SunShot
U.S. Department of Energy

NEW IDEAS FOR SEEDING YOUR SOLAR MARKETPLACE

Program Pilots & Embedded Experiments

An interactive workshop exploring what's next for solar deployment

energy.gov/sunshot

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A Grand Challenge to Make Solar Energy Economical

2008

NATIONAL ACADEMY OF ENGINEERING

GRAND CHALLENGES FOR ENGINEERING

How do you make solar energy more economical?

Other new materials for solar cells may help reduce fabrication costs. "This area is where breakthroughs in the science and technology of solar cell materials can give the greatest impact on the cost and widespread implementation of solar electricity," Caltech chemist Nathan Lewis writes in *Science*. [Lewis 799]

A key issue is material purity. Current solar cell designs require high-purity, and therefore expensive, materials, because impurities block the flow of electric charge. That problem would be diminished if charges had to travel only a short distance, through a thin layer of material. But thin layers would not absorb as much sunlight to begin with.

One way around that dilemma would be to use materials thick in one dimension, for absorbing sunlight, and thin in another direction, through which charges could travel. One such strategy envisions cells made with tiny cylinders, or nanorods. Light could be absorbed down the length of the rods, while charges could travel across the rods' narrow width. Another approach involves a combination of dye molecules to absorb sunlight with titanium dioxide molecules to collect electric charges. But large improvements in efficiency will be needed to make such systems competitive.

SunShot: An Effort to Make Solar Cost-competitive

2011

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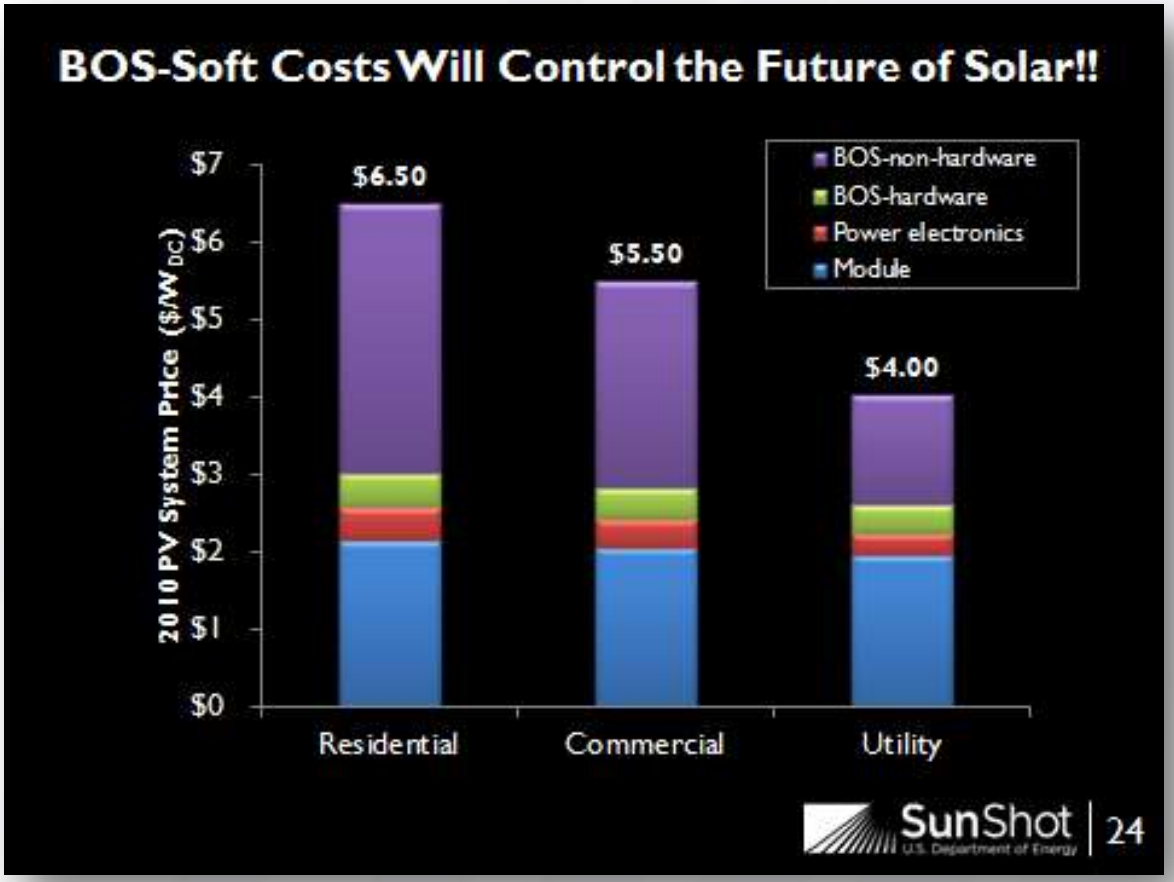
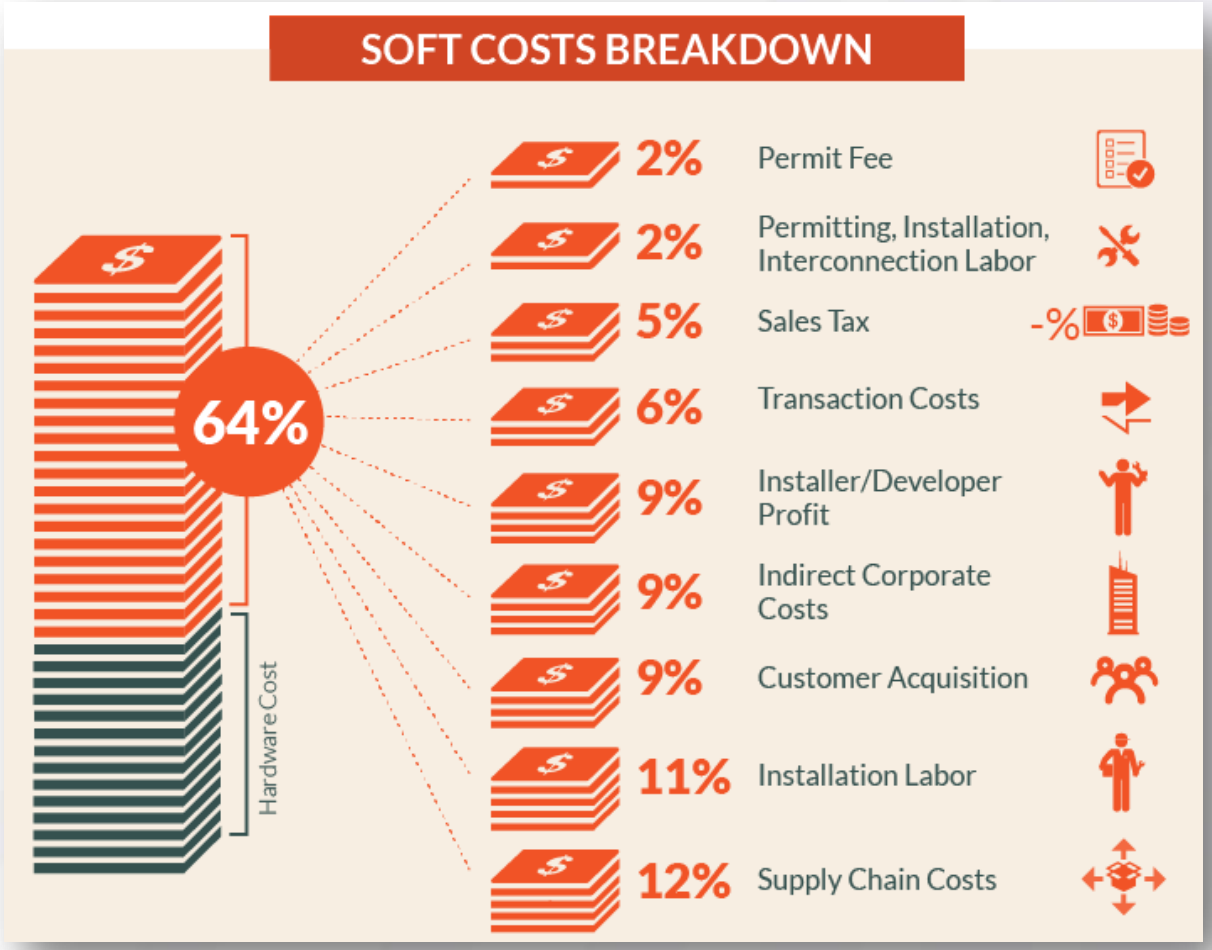


Tackling Soft Costs at the Sources



Tackling Soft Costs at the Sources

Red tape related to solar installations can drive up costs and limit solar adoption. In the U.S., there are

18,000 JURISDICTIONS,
3,000 UTILITIES,
50 STATES,

with different rules and regulations.

DSIRE™
Database of State Incentives for Renewables & Efficiency

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  1140
+  391
  1531
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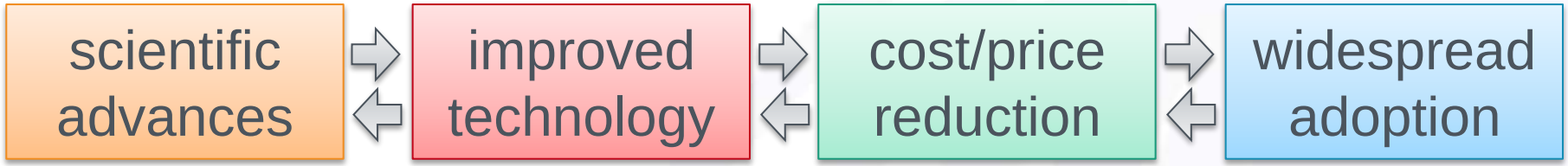
financial incentive programs for renewable energy
rules, regulations & policies for renewable energy
unique ways to sell solar

The Solar Grand Challenge at its Critical Point

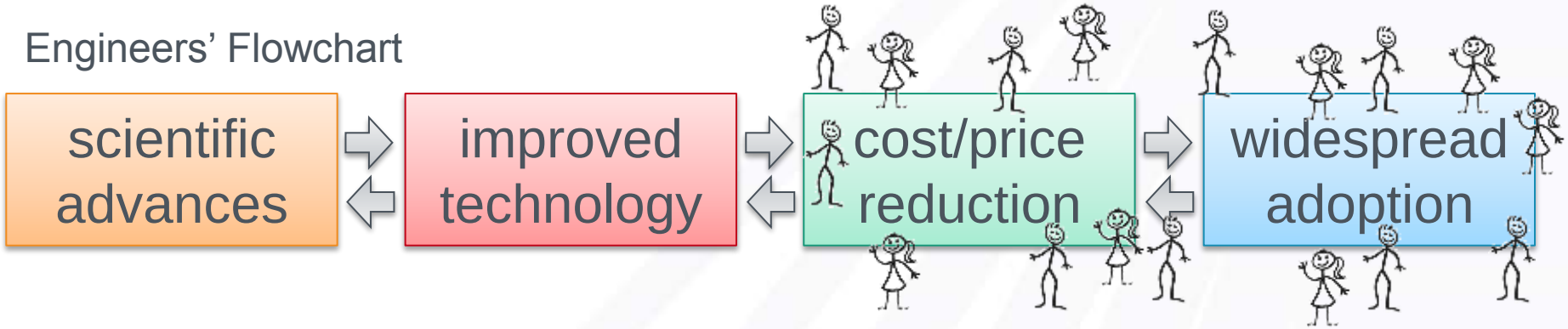
Engineers' Flowchart



$\eta_{cell} \rightarrow \eta_{SQ}$	$\eta_{module} \geq 20\%$	50 ¢/W PV	2030: 14% solar
$T_{HTF} \geq 650\ ^{o}C$	$\tau_{life} \geq 25$ years	10 ¢/W hard BOS	2050: 27% solar
100% peak load	$V_{THD} < 5\%$	40 ¢/W soft BOS	

The Solar Grand Challenge at its Critical Point

Engineers' Flowchart



"Unlike physics, where we can fundamentally figure out the upper limit for the efficiency of solar cells, there is no such limit to bureaucracy."

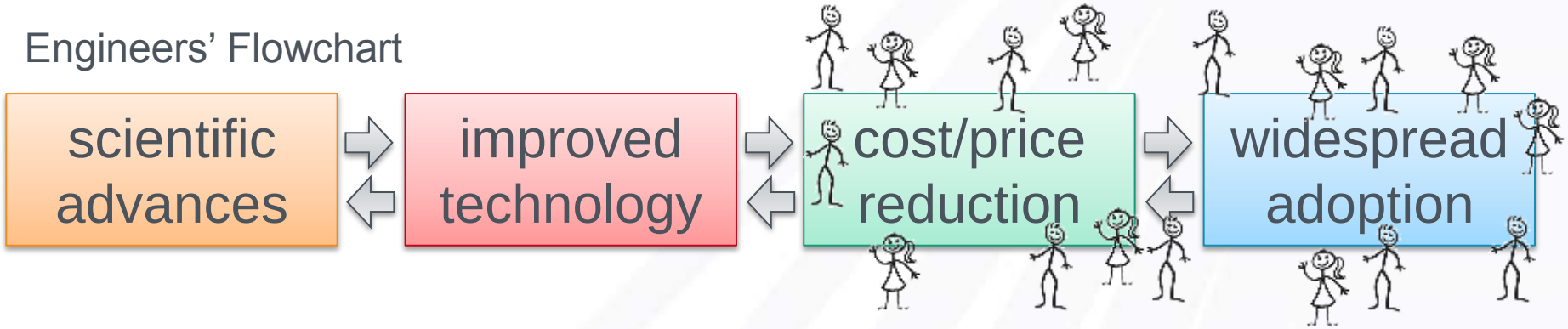
- Minh Le, DOE

soft costs

processes policies
codes standards
supply demand
rules regulations
markets barriers
behaviors beliefs

The Science of Soft Costs

Engineers' Flowchart



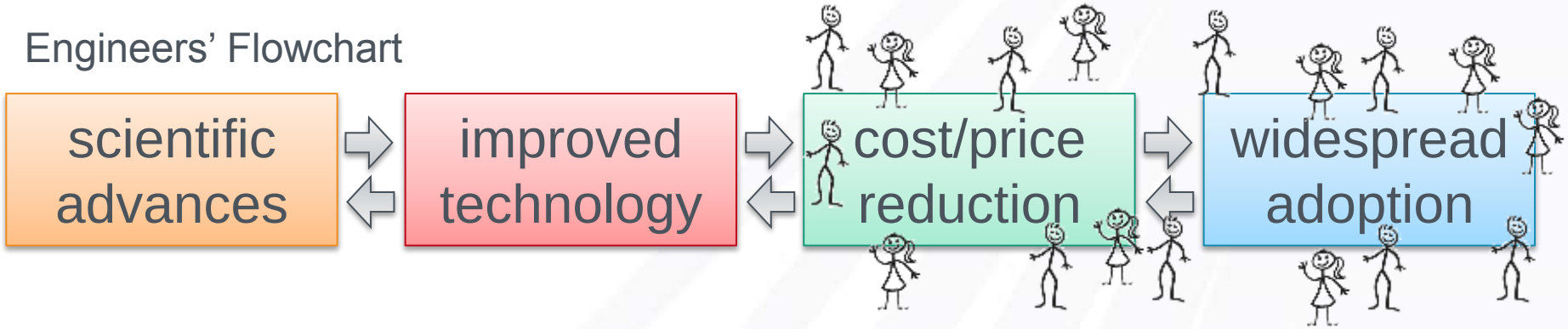
Is there a science of soft costs?

- The science of people
- The science of decisions
- The science of processes

soft costs
processes policies
codes standards
supply demand
rules regulations
markets barriers
behaviors beliefs

The Science of Soft Costs

Engineers' Flowchart



Is there a science of soft costs?

- Social science
- Behavioral science
- Economics

soft costs
processes policies
codes standards
supply demand
rules regulations
markets barriers
behaviors beliefs

The Science of Soft Costs

Soft Cost Scientists' Flowchart

scientific advances

big data analysis
field experiments
predictive models
social networks

Applying Soft Cost Science

reduced soft costs

faster adoption

New Ideas for Seeding Your Solar Marketplace

Program Pilots & Embedded Experiments

Soft Cost Scientists' Flowchart

scientific advances

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Applying Soft Cost Science

reduced soft costs

faster adoption

WORKSHOP GOALS

1. Soft cost scientists to learn the next big **questions**
2. Soft cost program managers to learn new **tools**
3. New researcher-implementer **teams** to form and invent new soft cost experiments

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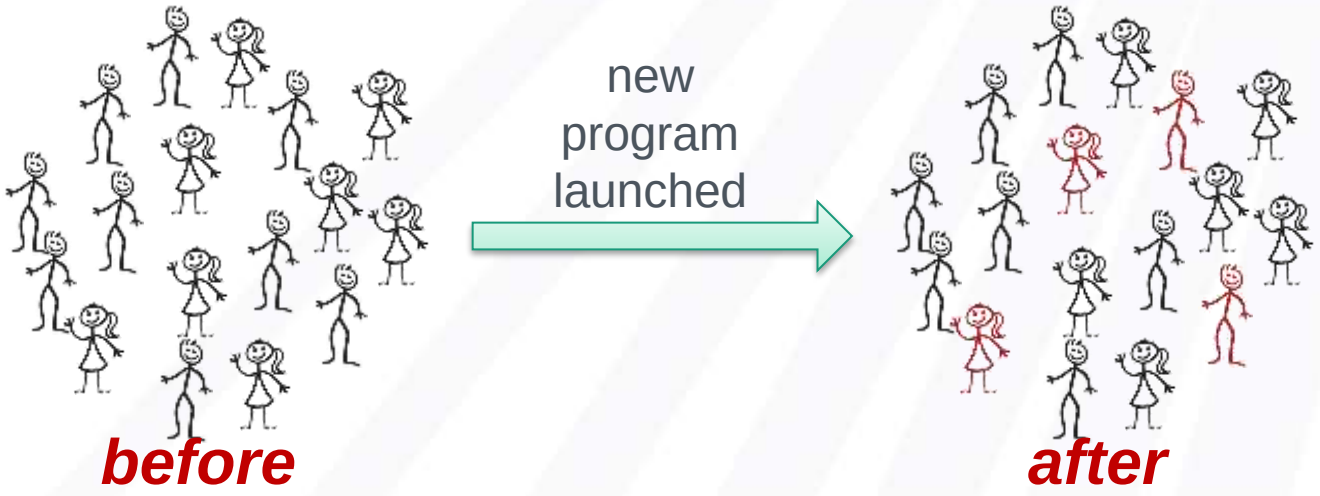
The New Soft Cost Toolbox

Measuring soft cost progress



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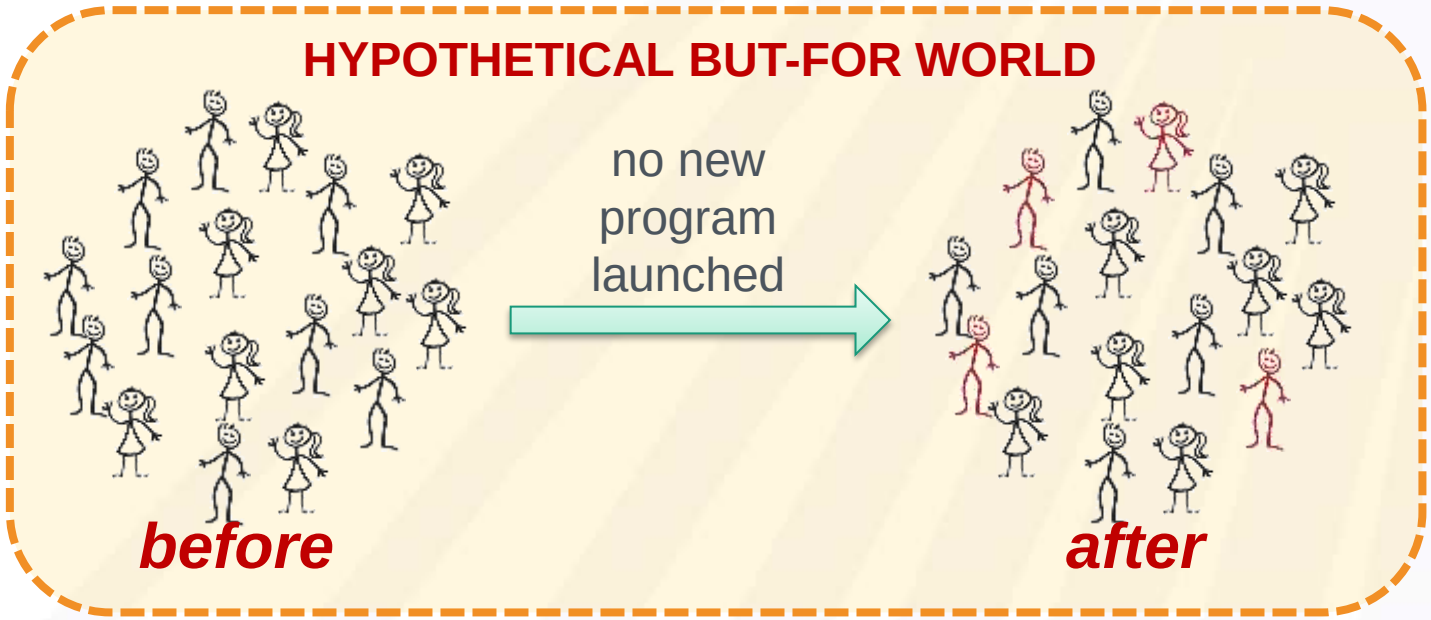
The New Soft Cost Toolbox

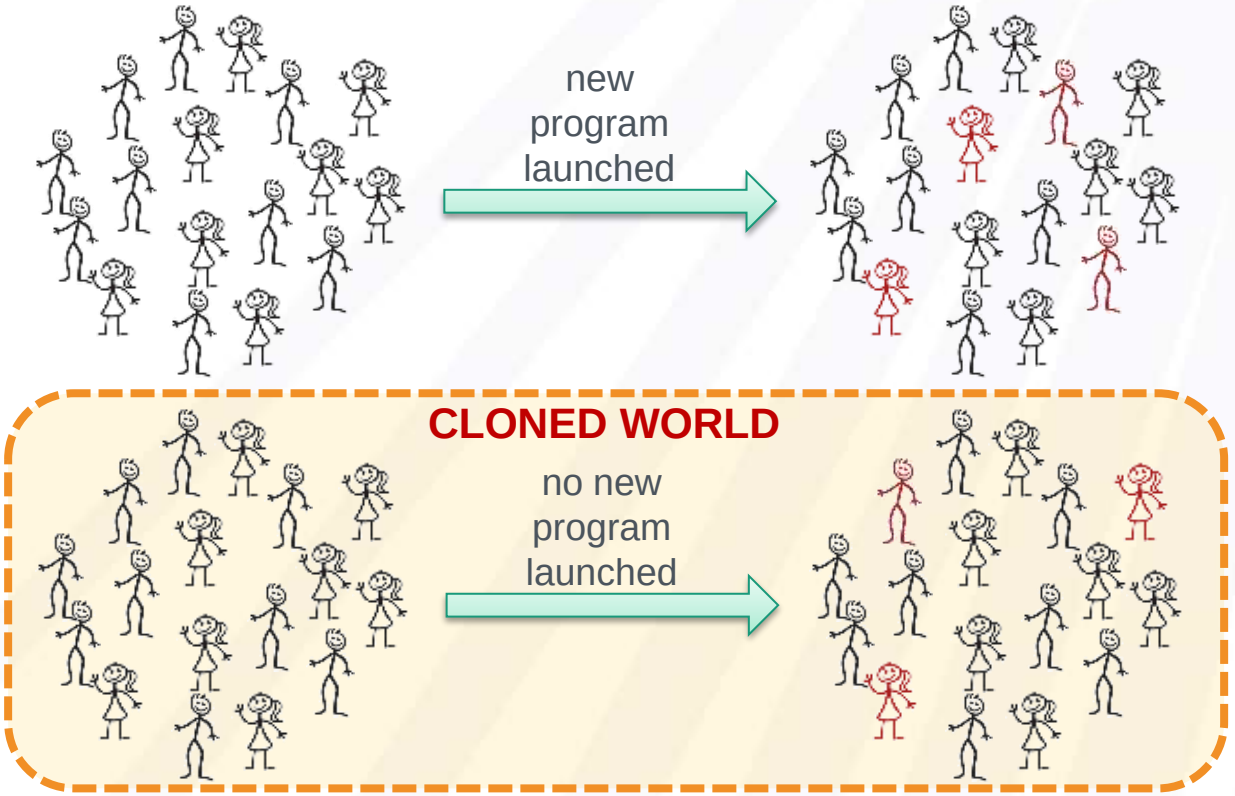
Measuring soft cost progress



Problem: We haven't invented a time machine yet.

The New Soft Cost Toolbox

Measuring soft cost progress



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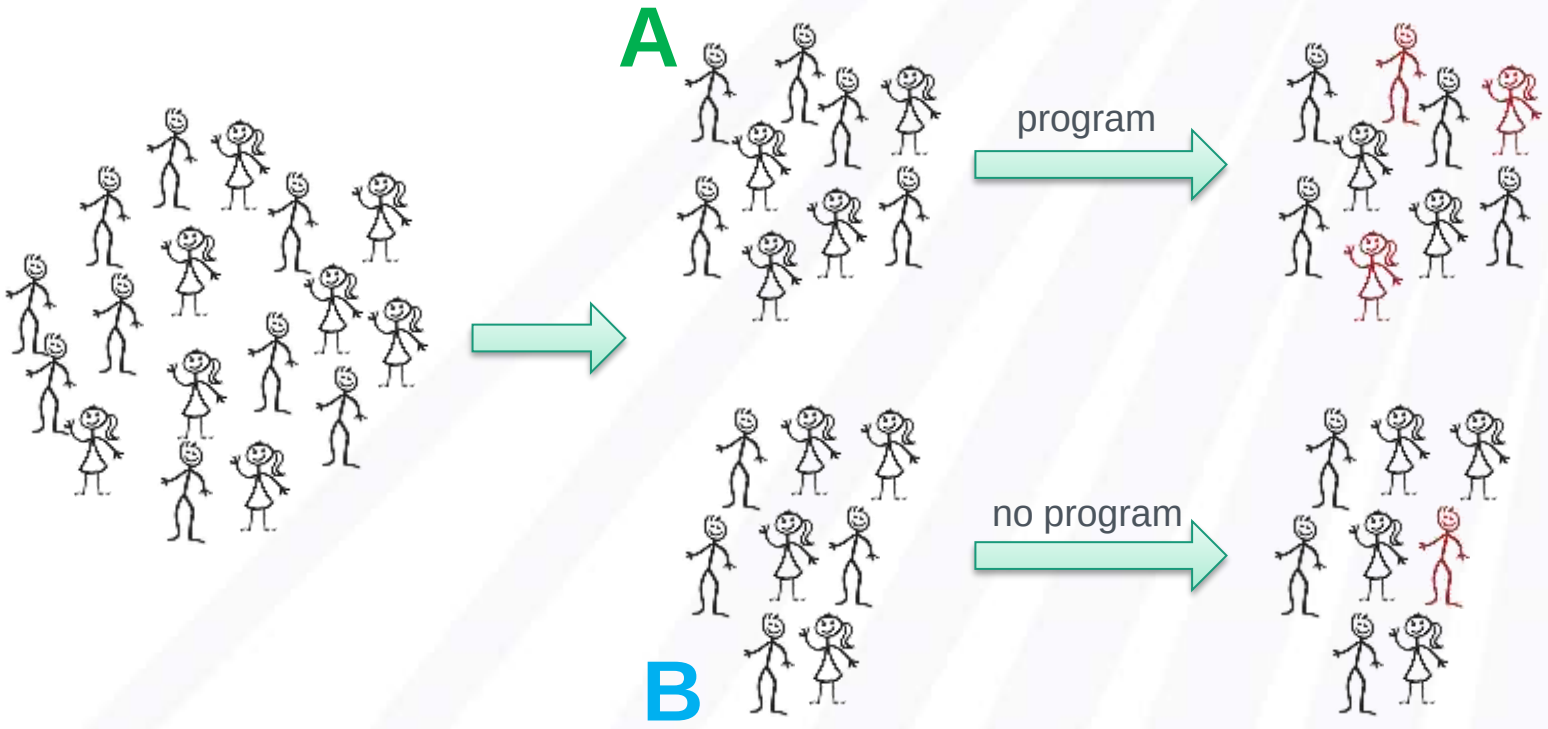
The New Soft Cost Toolbox

Randomized **C**ontrol **T**rial – the gold standard for measuring if a new program is effective



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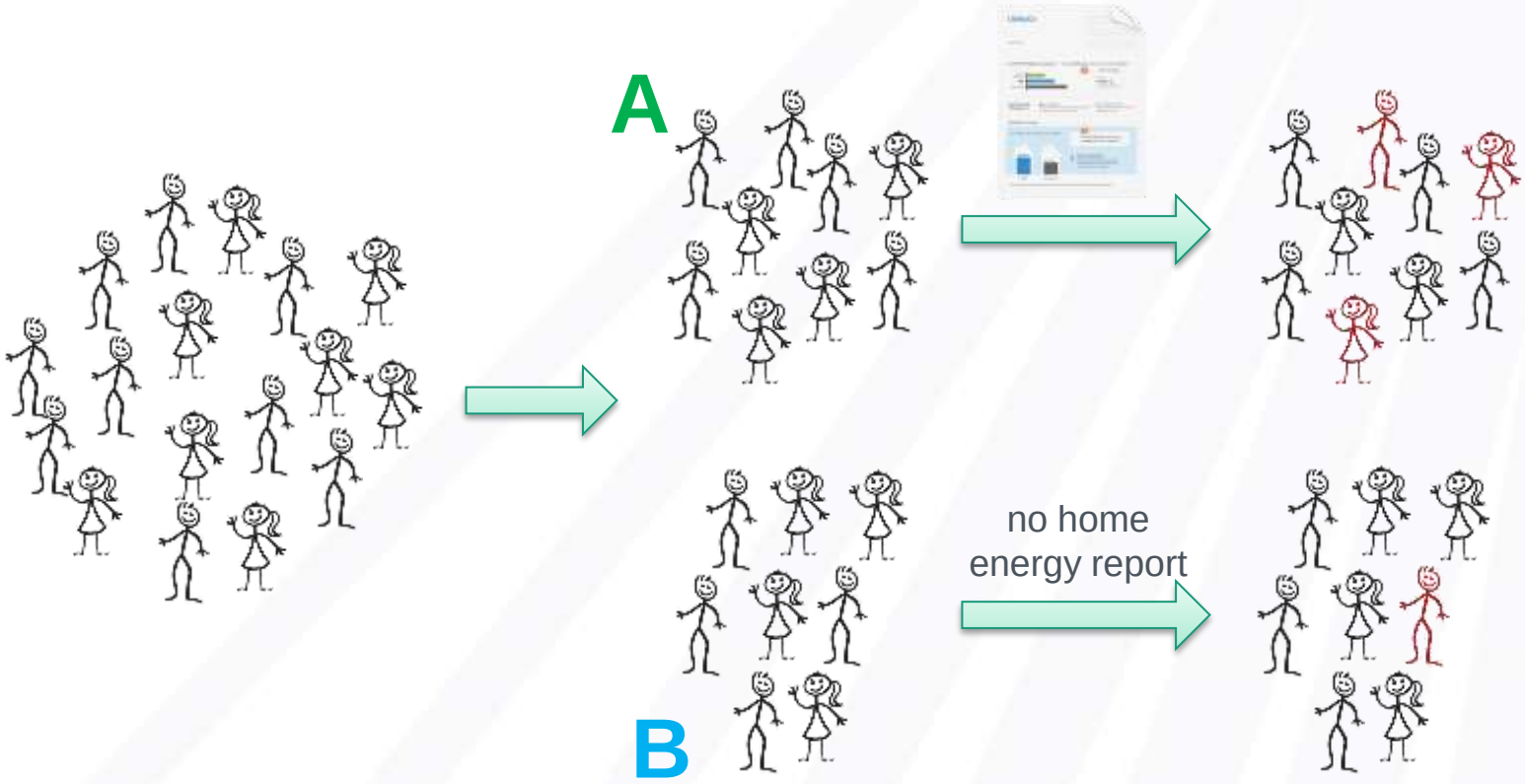
Opower: World's Largest Behavioral Experiment

Energy Efficiency RCT: 93 utilities, 32M customers



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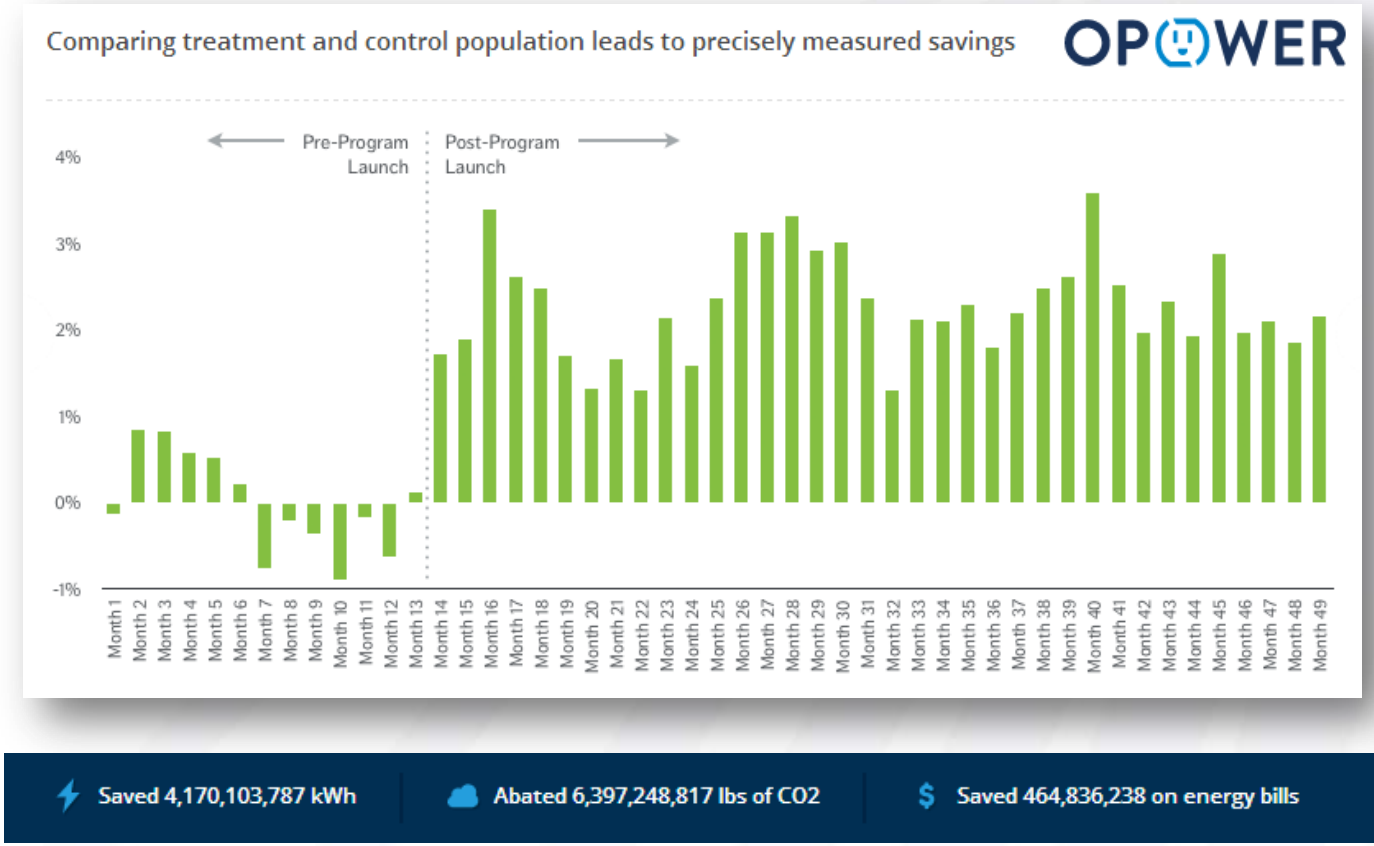
Opower: World's Largest Behavioral Experiment



H. Allcott, "Social Norms and Energy Conservation," *Journal of Public Economics* (2011).

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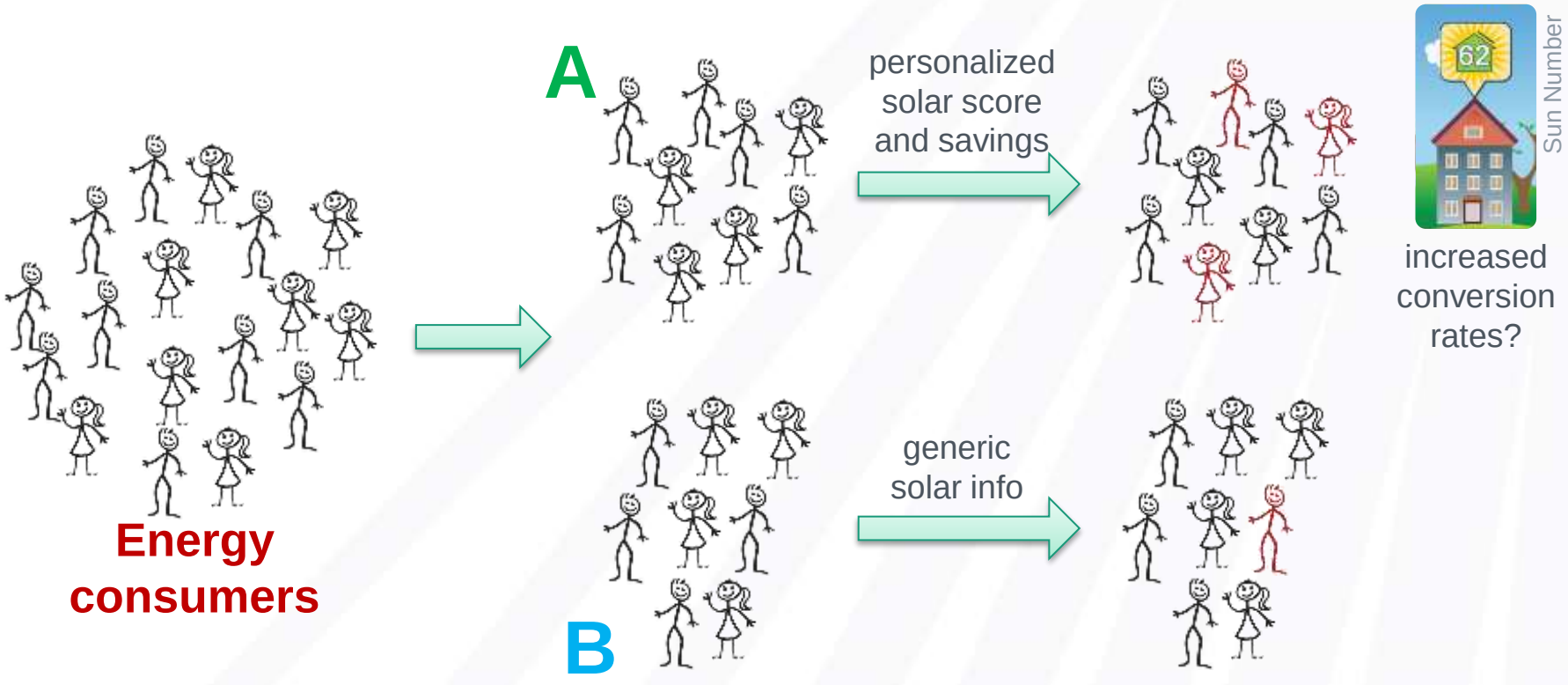
Solar Deployment RCT Examples



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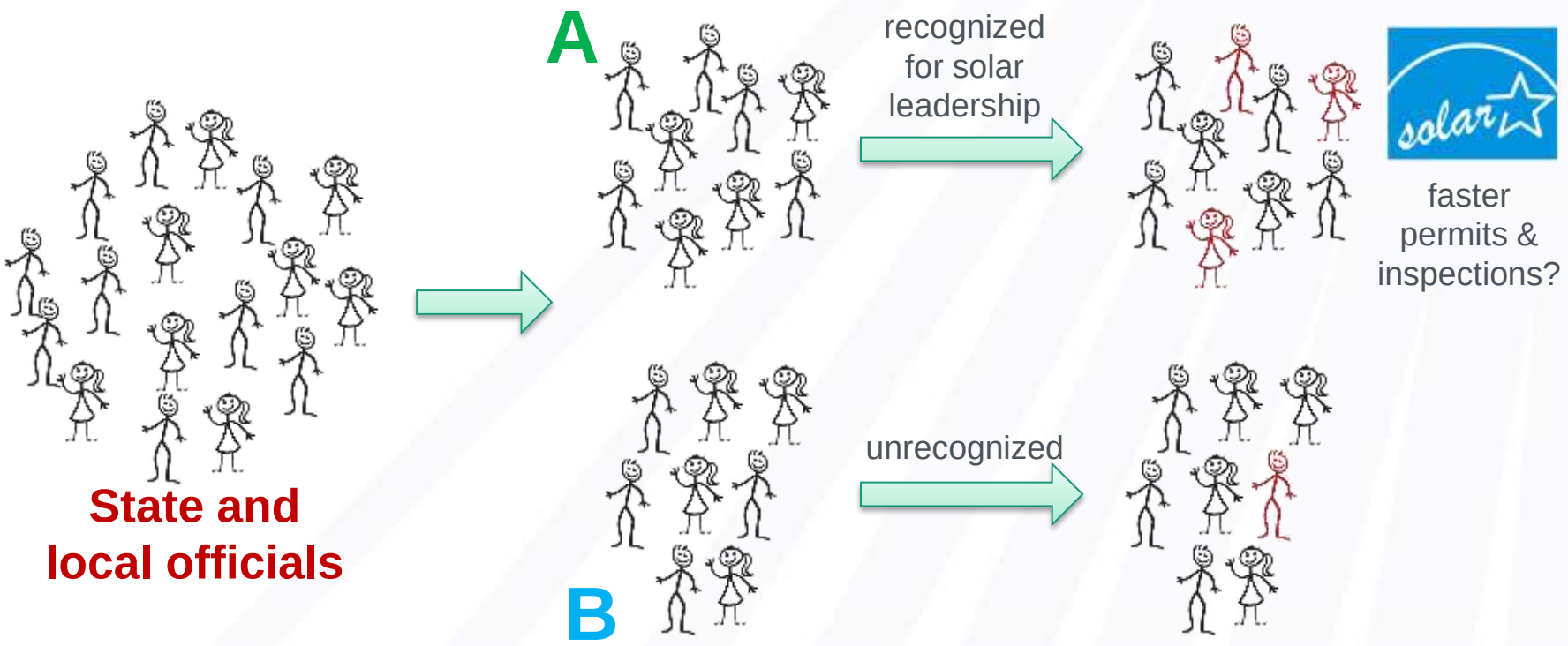
Solar Deployment RCT Examples



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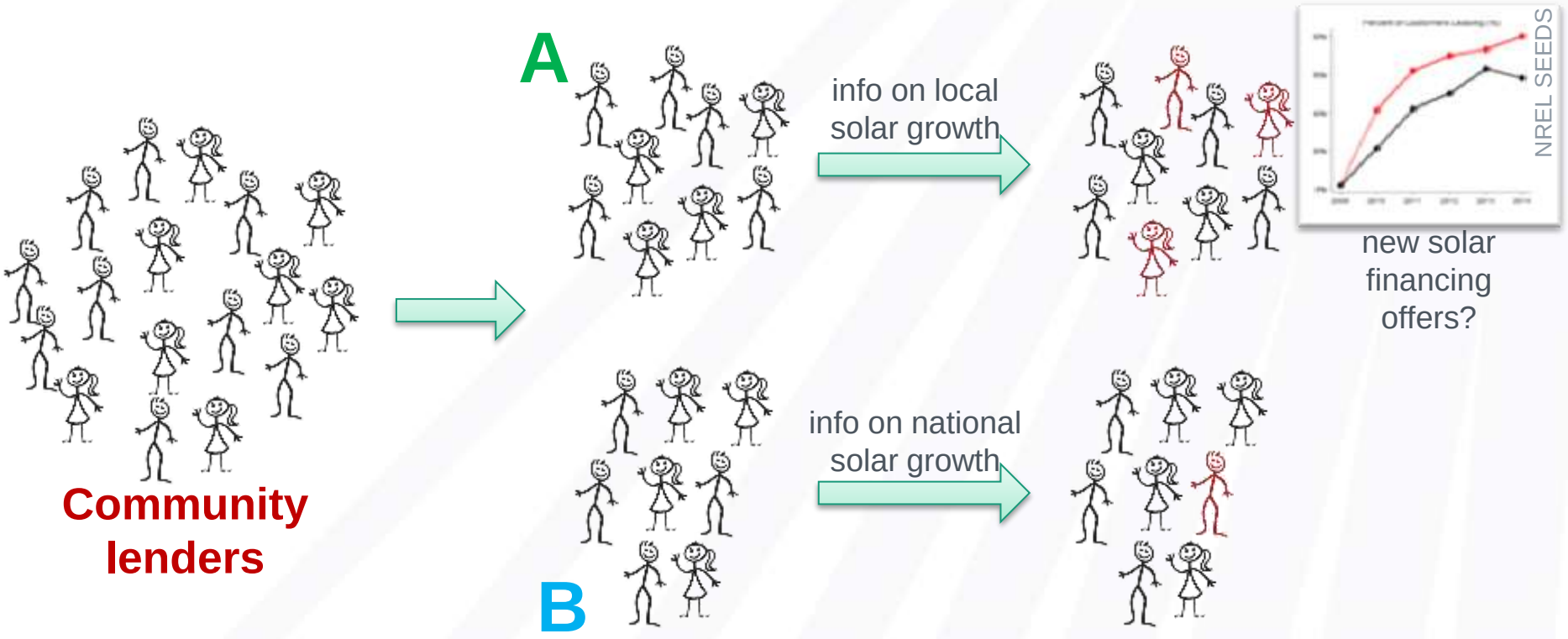
Solar Deployment RCT Examples



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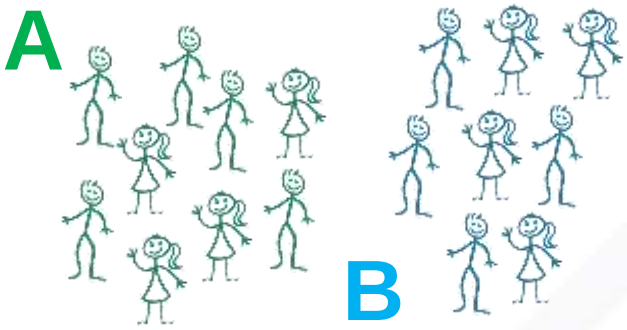
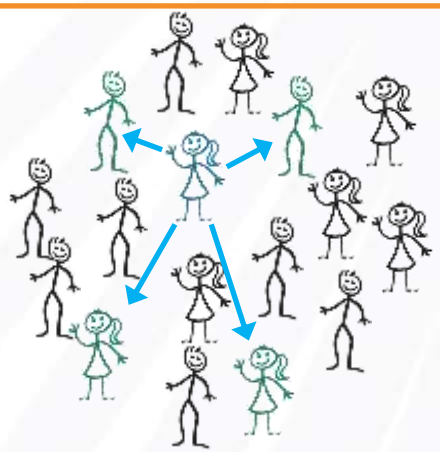
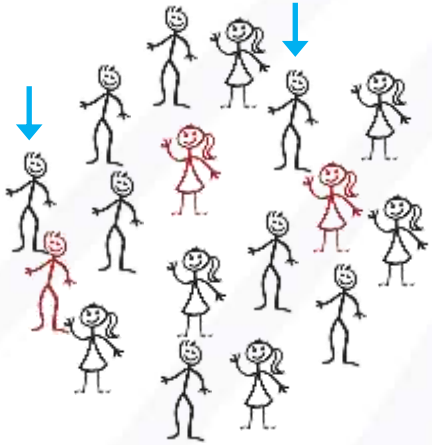
The New Soft Cost Toolbox



randomized control trials



peer effects



predictive models

SEIA

social sharing

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New Ideas for Seeding Your Solar Marketplace

Program Pilots & Embedded Experiments

9:00	Introduction Adam B. Cohen, DOE SunShot Fellow
9:10	**Keynote** Catherine Wolfram, E2e Project, UC Berkeley
9:40	**Soft Cost Grand Challenges** *Soft cost doers present on their newest ideas* Vikram Agarwal, CEO, EnergySage Jack Clark, Director of Policy, CCSE Jessie Denver, Director of GroupEnergy, Vote Solar
10:15	Coffee Break
10:30	**New Soft Cost Solution Set** *Soft cost scientists present on their newest tools* Easan Drury, NREL Kiran Lakkaraju, Sandia Labs Bill Wiehl, Facebook ** Other workshops begin at this time

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New Ideas for Seeding Your Solar Marketplace

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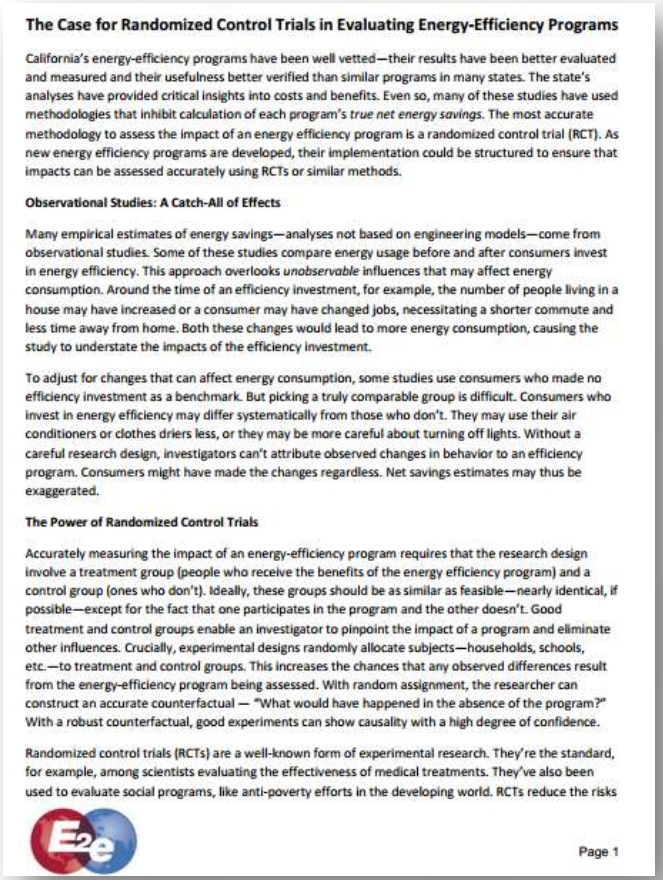
11:15	Overview of Brainstorming Sessions Adam B. Cohen, DOE SunShot Fellow
11:25	**Brainstorming Sessions** *Soft cost analyst facilitators:* Anna Brockway, DOE SunShot Fellow Elizabeth Doris, NREL Geoff Klise, Sandia Labs
12:00	Working Lunch (Continue Brainstorming)
1:00	**Finalize Solar Program Pitches**
1:30	**Solar Program Pitches**
2:00	Workshop Adjourns

New Ideas for Seeding Your Solar Marketplace

Program Pilots & Embedded Experiments



The Case for Randomized Control Trials in Evaluating Energy-Efficiency Programs

California's energy-efficiency programs have been well vetted—their results have been better evaluated and measured and their usefulness better verified than similar programs in many states. The state's analyses have provided critical insights into costs and benefits. Even so, many of these studies have used methodologies that inhibit calculation of each program's *true net energy savings*. The most accurate methodology to assess the impact of an energy efficiency program is a randomized control trial (RCT). As new energy efficiency programs are developed, their implementation could be structured to ensure that impacts can be assessed accurately using RCTs or similar methods.

Observational Studies: A Catch-All of Effects

Many empirical estimates of energy savings—analyses not based on engineering models—come from observational studies. Some of these studies compare energy usage before and after consumers invest in energy efficiency. This approach overlooks *unobservable* influences that may affect energy consumption. Around the time of an efficiency investment, for example, the number of people living in a house may have increased or a consumer may have changed jobs, necessitating a shorter commute and less time away from home. Both these changes would lead to more energy consumption, causing the study to understate the impacts of the efficiency investment.

To adjust for changes that can affect energy consumption, some studies use consumers who made no efficiency investment as a benchmark. But picking a truly comparable group is difficult. Consumers who invest in energy efficiency may differ systematically from those who don't. They may use their air conditioners or clothes driers less, or they may be more careful about turning off lights. Without a careful research design, investigators can't attribute observed changes in behavior to an efficiency program. Consumers might have made the changes regardless. Net savings estimates may thus be exaggerated.

The Power of Randomized Control Trials

Accurately measuring the impact of an energy-efficiency program requires that the research design involve a treatment group (people who receive the benefits of the energy efficiency program) and a control group (ones who don't). Ideally, these groups should be as similar as feasible—nearly identical, if possible—except for the fact that one participates in the program and the other doesn't. Good treatment and control groups enable an investigator to pinpoint the impact of a program and eliminate other influences. Crucially, experimental designs randomly allocate subjects—households, schools, etc.—to treatment and control groups. This increases the chances that any observed differences result from the energy-efficiency program being assessed. With random assignment, the researcher can construct an accurate counterfactual — "What would have happened in the absence of the program?" With a robust counterfactual, good experiments can show causality with a high degree of confidence.

Randomized control trials (RCTs) are a well-known form of experimental research. They're the standard, for example, among scientists evaluating the effectiveness of medical treatments. They've also been used to evaluate social programs, like anti-poverty efforts in the developing world. RCTs reduce the risks

E2e

Page 1

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← E2e RCT Primer for Energy Programs

http://e2e.haas.berkeley.edu

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Brainstorming Groups

A

Anna Brockway
DOE SunShot Fellow

B

Liz Doris
NREL

C

Geoff Klise
Sandia Labs