

The Future of the Grid

Policy, Technology, and Market Changes

Casey Canfield, Assistant Professor (@caseycan)
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FRANK BIENEWALD/GETTY IMAGES

The electricity industry is changing.

California Aims to Drop Fossil Fuels for Electricity by 2045

By The Associated Press

Sept. 10, 2018

DANIEL ALARCON SCIENCE 08.23.18 06:00 AM

3,587 views | Mar 1, 2018, 12:01am

Blockchain Microgrids Could Give The Utility Death Spiral A Fresh Spin



Jeff McMahon Contributor 

From Chicago, I write about green technology, energy, environment.

WHAT HAPPENED IN THE DARK: PUERTO RICO'S YEAR OF FIGHTING FOR POWER

Agenda

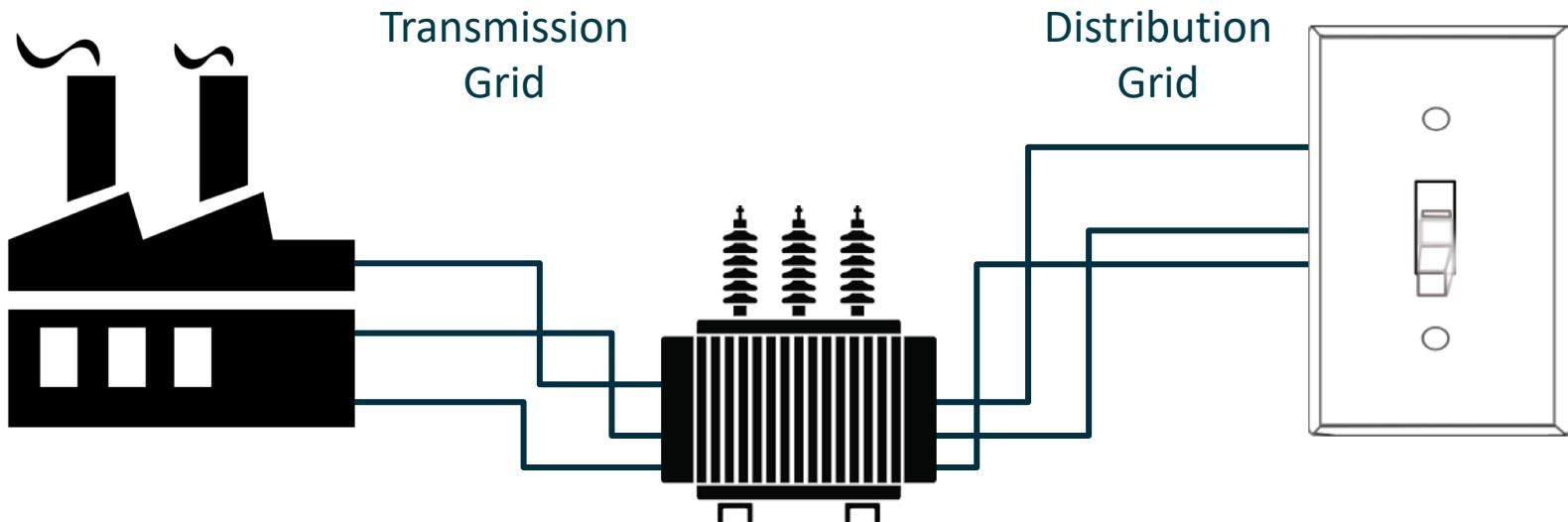
Today

A Future

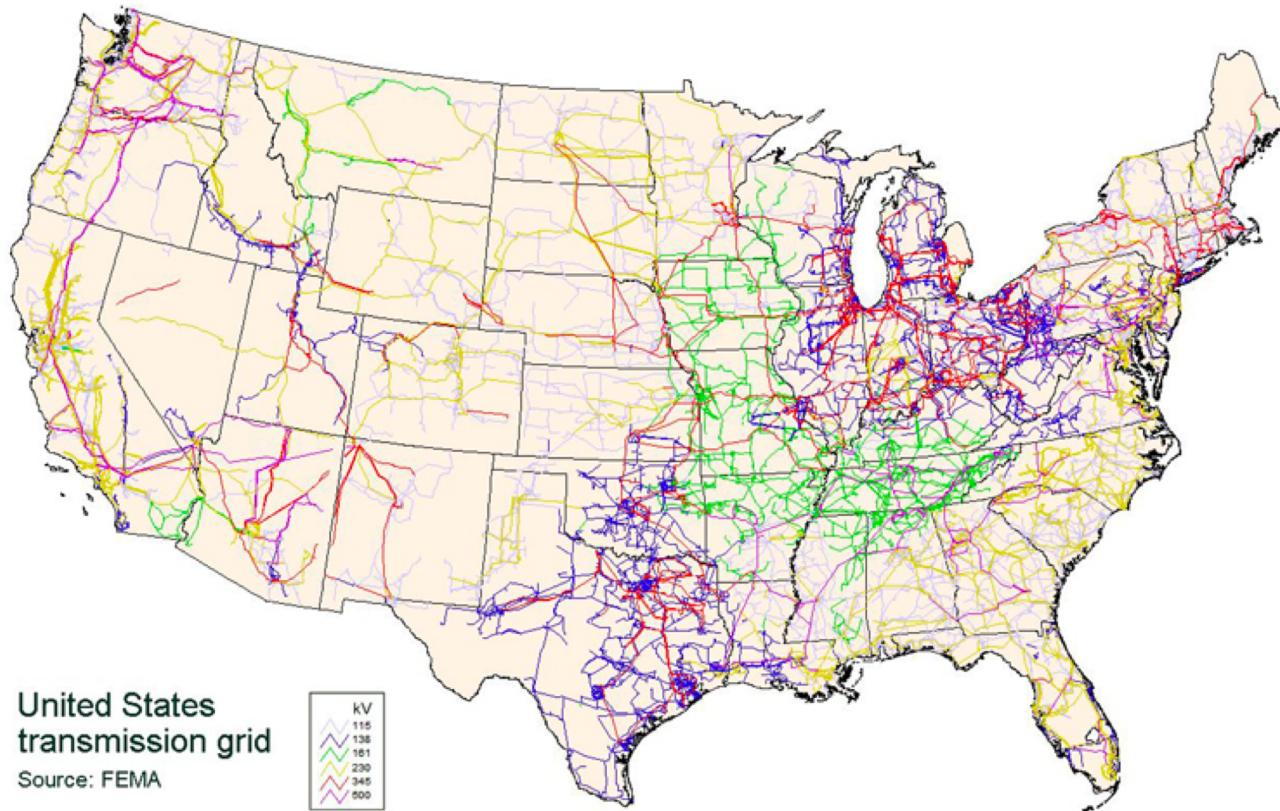
How to
Get There?

Now
What?

The grid transmits and distributes.

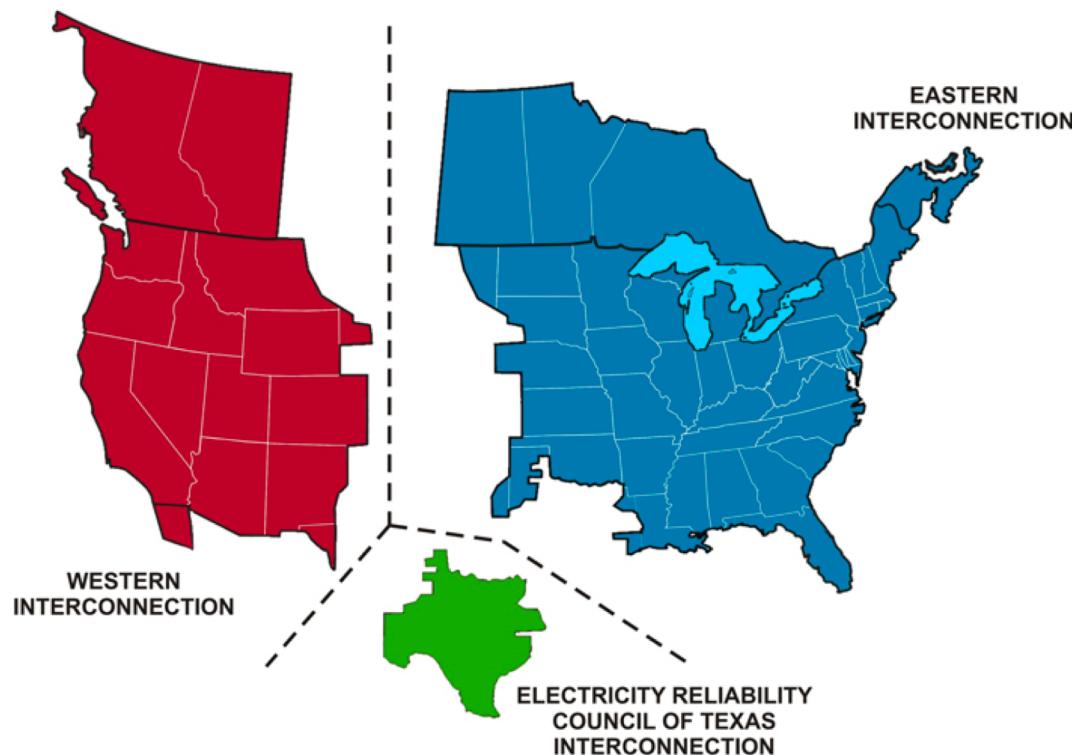


The grid is interconnected.



Supply and demand must be balanced.

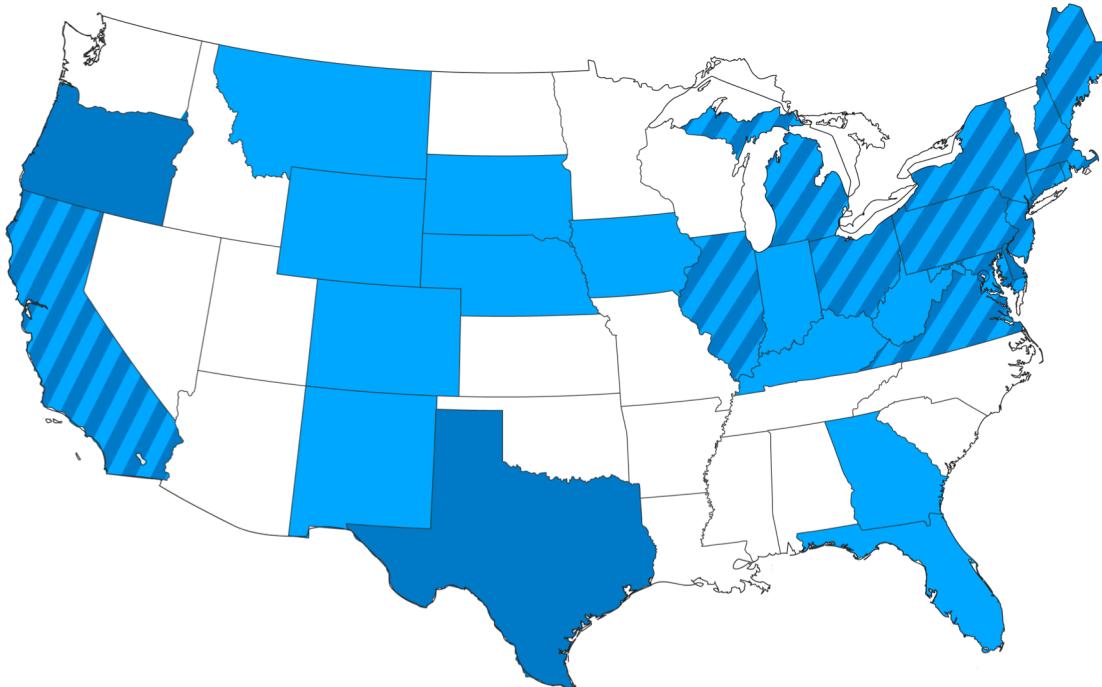
North American Electric Reliability Corporation Interconnections



Blackouts are still a frequent problem.



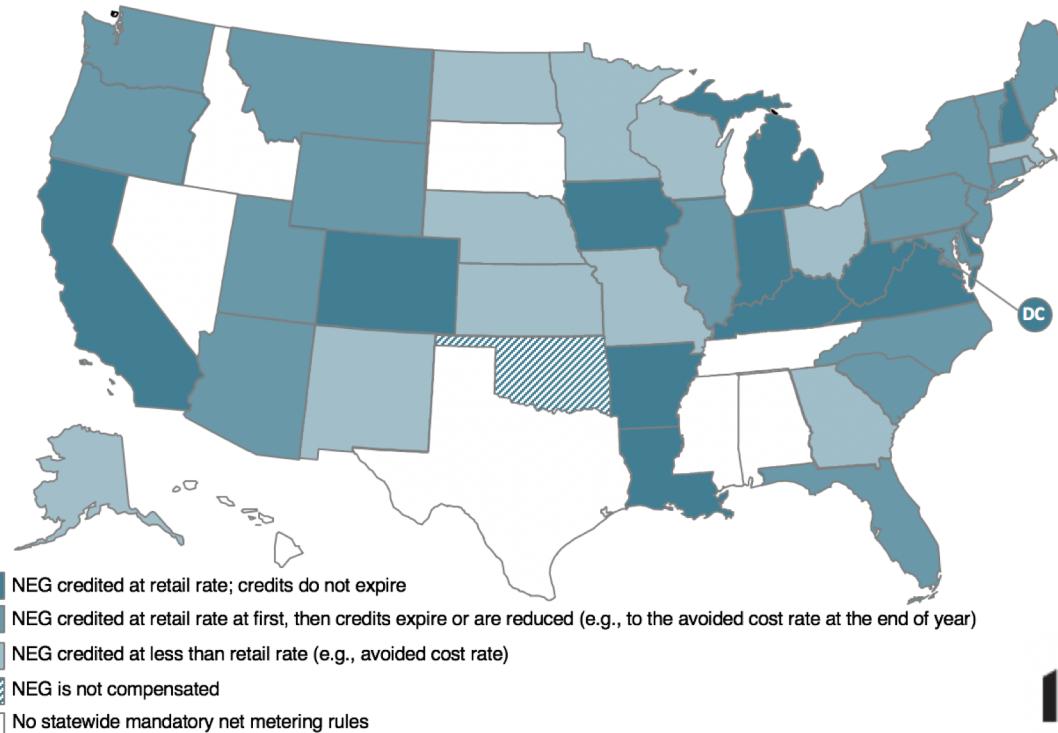
Regulated vs. Restructured Markets



The policy environment varies.

Customer Credits for Monthly Net Excess Generation (NEG) Under Net Metering

www.dsireusa.org / July 2016



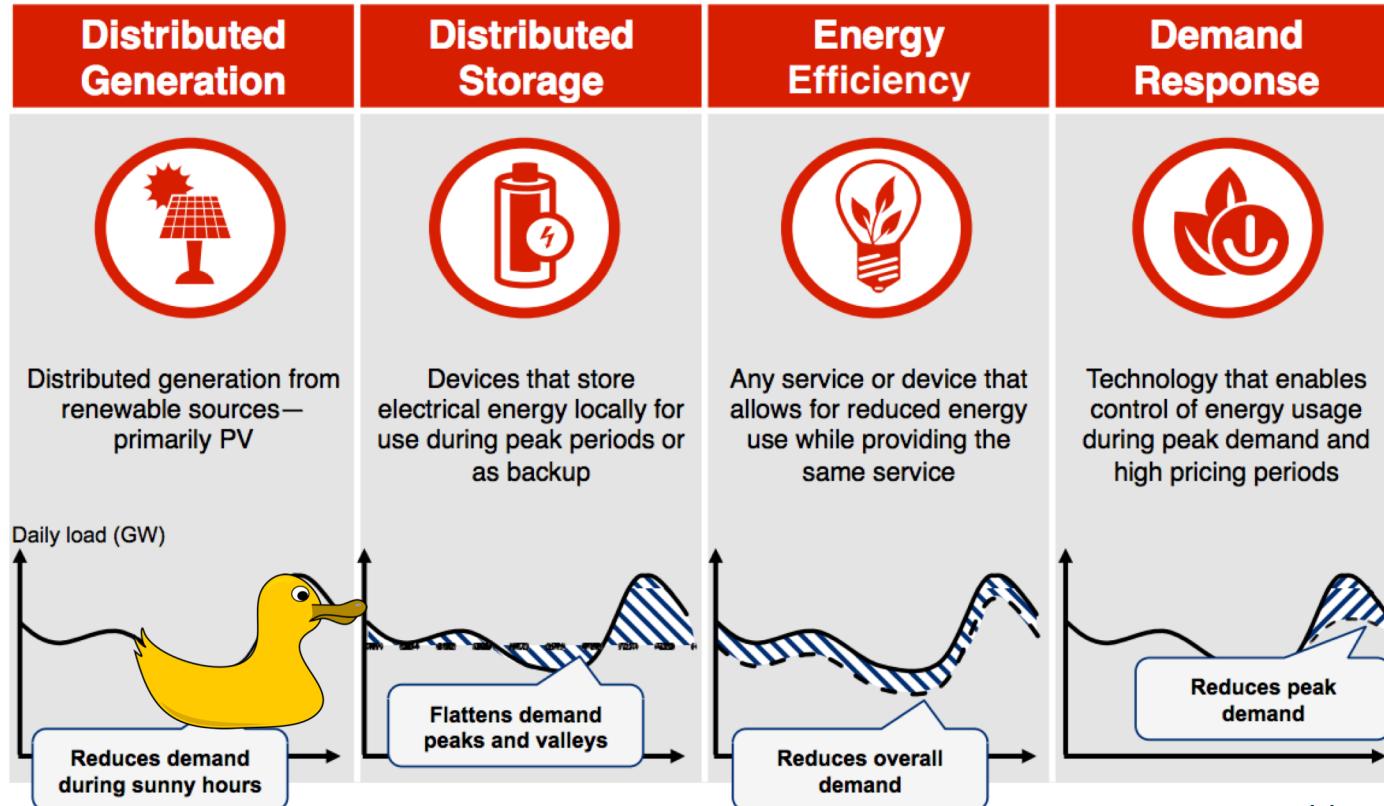
Three trends are shifting the industry.

Decentralization

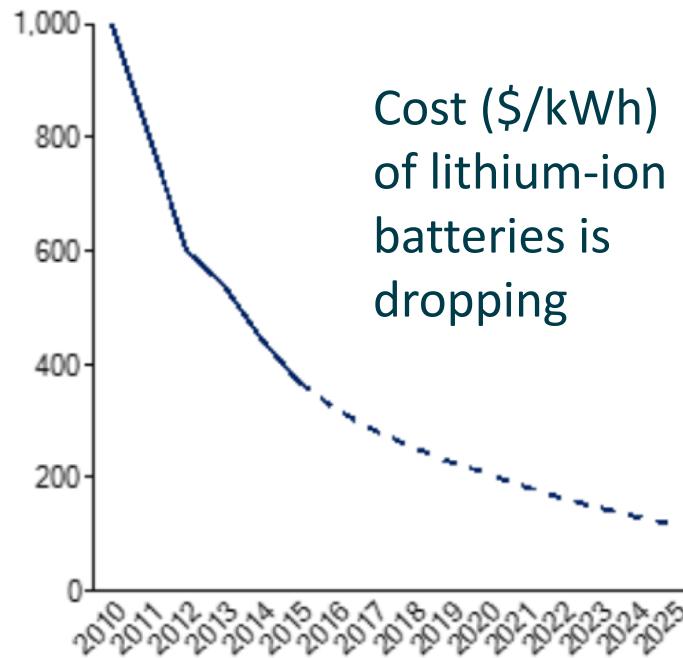
Electrification

Digitalization

Decentralization: Controlling demand

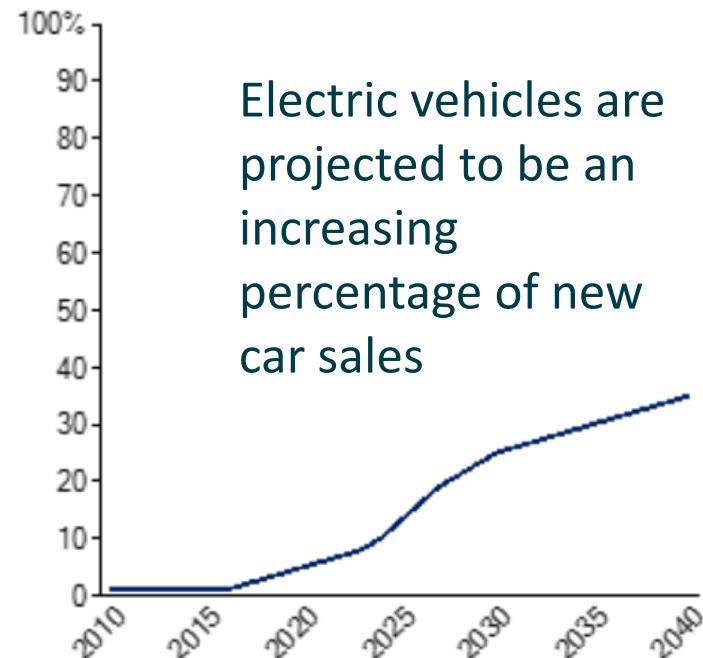


Electrification: Shifting boundaries



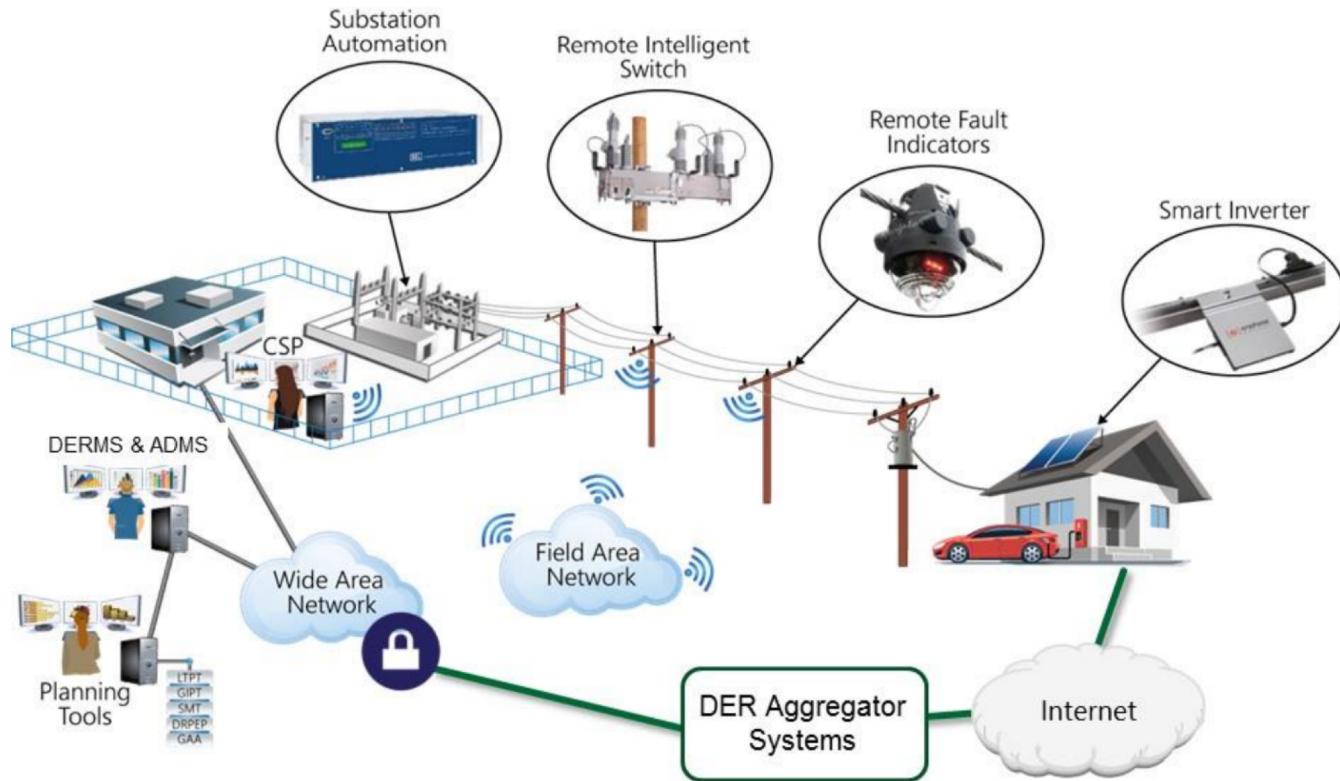
Cost (\$/kWh)
of lithium-ion
batteries is
dropping

Source: Bloomberg



Source: Bloomberg

Digitalization: Information overload



Adapted from Southern California Edison

Agenda

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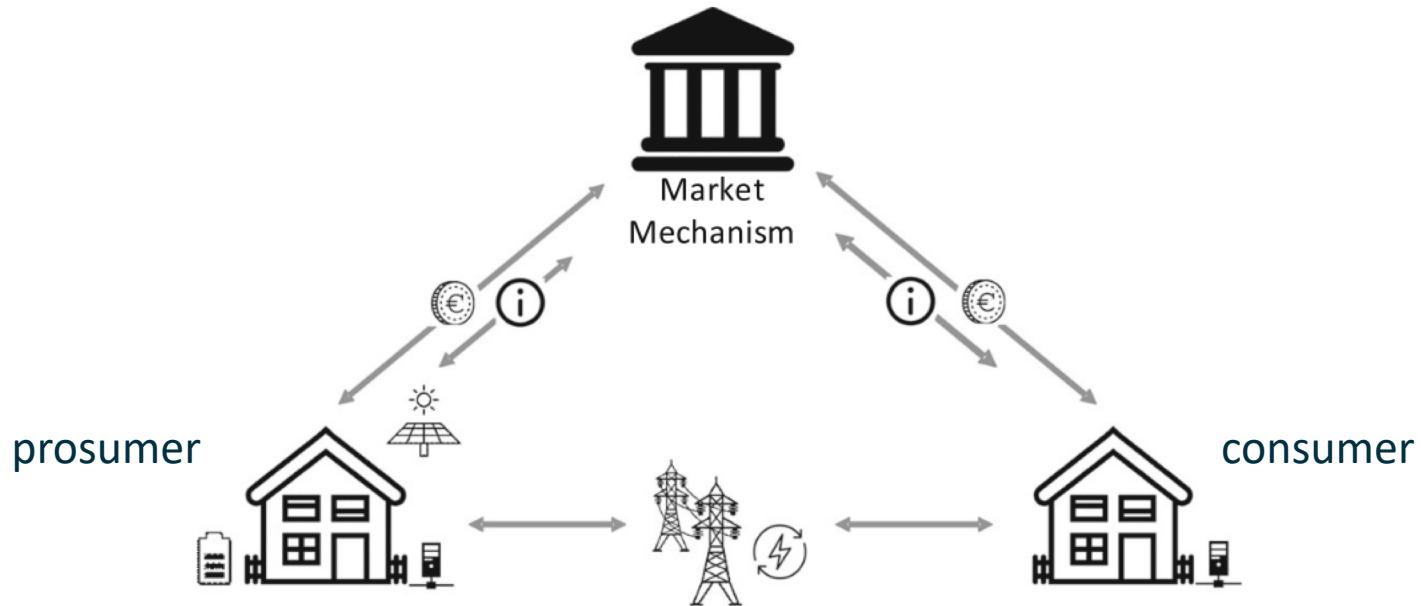
How to
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Imagine a future ...

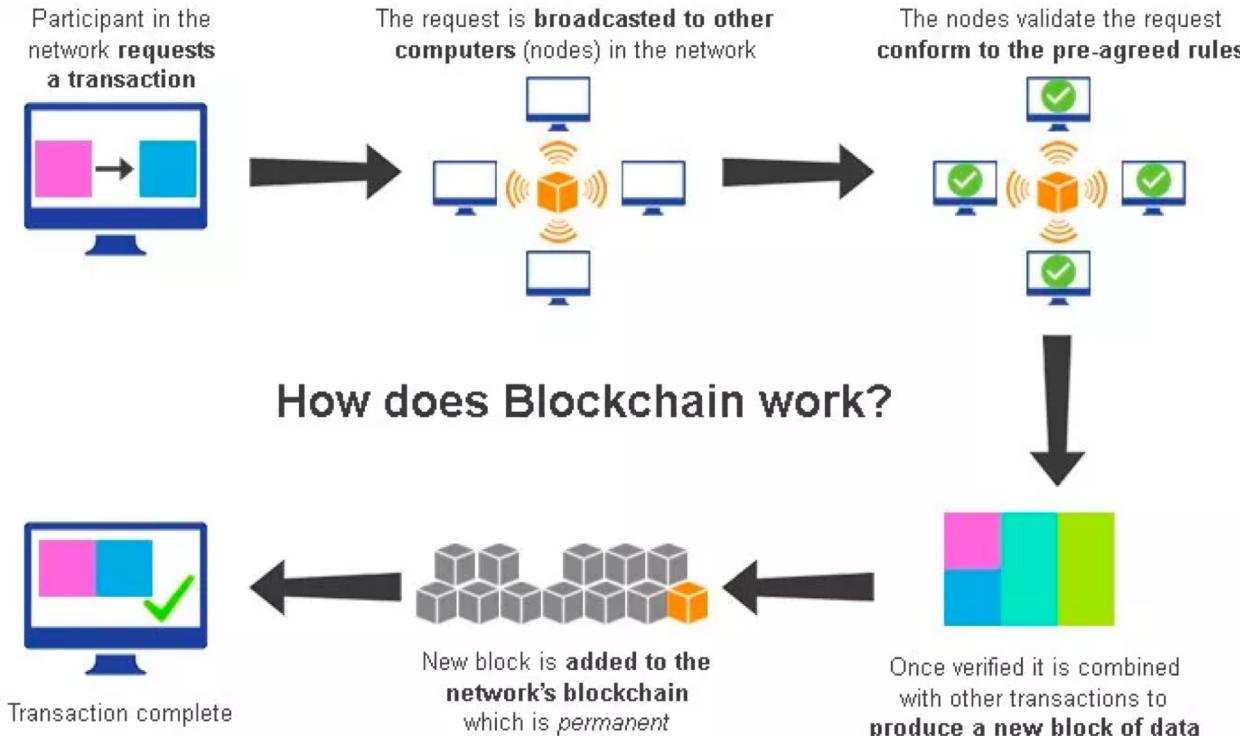


Local energy markets must manage transactions.



- **Information exchange (bid/ask orders)**
- **Money transfer**
- **Physical energy exchange via grid**

Blockchain is a possible market mechanism.



Brooklyn is testing a blockchain-based microgrid.

Applied Energy 210 (2018) 870–880



ELSEVIER

Contents lists available at [ScienceDirect](#)

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy



Designing microgrid energy markets A case study: The Brooklyn Microgrid



Esther Mengelkamp ^{a,*}, Johannes Gärttner ^a, Kerstin Rock ^b, Scott Kessler ^b, Lawrence Orsini ^b, Christof Weinhardt ^a

^a Karlsruhe Institute of Technology (KIT), Institute for Information Systems and Marketing, Fritz-Erler-Str. 23, 76133 Karlsruhe, Germany

^b L03 Energy, 621 Degraw Street, 11215 Brooklyn, New York, NY, USA

MISSOURI
S&T

HIGHLIGHTS

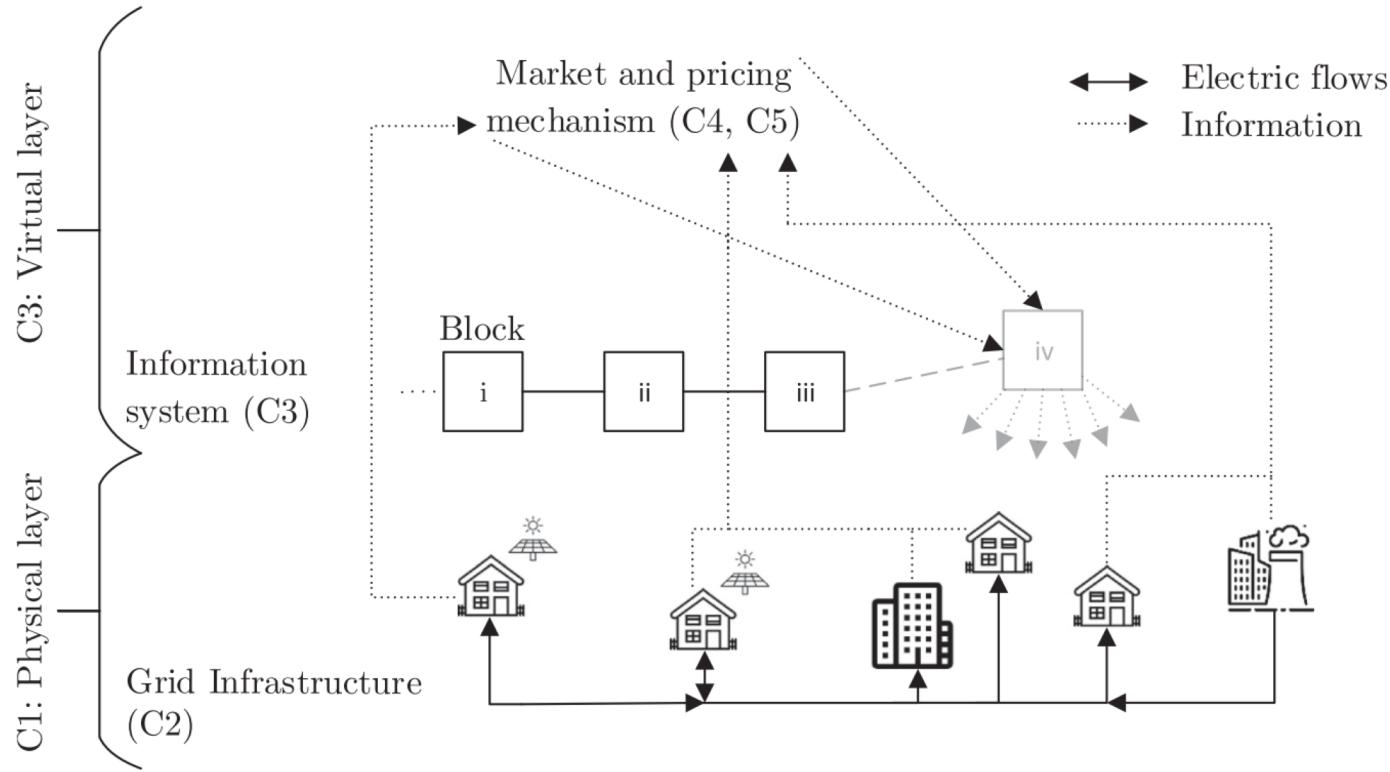
- State-of-the-art overview of blockchain-based local energy trading.
- 7 required components are derived for the design of microgrid energy markets.
- A case study, the Brooklyn Microgrid, is evaluated according to the 7 components.


L03 ENERGY

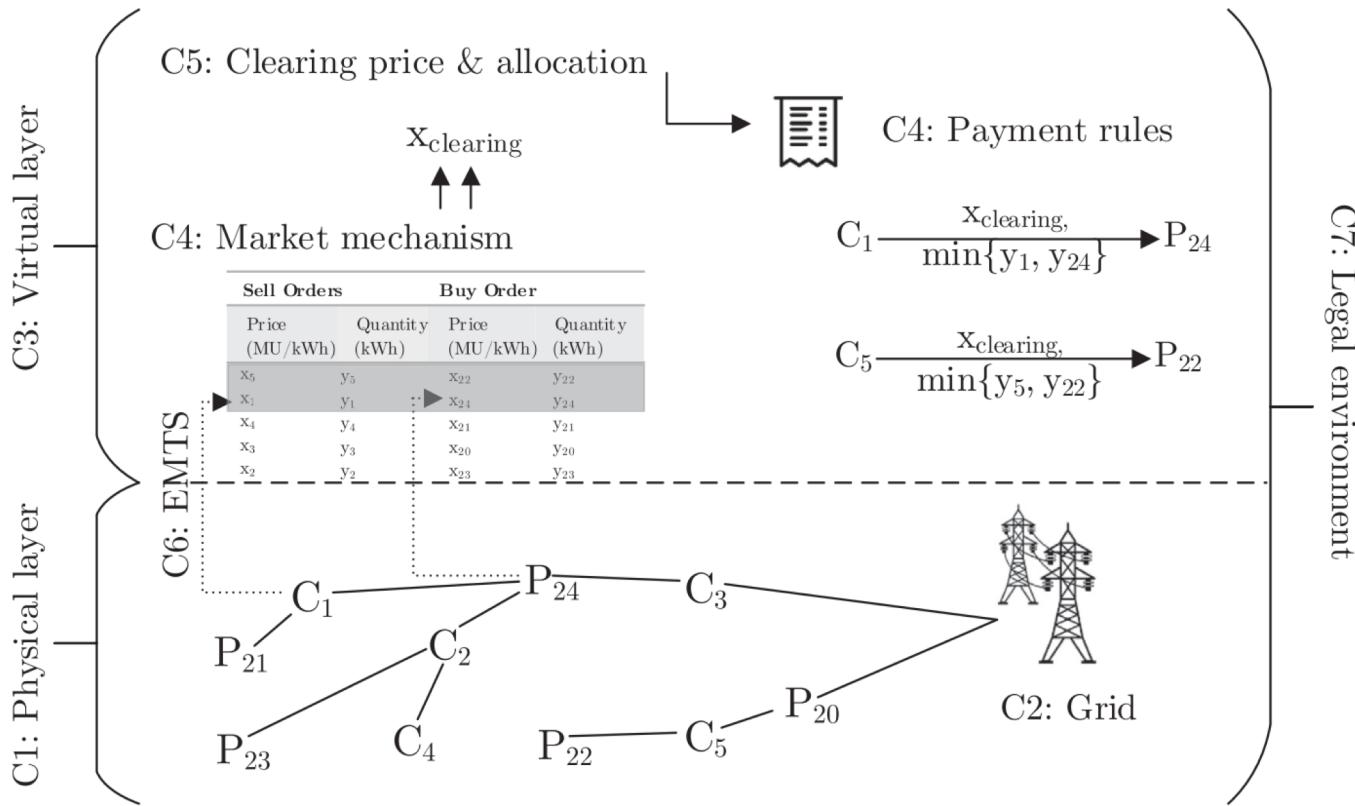


BROOKLYN
MICROGRID

The utility is still involved ... for now.



They are testing an auction-based market.



But not everyone is convinced.



By Patrick Thompson

JUN 02, 2018

Bitcoin Mining's Electricity Bill: Is It Worth It?

NEWS

Bitmain co-founder speaks about the dilemma between privacy and security



Published 4 days ago on September 22, 2018
By Ajay Narayan

BLOCKCHAIN

Exploring the Security Weaknesses of the Blockchain



By TechBullion PR

Posted on September 25, 2018

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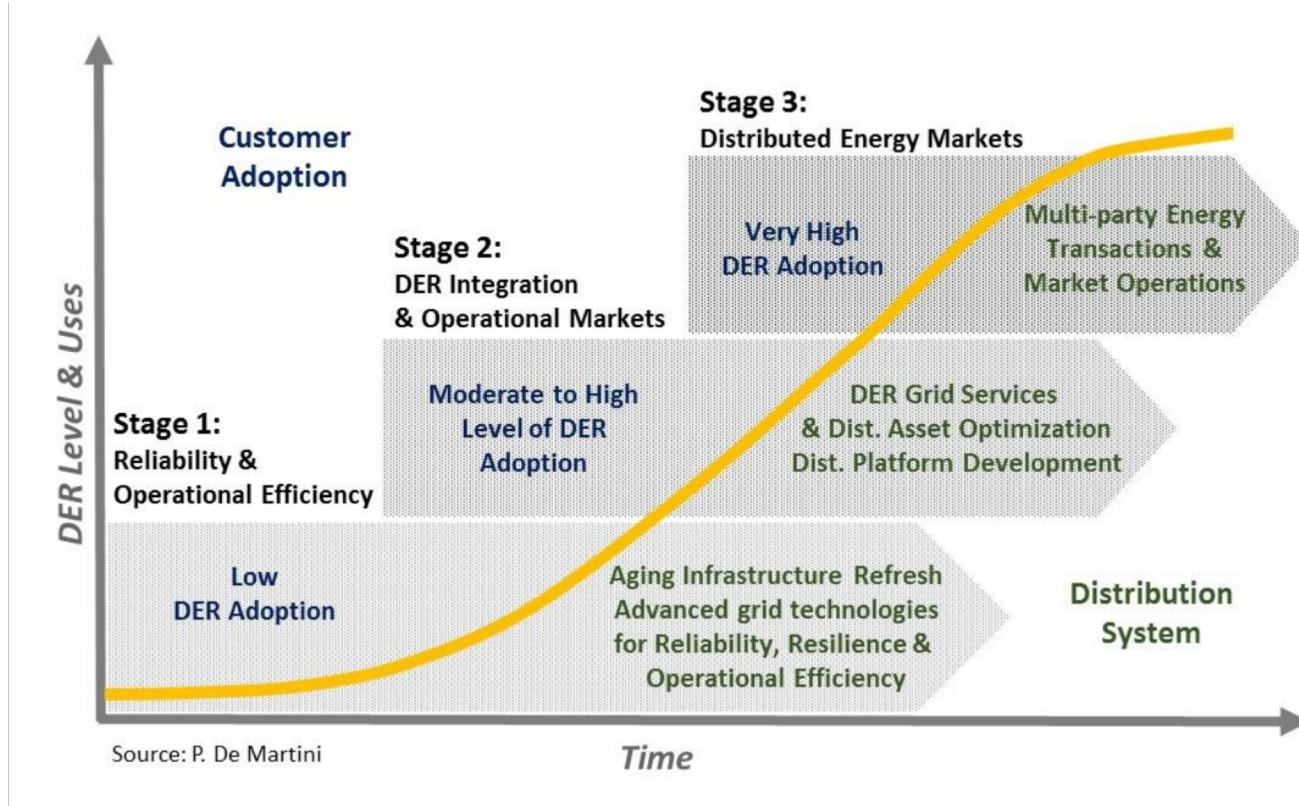
Now
What?

Now what?

How do we navigate
potential futures?

The Walk, Jog, Run Model reduces risk.

Note:
DER =
Distributed
Energy
Resources



I focus on the human part of complex problems.



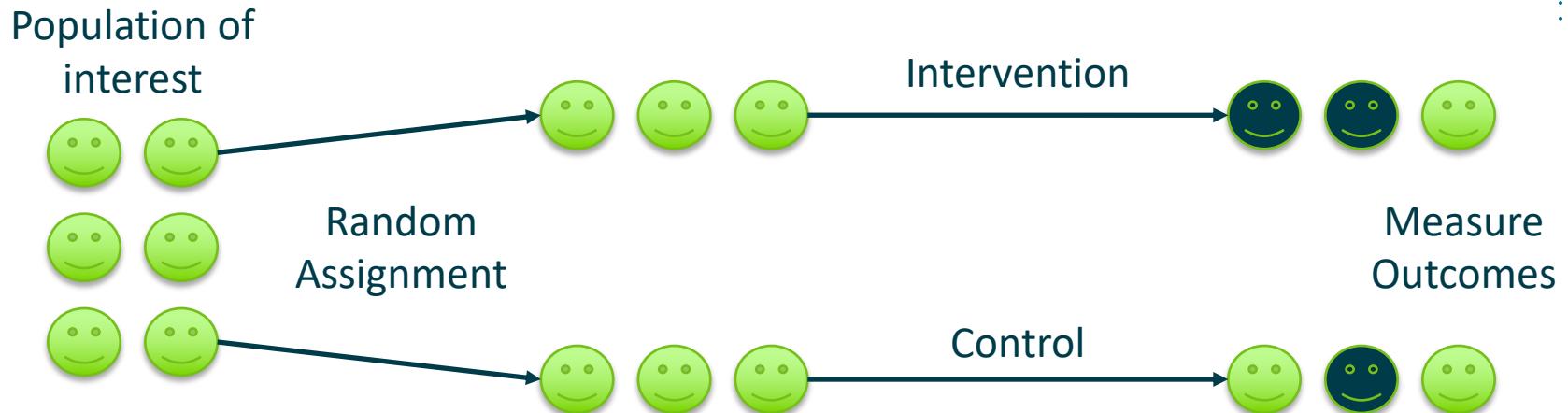
I use decision science to understand humans.

- > How should people make decisions?
(normative analysis)
- > How do people make decisions?
(descriptive research)
- > How can we help people make better decisions?
(prescriptive interventions)

We need an evidence-based strategy.



Randomized controlled trials are the gold standard.



Of course it's not that simple ...

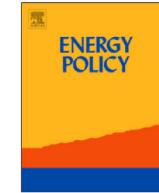
Energy Policy 62 (2013) 401–409



Contents lists available at [ScienceDirect](#)

Energy Policy

journal homepage: www.elsevier.com/locate/enpol



Setting a standard for electricity pilot studies



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^b Department of Social and Decision Sciences, Carnegie Mellon University, USA

^c Centre for Decision Research, Leeds University Business School, UK

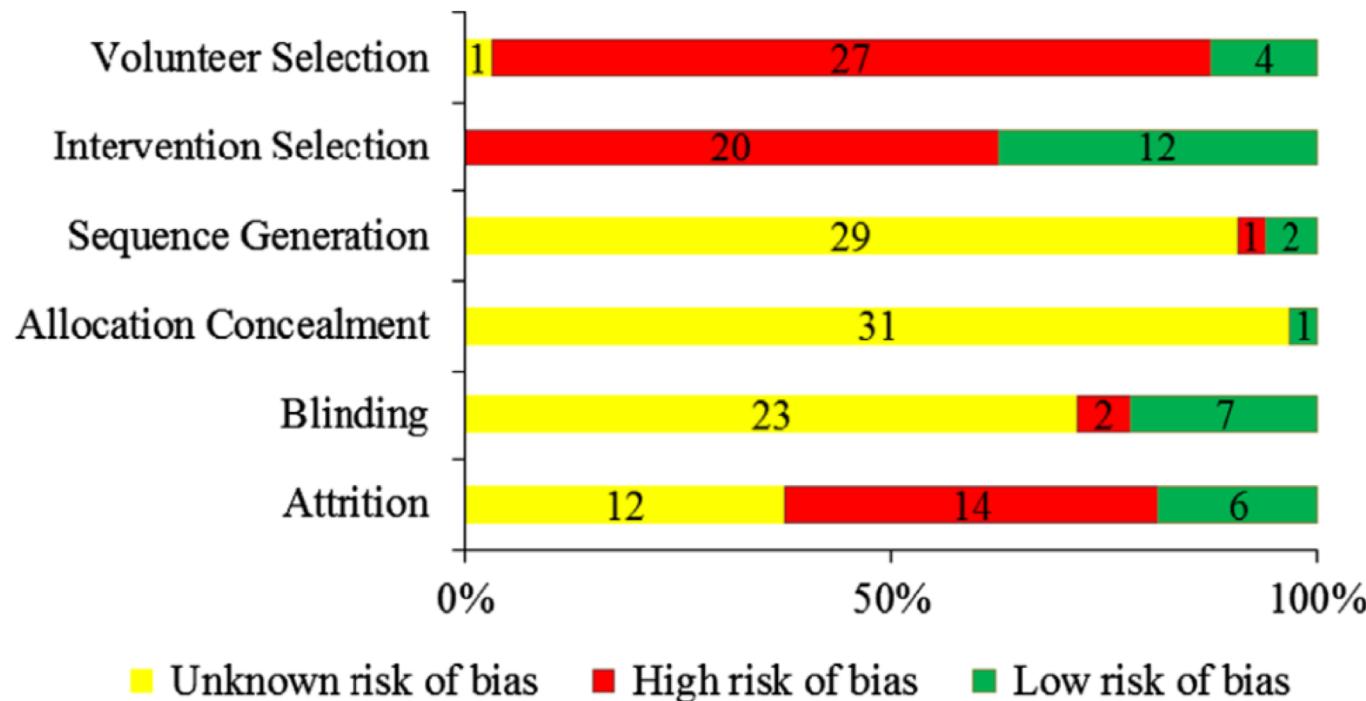
HIGHLIGHTS

- We conduct a meta-analysis of field studies of in-home displays, dynamic pricing, and automation on overall and peak use.
- Studies were assessed and adjusted for risk-of-bias from inadequate experimental design.
- Most studies were at high risk-of-bias from multiple sources.
- In-home displays provided the best overall reduction in energy use, approximately 3% after adjustment for risk-of-bias.
- Even after adjustment, automation approximately doubled the effectiveness of dynamic pricing on peak reduction from 6% to 14%.

There are 6 types of bias from medical trials.

Bias Type	High Risk	Low Risk
Volunteer	Opt-in	Opt-out
Intervention Selection	Chosen or assigned by a person	Random assignment after volunteering
Sequence Generation	Used non-random sequence	Used random sequence
Allocation Concealment	Not central randomization	Central randomization
Blinding	Participants knew about other interventions	Participants did not know about other interventions
Attrition	Data not missing at random	Accounts for missing data

Most electricity pilots are biased.



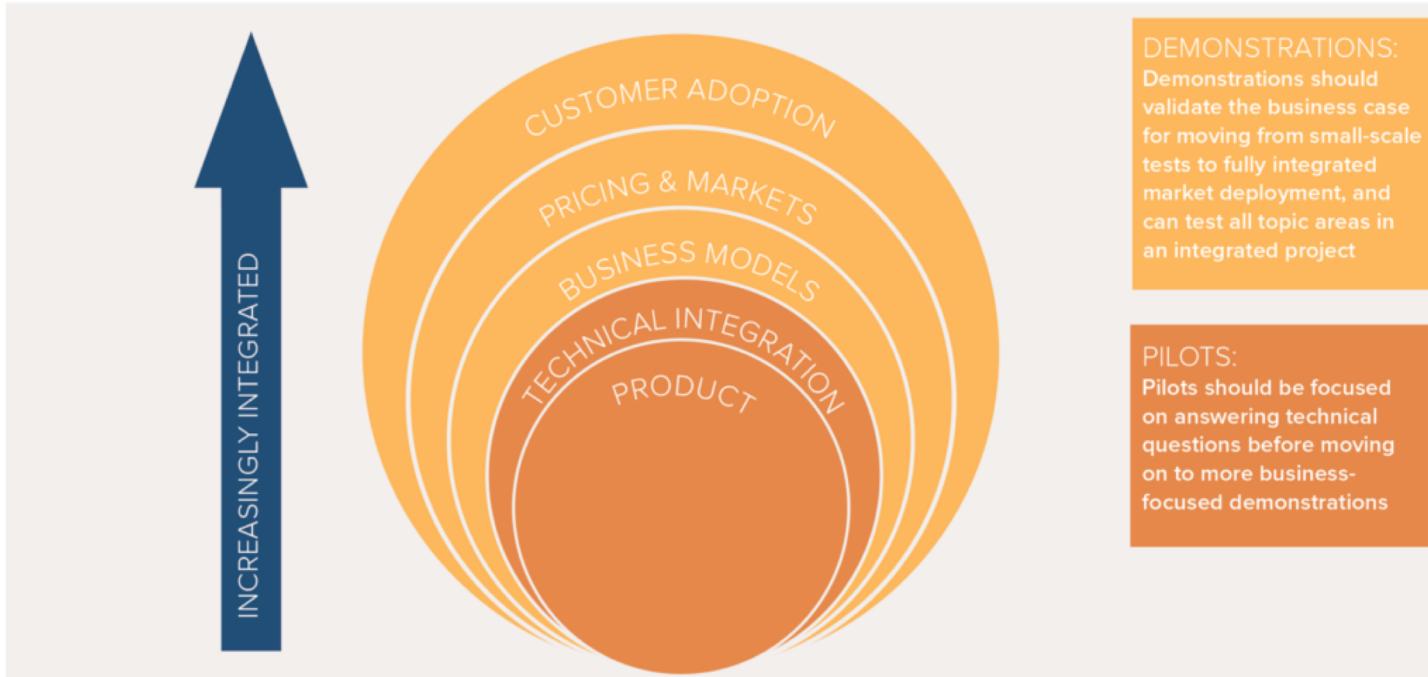
So results are over-estimated.

- > After accounting for bias:
 - The effects on reducing peak electricity use were roughly halved
 - > Dynamic pricing + Automation was most effective (~14%)
 - Most interventions were not statistically significant for reducing overall electricity use
 - > In Home Displays had a small statistically significant effect (~3%)

Company politics get in the way.



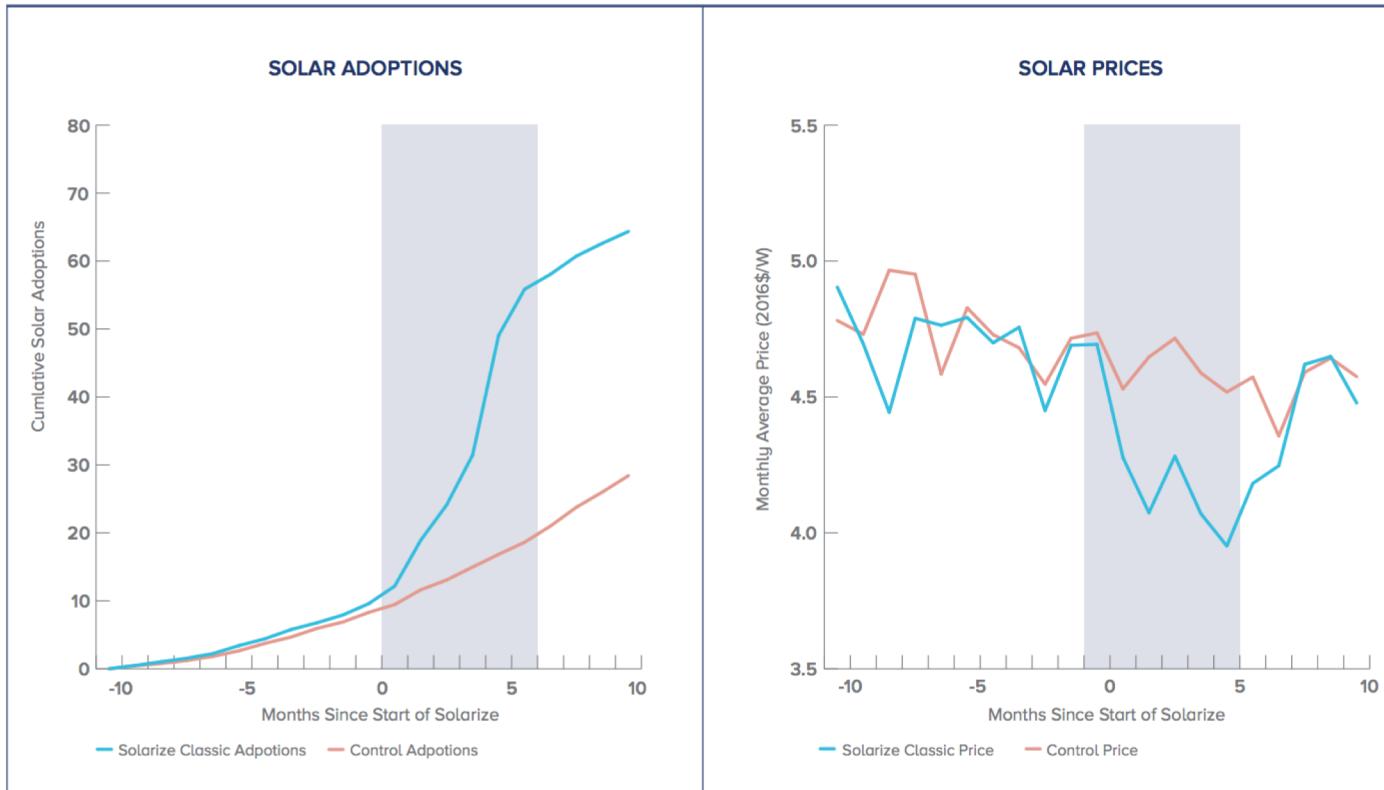
Not everyone is motivated by science.



Solarize campaigns are spreading.



Solarize increases adoption and reduces prices.

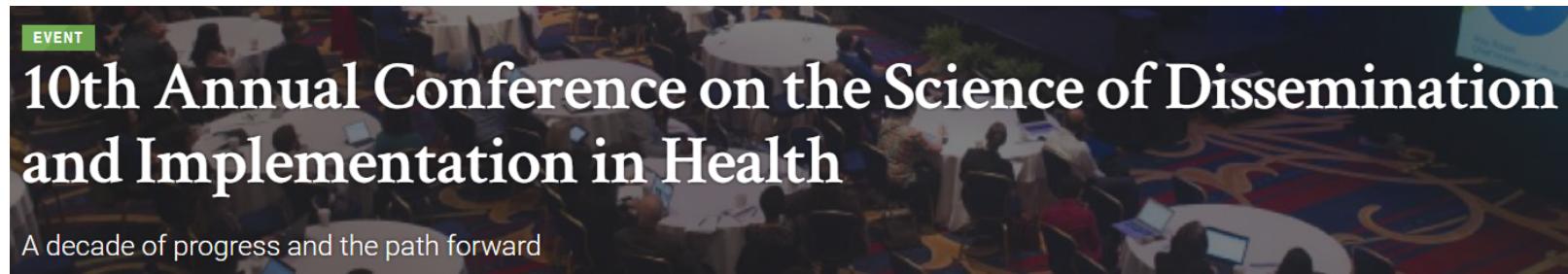


Variations influence the impact.

Model	Town Motivation	Length of Campaign	Pricing Offer	# Installers	Quote Comparison
Classic	Competitive Application	20 Weeks	Tiered	1	N/A
Select	Selected At Random	20 Weeks	Tiered	1	N/A
Express	Competitive Application	10-12 Weeks	Tiered	1	N/A
Prime	Competitive Application	20 Weeks	One Low Price	1	N/A
Choice	Competitive Application	20 Weeks	Tiered	2-3	In-Person
Online	Competitive Application	20 Weeks	N/A	5+	Online Platform

We need an implementation science for energy.

> *Implementation science* aims to better understand the “methods to improve the uptake, implementation, and translation of research findings into routine and common practices.”



So what should we do about it?

- > Do research on regulator and utility decision making
- > Do analysis to show the value of randomized controlled trials
- > Aggregate the results of experiments, pilots, and demonstrations
- > Train utilities, regulators, and policymakers on randomized controlled trials
- > Fund implementation science for energy

Agenda

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Let's review ...

- > The grid is interconnected
- > The regulatory, market, and policy environment varies by state
- > Decentralization, electrification, and digitalization are driving technology, market, and policy change
- > Blockchain-based microgrids are the future?!?!

Let's review ...

- > The walk/jog/run model outlines a slow evolution
- > Scientifically valid experiments are critical – especially for customer-facing programs
- > Many electricity pilots that involve customers are biased
- > We can use randomized controlled trials to optimize program designs

Future Opportunities



Participate

Advocate



Run
Experiments

Increase
Accessibility



Thank you

Contact me
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Source: Jordan Wirfs-Brock

Gallery of Famous Curves

