124 Franklin Street, Kingston Solar photovoltaics (PV) Analysis

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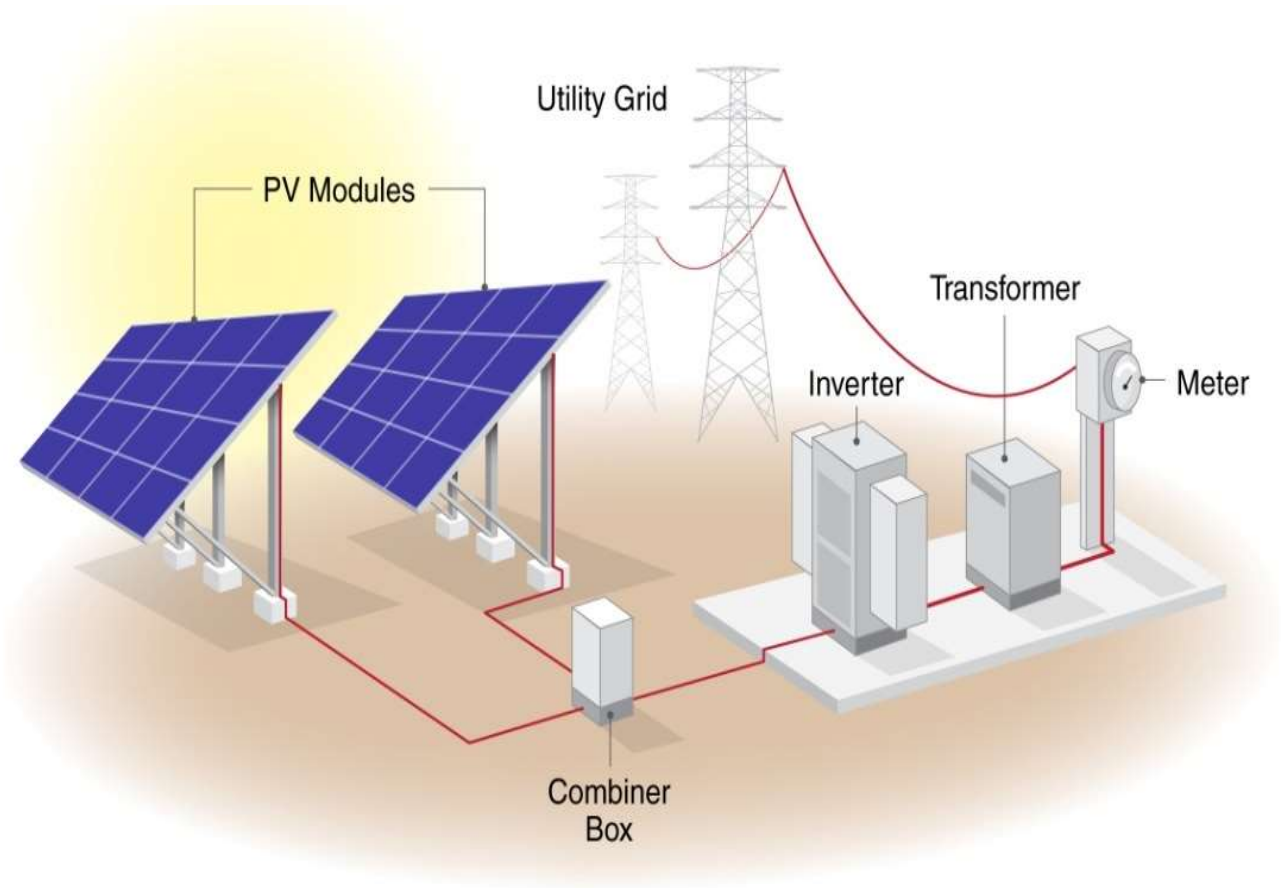
Overview

- Screening for solar photovoltaics (PV) opportunity at 124 Franklin Street, Kingston, NY was performed
- The purpose of this screening is to evaluate the techno-economic viability of on-site PV
- This screening should be treated as an initial step to prioritize and focus additional, in-depth analysis of potential renewable energy projects
- NREL used Aurora Solar to calculate PV system size based on solar access and thereafter used that as an input in System Advisory Model (SAM) to perform the techno-economic analysis

Grid-Tied PV Array Diagram



124 Franklin Street

North Side Front Entrance

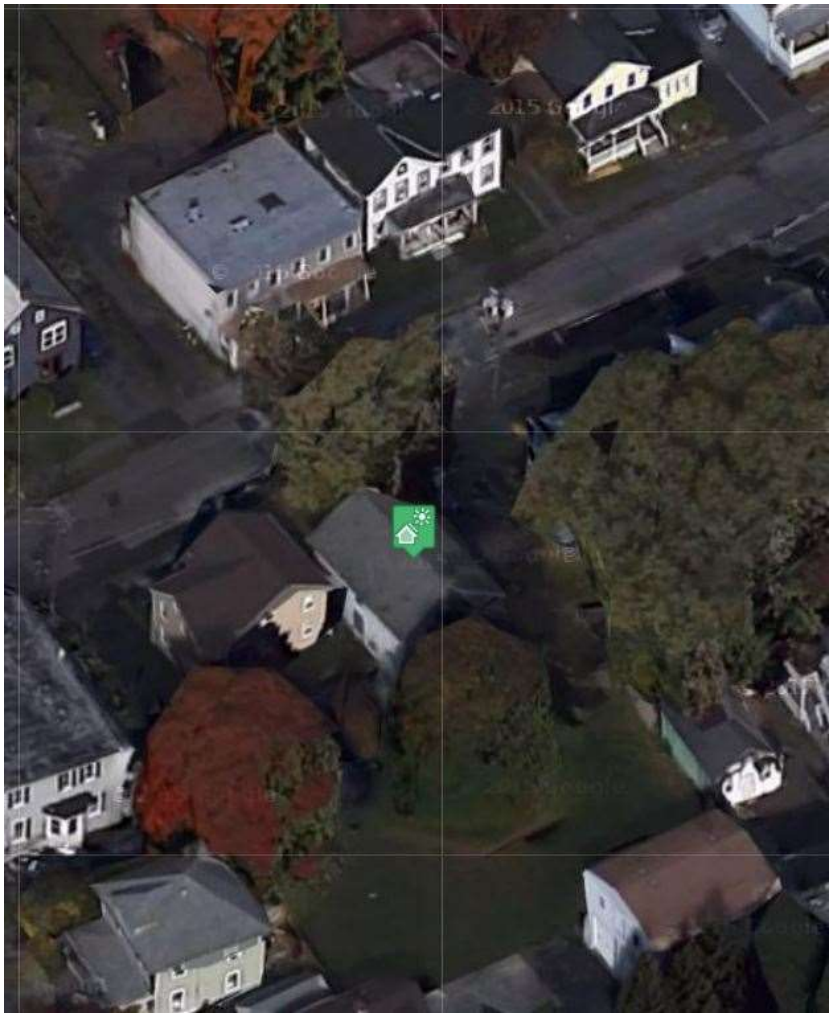
South West Side Back View

South East Side Back View

Source: Jimmy Salasovich

124 Franklin Street

Source: Google Earth



Source: Aurora Solar

PV Resource Data

- Hourly weather data for Kingston, NY was used in the analysis (TMY file)

- The average annual solar radiation is 4.63 kWh/m^2/day
  - US high: Phoenix, AZ = 6.57 kWh/m^2/day
  - US low: Buffalo, NY = 3.99 kWh/m^2/day

Month	Solar Radiation (kWh / m^2 / day)
January	3.09
February	3.89
March	4.65
April	5.46
May	5.91
June	6.03
July	6.26
August	5.80
September	5.09
October	3.84
November	3.09
December	2.47
Annual	4.63

Source: PVWatts

Net Metering

Incentive Type:	New York (PSL §66-j) - Net Metering*								
Eligible Renewable/ Other Technologies:	Solar			Micro-hydroelectric		Biogas	Micro CHP	Fuel Cell	
Applicable Sectors:	Residential	Non-Residential	Farm Service Solar	Residential	Non-Residential	Farm-Waste & Non-Residential	Residential	Residential	Non-Residential
Limit on System Size:	25 kW	Up to 2 MW	Up to 100 kW	25 kW	Up to 2 MW	1 MW	10 kW	10 kW	Up to 2.0 MW
Remote Net Metering:	No**	Yes	Yes	No**	Yes	Yes	No	No**	Yes
Limit on Overall Enrollment:	6% of 2005 Electric Demand per IOU for Solar, Biogas, Micro CHP, Micro-hydroelectric and Fuel Cells combined								

Incentive Type:	New York (PSL §66-l) - Net Metering*		
Eligible Renewable/ Other Technologies:	Wind		
Applicable Sectors:	Residential	Non-Residential	Farm-Service Wind
Limit on System Size:	25kW	Up to 2 MW	500 kW
Remote Net Metering:	No**	Yes	Yes

https://programs.dsireusa.org/system/program/detail/453

https://www.cenhud.com/dg/netmetering

Financing Scenario Analyzed

- Direct purchase financed with <u>100% and 0 % debt</u>
  - City-owned
  - City/non-profits are ineligible for federal (and state, if any) tax incentives

Utility

- Served by Central Hudson Gas and Electric Corp.
- Rates
  - Energy Rate: $0.13 /kWh

Technical Assumptions

	Assumption	Source
Technology	System on Rooftop	
Panel Tilt	• Follow the roof pitch on pitched rooftop	
Azimuth	Follows roof orientation for pitched roofs	
Degradation Rate	0.5%	SAM default
Total Installed Cost	$2.70/Wdc	U.S. Solar Photovoltaic System Cost Benchmark: Q1 2018; Ran Fu, David Feldman, and Robert Margolis, https://www.nrel.gov/docs/fy19osti/72399.pdf
Operations and Maintenance Cost	$16/kW-yr.	NREL ATB
Weather Data	TMY Hourly Data	TMY hourly data for Kingston, NY
Electricity Escalation Rate	2.5%	Assumed; need to clarify with the utility as well as from past bills [Important parameter which has a major impact on the economics].
Incentives	Not Applicable for Direct Purchase Scenario	
Total system losses	14.08%	SAM Defaults [would impact solar generation, if changed]

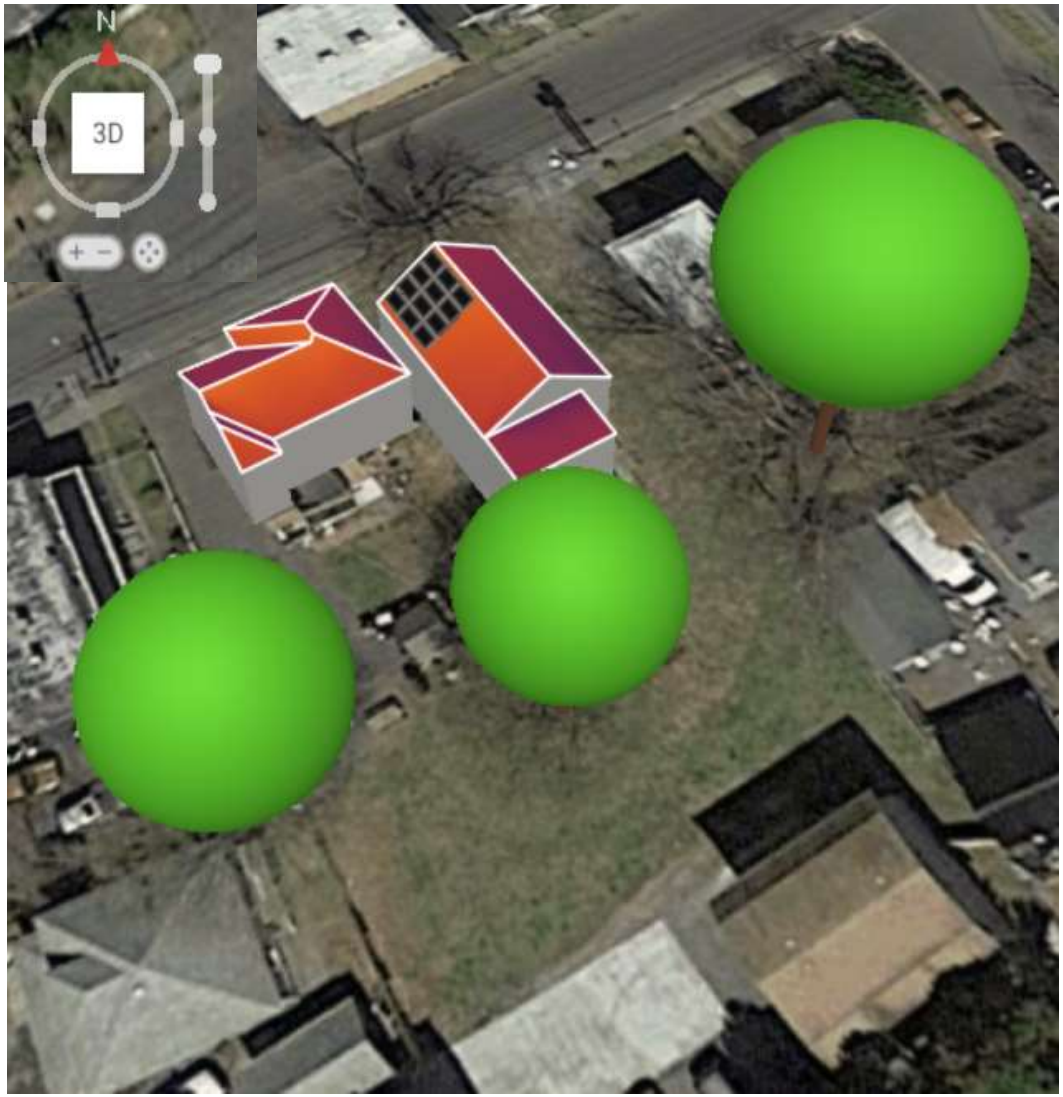
Financial Assumptions (Direct Purchase Model)

	Assumption	Source
Debt Percentage	100% and 0%	
Loan Term	25 years	
Loan Rate	3%/yr.	
Analysis Period	25 years	
Real Discount Rate	3.0%	Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis – 2018 Annual Supplement to NIST Handbook 135, Priya D. Lavappa Joshua D. Kneifel, https://nvlpubs.nist.gov/nistpubs/ir/2018/NIST.IR.85-3273-33.pdf
Nominal Discount Rate	2.8%	https://nvlpubs.nist.gov/nistpubs/ir/2018/NIST.IR.85-3273-33.pdf
Average Inflation Rate	-0.2%	https://nvlpubs.nist.gov/nistpubs/ir/2018/NIST.IR.85-3273-33.pdf
Federal Income Tax Rate	0%/yr.	Non-profit
State Income Tax Rate	0%/yr.	Non-profit
Sales Tax	0%	Non-profit
Property Tax	0%	City owns site
Cost of Acquiring Financing	$0	
Construction Financing	None	
Reserve Accounts	None	
Return on Equity	0%	
Federal ITC	0%	
MACRS	No	

SAM and Aurora Analysis

Aurora Solar Modeling

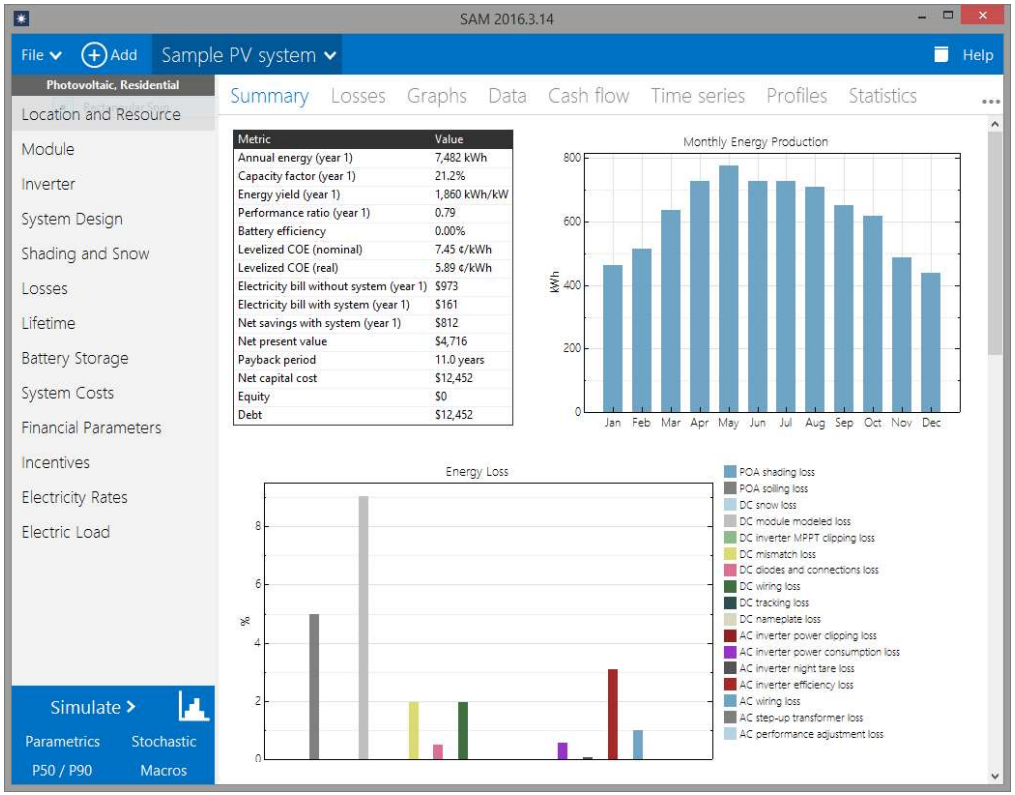
- Aurora Solar was used to determine the PV capacity
- PV Inputs:
  - 90 % minimum annual solar access
  - Landscape panel orientation
  - Tilt: Roof pitch
- PV Capacity : 4.1 kW



https://www.aurorasolar.com/

System Advisor Model (SAM)

Free software that combines detailed performance and financial models to estimate the cost of energy for systems



http://sam.nrel.gov/download

Technologies

- Photovoltaics, detailed & PVWatts
- Battery storage
- Concentrating solar power
- Wind
- Geothermal
- Biomass
- Solar water heating

Financials

- Behind-the-meter
- residential
- commercial
- Power purchase agreements
- single owner
- equity flips
- sale-leaseback
- Simple LCOE calculator

SAM Results

SAM Analysis Results –Direct Purchase with 100 % Debt

Option 1: Central Air Conditioner	
Metric	**124 Franklin Street**
Type	Roof mount
PV Size (kW)	4.1
PV System Annual Energy Production Year 1 (kWh)	4,815
Annual Site Load, (MMBTU/yr.)	50.9
Annual Site Load (kWh)	14,913
Percent Load Met by PV System Year 1 (%)	32%
Levelized COE Nominal (cents/kWh)	15.32
Net Capital Cost ($)	11,070
Loan Percent (%)	100%
Net Present Value ($)	$1,090
Simple Payback (years)	16.8

Comes from BEopt Results
(See Appendix)

Option 2: Mini-Split Heat Pump	
Metric	**124 Franklin Street**
Type	Roof mount
PV Size (kW)	4.1
PV System Annual Energy Production Year 1 (kWh)	4,815
Annual Site Load, (MMBTU/yr.)	27.5
Annual Site Load (kWh)	8,057
Percent Load Met by PV System Year 1 (%)	60%
Levelized COE Nominal (cents/kWh)	15.32
Net Capital Cost ($)	11,070
Loan Percent (%)	100%
Net Present Value ($)	$1,090
Simple Payback (years)	16.8

1 MMBTU = 292.9974 kWh https://business.directenergy.com/understanding-energy/energy-tools/conversion-factors

Buy Rate = Sell Rate ($0.13/kWh)

SAM Analysis Results –Direct Purchase with 0 % Debt

Option 1: Central Air Conditioner	
Metric	**124 Franklin Street**
Type	Roof mount
PV Size (kW)	4.1
PV System Annual Energy Production Year 1 (kWh)	4,815
Annual Site Load, (MMBTU/yr.)	50.9
Annual Site Load (kWh)	14,913
Percent Load Met by PV System Year 1 (%)	32%
Levelized COE Nominal (cents/kWh)	15.00
Net Capital Cost ($)	11,070
Loan Percent (%)	0%
Net Present Value ($)	$1,349
Simple Payback (years)	16.8

Comes from BEopt Results
(See Appendix)

Option 2: Mini-Split Heat Pump	
Metric	**124 Franklin Street**
Type	Roof mount
PV Size (kW)	4.1
PV System Annual Energy Production Year 1 (kWh)	4,815
Annual Site Load, (MMBTU/yr.)	27.5
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Net Capital Cost ($)	11,070
Loan Percent (%)	0%
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1 MMBTU = 292.9974 kWh https://business.directenergy.com/understanding-energy/energy-tools/conversion-factors

Buy Rate = Sell Rate ($0.13/kWh)

Parametric Analysis Option 1: Central Air Conditioner (100% Debt)

Variables	Inputs Varied			Outputs	
	PV Installed Cost $/W	Loan Rate	Electricity Escalation Rate	NPV($)	Simple Payback Period (yrs.)
PV Installed Cost	2	3%	2.50%	4,027	13.0
PV Installed Cost	2.50	3%	2.50%	1,930	15.7
PV Installed Cost	2.70	3%	2.50%	1,090	16.8
PV Installed Cost	3	3%	2.50%	-168	18.4
PV Installed Cost	3.5	3%	2.50%	-2,266	20.9
Loan Rate	2.70	1.50%	2.50%	2,898	16.8
Loan Rate	2.70	2%	2.50%	2,314	16.8
Loan Rate	2.70	2.50%	2.50%	1,712	16.8
Loan Rate	2.70	5%	2.50%	-1,577	16.8
Loan Rate	2.70	6%	2.50%	-3,012	16.8
Electricity Escalation Rate	2.70	3%	0%	-2,103	21.3
Electricity Escalation Rate	2.70	3%	1%	-962	19.1
Electricity Escalation Rate	2.70	3%	1.50%	-326	18.2
Electricity Escalation Rate	2.70	3%	2%	355	17.5
Electricity Escalation Rate	2.70	3%	3%	1,880	16.2

- PV installed cost, the loan rate, and annual electricity cost escalation rate assumptions have a large impact on net present value (NPV)
- Lowering the PV installed cost and increasing the electricity cost escalation rate lowers the simple payback period
- The loan rate does not affect the simple payback, which only considers the installed cost and the value of the electricity generated

Parametric Analysis Option 2: Mini-Split Heat Pump (0% Debt)

Variables	Inputs Varied		Outputs	
	PV Installed Cost $/W	Electricity Escalation Rate	NPV($)	Simple Payback Period (yrs.)
PV Installed Cost	2	2.50%	4,219	13.0
PV Installed Cost	2.50	2.50%	2,169	15.7
PV Installed Cost	2.70	2.50%	1,349	16.8
PV Installed Cost	3	2.50%	119	18.4
PV Installed Cost	3.5	2.50%	-1,931	20.9
Electricity Escalation Rate	2.70	0%	-1,845	21.3
Electricity Escalation Rate	2.70	1%	-703	19.1
Electricity Escalation Rate	2.70	1.50%	-68	18.2
Electricity Escalation Rate	2.70	2%	614	17.5
Electricity Escalation Rate	2.70	3%	2,139	16.2

- PV installed cost and annual electricity cost escalation rate have a large impact on NPV
- Lowering the PV installed cost and increasing the annual electricity cost escalation rate lowers the simple payback period

Key Takeaways

- 4.1 kW of roof mount PV system can be installed at 124 Franklin Street
- Option 1 (Central Air Conditioner): 32% of the load (estimated total building electricity and natural gas consumption) can be met by the proposed PV system (Year 1)
- Option 2 (Mini-Split Heat Pumps): 60% of the load (estimated electricity consumption with no natural gas consumption) can be met by the proposed PV system (Year 1)
- Two scenarios were evaluated, one with 100% debt and other with 0% debt
- Net present value (NPV) of 0% debt scenario is more positive than 100% debt scenario's NPV while the simple payback period remains same
- Parametric analysis was performed on various on various parameters
  - Option 1 (Central Air Conditioner) with 100% debt
    - If the installed PV cost is 3.0 $/Wdc or above, or if the loan rate is 5% or above, or electricity escalation rate is less than 1.5%, while other parameters remain the same, the NPV would be negative and installing PV solar would not be economically favorable.
  - Option 2 (Mini-Split Heat Pumps) with 0% debt
    - If the installed PV cost is above 3.0 $/Wdc or electricity cost escalation rate is less than 1.5%, while other parameters remain the same, the NPV would be negative and installing PV solar would not be economically favorable.

Contact Information:

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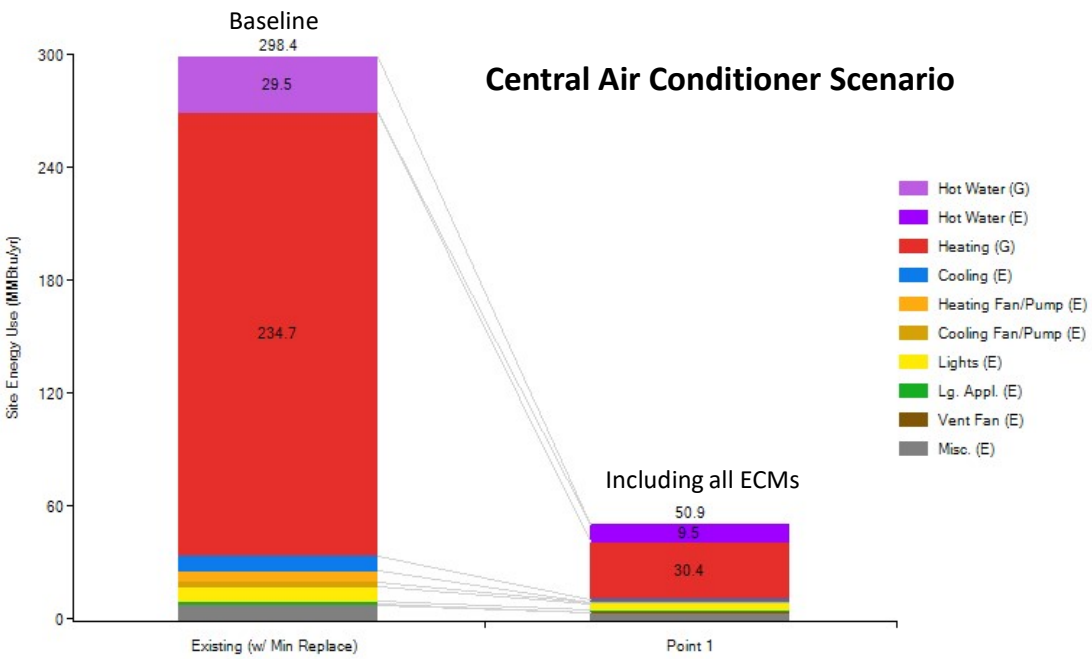
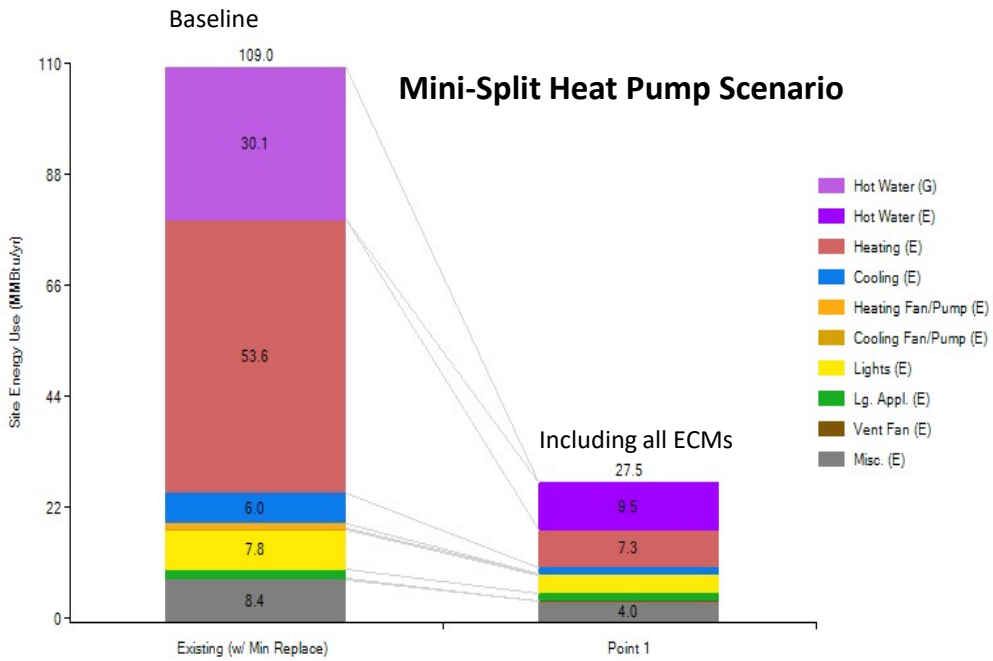
Appendix

HVAC Types


Central Air Conditioner Scenario
Baseline
298.4
29.5
234.7
Including all ECMs
50.9
9.5
30.4
Site Energy Use (MMBtu/yr)
300
240
180
120
60
0
Existing (w/ Min Replace)
Point 1
Hot Water (G)
Hot Water (E)
Heating (G)
Cooling (E)
Heating Fan/Pump (E)
Cooling Fan/Pump (E)
Lights (E)
Lg. Appl. (E)
Vent Fan (E)
Misc. (E)


Mini-Split Heat Pump Scenario
Baseline
109.0
30.1
53.6
6.0
7.8
8.4
Including all ECMs
27.5
9.5
7.3
4.0
Site Energy Use (MMBtu/yr)
110
88
66
44
22
0
Existing (w/ Min Replace)
Point 1
Hot Water (G)
Hot Water (E)
Heating (E)
Cooling (E)
Heating Fan/Pump (E)
Cooling Fan/Pump (E)
Lights (E)
Lg. Appl. (E)
Vent Fan (E)
Misc. (E)

Measures

124 Franklin Street			
Parametric Case:	**Baseline/Existing Conditions**	**Option 1: Mini-Split Heat Pumps for Space Cooling and Heating**	**Option 2: Air Conditioner with Natural Gas Furnace**
Number of Stories:	2	2	2
Wall Insulation:	None	R-23 Closed Cell Spray Foam	R-23 Closed Cell Spray Foam
Attic Insulation:	R-13 loose fiberglass	Ceiling R-60 Cellulose	Ceiling R-60 Cellulose
Basement Insulation:	None	Ceiling R-30 Closed Cell Spray	Ceiling R-30 Closed Cell Spray
Windows:	Single pane	Low-E, Double, Non-metal, Air,M-Gain	Low-E, Double, Non-metal, Air,M-Gain
Doors:	Wood	Fiberglass	Fiberglass
Air Leakage:	1.7 ACH	0.07 ACH	0.07 ACH
HVAC Heating:	Coal stove and 2x fireplaces	Mini-Split Heat Pumps 9kBtuh/unit - SEER 33, 14.2 HSPF	Furnance, Gas 92.5 % AFUE
HVAC Cooling:	There was no space cooling in existing building but SEER 14 space cooling was assumed so that a comparison could be made between the parametric options	Mini-Split Heat Pumps 9kBtuh/unit - SEER 33, 14.2 HSPF	Air Conditioner SEER 24.5
HVAC Ducts:	Uninsulated	n/a	7.5 % Leakage,R-8
Water Heating:	80% efficient natural gas	Electric Tankless	Electric Tankless
Water Heating Distribution:	Not insulated	R-2, Trunch Branch, Copper	R-2, Trunch Branch, Copper
Lighting:	100% Incandescent lights	100 % LED lights	100 % LED lights
Plug Loads:	Standard efficiency, but note the building was empty but standard appliances with an equipment power density of 1.0 Watts per sq ft. are assumed for the baseline so that a comparison could be made between the parametric options	0.5 Watts per sq ft.	0.5 Watts per sq ft.

Disclaimer

- The analysis is based on projections, estimates or assumptions made on a best-effort basis, based upon expectations of current and future conditions at the time they were developed.
- The analysis was prepared with information available at the time the analysis was conducted. Analysis results could be different if new information becomes available and is incorporated.
- This analysis relies on site information provided to NREL that has not been independently validated by NREL.