

Equity in Policy-Driven Solar Markets

Distribution of Economic Returns, Rents, and Expenditures in the Massachusetts RPS Solar Carve-Out II Program

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Research Context and Question

Massachusetts has implemented policy to purposefully grow a state solar PV market.

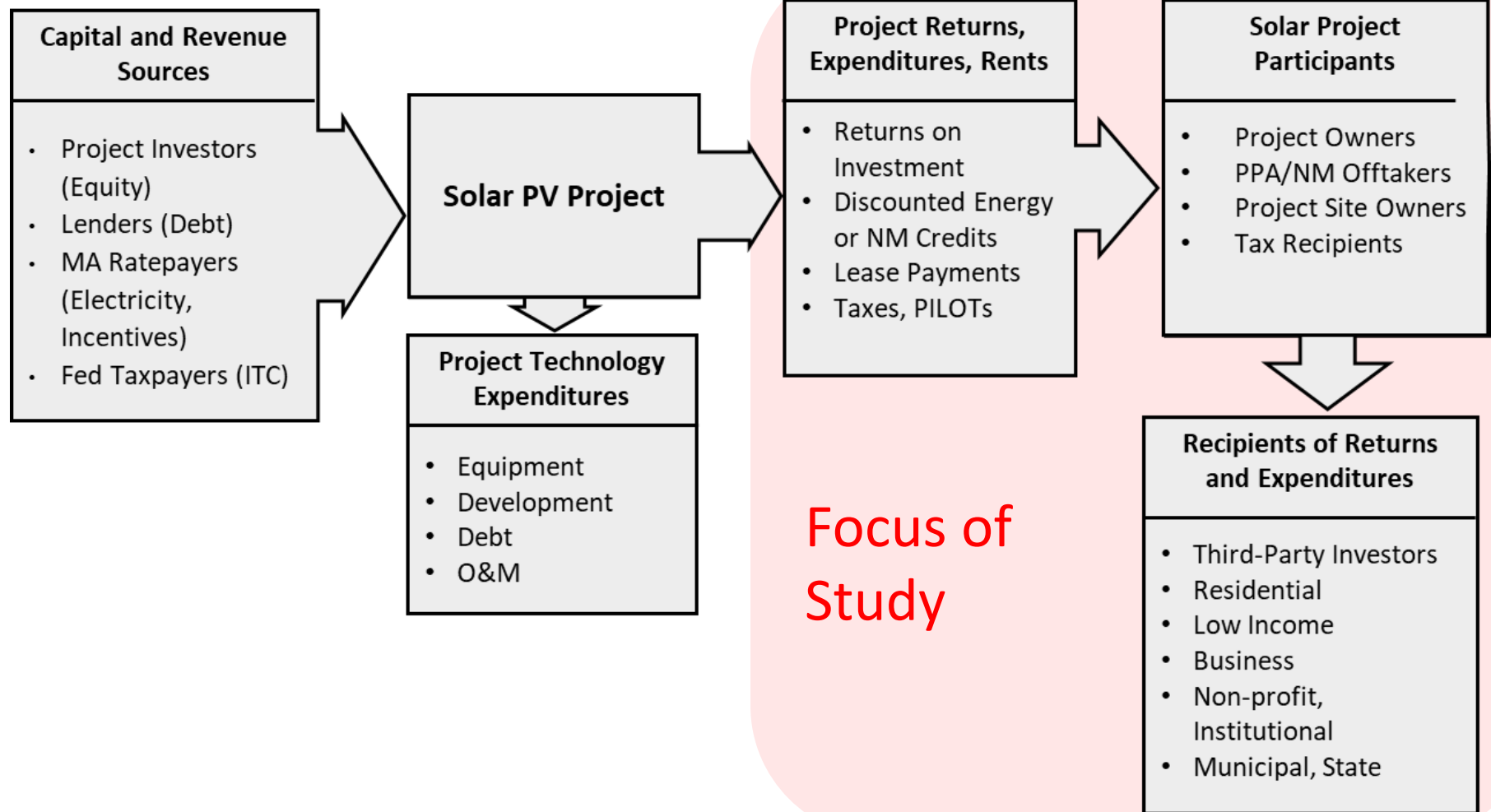
At cost to ratepayers, the solar program provides economic benefits to solar system suppliers and sales/installation jobs, and environmental benefits for the Commonwealth.

Substantial other benefits associated with project investment returns, electric and net metering bill savings, lease or PILOT payments.

What are the magnitude and distribution of these policy-driven benefits of solar market development?

How does policy design influence the equity of this distribution?

PV Project – Schematic of Economic Flow



Case Study: MA RPS Solar Carve-Out II Program

- 2014-2019 Solar Incentive Program
- Program Applications and Installations complete
- Robust project database – capacity, facility type, installed costs, etc.
- Policy differentiated incentives by solar project types and off-takers

For Project Study, we categorized projects by Project Type

- Commercial
- Community Shared Solar
- Low Income
- Non-Profit / Institutional
- Other
- Public/Government
- Residential

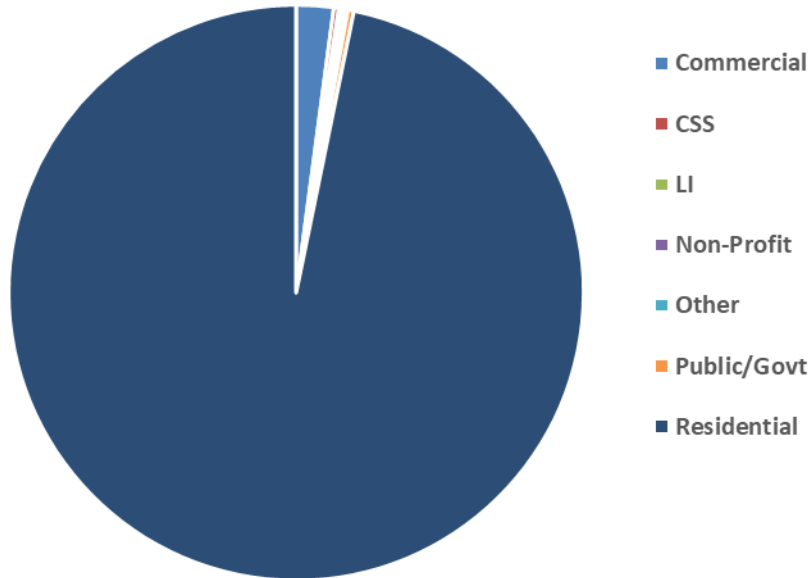
and Ownership

- Direct Owned
- Third-Party Owned

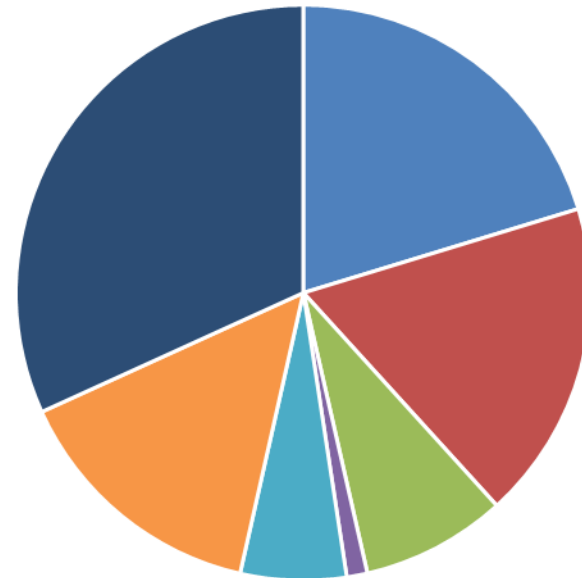
and Year Installed

Solar Carve-Out II Program Distribution by Project Type

Number of Projects
Total = 75,905



Installed Capacity
Total = 1,728 MW



Key Financial Assumptions

Project Type	Ownership	Electricity Retail Rate (2014, 2%/yr escalation)	Electric or NM Off-Taker Discount	PILOT / Lease Payment Agreement	Percent Project Equity Financed	Loan Rate and Term		Federal Tax Rate		State Tax Rate
		per kWh		annually / MW		rate	years	2014-2017	2018-2019	
Commercial	3rd Party	\$0.15	15%	\$12,500	55%	6.0%	10	35%	21%	8%
	Direct	\$0.15			55%	6.0%	13	35%	21%	8%
Community Shared Solar	3rd Party	\$0.15	15%	\$12,500	55%	6.0%	11	35%	21%	8%
	Direct	\$0.15			55%	6.0%	12	20%	20%	8%
Low Income	3rd Party	\$0.15	15%	\$12,500	55%	6.0%	11	35%	21%	8%
	Direct	\$0.15			100%	6.0%	0	0%	0%	0%
Non-Profit / Other	3rd Party	\$0.15	15%	\$12,500	55%	6.0%	11	35%	21%	8%
	Direct	\$0.15			100%	6.0%	0	0%	0%	0%
Public/Govt	3rd Party	\$0.15	15%	\$12,500	55%	6.0%	11	35%	21%	8%
	Direct	\$0.15			0%	6.0%	14	0%	0%	0%
Residential	3rd Party	\$0.18	15%		55%	6.5%	9	35%	21%	8%
	Direct	\$0.18			55%	5.5%	12	20%	20%	5%

Recipient/Ownership Assumptions

Off-taker Recipients for 3rd Party Ownership		Project Type					
		Comm	CSS	LI	Non-Profit	Public/Govt	Resid
Recipients	Commercial	100%	25%				
	Low Income			60%			
	Non-Profit				100%		
	Public/Govt		25%			100%	
	Residents		50%	40%			100%
	Solar Financiers						

Rent/Return Recipients for Direct Ownership		Project Type					
		Comm	CSS	LI	Non-Profit	Public/Govt	Resid
Recipients	Commercial	100%					
	Low Income			100%			
	Non-Profit				100%		
	Public/Govt					100%	
	Residents		100%				100%
	Solar Financiers						

Project Distribution as 3rd Party vs. Direct Ownership

Project Type	Year											
	2014		2015		2016		2017		2018		2019	
	3rd-Party OwnedTh	Direct Owned	3rd-Party Owned	Direct Owned	3rd-Party Owned	Direct Owned	3rd-Party Owned	Direct Owned	3rd-Party Owned	Direct Owned	3rd-Party Owned	Direct Owned
Commercial	70%	30%	70%	30%	70%	30%	70%	30%	70%	30%	70%	30%
CSS	99%	1%	99%	1%	99%	1%	99%	1%	99%	1%	99%	1%
Low Income	95%	5%	95%	5%	95%	5%	95%	5%	95%	5%	95%	5%
Non-Profit	90%	10%	90%	10%	90%	10%	90%	10%	90%	10%	90%	10%
Public/Govt	95%	5%	95%	5%	95%	5%	95%	5%	95%	5%	95%	5%
Residential	57%	43%	71%	29%	72%	28%	51%	49%	43%	57%	40%	60%

Cash Flow Spreadsheet Model

(normalized to a 1 MW installation)

Solar Photovoltaic Project Simple Financial Model			Financial Model adapted by UMass Clean Energy Extension to analyze Cash Flow of Economic Rents of Solar Projects (2019, 2020).			
RPS Solar Carve-Out Program v1.0						
DATA ENTRY AND FINANCIAL SUMMARY						
			Key			
Sheet ID	Com 3P 14		User Entry Cells			
Project Type	Commercial		Calculated Cells			
SREC I or SREC II Project	SREC II		UMass CEE New/Mod Input			
Project Start Year	2014		Not Used			
Select Taxable or Non-Taxable Entity	Taxable (Corporation)					
Project and Customer Cost Assumptions			Tax Assumptions			
Solar Photovoltaic System Size	1000000	Watts (DC STC)	Federal Tax Rate	35%		
Total System Cost/Watt	\$ 2.45	\$/Watt (DC STC)	State Tax Rate	8%		
Total System Cost	\$ 2,447,376		Effective Tax Rate	40%		
SREC Factor	0.90		Federal Tax Credit	30%		
State Solar Residential Income Tax Credit	0					
Project Performance and Savings/ Cost Assumptions			5 Year Accelerated Schd (MACRS)			
Project Life	25	Years	Depreciation	20.00%		
Electricity Revenue (Avoided Costs)	\$ 0.15	\$/kWh	Asset Basis			
Electricity Revenue (Avoided Costs) Annual Adjustor	2.0%	%	Gross Cost	\$ 2,447,376		
Annual Operations and Maintenance Cost Factor	\$ 21.00	\$/kW/Year	State/CEC Rebate	\$ -		
Electric or Net-Metering Off-taker Discount	15.0%	%	Less 50% of Federal Tax Credit	(\$ 367,106)		
PILOT / Lease Payment Agreement	\$ 12,500	\$/MW/year (for Project Life)	Asset Basis	\$ 2,080,270		
			Financing Assumptions			
			% Financed w/ Cash	55%		
			% Financed w/ Loan	15%		
			Loan Interest Rate	6%		
			Loan Period	10		
			Net Cost	\$ 2,447,376		
			Loan	\$ 367,106		
PRO FORMA AND PRODUCTION						
Project Output			Start-Up	Year 1	Year 2	Year 3
Annual Generation (kWh)				1,165,080	1,159,255	1,153,458
FINANCIAL SCHEDULES						
INCOME STATEMENT						
Electricity Revenue			\$ 174,762	\$ 177,366	\$ 180,009	
Off-Taker Discounts			\$ (26,214)	\$ (26,606)	\$ (27,001)	
PILOT / Lease Payment Agreement			\$ (12,500)	\$ (12,500)	\$ (12,500)	
SREC II Revenue		\$	\$ 373,292	\$ 304,652	\$ 281,328	
REC Revenue		\$	\$ -	\$ -	\$ -	
Operations & Maintenance Costs			\$ (21,000)	\$ (21,525)	\$ (22,063)	
Inverter Replacement Cost			\$ -	\$ -	\$ -	
Federal Depreciation Expense			\$ (416,054)	\$ (665,686)	\$ (399,412)	
Interest Expense			\$ (22,026)	\$ (20,355)	\$ (18,584)	
Federal taxes saved/(paid)		\$	\$ -	\$ (4,534)	\$ 103,858	
State taxes saved/(paid) [can not deduct federal depreciation expense]		\$	\$ -	\$ (37,305)	\$ (32,083)	
Net Income		\$	\$ -	\$ 8,420	\$ (192,878)	\$ (31,667)
CASH FLOW STATEMENT						
Cash From Operations (Net Income - Fed Depr Exp)		\$	\$ -	\$ 424,474	\$ 472,808	\$ 367,745
Cash From Investing		\$	\$ (2,447,376)	\$ -	\$ -	\$ -
Installed PV Cost		\$	\$ (2,447,376)	\$ -	\$ -	\$ -
One Time Federal Solar Investment Tax Credit		\$	\$ 734,213	\$ -	\$ -	\$ -
Cash From Financing		\$	\$ 367,106	\$ -	\$ -	\$ -
Loan Disbursement		\$	\$ 367,106	\$ -	\$ -	\$ -
Loan Repayment (Principle)		\$	\$ -	\$ (27,852)	\$ (29,523)	\$ (31,294)
Annual Cash Flow		\$	\$ (1,346,057)	\$ 396,622	\$ 443,285	\$ 336,451
Cumulative Cash Flow		\$	\$ (1,346,057)	\$ (949,434)	\$ (506,149)	\$ (169,698)
ECONOMIC RETURN/RENT/EXPENDITURE SCHEDULES						
			Year 0	Year 1	Year 2	Year 3
Economic Recipients	Discount Rate	NPV of Rent				
Solar Financiers	5%	\$ 1,285,943	\$ (1,346,057)	\$ 396,622	\$ 443,285	\$ 336,451
Commercial	5%	\$ 575,055	\$ -	\$ 38,714	\$ 39,105	\$ 39,501
Residents	5%	\$ -	\$ -	\$ -	\$ -	\$ -
Low Income	5%	\$ -	\$ -	\$ -	\$ -	\$ -
Public/Govt	5%	\$ -	\$ -	\$ -	\$ -	\$ -
Non-Profit	5%	\$ -	\$ -	\$ -	\$ -	\$ -
Total		\$ 1,860,998				

Technical/Financial Inputs – separate sheet for each Project Type, Installation Year, and Ownership (72 sheets)

Performance and Cash Flows out 30 years

Accounting of Economic Returns and Expenditures to Recipients – Cash Flow and NPV



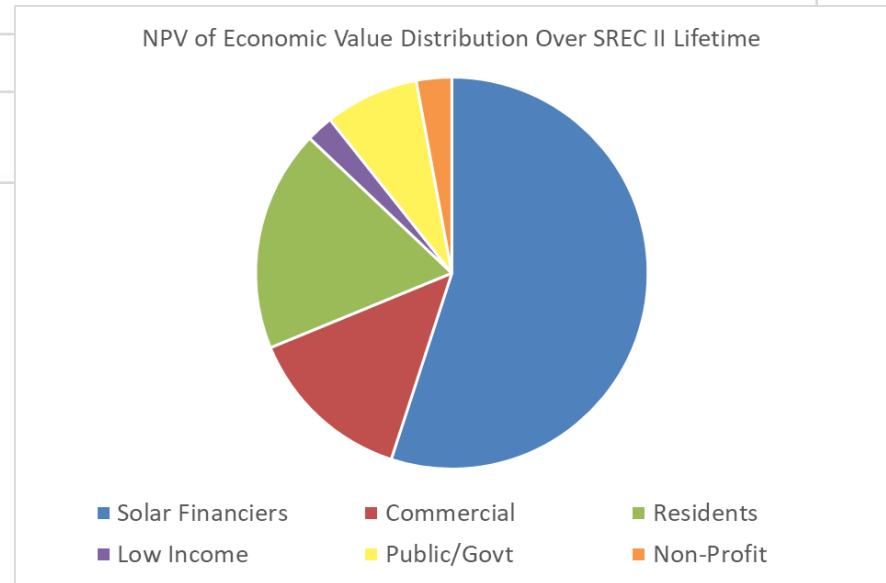
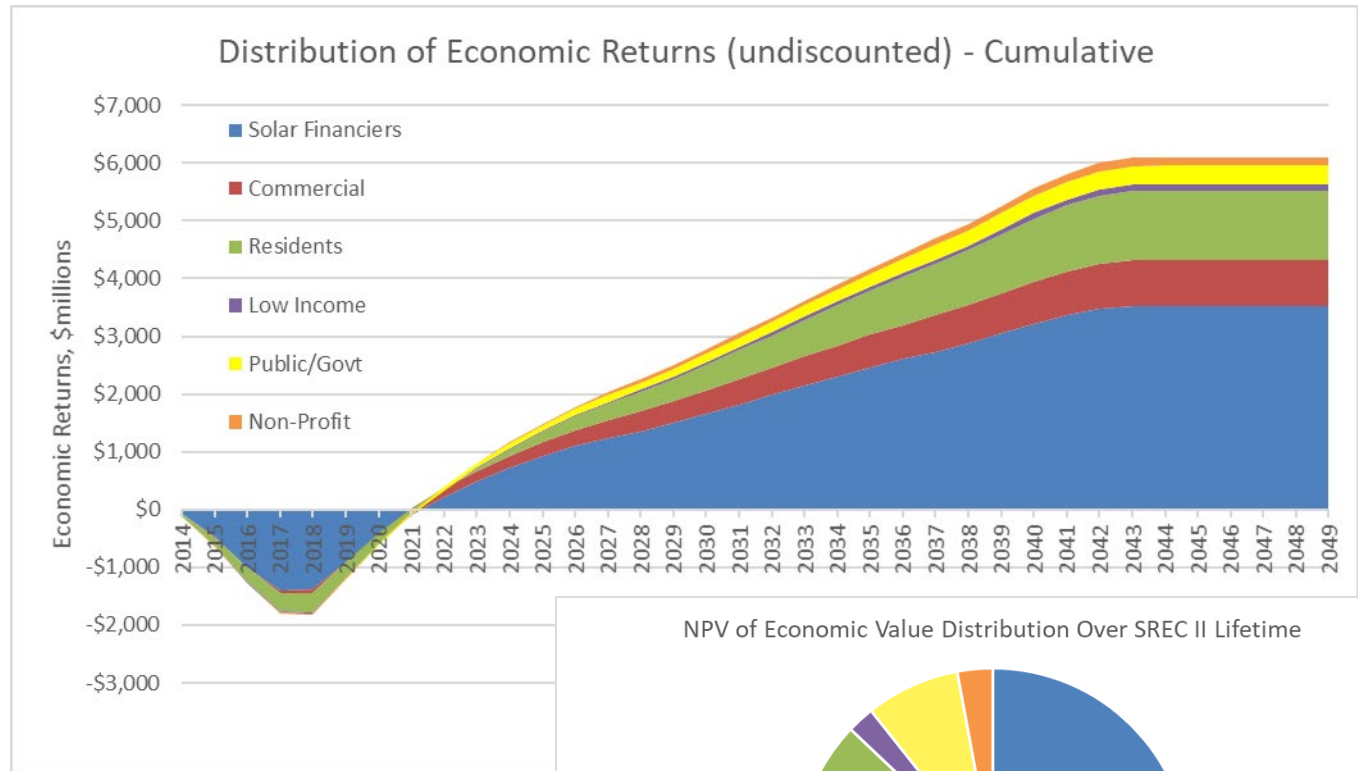
Cash Flows per MW are multiplied by MWs installed to get totals.



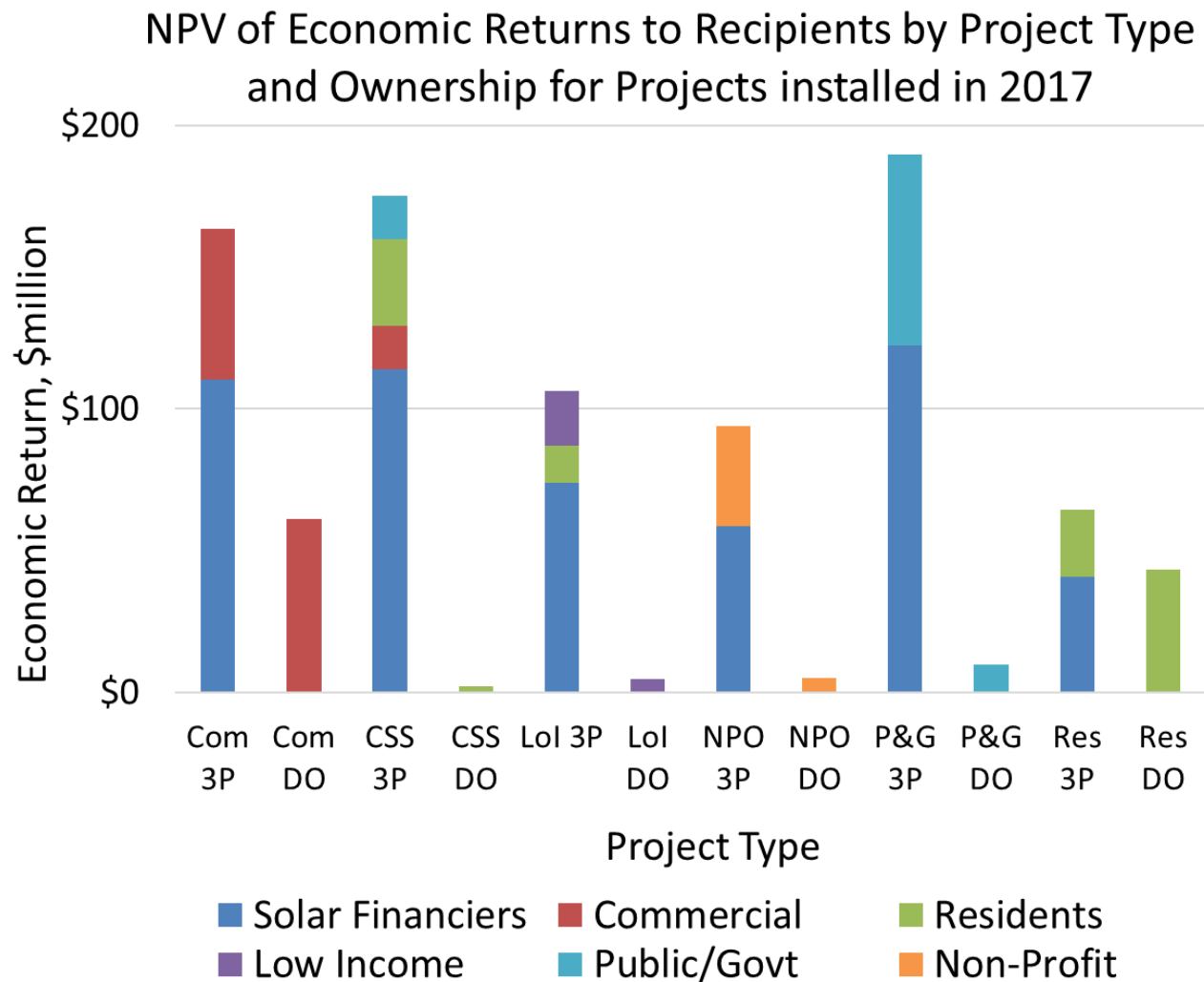
Distribution of Economic Returns over Total Installed Capacity

Solar Financiers are dominant recipients of economic returns over the course of the Solar Carve-Out II program.

Returns to Low Income, Public, Non-Profits recipients are slim.



Distribution of Economic Returns by project type and ownership



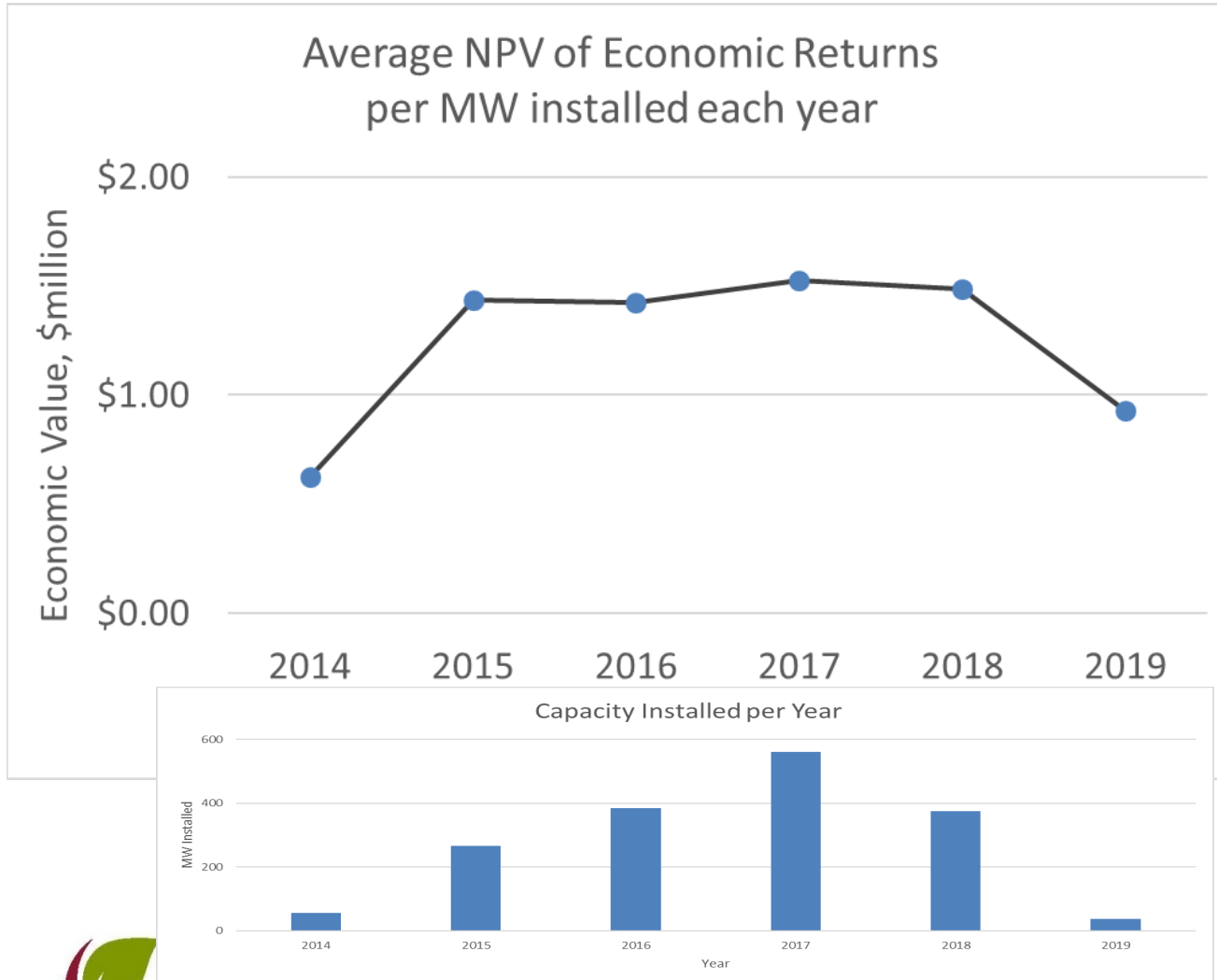
Magnitude of returns to recipients driven by MW installed, and by ownership.

Direct ownership installations for public/govt, non-profit, low income, and community shared solar is very limited, for policy and financial reasons.

Let's look at Economic Returns on a per MW basis

**to consider which types of project and ownership
lead to greater distributed benefits to recipients**

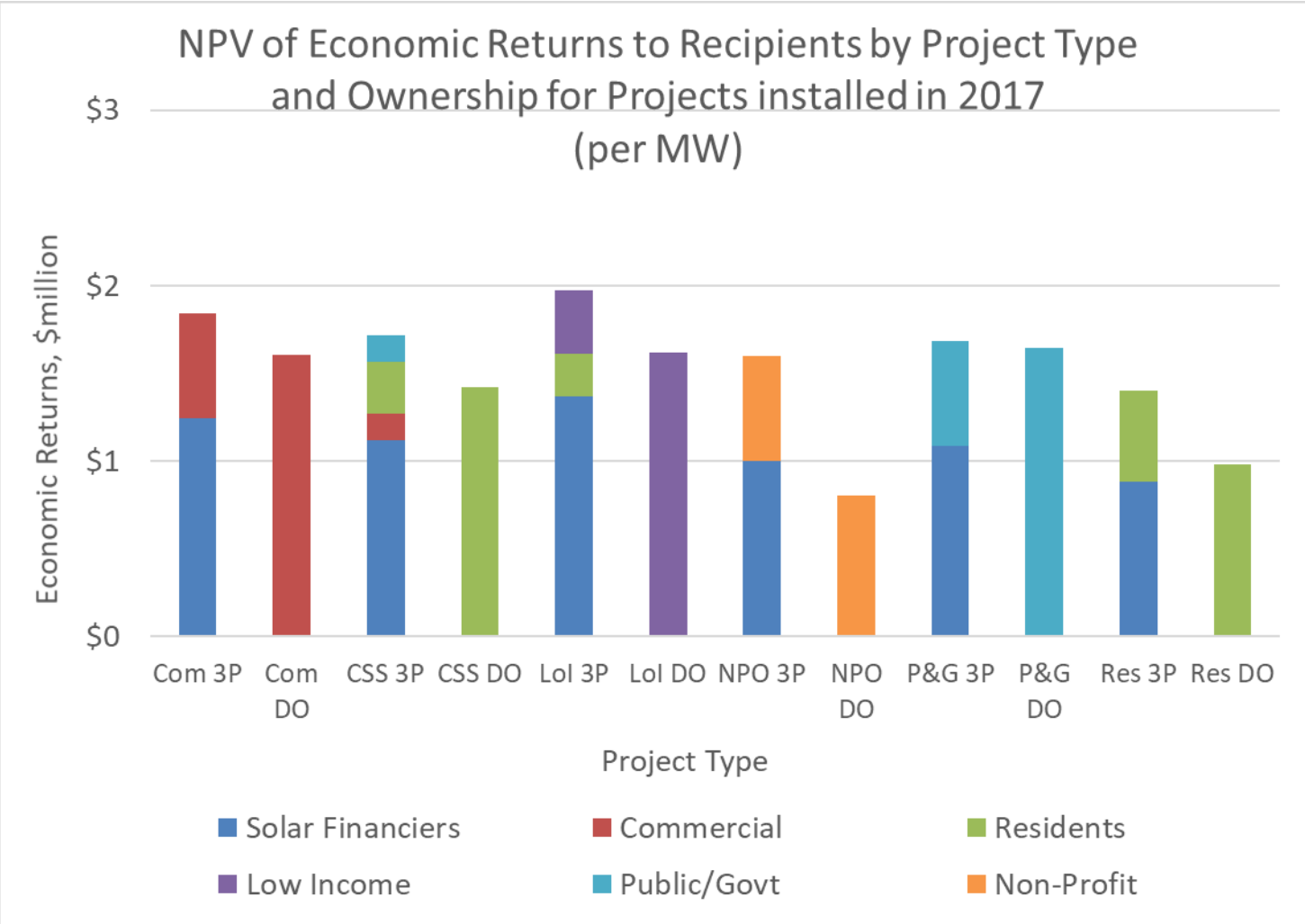
NPV of Economic Returns across all Installed Capacity per MW



Data provides stable NPV of Economic Returns per MW over core years of the Solar Carve-Out II program.

Analysis suggests NPV \rightarrow 0 at approx. 14% discount rate.

Distribution of Economic Returns per MW by project type and ownership



Third party ownership provides substantial portion of returns to solar financiers, and smaller returns to participating parties.

Direct ownership provides substantial returns to local recipients.

Not all recipients have same discount rate, so attractiveness of these returns may vary.

Further Research Questions

How do the magnitudes and recipients of economic returns map to geographical location and to income strata? How does this distribution relate to the cost to MA ratepayers and to income inequalities in MA/US.?

Are the dual policy objectives of rapid deployment of solar (and resulting GHG emission reductions) and equitable distribution of returns inherently at odds, or can both be substantively met?

What are policy and financial barriers and levers that can enhance the equity of solar development?

For the residential market, what is the distribution of installations and ownership models, across census tracts and household income levels?

How do these MA Solar Carve-Out II results transfer to other MA solar programs (e.g. SMART) and other U.S./EU solar policy programs?

Thank You

Questions/Thoughts?

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