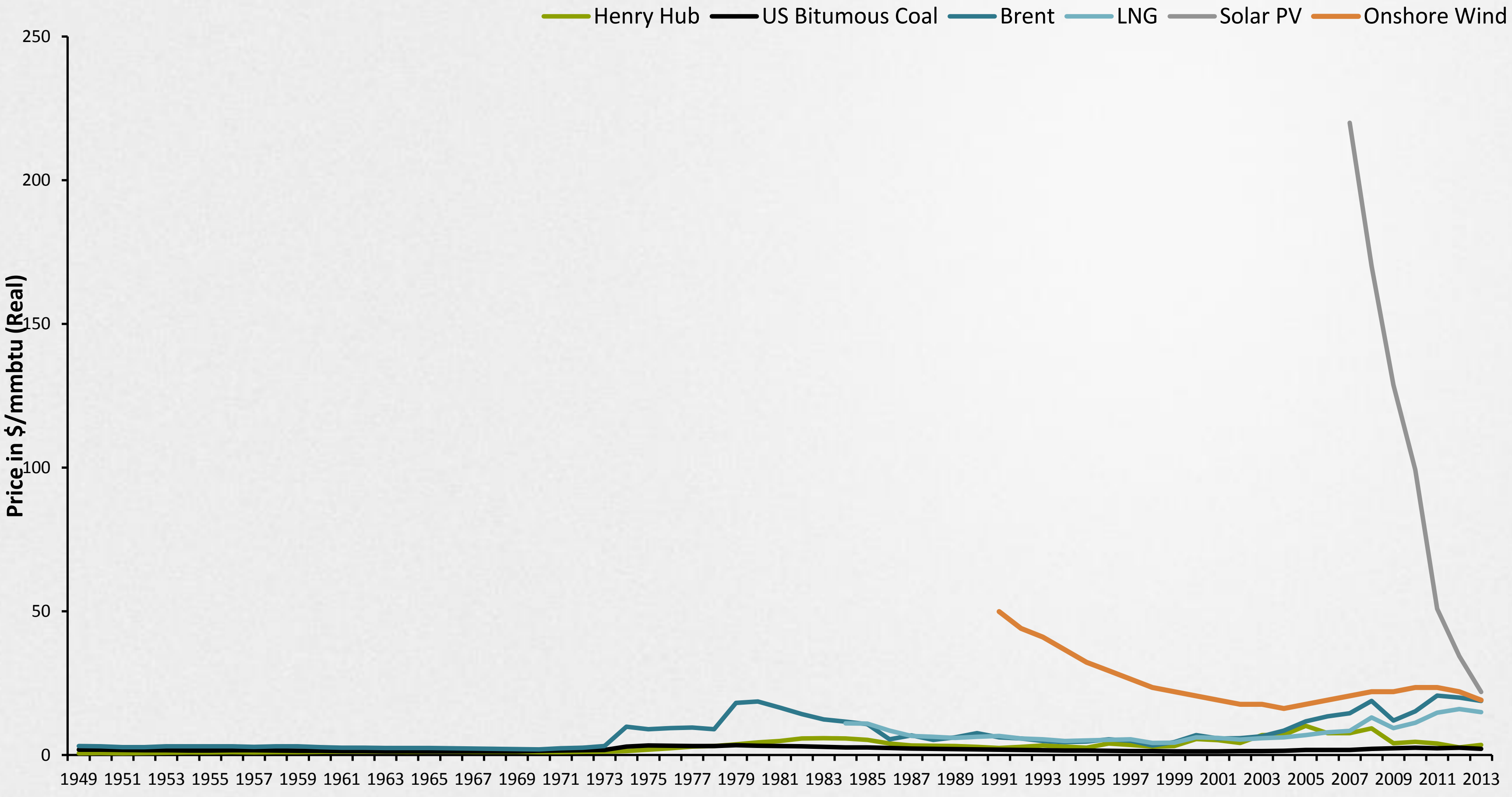
...→108 (–63%)
2010–11 new

...→≤50 (–83% to –85%)
2015 new

Site energy intensities in KWH/M2-Y; U.S. office median~293

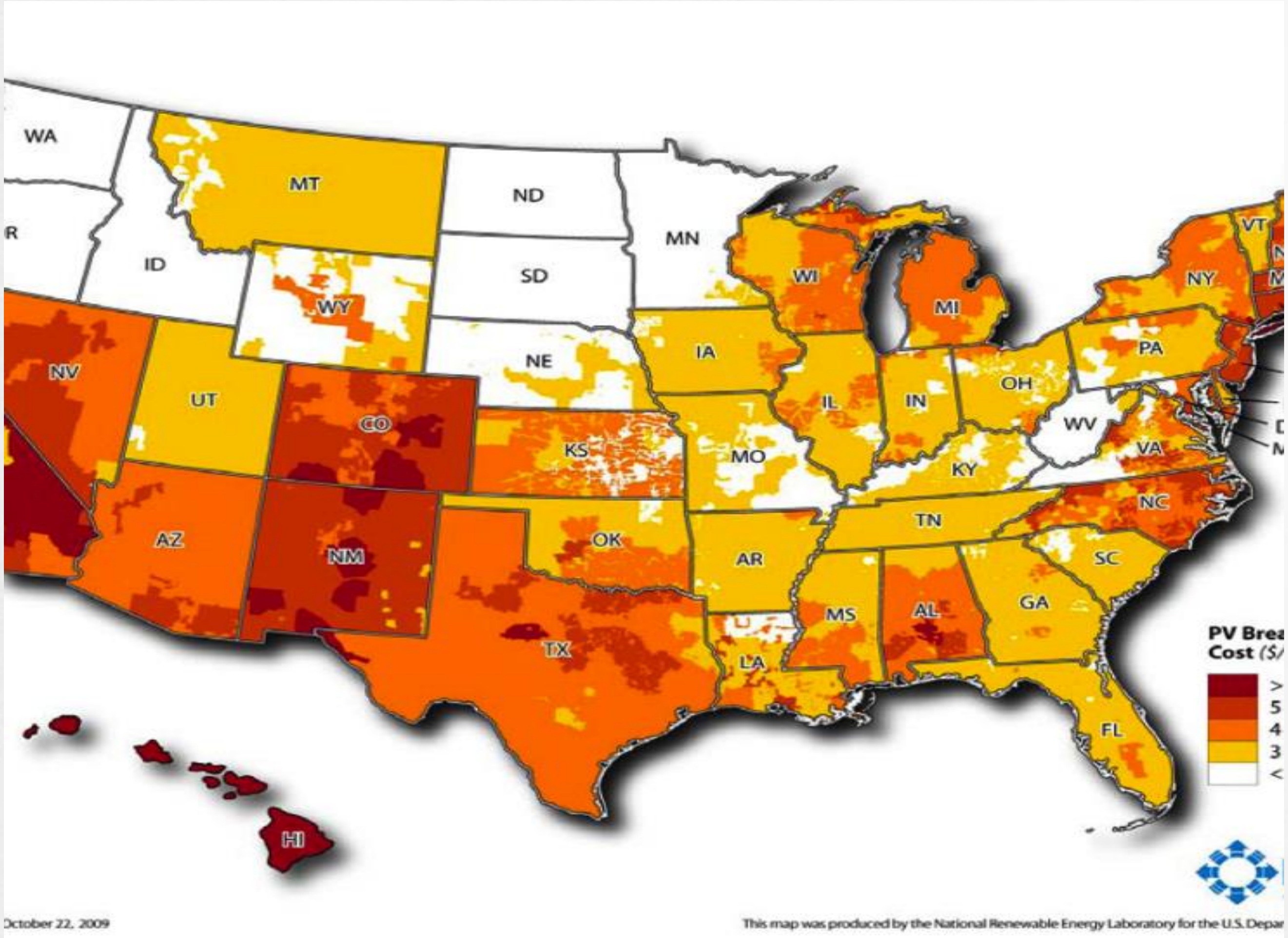
The price of solar continues to fall

Historical price of electricity by source (unsubsidized renewables)



Source: EIA, CIA, Bloomberg, Bernstein analysis and estimates

Meaning it may soon be cost competitive in much of the country

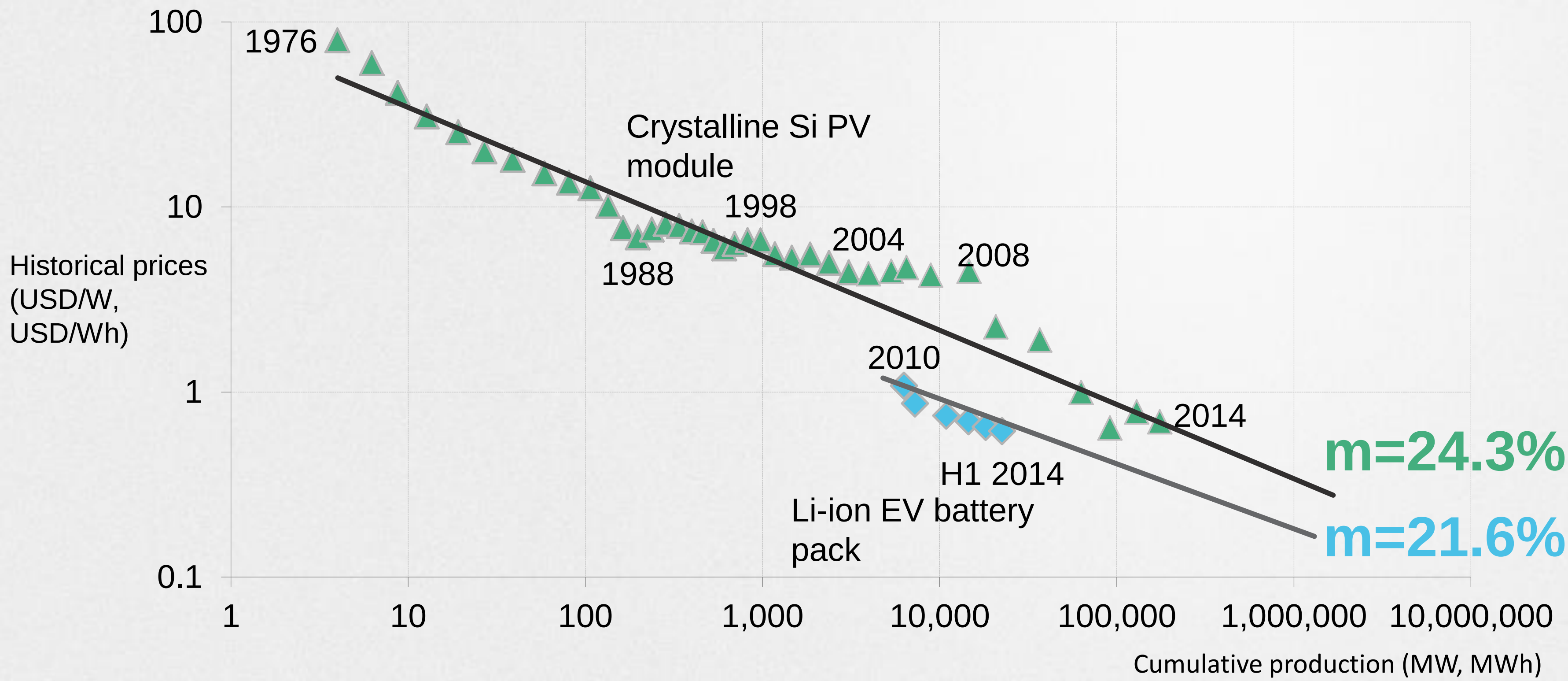


ure 6. Residential solar PV break-even cost ($/W) in 2015 using the base-cas
assumptions in Table 1 and the most common rate structure

For reference:

Austin Energy RFP from April 2015 yielded 1.2 GW of PV for under $0.04/kWh

Falling PV costs follow the experience curve, and batteries show signs of the same



Innovations starting to stick

More efficiency by connecting devices

$100

Automated email if no more ink

$10,000

No email if filter must be changed

Microgrids to drive resilience

Rocky Mountain Institute®

RMI OUTLET

plug into new ideas

JUL 11, 2013

8 COMMENTS

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Preparing for the Zombie Apocalypse: Are Microgrids Our Only Chance?

Like 189 Tweet 73

The electricity industry's been abuzz recently about the need for a more resilient grid. As a result, microgrids are quickly becoming the industry's topic *du jour*—in fact, they're the theme of the current July/August issue of IEEE's *Power & Energy* magazine. However, nobody is talking about what is likely the most compelling reason to invest in microgrids: *to prepare for the zombie apocalypse*.

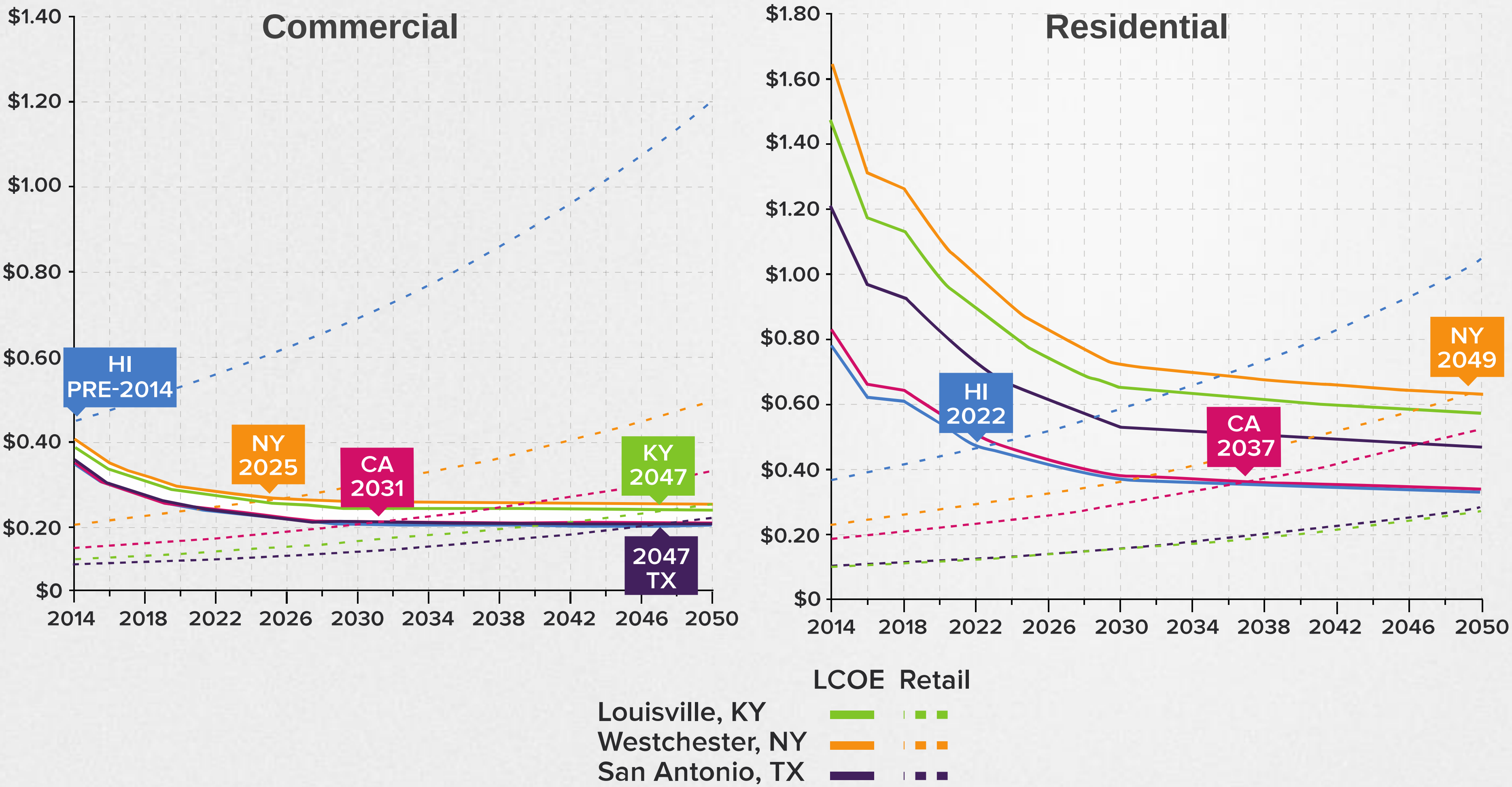
Scoff at your own peril, but consider this: *Doomsday Preppers*—a reality TV show about families who stock up on non-perishable food, ammunition, fuel,

The shift will continue

Trends pushing down the cost of solar, other renewables and energy efficiency	Examples
Increasing technical innovation	• New battery chemistries • New solar PV technologies
Synergistic solutions increasing the value of renewables	• Solar PV + battery storage • IT and storage for peak shaving
Data and internet of things increasing integration	• Sensors • Predictive software • Demand response automation
Innovative business models increasing customer bases	• No up front costs • Funnel analysis • Value beyond energy
Innovative financing reducing cost of capital	• Third-party financing • Green bonds • YieldCos

And even more disruptive change is always possible…although not necessarily desirable

RMI "Grid Defection" analysis



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Transformation can happen fast

Easter Parades on Fifth Avenue, New York 13 years apart

1900: where's the first car?

1913: where's the last horse?

Images: L, National Archive, www.archives.gov/research/american-cities/images/american-cities-101.jpg; R, shorpy.com/node/204.
Inspiration: Tona Seba's keynote lecture at AltCar, Santa Monica CA, 28 Oct 2014, http://tonyseba.com/keynote-at-altcar-expo-100-electric-transportation-100-solar-by-2030/

There are several different possible responses to these building trends

Combat

Wait and See

Embrace

The New York Public Service Commission's take on this

"Utilities, and this Commission, could respond to [the challenges facing the industry] by clinging to the traditional business model for as long as possible, relying on protective tariffs, regulatory delay, and other defenses against innovation.

Alternatively, we can identify and build regulatory, utility, and market models that create new value for consumers and support market entrants and this new form of intermodal competition—in other words, embrace the changes that are shaking the traditional system and turn them to New York's economic and environmental advantage.

We decisively take the latter approach."

—REV Regulatory Policy Order

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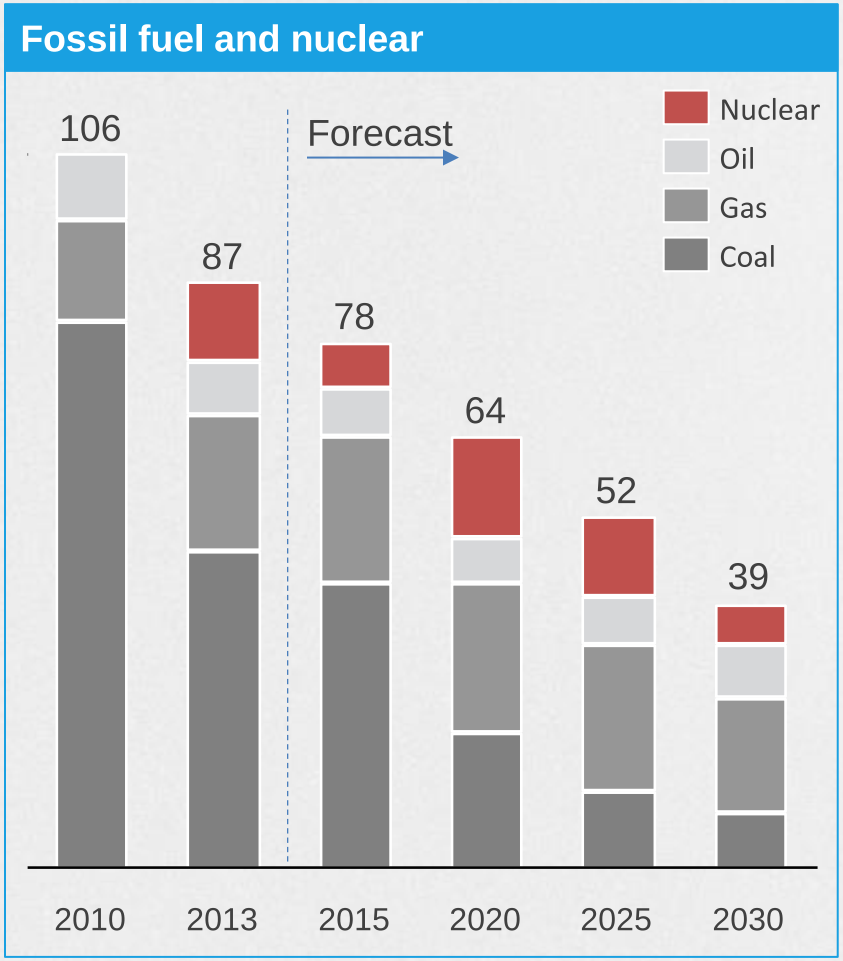
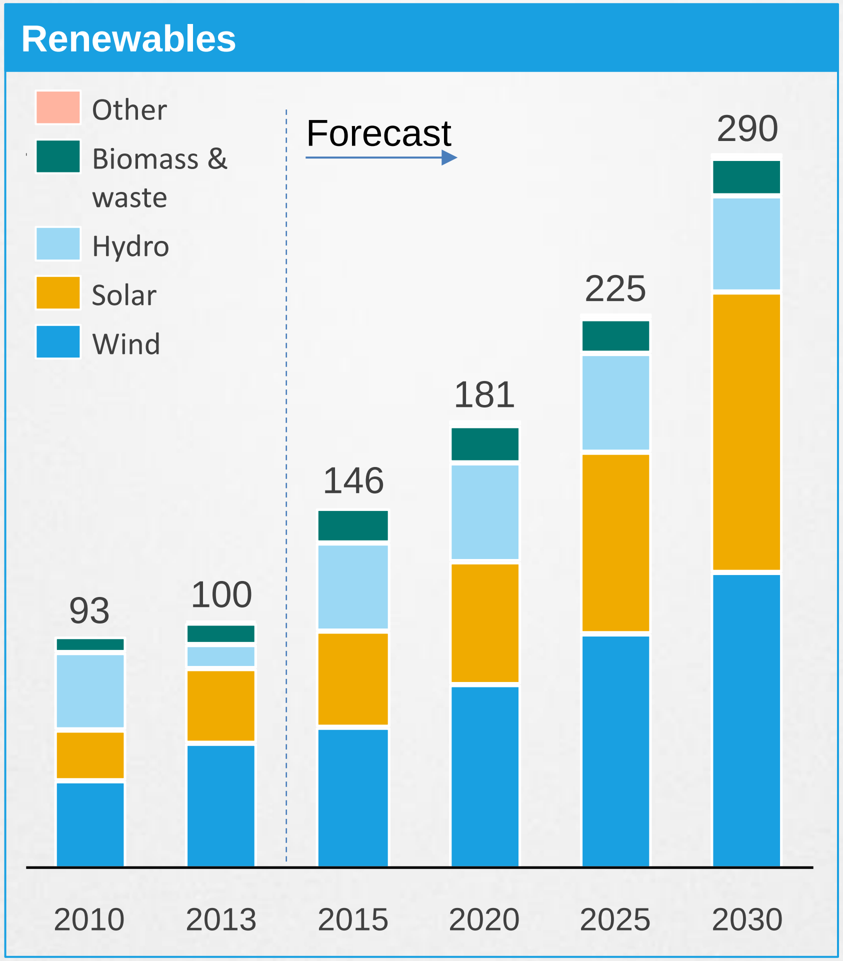
Reporting from the front lines

Globally: shifting make up of generation capacity additions

2010-2020 (GW)

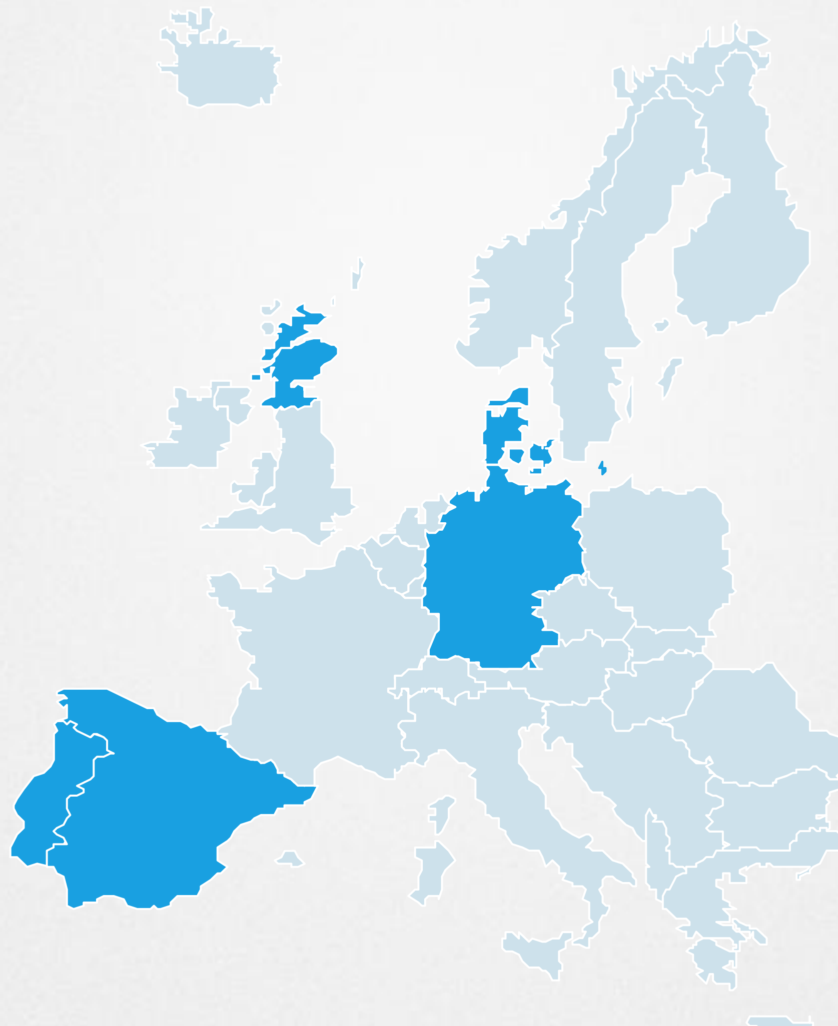




Source: Bloomberg New Energy Finance

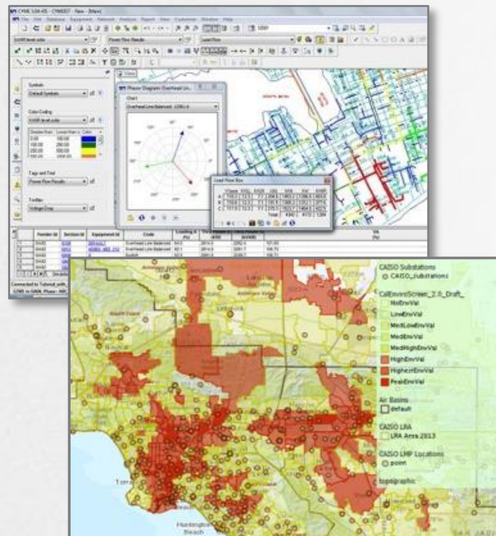
Europe: choreographing variable renewable generation

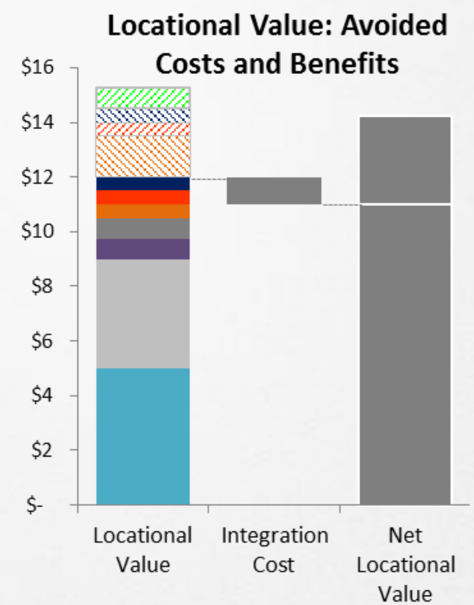
44%	**Scotland**
50%	**Denmark** (33% wind; 2013 windpower peak 136%-55% for all December)
25%	**Germany** (2013 peak 70%)
60%	**Portugal** (peak 100% in 2011; 70% for the whole first half of 2013, incl, 26% wind & 34% hydro; 17% in 2005)
42%	**Spain** (including 21% wind, 14% hydro, 5% solar)



California: planning & rate design

Identify Distribution Planning Areas → **Perform Planning Analyses** → **Calculate Locational Net Value**





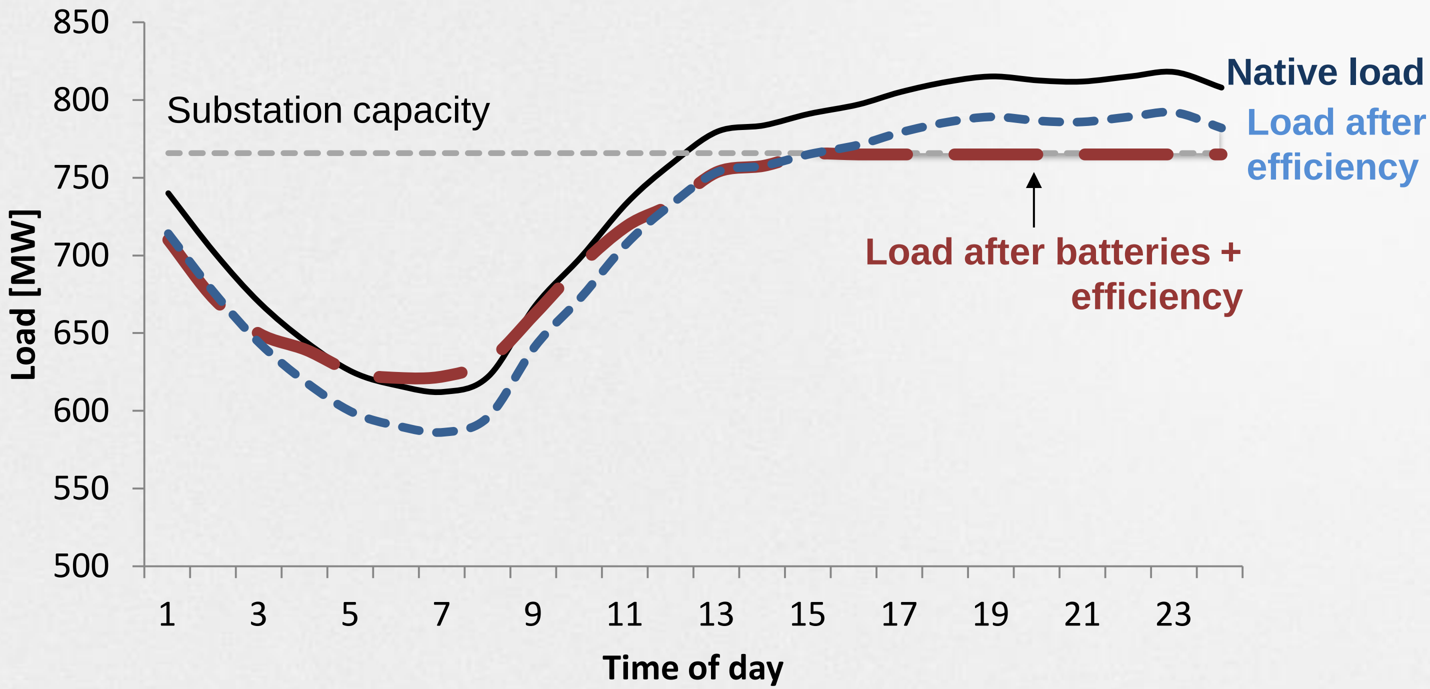
- Time-of-use rates, minimum bill
- Demonstration projects
- Valuing distributed resources

Source: MTS WG - SolarCity

New York: driving system efficiency

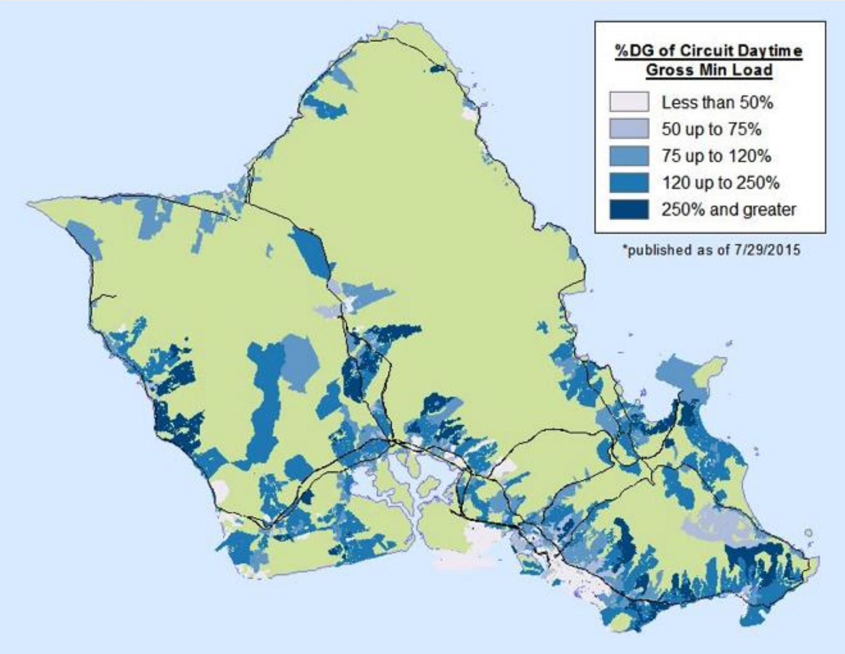
Reforming the Energy Vision (REV) proceeding

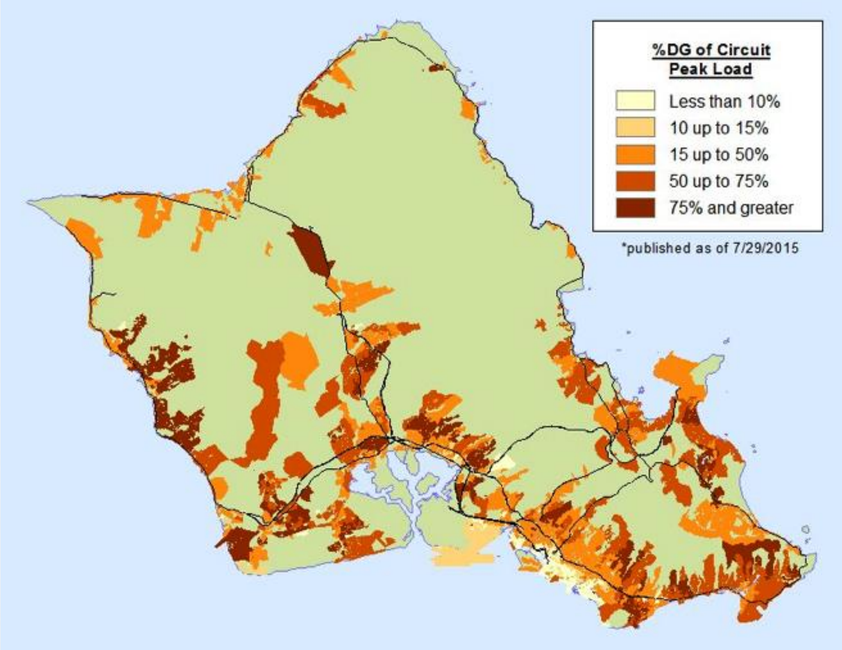
Example: Avoid a $700MM in substation upgrades in New York City by harnessing distributed batteries & energy efficiency



- Distributed system platform
- DER providers as partners and customers, not competitors
- New revenue sources and performance incentives

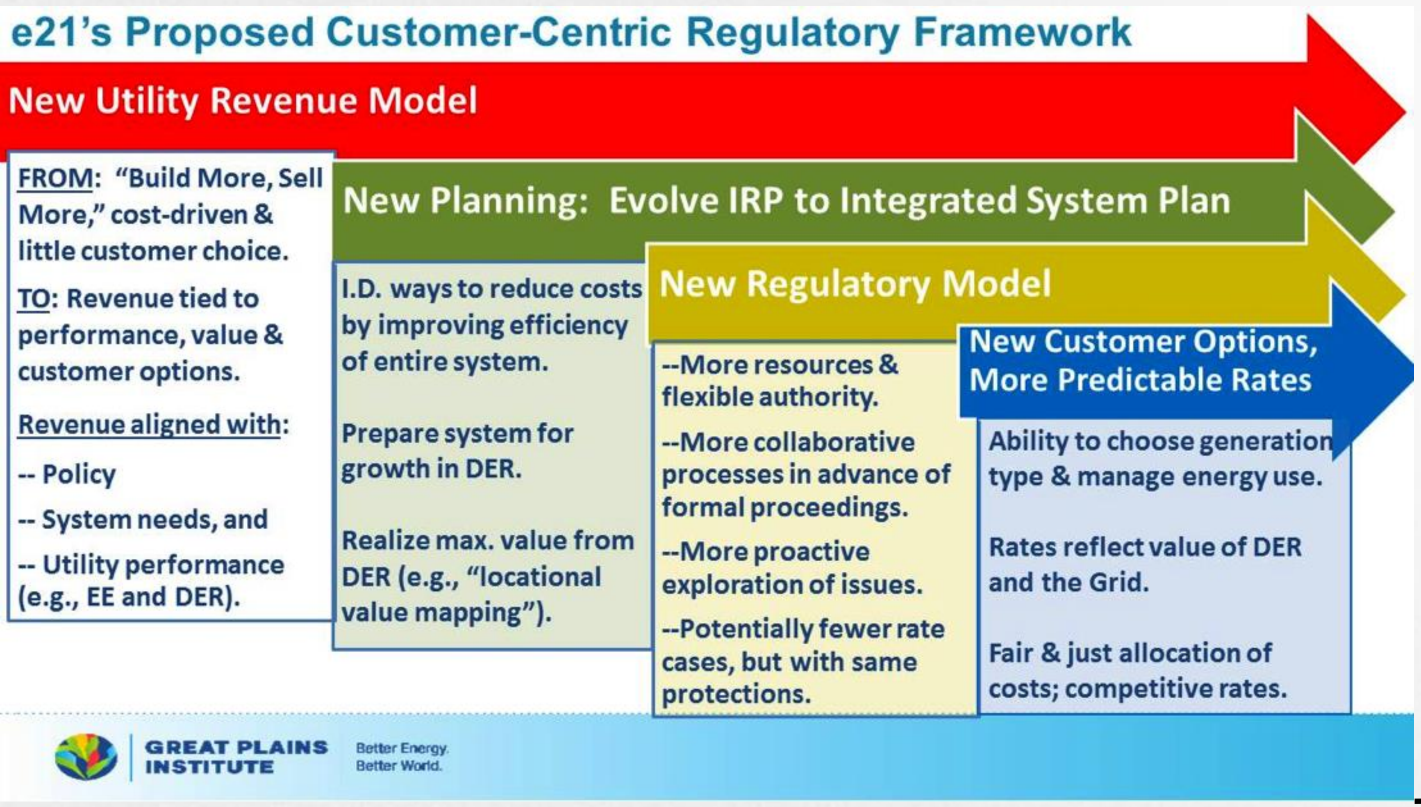
Hawaii: 100% renewables by 2045





- Reconsideration of net metering & rate design
- Role of smart inverters

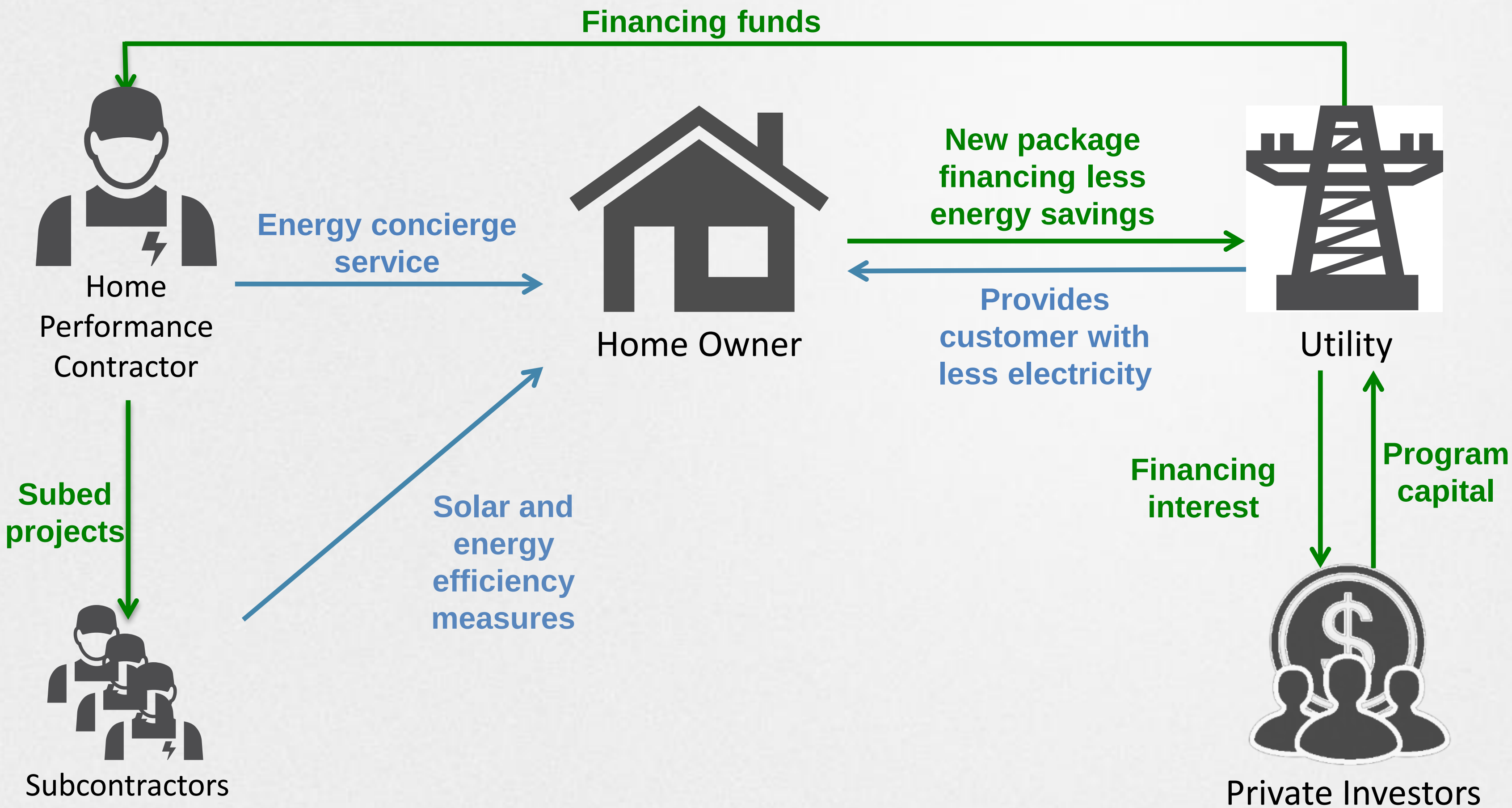
Minnesota: performance based regulation



- Performance-based regulation
- Integrated Resource Planning
- Rate reform

Fort Collins: the utility's role in a net zero electricity system

Integrated Utility Services (IUS) model



At the end of the day, these places are wrestling with many of the same questions

- What are the pathways along which the electricity system might evolve, and which are preferred?
- What is the real value of distributed resources, and what's the best way to reflect that in pricing and compensation mechanisms?
- How do you plan the electricity system when resources are increasingly outside the utility's control?
- How do you ensure reliability and efficient investment in that context?
- The system seems to be getting much more complex…what is the right balance of accuracy and simplicity?
- What is the role of the utility in enabling this future? (Hint—I think it's pretty important)
- How should the utility business model be reformulated to best align with customer and societal objectives? Should performance incentives be the icing on the donut, or the creamy filling?

5

Navigating the future is not simple

Lots of mixed messages and mental models: need to get the facts on the table

Wind, solar and other types of renewables will overtake coal (Fatih Birol, IEA)

If we use even 1/3 of known fossil fuels, global warming will be well above 2^{o}C

Without subsidies, renewables can soon compete with fossil-based electricity in much of the world

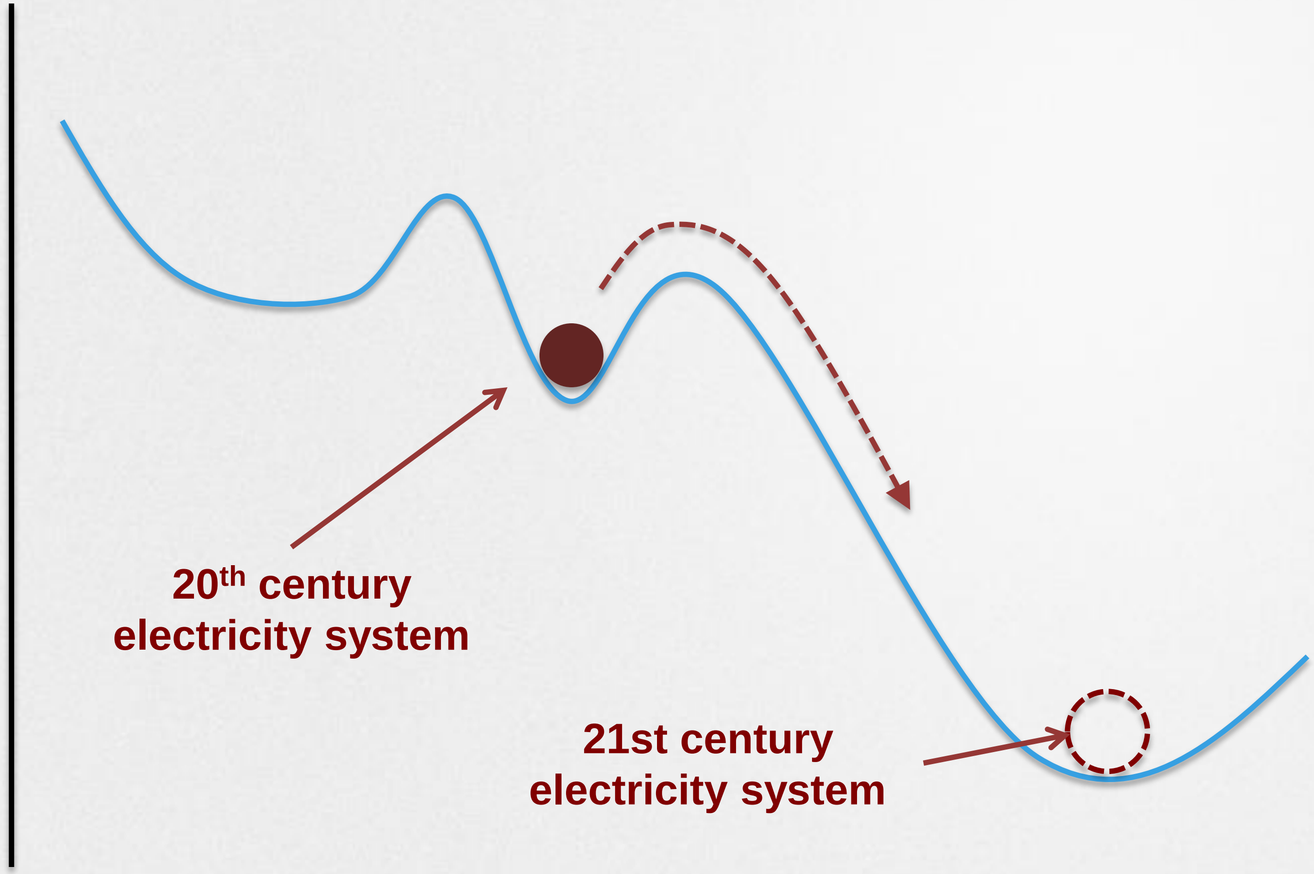
Two billion poor people around the world need coal-based energy for development

Renewables are still too expensive and batteries will never work

You cannot balance an electritity grid with mostly renewables

We have a physics problem

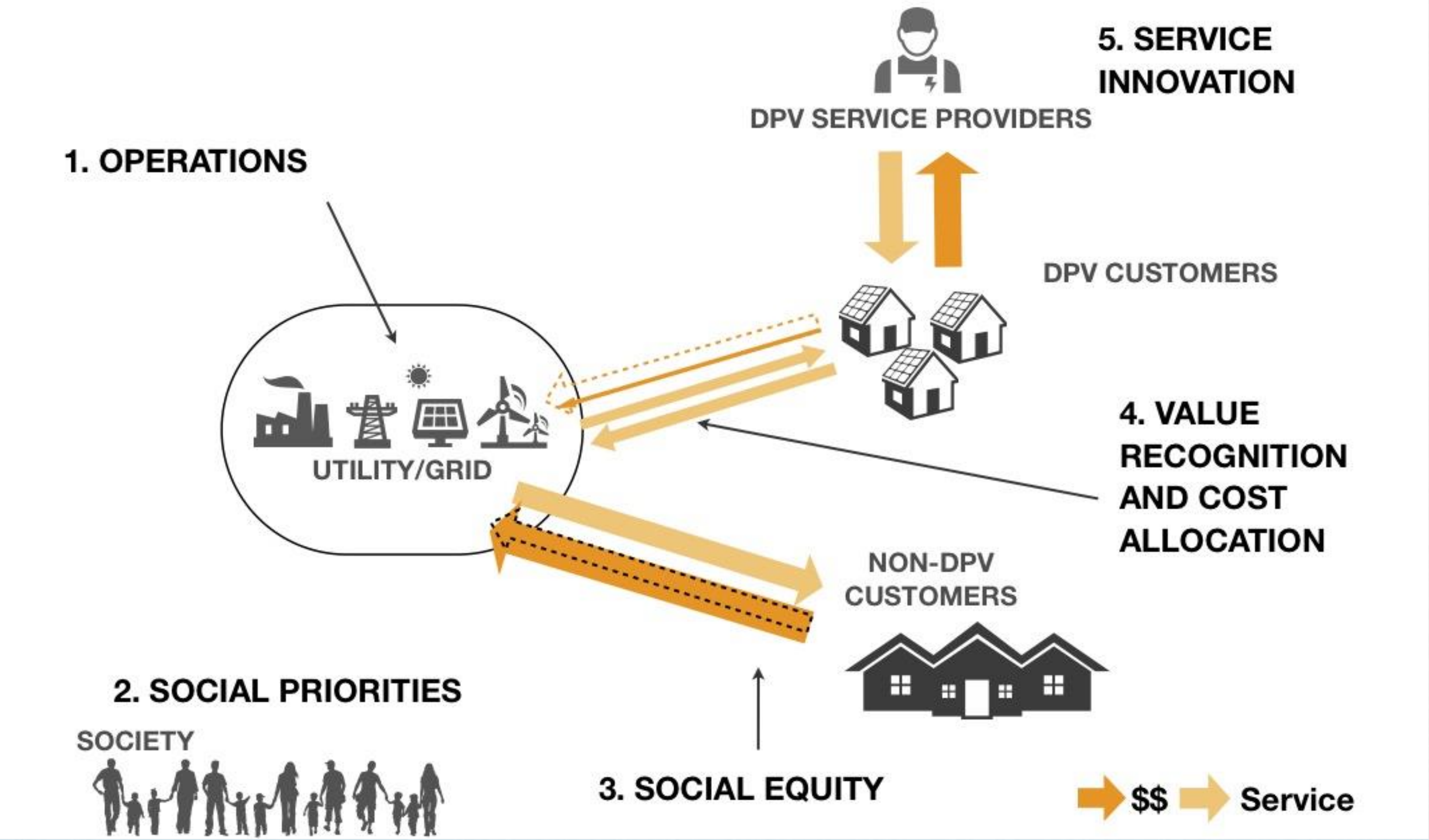
Reaching an new optimum will require significant energy



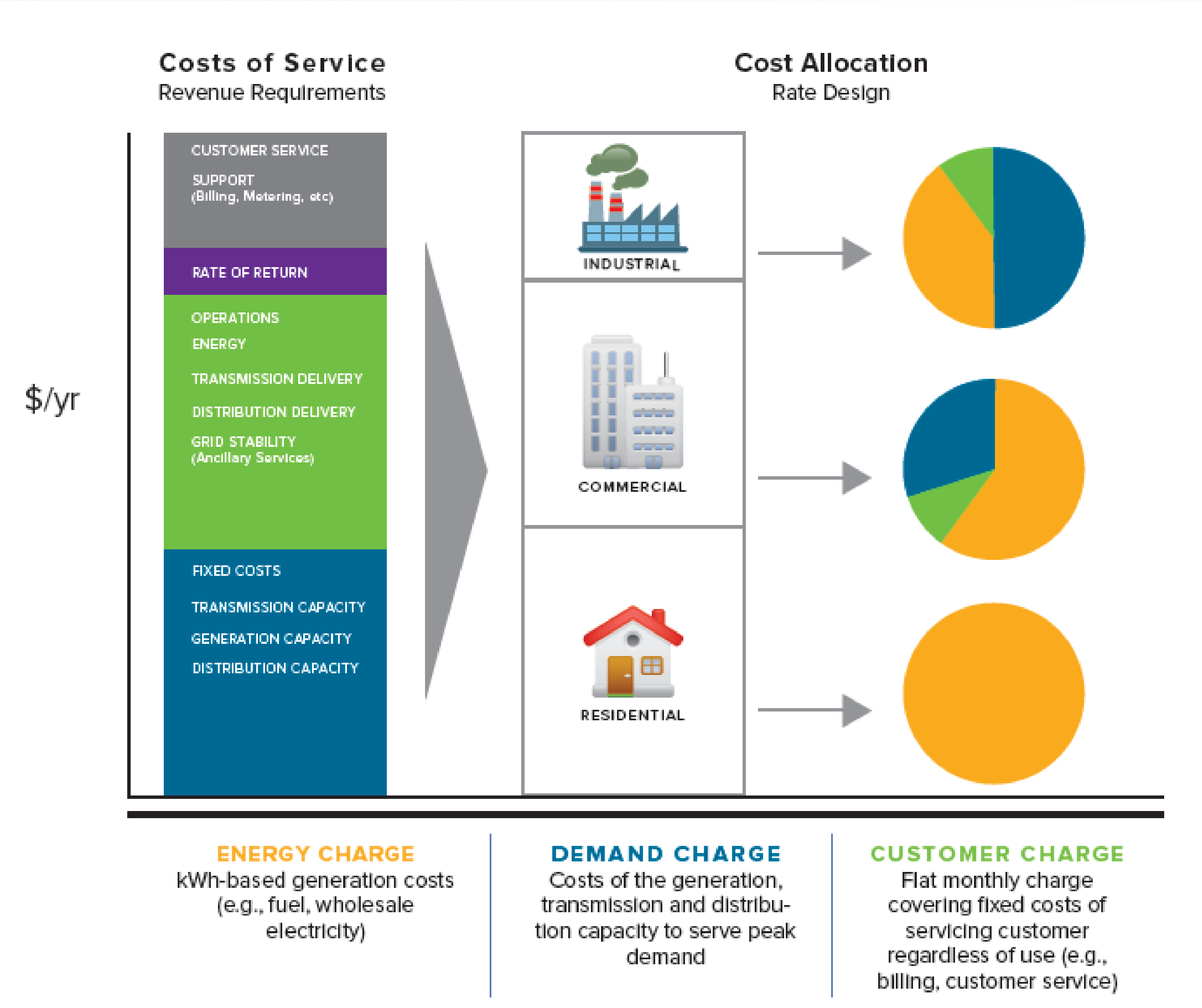
Why are we stuck in the current state?

STAKEHOLDER	MAJOR ROADBLOCKS	SIGNS OF HOPE
MASS MARKET CUSTOMERS	• Usually think about energy 5-10 minutes a year	• Nest, Opower, Tesla • Superstorm Sandy
LEGISLATORS	• Partisan by definition • Many conflicting priorities	• Hawaii • Green Tea Party
REGULATORS	• High turnover • Reactive rather than proactive • Risk averse	• REV Proceeding in NY • California, Minnesota
UTILITIES	• Many misaligned incentives • Hard to innovate in a reliability-driven world	• Lots

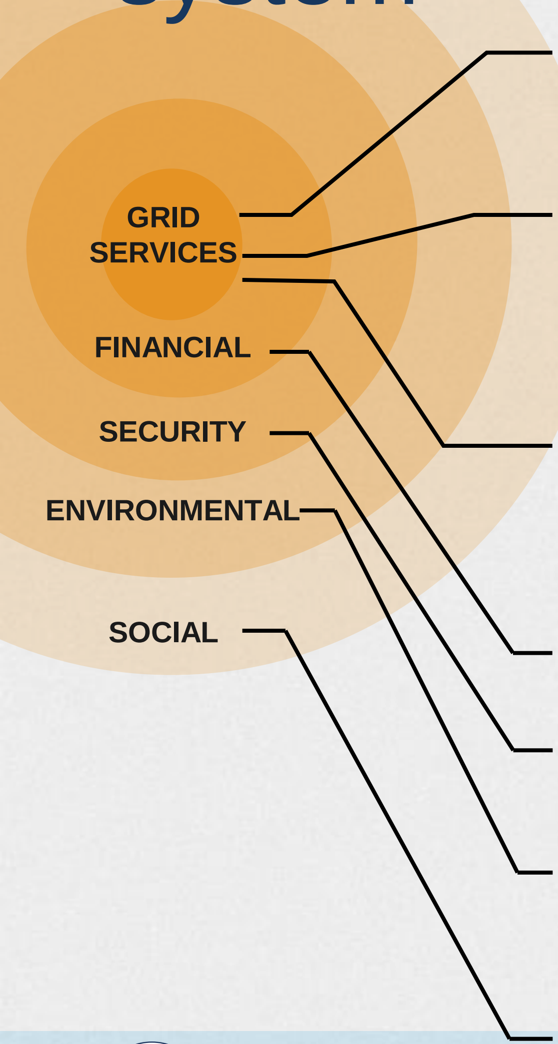
Models designed for an historically centralized system are misaligned with current trends



Typical rate design disguises the true marginal cost of service



There is a lack of clarity on the value that new technologies provide to the system



ENERGY
- energy
- system losses

CAPACITY
- generation capacity
- transmission & distribution capacity
- DPV installed capacity

GRID SUPPORT SERVICES
- reactive supply & voltage control
- regulation & frequency response
- energy & generator imbalance
- synchronized & supplemental operating reserves
- scheduling, forecasting, and system control & dispatch

FINANCIAL RISK
- fuel price hedge
- market price response

SECURITY RISK
- reliability & resilience

ENVIRONMENTAL
- carbon emissions
- criteria air pollutants (SO_x, NO_x, PM_{10})
- water
- land

SOCIAL
- Economic development (jobs and tax revenues)

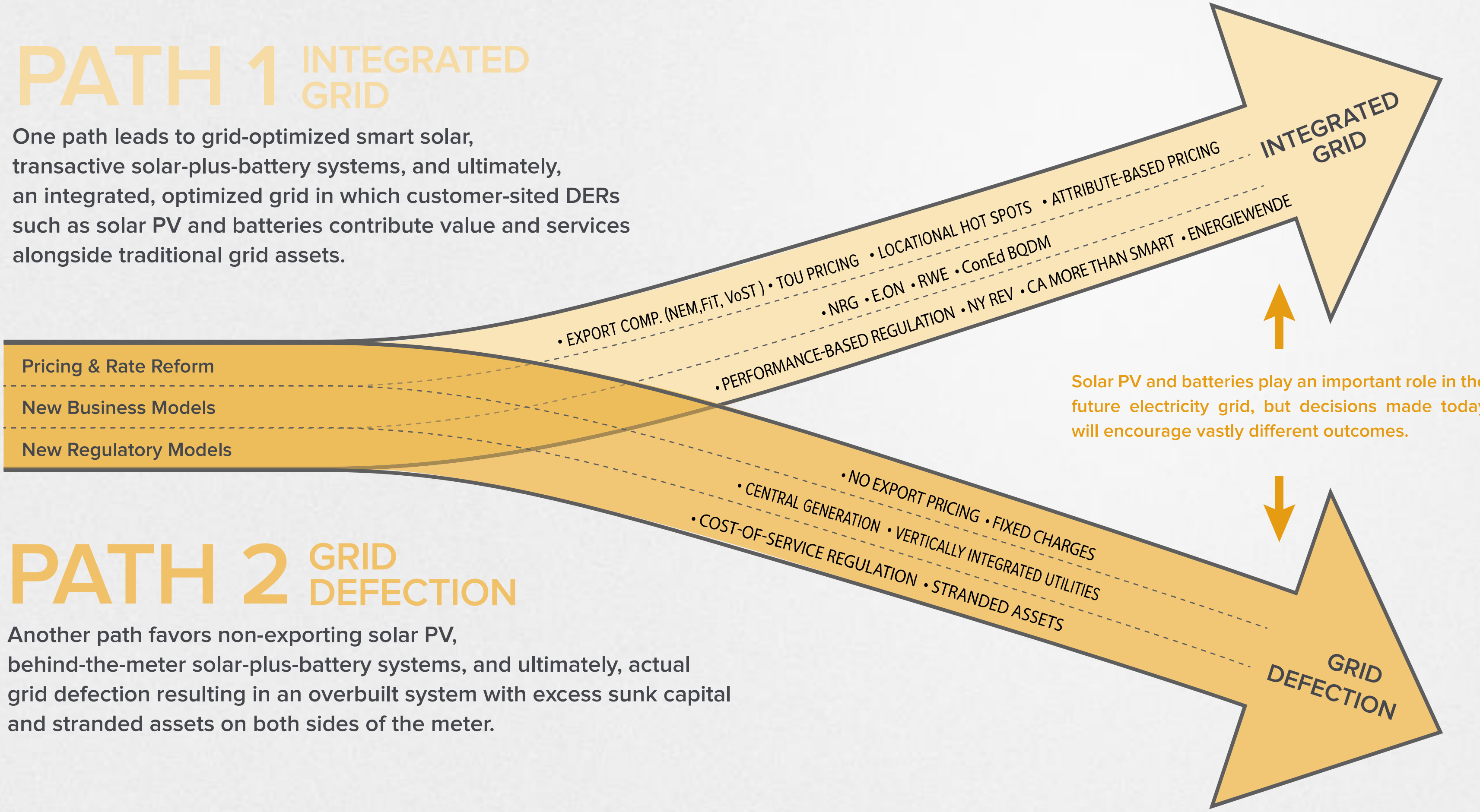
- Electric Energy – Time Shift
- Electric Supply Capacity
- Load Following
- Area Regulation
- Electric Supply Reserve Capacity
- Voltage Support
- Transmission Support
- Transmission Congestion Relief
- Time-of-Use Cost Management
- Demand Charge Management
- Demand Charge Management
- Electric Service Reliability
- Electric Service Power Quality
- Renewables Capacity Firming

Two potential paths forward?

POSSIBLE TRAJECTORIES FOR ELECTRICITY GRID EVOLUTION

PATH 1 INTEGRATED GRID

One path leads to grid-optimized smart solar, transactive solar-plus-battery systems, and ultimately, an integrated, optimized grid in which customer-sited DERs such as solar PV and batteries contribute value and services alongside traditional grid assets.

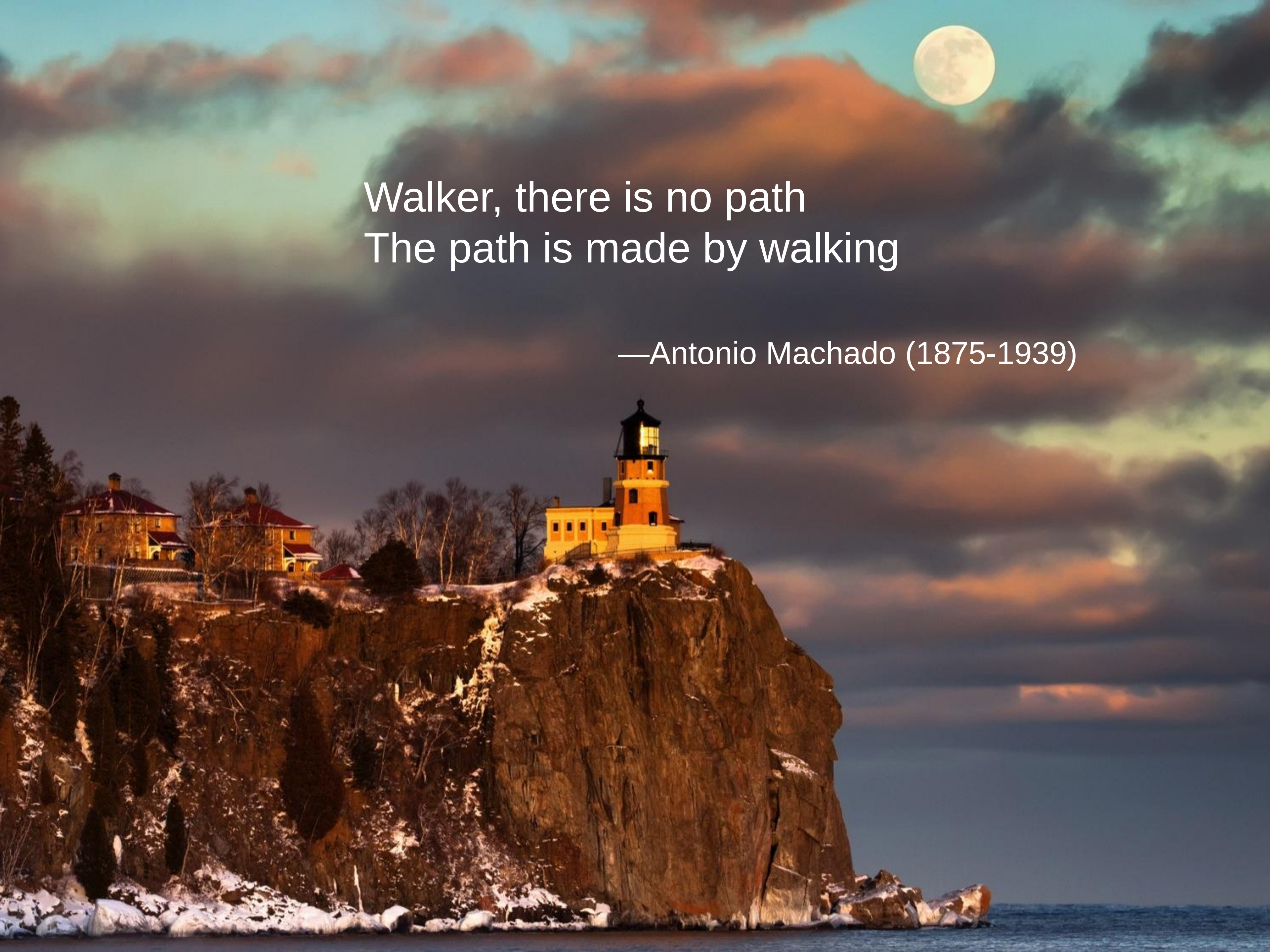


PATH 2 GRID DEFECTION

Another path favors non-exporting solar PV, behind-the-meter solar-plus-battery systems, and ultimately, actual grid defection resulting in an overbuilt system with excess sunk capital and stranded assets on both sides of the meter.

Where to from here?

- What is your vision for the electricity system in 5-10 years? What objectives are you trying to meet?
- Recognizing that the utility has a foundational role in realizing that vision, how might its business model need to be modified or how can it best partner with customers and service providers?
- How can you start to get a handle on the value that different types of resources can provide, so that customers, service providers, and the utility can all be fairly compensated?
- How can planning appropriately account for new, customer-driven technologies, and how can flexibility be optimized to integrate new resources?
- What types of programs can be put in place now to enable innovation?


Walker, there is no path
The path is made by walking
—Antonio Machado (1875-1939)

Thank you

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