Energy+Environmental Economics

Grid of the Future
Industry of the Future

The Evolution of Alberta’s Energy Markets

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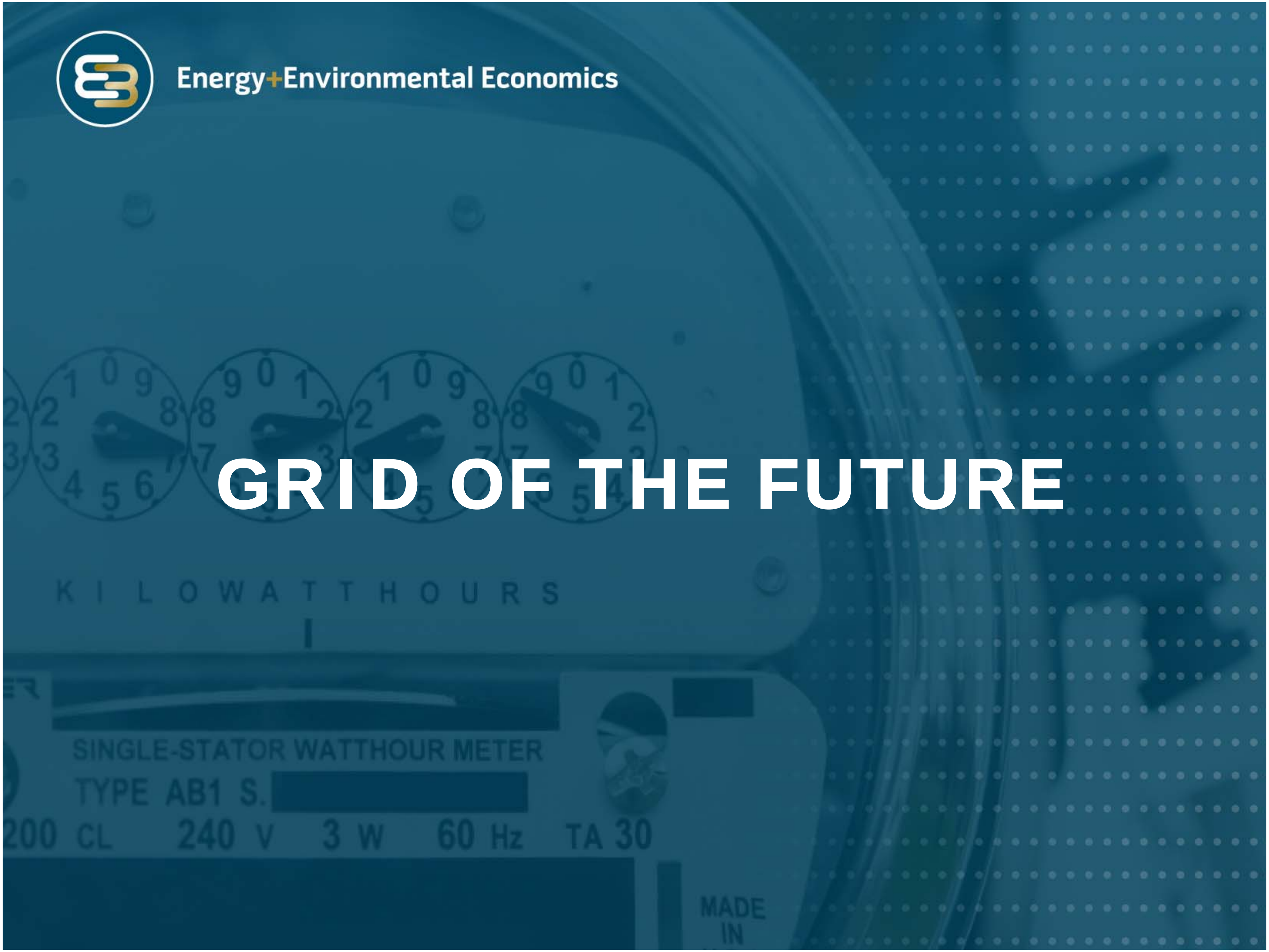

GRID OF THE FUTURE

Theme

- **Broad changes are sweeping through society that will have lasting impacts on the electricity sector**

  1. **"Technology":** Technological change in data processing, communications and manufacture are making new technologies available and cost-effective
  2. **"Policy":** Climate change and the need to decarbonize our economy will require the development of massive quantities of low-carbon electricity
  3. **"Democracy":** Consumers are increasingly wishing to take control of their own destiny, decentralizing the focus of decision-making

- **The role of utilities will need to continue to evolve to respond to these changes in ways that preserve value for their shareholders and ratepayers**

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“Technology”

Renewables

- Solar PV costs have declined tremendously in the last decade
- Wind and solar are now cost-competitive with conventional resources in many markets —***<u>even without subsidies!</u>***
- Rooftop solar can be installed at below the embedded cost rate in some jurisdictions

Solar PPA Prices Over Time

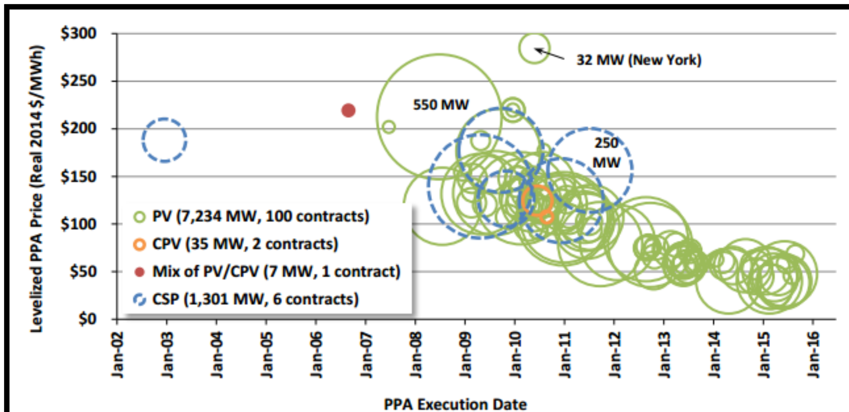


Figure 15. Levelized PPA Prices by Technology, Contract Size, and PPA Execution Date

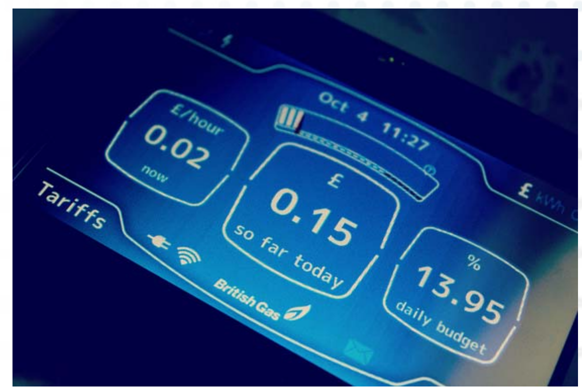
Source: Utility Scale Solar 2014 (LBNL, 2014)

Energy storage

- There is increasing interest in grid-connected energy storage for renewable integration and investment deferral
- Battery costs are declining rapidly with manufacturing scale-up and technology advances
- Lithium-ion appears to be following the photovoltaic path

IT and communications

- Smart devices and advanced communications networks provide new mechanisms to facilitate customer response
- Improved access to data and control systems will enable response to occur seamlessly and with little effect on consumer experience



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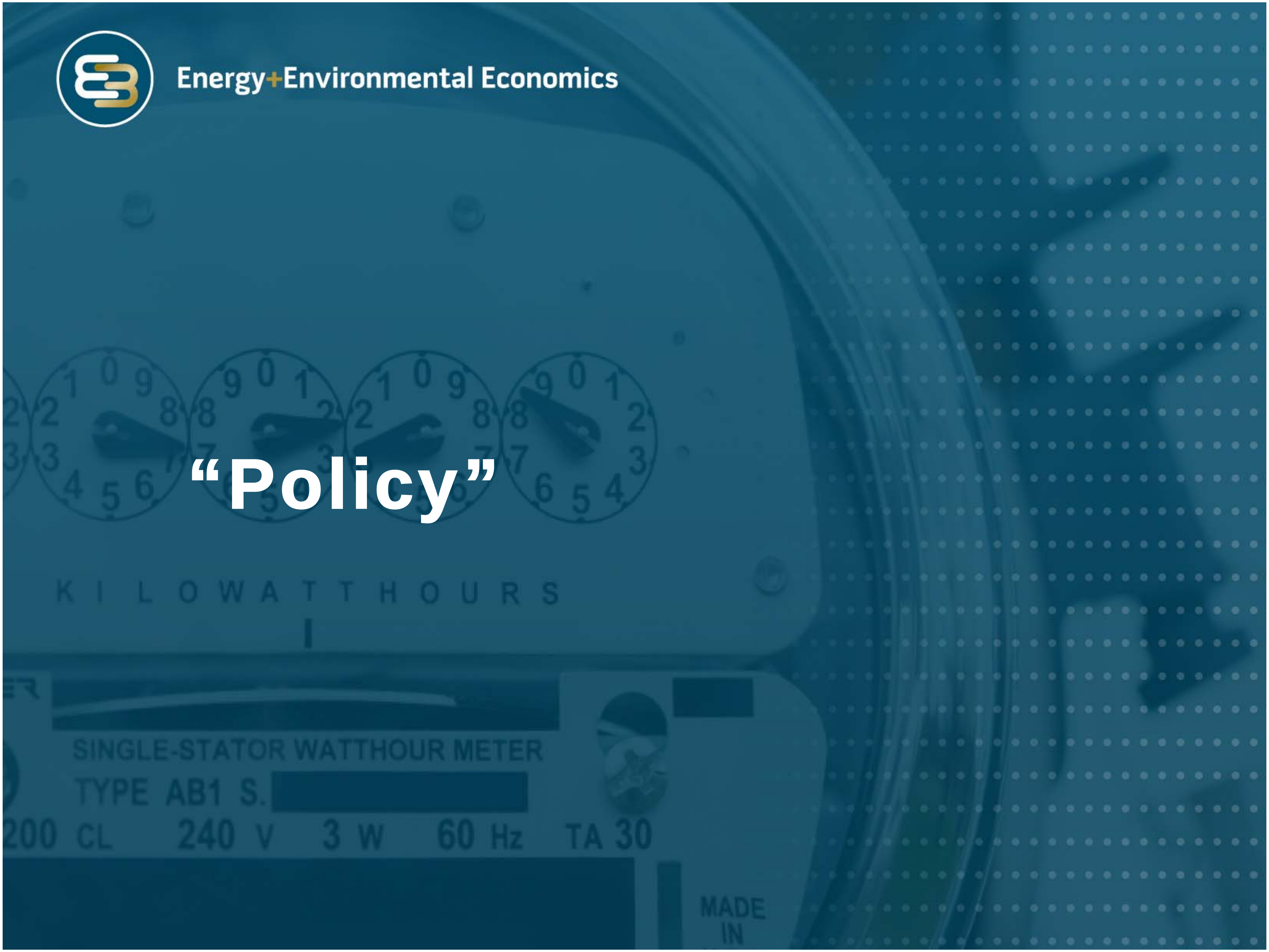
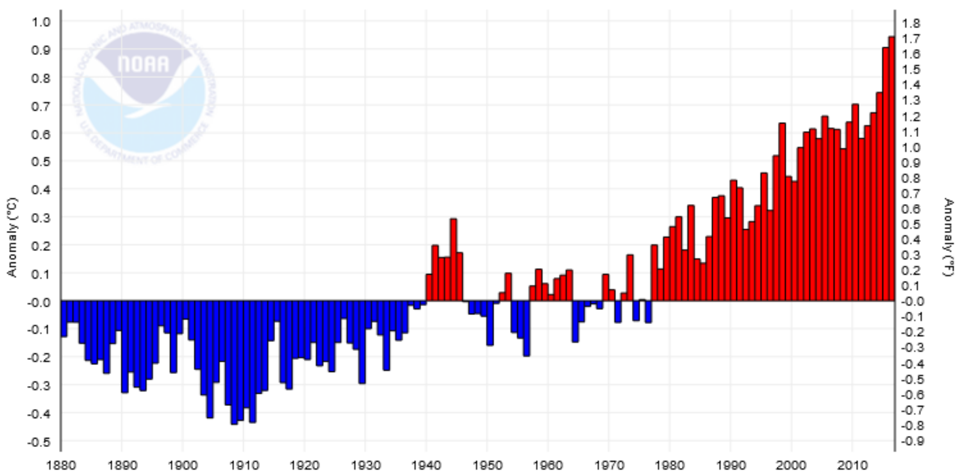


“Policy”

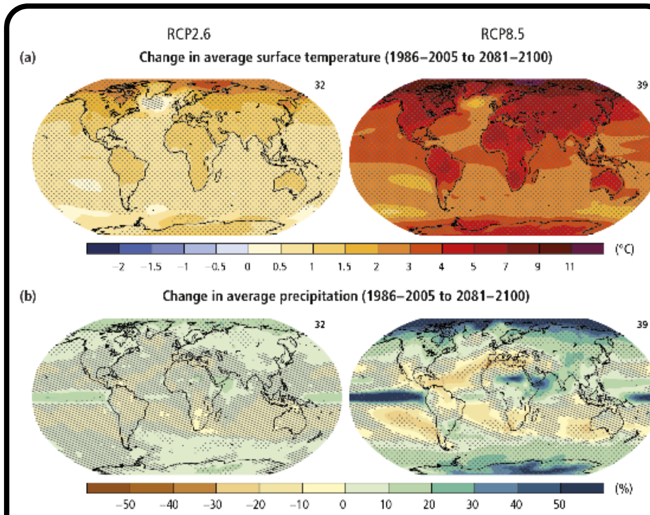
Deep reductions in greenhouse gas emissions are called for globally

- **The 2016 Paris agreement committed industrialized nations to 80% reductions below 1990 levels by 2050**
  - Roughly consistent with IPCC/UNFCC goal of keeping global average temperature rise within 2°C to avert catastrophic climate change
- **If current trends continue, 2°C aggregate warming will be exceeded**

Global Land and Ocean Temperature Anomalies, January-December



Source: NOAA, https://www.ncdc.noaa.gov/monitoring-references/faq/indicators.php Global annual average temperature measured over land and oceans. Red bars indicate temperatures above and blue bars indicate temperatures below the 1901-2000 average temperature.

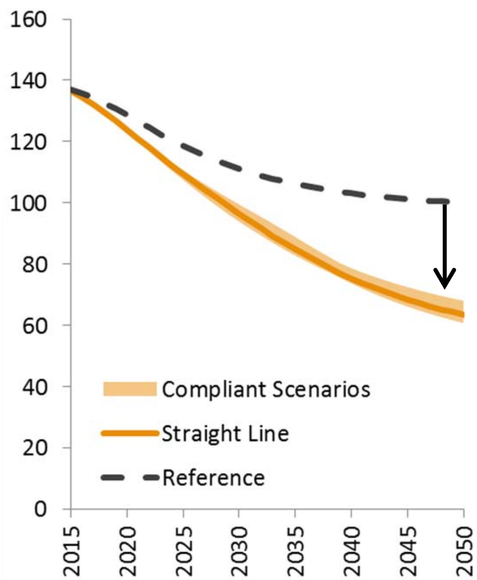


Source: IPCC Global Assessment Report 5, SPM.07

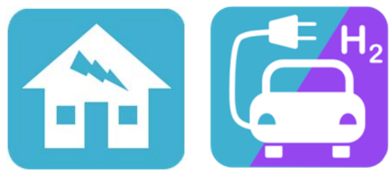
Economy-wide decarbonization requires four energy transitions

1. Efficiency and Conservation

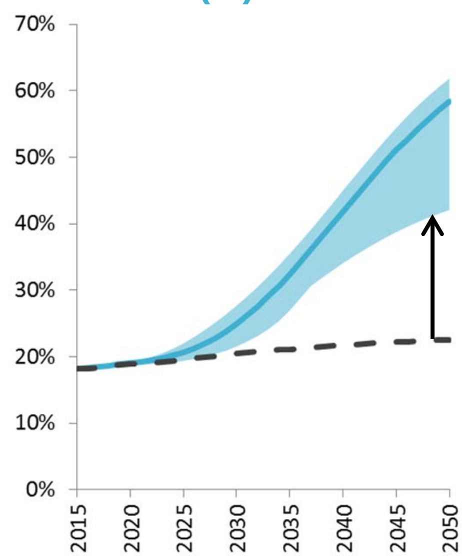
Energy use per capita (MMBtu/person)



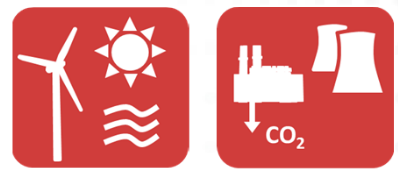
2. Fuel Switching



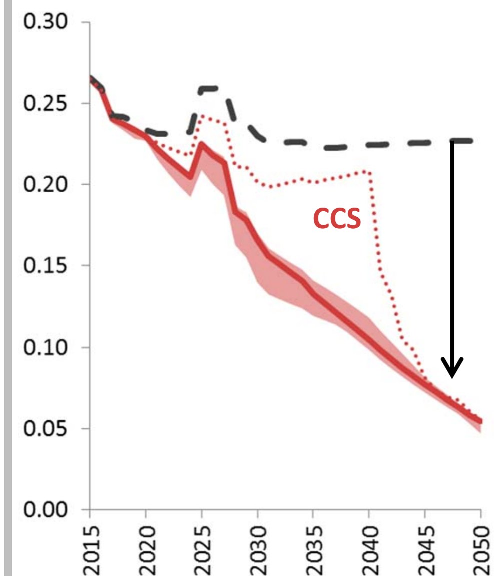
Share of electricity & H_2 in total final energy (%)



3. Decarbonize electricity

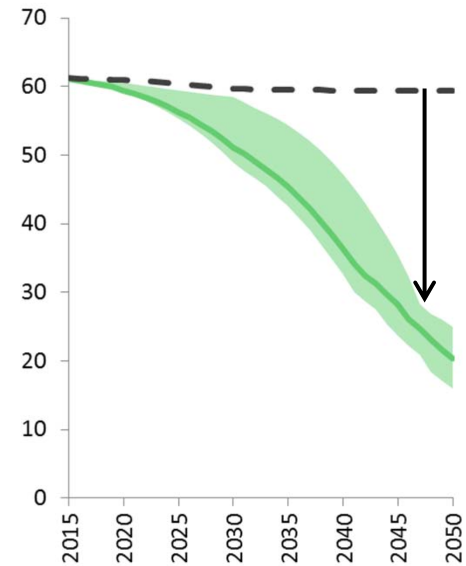


Emissions intensity (tCO2e/MWh)



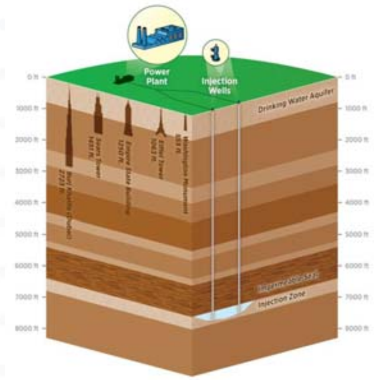
4. Decarbonize fuels (liquid & gas)

Emissions intensity (tCO2/EJ)



Three Sources of Low-Carbon Electricity

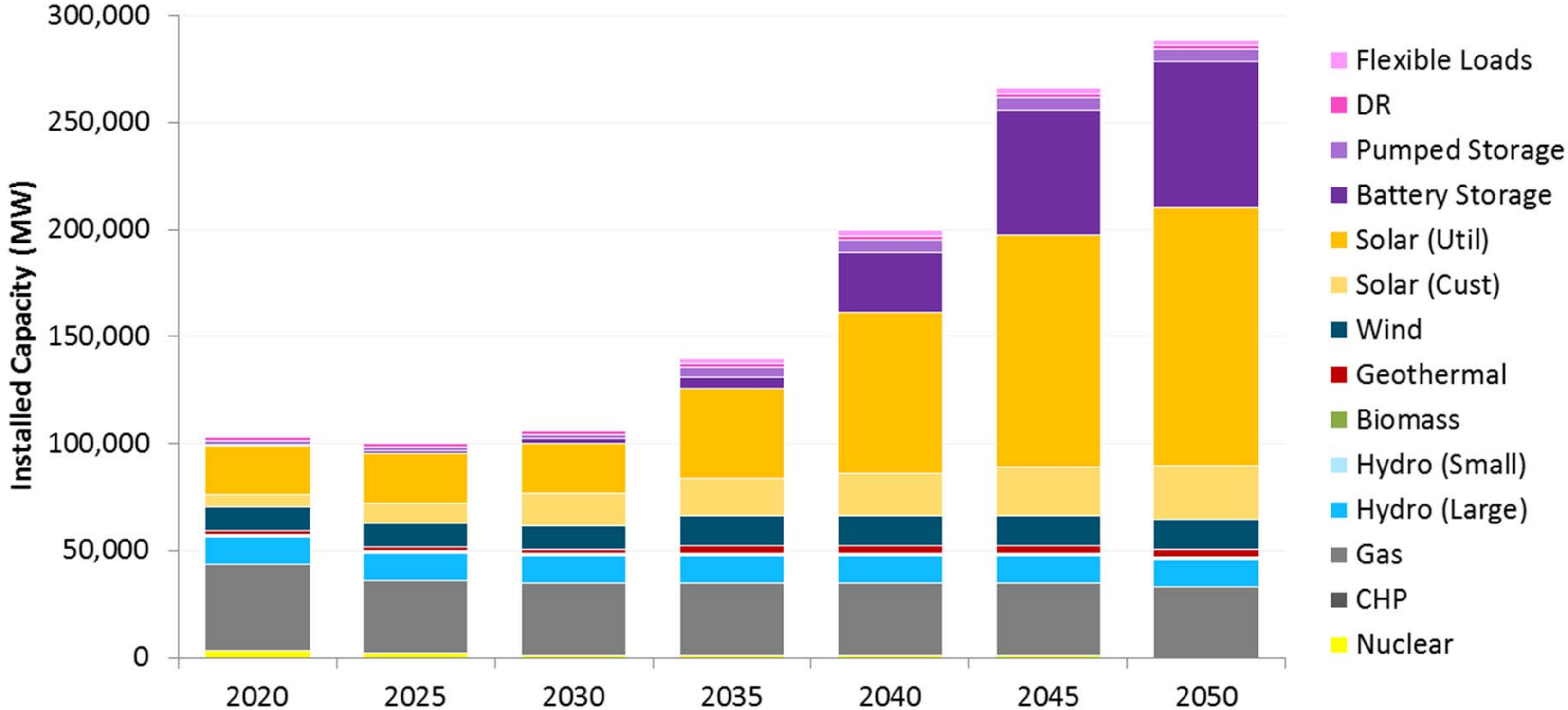
1. **Renewable**
   - **Hydroelectric:** *high-quality, low-carbon resource in the Northwest that can help to balance wind and solar power*
   - **Wind:** *high quality resources in West, particularly East of the Rockies, intermittent availability*
   - **Solar:** *high quality resources across the Southwest, intermittent availability*
   - **Geothermal:** *resource limited*
   - **Biomass:** *resource limited*
2. **Nuclear**
3. **Fossil generation with carbon capture and storage (CCS)**



One look at a GHG-compliant Pathway for California

+ Resources selected by E3's RESOLVE model to meet electric sector's share of 2050 GHG abatement goals

- Electric sector reduces emissions to 20 MMT by 2050 while serving higher loads from electrification of transportation, buildings and industry



"Democracy"

Consumer empowerment is resulting in a decentralization of decision-making

- **Restructuring of the electric utility industry in the 1990s invited new entities into the industry**
  - Direct access (DA), electric service providers (ESPs), independent system operators (ISOs)
- **Municipalization and community-choice aggregation (CCA) allow local control of energy decisions**
- **Rooftop solar and demand response empower small customers**
- **More difficult to justify large, centralized infrastructure investments**

Retail rate design from a utility perspective

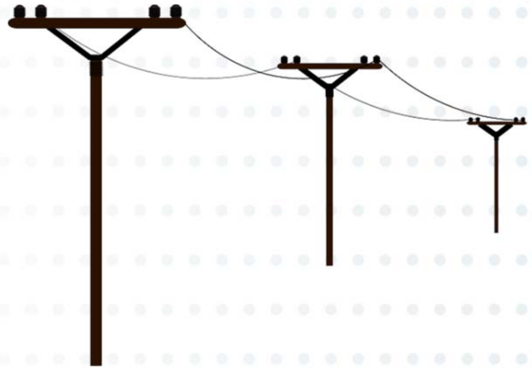
+ **Utilities have traditionally viewed rate design as a part of the cost allocation / ratemaking process**
    - COSA study identifies classes of customers and allocates costs among them
    - Rates are designed to collect the class-specific revenue requirement from the class as a whole
    - Each customer pays a fair share of the utility's total cost
    - A customer's bill should generally align with utility's cost to serve it, but some imprecision is tolerated due to pooled nature of costs, and to keep rate designs manageable for utility and customers

Utilities think of rates in the same way politicians think of taxes!

Utility view is driven by structure of its embedded costs

+ Vast majority of costs in utility rates today are fixed costs

- Utility capital investments form the "rate base", a portion of which is recovered each year from customers based on depreciation schedules
- Electricity production and delivery requires significant capital investments
  - Power stations
  - Transmission lines and substations
  - Distribution poles, wires and transformers
- Variable costs are only O&M and fuel



Traditional utility view has little room for customer response

- **Rates are set as part of a careful, political process designed to produce equitable outcomes**
- **Customer response, also called "bypass", upsets this balance**
  - Customers are motivated to minimize their bills through consumption decisions
  - Direct access and net energy metering are the most extreme examples of this
  - Utilities respond with fixed monthly charges and "ratchet" demand charges

Economists prefer taxes that are non-distortionary, i.e., they do not change behavior of consumers or producers

Why should utilities want customer response?

1. **Because customers want choice!**
   - Customers want to manage their bills and many want rooftop PV
2. **Because there can be cost savings for the utility right now**
   - Utilities can avoid fuel and investment costs
   - DER increasingly cost-effective
3. **Because we will need customer response—a lot of it—in the long term**
   - Renewables integration and greenhouse gas reduction
   - Resilience against major disruptions
   - Innovation from new market entrants

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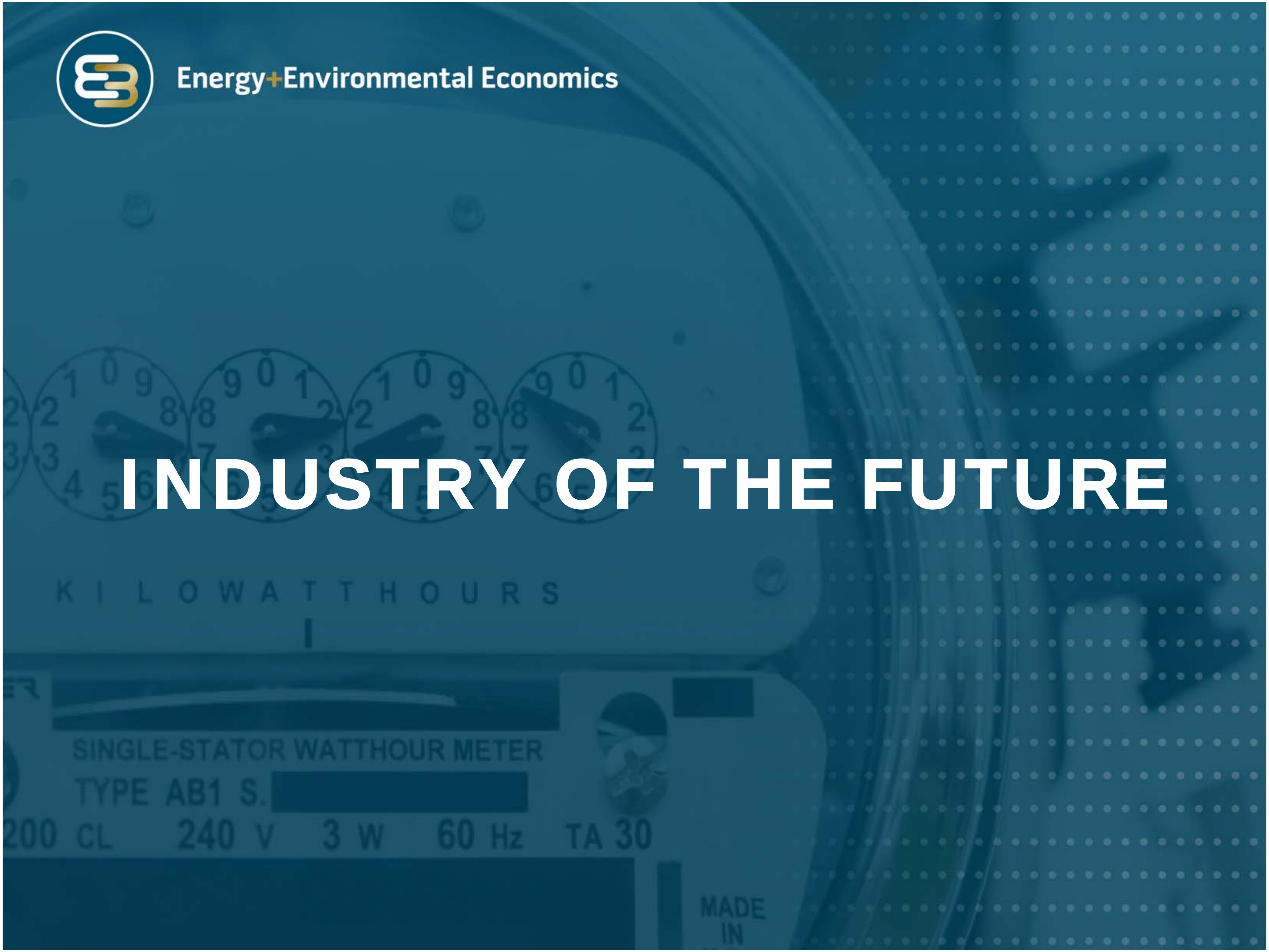


INDUSTRY OF THE FUTURE

Initial thoughts

- Historically, we have planned and operated power systems assuming resources are flexible and load is inflexible
- Technology, Policy and Democracy are driving change through expansion of intermittent generation and enabling customer response
- Utilities are responding in states like California and New York by evolving their markets and business models

Will customer choice and innovation proliferate?

Historic Electricity Industry

Relatively homogenous customers within each rate class

Volatility and uncertainty handled via command-and-control regulation

Generation mostly centralized

Majority of costs recovered volumetrically in an era of continual load growth

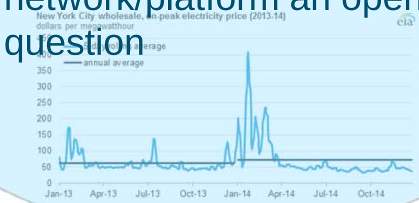
Tomorrow's Industry?

Rise of the prosumer; demand profiles diversify

Volatility and uncertainty addressed via markets, increased consumer control over demand, and strategic regulation

Generate a diverse mix of centralized and distributed technology, including storage, microgrids, and solar

Usage and payment of the electric network/platform an open question



Reliability

Affordability

Implications for market participants

Customers

Technology affords increasing opportunities to manage energy services and costs

Utilities

Continued pressure to become the “utility of the future” as Technology and Democracy make more monopoly services contestable

Transmission Developers

Increased focus on integration of remote renewable resources and managing new flows and system changes

Wholesale Markets

Increasing value as a means to manage variable resources and facilitate customer response

IPPs

Times are tough now, but trend is still toward more competition with potentially more opportunity if the utility of the future is a “skinny” one

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How will the grid of the future be organized?

What Happens to Utilities when Regulated Bundled Rates are used in Competitive Markets?

- They can experience uneconomic bypass of their monopoly services with increases in costs and rates.
- At the extreme, unmitigated cost increases lead to a death spiral that eventually leads to rate and market restructuring and the potential for stranded cost recovery proceedings
- Electricity deregulation has many similarities to cable industry

Natural Gas

- Complete unbundling of both costs and functions created separate Pipelines, Marketers and Buyers
- Open seasons matched contract terms and anchor tenants with new investments

Railroad

- Had inflexible and noncompetitive bundled regulated rates when trucking and airlines industry become deregulated; this created substantial amounts of uneconomic bypass

Airline

- Also had highly regulated bundled rates (by distance) prior to deregulation and Sabre system implementation

Telephone

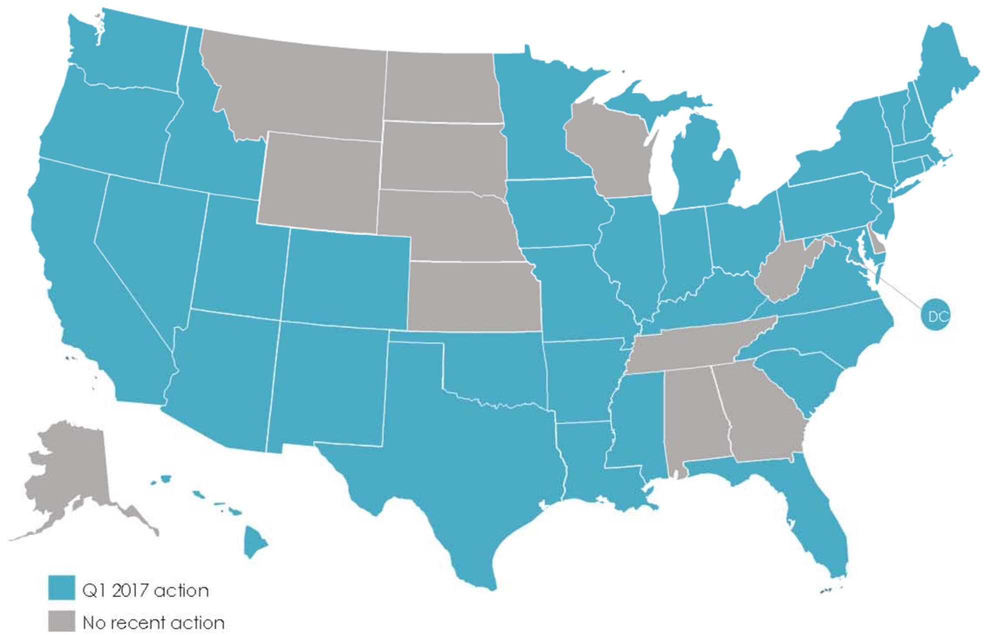
- Opened up long distance common carrier service to all providers.
- Implemented multi-part rates, similar to what we are proposing

Technology, policy and democracy → leads to many questions on the future of the grid

- **E3 is active in examining grid modernization, utility business models, and rate reform in many jurisdictions**
  - Most notably in California, Hawai'i, and New York

- **Experience shows there is no one right path forward**
  - Each path must be tailored to a jurisdiction's unique circumstances

Q1 2017 Action on Grid Modernization, Energy Storage, and Utility Reform



Type of Action	# of Actions	% by Type	# of States
Deployment	36	24%	19
Policies	29	20%	16
Financial Incentives	25	17%	11
Studies and Investigations	22	15%	16 + DC
Business Model and Rate Reform	18	12%	13
Planning and Market Access	18	12%	12
Total	**148**	**100%**	**37 States + DC**

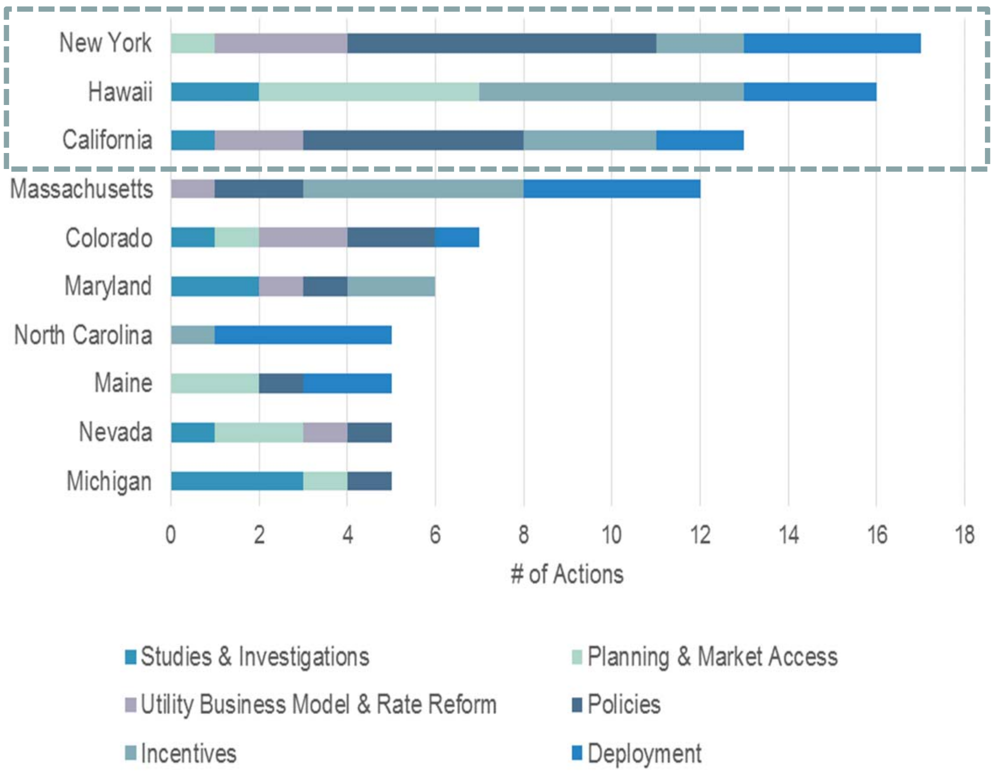
Note: The "# of States/ Districts" total is not the sum of the rows because some states have multiple actions. Percentages are rounded and may not add up to 100%.

Source: NC Clean Energy Technology Center

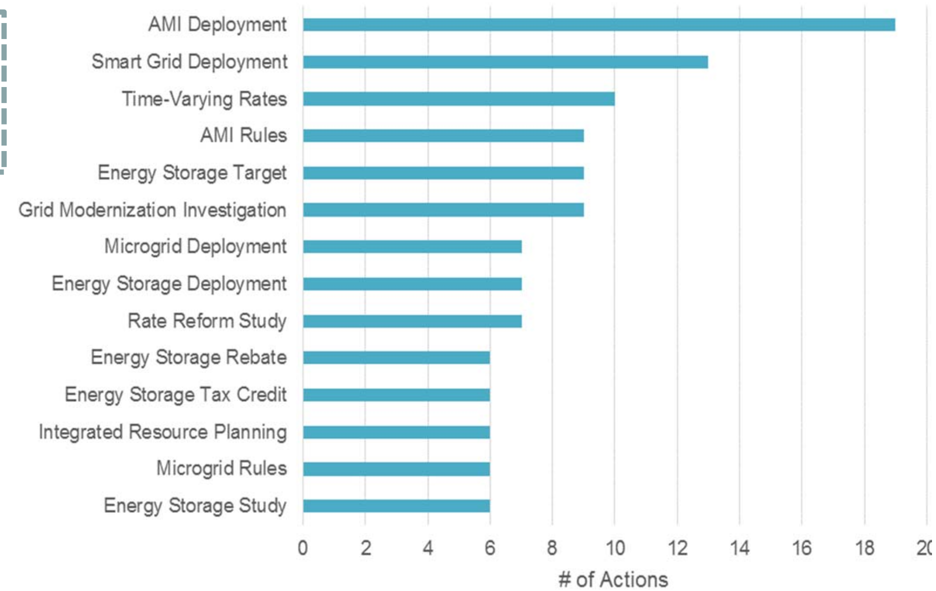
Several jurisdictions are pushing action on rate reform, grid modernization, and new utility business models

E3 is particularly active in states such as New York, Hawai'i, and California, but we work in every U.S. jurisdiction

Top Ten Most Active States of Q1 2017 By Number of Actions



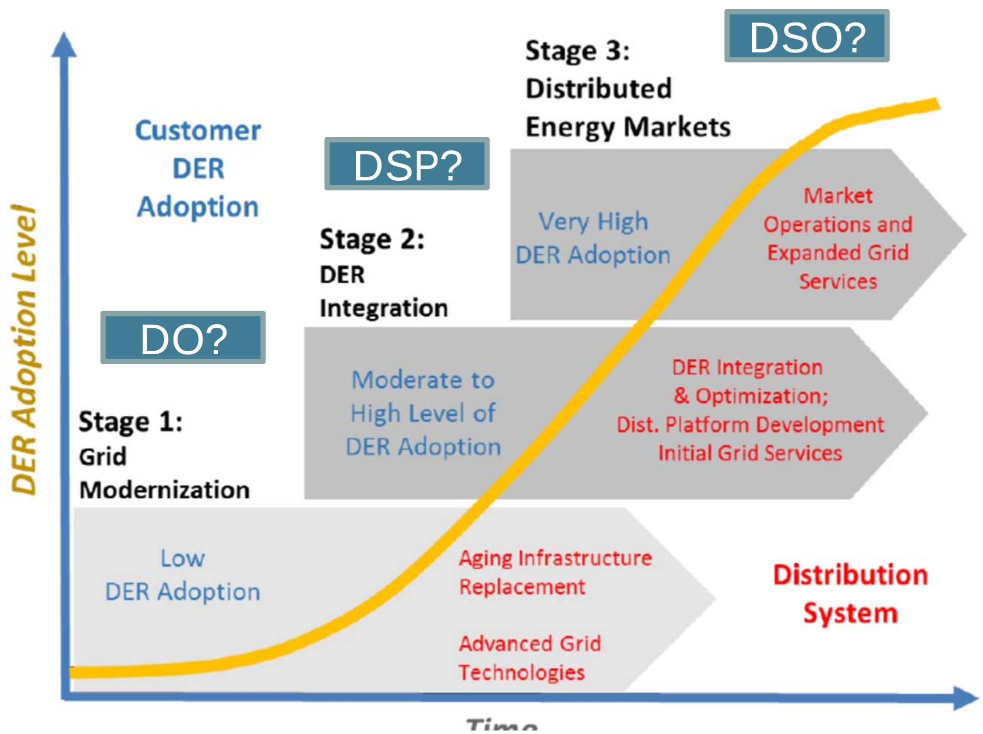
Most Common Types of Actions Taken in Q1 2017



Source: NC Clean Energy Technology Center

How will distribution utilities and markets operate in the future?

Distribution Utility and Market Evolution



Source: New York Joint Utilities Supplemental Distribution System Implementation Plan (SDSIP)

+ **There are many <u>different</u> and <u>valid</u> ways to think about how the electric distribution system will operate in the future**
  1. **DO** = **D**istribution System **O**wner/**O**perator
  2. **DSP** = **D**istribution **S**ystem **P**latform
  3. **DSO** = **D**istribution **S**ystem **O**perator
  - **Virtual** vs. **Real =** Tariff-based pricing vs. bid-based markets

Pricing and retail market design are key considerations as technology, policy, and democracy advance

Fundamental Pricing Signals

seconds
- Frequency regulation
- Volt/VaR regulation
- Spinning reserves
- Emissions

minutes
- Spinning reserves
- Energy
- Emissions

hours
- Energy
- Emissions

months
- Capacity
    - Generation

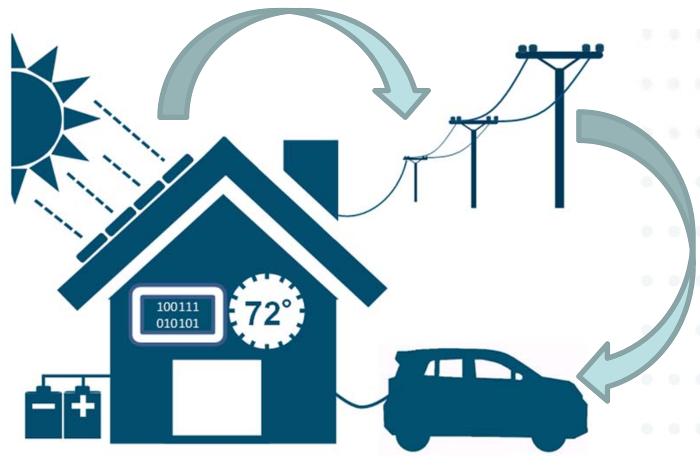
years
- Capacity
    - Generation
    - Transmission
    - Distribution

Today's Utility	Future Utility
Regulated Monopoly Wholesale Markets Limited DER Penetration / Retail Markets	New Business/ Operating Model? More Active Customers + New Technologies? Transformed Markets?
Average rates and blunted price signals: Average ¢/kWh Flat $/kW	More accurate and dynamic pricing signals: Dynamic ¢/kWh? Variable $/kW? Other billing determinants?

A "smart" multi-part dynamic retail rate or tariff is one pricing solution that also serves to create a virtual retail market

- **Existing rates and tariffs do not effectively encourage dispatchable or high value DERs nor do they allow for efficient recovery of utility costs**
- **A multi-part dynamic rate or tariff can work in tandem with other utility or state programs and it can also accommodate various public policy and regulatory goals**
- **This offers utilities in jurisdictions like the Pacific Northwest the opportunity to create virtual retail markets based on rates and tariffs rather than entirely new distribution level markets**

Energy and other products/services to the grid?

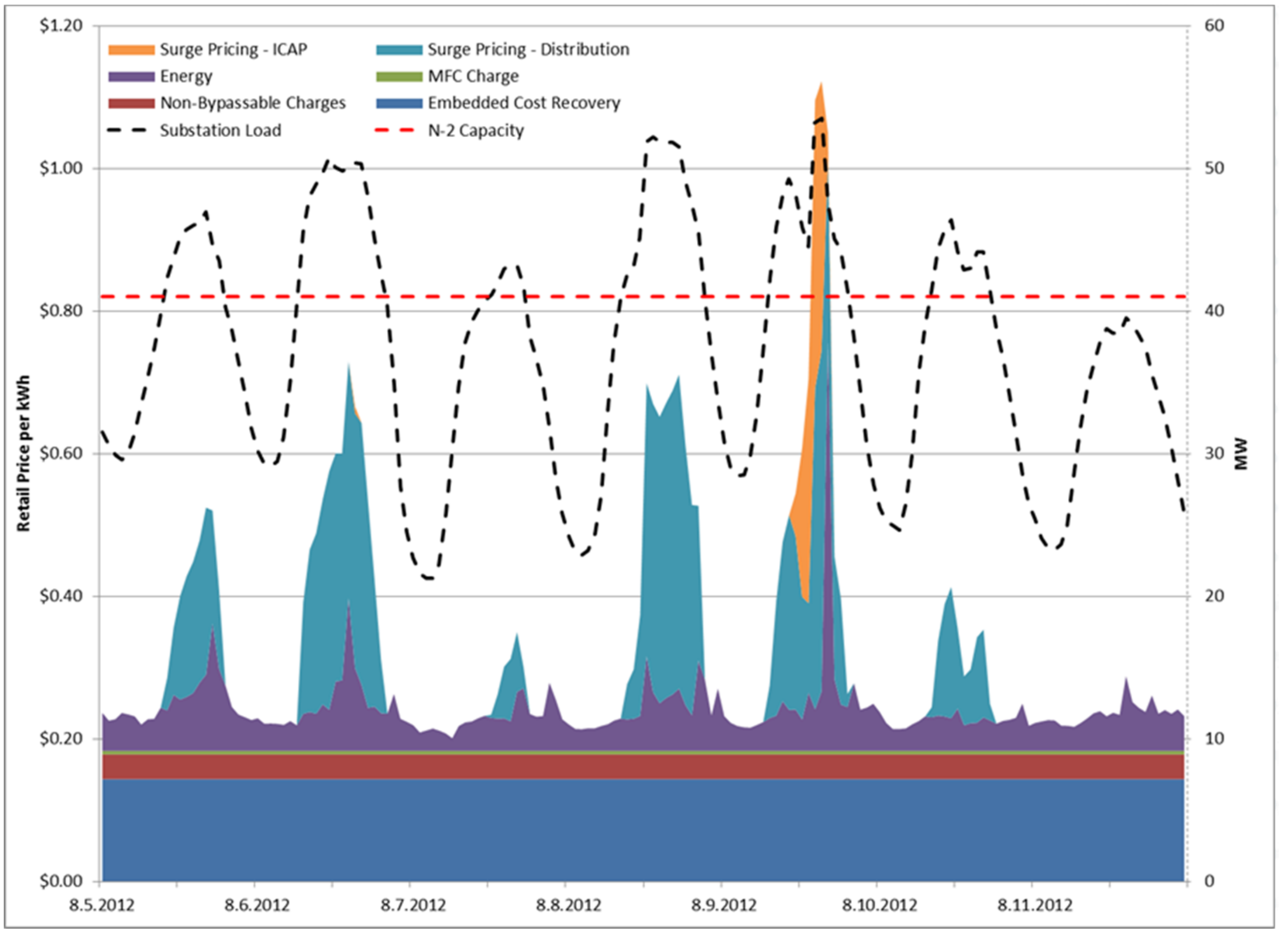


Energy and othe
products/ service
to the customer?

Part 1: *Embedded Costs* Customer Charge	$/customer? Other?
Part 2: *Embedded Costs* Network/Grid Access Charge	$/kW, $/kWh? Other?
Part 3: *Marginal Costs* Value-Based Charge/Payment	$/kW, $/kWh? Other?

New York example of dynamic pricing in a distribution constrained area

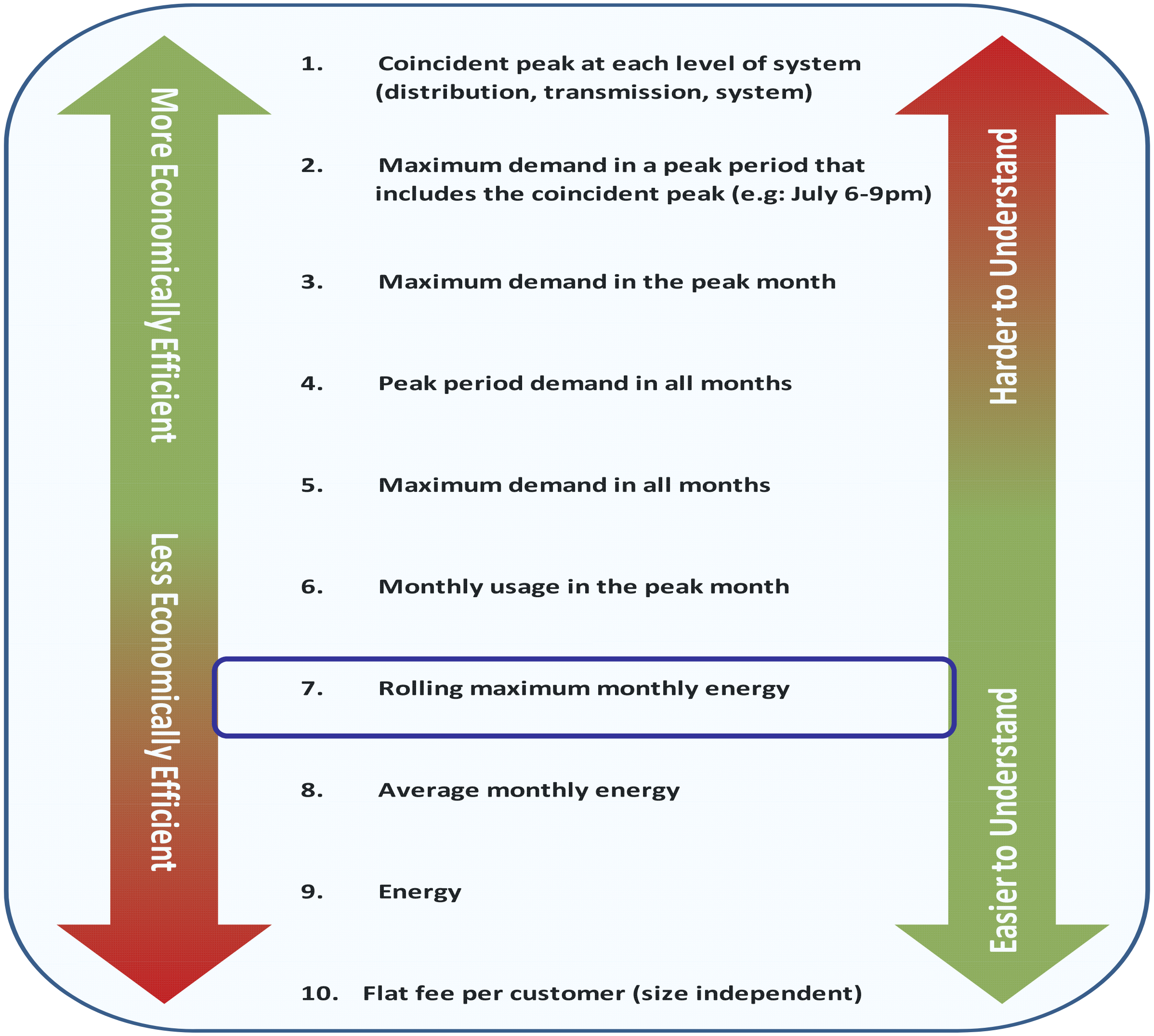
Hourly prices by component, sub-station capacity limit and loads



Only these components are credited for exports for self-generation

Public purpose and utility embedded costs

NY Full Value Tariff: Network Subscription Choices



http://www.ethree.com/wp-content/uploads/2016/12/Full-Value-Tariff-Design-and-Retail-Rate-Choices.pdf

What can a "smart" multi-part dynamic rate do?

A multi-part dynamic rate has several innovations that can serve as tools to achieve diverse goals

Enables Smart Grid Technologies

- Dynamic prices send technology agnostic signals to enable a whole host of DERs
  - More Efficient Appliances
  - Storage
  - Smart EV charging
  - Smart HVAC
  - Smart Water Heaters
  - Smart Inverters

Innovative Pricing can Capture "D" Value

- "D" value of utility distribution and sub-transmission translated to customers as "prices to beat" to enable DER participation, enabling equitable and economical management of grid costs
- Sources of value can be communicated in a variety of ways including hourly real-time price signals or utility program payments

Enables Utility Business Model Change

- Encourages creation of business models that can lead to greater customer adoption of high value DERs rather than DERs that have low, zero, or negative value
- Utilities can begin to offer new and different products/services

Rationalization of Rate Design

- Utilities may have better and more transparent fixed-cost recovery through a multi-part rate that has an explicit mechanism, potentially forestalling future issues with retail rates like net energy metering cost shifts
- The rate or tariff can be implemented rapidly or gradually, e.g. initially opt-in only

E3 has proposed such a rate in New York, which served as the basis for the ConEd Smart Home rate available at: http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={A0BF2F42-82A1-4ED0-AE6D-D7E38F8D655D}

Key takeaways for the Alberta's Key Stakeholders

- **There are many different and valid ways to think about how utilities and retail markets will be organized and operate in the future**

- **There is no one-size-fits-all solution and each jurisdiction will have to chart its own path balancing factors like:**
  - Size and value of potential DER and retail markets
  - The costs of grid modernization and foundational investments needed to enable DER and retail markets
  - Tailored and implementable transition strategies that address customer impact, utility business models, policy goals, and retail market competition concerns

- **A good place to start might be what NY is calling virtual retail markets through utility offered dynamic rates/tariffs coupled with more operational control over DERs**

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Thank You!

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