



Economic Drivers of PV Analysis

For Presentation to

ISO-New England

Distributed Generation Forecast Working Group

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Craig Schultz

Principal, Renewable Energy

ICF International

703-934-3000

Craig.Schultz@icfi.com

Intended Use of the Presentation

- This presentation is for Distributed Generation Forecast Working Group (DGFWG) discussion
- This presentation should not be interpreted as a standalone document
 - Offers an overview of a much more detailed draft narrative report that is available on the ISO-NE website

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Contents



- Overview of economic drivers of PV analysis
- Assumptions on individual inputs
- Descriptions of summary measures
- Tables of baseline results
- Summary of results & additional PV industry description
- Appendices: Waterfall charts of baseline results and tables of results for two alternative scenarios
- Q&A and analysis points of contact

Purpose of Study



- ICF was contracted by ISO-NE to deconstruct PV economics into individual drivers to help inform ISO-NE's 2015 PV forecast process
 - In response to stakeholder feedback that PV economics need to be considered as part of the forecast process
 - Help illustrate the complex interplay of public and private investment and business models commonly involved in PV commercialization
- Characterize the relative importance of economic drivers under standardized and simplified assumptions
 - Across states & customer types
 - Does NOT analyze the cost-effectiveness of Federal, state, or utility PV policies nor make value judgments about the need for, or appropriateness of, such policies
- Assess how economic drivers may change over time
 - Due to changes in technology cost and performance, electricity rates, Federal & state incentives, etc.

Analysis Guideposts



- Standardization
 - Comparability across states, customer types, & project start years

- Openness
 - Reliance on public data, especially multi-state Federal data

- Evenhandedness

- Maintain reasonable scope & timeline

Obtained Input from Working Group



- Presented analysis purpose and draft assumptions at December 15 DGFWG meeting to allow for stakeholder feedback at and shortly after the meeting

- Stakeholder feedback was divided into 45 separate comments or suggestions; the disposition of these 45 items is provided in a “comment response matrix” posted on ISO-NE’s website

- Modified a number of modeling inputs & narrative report explanations based on stakeholder feedback
 - Changes in inputs affect outputs/results

Analysis Framework by the Numbers



- 23 types of inputs (listed on next slide)
 - Includes 16 “economic drivers of PV”
 - Discounted cash flow results are calculated for each driver

- 5 summary measures of PV
 - Sub-totals of economic drivers
 - Holistic ways to think about the economics of PV

- 54 combinations of results
 - 6 New England states
 - 3 customer types (residential, commercial, & utility scale)
 - 3 project start years (2015, 2019, & 2024)

Inputs to Analysis



1. PV System Size (Capacity)
2. PV System Configuration
3. PV Electricity Output
4. On-Site Consumption Offset by PV Electricity Output
5. Net Metered Volumes
6. Project Duration
7. Salvage Value
8. General Inflation Rate
9. Installed Cost*
10. Operations and Maintenance (O&M) Cost*
11. Property Tax*
12. Inverter Replacement Cost*
13. Straightline Federal Depreciation*
14. Wholesale Electricity Rates*
15. Federal Investment Tax Credit*
16. Federal Accelerated Depreciation*
17. Project Debt*
18. Retail Electricity Rates (for self-generation volumes)*
19. Net Metering Rates: Wholesale vs. Retail Compensation* (note: this input produces two drivers)
20. Renewable Energy Credits (RECs)*
21. Property and Sales Tax Exemptions*
22. Other Major State Incentives*
23. Discount Rate*

** = Also is an “economic driver” with discounted cash flows calculated*

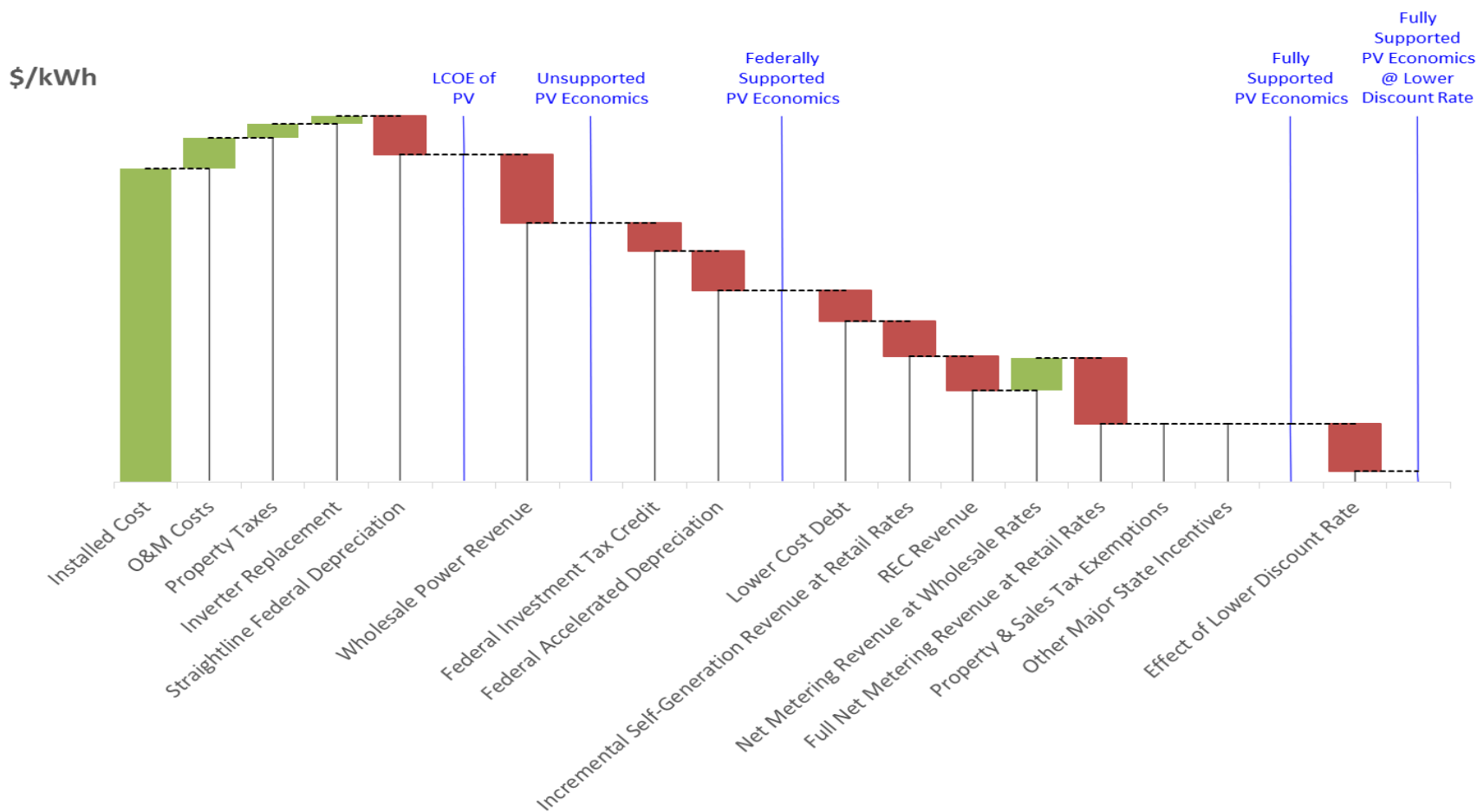
Summary Measures from Analysis



- Levelized Cost of Energy (LCOE)
- Unsupported PV Economics
- Federally Supported PV Economics
- Fully Supported PV Economics
- Fully Supported PV Economics at Lower Discount Rate

Like economic drivers, all summary measures reflect 25-year discounted cash flows

Generic Waterfall Chart with Economic Drivers and Summary Measures



Limitations of Analysis



- General assumptions used in order to present standardized outputs
 - Not a substitute for individual project analysis, but a characterization of major factors at play and how they differ across states, customer types, and over time
- Annualized analysis in most cases
 - But, applied hourly PV production vs. customer consumption volumes
- Not a normative review of Federal, state, or utility PV policies
- Not a review of the Value of Solar nor the grid integration of renewable energy
- Not a forecast of PV capacity deployment, electricity production, nor incentive levels in the region
- How analysis methods & results will inform ISO-NE PV forecasts will be developed by ISO-NE in consultation with the DGFWG as part of ISO-NE's 2015 PV forecast

Analysis Input Assumptions/ Economic Drivers

Input #1: PV System Size (Capacity)

- Residential: 5 kW DC
- Commercial: 100 kW DC
- Utility Scale: 2,000 kW DC
- Sizes are roughly consistent with averages in New England data

Input #2: PV System Configuration

- Crystalline silicon panels (Trina)

- Solectria inverters

- Fixed-axis systems

- Tilt angle
 - 25 degree for residential
 - 10 degree for commercial low slope ballast system
 - 25 to 30 degree for utility scale (depending on state)

Input #3: PV Electricity Output

- Used National Renewable Energy Laboratory (NREL) System Advisor Model (SAM) to create 8,760-hour net AC output profiles from specific systems
- Typical Meteorological Year (TMY3) weather files for:
 - Boston, MA; Hartford, CT; Providence, RI; Burlington, VT; Concord, NH; and Portland, ME
- Calibrated NREL SAM output to ISO-NE state capacity factors from *PV Energy Forecast Update*, September 2014 (specifics are described in the associated narrative report)
- Assumed 5% improvement in year 1 system performance by 2019 vs. current technology and another 5% improvement in year 1 performance vs. 2015 levels by 2024
- Output degradation from installed systems of 0.5% per year

Input #4: On-Site Consumption Offset by PV Electricity Output



- Consumption shape: utility rate class wide hourly consumption profiles applied
- Consumption level: year 1 PV production equals 100% of annual on-site electricity consumption
- Only used to calculate hourly self-generation (defined on next slide) vs. net metered volumes

Input #5: Net Metered Volumes

- This analysis defined net metering somewhat differently than how it is typically billed
 - Interval (in this simple model, hourly) distributed PV production in excess of interval on-site electricity consumption
 - Physical power actually being fed back into the utility distribution system
 - PV electricity consumed on-site is labeled as “self-generation”
- Assumed virtual net metering (VNM) of utility scale systems up to state project caps
 - Utility scale PV production in excess of net metering limits sold at wholesale rates
 - VNM distinction did not apply where Vermont SPEED standard offer assumptions were applied

Input #6: Project Duration

- 25-year project (investment) duration assumed
- Many PV investment analyses use 20-year or 25-year project durations
- Longer durations, other factors equal, lead to better PV economics
 - Revenues in out years typically far exceed operating costs
- PV systems can physically operate for 30 years or more, but several factors mitigate against using that long of a duration
 - Roof replacement cycles
 - Land use changes
 - Host ownership changes
 - Equipment warranties and performance degradation
 - Technology changes

Input #7: Salvage Value

- Assumed zero net salvage value
 - Potential positive or negative salvage values in practice (e.g., value of components vs. decommissioning costs, disposal, surety bond, & site reconditioning costs)

- Little comprehensive data available on salvage values of current PV technology systems

Input #8: General Inflation Rate

- Assumed 1.83% annual rate
 - Applies to installed cost and O&M costs
 - Consistent with inflation rate within DOE *Annual Energy Outlook* wholesale and retail electricity price projections

- Recent 10-year inflation expectations rate from Federal Reserve Bank of Cleveland

Input #9: Installed Cost (Description)

- Residential data based on recent DOE SunShot pricing report, including some state-specific break-outs, and from DGFWG stakeholder input; commercial data from SunShot report; utility scale data from recent Rhode Island analysis
- 2014 data are below:
 - Residential: \$4.29/watt DC (applicable to ~ 5 kW system)
 - Commercial: \$3.40/watt DC (applicable to ~ 100 kW system)
 - Utility Scale: \$2.15/watt DC (applicable to ~ 2,000 kW system)
- Used DOE *Annual Energy Outlook* decline rates to estimate future year PV real installed costs and added price inflation
- Added sales tax (where applicable) to equipment portion so that value of tax exemption can be displayed later in the analysis

Input #9: Installed Cost (Data)



Customer Type	Currency	Costs for 2015 Project Starts	Costs for 2019 Project Starts	Costs for 2024 Project Starts
Residential	Real 2014 dollars	\$4,010/kW _{DC}	\$3,660/kW _{DC}	\$3,440/kW _{DC}
	Nominal dollars	\$4,080/kW _{DC}	\$4,010/kW _{DC}	\$4,120/kW _{DC}
Commercial	Real 2014 dollars	\$3,170/kW _{DC}	\$2,900/kW _{DC}	\$2,730/kW _{DC}
	Nominal dollars	\$3,230/kW _{DC}	\$3,180/kW _{DC}	\$3,270/kW _{DC}
Utility Scale	Real 2014 dollars	\$2,010/kW _{DC}	\$1,840/kW _{DC}	\$1,720/kW _{DC}
	Nominal dollars	\$2,040/kW _{DC}	\$2,010/kW _{DC}	\$2,070/kW _{DC}

Data are from a combination of Federal government and New England sources described on the prior slide; costs increase in nominal dollars as cumulative price inflation exceeds real cost reductions.

Input #10: Operations and Maintenance (O&M) Cost



- Initial (year 1) values from DOE *Annual Energy Outlook* and SunShot documents
 - Residential: \$32.80/kW DC
 - Commercial: \$23.50/kW DC
 - Utility Scale: \$20.49/kW DC

- Applied general price inflation rate for future year O&M costs

Input #11: Property Tax

- Though property tax exemptions are prevalent in New England, tax is added so that the value of tax exemptions can be displayed later in the analysis

- Wide range of property tax rates in practice

- Assumed annual property tax at 0.5% of installed PV costs
 - State capacity tax at fixed-level for commercial and utility scale systems in Vermont



Input #12: Inverter Replacement Cost

- Assumed one-time inverter replacement in year 15 of project
- Inverter replacement at 8% of original (nominal) installed cost
- Prudent to plan or accrue for inverter replacement

Input #13: Straightline Federal Depreciation



- Applied so that marginal value of Federal accelerated depreciation incentive can be displayed later in the analysis
- 100% of capital basis over 20 years (5% per year)
- Marginal Federal income tax rate of 35%

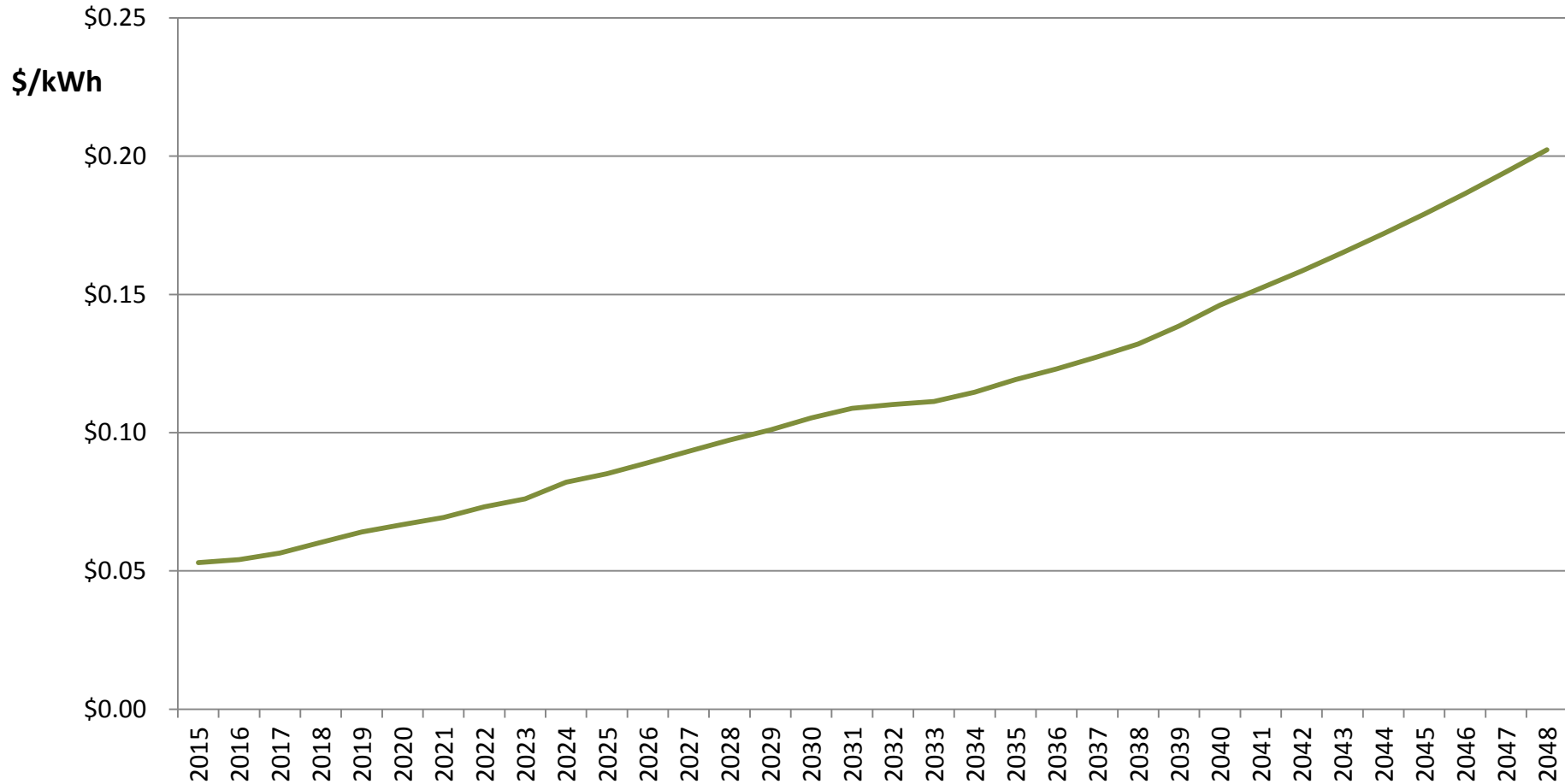
Input #14: Wholesale Electricity Rates (Description)



- DOE *Annual Energy Outlook* prices for 2015 through 2040
 - Northeast Power Coordinating Council/Northeast Reference Case
 - E.g., 2015 price is \$.053/kWh

- Prices for 2041 through 2048 were extrapolated based on average rate of change between 2015 and 2040

Input #14: Wholesale Electricity Rates (Graph)



Based upon U.S. Department of Energy generation price data from *Annual Energy Outlook*

Input #15: Federal Investment Tax Credit



- 30% Federal investment tax credit (ITC) for 2015 project start year

- 10% Federal investment tax credit (ITC) for 2019 and 2024 project start years

- Project owner has sufficient tax liability and fully monetizes ITC in year 1 of project (i.e., no carry-forward of tax benefits)
 - Analysis assumed third party private ownership (e.g., PPA structure) for residential hosted systems and systems hosted by non-profit or public agency customers

Input #16: Federal Accelerated Depreciation



- Applied to 85% of installed costs for 2015 project start year
 - Capital basis is reduced by half of the 30% ITC
- Applied to 95% of installed costs for 2019 and 2024 project start years (due to decline in ITC)
- 200% declining balance with half-year convention depreciation schedule used; 35% marginal Federal income tax rate applied
- Project owner has sufficient tax liability to efficiently monetize Federal MACRS (modified accelerated cost-recovery system) accelerated depreciation; no state depreciation assumed
 - Analysis assumed third party private ownership (e.g., PPA structure) for residential hosted systems and systems hosted by non-profit or public agency customers

Input #17: Project Debt

- Assumed 50% debt/50% equity capital structure

- Fixed-rate loan at 5% interest rate over 15 years
 - Loan rate is below standard 10% discount rate used in the analysis

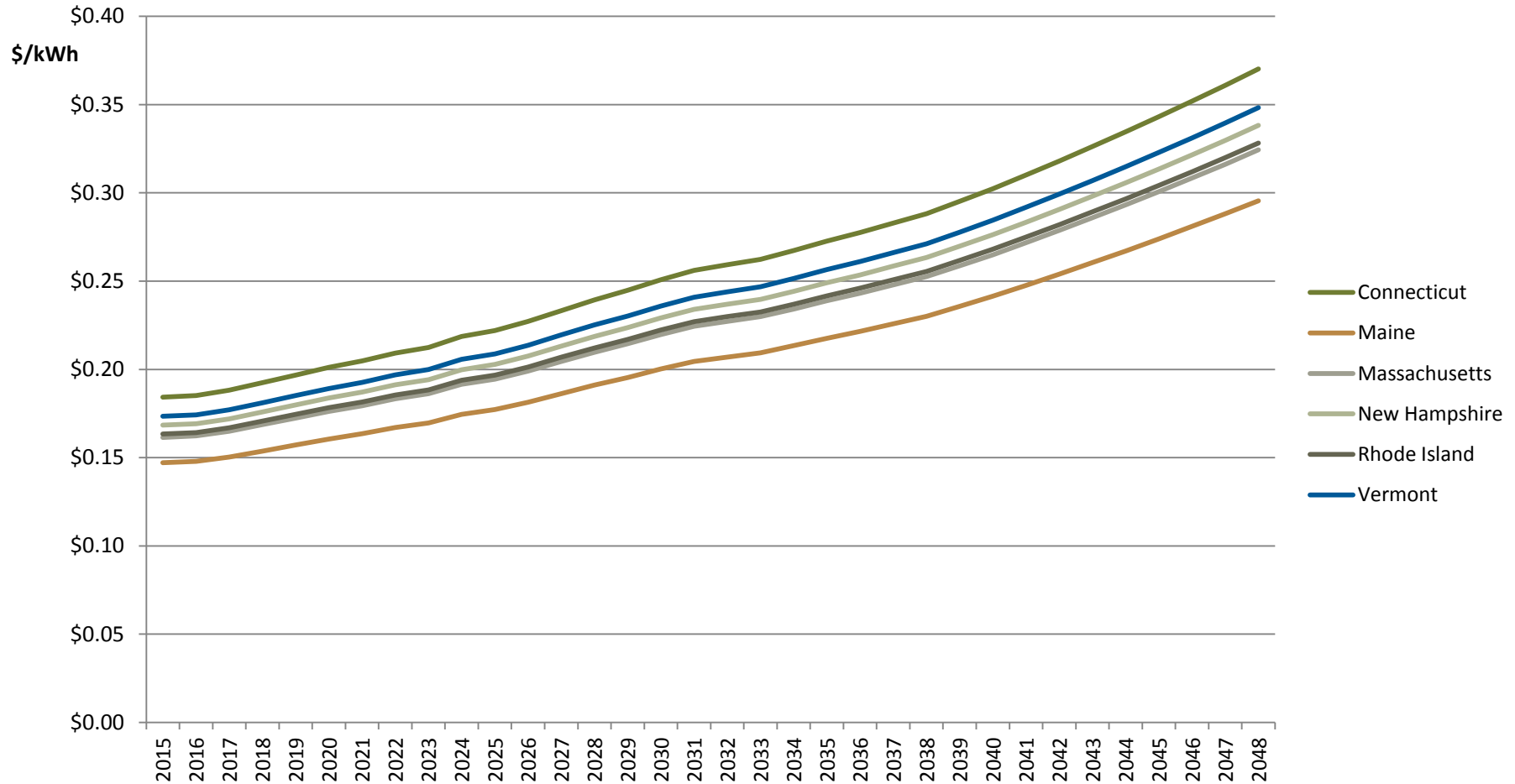
- Outcomes with higher and lower debt/equity percentages and shorter loan duration are briefly summarized in narrative report

Input #18: Retail Electricity Rates (for self-generation volumes)



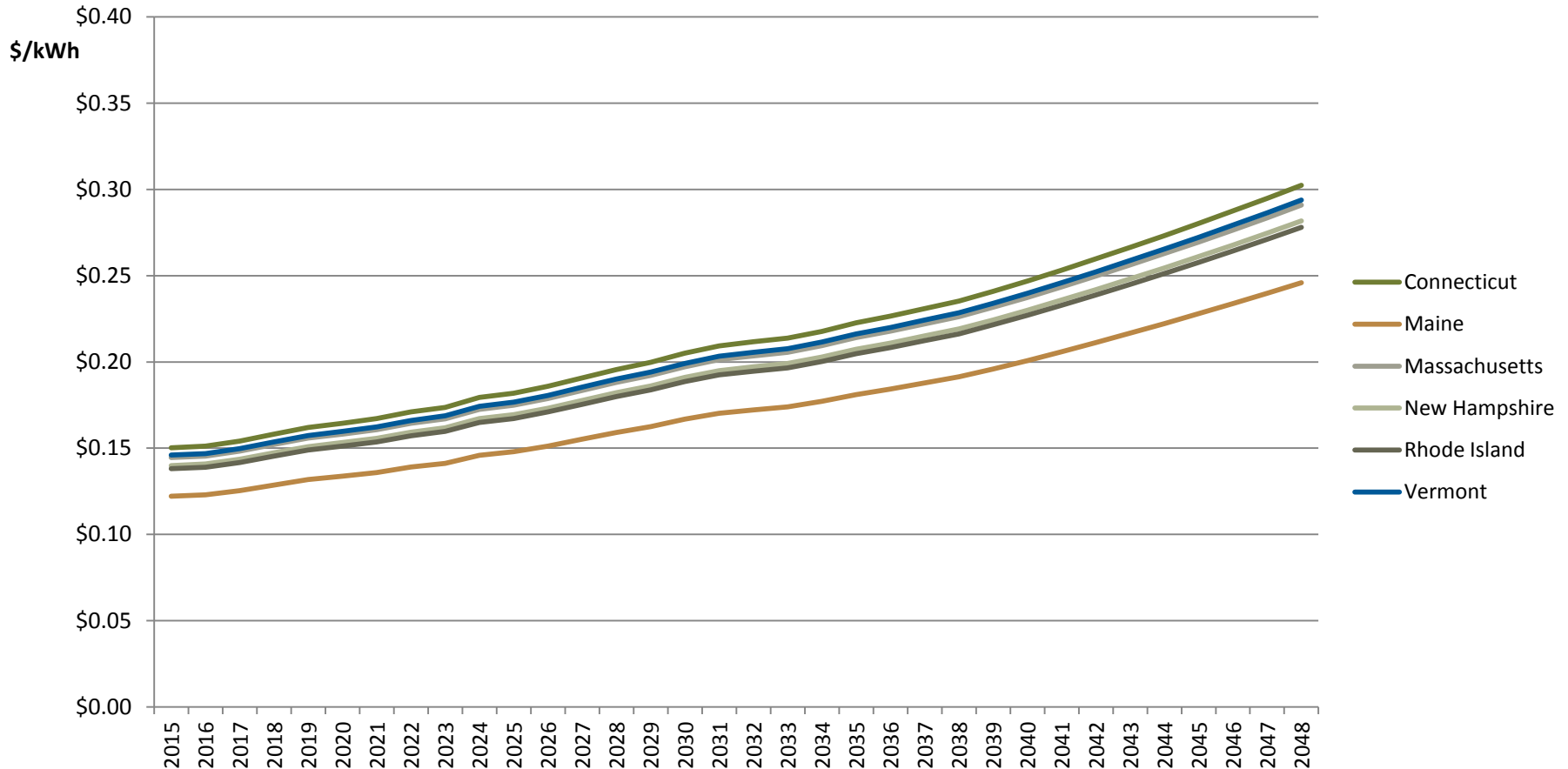
- Statewide data from DOE Energy Information Administration for residential and commercial customers were used
 - Averaged August 2014 YTD and August 2013 YTD data (to modulate the effect of 2014 polar vortex events) to obtain 2015 values
 - Table and waterfall chart values are exhibited as incremental retail price benefit above wholesale prices
- DOE *Annual Energy Outlook* annual rate of change estimates for New England residential and commercial electricity prices were used to estimate 2016 through 2040 prices
- Prices for 2041 through 2048 were extrapolated based on average rate of change between 2015 and 2040
- Reduction in commercial rates (\$.01/kWh) applied due to peak demand charges often not being fully offset by PV production

Input #18: Retail Electricity Prices: Residential



Based upon U.S. Department of Energy data

Input #18: Retail Electricity Prices: Commercial



Based upon U.S. Department of Energy data;
prices displayed are before peak demand offset adjustment mentioned previously.

Input #19: Net Metering Rates: Wholesale vs. Retail Compensation



- Assumed net metering (including virtual net metering) customers receive full retail rates for net metered volumes
 - Non-bypassable charges not included

- Display net metering compensation at wholesale and at retail rates so that difference is visible
 - I.e., value of net metering volumes at wholesale prices is exhibited and compared to value of same volumes at retail prices

- Assume that aggregate net metering caps for states and utilities will not be constraints on PV economics
 - But provide wholesale and retail net metering compensation to illustrate values involved if net metering caps or policies may change

Input #20: Renewable Energy Credits (RECs)



- Assumed that project owner sells (does not retain and retire) RECs
- Massachusetts SREC II
 - Applicable to 2015 and 2019 project start years
 - Used soft auction floor values net of administrative fees for first 10 years
 - Assumed utility scale developers hedge SRECs at 80% of this level
 - Applied SREC multiplication factors for Market Sectors A, B, and Managed Growth, respectively
 - Sell RECs at Tier I prices thereafter
- Connecticut small ZRECs for residential & commercial systems for 2015 & 2019 project start years
- Tier I REC exports elsewhere
 - \$.050/kWh assumed from 2015-2025, declining by \$.002/kWh annually thereafter until reaching \$.010/kWh in 2045 and remaining flat for 2046-2048
 - This is not a REC price forecast, but only a set of basic assumptions for the study

Input #21: Property and Sales Tax Exemptions



- Though sales and property tax exemptions are prevalent in New England, taxes are applied at earlier stage in the analysis so that the value of exemptions can be displayed
- State sales and state/municipal property tax exemptions are applied by state and customer type, as appropriate

Input #22: Other Major State Incentives



- Outside the scope of this effort to capture the multitude of other incentives available from states, localities, and utilities. Also, forecasting some incentive programs involves a relatively high degree of uncertainty, which increases over time.
- Applied a limited number of “other” state incentives (i.e., beyond RECs, net metering, & sales/property tax exemptions)
 - Connecticut: Residential solar investment program
 - New Hampshire: Residential and C&I rebates
 - Rhode Island: Renewable Energy Growth Program
 - Vermont: SPEED standard offer (utility scale), solar net metering credit (residential & commercial), and investment tax credit (commercial)
- Discounted the cash flows (up to 25 years) available under these incentives, as was done with all economic drivers in the analysis

Input #22: Other Major State Incentives



- Scenarios (not predictions) were run for periods when incentive levels were especially uncertain
 - Connecticut ZRECs (2019 project starts)
 - New Hampshire residential and commercial solar rebates (2019 and 2024 project starts)
 - Rhode Island Renewable Energy Growth Program (2019 project starts)
 - Vermont SPEED and solar net metering credits (2019 project starts)
- Baseline (reflected in tables and waterfall charts)
 - Incentives change between project start years in the same ratio as MA SRECs vs. Tier 1 RECs
- Alternative Scenario 1: Incentives remain at 2015 project start levels (results in table appendices)
- Alternative Scenario 2: Incentives are unavailable (results in table appendices)

Input #23: Discount Rate

- Standard investor discount rate of 10% applied throughout the analysis (to discount cash flows from economic drivers and sub-total them for summary measures)

- Discount rate is endogenous to the analysis

- Also displayed difference in final results if a lower discount rate of 5% was used
 - This lower rate is applicable not to typical solar developers, but to entities with less aggressive investment return goals or that ascribe large societal values to PV projects

Summary: Connecticut State Policy Inputs



- Net metering: Net metering project cap of 3,000 kW (virtual net metering)
- Renewable energy credits: For 2015 and 2019 project starts, apply small ZREC program for residential and commercial customer types for first 15 years of project operation and Tier I REC prices thereafter. Tier I REC prices applied for utility scale customer type.
- Property tax exemptions: Applied to all customer types
- Sales tax exemptions: Applied to all customer types
- “Other” state incentives: Solar investment program for residential customer type for 2015 project starts (at performance-based incentive level average of estimated steps 6 & 7 for first 6 years for third-party owned systems)



Summary: Maine State Policy Inputs

- Net metering: Net metering (i.e., net energy billing) project cap of 660 kW
- Renewable energy credits: Apply Tier 1 REC prices
- Property tax exemptions: None applied
- Sales tax exemptions: None applied
- “Other” state incentives: None applied

Summary: Massachusetts State Policy Inputs



- Net metering: Class III net metering project cap of 2,000 kW
- Renewable energy credits: For 2015 and 2019 project starts, apply SREC II at soft auction floor prices (net of fee) with appropriate SREC price multiplication factors by project size for first 10 years of project operation and Tier I REC prices thereafter. Utility scale developers hedge SRECs at 80% of level described above. Apply Tier 1 REC prices for 2024 project starts.
- Property tax exemptions: None applied, due to assumed third-party solar developer or independent power producer ownership of all projects
- Sales tax exemptions: Applied to all customer types
- “Other” state incentives: None applied

Summary: New Hampshire State Policy Inputs



- Net metering: Net metering project cap of 1,000 kW
- Renewable energy credits: Apply Tier 1 REC prices
- Property tax exemptions: Applied to residential and commercial customer types
- Sales tax exemptions: No sales tax, so no exemption is relevant
- “Other” state incentives: Small renewable electrical generation systems rebate for residential customer type and commercial & industrial incentive program for commercial customer type

Summary: Rhode Island State Policy Inputs



- Net metering: Net metering project cap of 5,000 kW
- Renewable energy credits: Apply Tier 1 REC prices
- Property tax exemptions: 40% exemption applied to residential customer type, and 20% exemption applied to commercial and utility scale customer types
- Sales tax exemptions: Applied to all customer types
- “Other” state incentives: For 2015 and 2019 project starts, estimated Renewable Energy Growth Program rates for bundled physical power & RECs are applied for residential, commercial, and utility scale customer types

Summary: Vermont State Policy Inputs



- Net metering: Net metering project cap of 500 kW, with higher cap for military and certain other applications
- Renewable energy credits: Apply Tier 1 REC prices (including to SPEED standard offer participants)
- Property tax exemptions: Applied to residential customer type (including for \$4/kW state capacity tax)
- Sales tax exemptions: Applied to residential and commercial customer types
- “Other” state incentives: Investment tax credit for commercial customer type (declining with Federal ITC). For 2015 and 2019 project starts, SPEED standard offer program for utility scale customer type and solar net metering credits for residential and commercial customer types.

Summary Measures

Summary Measure: Levelized Cost of Energy (LCOE)



Equation used:

+ Installed cost

+ O&M costs

+ Property taxes

+ Inverter replacement

- Straightline Federal depreciation

Apply standard discount rate to obtain present value of cash flows from equation

Note: The LCOE measure used here is not meant to compare different (e.g., solar & non-solar) technologies.

Summary Measure: Unsupported PV Economics



Equation used:

Levelized Cost of Energy (LCOE)

- Wholesale power revenue

Apply standard discount rate to obtain present value of cash flows from equation

Summary Measure: Federally Supported PV Economics



Equation used:

Unsupported PV Economics

- **Federal investment tax credit**
- **Federal accelerated depreciation** (marginal value vs. straightline depreciation)

Apply standard discount rate to obtain present value of cash flows from equation

Summary Measure: Fully Supported PV Economics



Equation used:

Federally Supported PV Economics

- Lower cost debt
- Incremental self-generation revenue at retail rates
- Renewable energy credit revenue
- + Net metering revenue at wholesale rates
- Full net metering revenue at retail rates
- Property & sales tax exemptions
- Other major state incentives

Apply standard discount rate to obtain present value of cash flows from equation

Summary Measure: Fully Supported PV Economics at Lower Discount Rate



Equation used:

Fully Supported PV Economics

- **Difference in summary measure using lower discount rate vs. standard discount rate**

Tables of Results: Baseline Scenario

Table of Results: 2015 Project Starts (Connecticut, Maine, & Massachusetts)



(Data below in \$/kWh)

State =>	CT	CT	CT	ME	ME	ME	MA	MA	MA
Customer Type =>	Residential	Commercial	Utility Scale	Residential	Commercial	Utility Scale	Residential	Commercial	Utility Scale
Installed Cost	\$0.391	\$0.335	\$0.195	\$0.409	\$0.356	\$0.203	\$0.407	\$0.352	\$0.204
O&M Costs	\$0.032	\$0.025	\$0.020	\$0.034	\$0.026	\$0.021	\$0.033	\$0.026	\$0.021
Property Taxes	\$0.017	\$0.015	\$0.009	\$0.018	\$0.016	\$0.009	\$0.018	\$0.015	\$0.009
Inverter Replacement	\$0.007	\$0.006	\$0.004	\$0.008	\$0.007	\$0.004	\$0.008	\$0.007	\$0.004
Straightline Federal Depreciation	(\$0.056)	(\$0.048)	(\$0.028)	(\$0.059)	(\$0.052)	(\$0.029)	(\$0.059)	(\$0.051)	(\$0.029)
Levelized Cost of Energy (LCOE) of PV	\$0.391	\$0.332	\$0.199	\$0.409	\$0.353	\$0.207	\$0.407	\$0.349	\$0.208
Wholesale Power Revenue	(\$0.076)	(\$0.076)	(\$0.076)	(\$0.076)	(\$0.076)	(\$0.076)	(\$0.076)	(\$0.076)	(\$0.076)
Unsupported PV Economics	\$0.315	\$0.256	\$0.123	\$0.333	\$0.277	\$0.131	\$0.331	\$0.273	\$0.132
Federal Investment Tax Credit	(\$0.103)	(\$0.088)	(\$0.052)	(\$0.109)	(\$0.094)	(\$0.054)	(\$0.108)	(\$0.093)	(\$0.054)
Federal Accelerated Depreciation	(\$0.031)	(\$0.026)	(\$0.015)	(\$0.032)	(\$0.028)	(\$0.016)	(\$0.032)	(\$0.028)	(\$0.016)
Federally Supported PV Economics	\$0.181	\$0.141	\$0.056	\$0.193	\$0.155	\$0.061	\$0.191	\$0.153	\$0.062
Lower Cost Debt	(\$0.037)	(\$0.031)	(\$0.018)	(\$0.038)	(\$0.033)	(\$0.019)	(\$0.038)	(\$0.033)	(\$0.019)
Incremental Self-Generation Revenue at Retail Rates	(\$0.053)	(\$0.040)	\$0.000	(\$0.036)	(\$0.025)	\$0.000	(\$0.042)	(\$0.036)	\$0.000
REC Revenue	(\$0.077)	(\$0.077)	(\$0.047)	(\$0.047)	(\$0.047)	(\$0.047)	(\$0.184)	(\$0.167)	(\$0.108)
Net Metering Revenue at Wholesale Rates	\$0.046	\$0.041	\$0.076	\$0.047	\$0.041	\$0.030	\$0.047	\$0.041	\$0.076
Full Net Metering Revenue at Retail Rates	(\$0.130)	(\$0.087)	(\$0.162)	(\$0.105)	(\$0.070)	(\$0.052)	(\$0.116)	(\$0.085)	(\$0.156)
Property & Sales Tax Exemptions	(\$0.028)	(\$0.024)	(\$0.014)	\$0.000	\$0.000	\$0.000	(\$0.011)	(\$0.010)	(\$0.006)
Other Major State Incentives	(\$0.050)	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000
Fully Supported PV Economics	(\$0.148)	(\$0.077)	(\$0.109)	\$0.013	\$0.020	(\$0.026)	(\$0.152)	(\$0.137)	(\$0.151)
Effect of Lower Discount Rate	(\$0.021)	(\$0.030)	(\$0.021)	(\$0.043)	(\$0.037)	(\$0.023)	(\$0.013)	(\$0.010)	(\$0.009)
Fully Supported PV Economics @ Lower Discount Rate	(\$0.169)	(\$0.108)	(\$0.131)	(\$0.030)	(\$0.016)	(\$0.049)	(\$0.165)	(\$0.147)	(\$0.160)

Table of Results: 2015 Project Starts (New Hampshire, Rhode Island, & Vermont)



(Data below in \$/kWh)

State =>	NH	NH	NH	RI	RI	RI	VT	VT	VT
Customer Type =>	Residential	Commercial	Utility Scale	Residential	Commercial	Utility Scale	Residential	Commercial	Utility Scale
Installed Cost	\$0.405	\$0.351	\$0.200	\$0.406	\$0.350	\$0.203	\$0.446	\$0.382	\$0.221
O&M Costs	\$0.034	\$0.027	\$0.021	\$0.033	\$0.026	\$0.021	\$0.036	\$0.028	\$0.023
Property Taxes	\$0.018	\$0.016	\$0.009	\$0.018	\$0.015	\$0.009	\$0.020	\$0.021	\$0.014
Inverter Replacement	\$0.008	\$0.007	\$0.004	\$0.008	\$0.006	\$0.004	\$0.008	\$0.007	\$0.004
Straightline Federal Depreciation	(\$0.060)	(\$0.052)	(\$0.030)	(\$0.058)	(\$0.050)	(\$0.029)	(\$0.065)	(\$0.055)	(\$0.032)
Levelized Cost of Energy (LCOE) of PV	\$0.405	\$0.348	\$0.204	\$0.406	\$0.347	\$0.207	\$0.446	\$0.383	\$0.230
Wholesale Power Revenue	(\$0.076)	(\$0.076)	(\$0.076)	(\$0.076)	(\$0.076)	(\$0.076)	(\$0.076)	(\$0.076)	(\$0.076)
Unsupported PV Economics	\$0.329	\$0.272	\$0.129	\$0.330	\$0.271	\$0.131	\$0.370	\$0.308	\$0.154
Federal Investment Tax Credit	(\$0.110)	(\$0.096)	(\$0.055)	(\$0.107)	(\$0.092)	(\$0.053)	(\$0.118)	(\$0.101)	(\$0.059)
Federal Accelerated Depreciation	(\$0.033)	(\$0.028)	(\$0.016)	(\$0.032)	(\$0.027)	(\$0.016)	(\$0.035)	(\$0.030)	(\$0.017)
Federally Supported PV Economics	\$0.186	\$0.148	\$0.058	\$0.191	\$0.152	\$0.062	\$0.217	\$0.176	\$0.078
Lower Cost Debt	(\$0.039)	(\$0.034)	(\$0.019)	(\$0.038)	(\$0.033)	(\$0.019)	(\$0.042)	(\$0.036)	(\$0.021)
Incremental Self-Generation Revenue at Retail Rates	(\$0.046)	(\$0.035)	\$0.000	(\$0.078)	(\$0.055)	\$0.000	\$0.000	\$0.000	\$0.000
REC Revenue	(\$0.047)	(\$0.047)	(\$0.047)	(\$0.047)	(\$0.047)	(\$0.047)	(\$0.047)	(\$0.047)	(\$0.047)
Net Metering Revenue at Wholesale Rates	\$0.047	\$0.041	\$0.046	\$0.047	\$0.041	\$0.076	\$0.076	\$0.076	\$0.076
Full Net Metering Revenue at Retail Rates	(\$0.120)	(\$0.081)	(\$0.091)	(\$0.173)	(\$0.107)	(\$0.124)	(\$0.211)	(\$0.192)	(\$0.124)
Property & Sales Tax Exemptions	(\$0.018)	(\$0.016)	\$0.000	(\$0.020)	(\$0.014)	(\$0.008)	(\$0.031)	(\$0.010)	\$0.000
Other Major State Incentives	(\$0.066)	(\$0.049)	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	(\$0.024)	\$0.000
Fully Supported PV Economics	(\$0.103)	(\$0.072)	(\$0.053)	(\$0.117)	(\$0.063)	(\$0.061)	(\$0.038)	(\$0.057)	(\$0.038)
Effect of Lower Discount Rate	(\$0.020)	(\$0.019)	(\$0.022)	(\$0.032)	(\$0.029)	(\$0.021)	(\$0.042)	(\$0.025)	(\$0.018)
Fully Supported PV Economics @ Lower Discount Rate	(\$0.123)	(\$0.091)	(\$0.075)	(\$0.148)	(\$0.092)	(\$0.081)	(\$0.080)	(\$0.082)	(\$0.056)

Table of Results: 2019 Project Starts (Connecticut, Maine, & Massachusetts)



(Data below in \$/kWh)

State =>	CT	CT	CT	ME	ME	ME	MA	MA	MA
Customer Type =>	Residential	Commercial	Utility Scale	Residential	Commercial	Utility Scale	Residential	Commercial	Utility Scale
Installed Cost	\$0.366	\$0.314	\$0.183	\$0.383	\$0.334	\$0.190	\$0.381	\$0.330	\$0.191
O&M Costs	\$0.033	\$0.025	\$0.020	\$0.034	\$0.027	\$0.021	\$0.034	\$0.027	\$0.021
Property Taxes	\$0.016	\$0.014	\$0.008	\$0.017	\$0.015	\$0.008	\$0.017	\$0.015	\$0.008
Inverter Replacement	\$0.007	\$0.006	\$0.003	\$0.007	\$0.006	\$0.004	\$0.007	\$0.006	\$0.004
Straightline Federal Depreciation	(\$0.053)	(\$0.045)	(\$0.026)	(\$0.056)	(\$0.048)	(\$0.028)	(\$0.055)	(\$0.048)	(\$0.028)
Levelized Cost of Energy (LCOE) of PV	\$0.369	\$0.313	\$0.188	\$0.386	\$0.333	\$0.196	\$0.384	\$0.330	\$0.197
Wholesale Power Revenue	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)
Unsupported PV Economics	\$0.279	\$0.223	\$0.098	\$0.296	\$0.243	\$0.106	\$0.294	\$0.240	\$0.107
Federal Investment Tax Credit	(\$0.032)	(\$0.028)	(\$0.016)	(\$0.034)	(\$0.030)	(\$0.017)	(\$0.034)	(\$0.029)	(\$0.017)
Federal Accelerated Depreciation	(\$0.038)	(\$0.033)	(\$0.019)	(\$0.040)	(\$0.035)	(\$0.020)	(\$0.040)	(\$0.035)	(\$0.020)
Federally Supported PV Economics	\$0.208	\$0.163	\$0.063	\$0.222	\$0.179	\$0.069	\$0.220	\$0.176	\$0.070
Lower Cost Debt	(\$0.034)	(\$0.029)	(\$0.017)	(\$0.036)	(\$0.031)	(\$0.018)	(\$0.036)	(\$0.031)	(\$0.018)
Incremental Self-Generation Revenue at Retail Rates	(\$0.055)	(\$0.040)	\$0.000	(\$0.036)	(\$0.023)	\$0.000	(\$0.043)	(\$0.036)	\$0.000
REC Revenue	(\$0.068)	(\$0.068)	(\$0.044)	(\$0.044)	(\$0.044)	(\$0.044)	(\$0.151)	(\$0.136)	(\$0.089)
Net Metering Revenue at Wholesale Rates	\$0.055	\$0.048	\$0.090	\$0.055	\$0.049	\$0.036	\$0.056	\$0.049	\$0.090
Full Net Metering Revenue at Retail Rates	(\$0.141)	(\$0.094)	(\$0.176)	(\$0.114)	(\$0.076)	(\$0.056)	(\$0.126)	(\$0.092)	(\$0.169)
Property & Sales Tax Exemptions	(\$0.026)	(\$0.023)	(\$0.013)	\$0.000	\$0.000	\$0.000	(\$0.010)	(\$0.009)	(\$0.005)
Other Major State Incentives	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000
Fully Supported PV Economics	(\$0.061)	(\$0.043)	(\$0.097)	\$0.048	\$0.053	(\$0.013)	(\$0.089)	(\$0.080)	(\$0.121)
Effect of Lower Discount Rate	(\$0.054)	(\$0.045)	(\$0.029)	(\$0.059)	(\$0.050)	(\$0.031)	(\$0.035)	(\$0.030)	(\$0.020)
Fully Supported PV Economics @ Lower Discount Rate	(\$0.115)	(\$0.088)	(\$0.126)	(\$0.011)	\$0.002	(\$0.044)	(\$0.124)	(\$0.109)	(\$0.141)

Table of Results: 2019 Project Starts (New Hampshire, Rhode Island, & Vermont)



(Data below in \$/kWh)

State =>	NH	NH	NH	RI	RI	RI	VT	VT	VT
Customer Type =>	Residential	Commercial	Utility Scale	Residential	Commercial	Utility Scale	Residential	Commercial	Utility Scale
Installed Cost	\$0.379	\$0.329	\$0.188	\$0.380	\$0.328	\$0.190	\$0.417	\$0.358	\$0.208
O&M Costs	\$0.035	\$0.027	\$0.022	\$0.034	\$0.026	\$0.021	\$0.037	\$0.029	\$0.023
Property Taxes	\$0.017	\$0.015	\$0.009	\$0.017	\$0.014	\$0.008	\$0.018	\$0.020	\$0.013
Inverter Replacement	\$0.007	\$0.006	\$0.004	\$0.007	\$0.006	\$0.004	\$0.008	\$0.007	\$0.004
Straightline Federal Depreciation	(\$0.056)	(\$0.049)	(\$0.028)	(\$0.055)	(\$0.047)	(\$0.027)	(\$0.060)	(\$0.052)	(\$0.030)
Levelized Cost of Energy (LCOE) of PV	\$0.382	\$0.328	\$0.194	\$0.383	\$0.327	\$0.196	\$0.421	\$0.362	\$0.217
Wholesale Power Revenue	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)
Unsupported PV Economics	\$0.292	\$0.238	\$0.104	\$0.293	\$0.237	\$0.106	\$0.331	\$0.272	\$0.127
Federal Investment Tax Credit	(\$0.034)	(\$0.030)	(\$0.017)	(\$0.033)	(\$0.029)	(\$0.017)	(\$0.037)	(\$0.032)	(\$0.018)
Federal Accelerated Depreciation	(\$0.041)	(\$0.036)	(\$0.020)	(\$0.040)	(\$0.034)	(\$0.020)	(\$0.044)	(\$0.038)	(\$0.022)
Federally Supported PV Economics	\$0.217	\$0.173	\$0.066	\$0.220	\$0.174	\$0.069	\$0.250	\$0.203	\$0.087
Lower Cost Debt	(\$0.037)	(\$0.032)	(\$0.018)	(\$0.035)	(\$0.031)	(\$0.018)	(\$0.039)	(\$0.034)	(\$0.019)
Incremental Self-Generation Revenue at Retail Rates	(\$0.046)	(\$0.034)	\$0.000	(\$0.068)	(\$0.049)	\$0.000	\$0.000	\$0.000	\$0.000
REC Revenue	(\$0.044)	(\$0.044)	(\$0.044)	(\$0.044)	(\$0.044)	(\$0.044)	(\$0.044)	(\$0.044)	(\$0.044)
Net Metering Revenue at Wholesale Rates	\$0.055	\$0.048	\$0.054	\$0.056	\$0.049	\$0.090	\$0.090	\$0.090	\$0.090
Full Net Metering Revenue at Retail Rates	(\$0.130)	(\$0.088)	(\$0.098)	(\$0.166)	(\$0.107)	(\$0.121)	(\$0.220)	(\$0.195)	(\$0.120)
Property & Sales Tax Exemptions	(\$0.017)	(\$0.015)	\$0.000	(\$0.018)	(\$0.013)	(\$0.008)	(\$0.029)	(\$0.009)	\$0.000
Other Major State Incentives	(\$0.048)	(\$0.036)	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	(\$0.008)	\$0.000
Fully Supported PV Economics	(\$0.050)	(\$0.027)	(\$0.040)	(\$0.056)	(\$0.020)	(\$0.031)	\$0.007	\$0.003	(\$0.006)
Effect of Lower Discount Rate	(\$0.042)	(\$0.037)	(\$0.030)	(\$0.049)	(\$0.044)	(\$0.030)	(\$0.061)	(\$0.048)	(\$0.026)
Fully Supported PV Economics @ Lower Discount Rate	(\$0.093)	(\$0.064)	(\$0.069)	(\$0.105)	(\$0.064)	(\$0.061)	(\$0.054)	(\$0.044)	(\$0.032)

Table of Results: 2024 Project Starts (Connecticut, Maine, & Massachusetts)



(Data below in \$/kWh)

State =>	CT	CT	CT	ME	ME	ME	MA	MA	MA
Customer Type =>	Residential	Commercial	Utility Scale	Residential	Commercial	Utility Scale	Residential	Commercial	Utility Scale
Installed Cost	\$0.359	\$0.308	\$0.180	\$0.376	\$0.327	\$0.187	\$0.373	\$0.324	\$0.188
O&M Costs	\$0.034	\$0.026	\$0.021	\$0.036	\$0.028	\$0.022	\$0.036	\$0.028	\$0.022
Property Taxes	\$0.016	\$0.014	\$0.008	\$0.017	\$0.014	\$0.008	\$0.016	\$0.014	\$0.008
Inverter Replacement	\$0.007	\$0.006	\$0.003	\$0.007	\$0.006	\$0.003	\$0.007	\$0.006	\$0.003
Straightline Federal Depreciation	(\$0.052)	(\$0.044)	(\$0.026)	(\$0.054)	(\$0.047)	(\$0.027)	(\$0.054)	(\$0.047)	(\$0.027)
Levelized Cost of Energy (LCOE) of PV	\$0.364	\$0.309	\$0.187	\$0.381	\$0.329	\$0.194	\$0.378	\$0.325	\$0.195
Wholesale Power Revenue	(\$0.110)	(\$0.110)	(\$0.110)	(\$0.110)	(\$0.110)	(\$0.110)	(\$0.110)	(\$0.110)	(\$0.110)
Unsupported PV Economics	\$0.254	\$0.199	\$0.076	\$0.271	\$0.219	\$0.084	\$0.268	\$0.215	\$0.084
Federal Investment Tax Credit	(\$0.032)	(\$0.027)	(\$0.016)	(\$0.033)	(\$0.029)	(\$0.017)	(\$0.033)	(\$0.029)	(\$0.017)
Federal Accelerated Depreciation	(\$0.038)	(\$0.032)	(\$0.019)	(\$0.040)	(\$0.034)	(\$0.020)	(\$0.039)	(\$0.034)	(\$0.020)
Federally Supported PV Economics	\$0.184	\$0.140	\$0.042	\$0.198	\$0.155	\$0.047	\$0.196	\$0.152	\$0.048
Lower Cost Debt	(\$0.034)	(\$0.029)	(\$0.017)	(\$0.035)	(\$0.031)	(\$0.018)	(\$0.035)	(\$0.030)	(\$0.018)
Incremental Self-Generation Revenue at Retail Rates	(\$0.057)	(\$0.040)	\$0.000	(\$0.036)	(\$0.021)	\$0.000	(\$0.044)	(\$0.035)	\$0.000
REC Revenue	(\$0.037)	(\$0.037)	(\$0.037)	(\$0.037)	(\$0.037)	(\$0.037)	(\$0.037)	(\$0.037)	(\$0.037)
Net Metering Revenue at Wholesale Rates	\$0.068	\$0.059	\$0.110	\$0.068	\$0.060	\$0.044	\$0.068	\$0.060	\$0.110
Full Net Metering Revenue at Retail Rates	(\$0.157)	(\$0.105)	(\$0.196)	(\$0.126)	(\$0.085)	(\$0.062)	(\$0.140)	(\$0.102)	(\$0.188)
Property & Sales Tax Exemptions	(\$0.026)	(\$0.022)	(\$0.013)	\$0.000	\$0.000	\$0.000	(\$0.010)	(\$0.009)	(\$0.005)
Other Major State Incentives	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000
Fully Supported PV Economics	(\$0.059)	(\$0.034)	(\$0.111)	\$0.030	\$0.041	(\$0.026)	(\$0.001)	(\$0.002)	(\$0.090)
Effect of Lower Discount Rate	(\$0.056)	(\$0.046)	(\$0.029)	(\$0.058)	(\$0.049)	(\$0.030)	(\$0.056)	(\$0.048)	(\$0.029)
Fully Supported PV Economics @ Lower Discount Rate	(\$0.115)	(\$0.081)	(\$0.140)	(\$0.028)	(\$0.009)	(\$0.057)	(\$0.057)	(\$0.050)	(\$0.119)

Table of Results: 2024 Project Starts (New Hampshire, Rhode Island, & Vermont)



(Data below in \$/kWh)

State =>	NH	NH	NH	RI	RI	RI	VT	VT	VT
Customer Type =>	Residential	Commercial	Utility Scale	Residential	Commercial	Utility Scale	Residential	Commercial	Utility Scale
Installed Cost	\$0.372	\$0.323	\$0.185	\$0.373	\$0.322	\$0.187	\$0.409	\$0.352	\$0.204
O&M Costs	\$0.036	\$0.029	\$0.023	\$0.035	\$0.028	\$0.022	\$0.039	\$0.030	\$0.024
Property Taxes	\$0.017	\$0.015	\$0.008	\$0.016	\$0.014	\$0.008	\$0.018	\$0.019	\$0.012
Inverter Replacement	\$0.007	\$0.006	\$0.004	\$0.007	\$0.006	\$0.003	\$0.008	\$0.007	\$0.004
Straightline Federal Depreciation	(\$0.055)	(\$0.048)	(\$0.028)	(\$0.054)	(\$0.046)	(\$0.027)	(\$0.059)	(\$0.051)	(\$0.030)
Levelized Cost of Energy (LCOE) of PV	\$0.377	\$0.324	\$0.192	\$0.378	\$0.323	\$0.194	\$0.415	\$0.357	\$0.215
Wholesale Power Revenue	(\$0.110)	(\$0.110)	(\$0.110)	(\$0.110)	(\$0.110)	(\$0.110)	(\$0.110)	(\$0.110)	(\$0.110)
Unsupported PV Economics	\$0.267	\$0.214	\$0.081	\$0.267	\$0.213	\$0.084	\$0.305	\$0.247	\$0.105
Federal Investment Tax Credit	(\$0.034)	(\$0.029)	(\$0.017)	(\$0.033)	(\$0.028)	(\$0.016)	(\$0.036)	(\$0.031)	(\$0.018)
Federal Accelerated Depreciation	(\$0.040)	(\$0.035)	(\$0.020)	(\$0.039)	(\$0.034)	(\$0.020)	(\$0.043)	(\$0.037)	(\$0.021)
Federally Supported PV Economics	\$0.193	\$0.150	\$0.045	\$0.196	\$0.151	\$0.048	\$0.226	\$0.179	\$0.065
Lower Cost Debt	(\$0.036)	(\$0.031)	(\$0.018)	(\$0.035)	(\$0.030)	(\$0.017)	(\$0.038)	(\$0.033)	(\$0.019)
Incremental Self-Generation Revenue at Retail Rates	(\$0.048)	(\$0.033)	\$0.000	(\$0.045)	(\$0.031)	\$0.000	(\$0.050)	(\$0.037)	\$0.000
REC Revenue	(\$0.037)	(\$0.037)	(\$0.037)	(\$0.037)	(\$0.037)	(\$0.037)	(\$0.037)	(\$0.037)	(\$0.037)
Net Metering Revenue at Wholesale Rates	\$0.068	\$0.059	\$0.066	\$0.068	\$0.060	\$0.110	\$0.068	\$0.059	\$0.033
Full Net Metering Revenue at Retail Rates	(\$0.145)	(\$0.098)	(\$0.109)	(\$0.141)	(\$0.097)	(\$0.179)	(\$0.149)	(\$0.102)	(\$0.057)
Property & Sales Tax Exemptions	(\$0.017)	(\$0.015)	\$0.000	(\$0.018)	(\$0.013)	(\$0.007)	(\$0.029)	(\$0.009)	\$0.000
Other Major State Incentives	(\$0.029)	(\$0.021)	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	(\$0.007)	\$0.000
Fully Supported PV Economics	(\$0.051)	(\$0.026)	(\$0.054)	(\$0.012)	\$0.002	(\$0.083)	(\$0.010)	\$0.012	(\$0.015)
Effect of Lower Discount Rate	(\$0.048)	(\$0.041)	(\$0.029)	(\$0.056)	(\$0.047)	(\$0.029)	(\$0.062)	(\$0.049)	(\$0.034)
Fully Supported PV Economics @ Lower Discount Rate	(\$0.099)	(\$0.068)	(\$0.083)	(\$0.068)	(\$0.045)	(\$0.112)	(\$0.072)	(\$0.037)	(\$0.049)

Table of Results: Fully Supported PV Economics



(Data below in \$/kWh)

State =>	CT	CT	CT	ME	ME	ME	MA	MA	MA
Customer Type =>	Residential	Commercial	Utility Scale	Residential	Commercial	Utility Scale	Residential	Commercial	Utility Scale
2015 Project Starts	(\$0.148)	(\$0.077)	(\$0.109)	\$0.013	\$0.020	(\$0.026)	(\$0.152)	(\$0.137)	(\$0.151)
2019 Project Starts	(\$0.061)	(\$0.043)	(\$0.097)	\$0.048	\$0.053	(\$0.013)	(\$0.089)	(\$0.080)	(\$0.121)
2024 Project Starts	(\$0.059)	(\$0.034)	(\$0.111)	\$0.030	\$0.041	(\$0.026)	(\$0.001)	(\$0.002)	(\$0.090)
State =>	NH	NH	NH	RI	RI	RI	VT	VT	VT
Customer Type =>	Residential	Commercial	Utility Scale	Residential	Commercial	Utility Scale	Residential	Commercial	Utility Scale
2015 Project Starts	(\$0.103)	(\$0.072)	(\$0.053)	(\$0.117)	(\$0.063)	(\$0.061)	(\$0.038)	(\$0.057)	(\$0.038)
2019 Project Starts	(\$0.050)	(\$0.027)	(\$0.040)	(\$0.056)	(\$0.020)	(\$0.031)	\$0.007	\$0.003	(\$0.006)
2024 Project Starts	(\$0.051)	(\$0.026)	(\$0.054)	(\$0.012)	\$0.002	(\$0.083)	(\$0.010)	\$0.012	(\$0.015)

Summary of Results and Additional PV Industry Description

Summary of Results (part 1 of 3)

- Federal incentives have a substantial effect
 - E.g., ~\$.13-.15/kWh for residential 2015 project starts
- Decline in Federal ITC in 2017 is partially offset by increase in accelerated depreciation basis, but still a drag on PV economics (\$.03 to \$.08/kWh reduction)
- PV economics for 2015 project starts vary significantly across states, but converge somewhat between states over time
 - Due to the growing relative importance of wholesale and retail electricity prices to PV economics and the shrinking relative influence of state incentive policies over time (several state policies reach their capacity or other goals before 2024)
- Economics of PV without Federal and state support continue to improve at each interval
 - Due to assumed increasing physical power prices, decreases in real installed PV costs, and improvements in PV performance
 - However, these combined effects do not fully counteract the decline in the ITC

Summary of Results (part 2 of 3)



- Fully supported PV economics (including Federal, state, and other support) typically decrease for 2019 and 2024 project starts compared to 2015 project starts
 - The Federal incentive decline is generally not offset by non-Federal incentives, illustrating the interplay of policy support
- PV economics in certain markets post-2016 are dependent on the assumption that net metering policies remain in their current form
 - E.g., in markets without SREC/ZREC premia over Tier 1 RECs or long-term tariff, auction, or other solar rates
- Many economic drivers play a meaningful role in PV economics
 - Often, a dozen or more individual drivers have a levelized \$.01/kWh or larger effect

Summary of Results (part 3 of 3)

- General price inflation assumptions are quite important
 - Erosion in value of nominal-dollar PV incentives
 - Wholesale and retail electricity prices received for PV production
 - Installed costs in nominal dollars
- System size makes a large difference in PV economics
 - Some current state policies equalize economics between residential, commercial, and utility scale systems
- Largest economic drivers of PV in New England tend to be (in no particular order):
 - System installed cost (i.e., first cost)
 - Physical power revenue (wholesale, offsetting on-site requirements, net metering)
 - Renewable energy credit (REC) revenue (tends to decline over time)
 - Federal investment tax credit (declines after 2016)
 - Federal depreciation (effectively increases after 2016)

PV Installed Cost Scenarios & Trade Tariff Perspective



■ External PV installed cost forecasts

- Scarcity of public, recent, long-run forecasts
- Energy Information Administration, U.S. DOE, *Annual Energy Outlook 2014* reference case: ~30% cumulative real reduction vs. 2015 costs by 2040
- Black & Veatch/NREL (2012 Study): ~ 20% to 30% cumulative real reduction vs. 2015 costs by 2040
- DOE SunShot Vision Study: From current prices, ~50% to 65% reduction by 2020 depending on system size would be required

■ Possible effects of PV cell and panel (module) trade tariffs

- Anti-dumping and anti-subsidy tariffs can be combined
- Apply to certain Chinese and Taiwanese PV cell and panel makers
- Combined tariff rate often approximates 50% (with wide range)
- Even if tariff increased U.S. panel prices by 25%, effect on total installed PV costs would be relatively modest for residential and commercial systems; relatively larger on utility scale systems

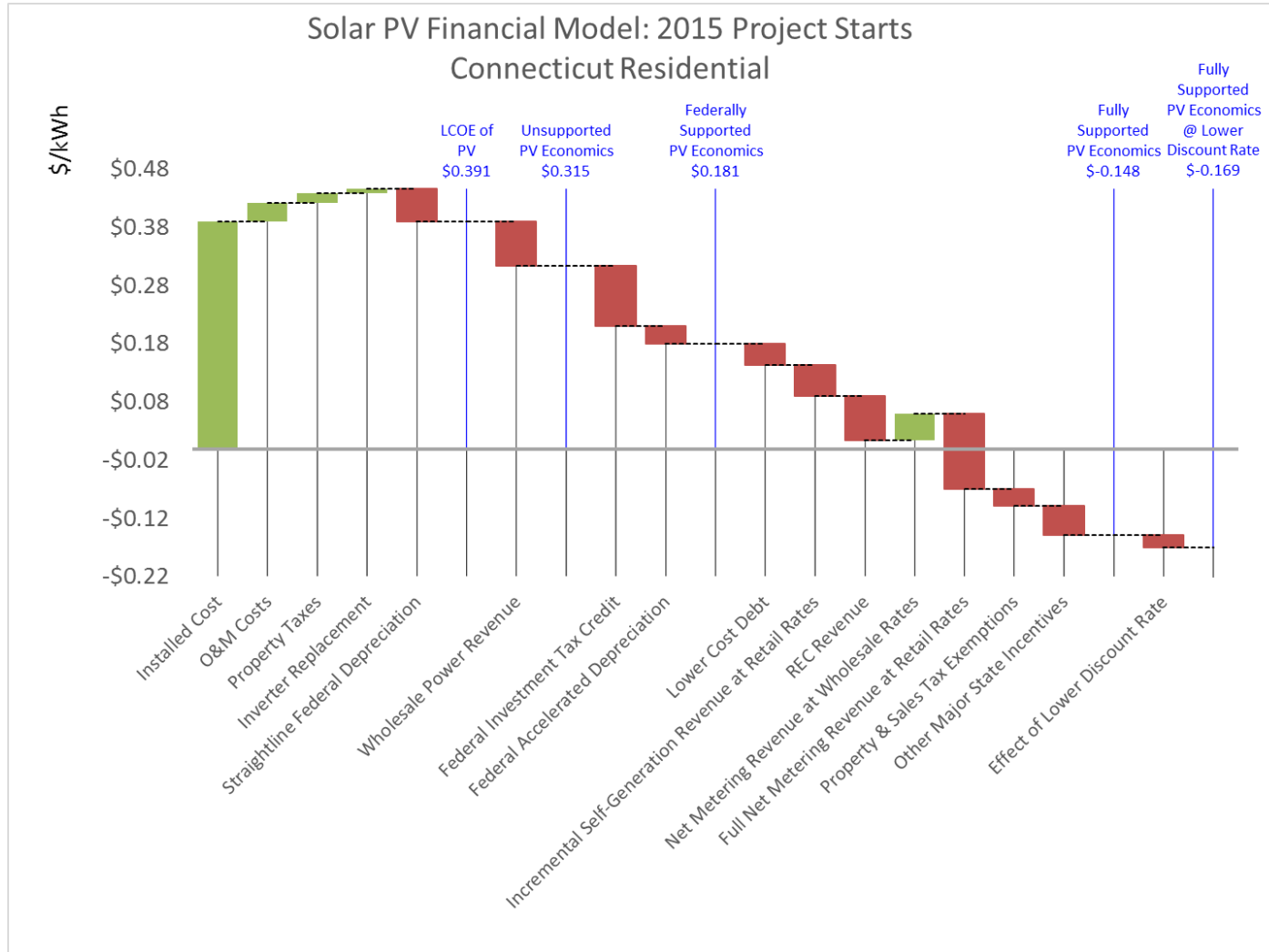
Financial Products Mapped to PV Hosts or Investors



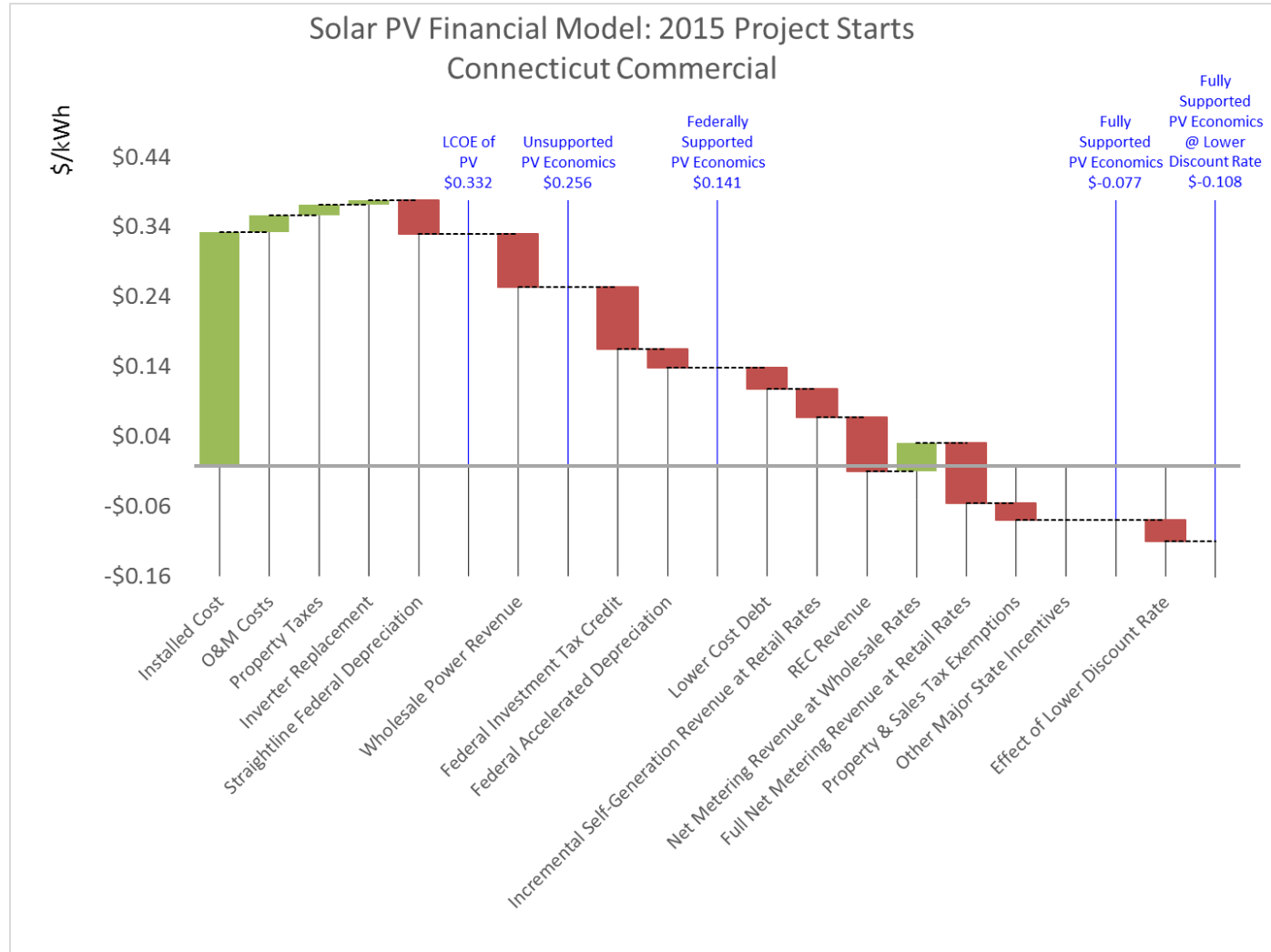
PV Host or Investor Type	Physical Description of Project	Transaction Description	Example Providers	Notes on Financing Involved
Homeowner	2 to 10 kW projects typically on the roof of a home and feeding power directly to the host.	Homeowner enters into a turnkey, long-term power purchase (PPA) or lease agreement with the system owner. The owner/developer will typically aggregate many projects into a portfolio and, then, sell the bundled projects into a finance facility (i.e., investment pool) that includes debt, strategic equity investors, and tax equity investors.	SolarCity Vivint SunRun SunPower	Projects are frequently third party financed through lease or PPA. However, outright system purchases by homeowners (with or without loans) are still common, but high PV first costs, as well as project ownership and REC complexity, dissuade many homeowners from purchasing systems. Property Assessed Clean Energy (PACE) programs allow homeowners to indirectly benefit from low-cost local government financing for PV systems.
Commercial and Industrial Business or Non-Profit or Government Agency	10 to 2,000 kW projects typically on the roof or property owned by host and feeding power directly to the host.	Customer (i.e., host) enters into an agreement to purchase power from the system owner/operator over a long term (15 to 25 years). Or, if the host has tax liability and desire to manage project, it can be self-financed.	SunPower SunEdison NRG Astrum	Projects are frequently third party financed through leases or PPAs, though self-ownership occurs regularly. Non-profits and government agencies must use third-party private ownership structures if they wish to benefit from PV tax benefits.
Community Solar (shared net metering by multiple legal entities)	Often 250kW+ projects.	Project developers work with subscribers located within the service territory of the utility where the project is located. These subscribers (individuals, businesses, non-profits, or government agencies) enter into agreements to purchase blocks of energy generated by the system.	SunShare Sol Partners Clean Energy Collective	Community solar projects are typically financed similarly to single-buyer PV projects of the same size.
Independent Power Producer	2,000 to 30,000+ kW projects located adjacent to transmission or distribution lines and feeding energy directly into the grid.	Project developer enters into a long-term purchase agreement with the utility (~20 years) that often includes the bundled sale of both the power and environmental attributes (i.e., RECs) generated by the system.	Recurrent NRG SunEdison	Projects are typically third-party financed through a power purchase agreement (PPA).
Fixed Income Financing (e.g., "YieldCos")	Aggregations of projects.	This financing mechanism is utilized to sell groups of smaller operating projects to investors that value long-term stable cash flows. The sale of the projects is typically to entities such as pension funds, YieldCos, and other fixed income structures.	SunEdison SunPower SolarCity Vivint	The fixed income facility will buyout the equity and debt of the project and looks for moderate returns on the purchase of the project.

Appendix: Waterfall Charts of Results for Baseline Scenario

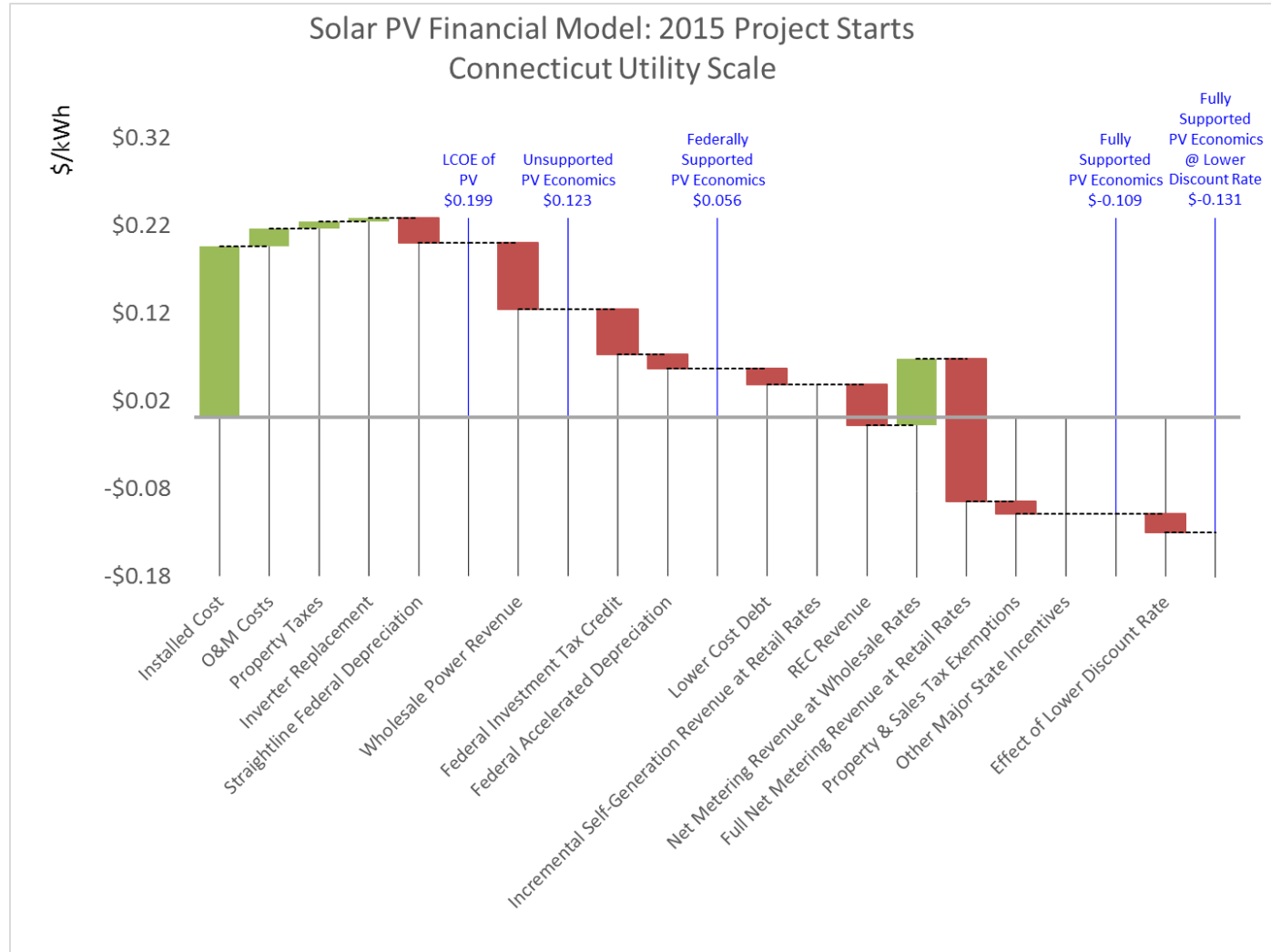
Results: Connecticut Residential, 2015 Project Starts



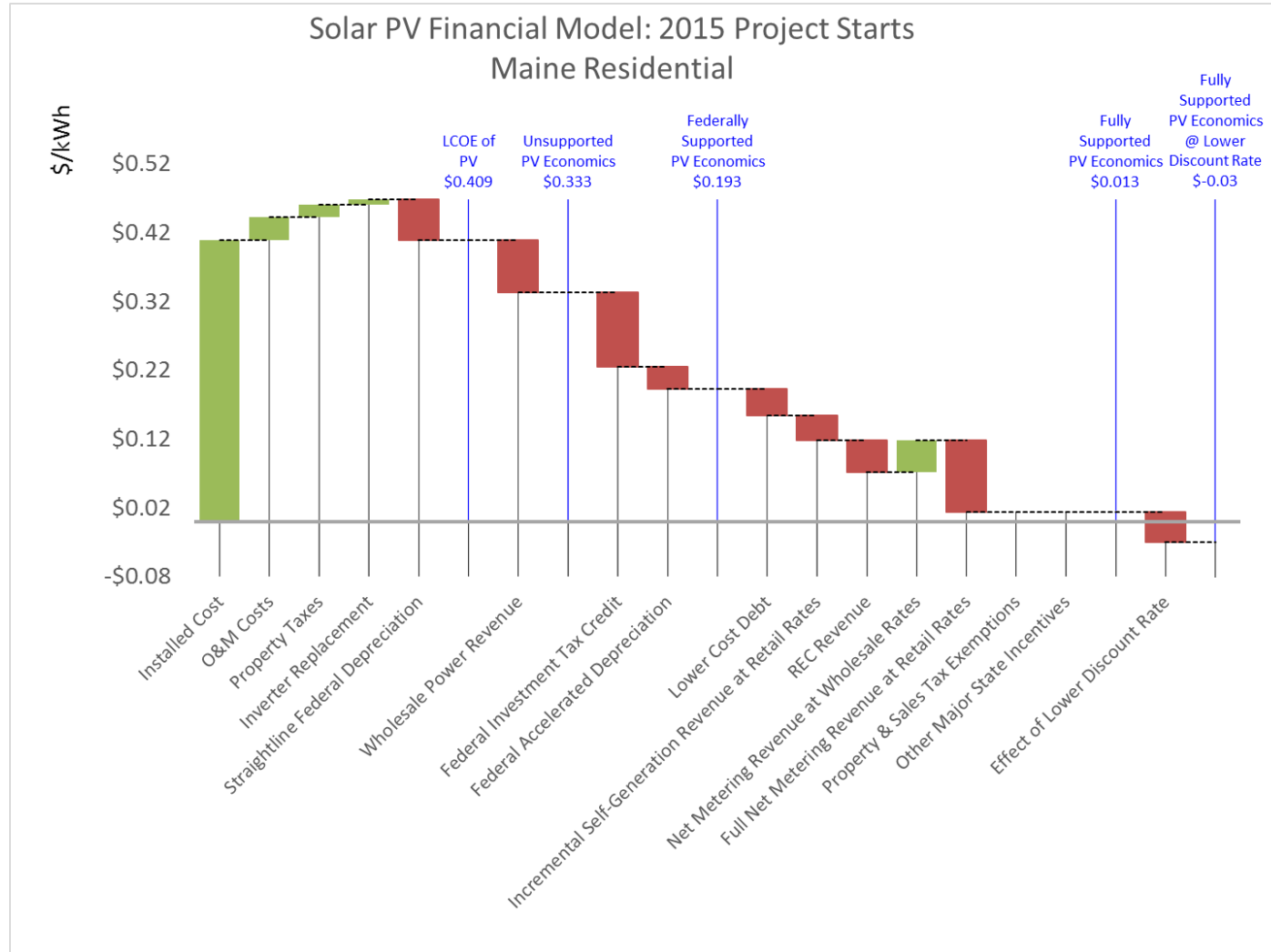
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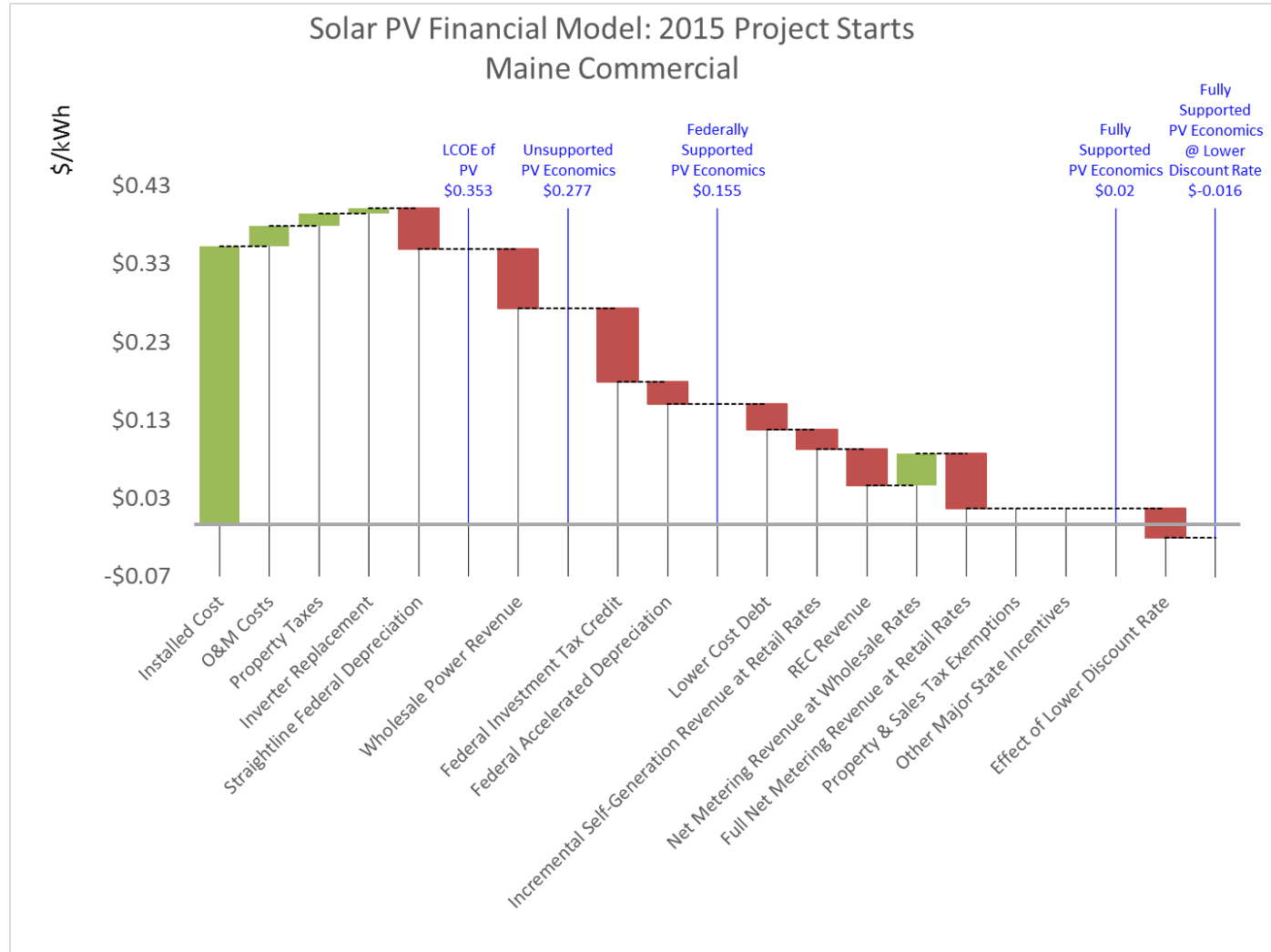
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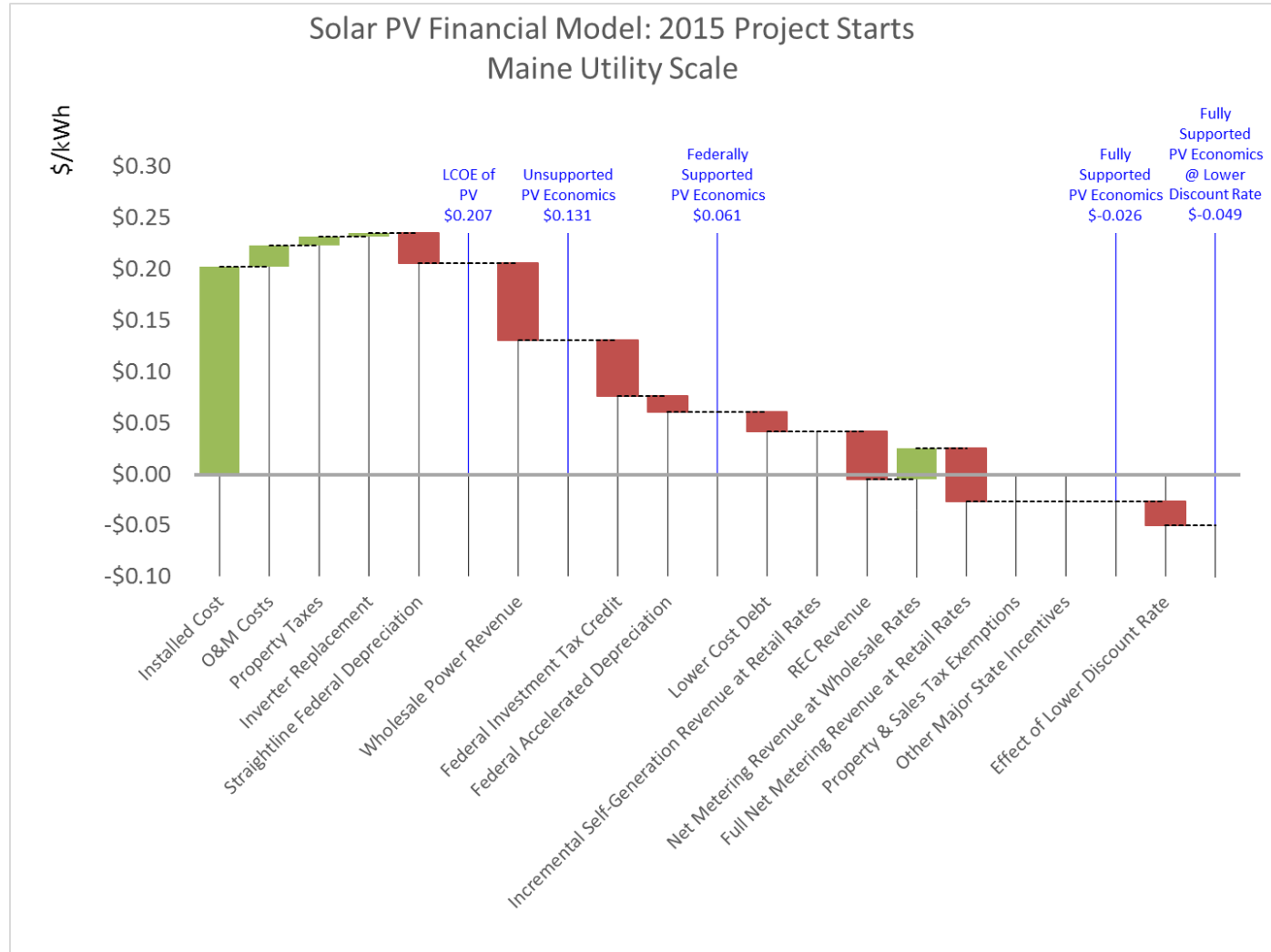
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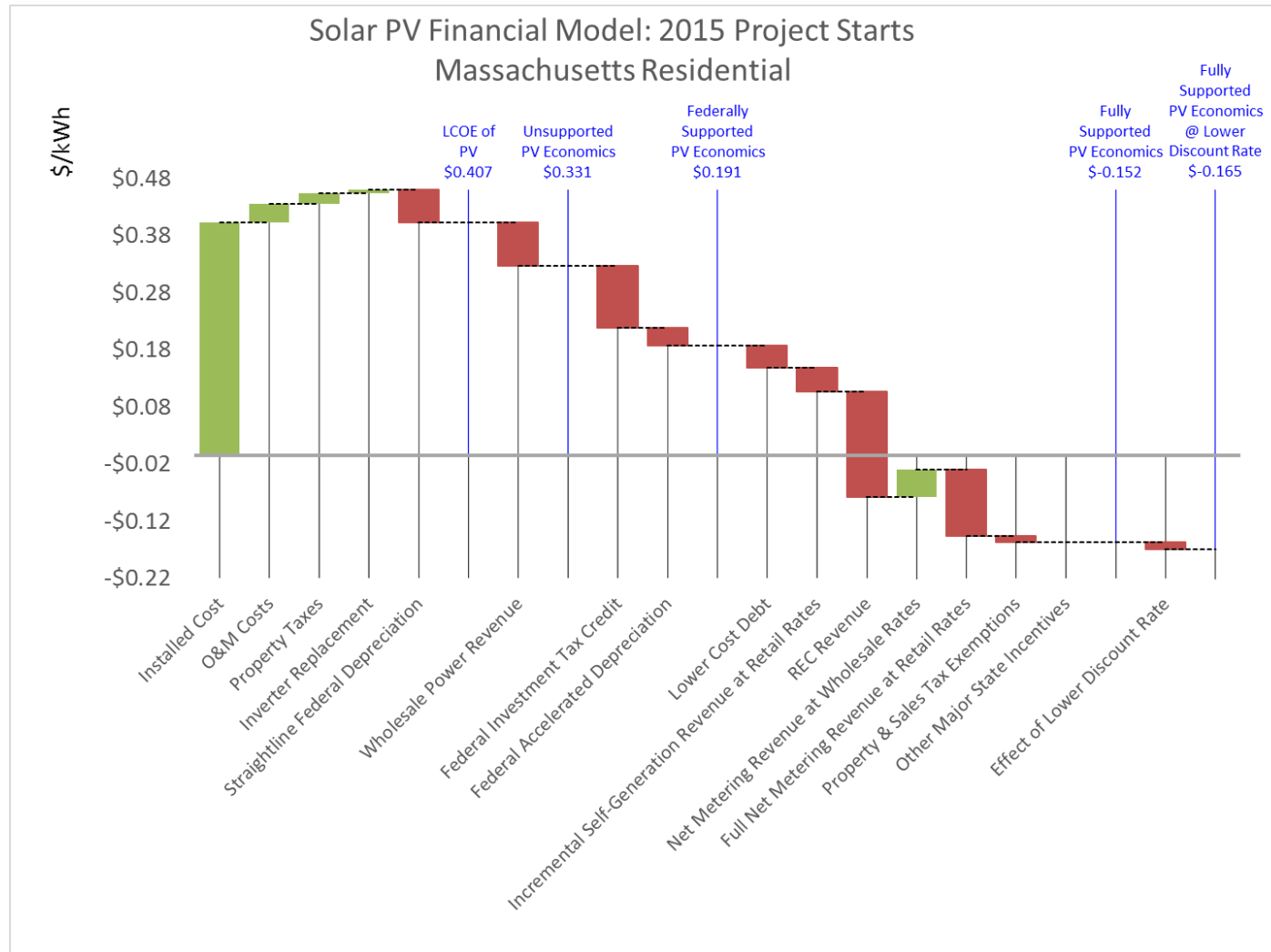
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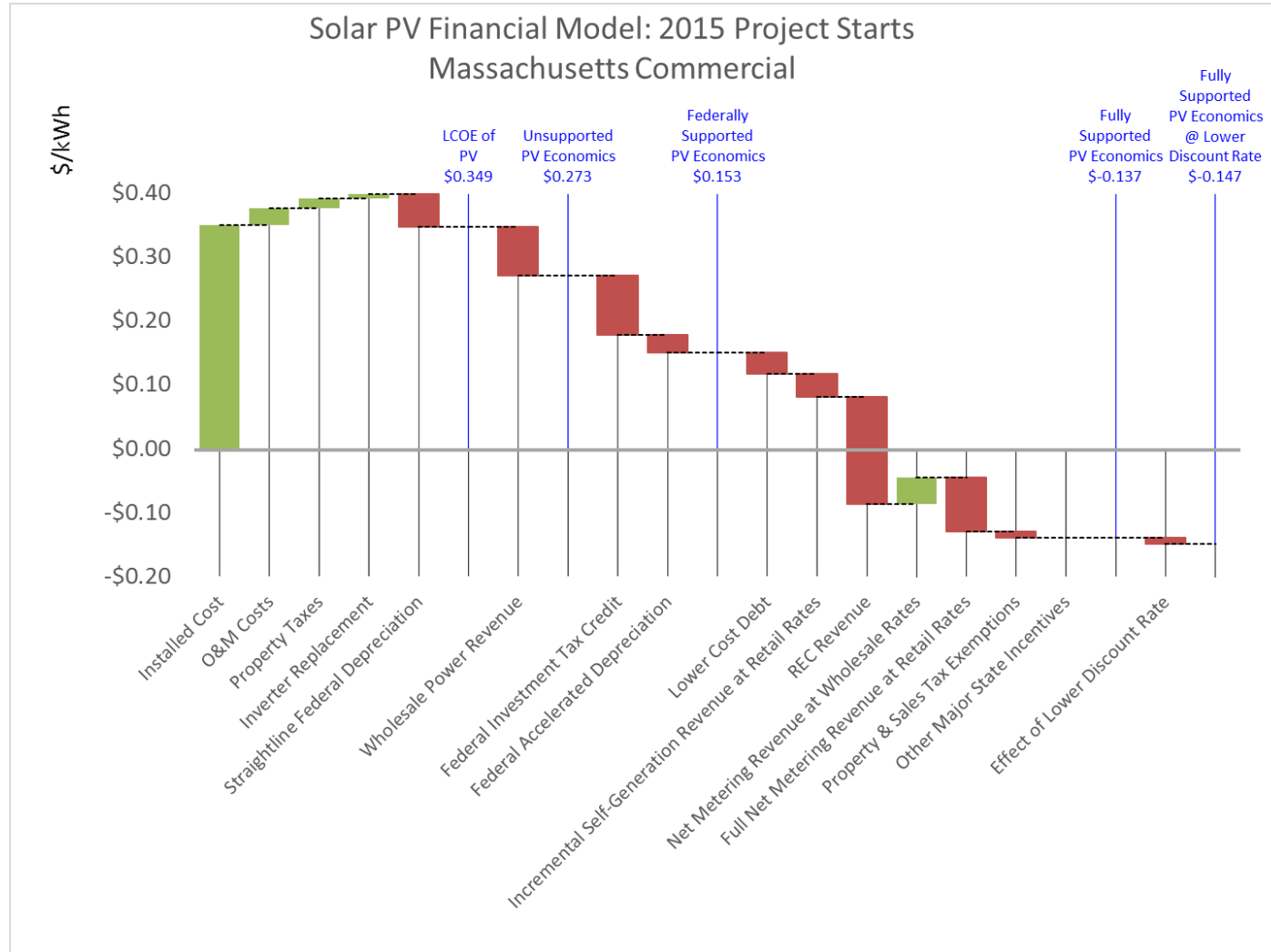
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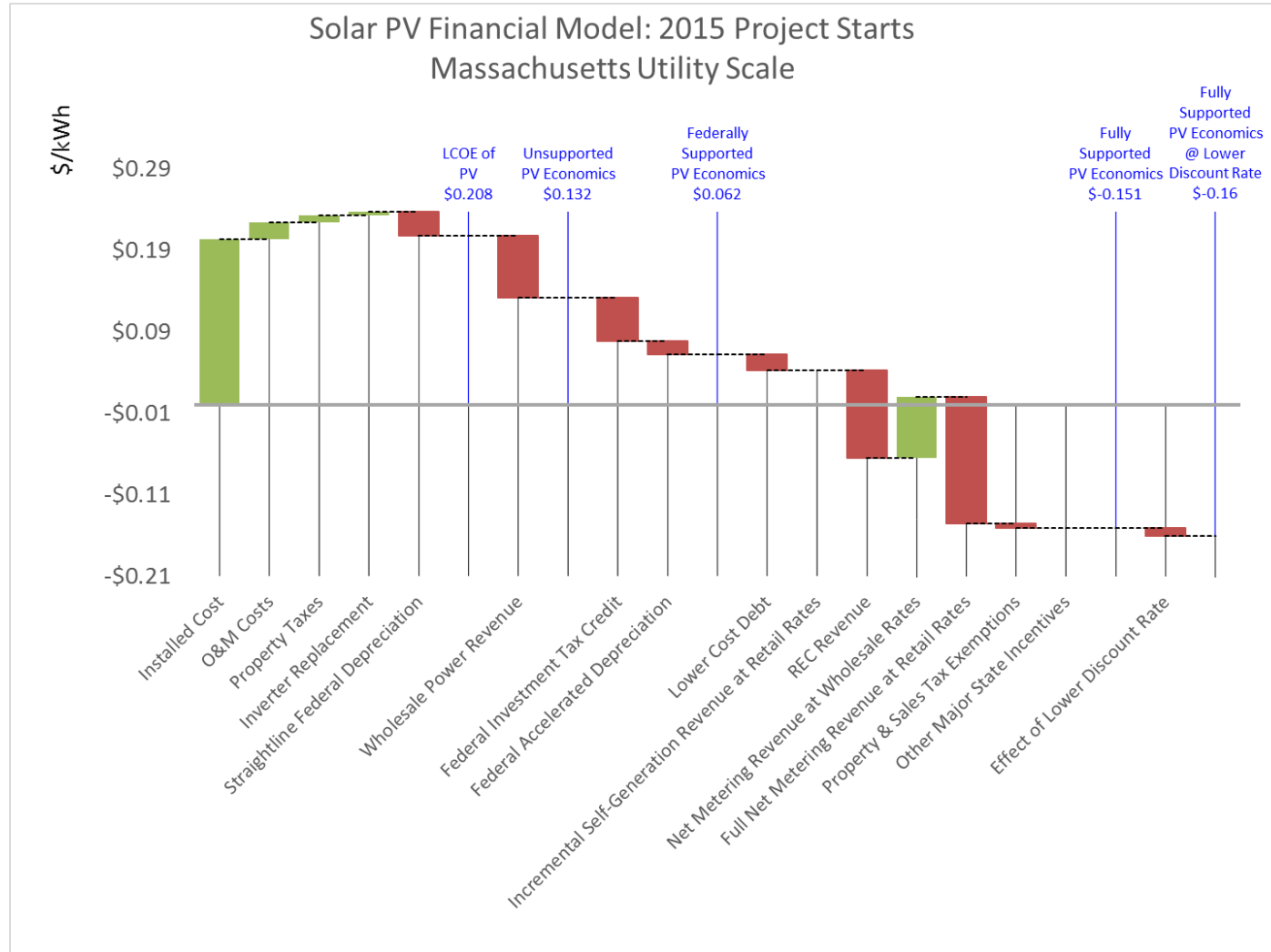
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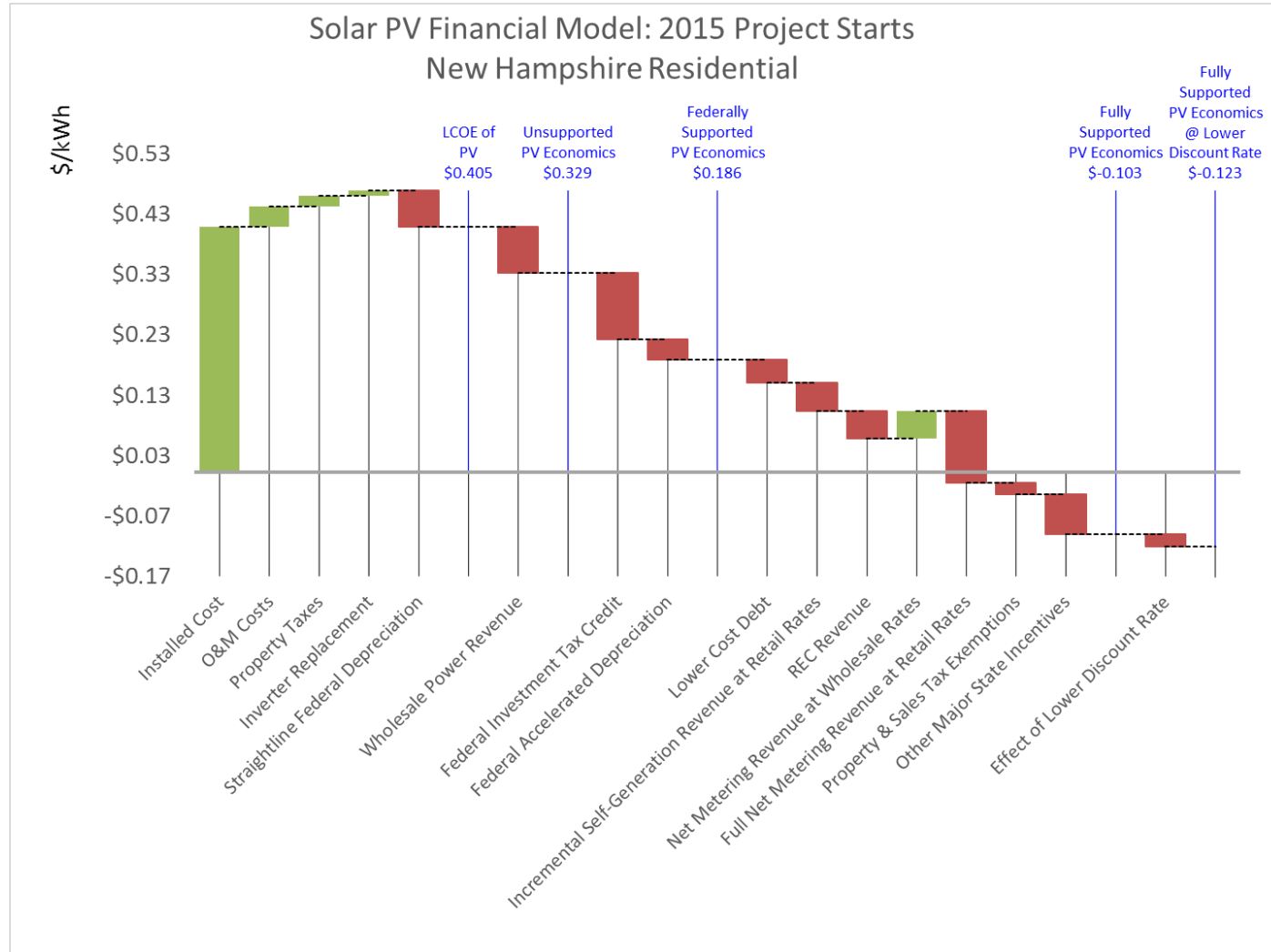
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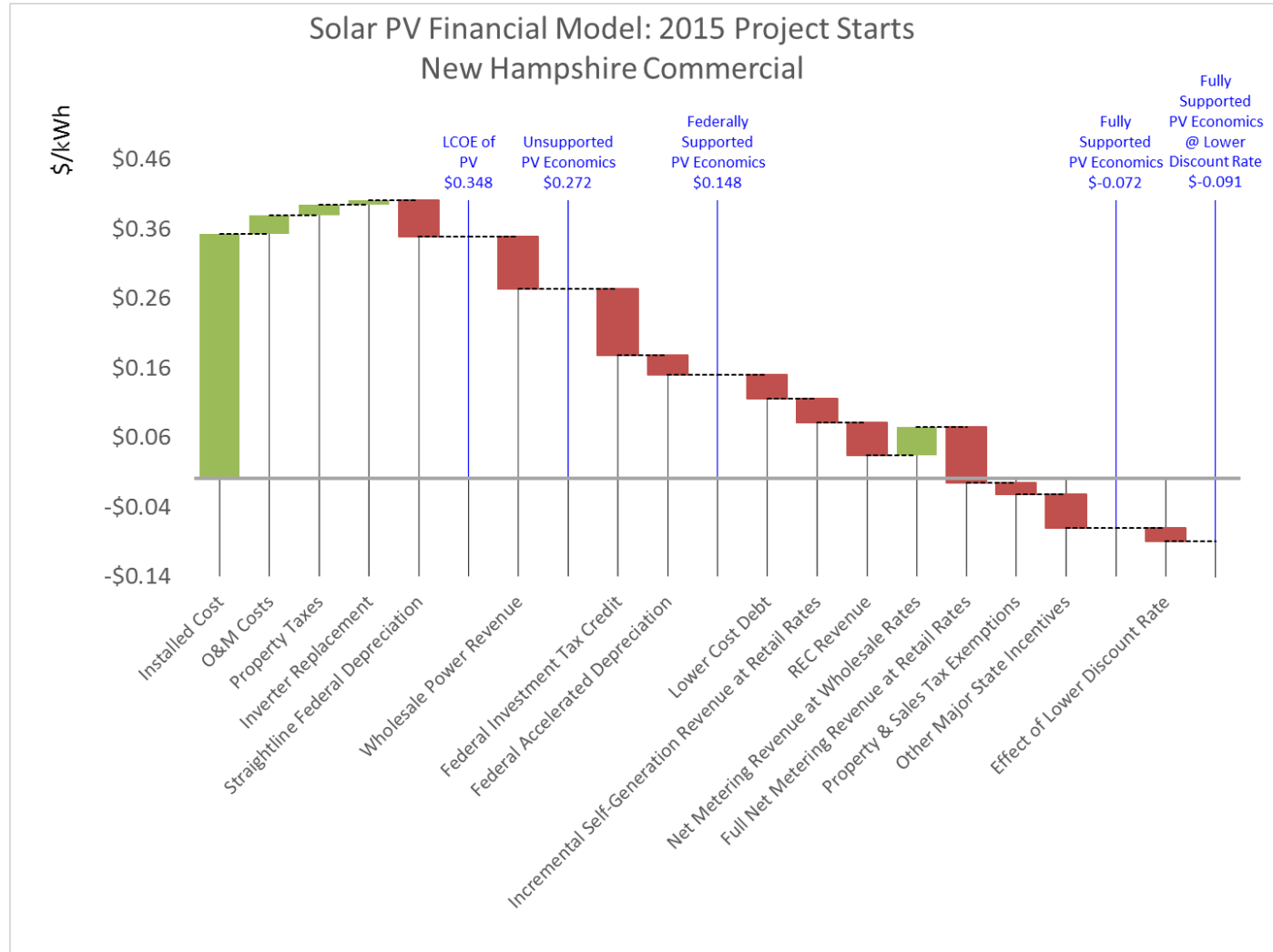
Results: Massachusetts Utility Scale, 2015 Project Starts



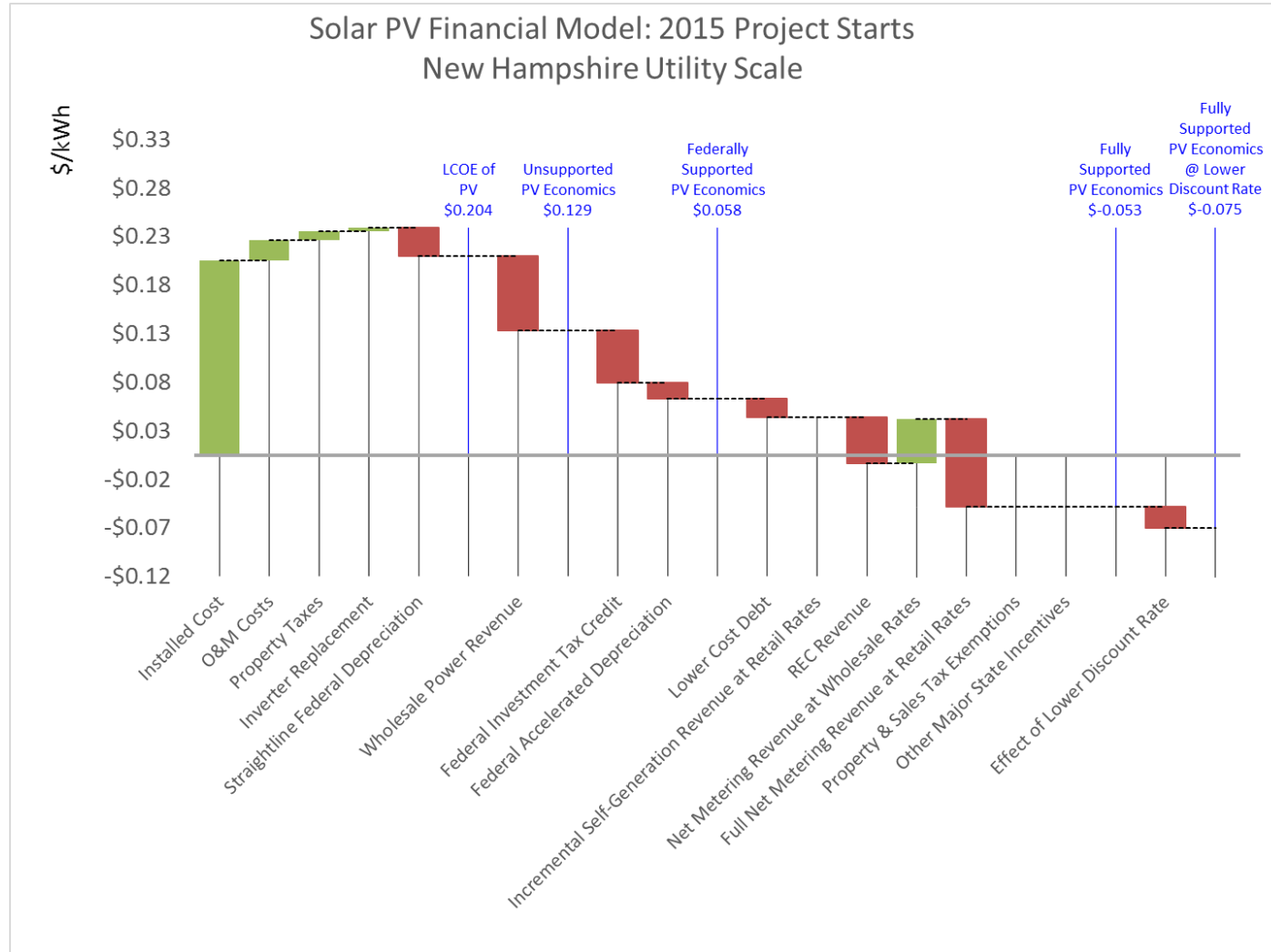
Results: New Hampshire Residential, 2015 Project Starts



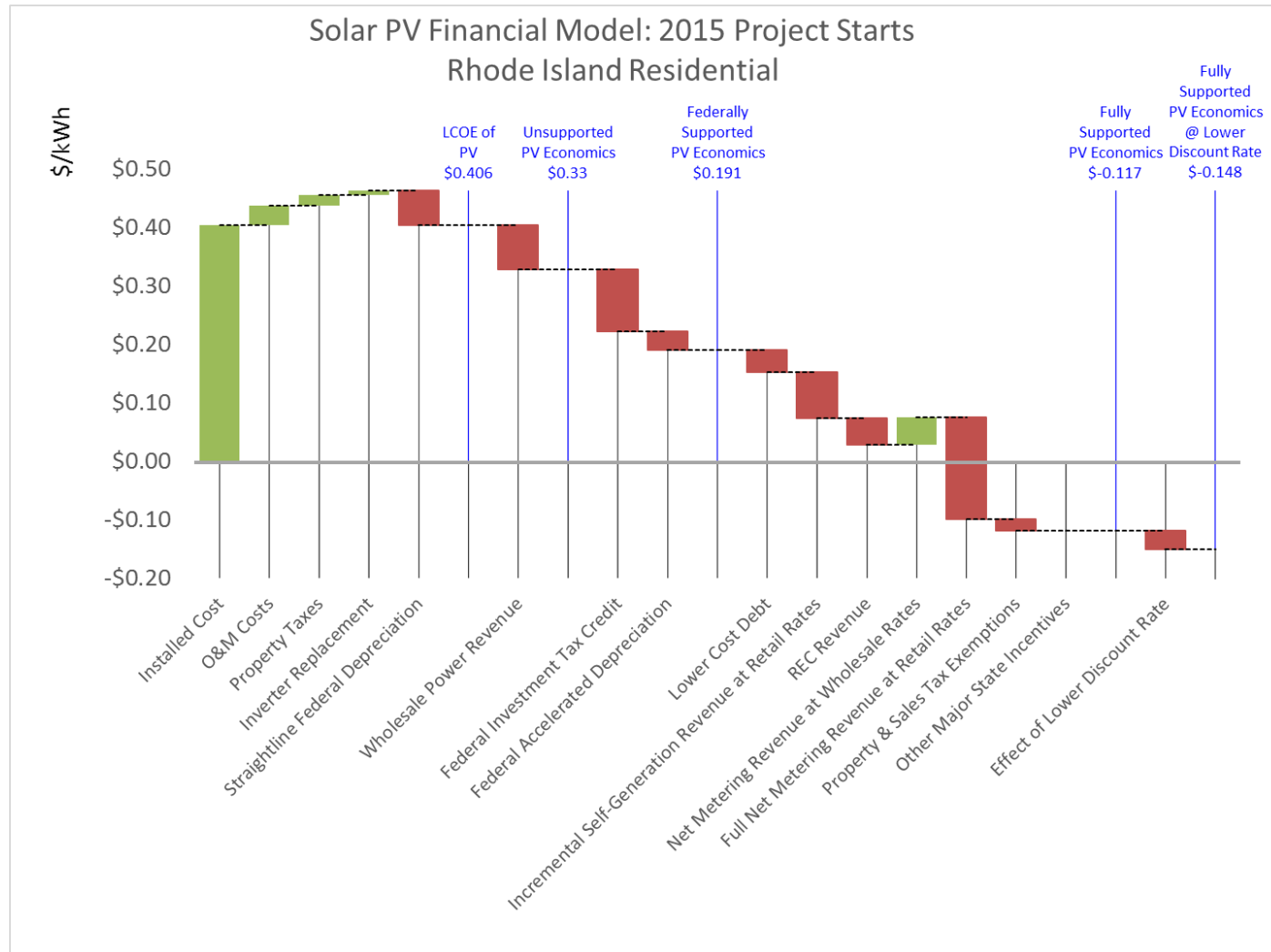
Results: New Hampshire Commercial, 2015 Project Starts



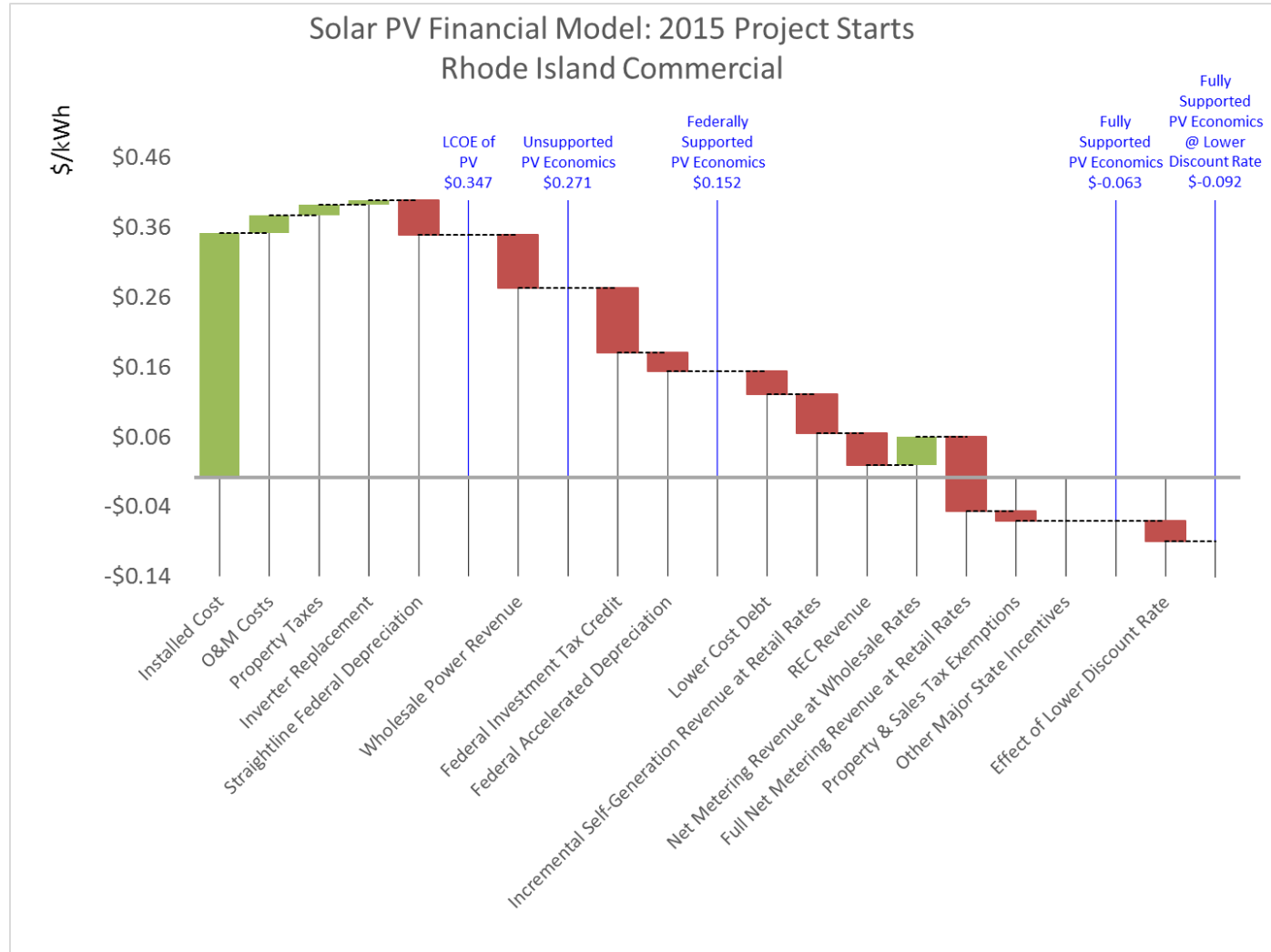
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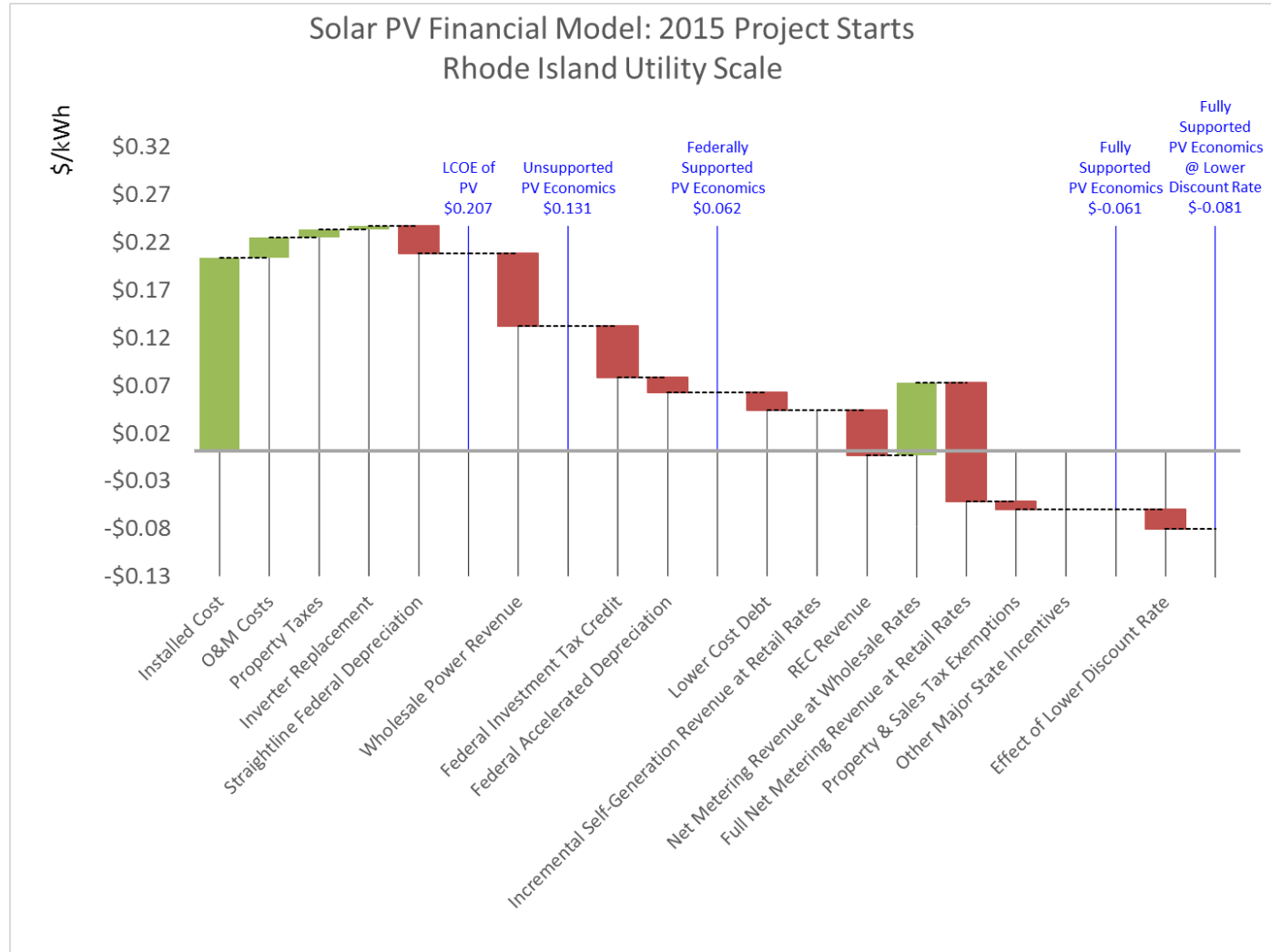
Results: Rhode Island Residential, 2015 Project Starts



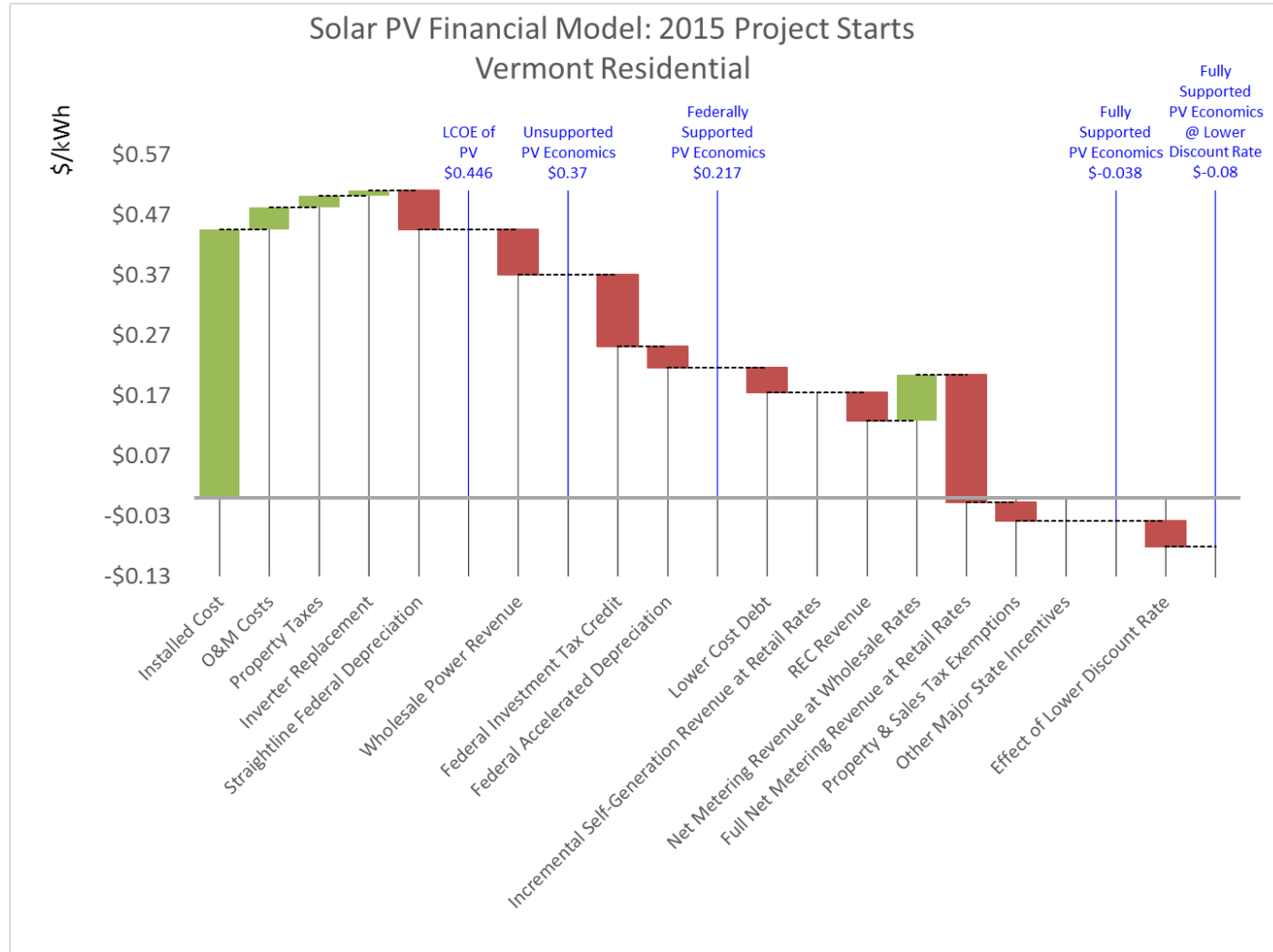
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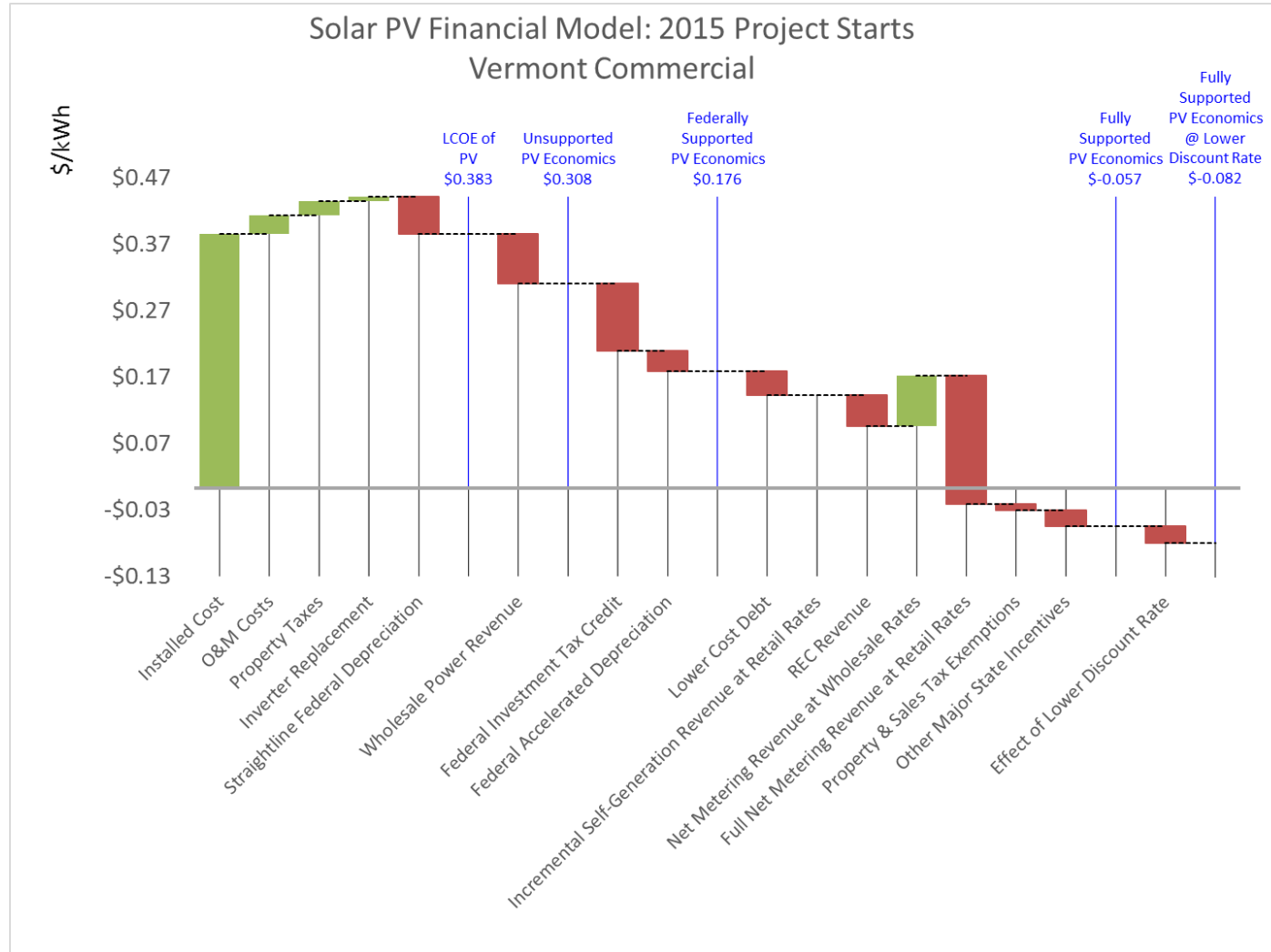
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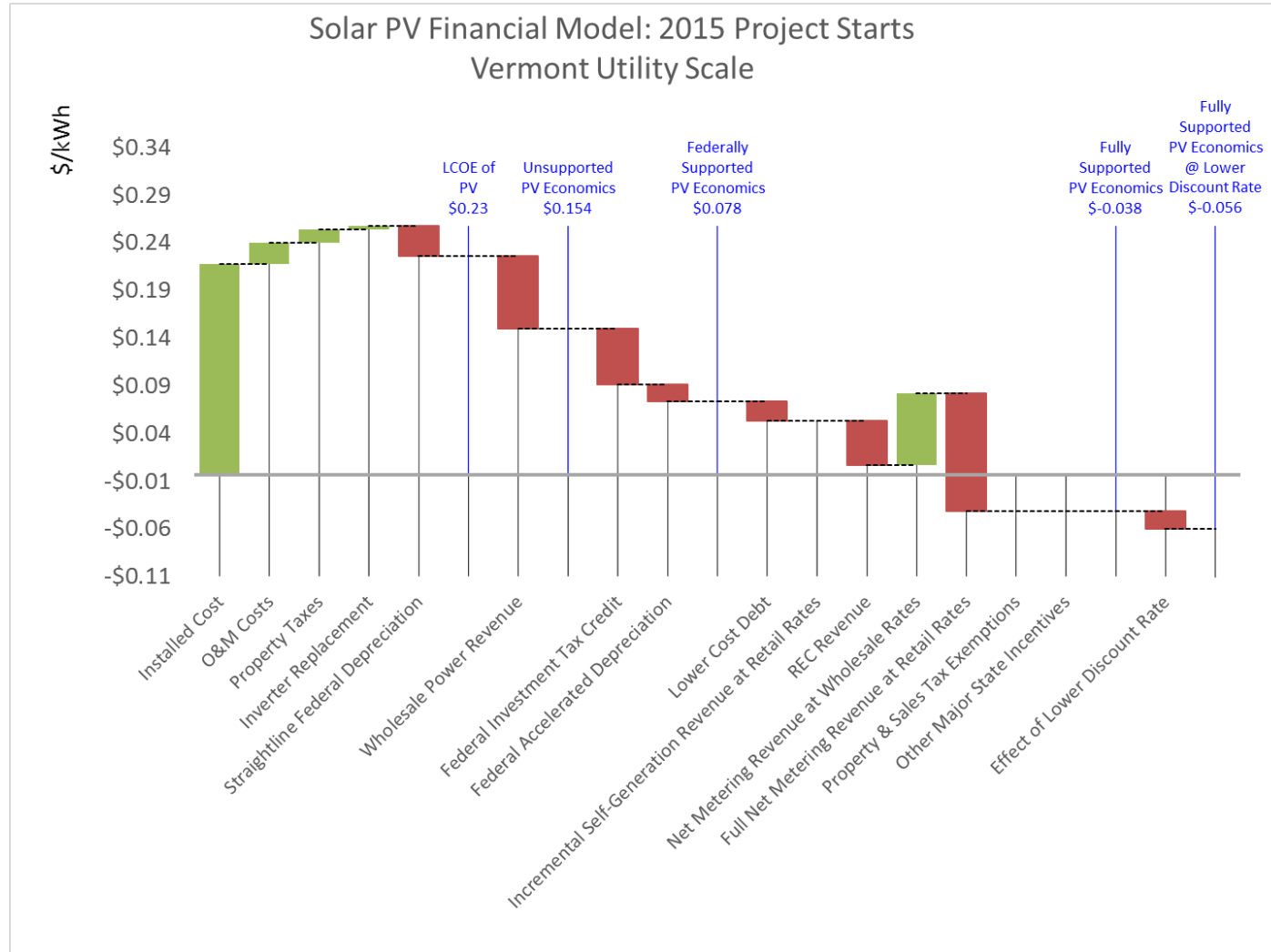
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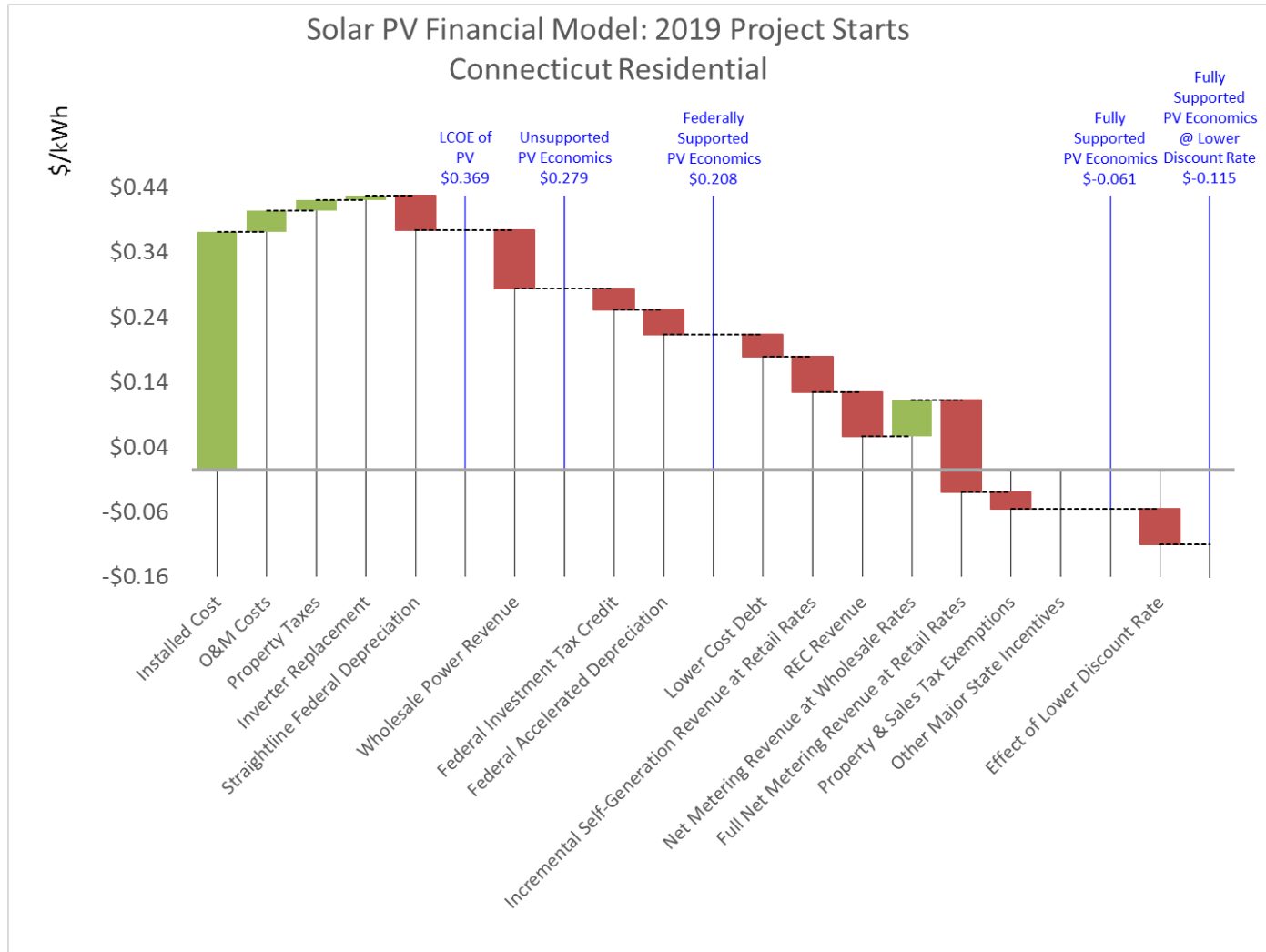
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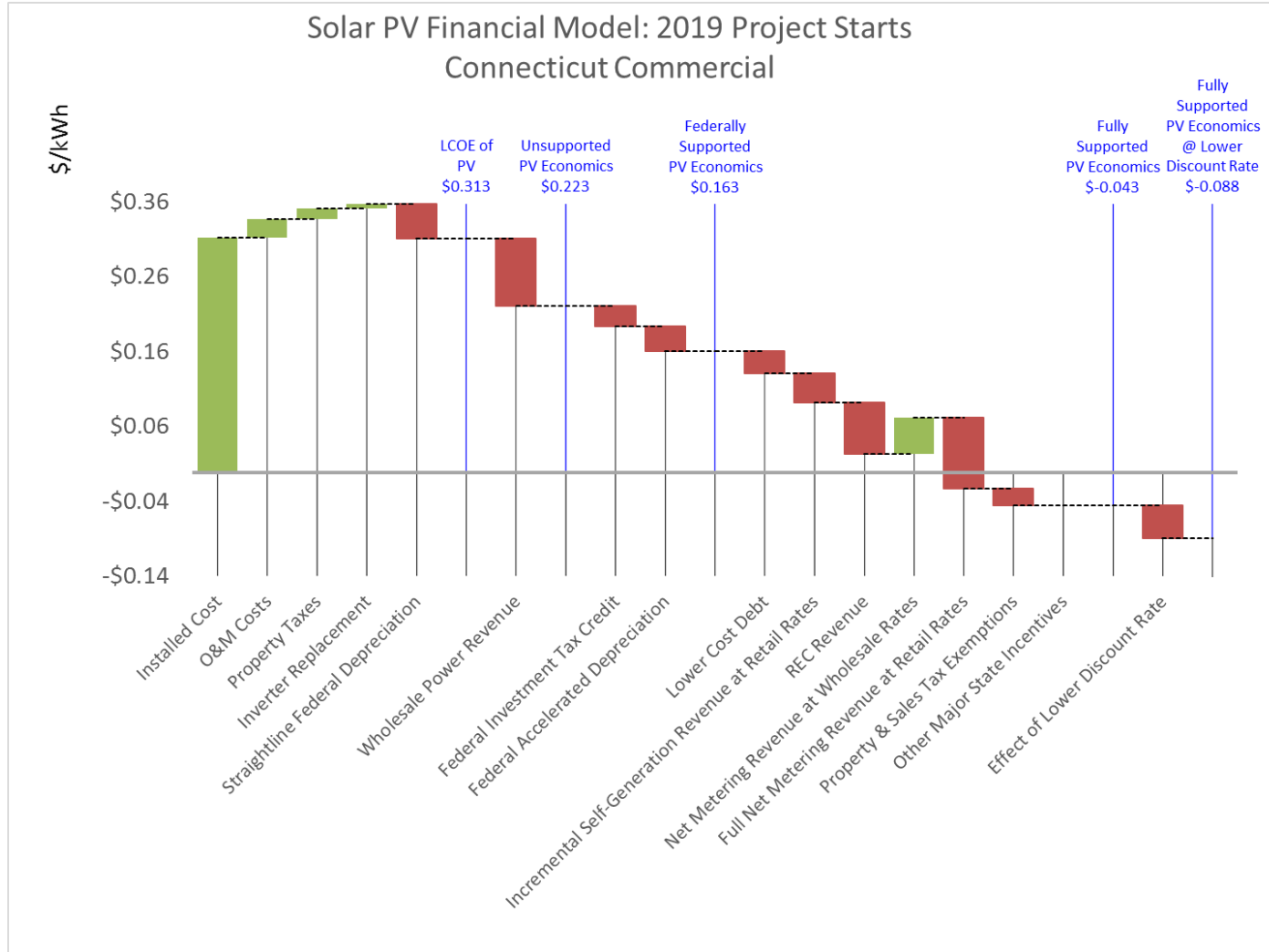
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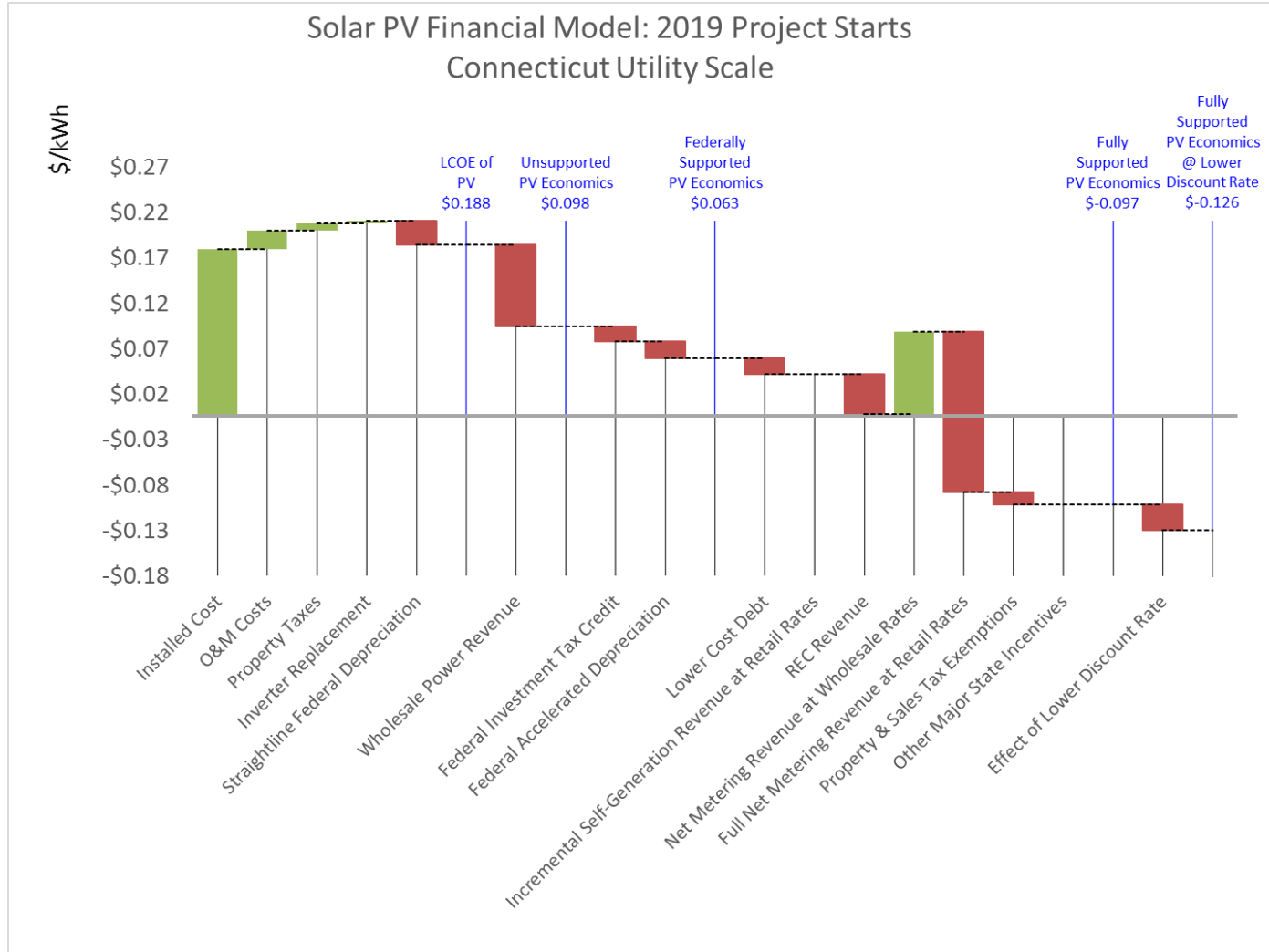
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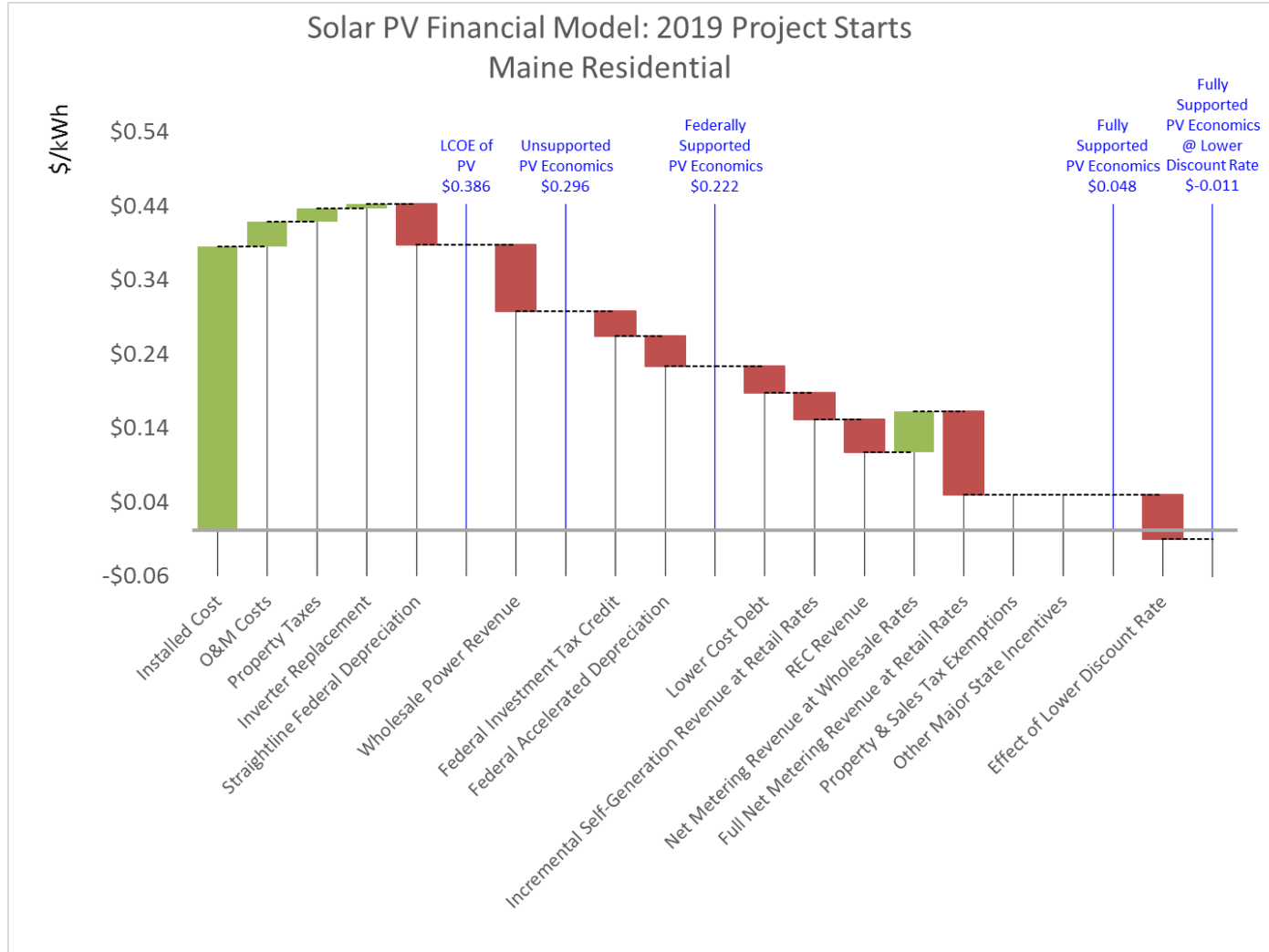
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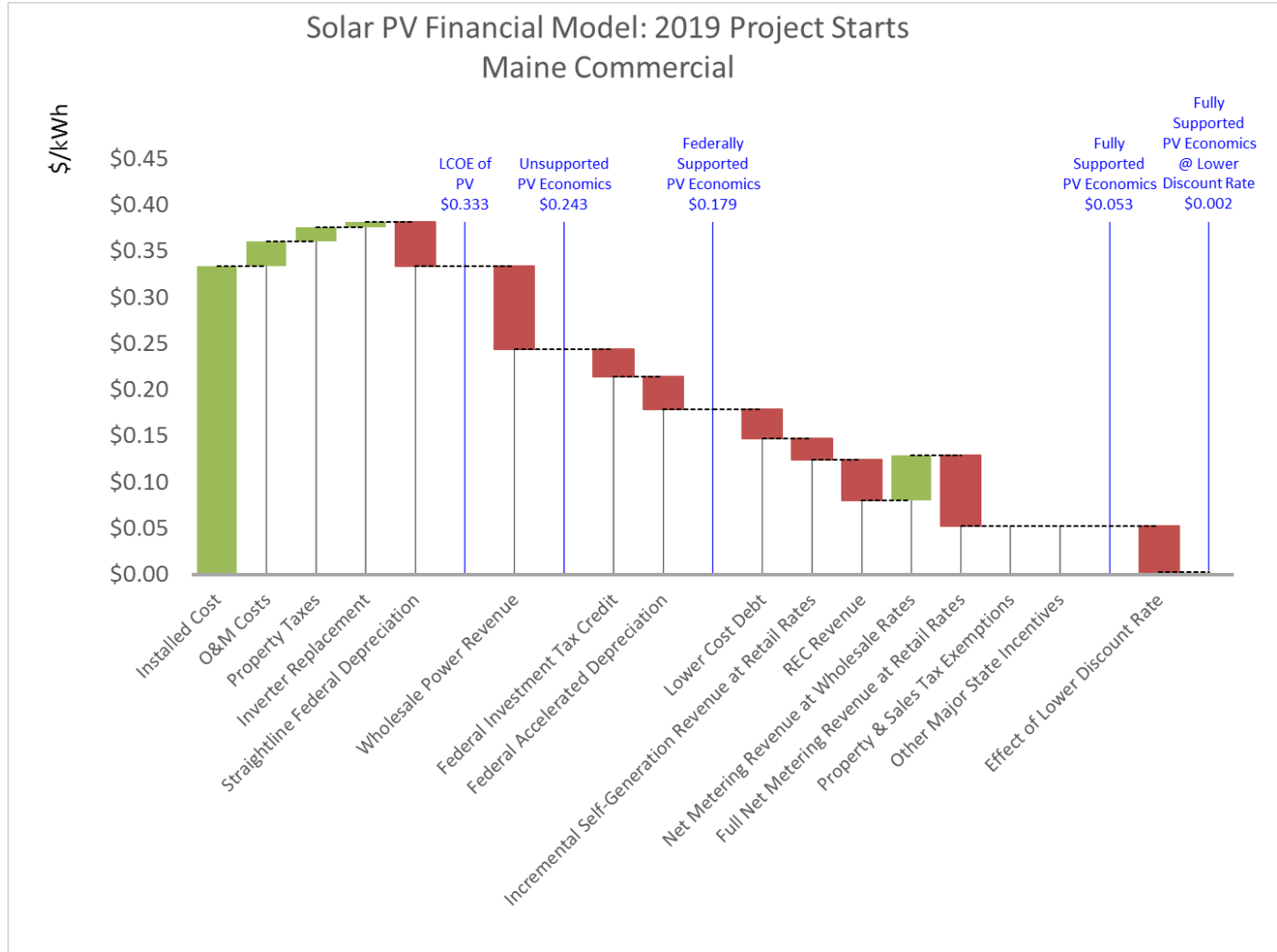
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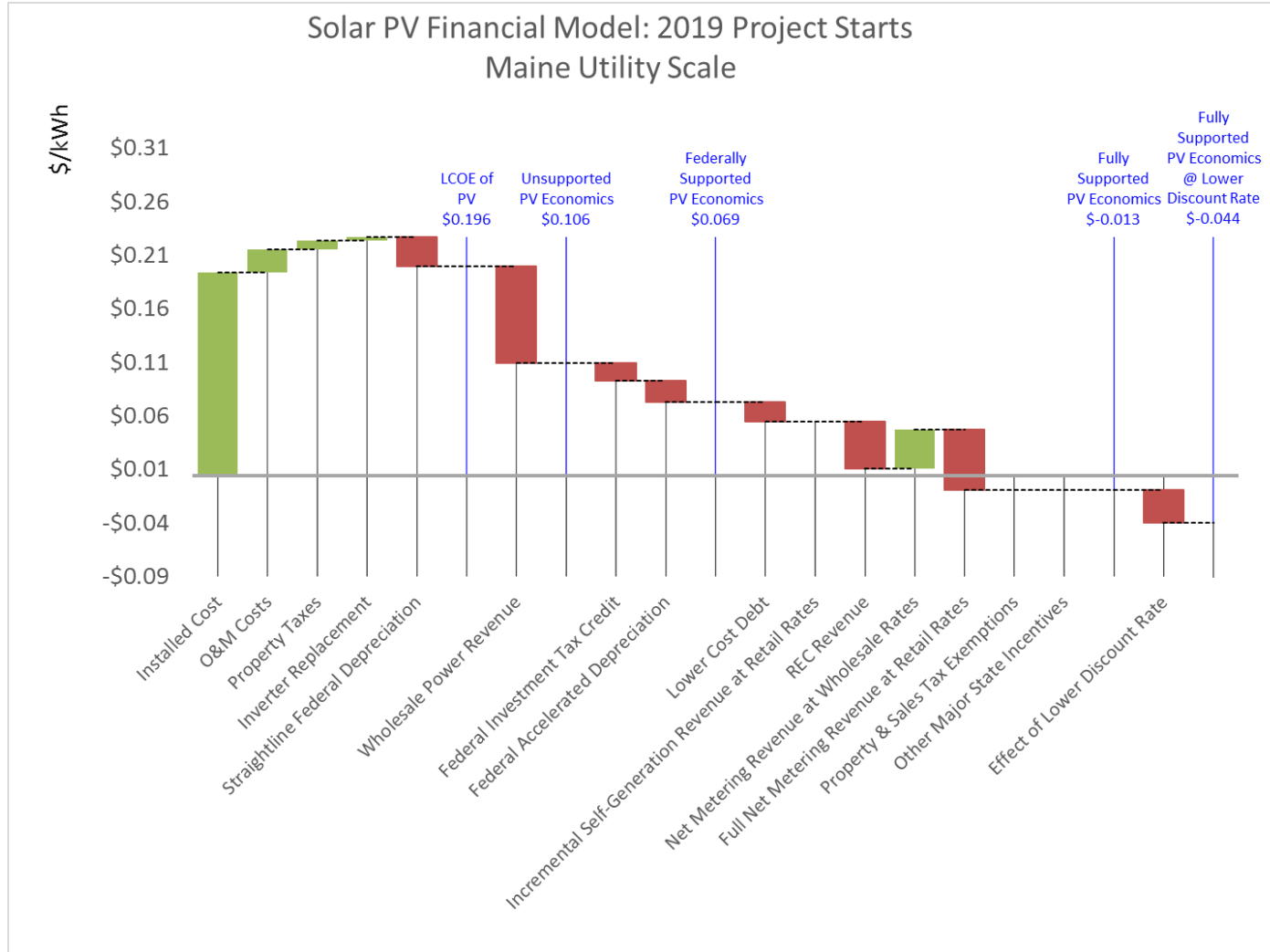
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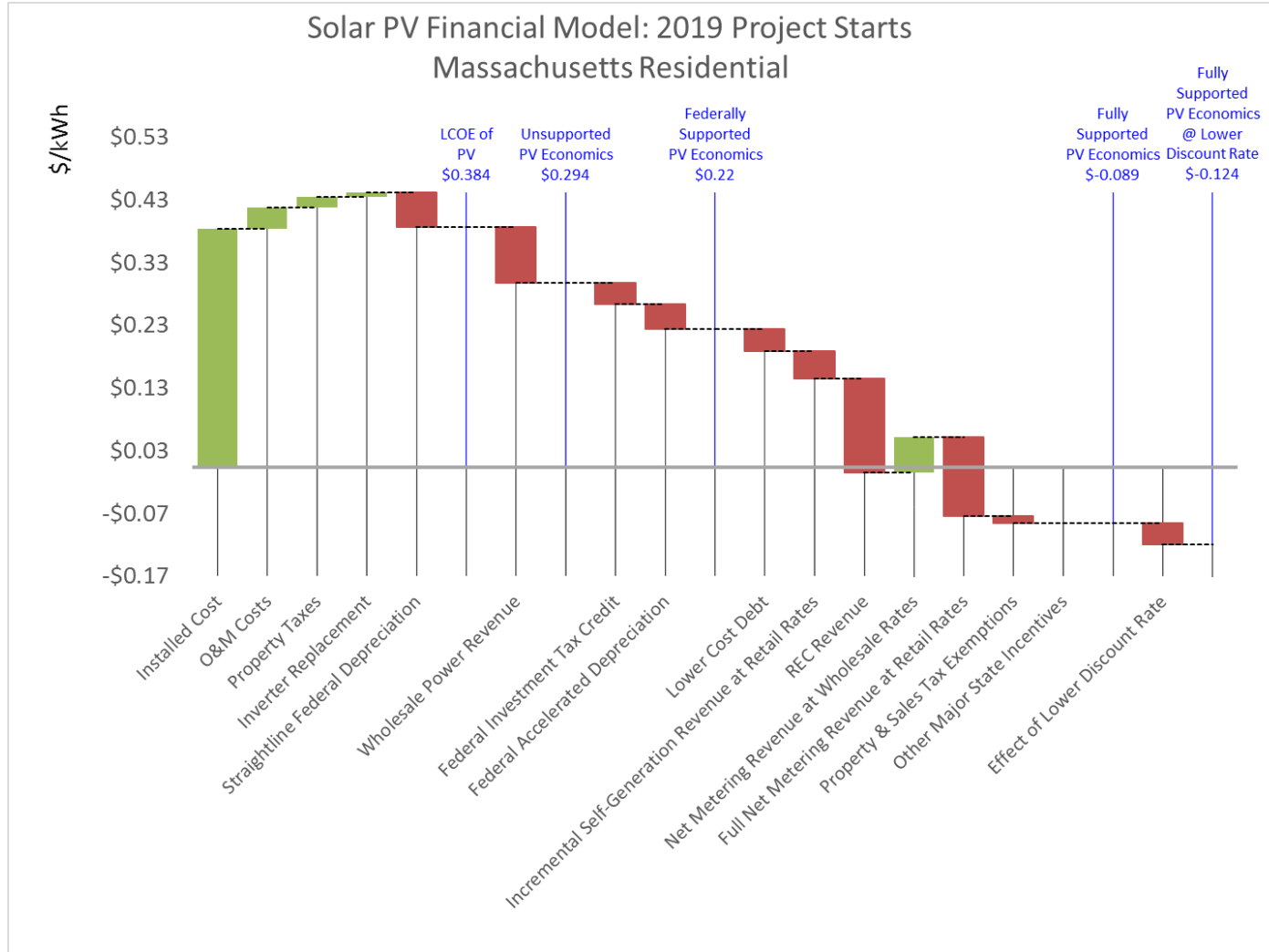
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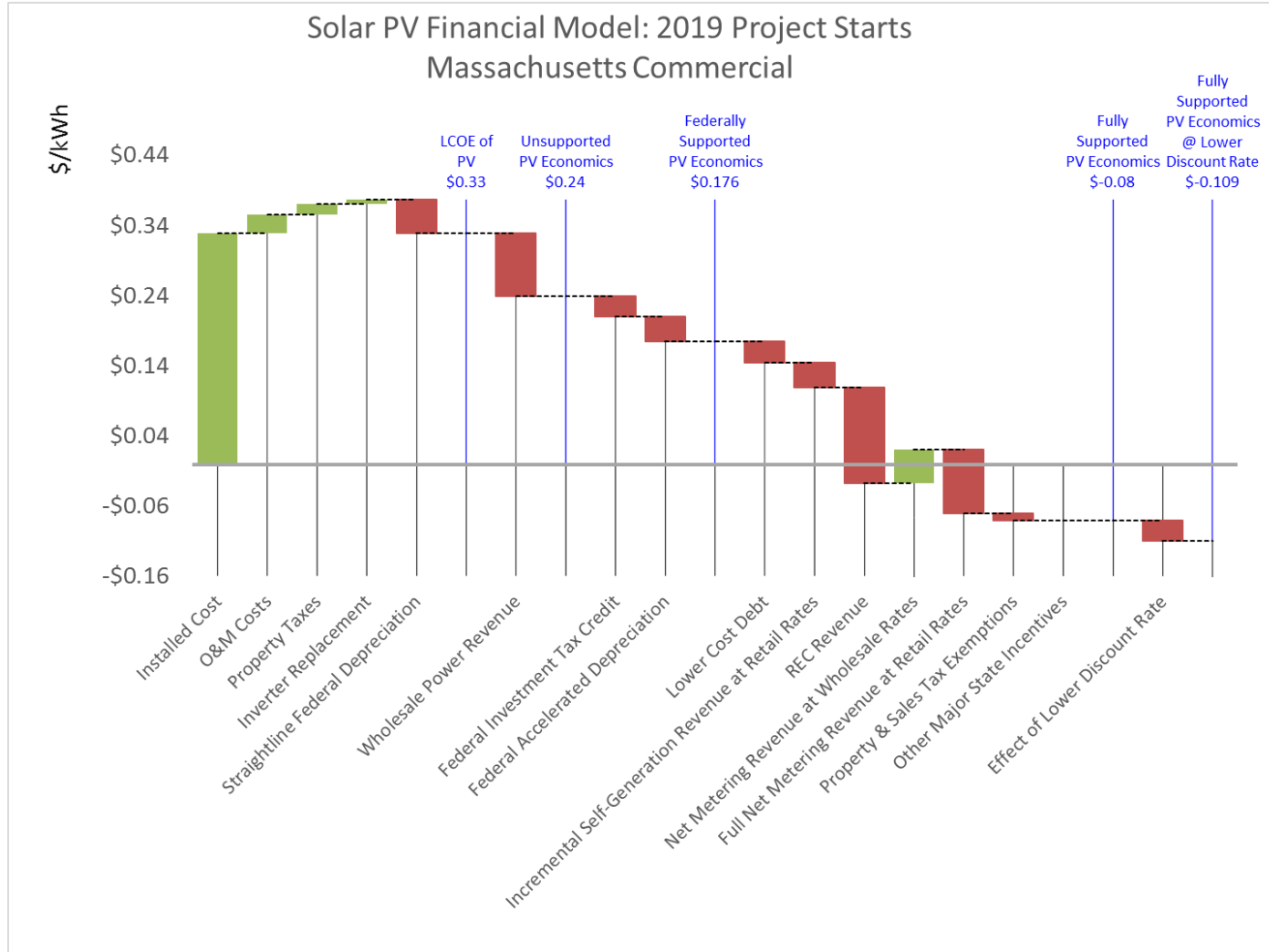
Results: Maine Utility Scale, 2019 Project Starts



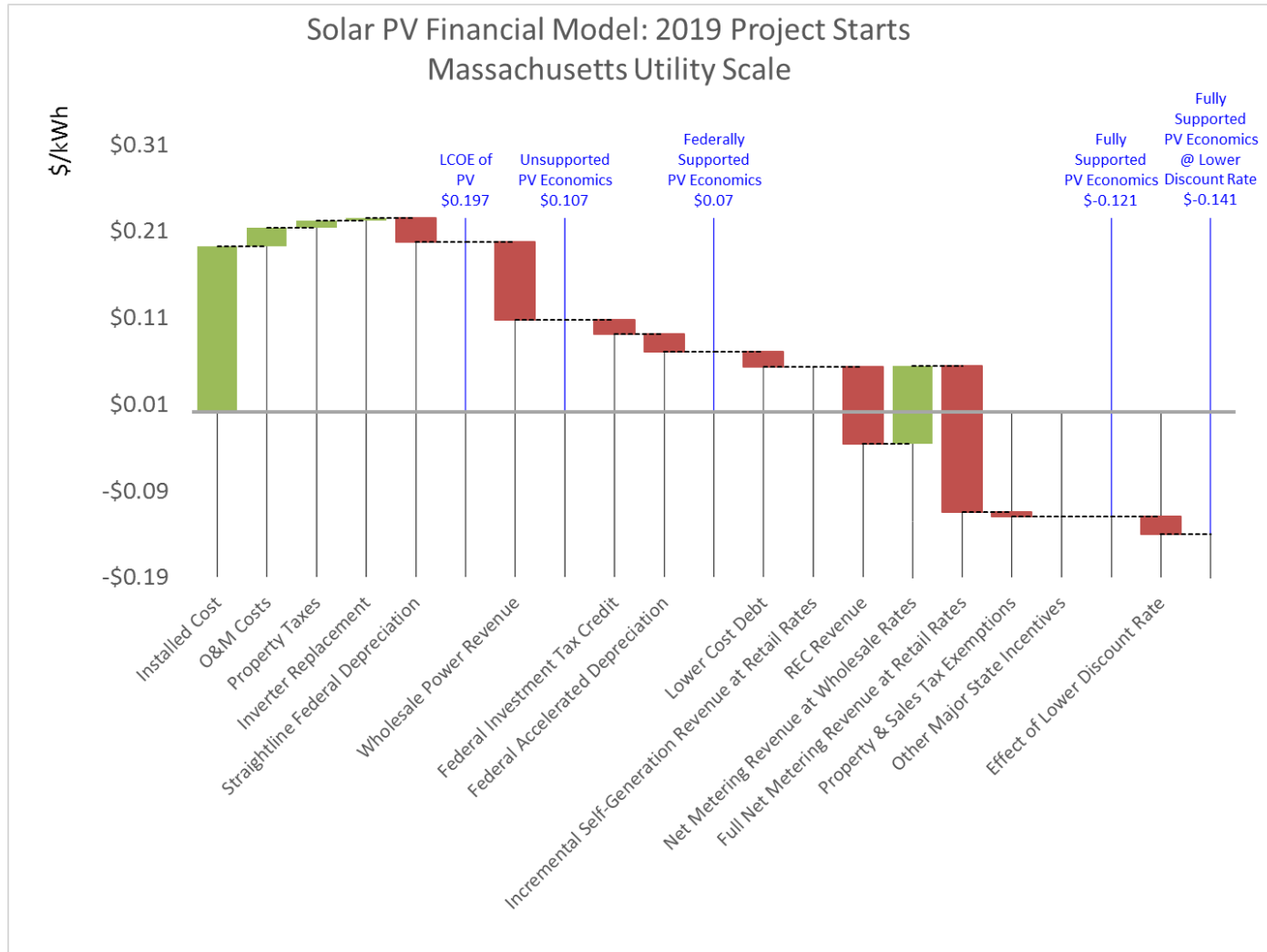
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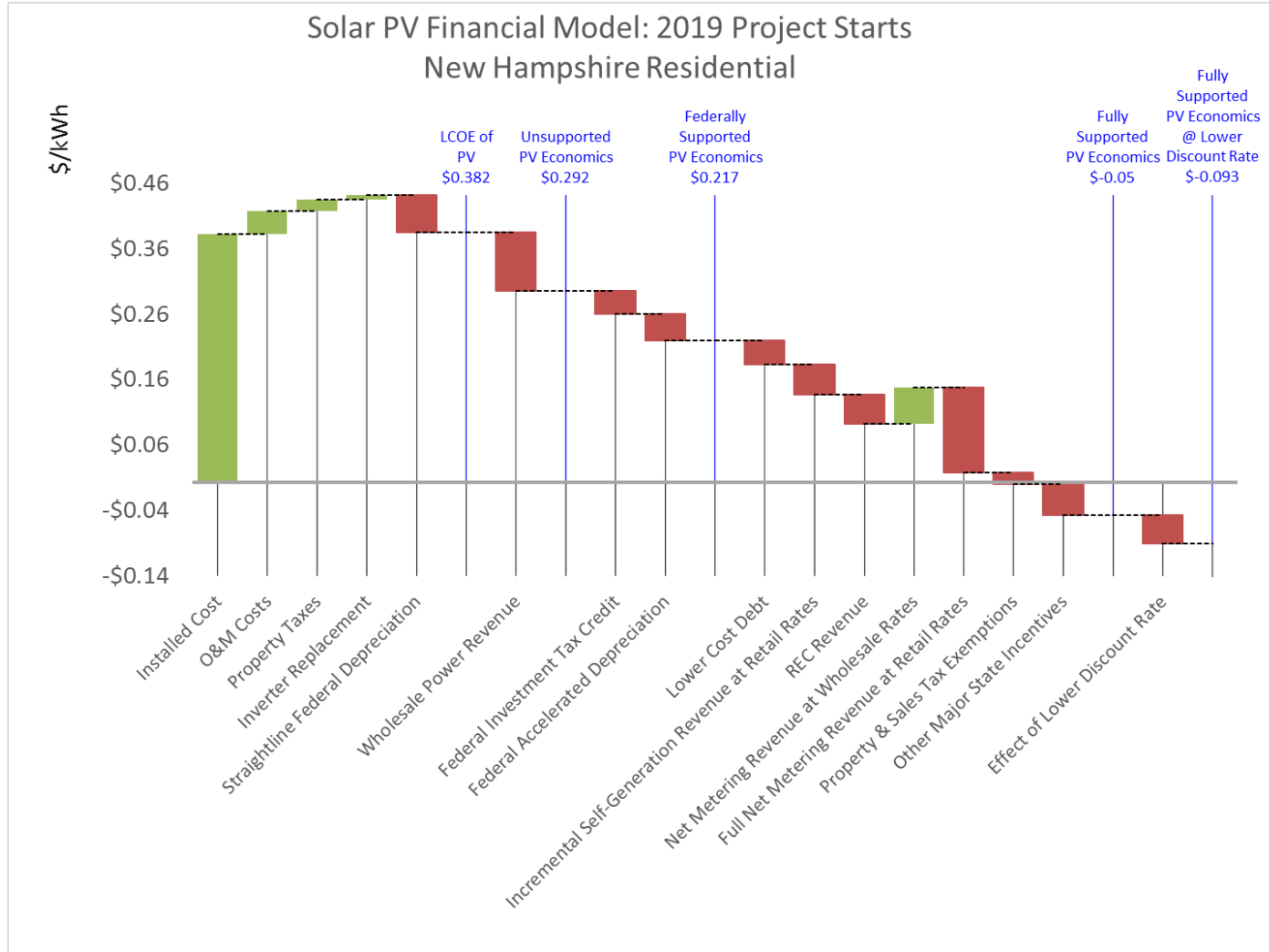
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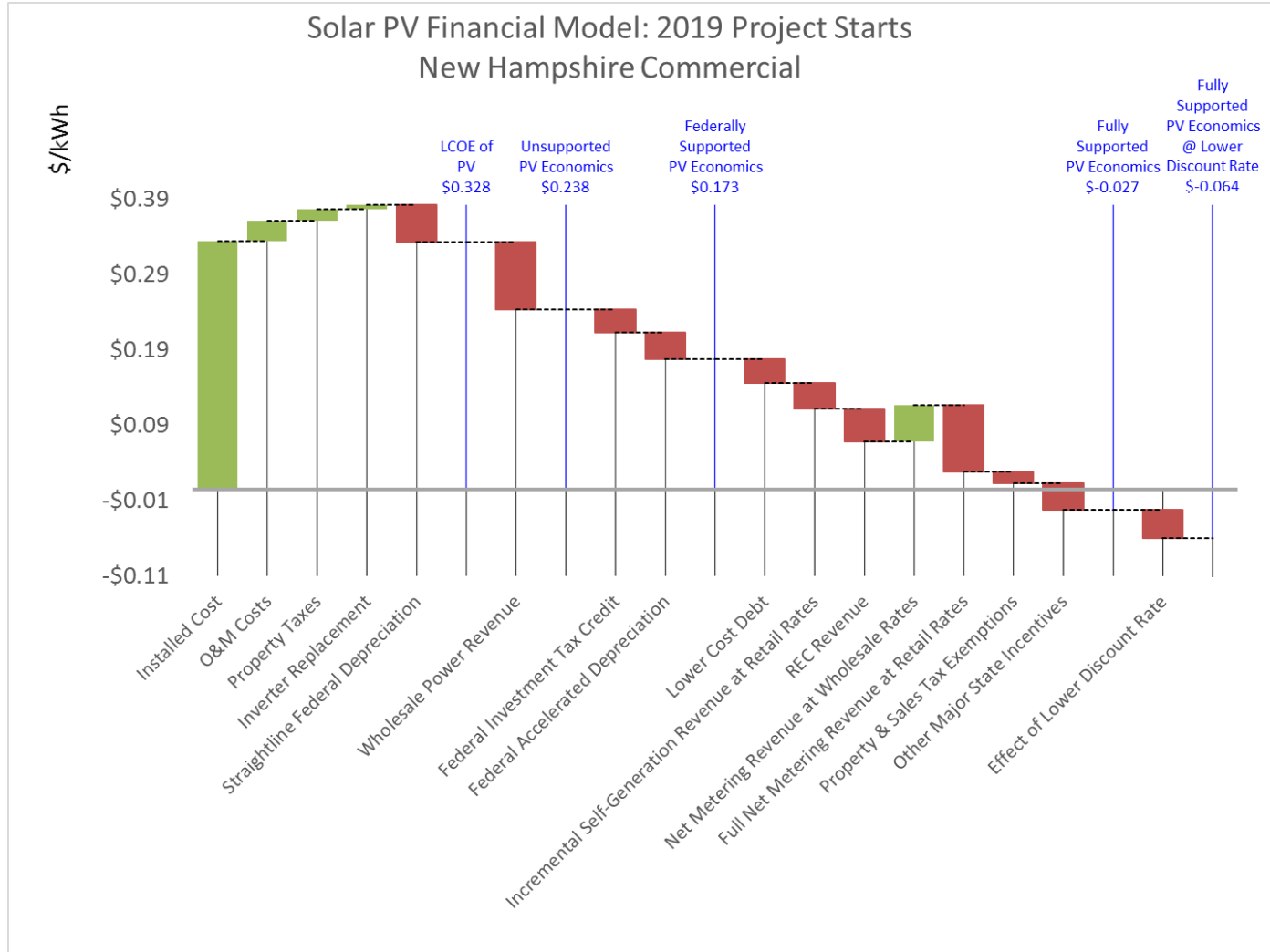
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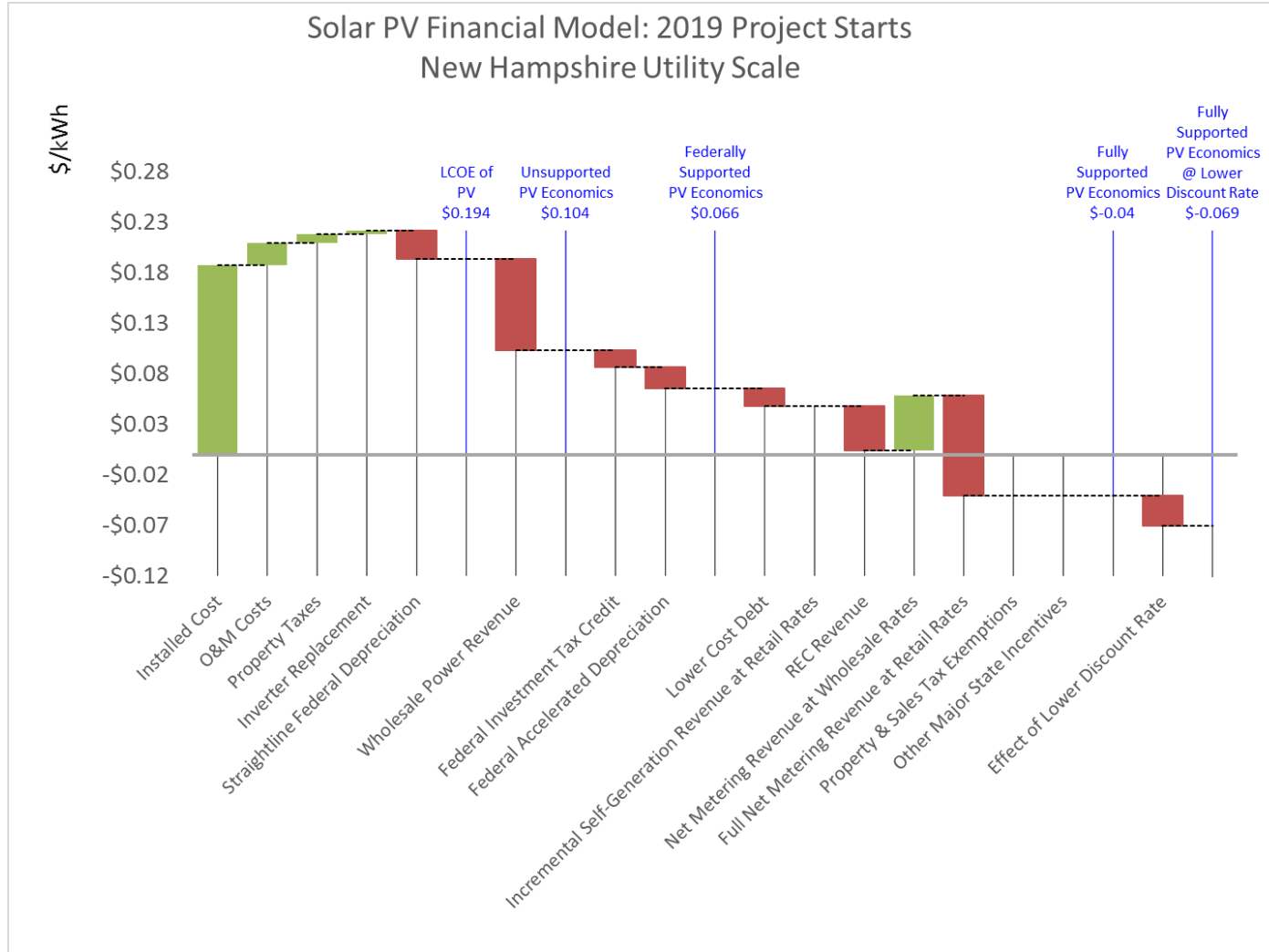
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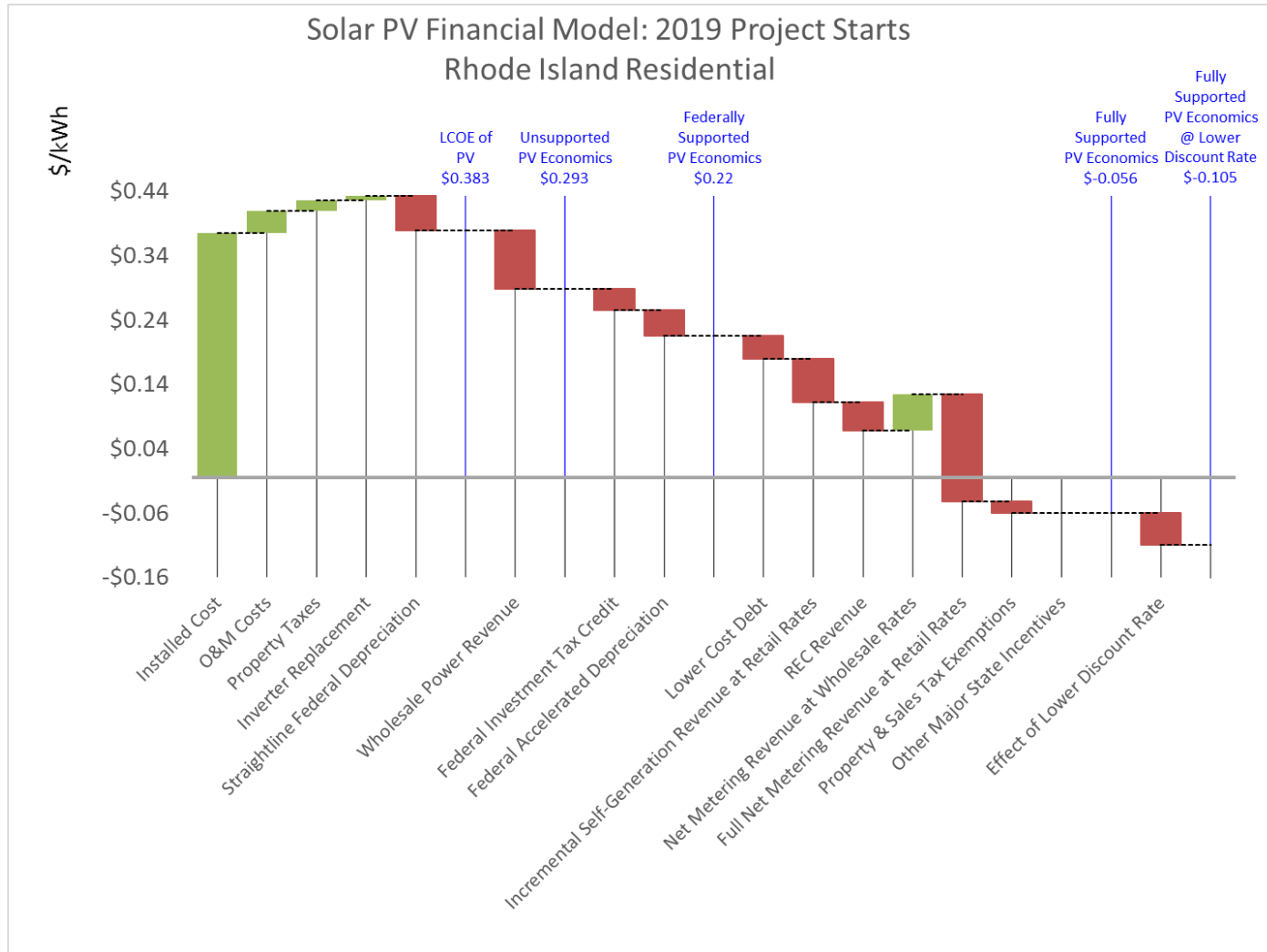
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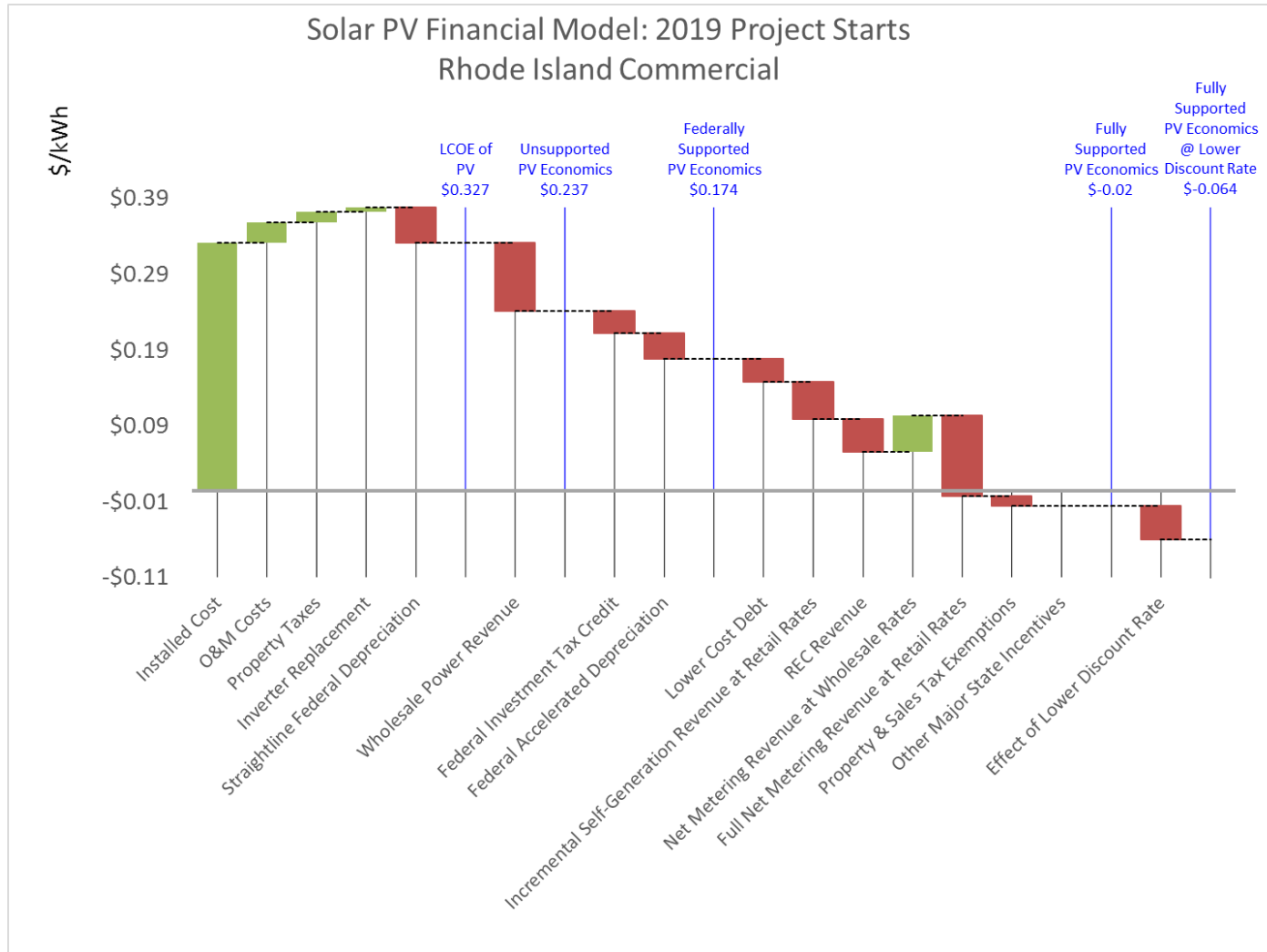
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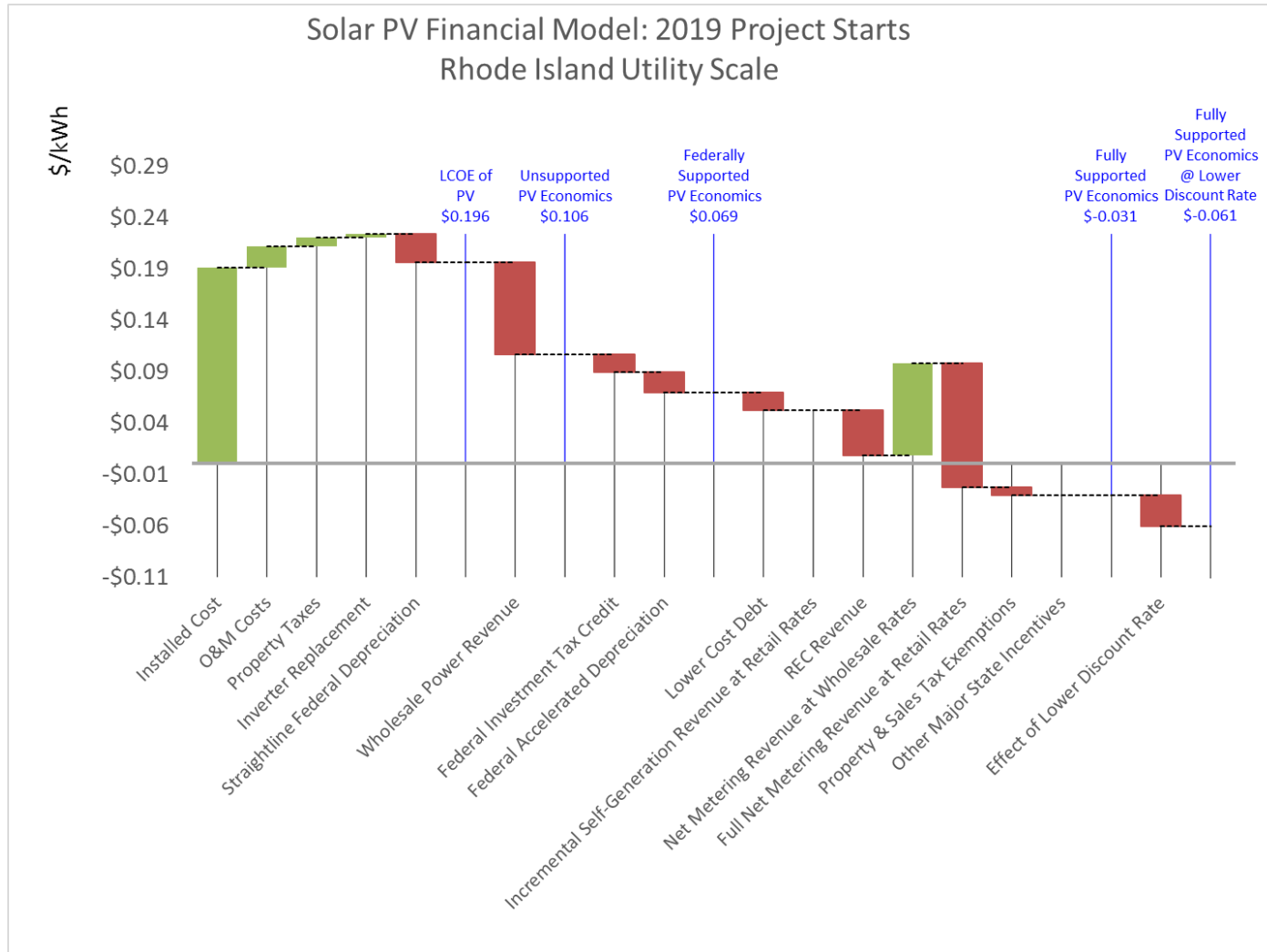
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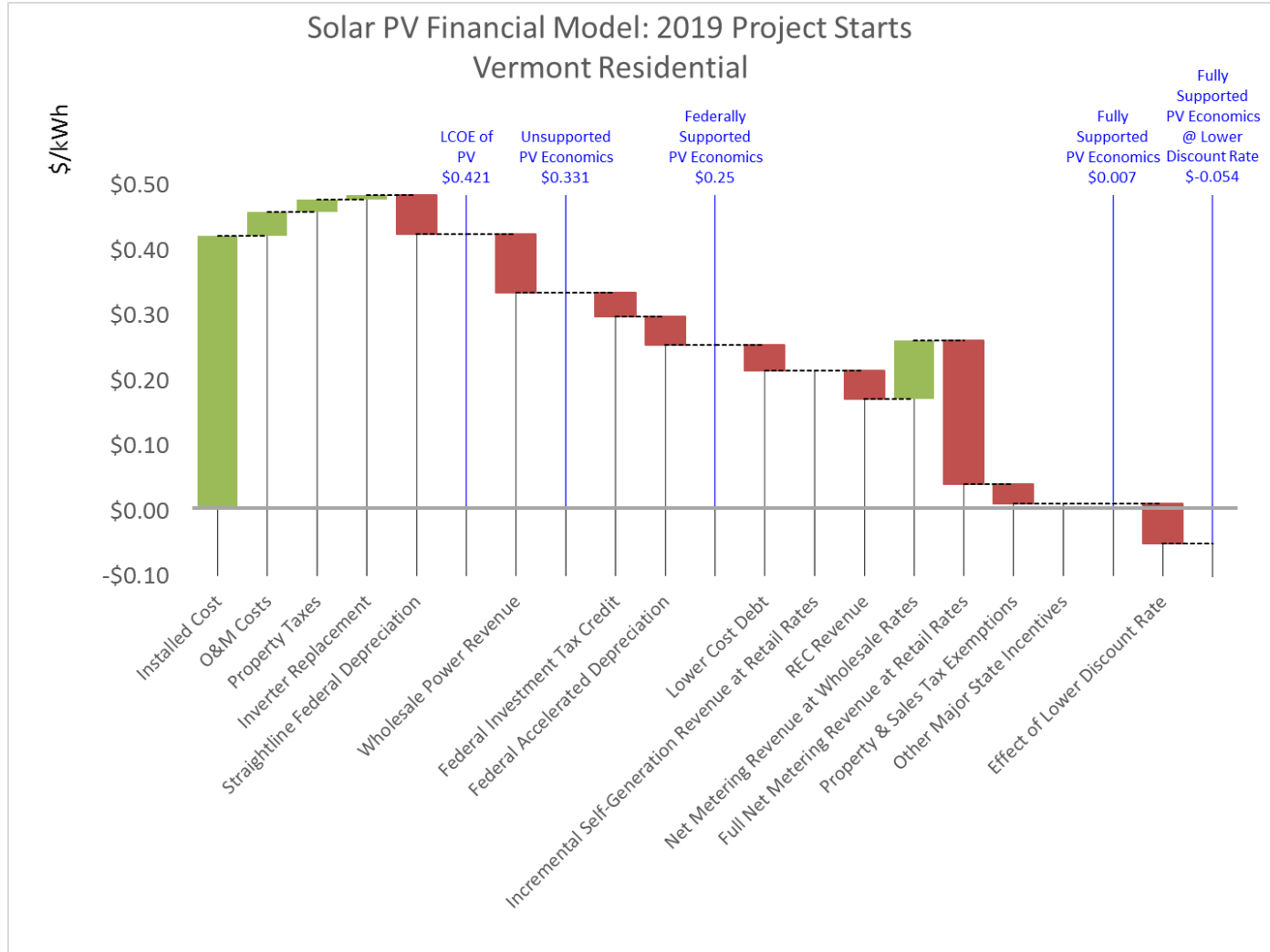
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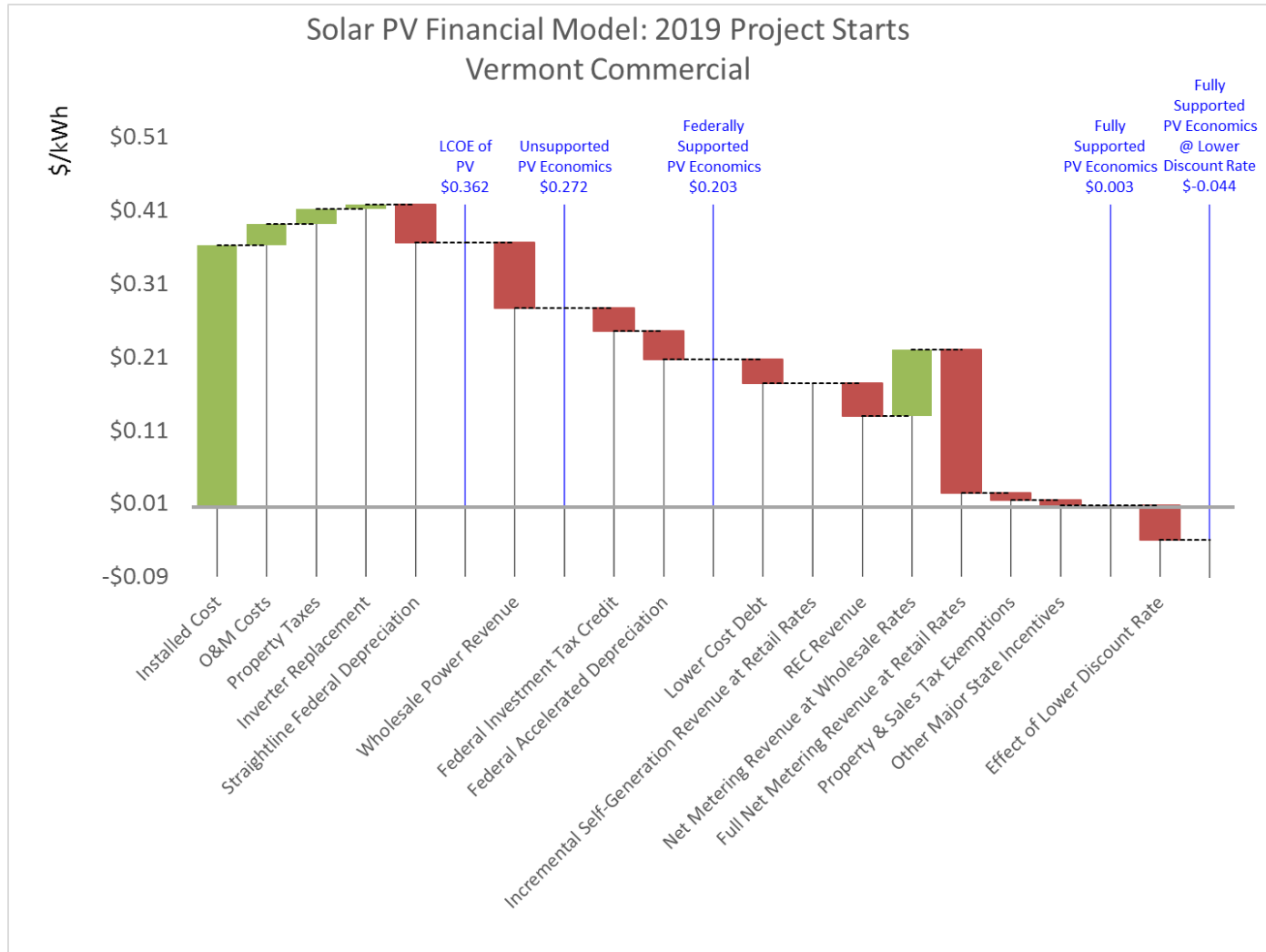
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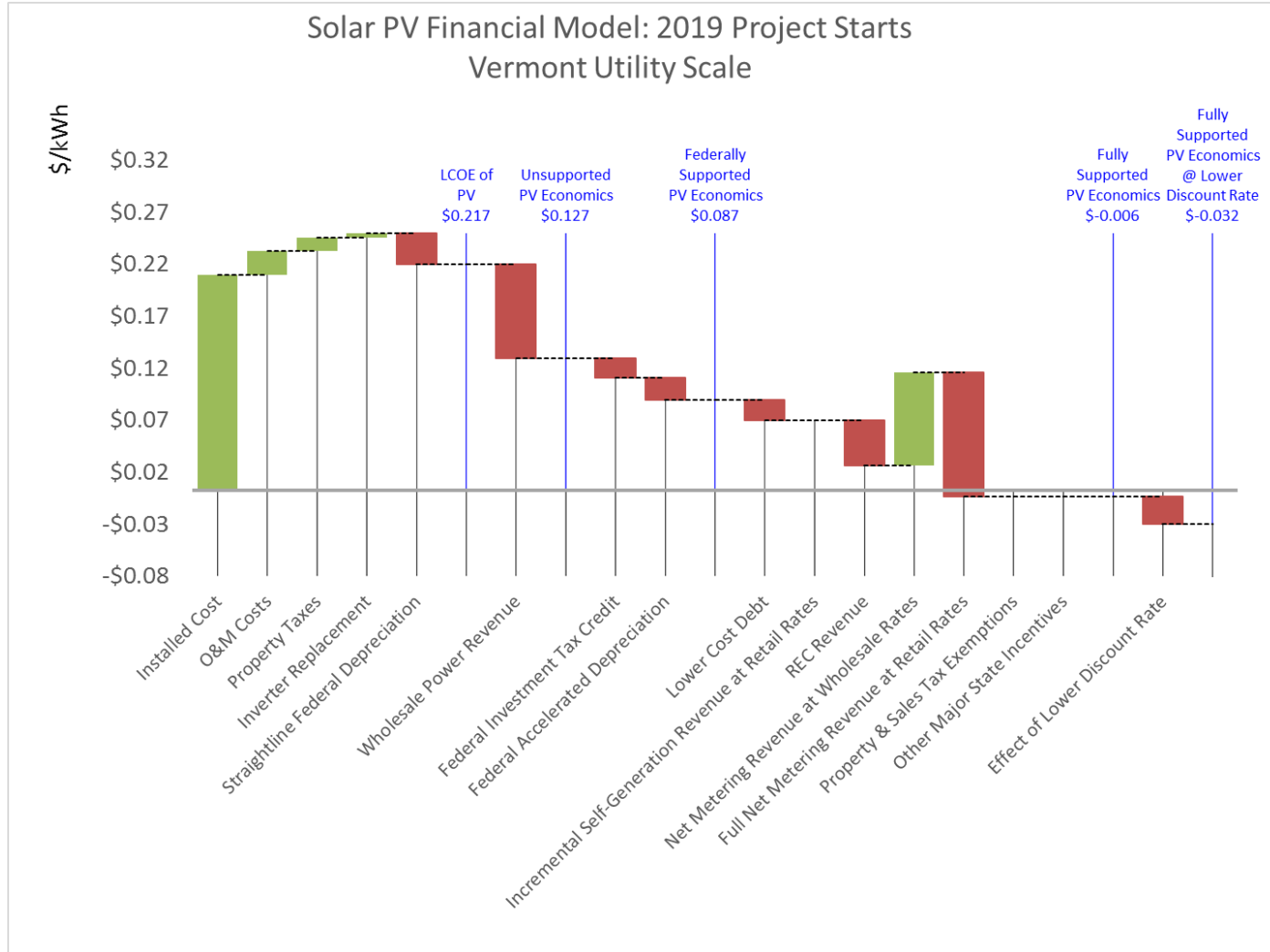
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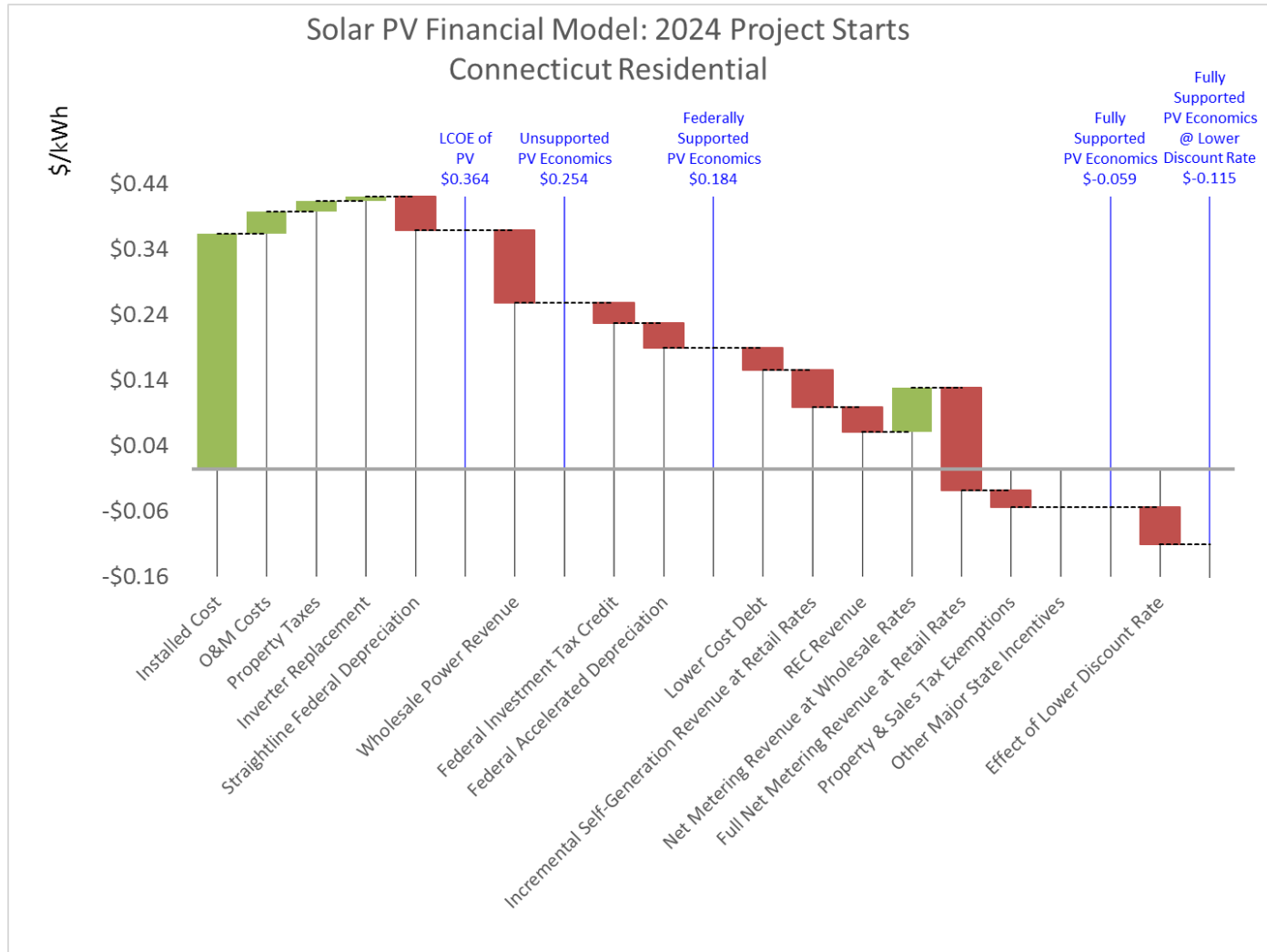
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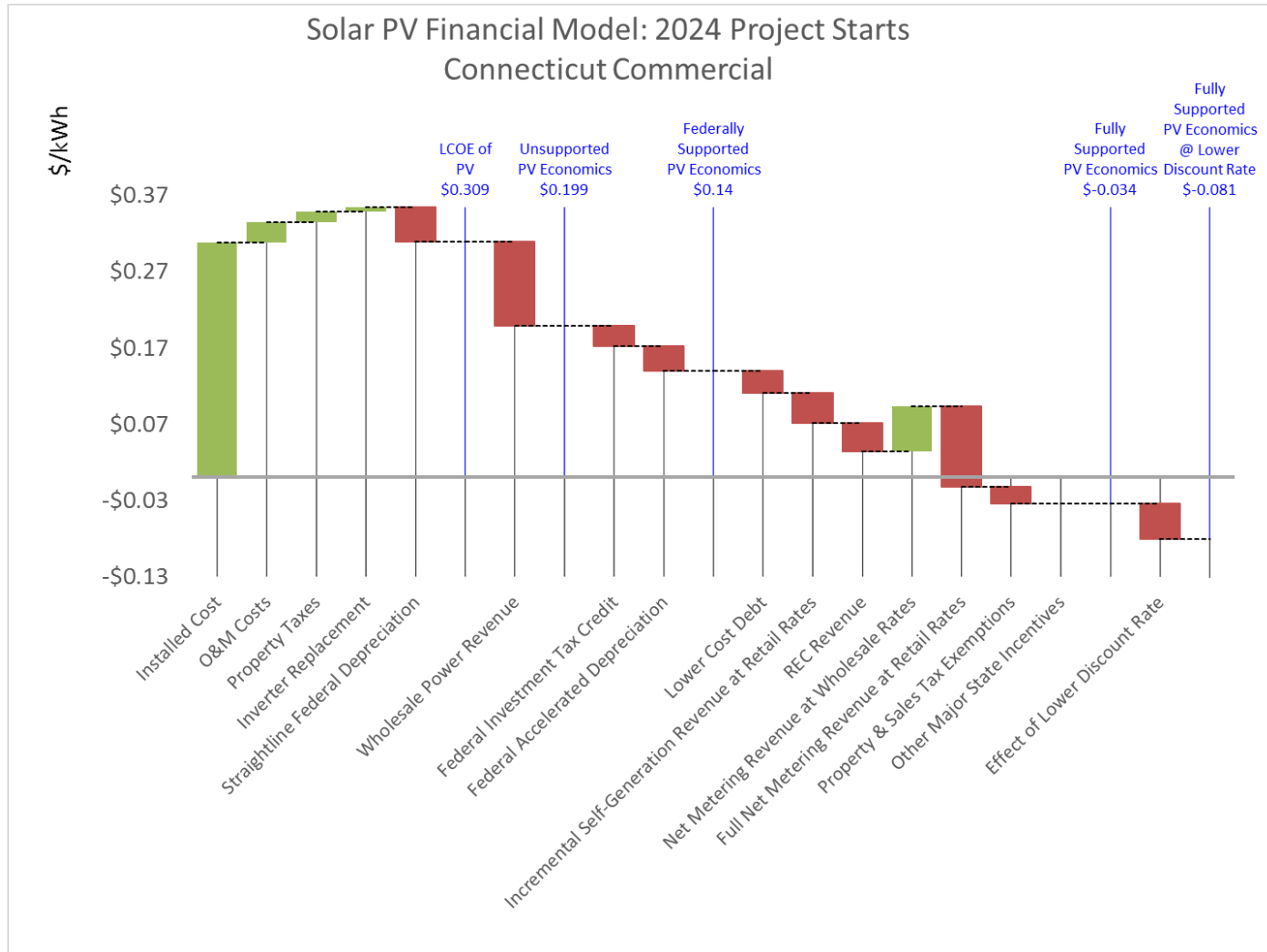
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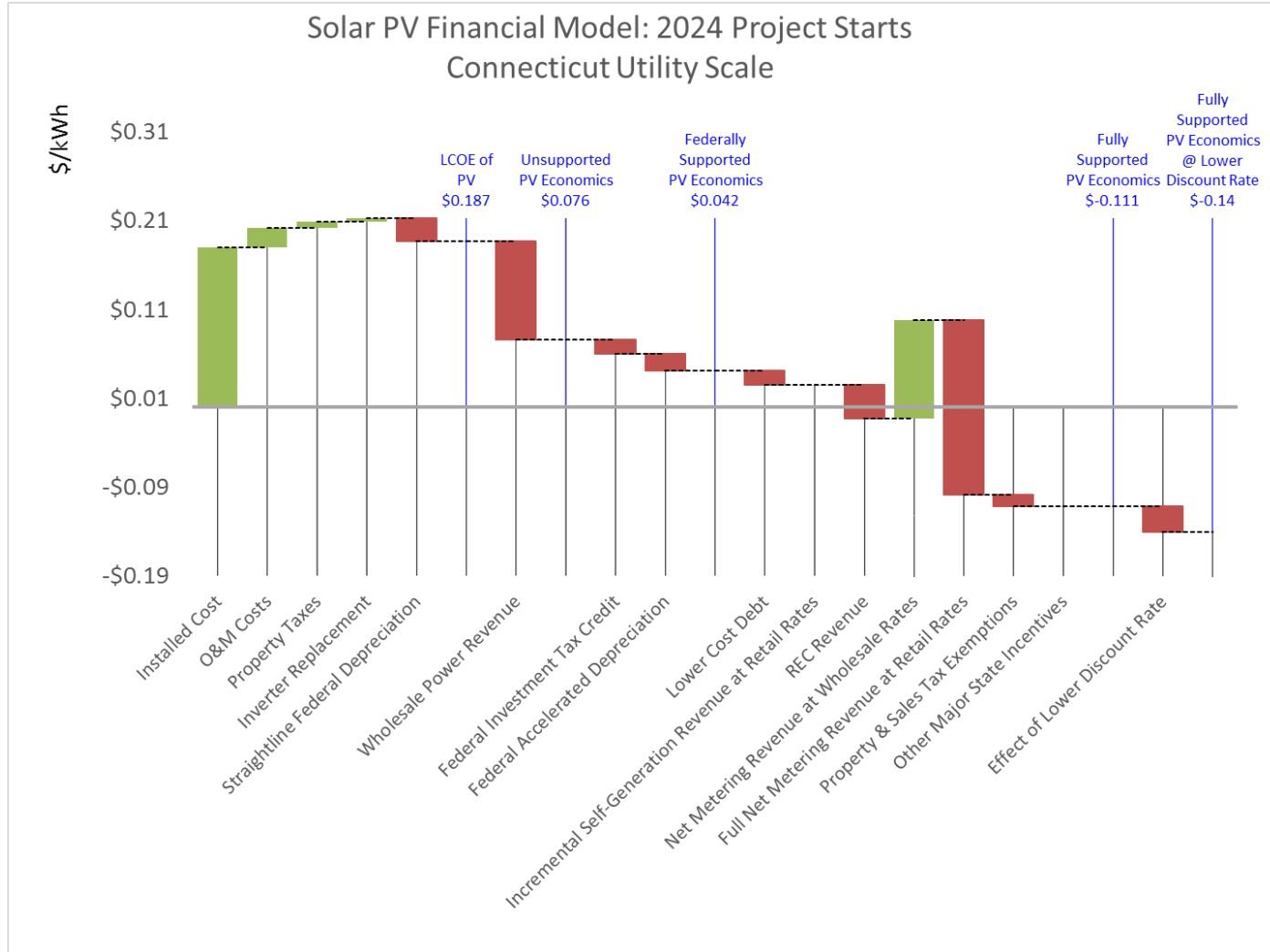
Results: Connecticut Residential, 2024 Project Starts



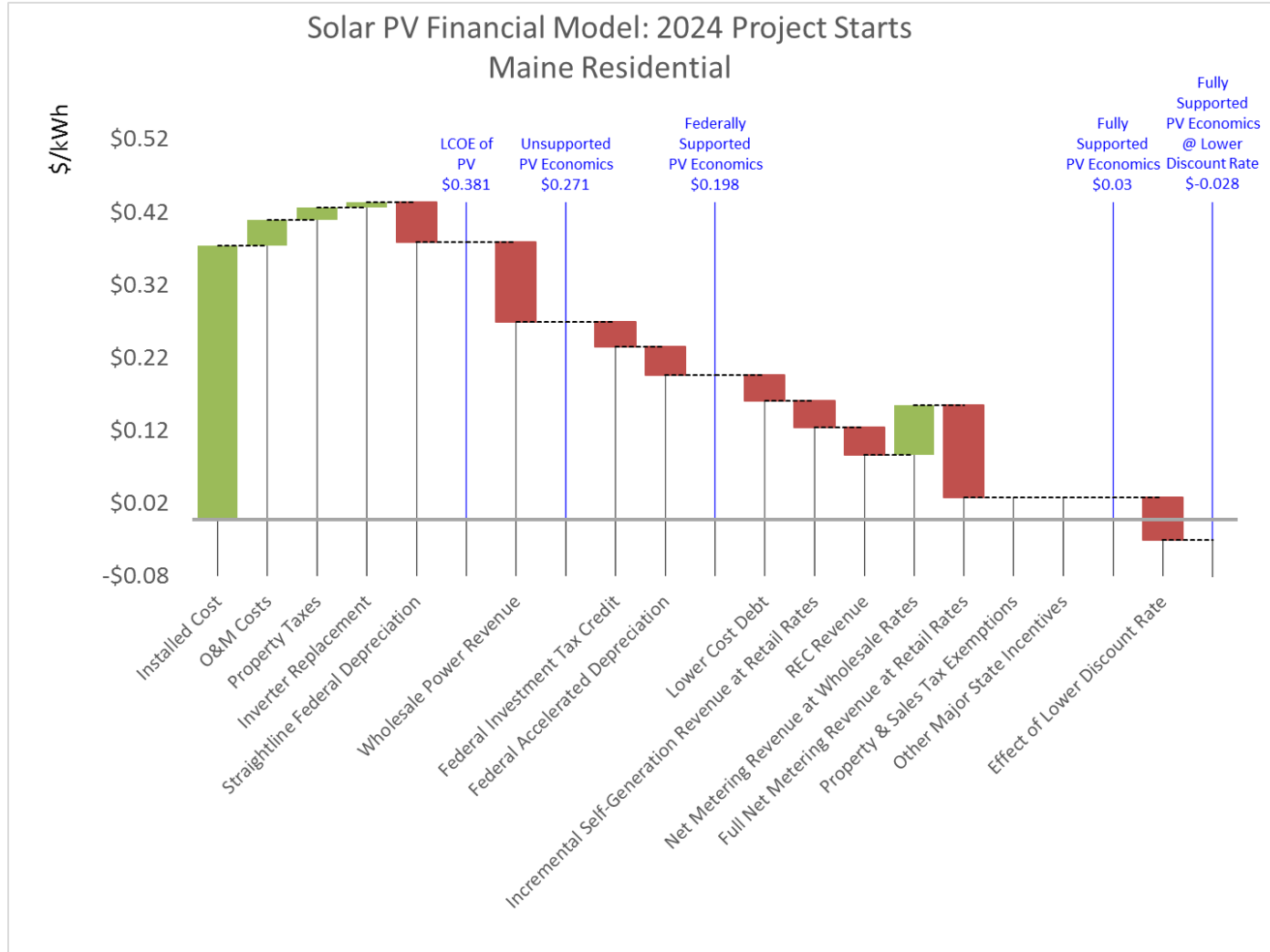
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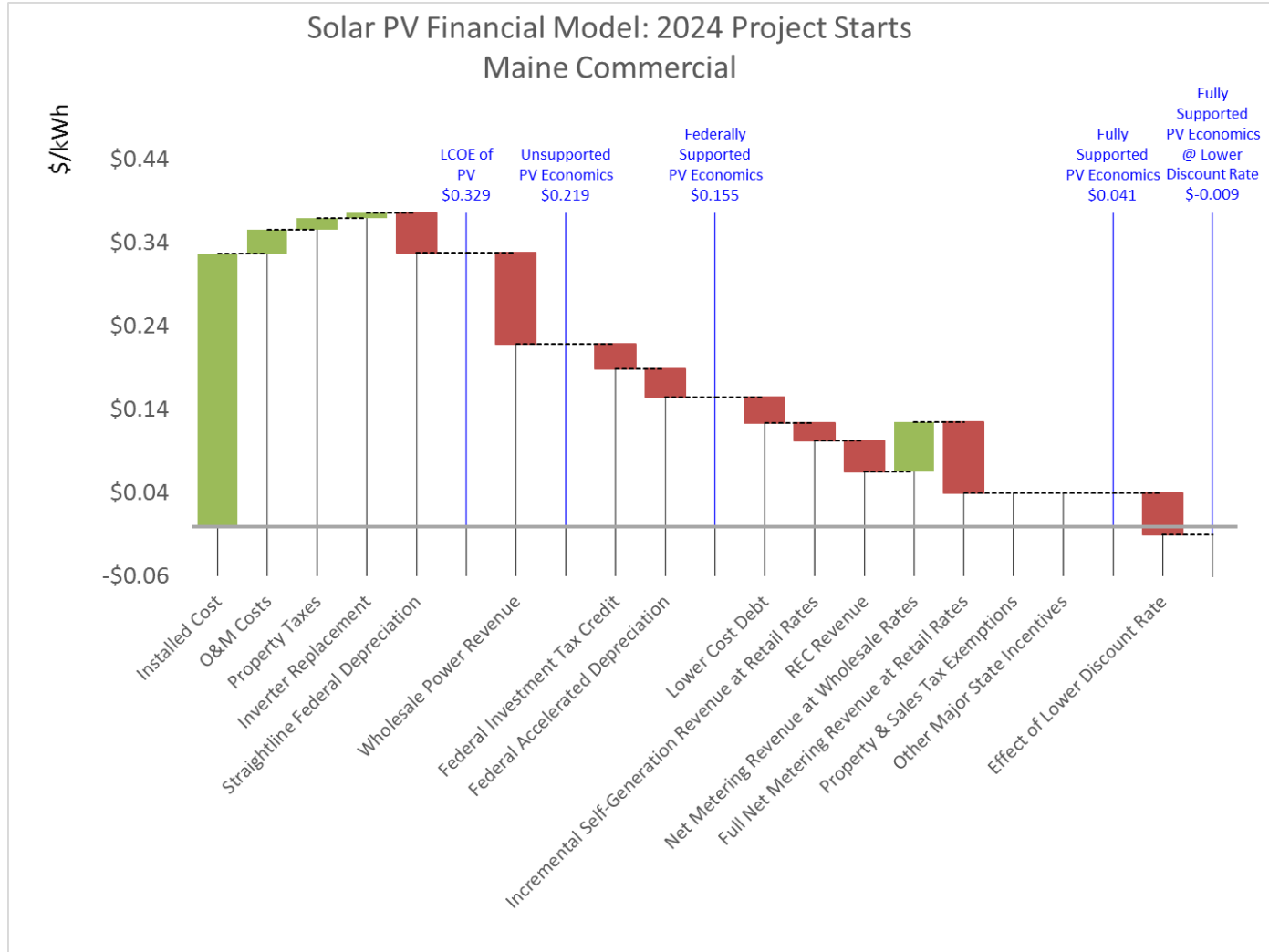
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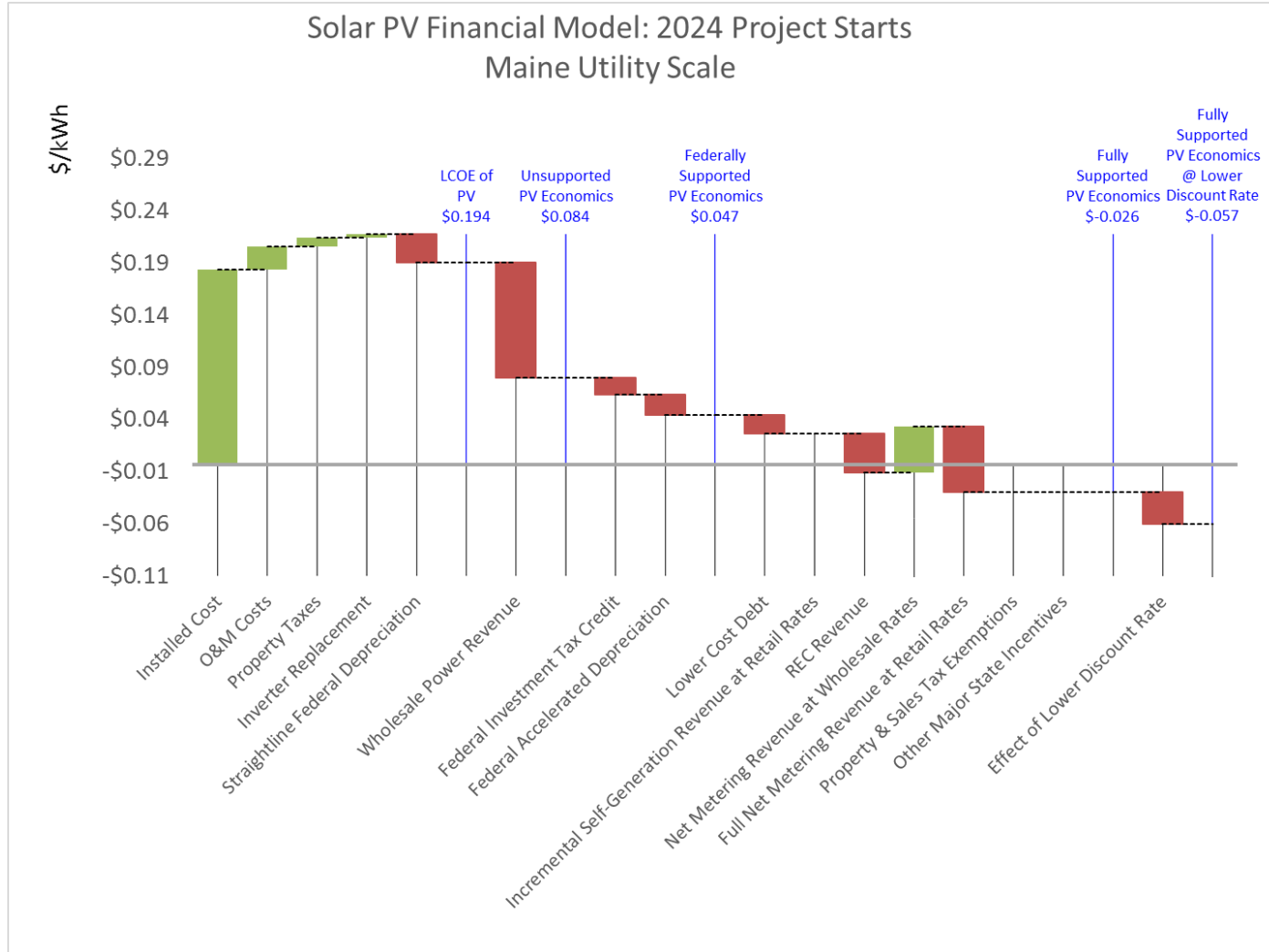
Results: Maine Residential, 2024 Project Starts



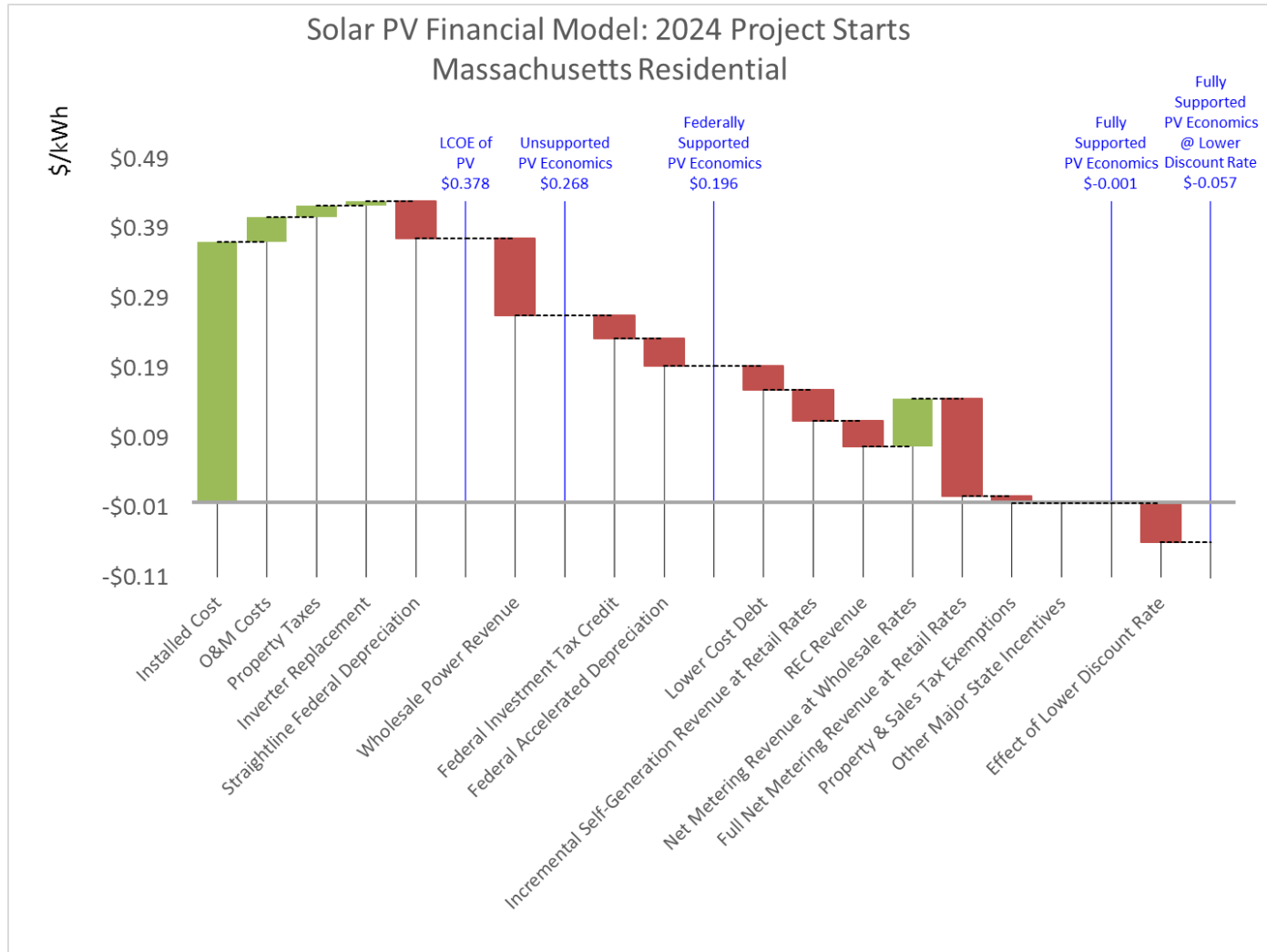
Results: Maine Commercial, 2024 Project Starts



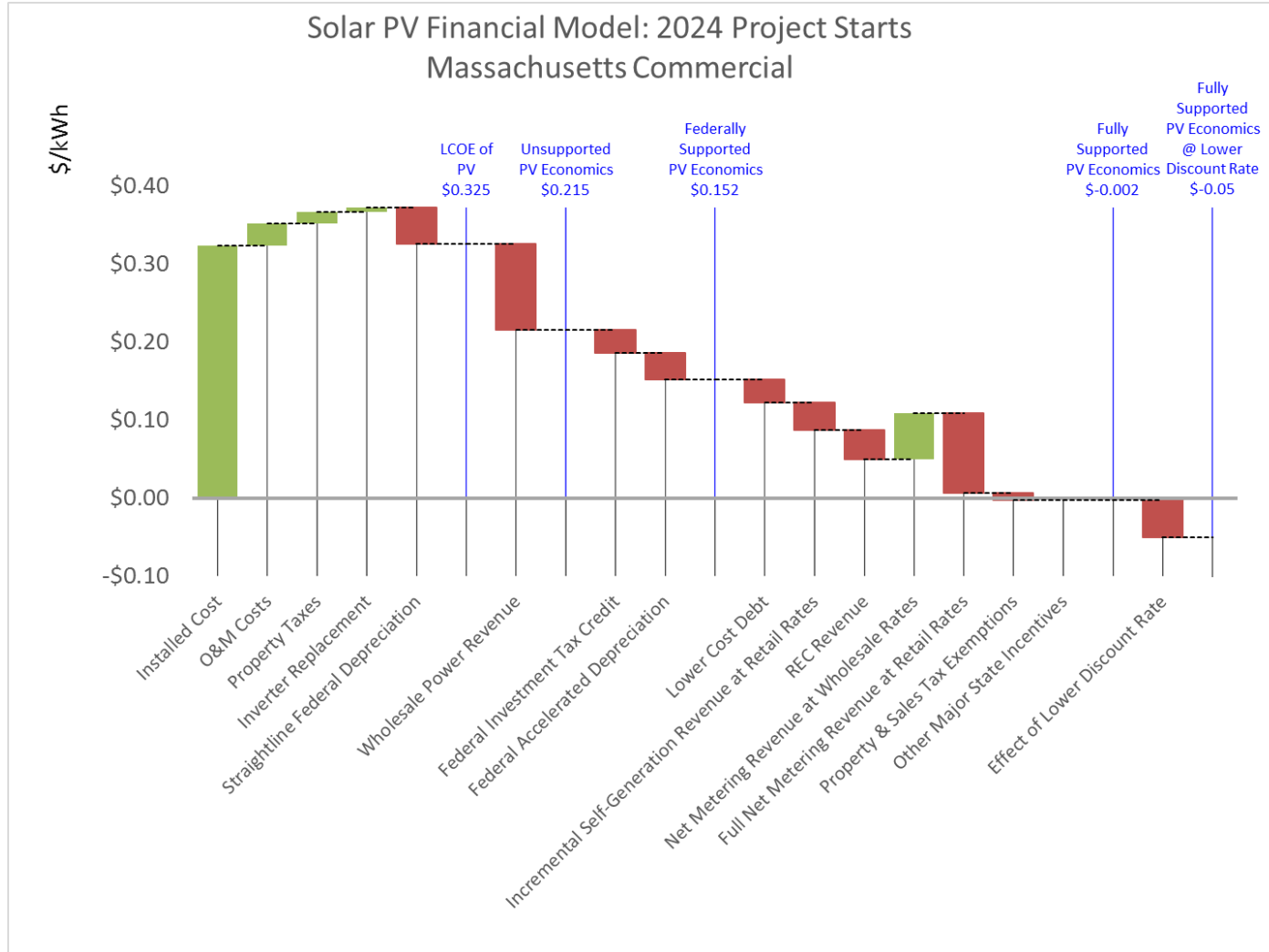
Results: Maine Utility Scale, 2024 Project Starts



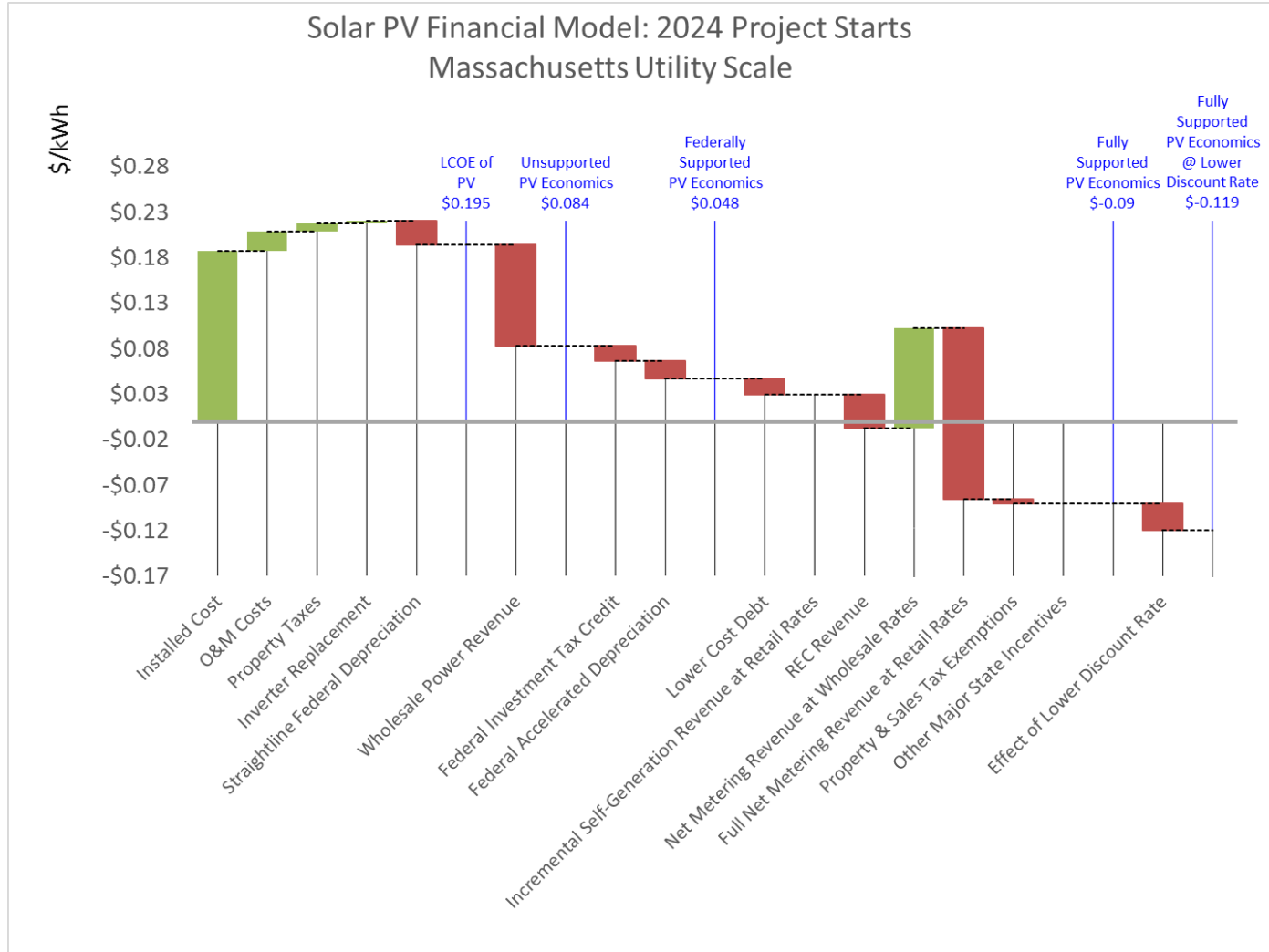
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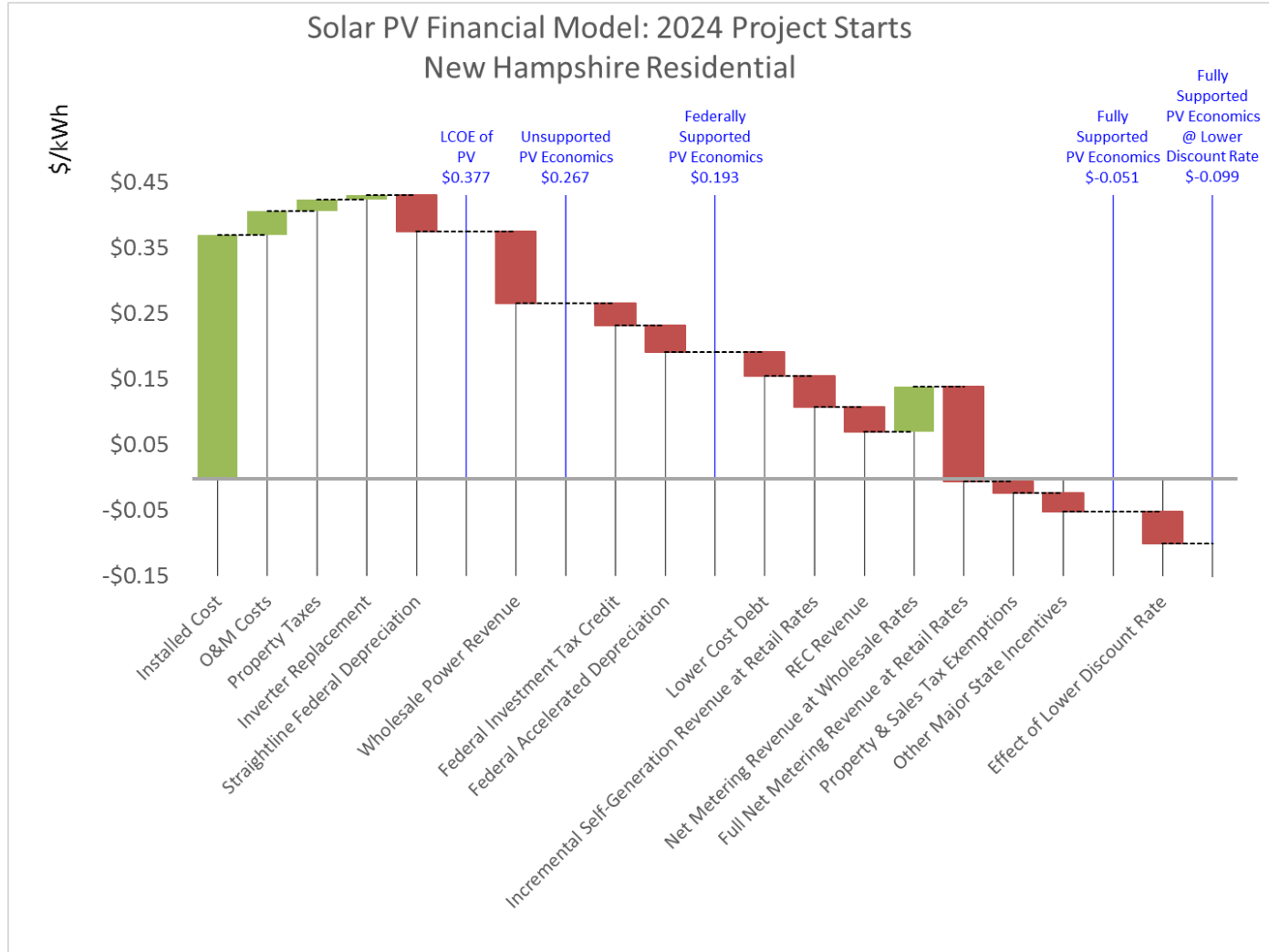
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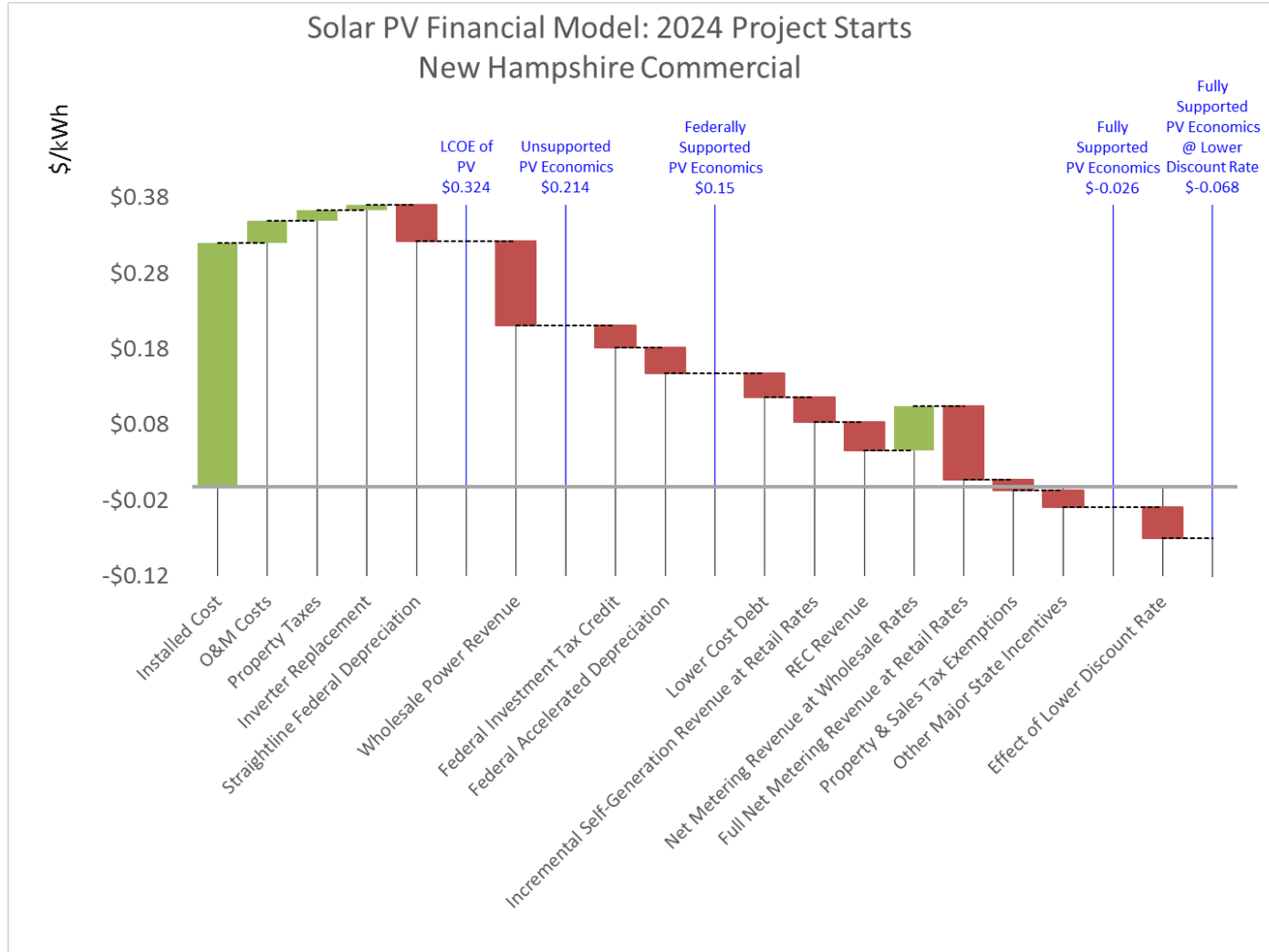
Results: Massachusetts Utility Scale, 2024 Project Starts



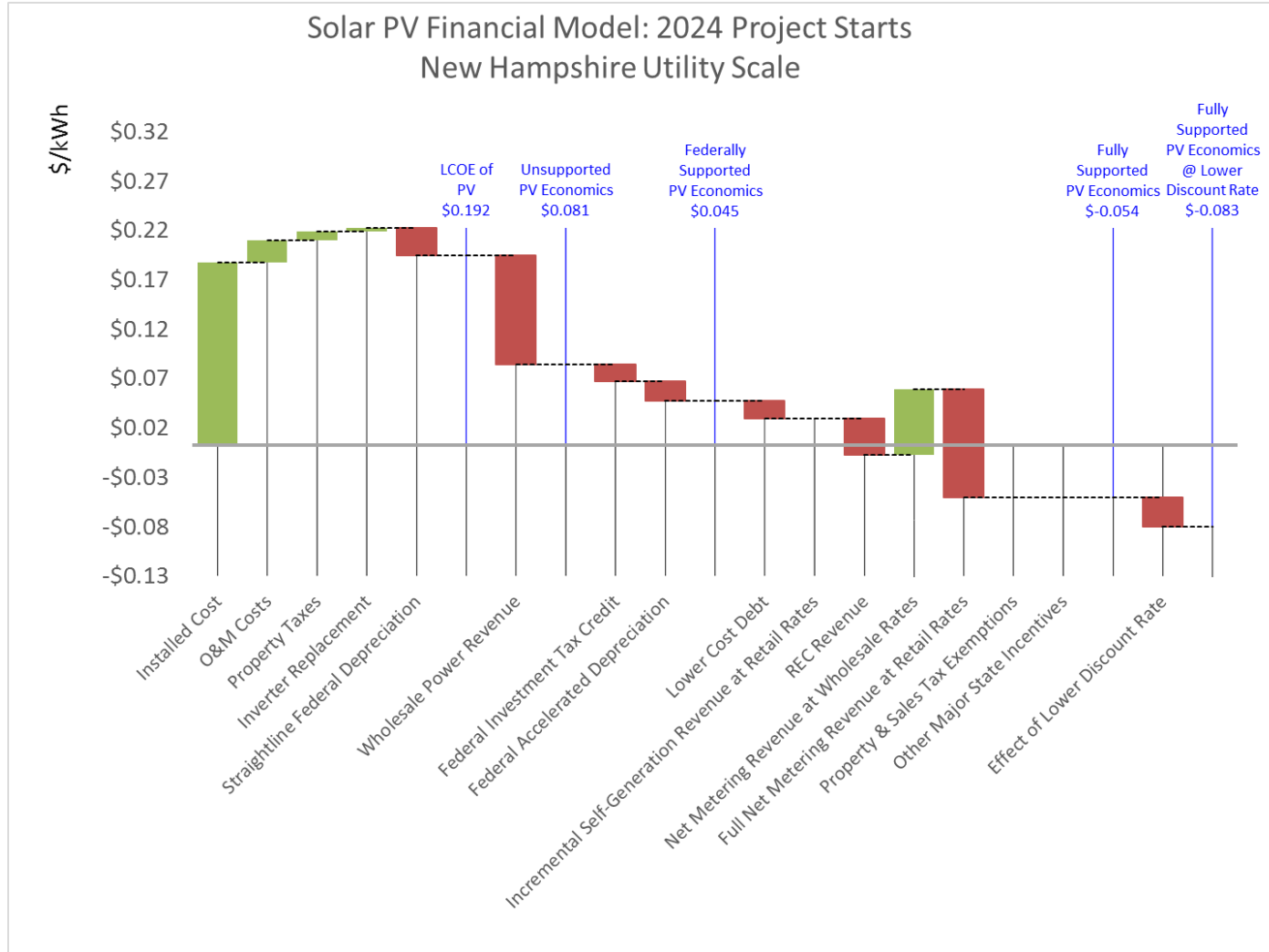
Results: New Hampshire Residential, 2024 Project Starts



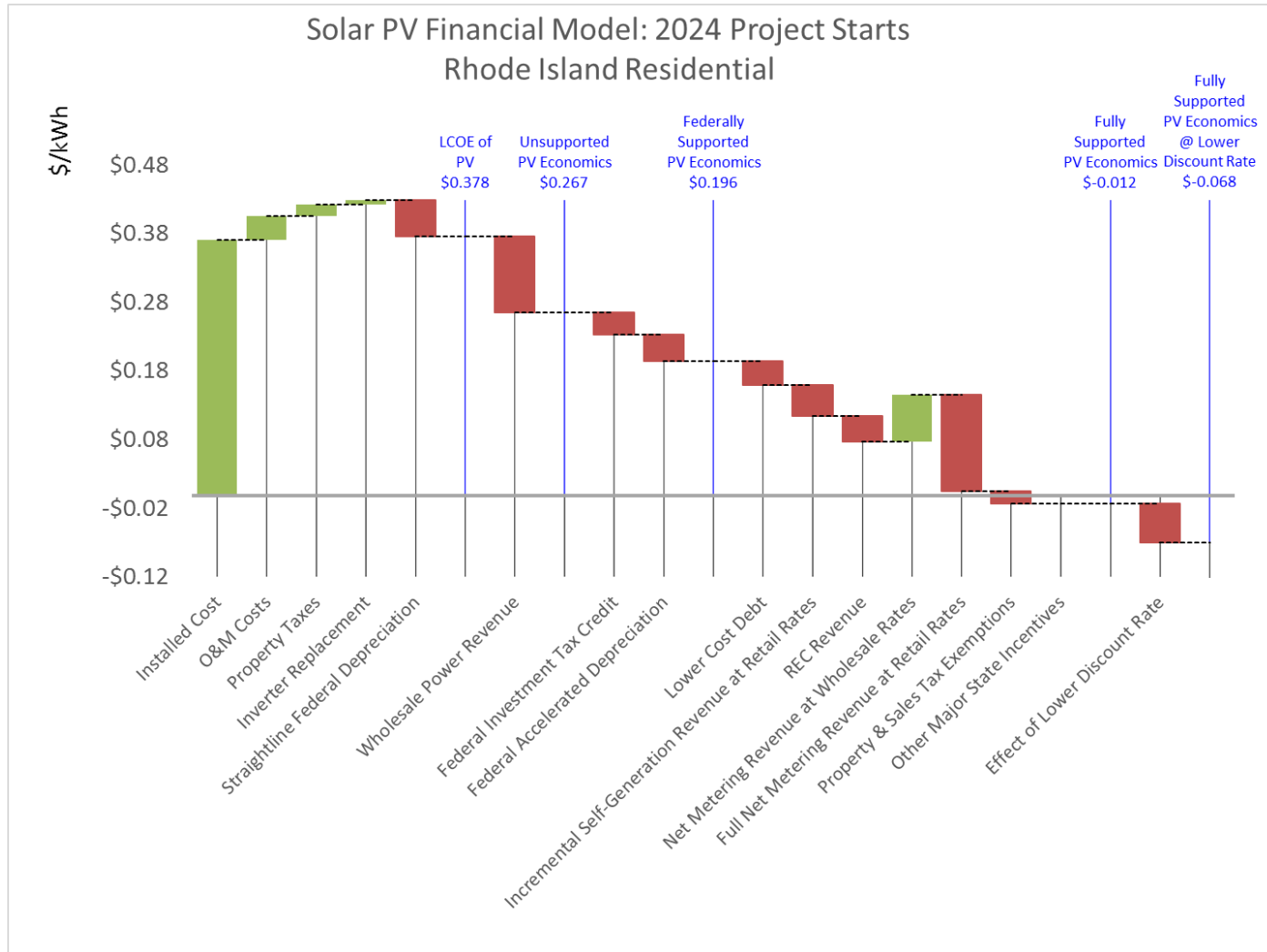
Results: New Hampshire Commercial, 2024 Project Starts



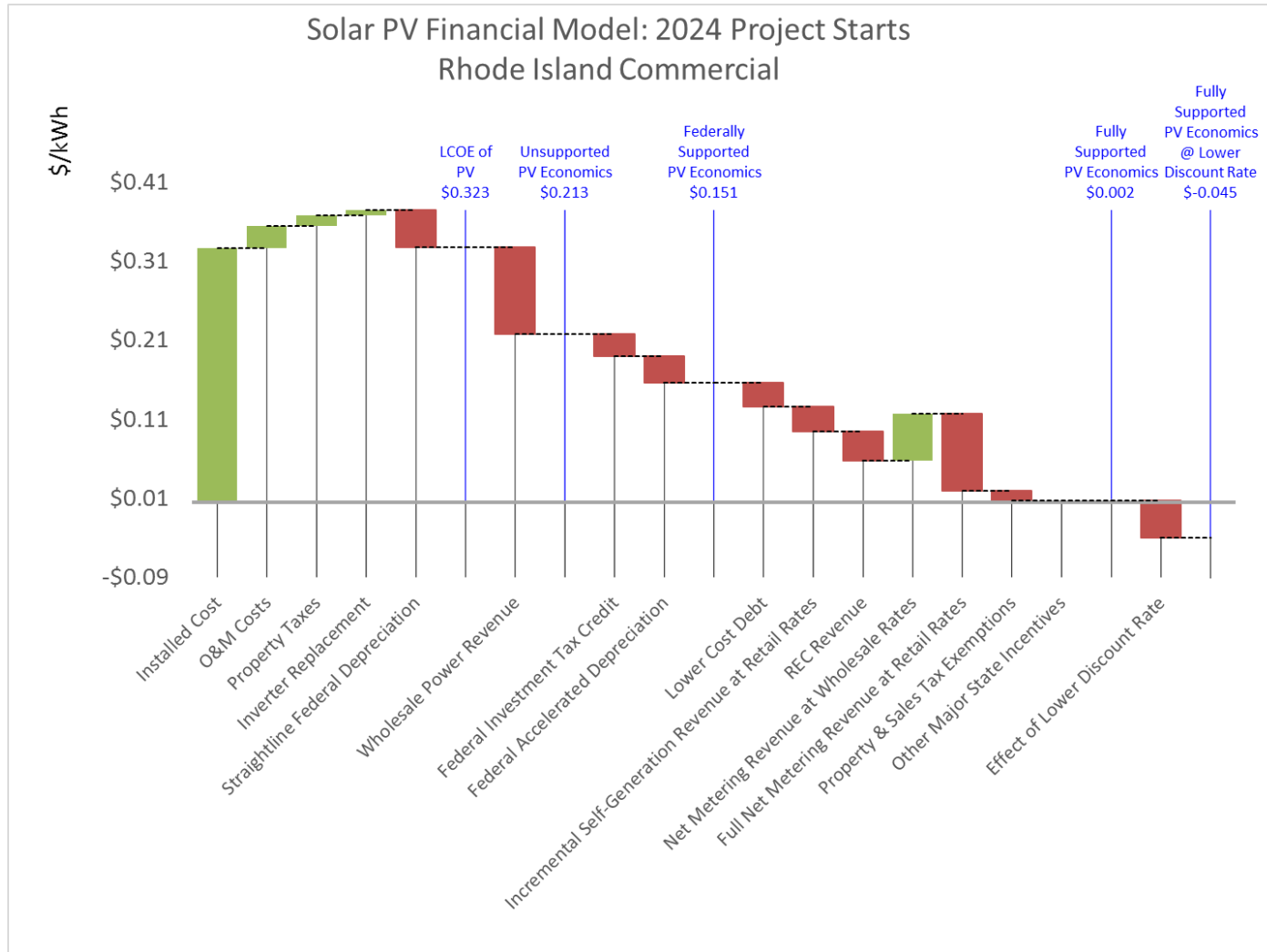
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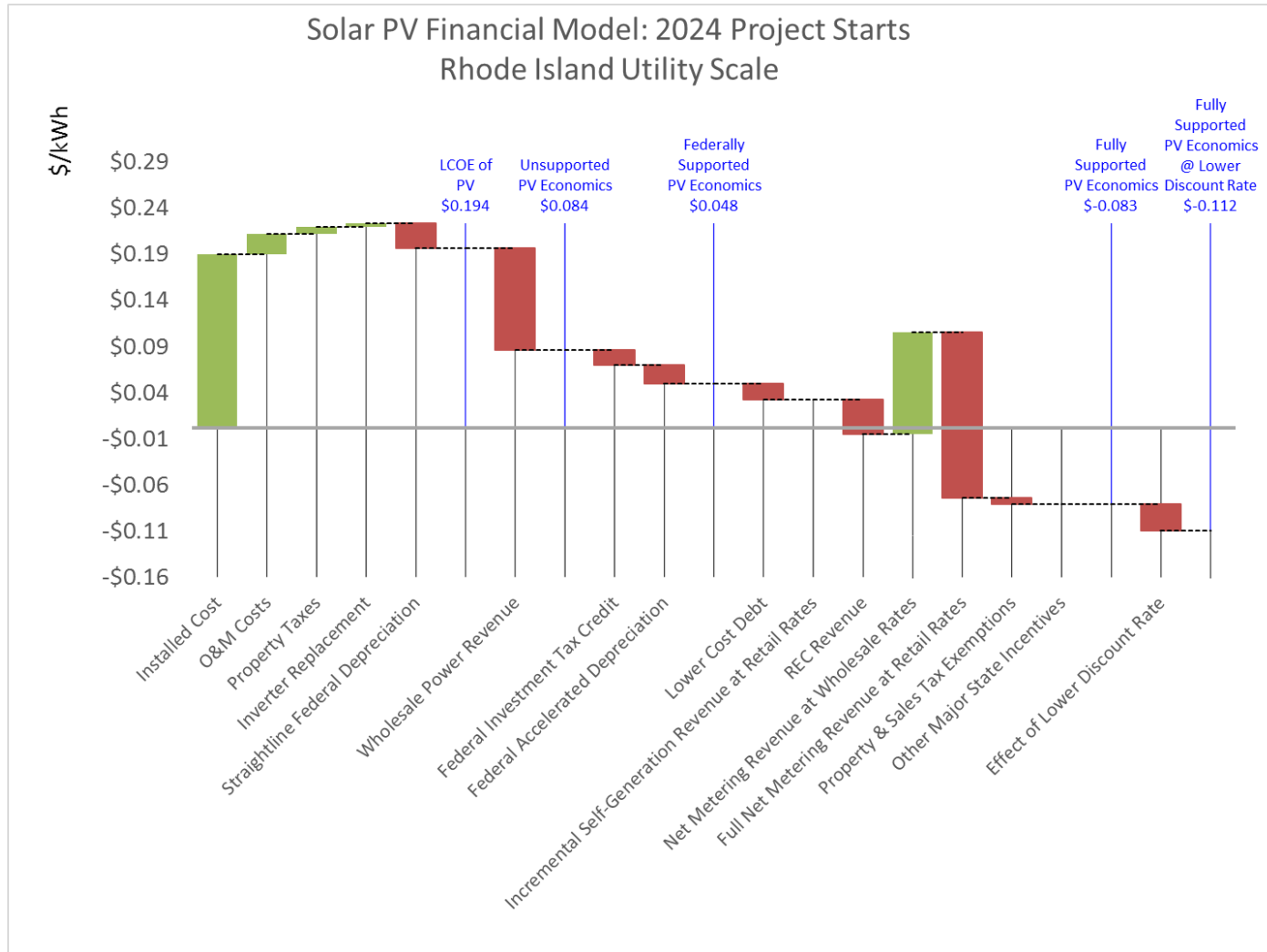
Results: Rhode Island Residential, 2024 Project Starts



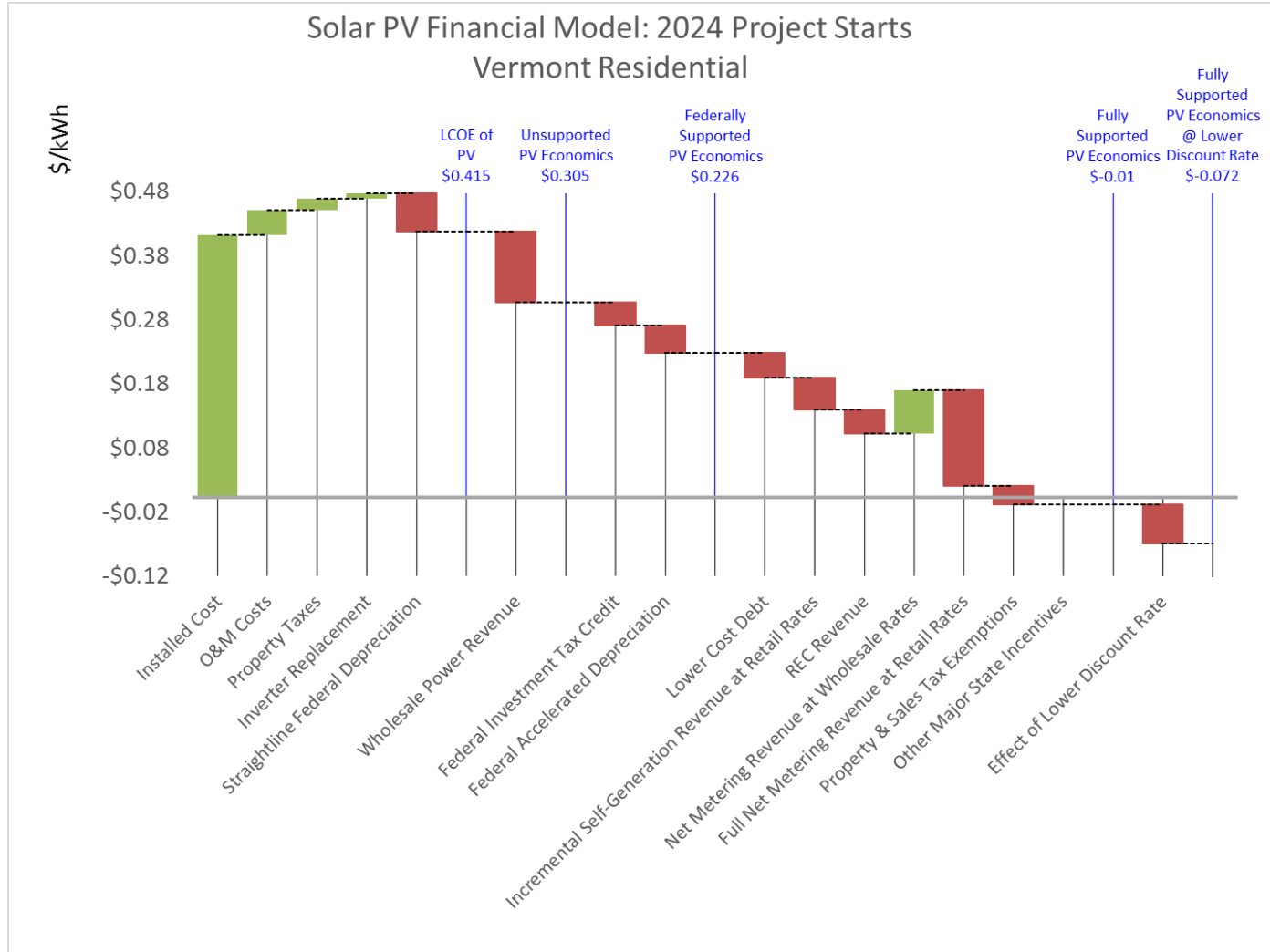
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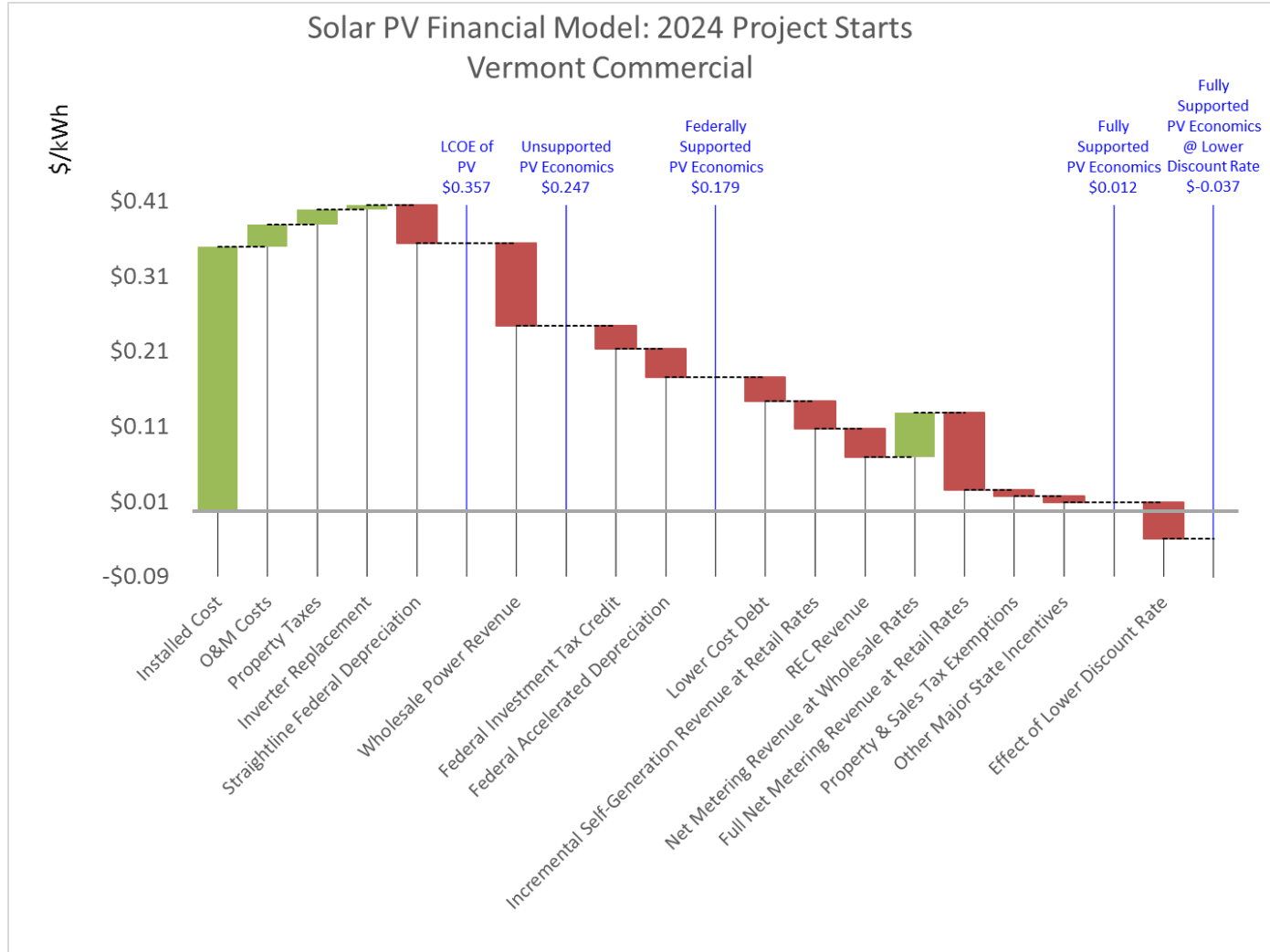
Results: Rhode Island Utility Scale, 2024 Project Starts



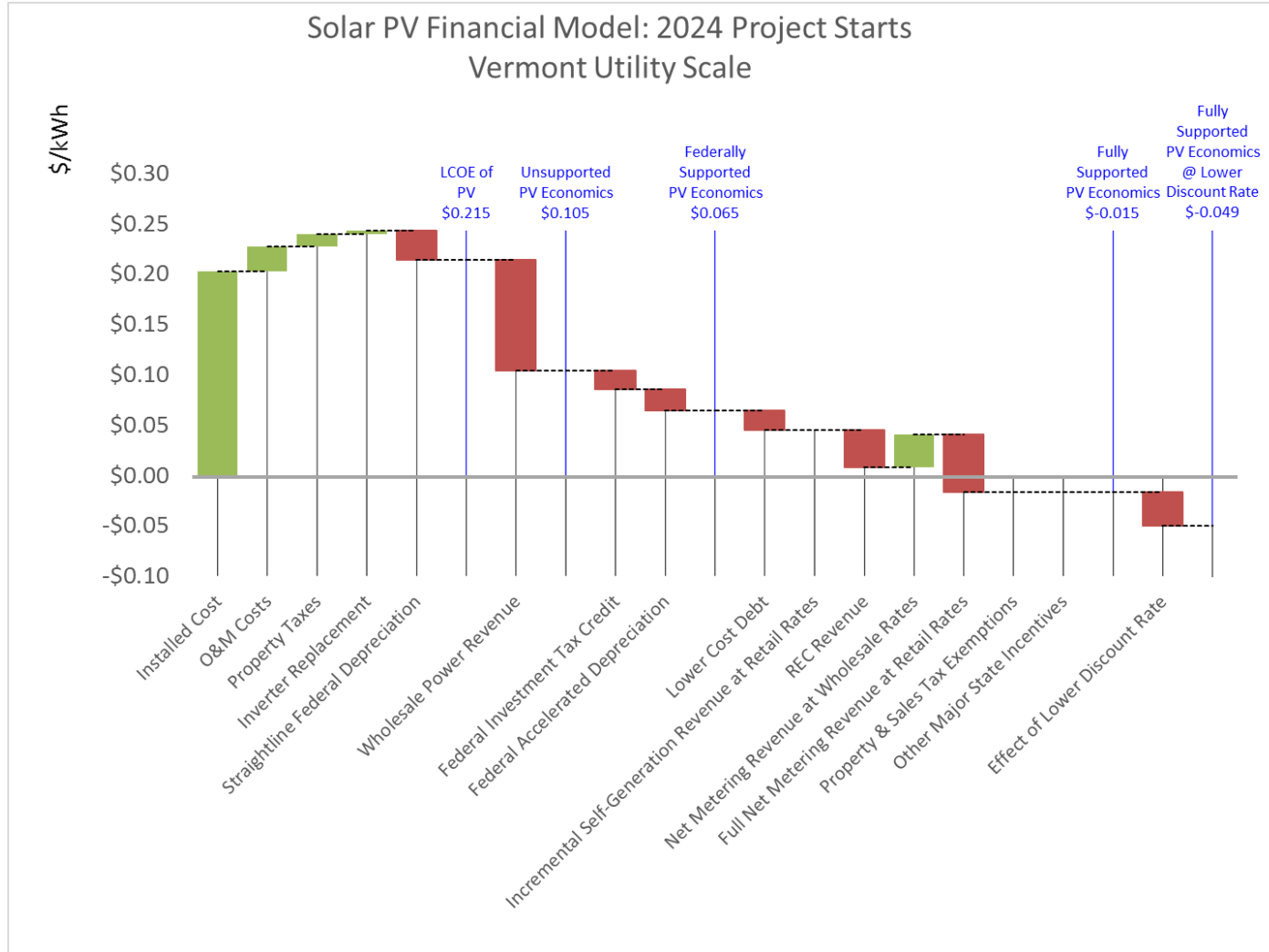
Results: Vermont Residential, 2024 Project Starts



Results: Vermont Commercial, 2024 Project Starts



Results: Vermont Utility Scale, 2024 Project Starts



Appendix: Alternative Scenario Results

(presented when different than baseline)

Table of Results: 2019 Project Starts



Alternative Scenario 1: Selected State Incentives Remain at 2015 Levels

(Data below in \$/kWh)

State =>	CT	CT	NH	NH	RI	RI	RI	VT	VT	VT
Customer Type =>	Residential	Commercial	Residential	Commercial	Residential	Commercial	Utility Scale	Residential	Commercial	Utility Scale
Installed Cost	\$0.366	\$0.314	\$0.379	\$0.329	\$0.380	\$0.328	\$0.190	\$0.417	\$0.358	\$0.208
O&M Costs	\$0.033	\$0.025	\$0.035	\$0.027	\$0.034	\$0.026	\$0.021	\$0.037	\$0.029	\$0.023
Property Taxes	\$0.016	\$0.014	\$0.017	\$0.015	\$0.017	\$0.014	\$0.008	\$0.018	\$0.020	\$0.013
Inverter Replacement	\$0.007	\$0.006	\$0.007	\$0.006	\$0.007	\$0.006	\$0.004	\$0.008	\$0.007	\$0.004
Straightline Federal Depreciation	(\$0.053)	(\$0.045)	(\$0.056)	(\$0.049)	(\$0.055)	(\$0.047)	(\$0.027)	(\$0.060)	(\$0.052)	(\$0.030)
Levelized Cost of Energy (LCOE) of PV	\$0.369	\$0.313	\$0.382	\$0.328	\$0.383	\$0.327	\$0.196	\$0.421	\$0.362	\$0.217
Wholesale Power Revenue	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)
Unsupported PV Economics	\$0.279	\$0.223	\$0.292	\$0.238	\$0.293	\$0.237	\$0.106	\$0.331	\$0.272	\$0.128
Federal Investment Tax Credit	(\$0.032)	(\$0.028)	(\$0.034)	(\$0.030)	(\$0.033)	(\$0.029)	(\$0.017)	(\$0.037)	(\$0.032)	(\$0.018)
Federal Accelerated Depreciation	(\$0.038)	(\$0.033)	(\$0.041)	(\$0.036)	(\$0.040)	(\$0.034)	(\$0.020)	(\$0.044)	(\$0.038)	(\$0.022)
Federally Supported PV Economics	\$0.208	\$0.163	\$0.217	\$0.173	\$0.220	\$0.174	\$0.069	\$0.250	\$0.203	\$0.087
Lower Cost Debt	(\$0.034)	(\$0.029)	(\$0.037)	(\$0.032)	(\$0.035)	(\$0.031)	(\$0.018)	(\$0.039)	(\$0.034)	(\$0.019)
Incremental Self-Generation Revenue at Retail Rates	(\$0.055)	(\$0.040)	(\$0.046)	(\$0.034)	(\$0.074)	(\$0.051)	\$0.000	\$0.000	\$0.000	\$0.000
REC Revenue	(\$0.075)	(\$0.075)	(\$0.044)	(\$0.044)	(\$0.044)	(\$0.044)	(\$0.044)	(\$0.044)	(\$0.044)	(\$0.044)
Net Metering Revenue at Wholesale Rates	\$0.055	\$0.048	\$0.055	\$0.048	\$0.056	\$0.049	\$0.090	\$0.090	\$0.090	\$0.090
Full Net Metering Revenue at Retail Rates	(\$0.141)	(\$0.094)	(\$0.130)	(\$0.088)	(\$0.176)	(\$0.109)	(\$0.128)	(\$0.220)	(\$0.198)	(\$0.124)
Property & Sales Tax Exemptions	(\$0.026)	(\$0.023)	(\$0.017)	(\$0.015)	(\$0.018)	(\$0.013)	(\$0.008)	(\$0.029)	(\$0.009)	\$0.000
Other Major State Incentives	\$0.000	\$0.000	(\$0.063)	(\$0.047)	\$0.000	\$0.000	\$0.000	\$0.000	(\$0.008)	\$0.000
Fully Supported PV Economics	(\$0.069)	(\$0.051)	(\$0.065)	(\$0.037)	(\$0.071)	(\$0.024)	(\$0.038)	\$0.007	\$0.001	(\$0.010)
Effect of Lower Discount Rate	(\$0.053)	(\$0.044)	(\$0.038)	(\$0.034)	(\$0.049)	(\$0.044)	(\$0.029)	(\$0.061)	(\$0.047)	(\$0.026)
Fully Supported PV Economics @ Lower Discount Rate	(\$0.122)	(\$0.094)	(\$0.102)	(\$0.071)	(\$0.120)	(\$0.068)	(\$0.067)	(\$0.054)	(\$0.046)	(\$0.036)

Table of Results: 2024 Project Starts

Alternative Scenario 1: Selected State Incentives Remain at 2015 Levels



(Data below in \$/kWh)

State => Customer Type =>	NH Residential	NH Commercial
Installed Cost	\$0.372	\$0.323
O&M Costs	\$0.036	\$0.029
Property Taxes	\$0.017	\$0.015
Inverter Replacement	\$0.007	\$0.006
Straightline Federal Depreciation	(\$0.055)	(\$0.048)
Levelized Cost of Energy (LCOE) of PV	\$0.377	\$0.324
Wholesale Power Revenue	(\$0.110)	(\$0.110)
Unsupported PV Economics	\$0.267	\$0.214
Federal Investment Tax Credit	(\$0.034)	(\$0.029)
Federal Accelerated Depreciation	(\$0.040)	(\$0.035)
Federally Supported PV Economics	\$0.193	\$0.150
Lower Cost Debt	(\$0.036)	(\$0.031)
Incremental Self-Generation Revenue at Retail Rates	(\$0.048)	(\$0.033)
REC Revenue	(\$0.037)	(\$0.037)
Net Metering Revenue at Wholesale Rates	\$0.068	\$0.059
Full Net Metering Revenue at Retail Rates	(\$0.145)	(\$0.098)
Property & Sales Tax Exemptions	(\$0.017)	(\$0.015)
Other Major State Incentives	(\$0.060)	(\$0.045)
Fully Supported PV Economics	(\$0.082)	(\$0.049)
Effect of Lower Discount Rate	(\$0.038)	(\$0.034)
Fully Supported PV Economics @ Lower Discount Rate	(\$0.120)	(\$0.083)

Table of Results: 2019 Project Starts

Alternative Scenario 2: Selected State Incentives Unavailable

(Data below in \$/kWh)



State =>	CT	CT	NH	NH	RI	RI	RI	VT	VT	VT
Customer Type =>	Residential	Commercial	Residential	Commercial	Residential	Commercial	Utility Scale	Residential	Commercial	Utility Scale
Installed Cost	\$0.366	\$0.314	\$0.379	\$0.329	\$0.380	\$0.328	\$0.190	\$0.417	\$0.358	\$0.208
O&M Costs	\$0.033	\$0.025	\$0.035	\$0.027	\$0.034	\$0.026	\$0.021	\$0.037	\$0.029	\$0.023
Property Taxes	\$0.016	\$0.014	\$0.017	\$0.015	\$0.017	\$0.014	\$0.008	\$0.018	\$0.020	\$0.013
Inverter Replacement	\$0.007	\$0.006	\$0.007	\$0.006	\$0.007	\$0.006	\$0.004	\$0.008	\$0.007	\$0.004
Straightline Federal Depreciation	(\$0.053)	(\$0.045)	(\$0.056)	(\$0.049)	(\$0.055)	(\$0.047)	(\$0.027)	(\$0.060)	(\$0.052)	(\$0.030)
Levelized Cost of Energy (LCOE) of PV	\$0.369	\$0.313	\$0.382	\$0.328	\$0.383	\$0.327	\$0.196	\$0.421	\$0.362	\$0.217
Wholesale Power Revenue	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)	(\$0.090)
Unsupported PV Economics	\$0.279	\$0.223	\$0.292	\$0.238	\$0.293	\$0.237	\$0.106	\$0.331	\$0.272	\$0.128
Federal Investment Tax Credit	(\$0.032)	(\$0.028)	(\$0.034)	(\$0.030)	(\$0.033)	(\$0.029)	(\$0.017)	(\$0.037)	(\$0.032)	(\$0.018)
Federal Accelerated Depreciation	(\$0.038)	(\$0.033)	(\$0.041)	(\$0.036)	(\$0.040)	(\$0.034)	(\$0.020)	(\$0.044)	(\$0.038)	(\$0.022)
Federally Supported PV Economics	\$0.208	\$0.163	\$0.217	\$0.173	\$0.220	\$0.174	\$0.069	\$0.250	\$0.203	\$0.087
Lower Cost Debt	(\$0.034)	(\$0.029)	(\$0.037)	(\$0.032)	(\$0.035)	(\$0.031)	(\$0.018)	(\$0.039)	(\$0.034)	(\$0.019)
Incremental Self-Generation Revenue at Retail Rates	(\$0.055)	(\$0.040)	(\$0.046)	(\$0.034)	(\$0.044)	(\$0.038)	\$0.000	\$0.000	\$0.000	\$0.000
REC Revenue	(\$0.044)	(\$0.044)	(\$0.044)	(\$0.044)	(\$0.044)	(\$0.044)	(\$0.044)	(\$0.044)	(\$0.044)	(\$0.044)
Net Metering Revenue at Wholesale Rates	\$0.055	\$0.048	\$0.055	\$0.048	\$0.056	\$0.049	\$0.090	\$0.090	\$0.090	\$0.027
Full Net Metering Revenue at Retail Rates	(\$0.141)	(\$0.094)	(\$0.130)	(\$0.088)	(\$0.127)	(\$0.094)	(\$0.174)	(\$0.217)	(\$0.183)	(\$0.055)
Property & Sales Tax Exemptions	(\$0.026)	(\$0.023)	(\$0.017)	(\$0.015)	(\$0.018)	(\$0.013)	(\$0.008)	(\$0.029)	(\$0.009)	\$0.000
Other Major State Incentives	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	(\$0.008)	\$0.000
Fully Supported PV Economics	(\$0.037)	(\$0.019)	(\$0.002)	\$0.009	\$0.008	\$0.003	(\$0.083)	\$0.010	\$0.015	(\$0.004)
Effect of Lower Discount Rate	(\$0.056)	(\$0.047)	(\$0.058)	(\$0.049)	(\$0.057)	(\$0.048)	(\$0.030)	(\$0.062)	(\$0.050)	(\$0.034)
Fully Supported PV Economics @ Lower Discount Rate	(\$0.093)	(\$0.066)	(\$0.060)	(\$0.040)	(\$0.049)	(\$0.045)	(\$0.113)	(\$0.052)	(\$0.035)	(\$0.038)

Table of Results: 2024 Project Starts

Alternative Scenario 2: Selected State Incentives Unavailable

(Data below in \$/kWh)



State =>	NH	NH
Customer Type =>	Residential	Commercial
Installed Cost	\$0.372	\$0.323
O&M Costs	\$0.036	\$0.029
Property Taxes	\$0.017	\$0.015
Inverter Replacement	\$0.007	\$0.006
Straightline Federal Depreciation	(\$0.055)	(\$0.048)
Levelized Cost of Energy (LCOE) of PV	\$0.377	\$0.324
Wholesale Power Revenue	(\$0.110)	(\$0.110)
Unsupported PV Economics	\$0.267	\$0.214
Federal Investment Tax Credit	(\$0.034)	(\$0.029)
Federal Accelerated Depreciation	(\$0.040)	(\$0.035)
Federally Supported PV Economics	\$0.193	\$0.150
Lower Cost Debt	(\$0.036)	(\$0.031)
Incremental Self-Generation Revenue at Retail Rates	(\$0.048)	(\$0.033)
REC Revenue	(\$0.037)	(\$0.037)
Net Metering Revenue at Wholesale Rates	\$0.068	\$0.059
Full Net Metering Revenue at Retail Rates	(\$0.145)	(\$0.098)
Property & Sales Tax Exemptions	(\$0.017)	(\$0.015)
Other Major State Incentives	\$0.000	\$0.000
Fully Supported PV Economics	(\$0.022)	(\$0.005)
Effect of Lower Discount Rate	(\$0.057)	(\$0.048)
Fully Supported PV Economics @ Lower Discount Rate	(\$0.079)	(\$0.053)

Additional Questions/Comments

Contacts



Jon Black, ISO-NE

Senior Engineer
413-540-4745

Jblack@iso-ne.com

Craig Schultz, ICF

Principal, Renewable Energy
703-934-3000

Craig.schultz@icfi.com