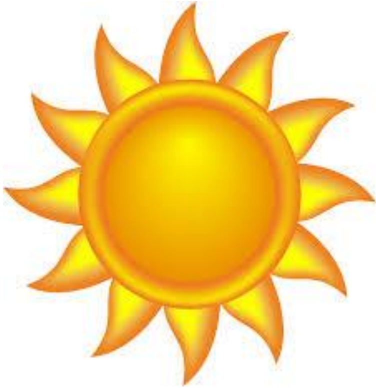
The Power of the People

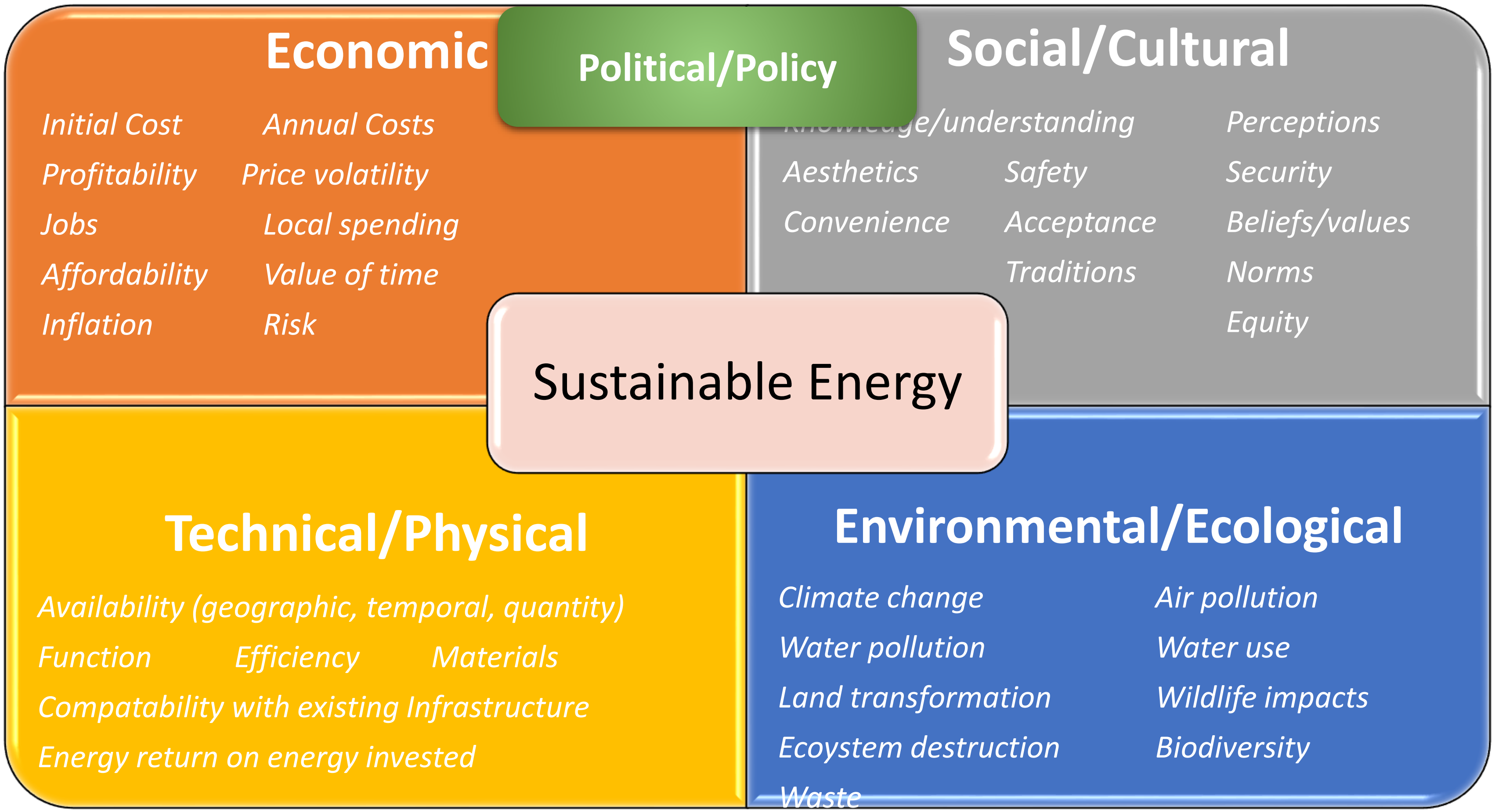
Socio-economic dimensions of community-based energy initiatives in the United States

http://www.windowinserts.com/products.html

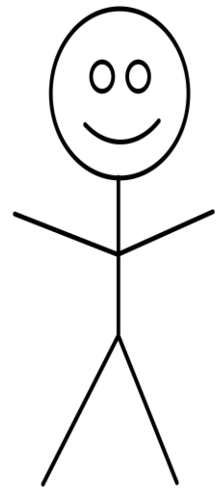
Dr. Sharon Klein
University of Maine School of Economics



What is Sustainable Energy?

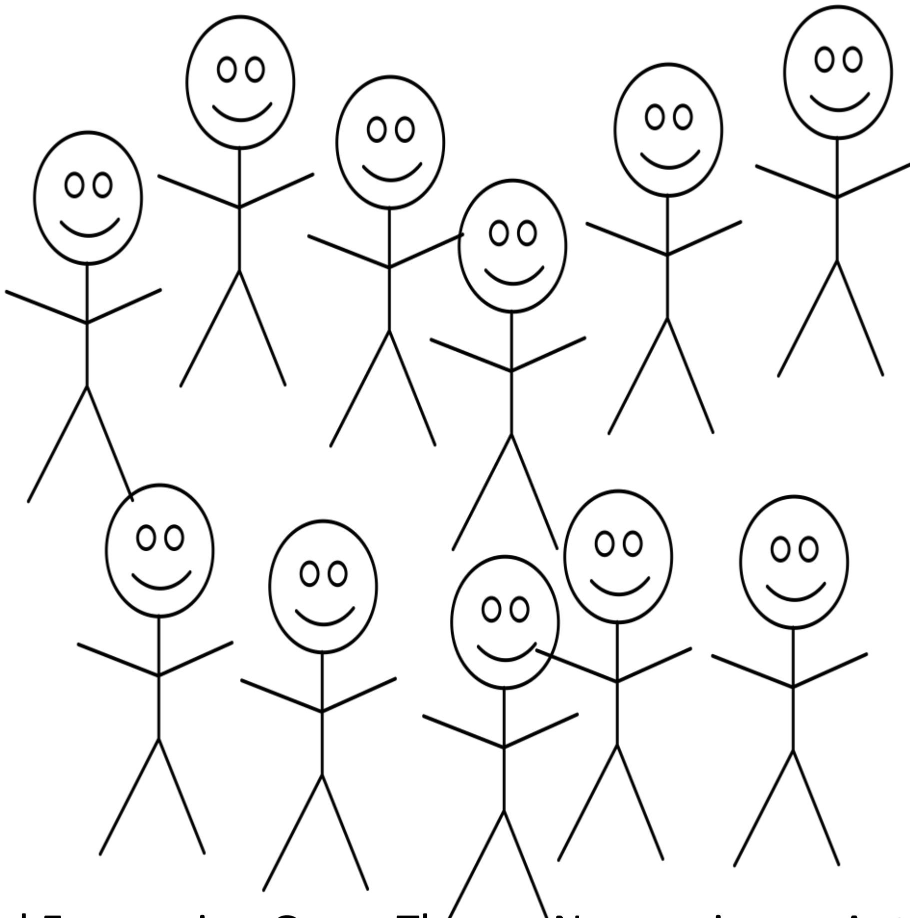


How do we get people to change?

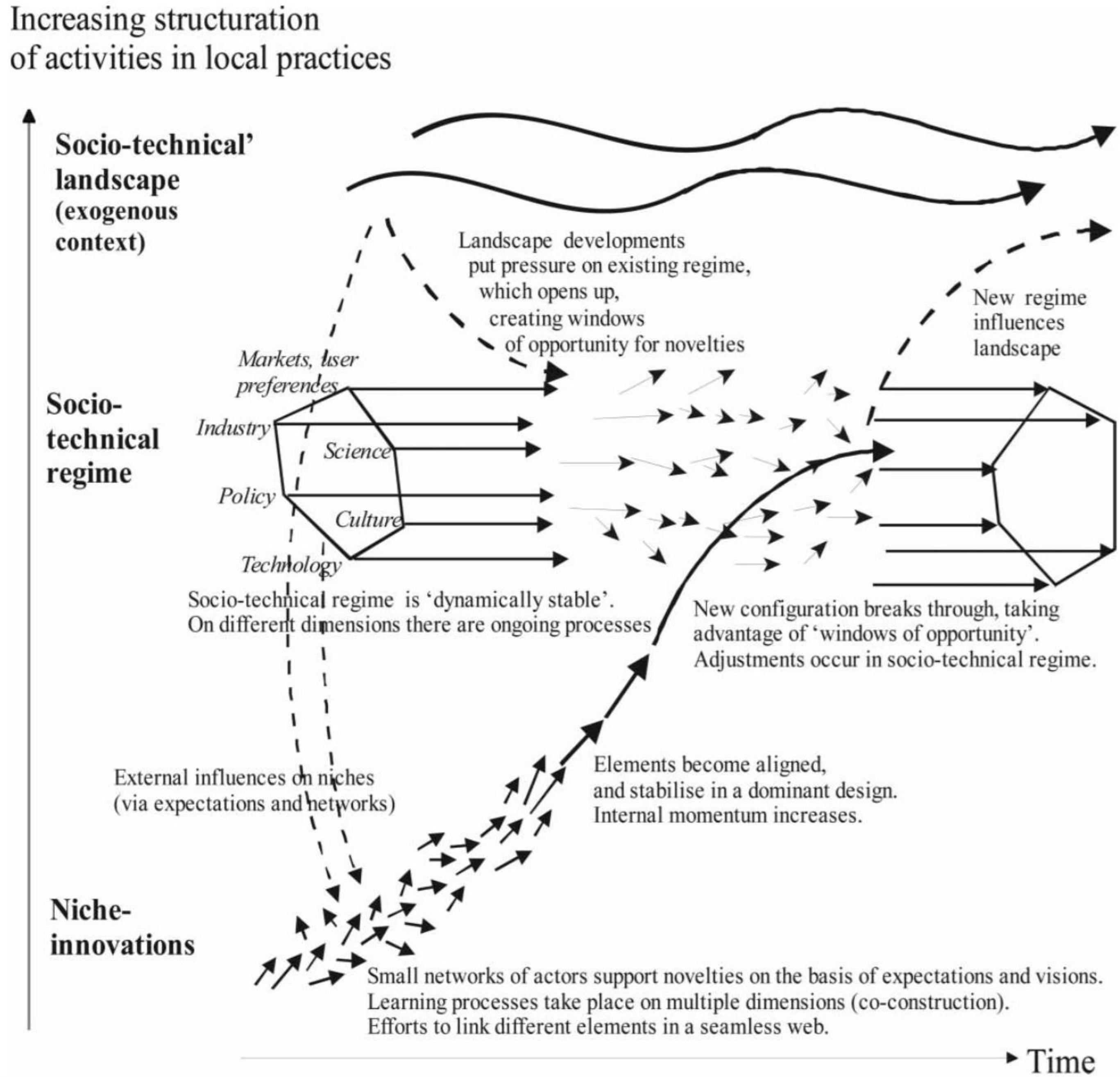


***Klein**, S.J.W. and S. Coffey, 2016, Building a sustainable energy future, one community at a time, Renewable and Sustainable Energy Reviews, vol. 60, pp. 867–880, doi: 10.1016/j.rser.2016.01.129.*

How do we get people to change?



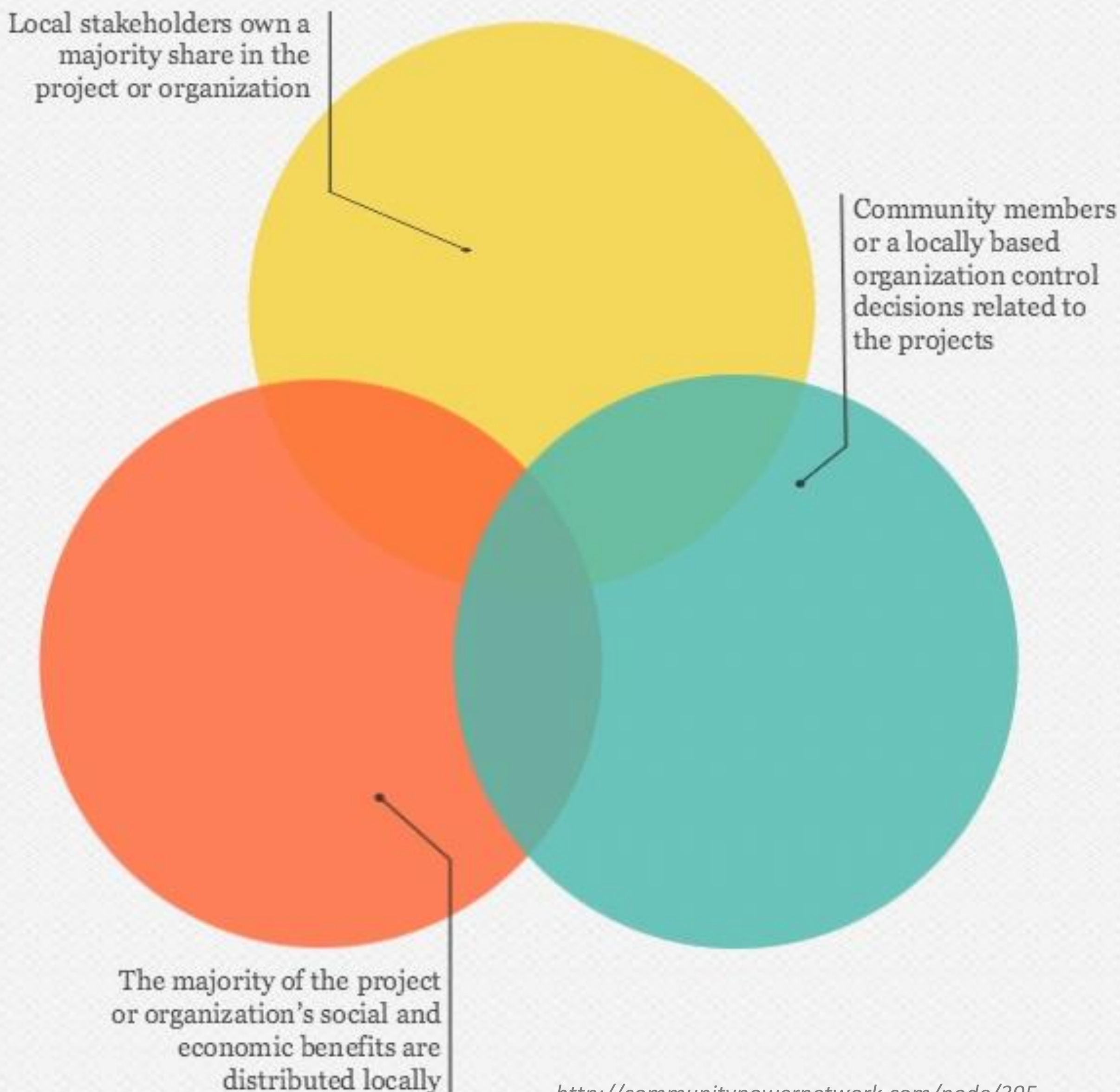
Behavioral Economics, Game Theory, Neuroscience, Anthropology, Sociology, Diffusion of Innovation Theory, Social Practice Theory, Strategic and Social Niche Management Theory



J. Schot and F. W. Geels, "Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy," Technol. Anal. Amp Strateg. Manag., vol. 20, no. 5, pp. 537–554, 2008.

What is Community Power?

A project or approach in which one (or more) of the following is true:



http://communitypowernetwork.com/node/395

Connected through:
Geography
Common Interests/goals

Sustainable Energy:
Renewable energy
Energy Efficiency
Conservation

Size?
How big is too big?
How small is too small?

Canadian Secretariat of the Commission for Environmental Cooperation, 2010

U.S. Department of Energy, 2011

Walker & Devine-Wright, 2008

2 Examples of Community Energy

Community Solar

Window Insert Builds

Source: https://ilsr.org

Why Community-based Solar?

- Expand access to solar
  - Only ¼ of U.S. residential buildings suitable for solar (NREL)
- Capacity in the United States projected to increase by

  1.8 GW through 2020

  (Green Tech Media)
- Peer effects, social norms more effective than individual incentives/education

Source: https://ilsr.org

What is Community-based Solar?

Provides power **or** financial **or** other benefits to a **group** of people

- Common local geographic area (town level or smaller)
- Common set of interests
- Some costs and/or benefits shared by group

Coughlin et. al, 2012

Walker & Devine-Wright, 2008

Where are Community-based Solar Projects in the US?

Asmus, P. (2008). Exploring New Models of Solar Energy Development. *The Electricity Journal, 21*(3), 61–70. **(4 projects)**

Farrell, J. (2010). *Community Solar Power: Obstacles and Opportunities* (Rep.). Minneapolis, MN: New Rules Project. **(8 projects)**

Coughlin, J., Grove, J., Irvine, L., Jacobs, J., Phillips, S. J., Sawyer, A., & J. W. (n.d.). *A Guide to Community Shared Solar: Utility, Private and Nonprofit Project Development* (pp. 1-76, Rep.). Golden, CO: National Renewable Energy Laboratory. **(9 projects)**

Model Rules for Shared Renewable Energy Programs (pp. 1-28, Rep.). (2013). Latham, NY: Interstate Renewable Energy Council. **(38 projects)**

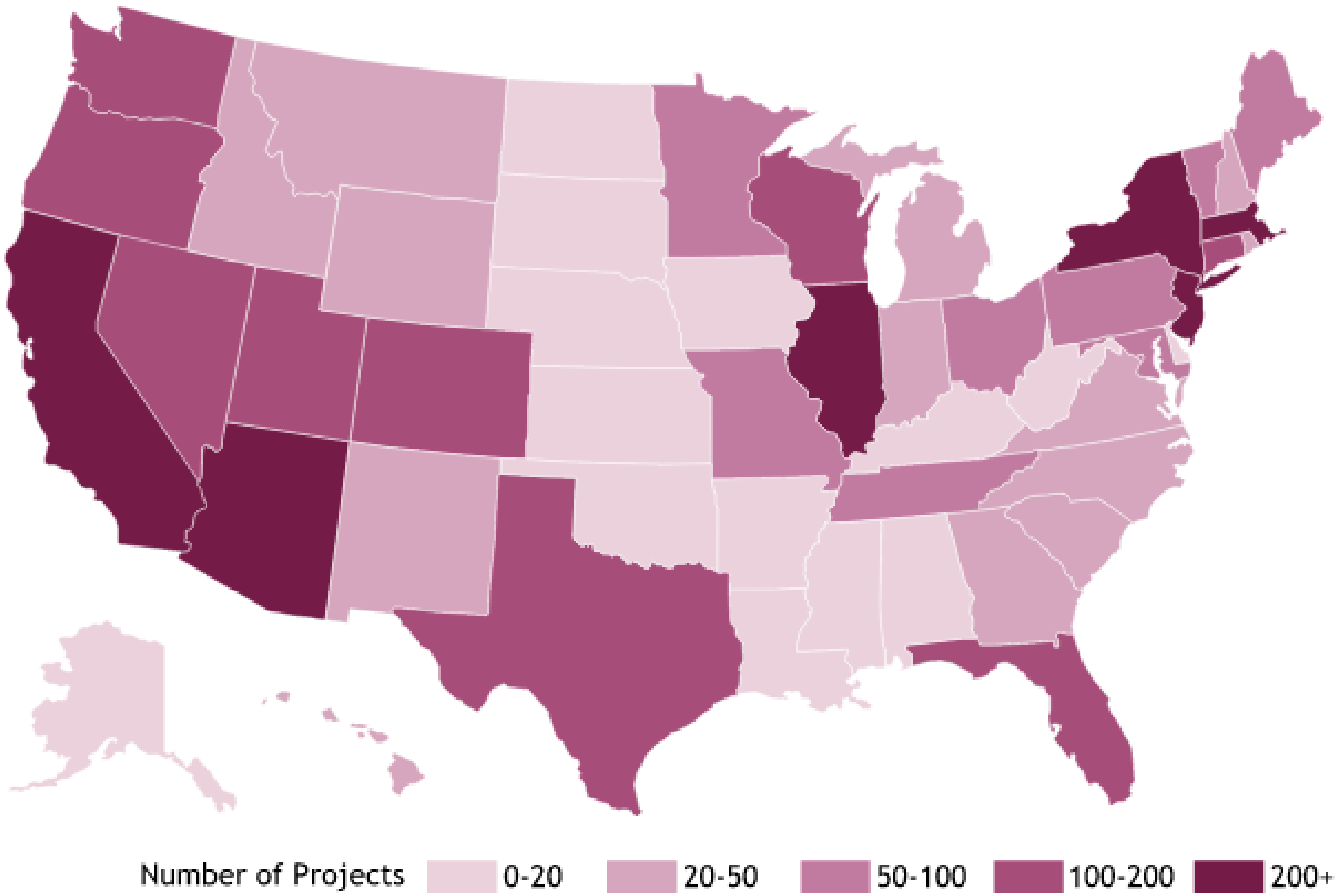
Siegrist, C. R., Barth, B., Campbell, B., Krishnamoorthy, B., & Taylor, M. (2013).*Utility Community Solar Handbook: Understanding and Supporting Utility Program Development* (Rep.). Washington, DC: Solar Electric Power Association. **(31 existing and planned projects)**

Noll, D, Dawes, M, & C., Rai, V. (2014). Solar Community Organizations and Active Peer Effects in the Adoption of Residential PV. *Energy Policy, 67,* 330-343. **(48 Solarize projects)**

Feldman, D., Brockway, A. M., Ulrich, E., & Margolis, R. (2015). *Shared Solar: Current Landscape, Market Potential, and the Impact of Federal Securities Regulation* (pp. 1-71, Tech.). Golden, CO: National Renewable Energy Laboratory. **(41 existing projects and 16 planned projects)**

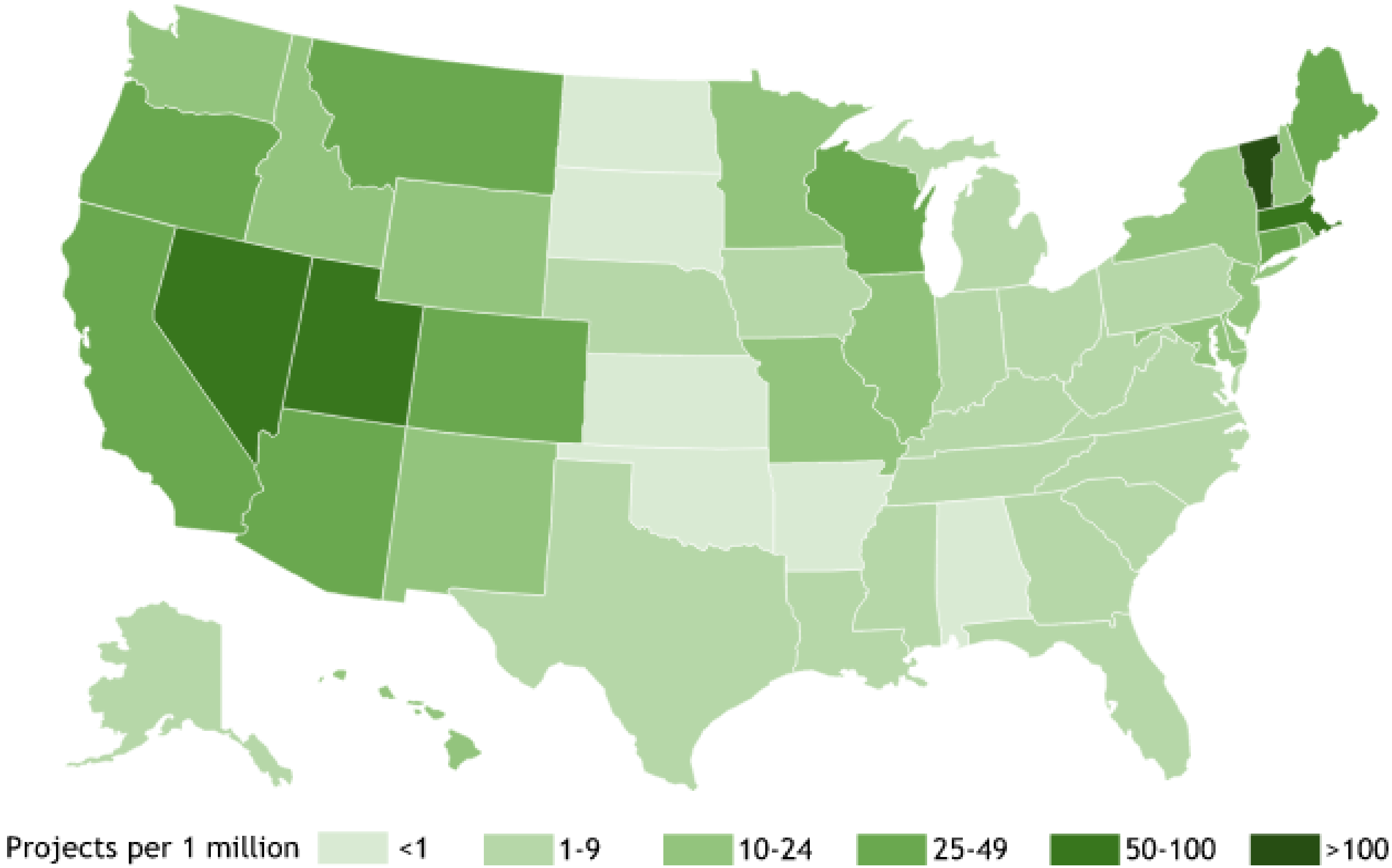
NEW US Community Solar Database

(>5,000 Community-based Solar Projects in 48 States)



COMING SOON (December?): http://communityenergyus.net/

Projects per Million Residents



COMING SOON (December?): http://communityenergyus.net/

1. **Solar Farm/Garden** *(shared solar, community solar)*

- Multiple people/businesses
- Single solar PV array
- Economies of scale

150 kW, Brattleboro VT, 6 residences & 3 businesses
Source: http://soverensolar.com/

http://energy.gov

2. **Bulk Purchase** *(Solarize, Solar Coops)*

- Multiple people/businesses
- Multiple solar PV (or thermal) arrays
- Reduced installation price – buying in bulk
- Urgency – limited time to participate
- Tiered pricing based on level of participation
  - More people = greater discount

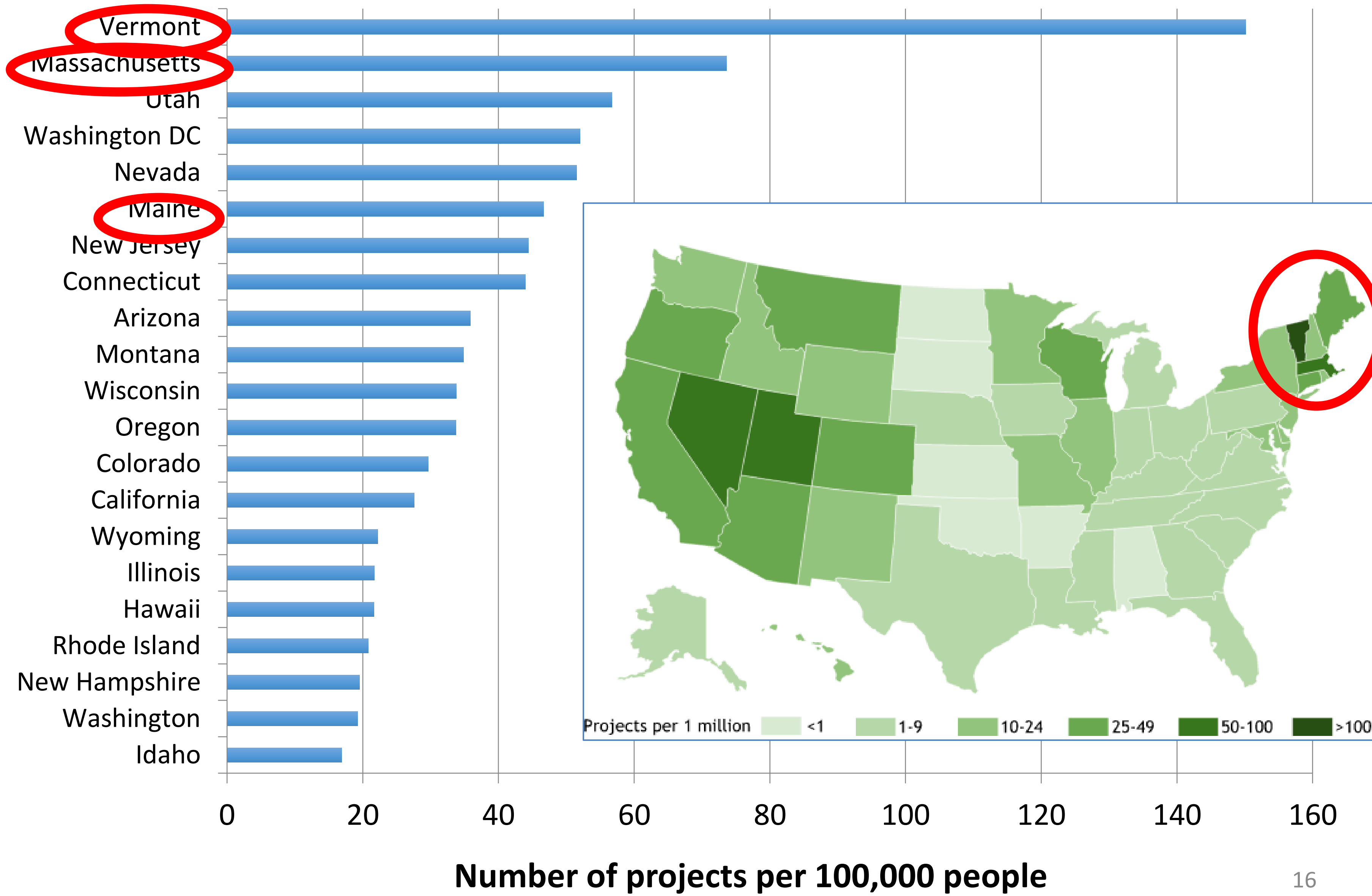
http://energy.gov

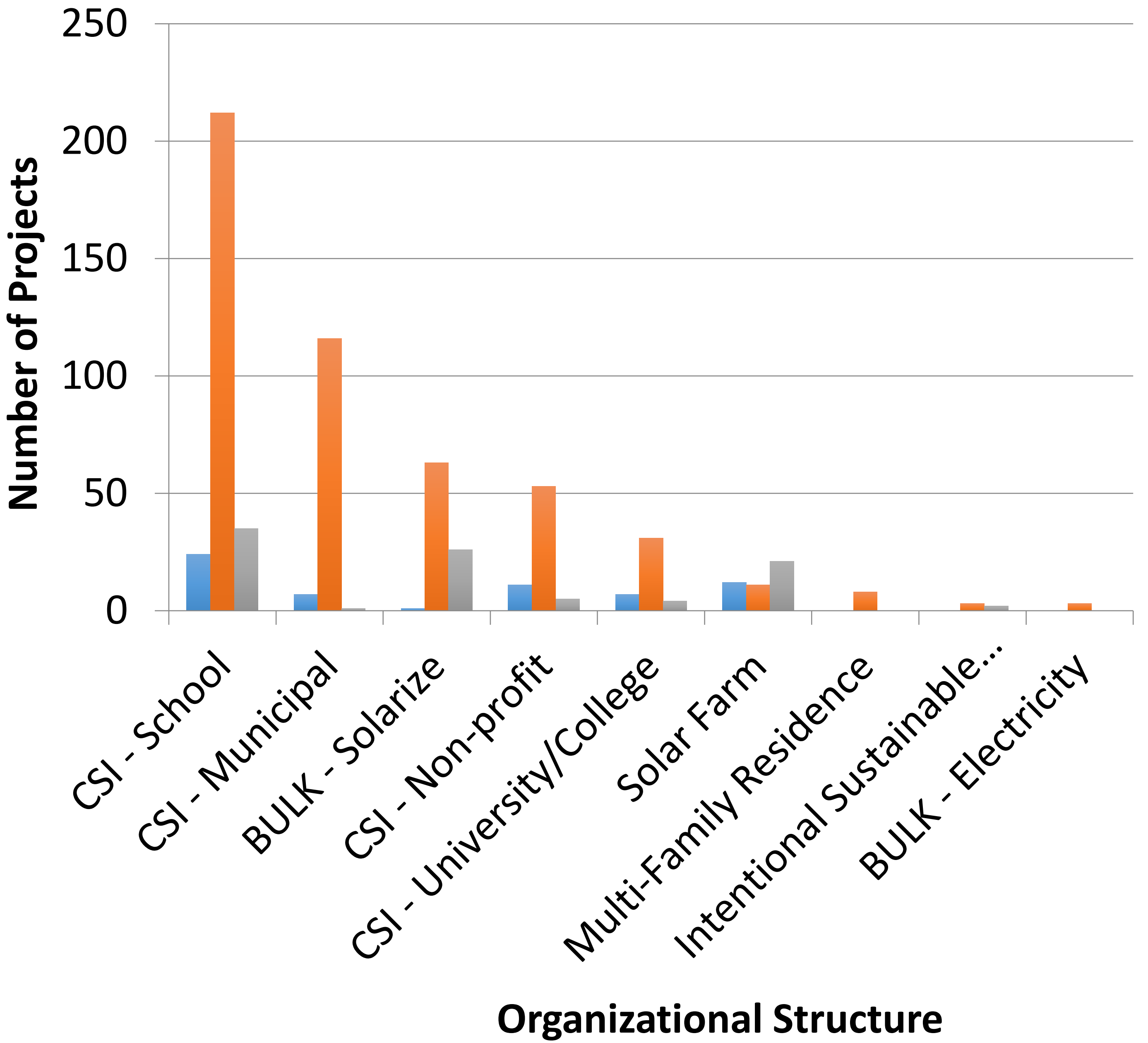
3. **Community-Serving Institutions (CSI)**
(Churches, Schools, Municipalities, etc)

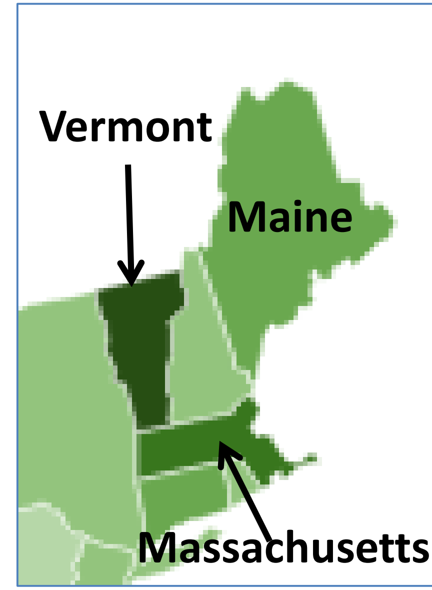
- Single institution serving multiple people
- Single or multiple array(s)
- Provide a "service" to a "community"
- Most with non-profit status (exception: some schools)

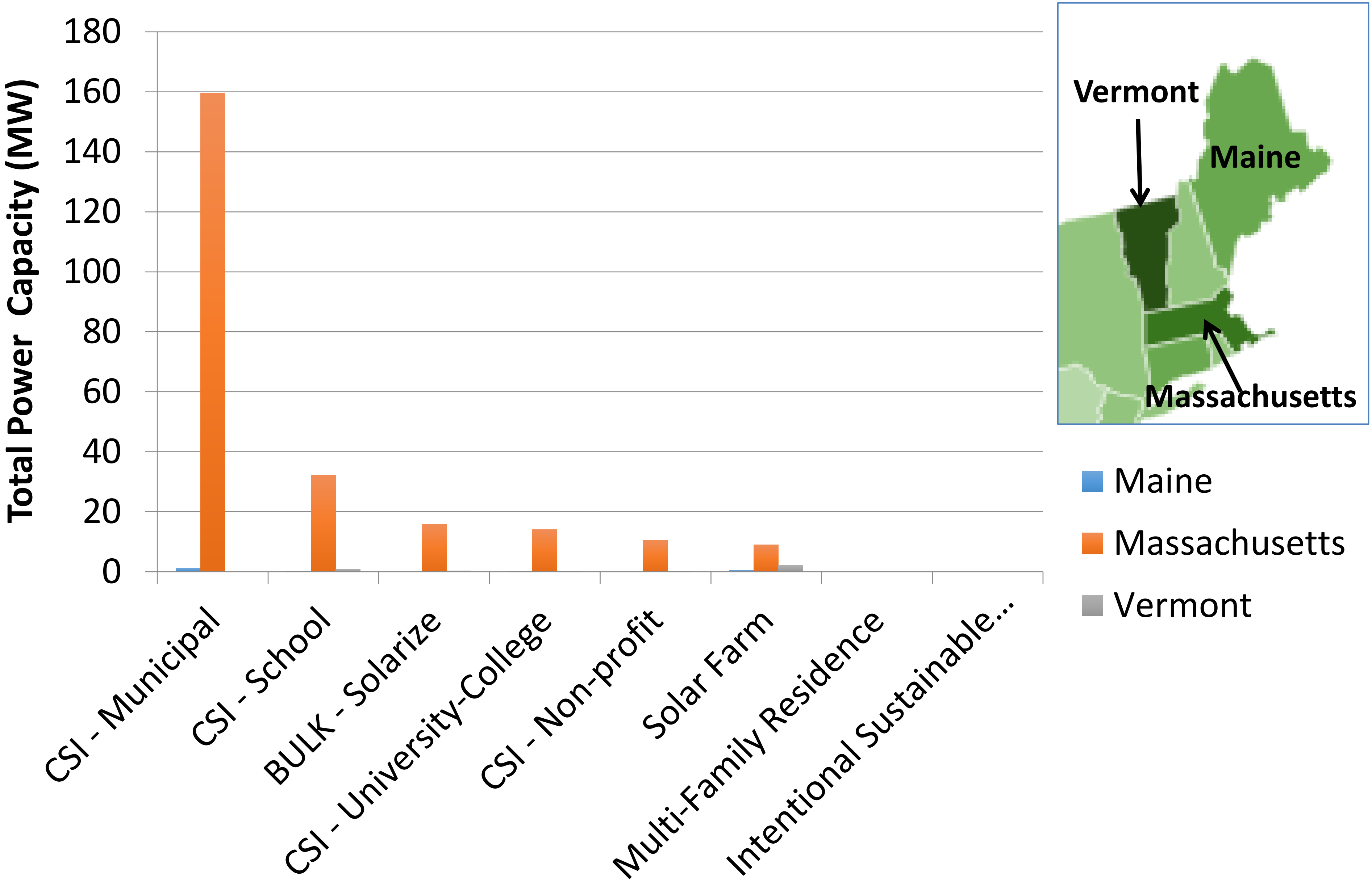
https://www.high-profile.com/sustainable-solar-development-of-closed-landfill-provides-revenue-benefits-to-billerica/

Top 20 Community-Based Solar States in US

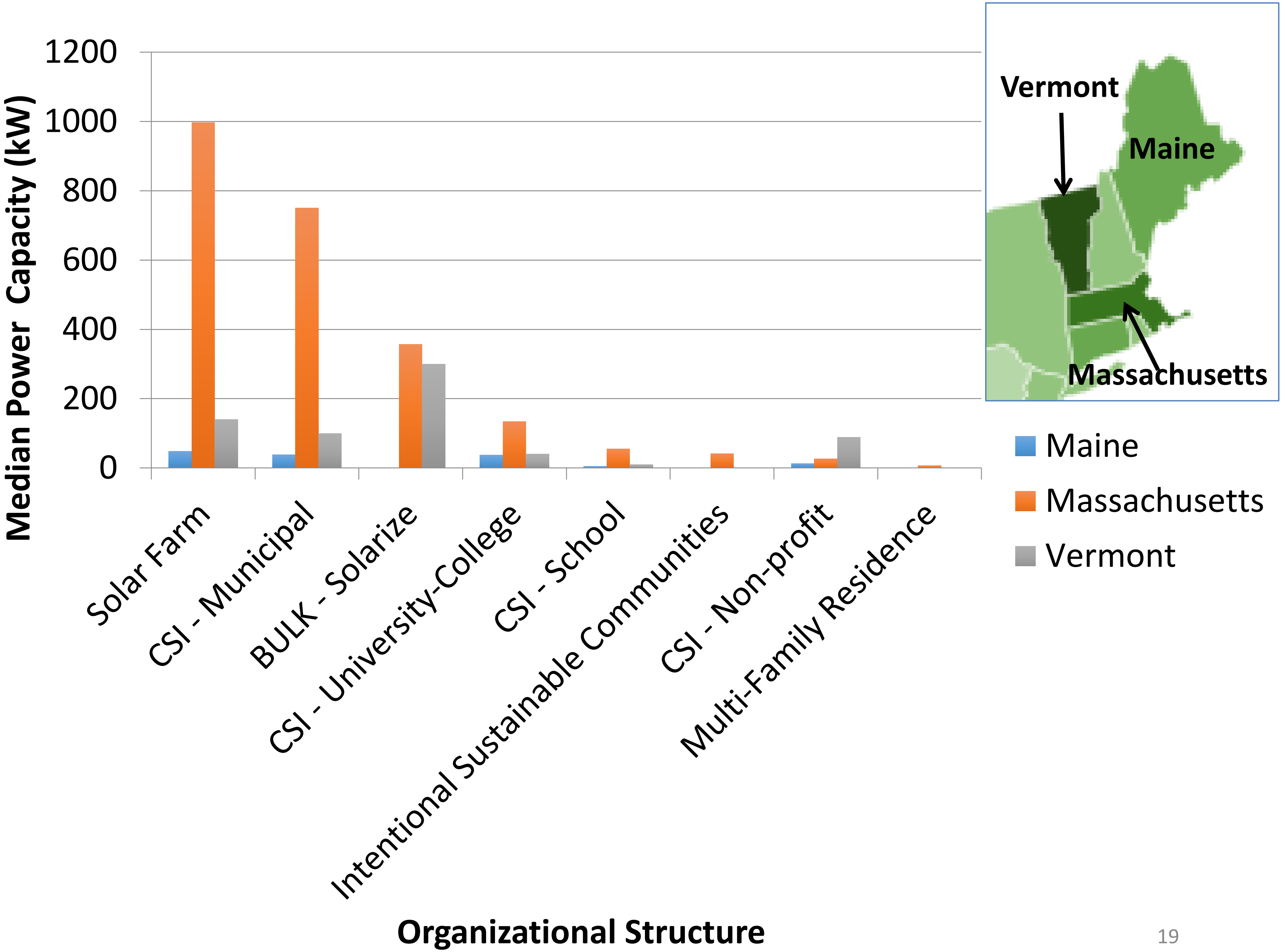



Number of Projects
250
200
150
100
50
0
CSI - School
CSI - Municipal
BULK - Solarize
CSI - Non-profit
CSI - University/College
Solar Farm
Multi-Family Residence
Intentional Sustainable...
BULK - Electricity
Organizational Structure
Maine
Massachusetts
Vermont

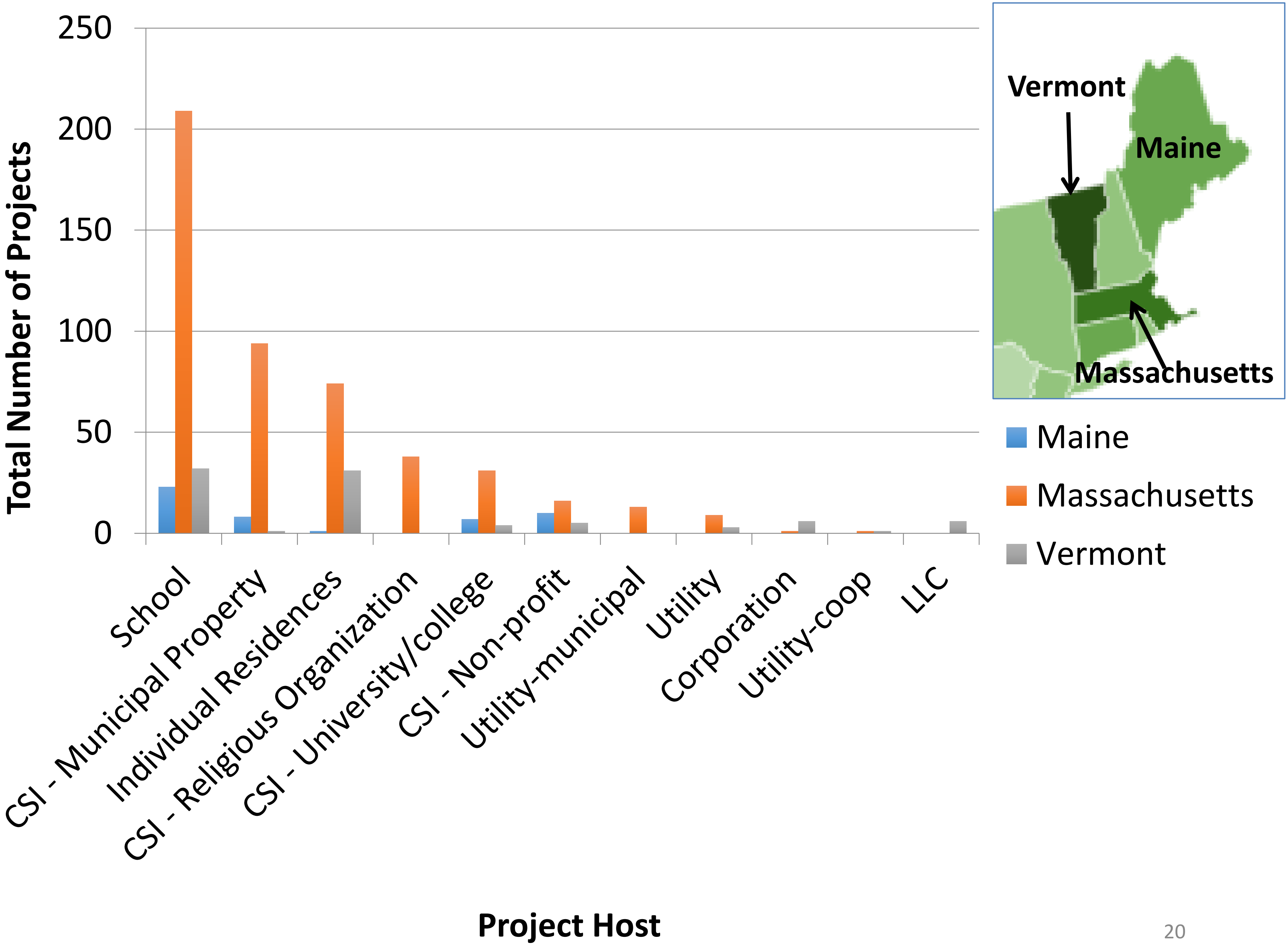

Vermont
Maine
Massachusetts

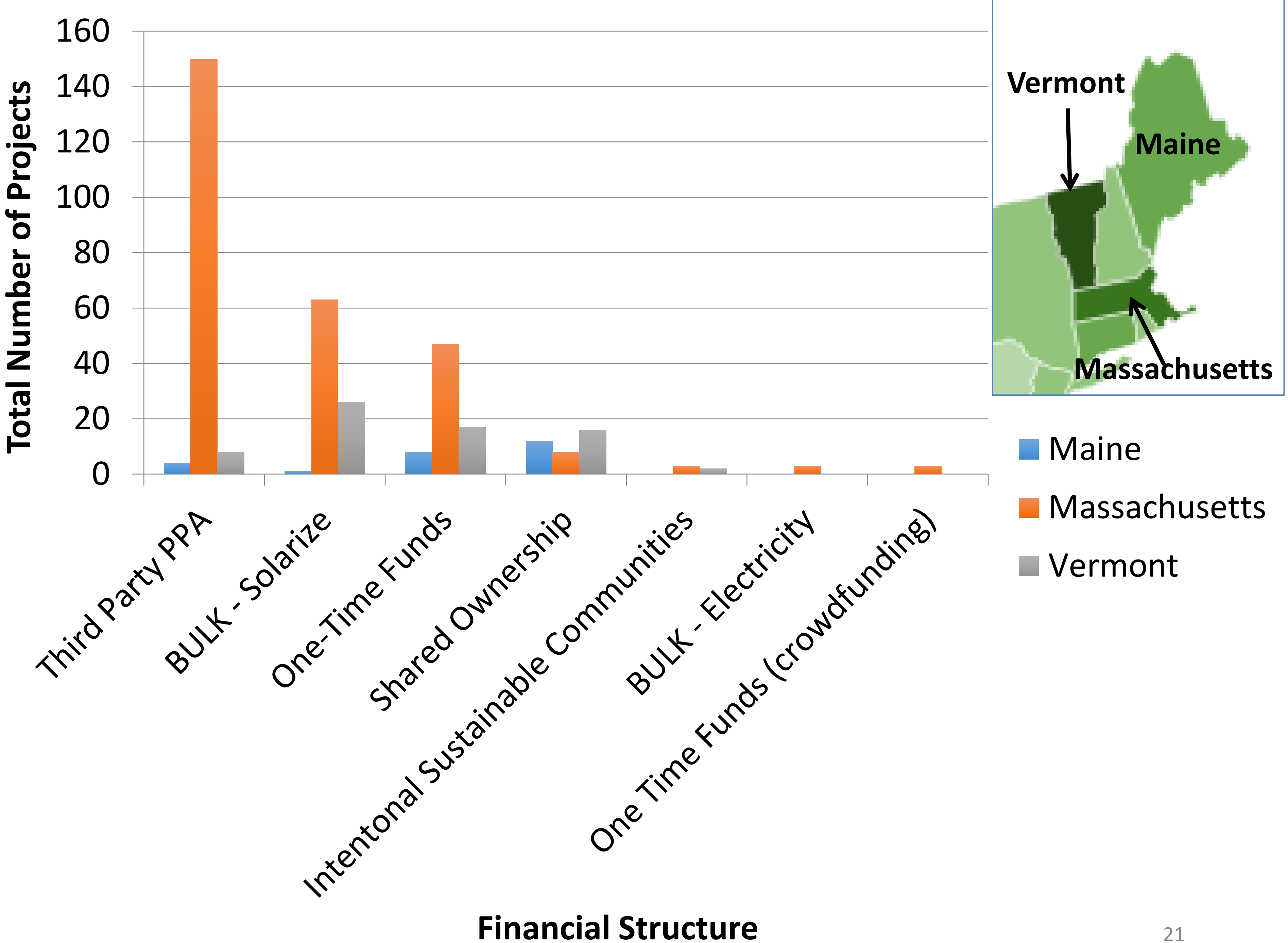


Organizational Structure



1200
1000
800
600
400
200
0
Median Power Capacity (kW)
Solar Farm
CSI - Municipal
BULK - Solarize
CSI - University-College
CSI - School
Intentional Sustainable Communities
CSI - Non-profit
Multi-Family Residence
Organizational Structure
Vermont
Maine
Massachusetts
Maine
Massachusetts
Vermont


250
200
150
100
50
0
Total Number of Projects
School
CSI - Municipal Property
Individual Residences
CSI - Religious Organization
CSI - University/college
CSI - Non-profit
Utility-municipal
Utility
Corporation
Utility-coop
LLC
Project Host
Vermont
Maine
Massachusetts
Maine
Massachusetts
Vermont

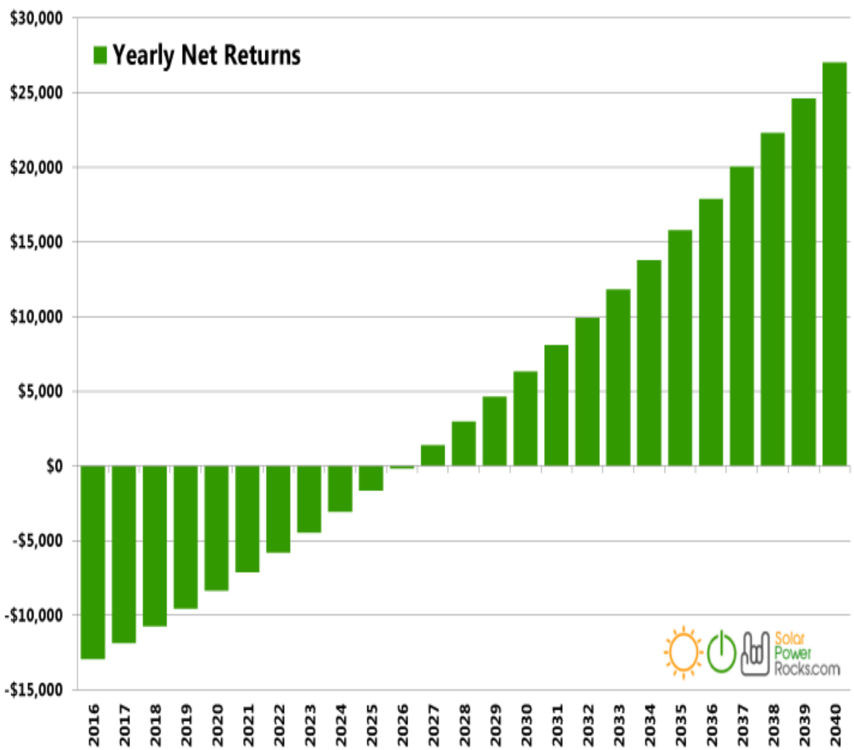

Total Number of Projects
160
140
120
100
80
60
40
20
0
Third Party PPA
BULK - Solarize
One-Time Funds
Shared Ownership
Intentonal Sustainable Communities
BULK - Electricity
One Time Funds (crowdfunding)
Financial Structure
Maine
Massachusetts
Vermont
Vermont
Maine
Massachusetts

Is community solar cost-competitive?

$$PV = \frac{ACF_t}{(1+r)^t}$$

$$NPV = [\sum_{t=1}^{T} PV] - C_{SYS}$$

ACF_t = annual cash flow
r = discount rate
t = year
NPV = net present value
PV = present value
C_{SYS} = Cost of system



Source: http://solarpowerrocks.com

Why is Discounting Important?

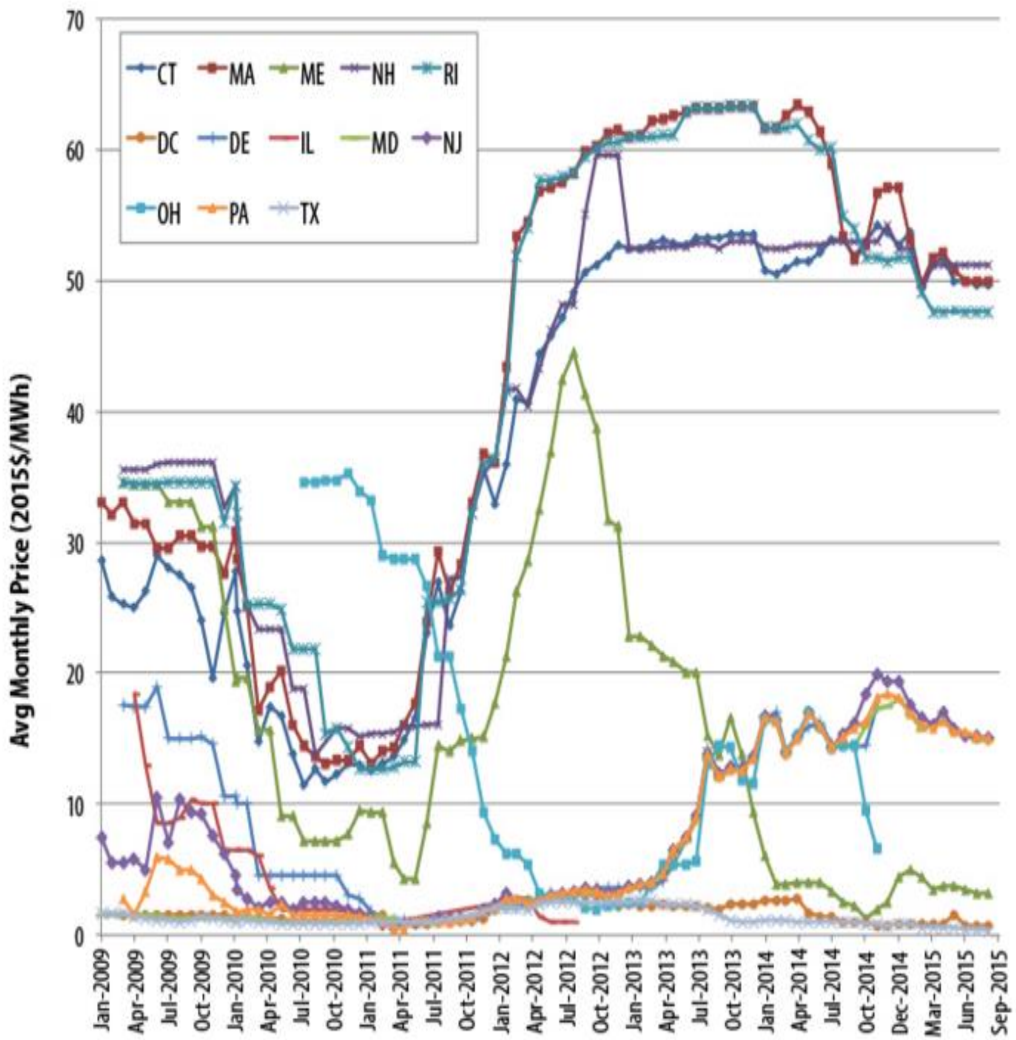
- Time Value of Money
- Inflation
- Opportunity cost
- Risk
- r = 5%

Now or in 10 years?

Simple payback period: ~~discounting~~

Important Solar Incentives (All 3 States)

- 30% Federal Tax Credit (FTC)
- Renewable Energy Credits (RECs)
  - $40/MWh
  - >50 kW



Important Solar Incentives (Massachusetts)

Solar Renewable Energy Credits (SRECs)

- Solar PV only
- Only generated in MA
- Price set by policy
- $285/ MWh in 2015 (decreases to $180 by 2025)

15% State Tax Credit

Source: http://mysolar.com/solar-renewable-energy-credits/

Important Solar Incentives (Vermont)

Solar Adder

- Price guarantee for solar electricity
- $.20/ kWh for systems up to 15 kW
- $.19/ kWh for systems over 15 kW
- First 10 years of system operation

Source: http://isasolar.com/

Other Solar Policies

	MA	VT	ME
Aggregate Net Metering Cap (% of peak load)	9%	15%	1%
Program Designed to Encourage Community Energy	Yes	No	Yes[1]
State Tax Credit/Rebate	15%[2]	$.50 - $2.10/W[3]	No
Sales Tax Exemption	Yes	Yes	No
Property Tax Exemption	Yes	Yes	No
Third Party Ownership	Yes	Yes	Yes
Low Interest Solar Financing	Yes	Yes	Yes

1. Closed December, 31, 2015
2. Available for residential systems only
3. Closed January 1, 2015

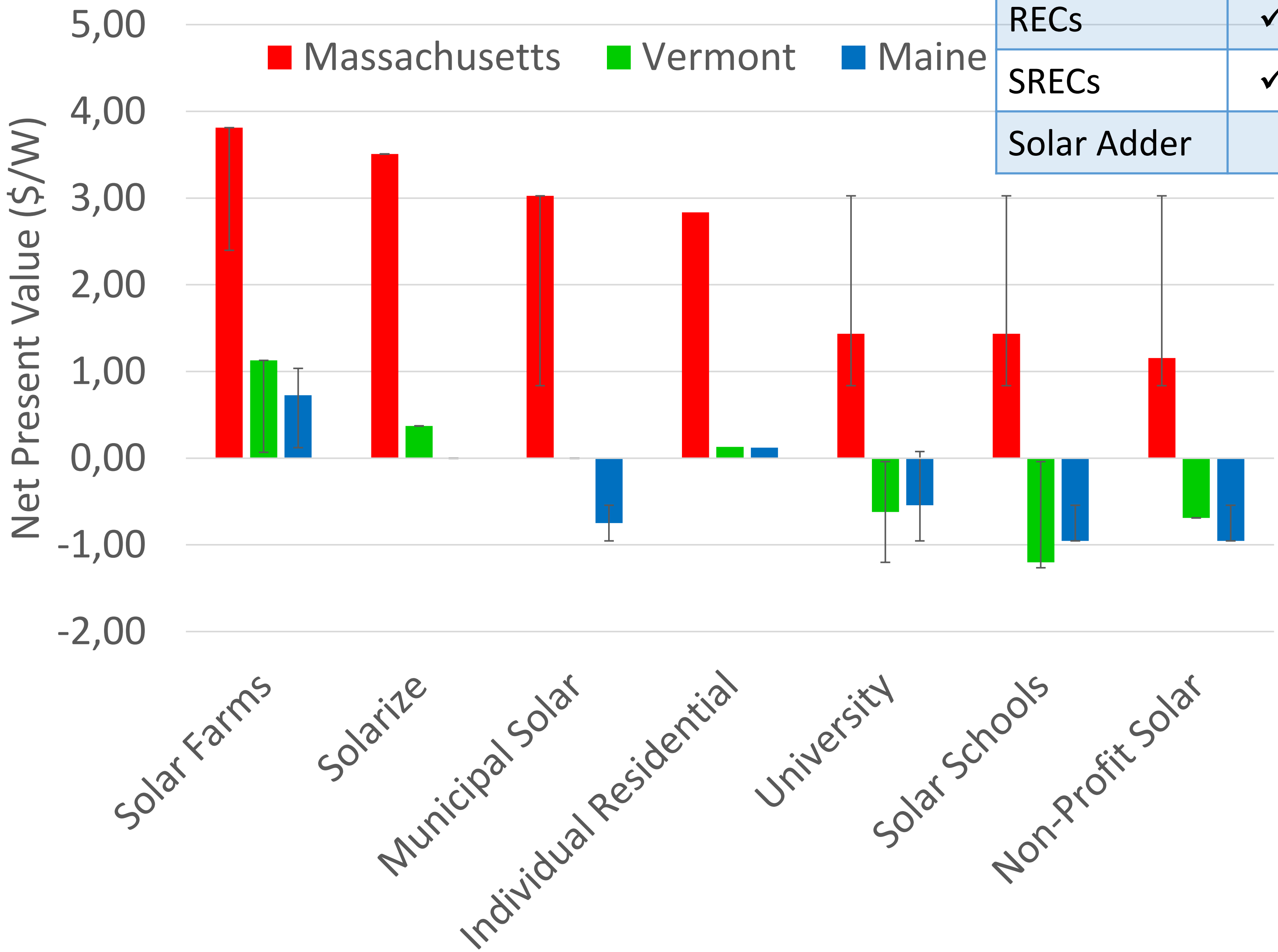
State Level Assumptions

Variable	Units	Default Value		
		Maine	Massachusetts	Vermont
C_{WATT} <25 kW	\$/W	\$3.59[1]	\$4.44[1]	\$4.44 [1]
25 kW ≤ C_{WATT} < 500 kW	\$/W	\$3.20[1]	\$4.14[1]	\$3.89[1]
500 kW ≤ C_{WATT}	\$/W	\$2.03[1]	\$2.62[1]	\$2.47[1]
P_{RETAIL}	\$/kWh	\$0.1577[2]	\$0.1767[2]	\$0.1775[2]
Solarize Discount	%	NA	25%	7%
Capacity Factor	%	13.2%[3]	13.6%[3]	13.8%[3]

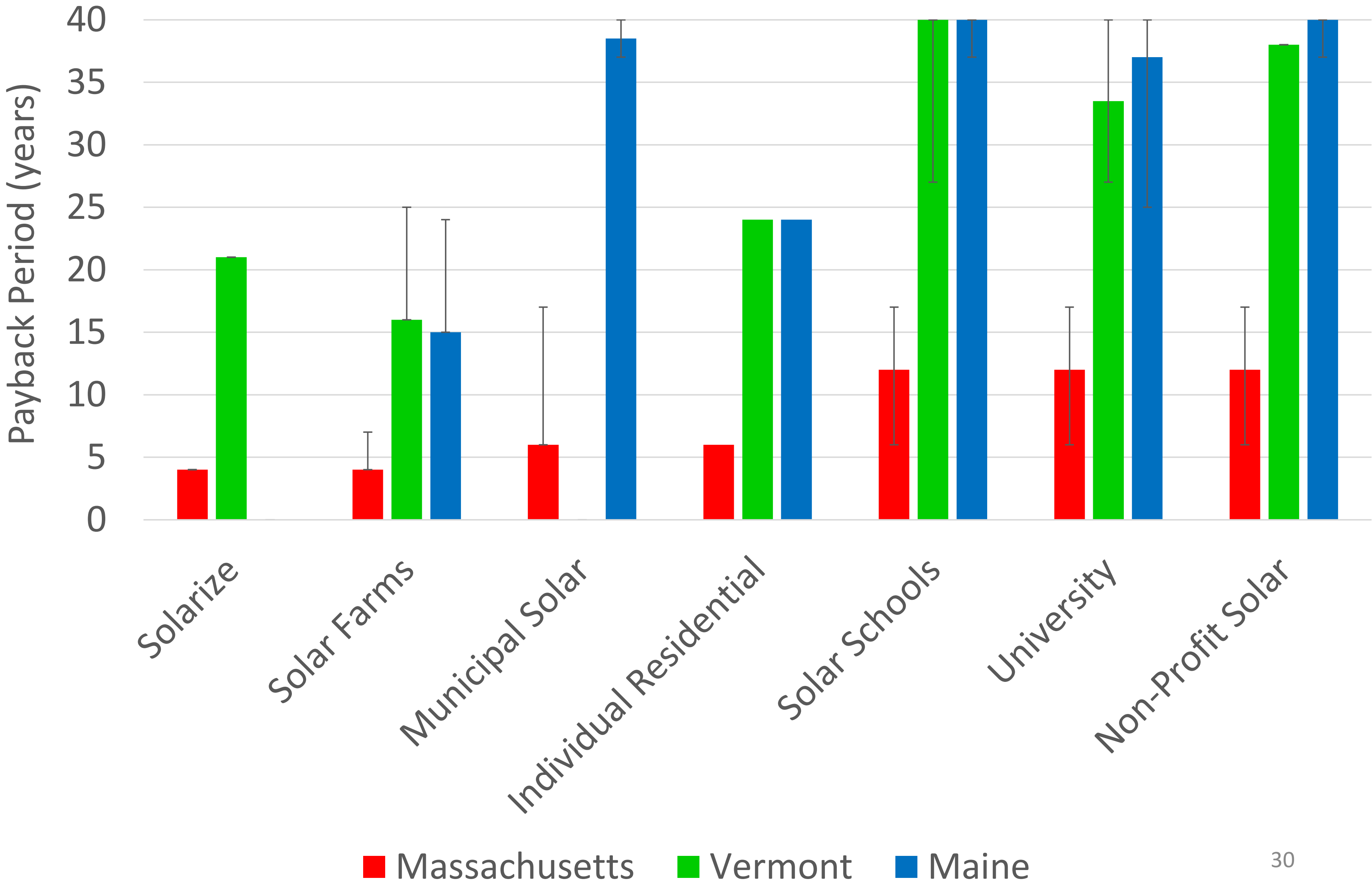
1. Lawrence Berkeley National Laboratory
2. Energy Information Administration
3. System Advisor Model

Results: NPV at 25 Years

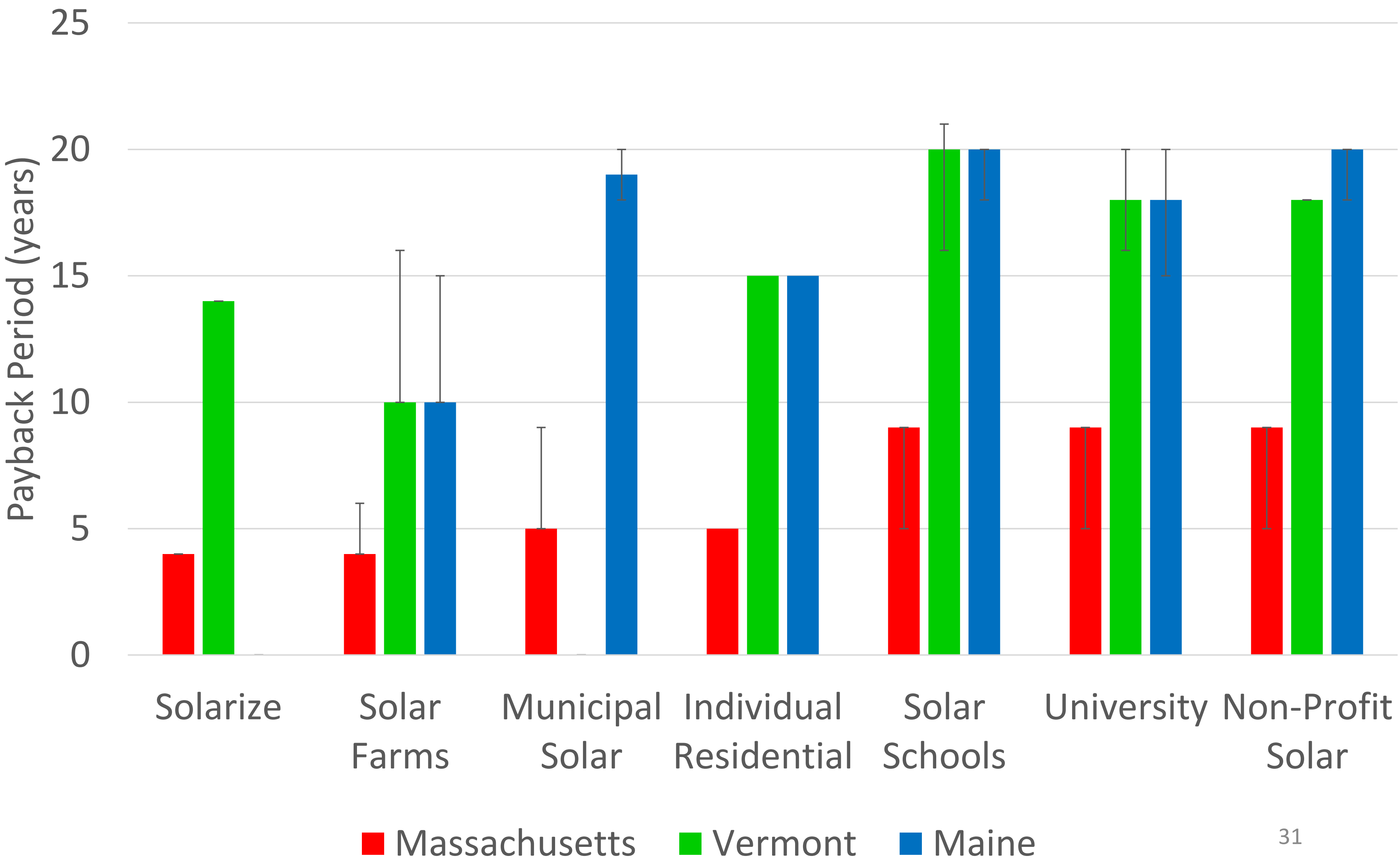
Incentive	MA	VT	ME
FTC	✓	✓	✓
STC	✓		
RECs	✓	✓	✓
SRECs	✓		
Solar Adder		✓	



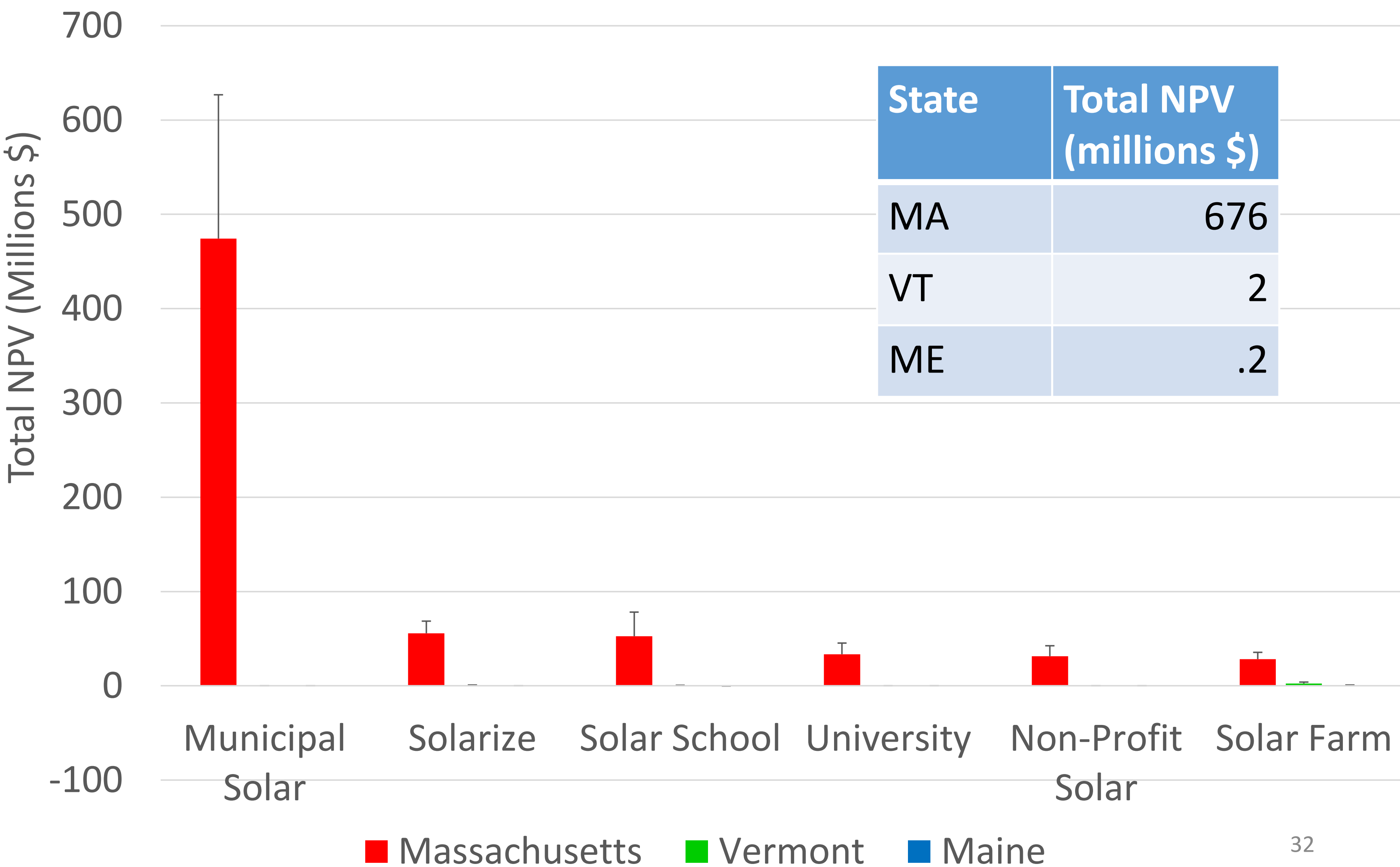
Results: Discounted Payback Period



Results: Simple Payback Period



Results: Total NPV



State	Total NPV (millions $)
MA	676
VT	2
ME	.2

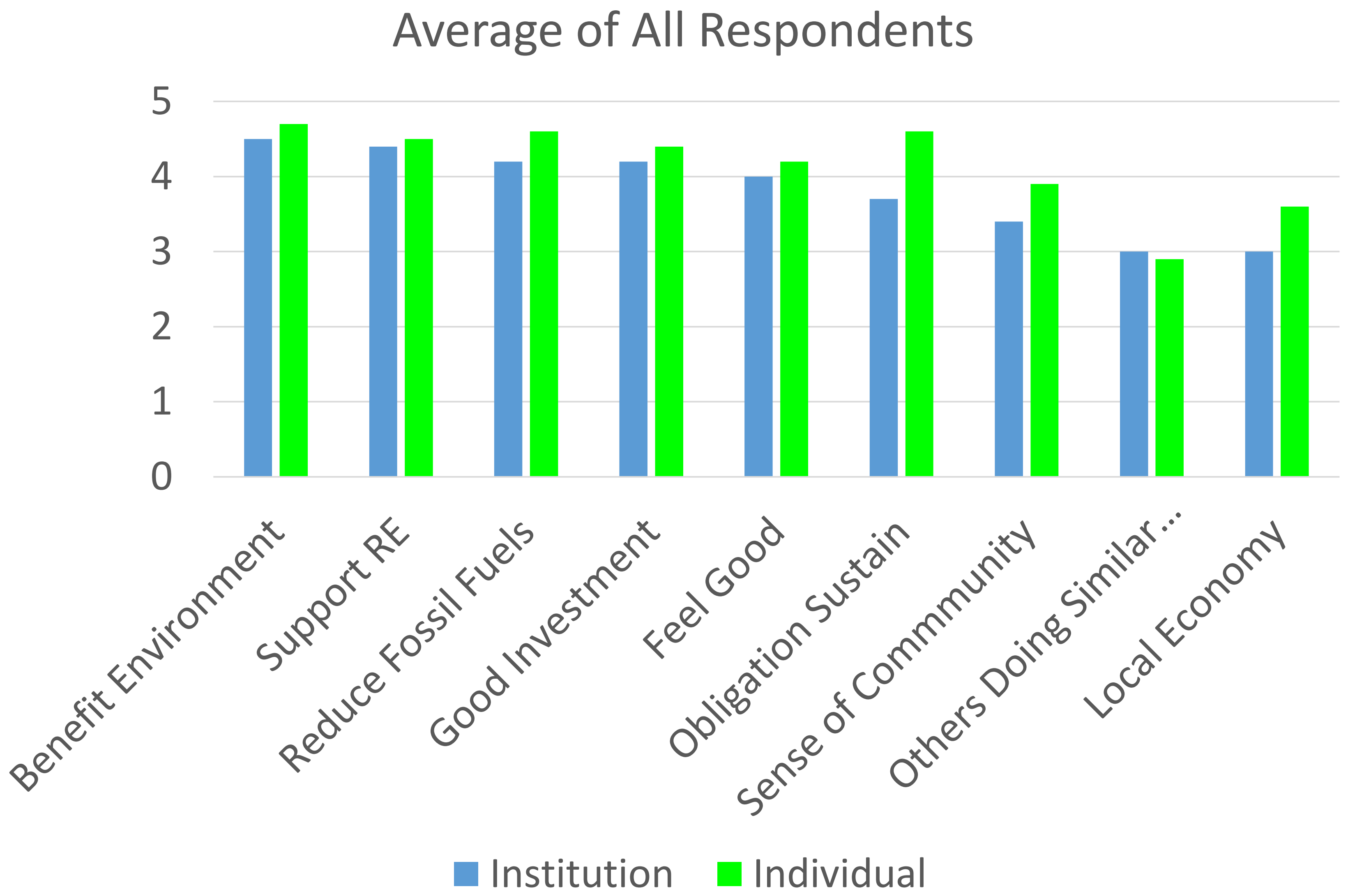
Tri-state survey 2015

Community Solar Category	# Sent	# Complete	# Partial	Completed Survey Response Rate
Solarize*				
Maine	0	0	0	N/A
Massachusetts	38	4	4	11%
Vermont	24	1	0	4%
TOTAL	*62*	*5*	*4*	*8%*
Solar Farms				
Maine	2	1	0	50%
Massachusetts	3	0	1	0%
Vermont	18	5	1	28%
TOTAL	*23*	*6*	*2*	*26%*
COMMUNITY-SERVING INSTITUTIONS				
Maine	36	4	2	11%
Massachusetts	287	19	7	7%
Vermont	37	3	0	8%
TOTAL	*360*	*26*	*9*	*7%*
ALL SURVEYS				
Maine	38	5	2	13%
Massachusetts	328	23	12	7%
Vermont	79	9	1	11%
TOTAL	**445**	**37**	**15**	**8.3%**

Who is participating (responding)?

- Wealthy (income > median)
- Educated (bachelor’s degree or higher)
- Democrat
- Caucasian
- Older (77% >50 yrs old)
- Mixed gender (20 men, 15 women)
- Homeowners (33, vs 2 renters)

Why are they doing it?



1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree

How are they doing it? (Organizational structures)

Grassroots (bottom-up) community-engagement

"I expressed my interest, along with others. We then invited ReVision Energy to attend a meeting to discuss the details of the project. I was very interested in advancing the solar farm, and so volunteered to become the President of the association. I kept potential members informed (by email) until nine individuals were willing to commit to the project by placing a deposit with ReVision. I then assisted in moving the project along until final closing in April of 2015. We are the first member-owned community ***solar farm*** *in* ***Maine****."*

How are they doing it? (Organizational structures)

New business model

"We learned about ***Vermont****'s net metering law, learned that GMP allows solar and pays a premium for it. We learned that multiple people can participate in one project. We knew that the IRS allows tax credits to be taken for off-site renewable energy assets. We then bought land, found an installer, applied for a permit, marketed our offering and took on customers. It is the customers who finance the project. We use E-mail to communicate our progress and encourage folks to follow through on their interest"*

Solar farm

How are they doing it? (Organizational structures)

Top-down, Existing organization

"I procured grant funding and carried out the program as part of my job" **Solarize, Vermont**

"Wrote application, recruited solar coach, generated marketing ideas, executed some marketing campaigns, spoke at public meetings." **Solarize**, **MA**

Conclusions – US Community Solar:

- Quickly growing in US
- Many varieties
  - Organizational
  - Financial
  - Host
  - State-based policies
- More cost-competitive than individual residential (3 states)
  - Depends on financial incentives
  - MA most profitable
  - Alternative financial structures needed to make non-profit cost competitive
  - **Solar Farms** most profitable
  - **Individual Residential** profitable in all 3states

Conclusions – US Community Solar:

- Similar demographics to residential PV adopters
- Motivated by environmental benefits more than financial/social
- Perceived ripple effect
- Participants are likely to engage in energy efficiency

2 Examples of Community Energy

Community Solar

Window Insert Builds

Source: https://ilsr.org

Window Insert Build in the News!

http://wabi.tv/2016/10/29/u-maine-students-stay-energy-efficient-while-helping-others/

What is a window insert?

Pine frame (white or natural) custom sized to fit window

Layers of transparent film on both sides
- tightly stretched/shrunk for optimal aesthetics
- creates 2 layers of “still air” which insulates twice as well as exterior storm

Weatherstripping around edge for snug fit to seal drafts from windows

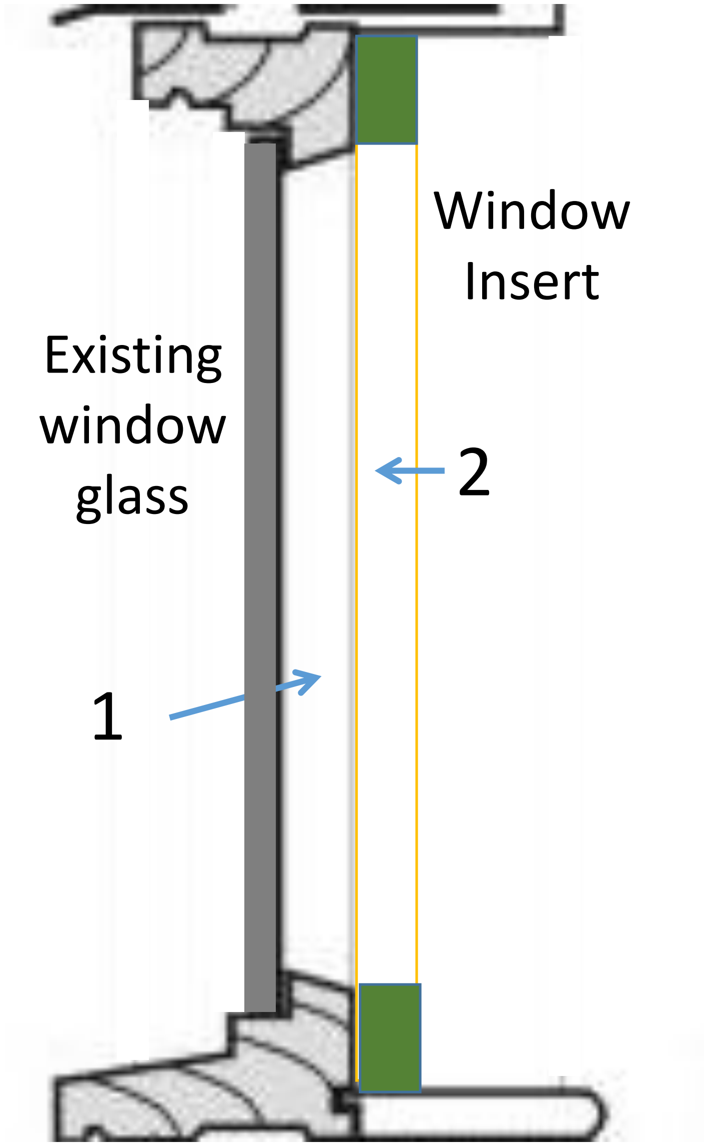
Insert being installed

Insert in place

Introduced by Topher Belknap at the 2nd Annual Midcoast Sustainable Living Expo, Maine (about 2008)

Two insulating spaces of "quiet air"

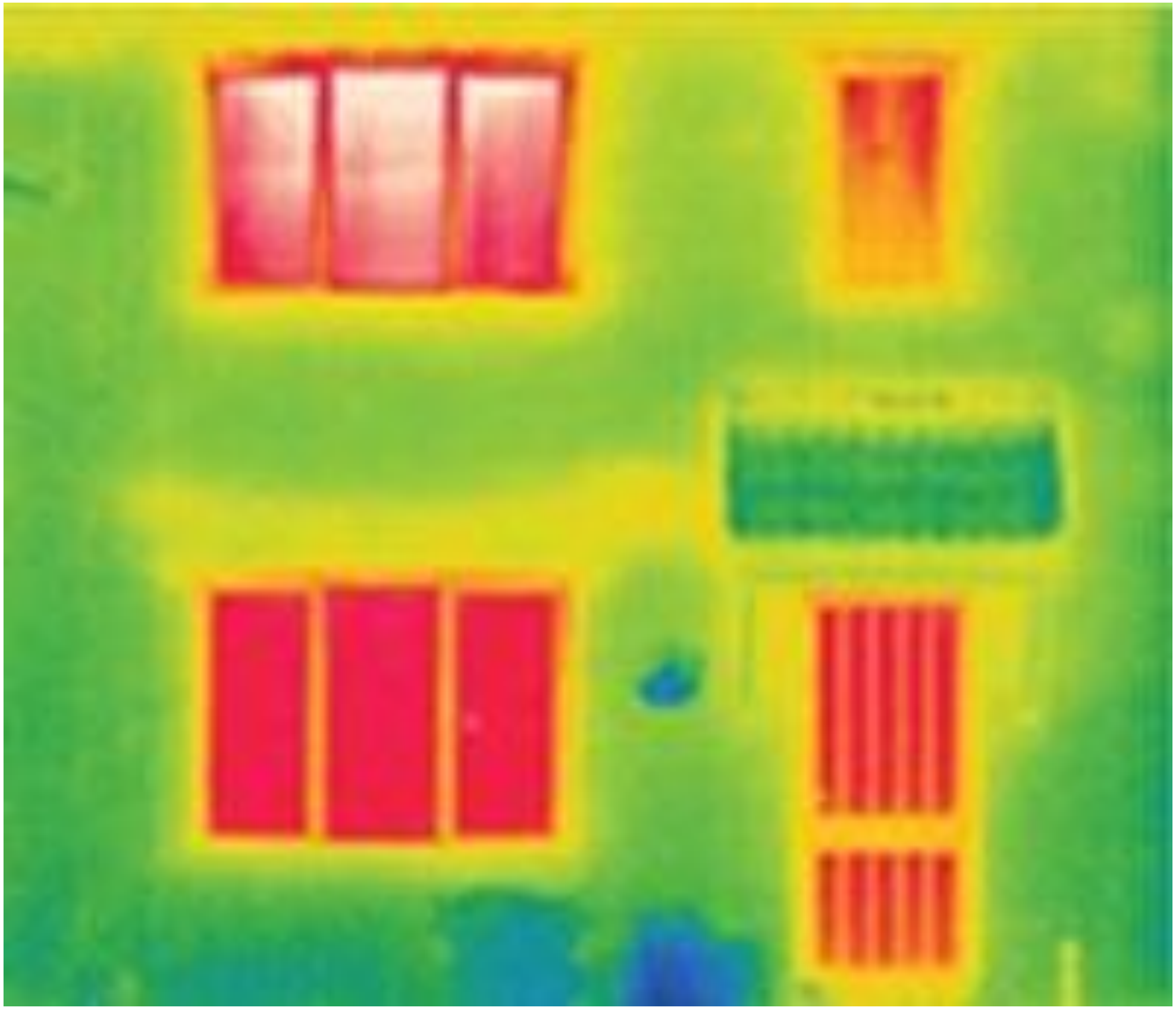
OUTSIDE



INSIDE

courtesy of Peter Garrett

A lot of heat can escape through windows



WindowDressers.Org

courtesy of Peter Garrett

Many ways to make inserts…

- DIY at home
- DIY community workshops (e.g., Unity College)
- DIY through community-serving institution (e.g., Island Institute)
- DIY community window insert builds (WindowDressers)
- Buy from a company (e.g., Indow Window)

What is a Community Build?

"Helping Mainers and the environment one window at a time"

BANGOR DAILY NEWS

'It's just unbelievable': Rockland nonprofit uses volunteer power to keep Mainers warmer in the winters

Abigail Curtis | BDN staff

Richard Cadwgan, a retired engineer from Rockport, is the president of Window Dressers, a growing nonprofit agency that aims to help Mainers stay warmer in the winter.

By Abigail Curtis, BDN Staff
Posted Oct. 26, 2014, at 6:31 a.m.

Community

Previous story:
« Shortage of volunteers prompts Harpswell to consider paying for 24/7 EMS

Next story:
Hyde School mourns Bath crash victim who was history, government teacher »

From the community

Area churches come together to build 500-plus energy-saving windows

Prev | Next 1 of 2

News | Blogs | Living | Sports | Opinion

1. One dead after officer-involved shooting in Smyrna
2. Mini-stampede in Houlton as herd of horses hits the road
3. National Weather Service keeping eye on potential weekend storm
4. The Wal-Mart effect: Crime rates plummet in Rockland, spike in Thomaston
5. Snowplow dislodges hidden 1913 time capsule at Caribou church

BDN MAINE Blogs


Community Builds
courtesy of Peter Garrett

WindowDressers

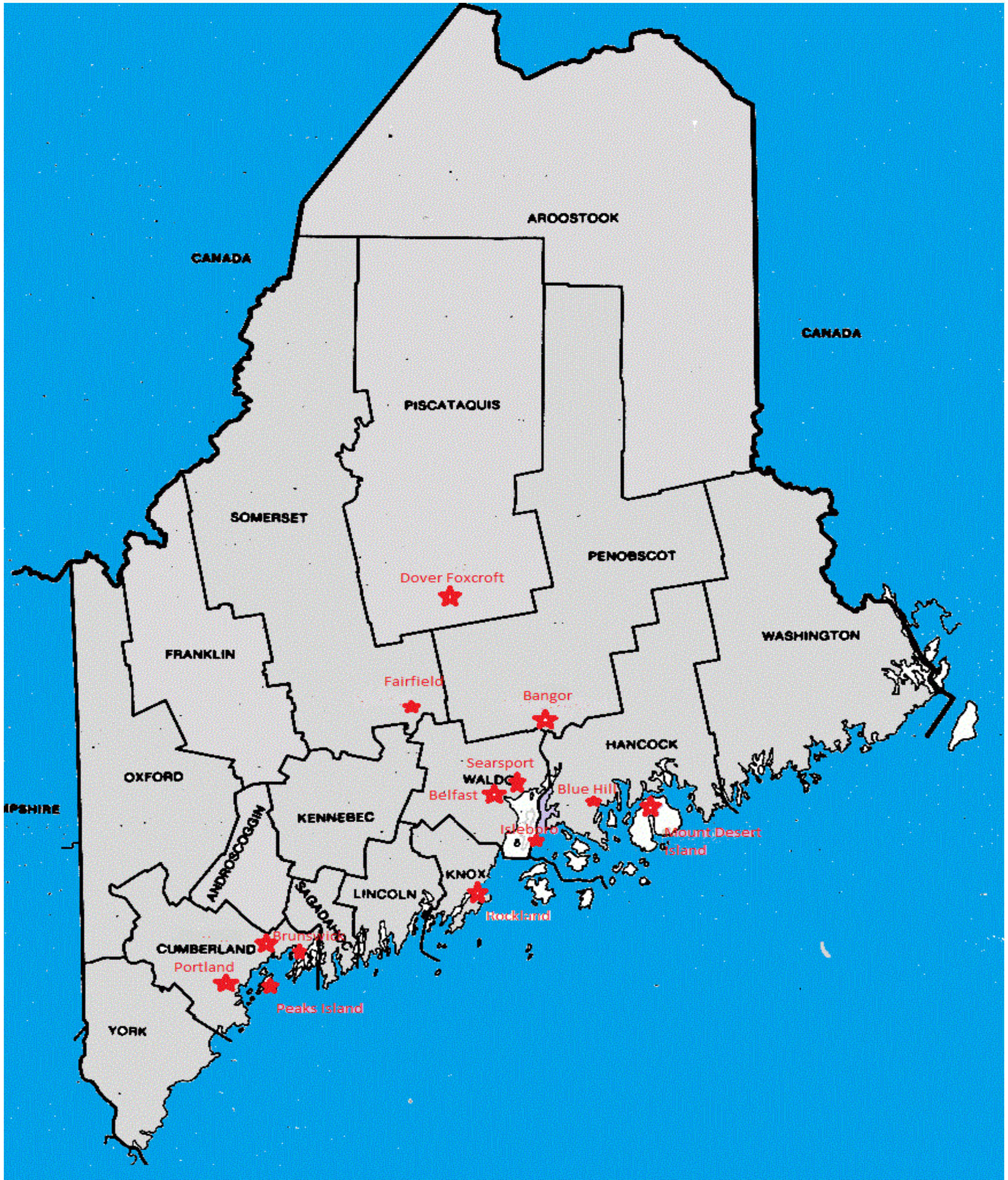
- Non-Profit organization, founded in 2008
- Volunteer-led
  - Headquarters in Rockland, ME
  - Local coordinators in 16 communities in Maine
- Economies of scale and volunteerism reduce insert cost
  - Bulk purchasing
  - Manufacturing frame components
- Brings communities together
  - Phase 1 Build – Wrap
  - Phase 2 Build – Build & Wrap
- Helps others
  - Donates ~25% of inserts to low income families
    ($10 for 10 inserts)

Efficiencies of Manufacturing

Computer-assisted chop-saw

Create labeled frame kits

Community Build Locations 2015



Community Window Insert Build (WindowDressers Model)

1. Identify volunteer coordinator(s) (*spring*)
2. Recruit customers to buy inserts (*spring/summer*)
3. Measure windows & send measurements to WD (*summer*)
4. Materials ordered/prepped (*summer/fall*)
5. Recruit volunteers for Community Build (*summer/fall*)
6. Build/wrap inserts at Community Build (*fall*)
7. Follow-up to fix any mistakes (*fall/winter*)

A Win-Win-Win-Win?

Economic

LOW Initial Cost NO Annual Costs

NEW SKILLS (Jobs)

Local spending on local materials

Affordable LOW Risk

Social/Cultural

Easy to use/understand

Aesthetics – don't notice them

Reduce oil use (improve security)

Education opportunity; Equitable

Easy to use) Diverse beliefs/values

Bring together community

Sustainable Energy

Technical/Physical

Available anywhere anytime

Functional Improve efficiency

Limited Materials

Compatable with existing Infrastructure

SAVE ENERGY!

Environmental/Ecological

REDUCE: Climate change Air pollution

Water pollution Water use

Land transformation Wildlife impacts

Ecoystem destruction Biodiversity

Waste … BY REDUCING FOSSIL FUEL USE

Window Insert Survey 2015-2016

Survey Name	Active Dates	Number of Responses	Target Population Size
Pre-Build (Bangor)	Oct - Nov	12	27
Post-Build (Bangor)	Nov - Mar	23	56
Post-Build (Other)	Nov - Mar	103	>500

Survey Results

Motivation for Participation	**Agree/Strongly Agree**	**Total Responses**	**Percentage of Respondents**
Conserve Energy	86	88	98%
Save Money	80	89	90%
Benefit the Environment	73	88	83%
Value Sense of Community	63	87	72%
Project Experience	**Satisfied/Very Satisfied OR Likely/Very Likely**	**Total Responses**	**Percentage of Respondents**
Overall Project Experience	113	114	99%
Recommend Project to a Friend	112	118	95%
Perceptions of Product Quality and Effectiveness	**Satisfied/Very Satisfied OR Agree/Strongly Agree**	**Total Responses**	**Percentage of Respondents**
Product Reduced Draft	89	92	97%
Product Increased Thermal Comfort	86	91	95%
Quality of Product	86	92	93%
Durability of Product	75	88	85%
I Changed my Normal Thermostat Settings After Installation	14[1] (Yes)	90	16%

Survey Results

“The volunteers were a good way to introduce the program, measure the windows, and get you involved. Having a member of your community be involved, from start to finish, really made the whole thing stand out. The fact that they are volunteers, and the whole thing is non-profit, led to a lot of confidence from the very start. I also think it is a good thing to have the people who ordered the windows participate in the building of them, as I did. Not only is it fun, but it adds to the whole community-generated-window idea.”

Survey Results

“Not only is this excellent experience, the opportunity gives those who are benefitting a chance to contribute.”

“Overall the program was incredibly productive and fun to work with. Good energy.”

“The set up for doing the builds is quite remarkable and very efficient.”

“I found it very important that different communities joined together in this project and had a very good time doing it. Sharing meals and music was fabulous.”

Service Learning

- Pilot course - ECO 370: Building Sustainable Energy Communities Through Service Learning
- Students learn about sustainable energy while taking action in their own community
- 10 students participated
- Helped coordinate every step of Bangor 2016 Window Insert Build (WIB)
- Designed & implemented a research project
- 1 student co-coordinating Fall 2016 build
- 60 students volunteering in Fall 2016 build
- 3 student research assistants


"DROP BEATS, NOT BOMBS"
-ABE LINCOLN

Future Work – Window Inserts

- Bangor Fall 2016 Build
- Collecting energy data (fuel & electricity bills)
- Compare projected savings to actual savings over time
- Examine customer reaction to real-time energy savings prediction – model being used on-site during measurements
- Continue analysis of existing survey results
- Post-season surveys
  - July 2016
  - June 2017
  - Collect energy bills for "advanced" customers
- Analysis of service learning research results
- Bangor 2016 Build (ethnography?)
- Incorporate WIB service-learning in 90-student class (Fall 2016)

Future Work – Community Solar

- Launch website – grow database
- National survey (larger sample size)
- Access real energy use data
- National policy/financial analysis
- Estimate net cost/benefit to state for incentives
- Multi-criteria decision analysis tool

Acknowledgements

This work is supported by…

- The USDA National Institute of Food and Agriculture, Hatch project 0230040.
- The Senator George J. Mitchell Center for Sustainability Solutions at the University of Maine

Want to learn more?

- **Klein**, S.J.W. and S. Coffey, 2016, Building a sustainable energy future, one community at a time, *Renewable and Sustainable Energy Reviews*, vol. 60, pp. 867–880, doi: 10.1016/j.rser.2016.01.129.
- **Klein, S.J.W.** and Coffey, S., 2016, United States Community Energy. *Handbook on Energy Transition and Participation* Springer VS, Wiesbaden; Lars Holstenkamp and Jörg Radtke, editors. *In press*.
- National Community Solar Partnership: http://energy.gov/eere/solarpoweringamerica/national-community-solar-partnership
- **COMING SOON (December?): http://communityenergyus.net/**

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Extra Slides

Why are they doing it?

"Promoting solar is as much personal as it is part of my job to reduce the cost of running the library for the taxpayers. Working in a building with solar panels is very satisfying for me as my personal values align every sunny day with my investment in my work."

– Municipal Solar Participant

"It became apparent to me that citizens could not rely on the government to advance clean energy. In order to… wean ourselves from the fossil fuels that are causing climate change, then, individuals must take the initiative."

-Solar Farm Participant

Possible Effects of Community Solar Participation

Ripple Effect: the "halo" associated with engaging in pro-environmental behavior may encourage an individual to subsequently adopt additional pro-environmental behaviors. (decrease energy use)

N. Mazar and Z. Chen-Bo, "Do Green Products Make Us Better People?," Psychological Sciences, vol. 21, no. 4, pp. 494–498, Apr. 2010.

Possible Effects of Community Solar Participation

Rebound Effect: gains in the efficiency of energy consumption result in an effective reduction in the per unit price of energy services. As a result, consumption of energy services should increase, partially offsetting the impact of the efficiency gain in fuel use. (increase energy use)

L. A. Greening, D. L. Greene, and C. Difiglio, “Energy efficiency and consumption — the rebound effect — a survey,” Energy Policy, vol. 28, no. 6–7, pp. 389–401, Jun. 2000.

Licensing Effect: Individuals establish moral credentials, and thus feel less obligated to scrutinize the moral implications of their actions immediately after receiving a moral boost by performing a good deed. (increase energy use)

N. Mazar and Z. Chen-Bo, “Do Green Products Make Us Better People?,” Psychological Sciences, vol. 21, no. 4, pp. 494–498, Apr. 2010.

I conserve energy by…	Before		After			
	Mean	SD	Mean	SD	Sig. (1-tailed)	95% LCB
Turning off lights when not needed	4.692	0.471	4.769	0.429	0.064	0
Adjusting my thermostat when no one is in the home	4.615	0.496	4.692	0.471	0.063	0
Turning off electronics when not needed	4.423	0.857	4.577	0.703	0.021*	0.038
Conserving water	4.308	0.618	4.423	0.578	0.021*	0.038
Using more energy efficient transportation	3.962	1.038	4.153	1.047	0.098	-0.038
Shutting down the computer when not in use for several hours	3.885	1.336	4.038	1.148	0.202	-0.154
Buying local food	3.808	0.939	4.038	0.958	0.016*	0.038
Unplugging appliances/electronics when not in use (or shutting off the power strip)	3.615	1.267	4.038	1.0786	0.001**	0.192

*indicates significance at the .05 level
**indicates significance at the .01 level
LCB = Lower Confidence Bound

I have made attempts to reduce fossil fuel energy in my home, including…	Before Participating in Project	While Participating in Project	After Participating in Project	Have Not Made Change
Updating to more efficient lighting	74%	13%	10%	3%
Buying energy efficient appliances	74%	6%	3%	16%
Adding insulation and/or weather-stripping	71%	0%	6%	23%
Reducing heat transfer through existing windows	65%	6%	6%	23%
Replacing old windows with more energy efficient windows	60%	3%	10%	27%
Upgrading heating system to more energy efficient technology	57%	3%	13%	27%
Installing an programmable thermostat	57%	0%	10%	33%
Having an energy audit	48%	10%	10%	32%

General Assumptions

Symbol	Description	Units	Default Value
C_{INV}	Cost of inverter replacement	$	9.5% of C_{SYS}[1]
d	Annual system degradation	%	0.50%[2]
None	Annual electricity price escalation	%	1.6%[3]
P_{REC}	REC price in year t	$/MWh	$40
r	Discount Rate	%	5%
T	System lifetime	years	25 years

1. Swift and Kenton, 2012
2. SAM
3. Energy Information Administration

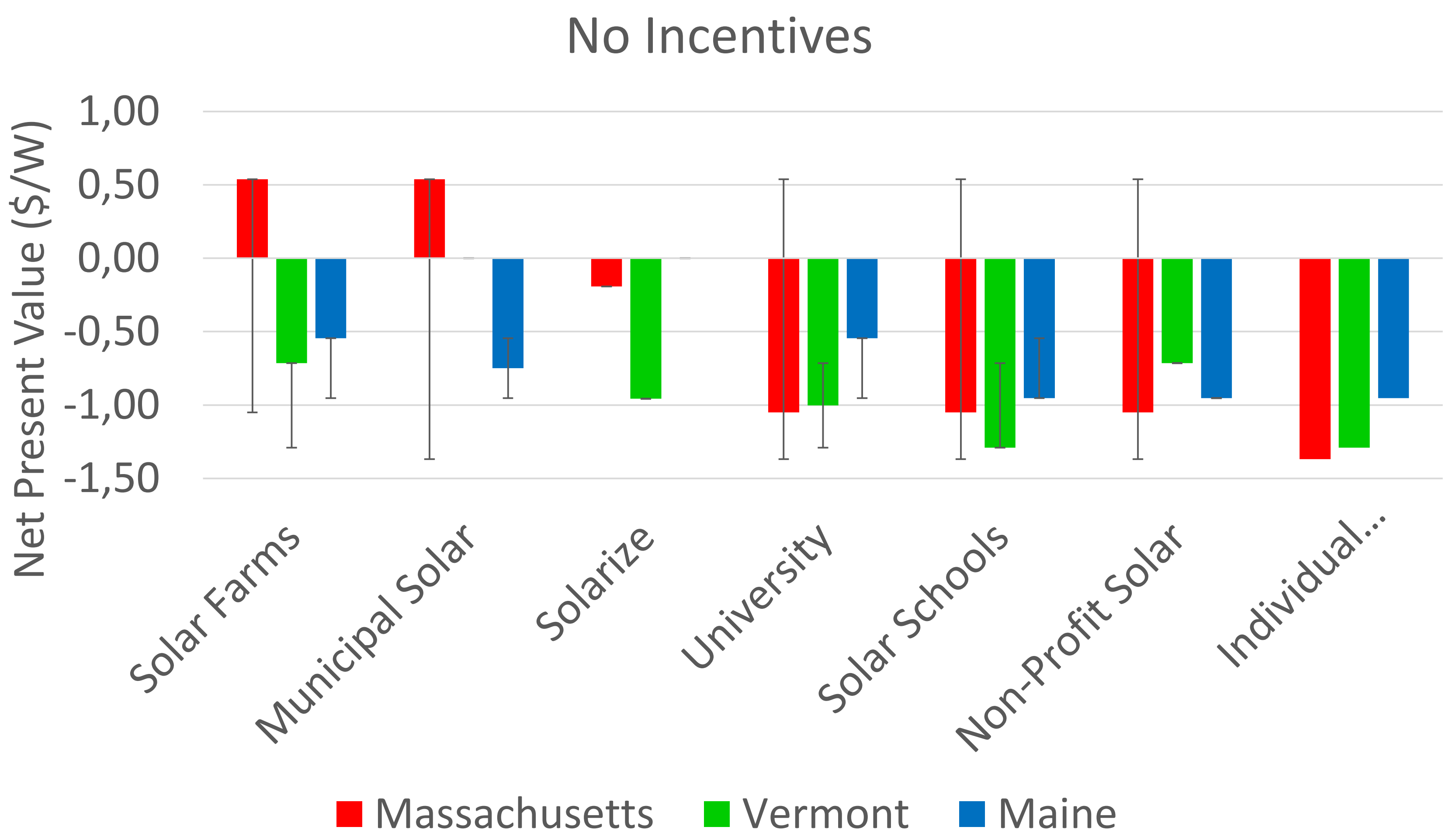
Capacity Factor

System Capacity * 8760 hours/year * Capacity Factor = Annual Production

Example: 10 kW * 8760 hours/year * .136 = 11,914 kWh/year

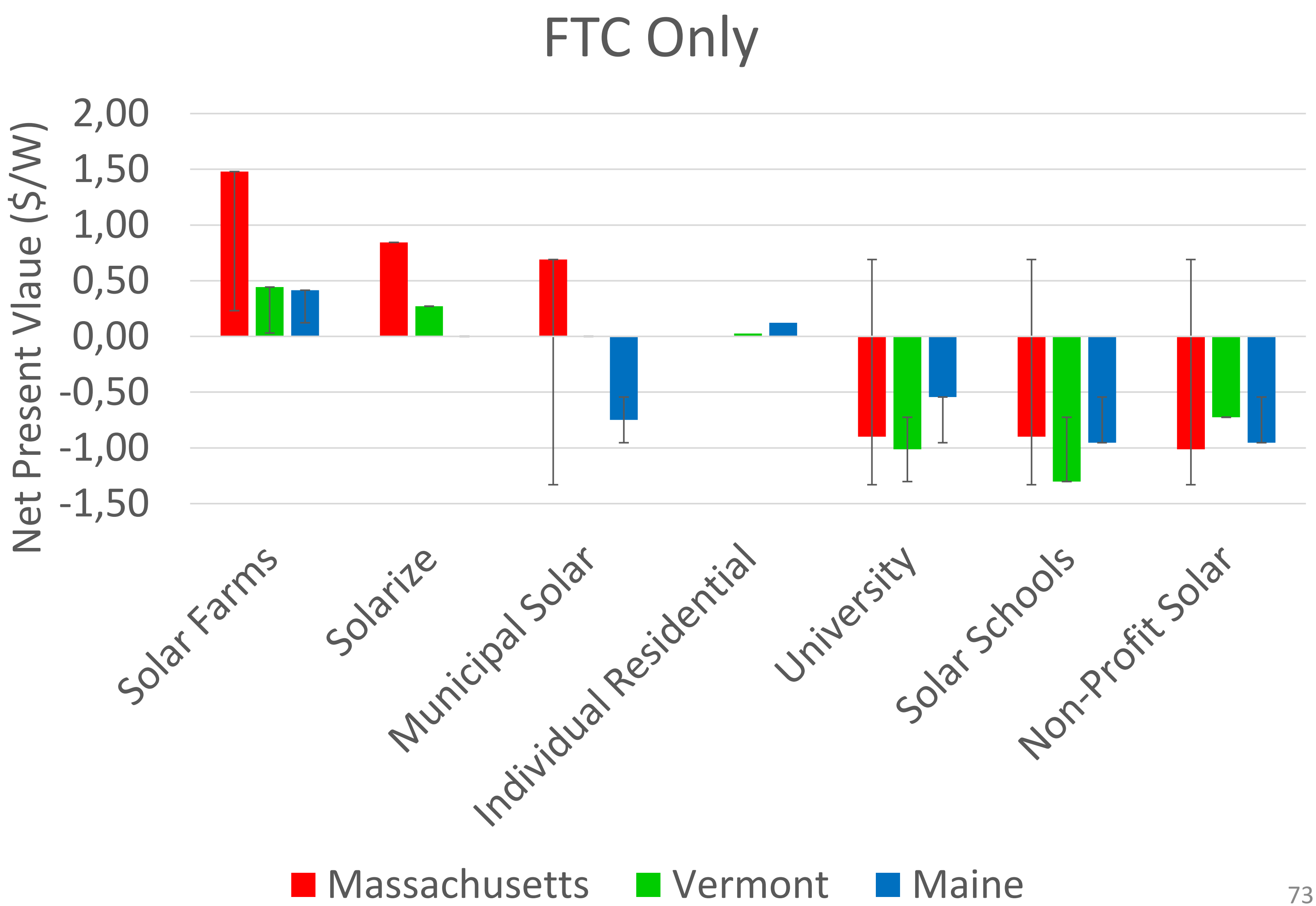
Results: NPV at 25 Years

Discount rate = 5%

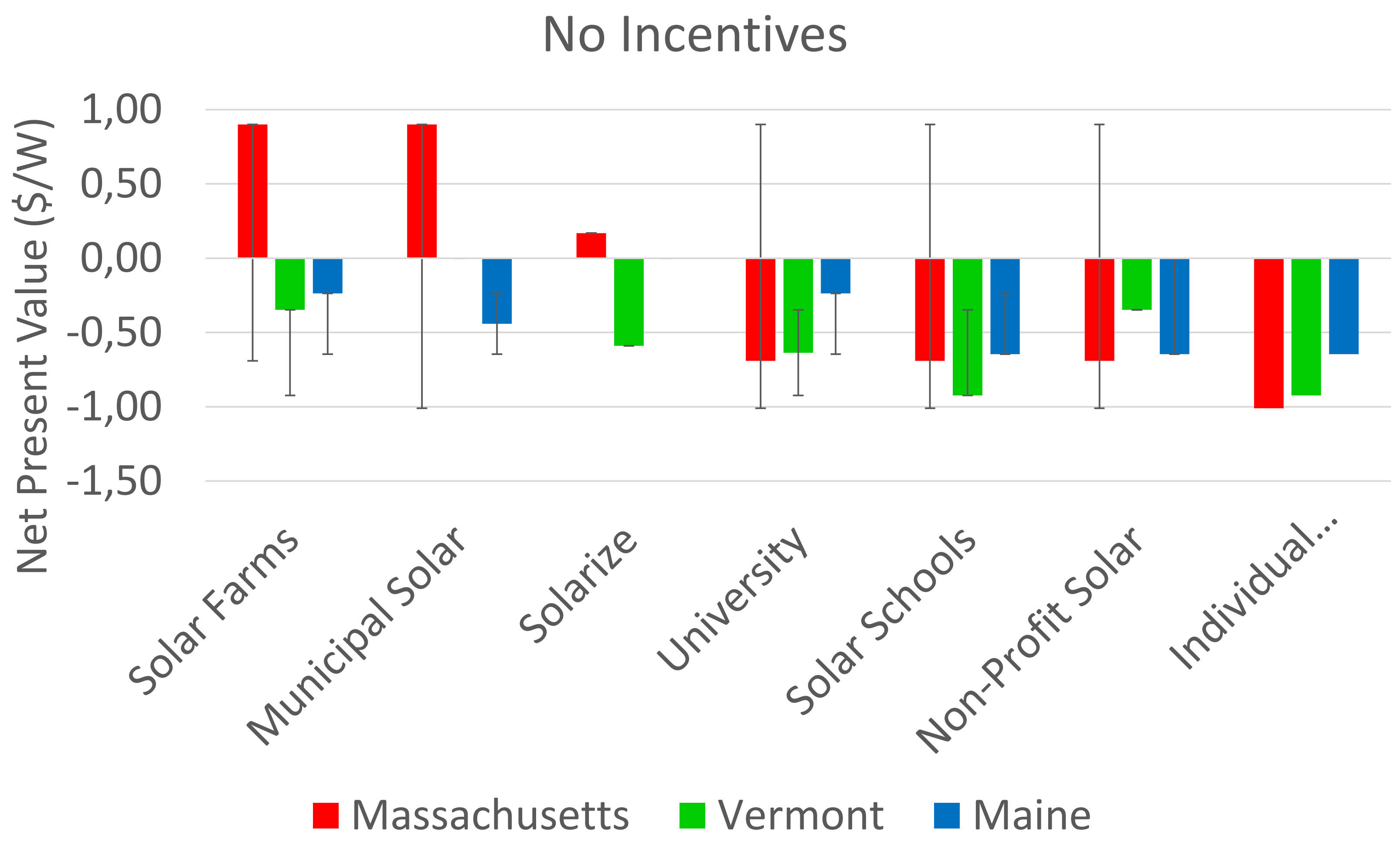


Results: NPV at 25 Years

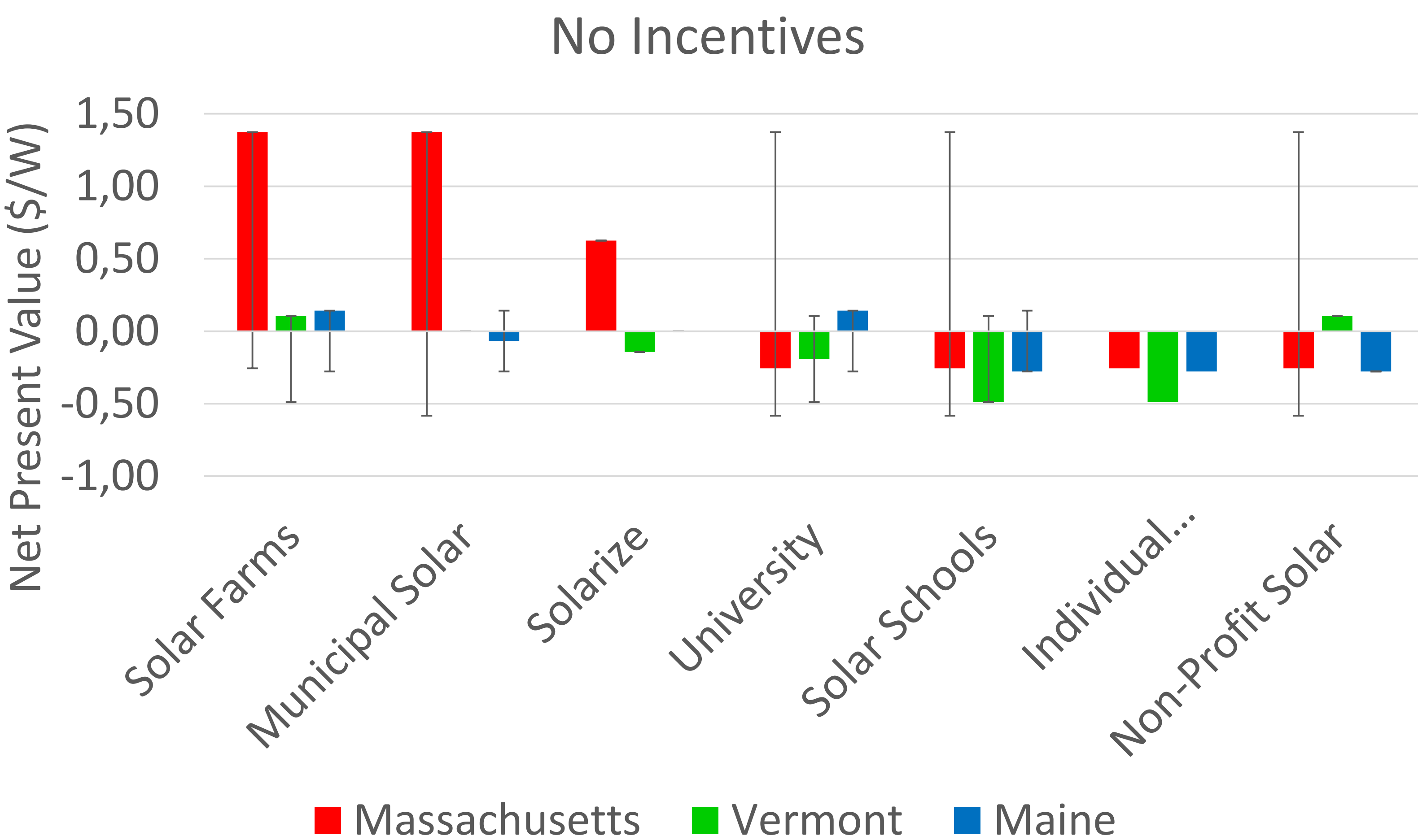
Discount rate = 5%



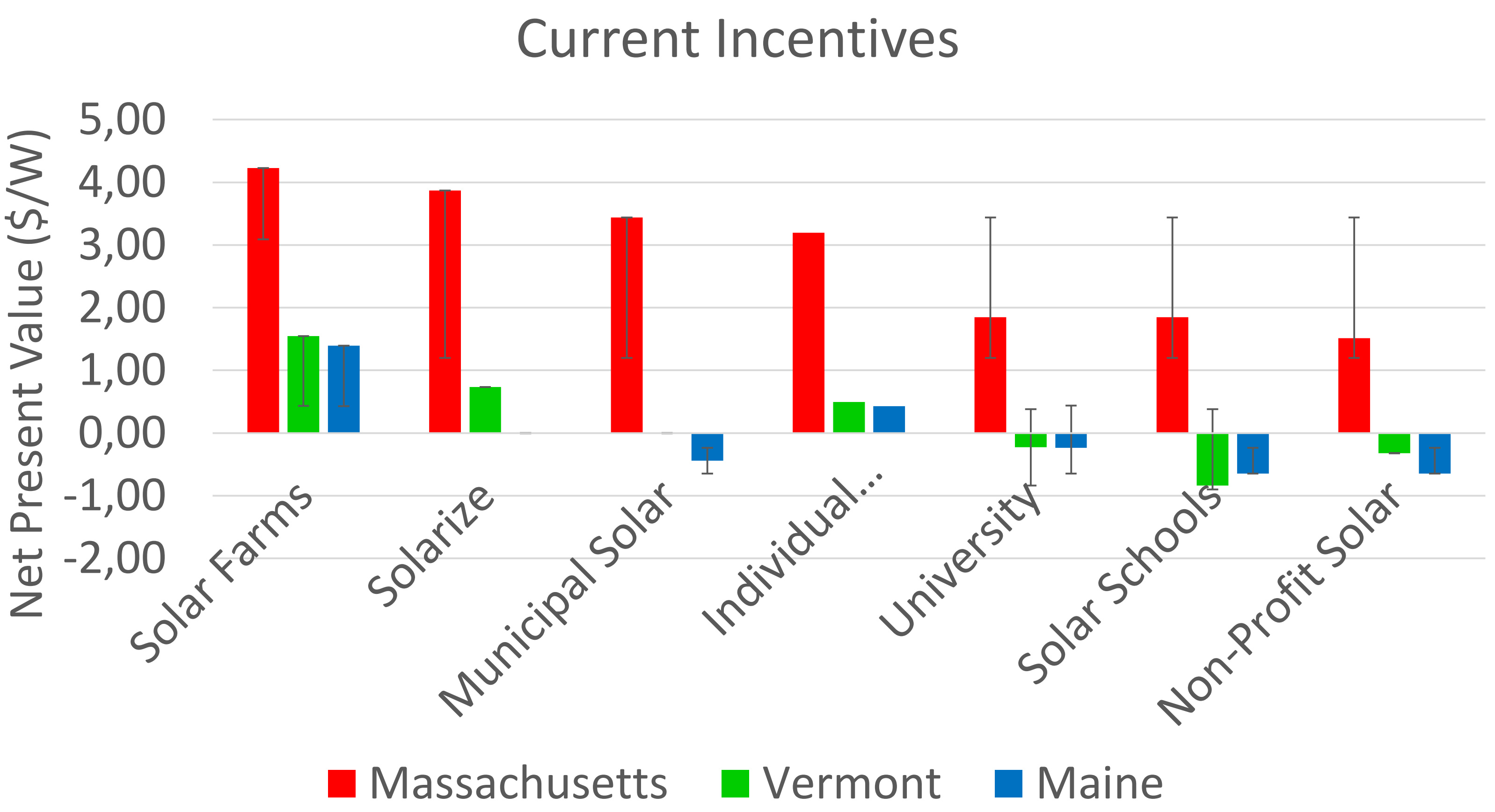
NPV at 30 Years: No Incentives



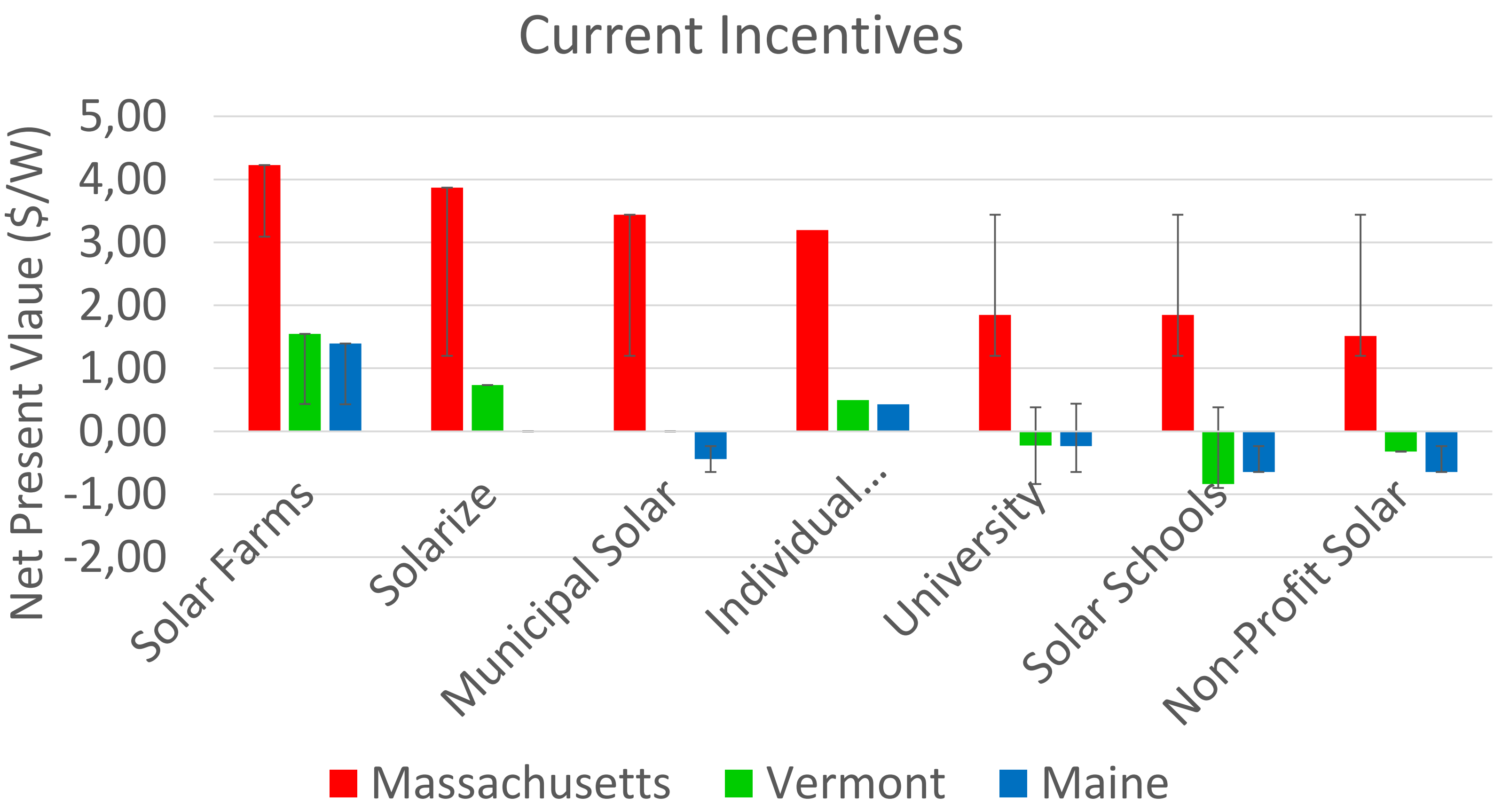
NPV at 40 Years: No Incentives



NPV at 30 Years: Current Incentives



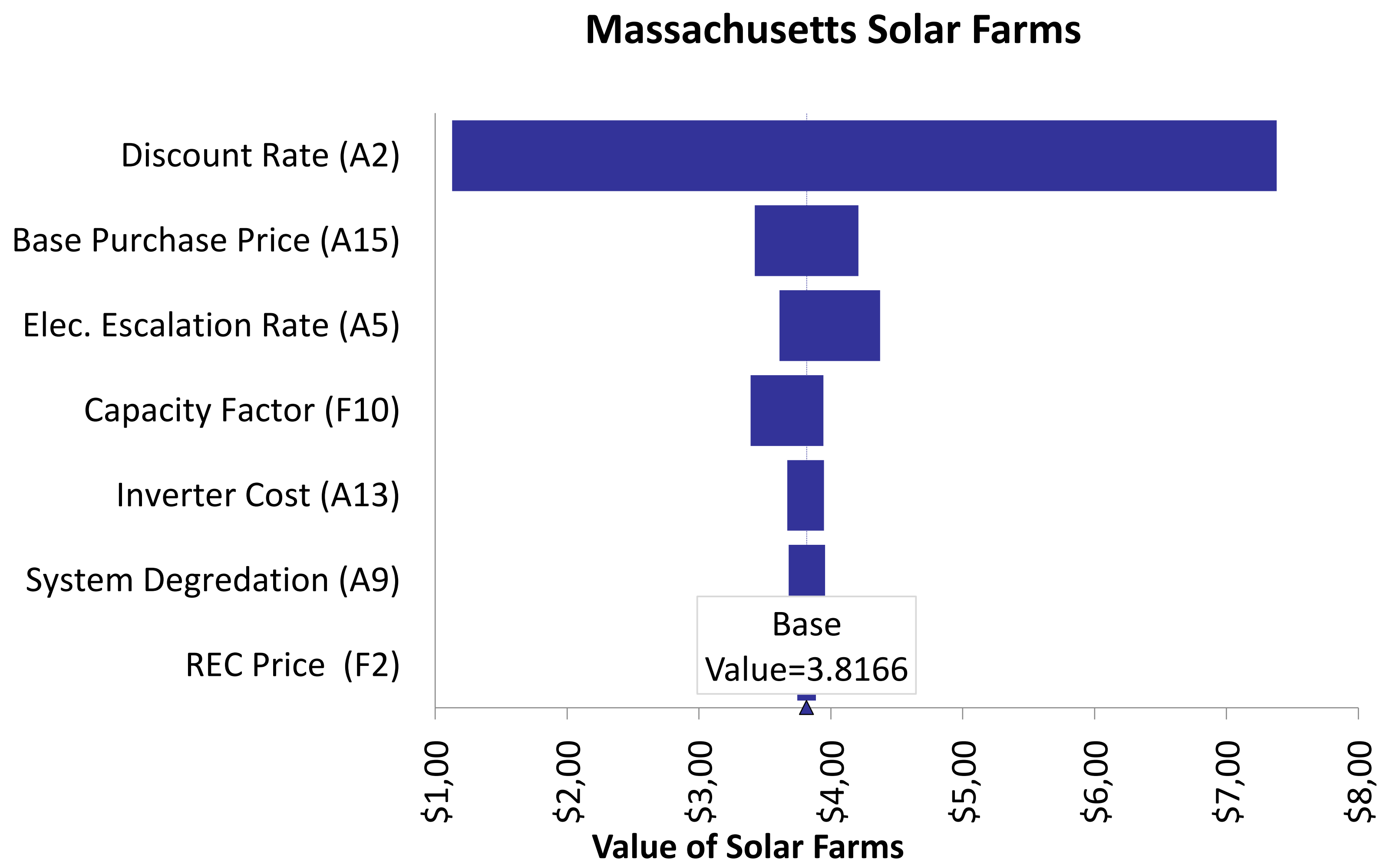
NPV at 40 Years: Current Incentives



Varied Inputs for Sensitivity Analysis

Symbol	Description	Units	Minimum	Nominal	Maximum
a	Elec. Escalation	%	1%	1.6%	3%
CF	Capacity Factor	%	12.6%	13.6%	14.9%
C_{INV}	Inverter Cost	% of system cost	0%	9.5%	20%
C_{WATT}	Base Purchase Price	$/W	3.55	4.44	5.33
d	System Degradation	%	0.2%	0.5%	0.8%
None	Capacity for price decrease	kW	10	25	50
None	Capacity for RECs	kW	25	50	75
None	Solarize Discount	%	15.0%	25.2%	40.0%
P_{REC}	REC Price	$/MWh	30	40	50
r	Discount Rate	%	0%	5%	15%

Sensitivity Analysis (Current Incentives)

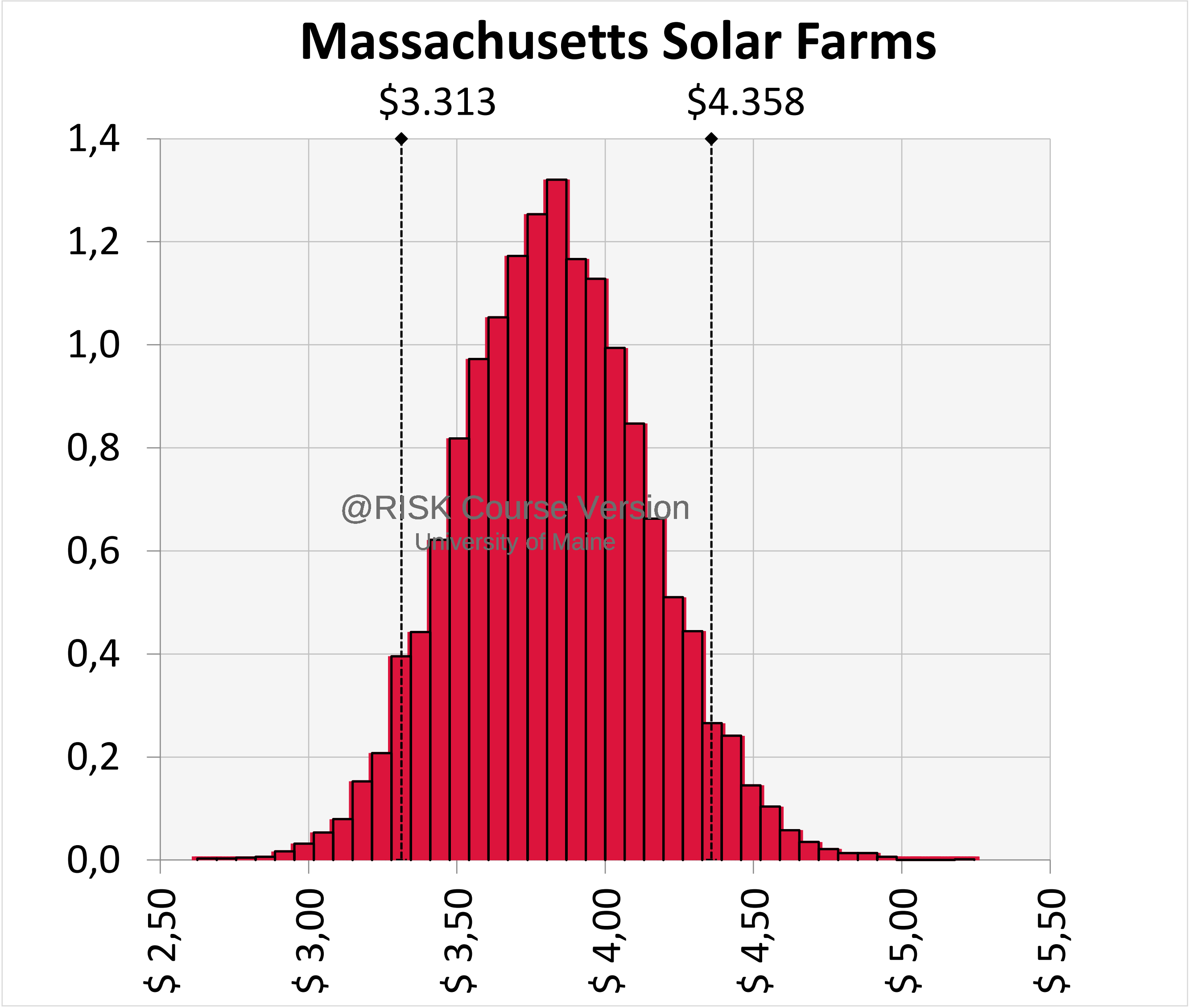


Monte Carlo Simulation (Current Incentives)

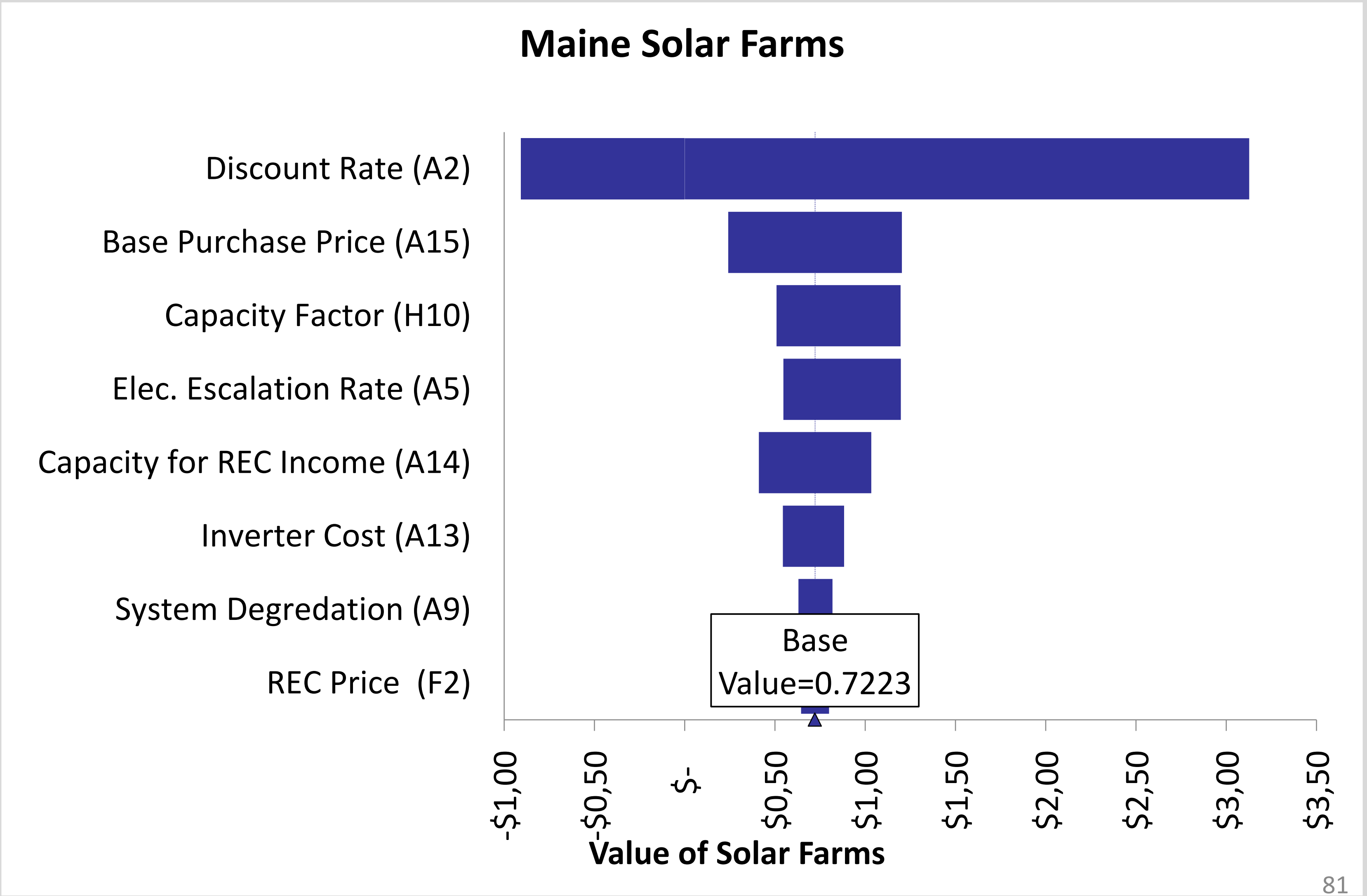
Discount Rate

Purchase Price

Elec. Escalation Rate



Sensitivity Analysis (Current Incentives)

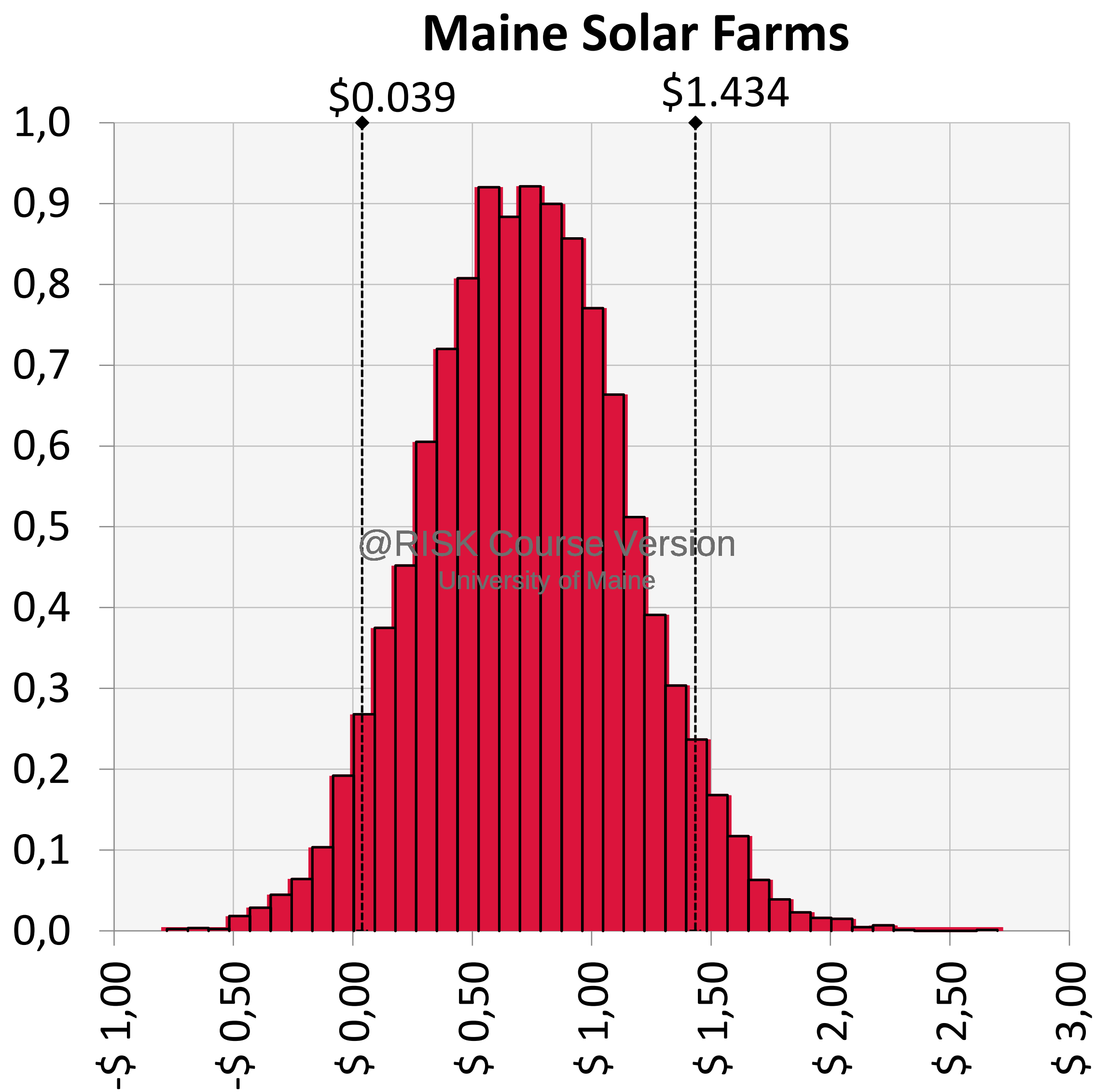


Monte Carlo Simulation (Current Incentives)

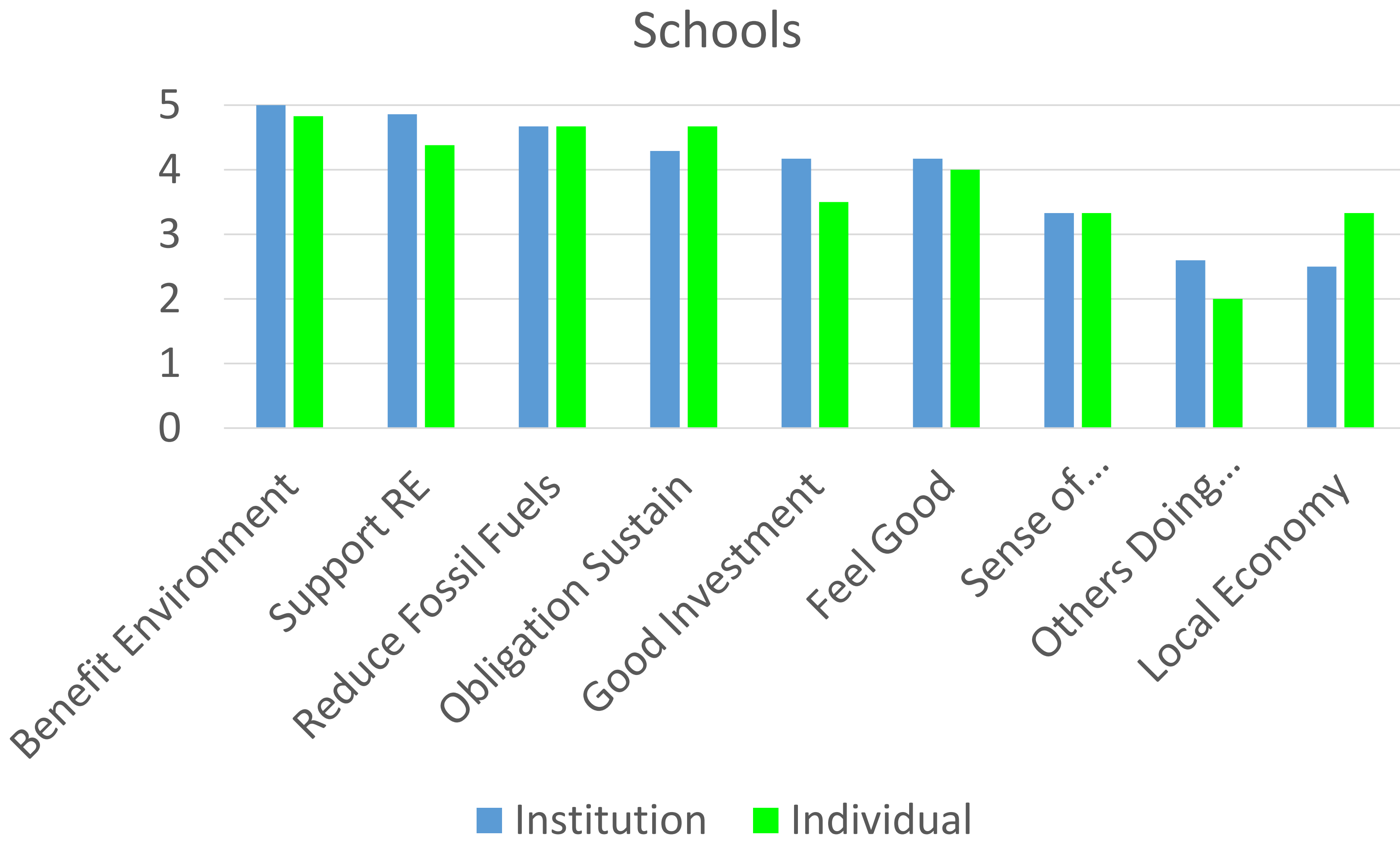
Discount Rate

Purchase Price

Capacity Factor

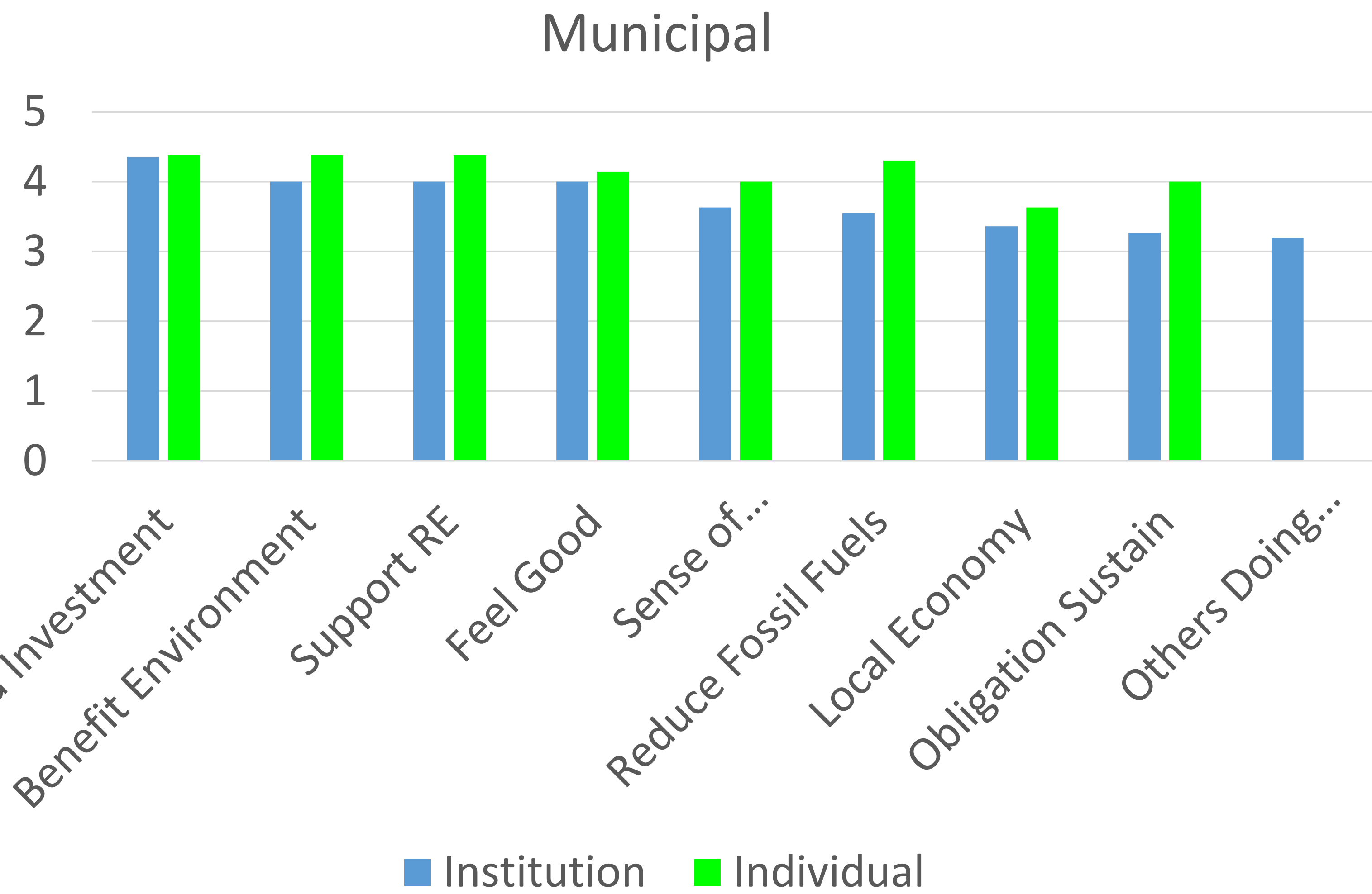


Individual vs. Institutional Motivations



1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree

Individual vs. Institutional Motivations



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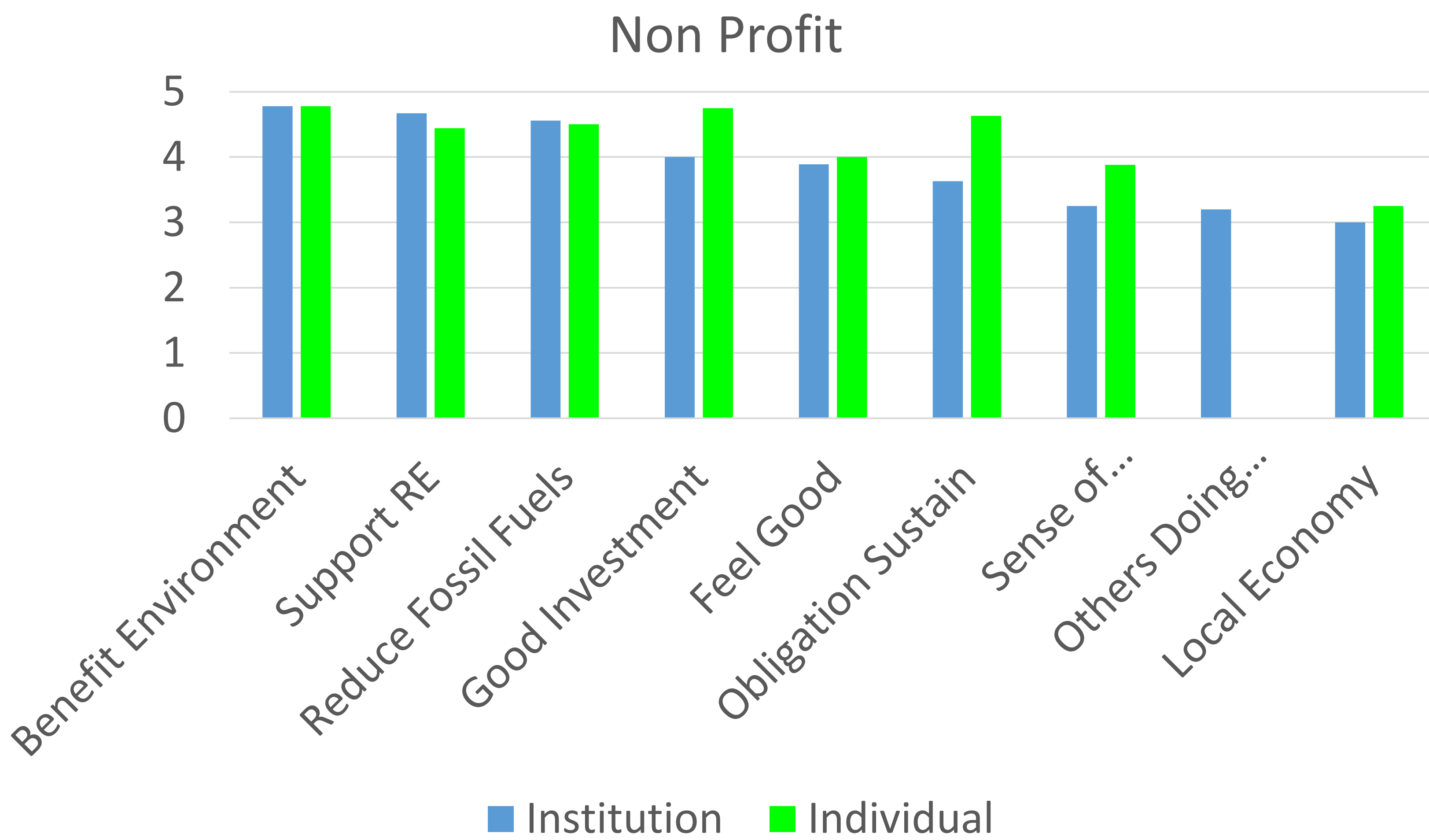
Individual vs. Institutional Motivations



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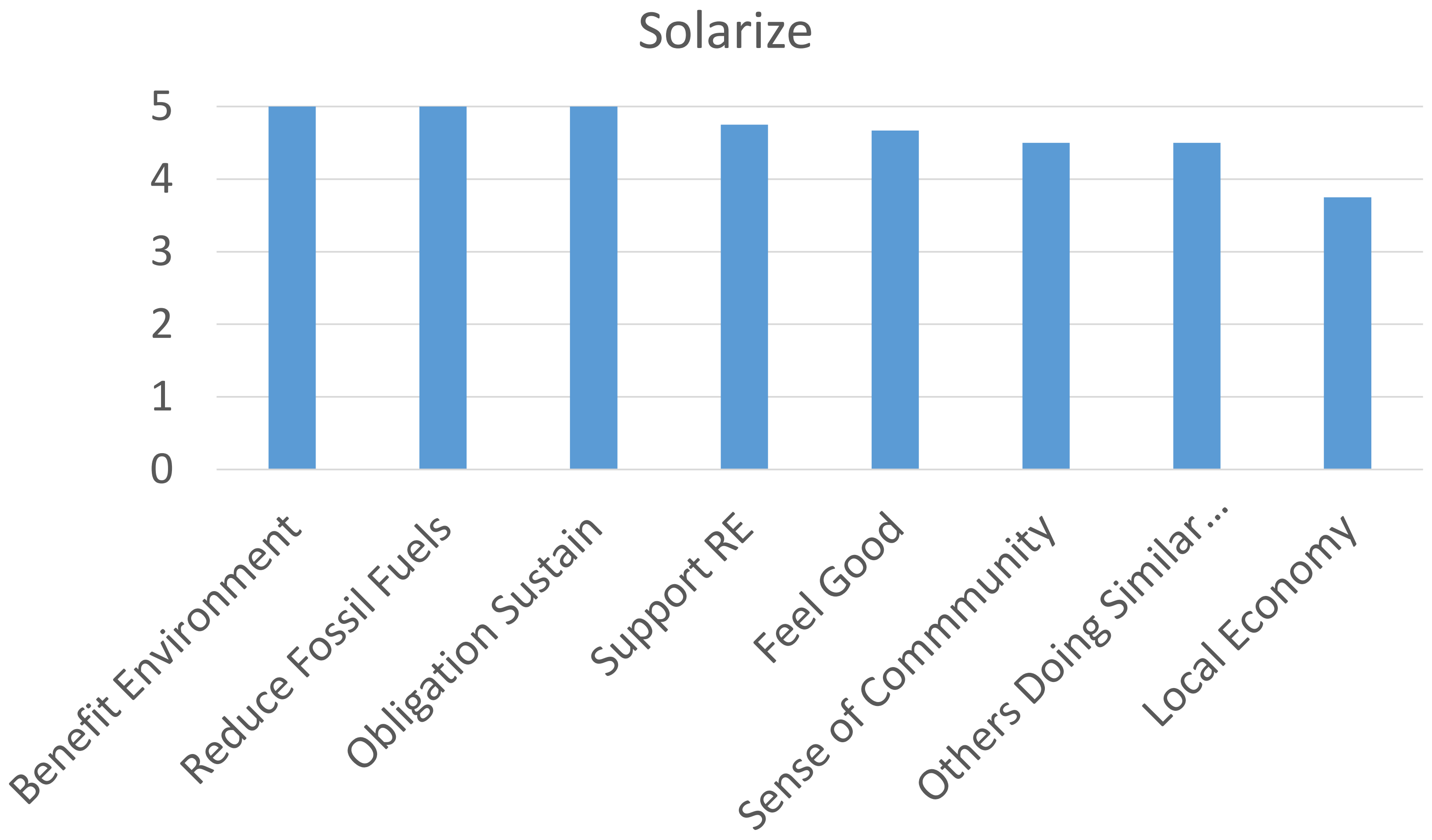
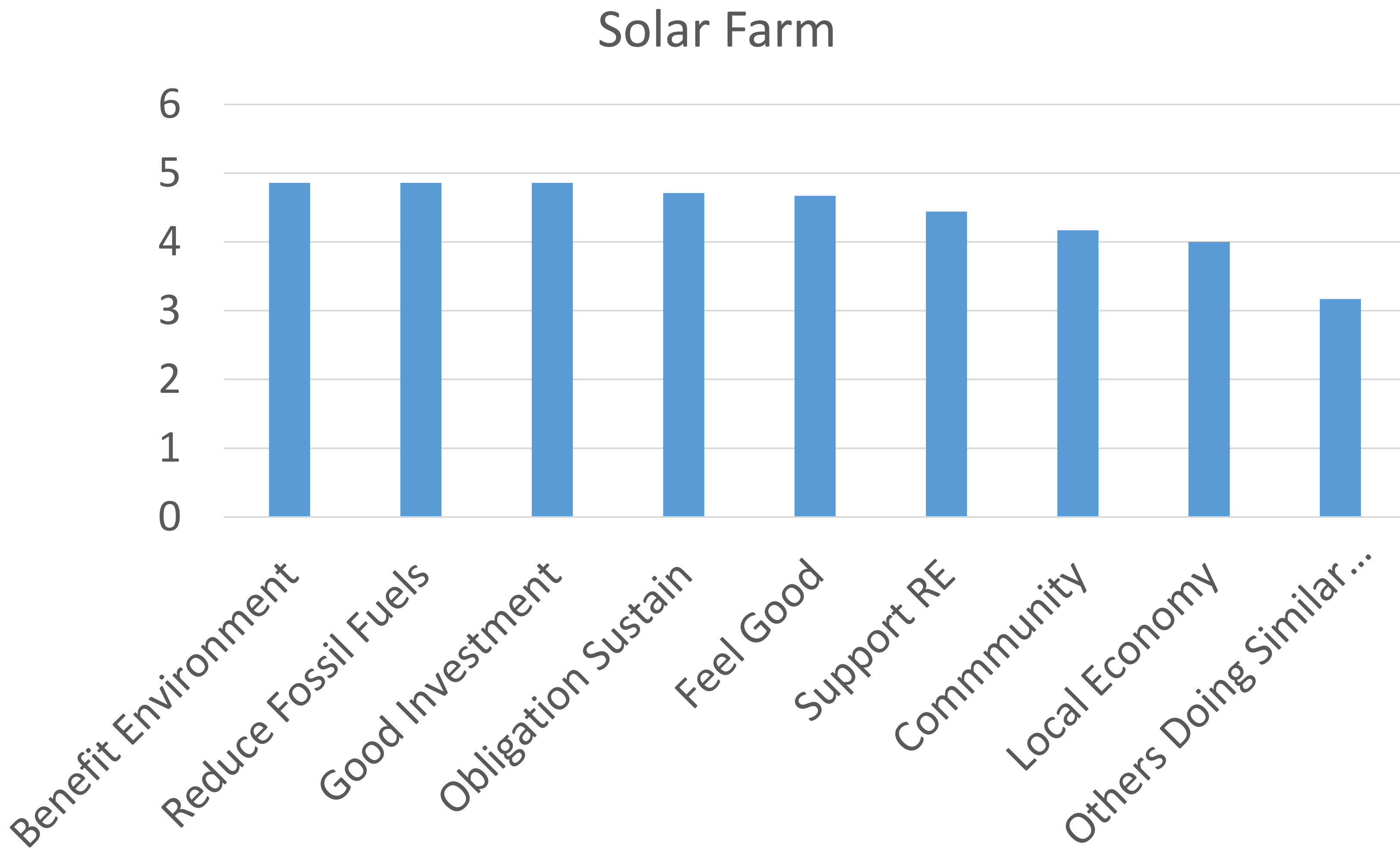
Individual Motivations



1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree

Individual Motivations



1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree

How are they doing it? (Organizational structures)

Grassroots (bottom-up) community-engagement

“*I attended Midcoast Green Collaborative meetings for several months. Discussion turned to formation of a community solar farm for those of us whose properties are not suitable for solar panel installation. I continued to meet with the group that formed around that topic and decided to join in and become a solar farmer. At one of the organizational meetings I agreed to become an officer (Secretary) of the association that was formed to operate this particular community solar farm*”

Vermont

How are they doing it? (Organizational structures)

Grassroots (bottom-up) community engagement

"Stated interest to follow-up recommendations in "The Inconvenient Truth" and solicited others in the congregation to come together to discuss, assigned individuals fact-finding responsibilites on hardware, vendors, contractors, state policy, etc. Eventually combined information and had a financial professional design a comparative spreadsheet to evaluate bids."

CSI – Non-profit

How are they doing it? (Organizational structures)

Top-down, Existing business

"*I conceived of this model of Community Solar in which participants own panels in the field . I leased the field, my company built the project and sold the panels*"

Solar farm

Vermont

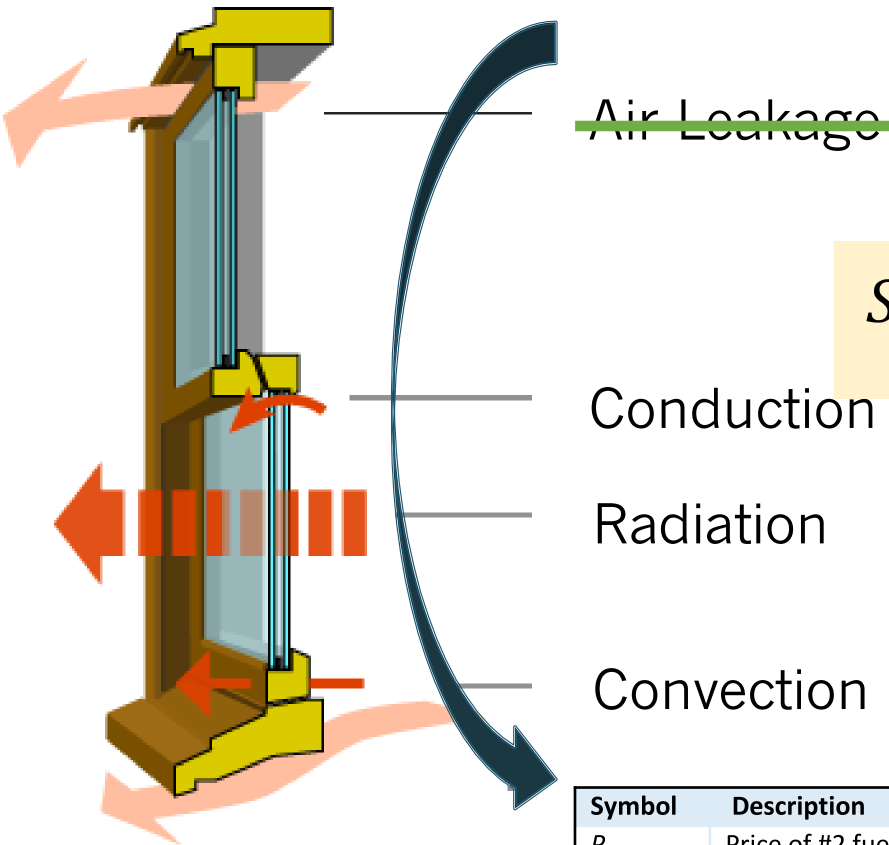
How are they doing it? (Organizational structures)

Top-down, Existing organization

"My role was to follow up on the initial lead from the minister; see if the appopriate committee wanted to proceed; administer the project and determine costs and options; tee it up for a church vote; negotiate the contract and oversee installation" **CSI Non-profit**, **MA**

"Our Head of School took on this project and initiated it. I was involved in the scheduling of the contractor, meter installment from State and payment." **CSI School**, **VT**

How much energy do they save?



$$Q = \frac{A \cdot d \cdot h}{R}$$

Q = heat loss (Btu/yr)
A = area (ft^2)
d = heating degree days (^oF day/yr)
h = hours/day
R = R-value (^oF-ft^2-h/Btu)

$$S = \frac{Q_{savings}}{E_{oil} \cdot \eta} \cdot P_{oil}$$

S = monetary savings (\$/yr)
$Q_{savings}$ = energy savings (MMBtu/yr)

$$C = P_{insert} \cdot A_{insert} \cdot (1 + t)$$

C = total upfront cost of inserts (\$); t = sales tax (5%)

$$PBP = \frac{C}{S}$$

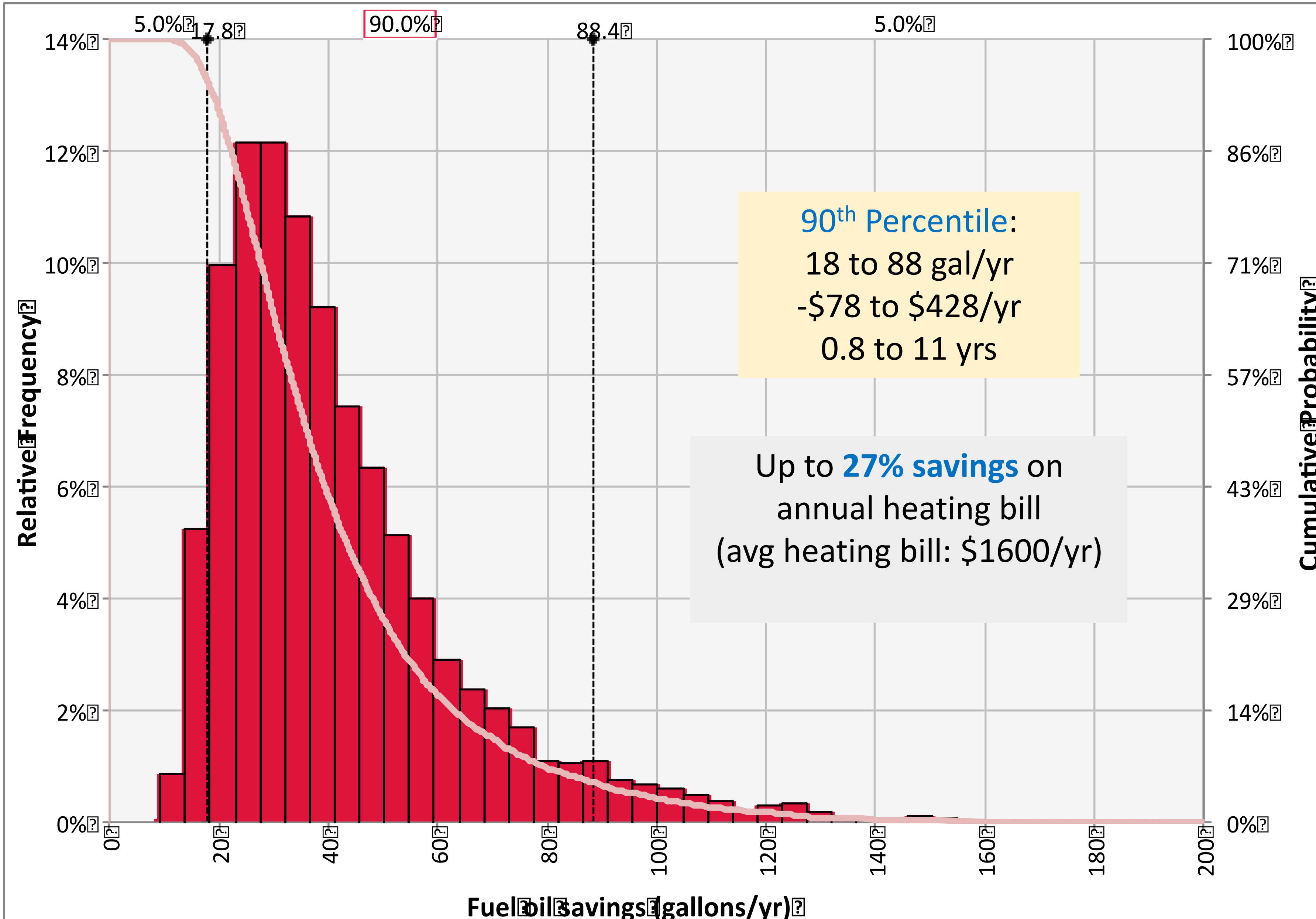
Symbol	Description	Minimum	Default	Maximum
P_{oil}	Price of #2 fuel oil (\$/gal) [15]	\$1.79	\$3.10	\$4.09
d	Heating degree days (^oF day/yr [17]	5,812	6,758	7,148
R_{insert}	R-value of inserts (^OF-ft^2-h/Btu)[1]	0.92	2.30	3.00
R_{win}	R-value of windows without inserts (F-ft^2-h/Btu) [16]	0.91	2.47	4.34
η	Efficiency of furnace/boiler [18]	0.78	0.82	0.85
P_{insert}	Price of inserts (\$/ft^2) [5]	\$1.65	\$2.67	\$3.68
E_{oil}	Energy content of #2 fuel oil (MMBtu/gallon) [18]	N/A	0.14	N/A

How much energy do they save?

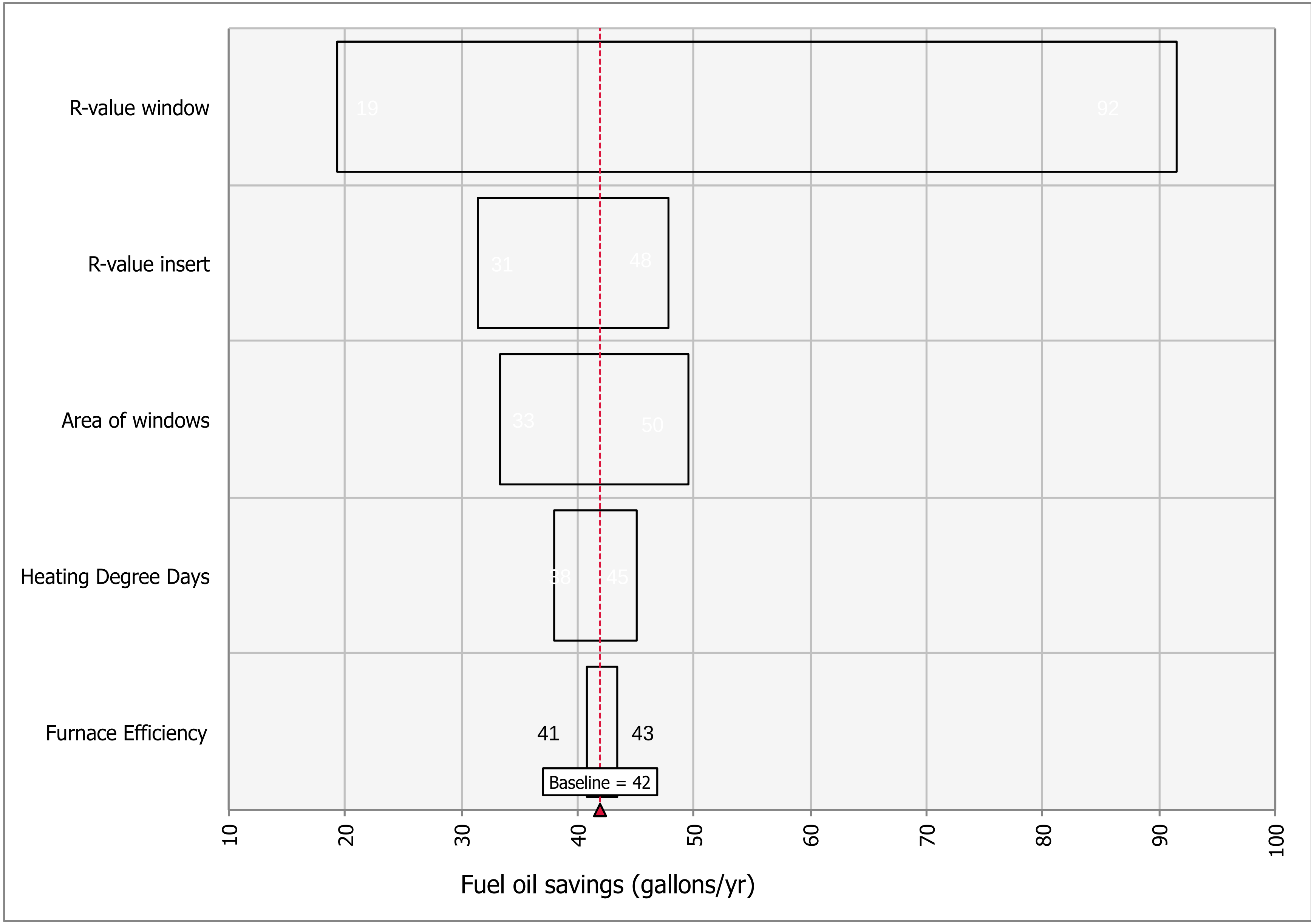
	Orono	Old Town	Base Case for Monte Carlo Analysis
Heat loss[1] through windows (MMBtu/yr)	24	19	10
Heat loss through windows + inserts (MMBtu/yr)	12	9	5
Energy savings from reduced heat loss (MMBtu/yr)	12	10	5
Energy savings (gallons of oil per yr)	108	86	42
Energy savings ($/yr)	335	268	130
Energy savings (MMBtu/ft^2)	0.04	0.04	0.03
Energy savings (gal oil/ft^2)	0.28	0.29	0.23
Payback period (years)	2.7	2.5	3.2

PBP for "Special Rate" ($10 for 10 inserts) <**1 month**!

Commercial Inserts ($20 to $30/$ft^2$): ~ **25 yr** PBP



5.0%
17.8
90.0%
88.4
5.0%
14%
12%
10%
8%
6%
4%
2%
0%
100%
86%
71%
57%
43%
29%
14%
0%
Relative Frequency
Cumulative Probability
90th Percentile:
18 to 88 gal/yr
-$78 to $428/yr
0.8 to 11 yrs
Up to 27% savings on
annual heating bill
(avg heating bill: $1600/yr)
0
20
40
60
80
100
120
140
160
180
200
Fuel oil savings (gallons/yr)



R-value window
19
92
R-value insert
31
48
Area of windows
33
50
Heating Degree Days
45
Furnace Efficiency
41
43
Baseline = 42
10
20
30
40
50
60
70
80
90
100
Fuel oil savings (gallons/yr)

Measuring R-value

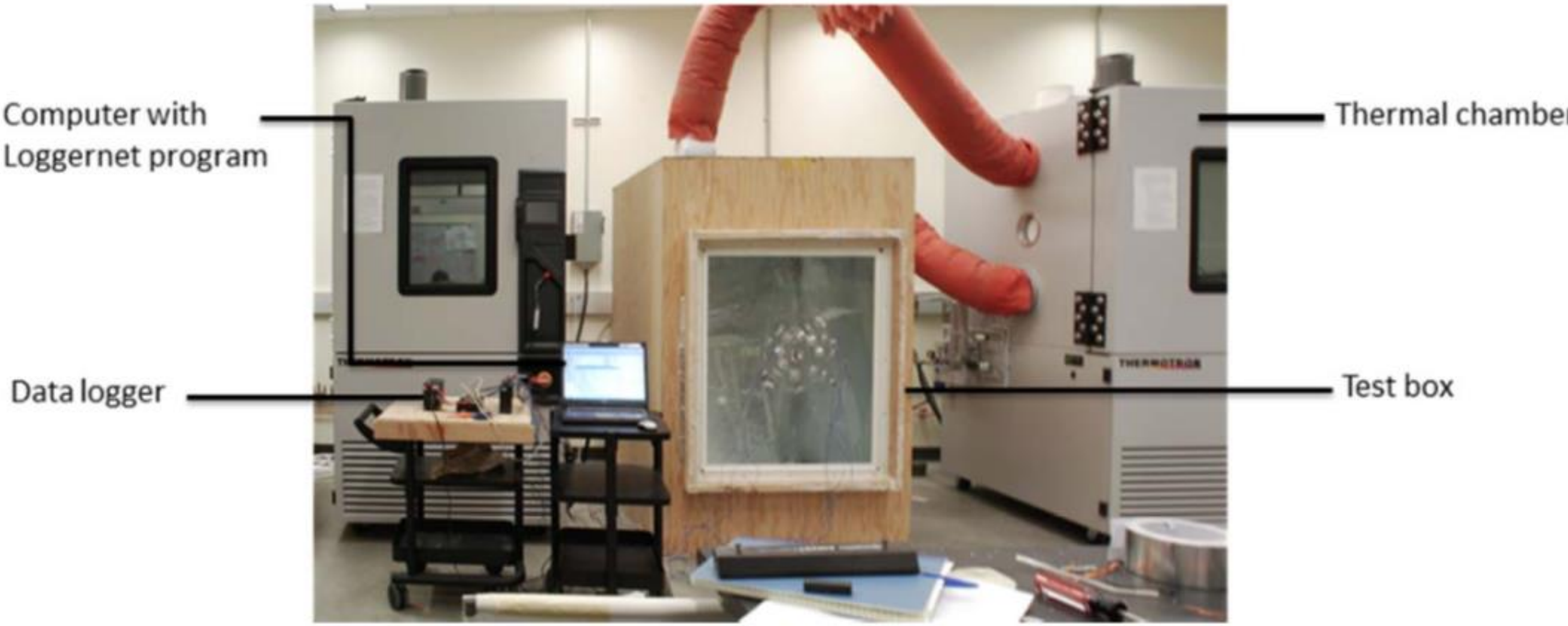


Figure 1. Insulated test enclosure located within the Green Building Research Laboratory (GBRL) at Portland State University.

David J. Sailor, "Oregon Best Commercialization Grant Program Final Report: Development, Testing, and Pilot Scale Evaluation of a new Retrofit Window Insulation Product - The Indow Window," Portland State University, Mar. 2013.