

**Photovoltaic Array System Study
for**

**Consentino Middle School
Haverhill, MA**

October 24, 2023

Prepared for:



**212 Battery St.
Burlington, VT 05401**

Prepared by:



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I. EXECUTIVE SUMMARY

This Report will include four options **Building + Canopies & Building Only** arrays both will also be presented with and without the SMART solar incentive program. The Solar Massachusetts Renewable Energy Target (SMART) is DOER's incentive program established to support the development of solar in Massachusetts, This is a falling block program and estimated incentives have been calculated using block 14 of 16.

Building + Canopies: The Constentino Middle School has a potential photovoltaic layout consisting of 4 groups of panels, 2 roof mounted and 2 parking canopies, totaling a quantity of 1,568 panels (430W each) providing approximately 206.4KWdc roof mounted & 467.84KWdc for the canopies totaling 674.24KWdc power. This would produce an estimated annual production of 758,839 kilowatt hours (kWH) per year or approximately 95.7% of the yearly building consumption.

Under direct ownership the Town's cost for the **Building + Canopies (Not on SMART program)** PV System is approximately \$3.5/Watt for roof mounted systems and \$4.5/Watt of Canopy systems amounting to \$2,827,680 up front cost. Over a 20-year period an estimated \$3,642,420 in electrical energy cost savings would be produced. The payback analysis indicates a 15-year simple payback and a discounted payback of 17-years.

Under direct ownership the Town's cost for the **Building + Canopies (On SMART program)** PV System is approximately \$3.5/Watt for roof mounted systems and \$4.5/Watt of Canopy systems amounting to \$2,827,680 + \$1,080,000 (for battery storage & application fees required for SMART systems over 500KW). For a total up front cost of \$3,907,680 . Over a 20-year period an estimated \$3,642,420 in electrical energy cost savings would be produced and an estimate \$51,190/yr in SMART program incentives. A demand charge reduction has also been included in our calculations. The payback analysis indicates a 14-year simple payback and a discounted payback of 17-years.

Building Only: The Constentino Middle School has a potential photovoltaic layout consisting of 2 groups of panels totaling a quantity of 480 panels (430W each) providing approximately 206.4KWdc power. This would produce an estimated annual production of 236,308 kilowatt hours (kWH) per year or approximately 29.8% of the yearly building consumption.

Under direct ownership the Town's cost for the **Building Only (Not on SMART program)** PV System is approximately \$3.5/Watt amounting to \$722,400. Over a 20-year period an estimated \$1,134,278 in electrical energy cost savings would be produced. The payback analysis indicates a 13-year simple payback and a 15-year discounted payback.

Under direct ownership the Town's cost for the **Building Only (On SMART program)** PV System is approximately \$3.5/Watt amounting to \$722,400 + \$15000 (approximate application fees) for a total up front cost of \$737,400. Over a 20-year period an estimated \$1,134,278 in electrical energy cost savings would be produced and an estimate \$10,470/yr in SMART program incentives. The payback analysis indicates a 11-year simple payback and a 13-year discounted payback.

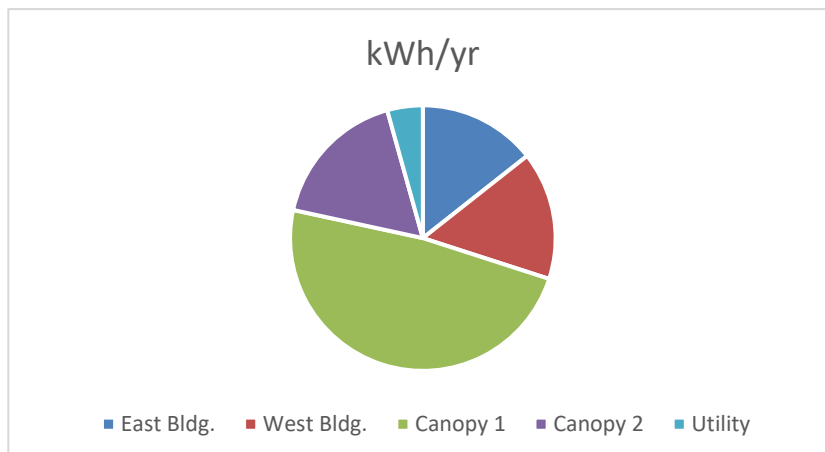
Currently there are tax credits available under the Inflation Reduction Act for 30% of the system's cost. Please see table 2 in the Economic Analysis section for estimated investment cost and payback period after tax credits are applied.

II. TECHNICAL

The buildings potential system size and production were estimated using REVIT to layout potential panels and PV Watts which is provided by the National Renewable Energy Laboratory (NREL). Sunpower 430W panels were used in this model as they have a high efficiency, refer to Appendix D for panel cutsheet. A set back from roof edges of 10 feet was used as this is best practice utilizing Unirac's recommendations. On the flat roof arrays a self-ballasted racking system would be suggested limiting penetrations to the new roof. PV Watts is utilized to estimate kWh per month and year based on system size, location, orientation, system losses and array tilt, this information has been extracted, see tables below. A panel layout can be found in Appendix B and PV Watts Calculations in Appendix C.

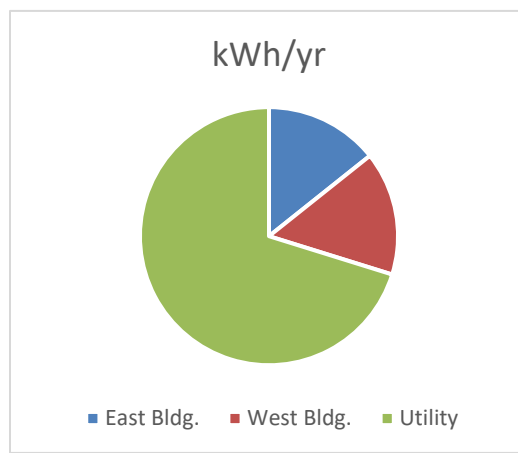
Building + Canopies

	Group East Building	Group West Building	Group Canopy 1	Group Canopy 2A	Group Canopy 2B	Total	Building Consumption per energy model
Panel QTY	231	249	780	154	154	1568	N/A
kW	99.33	107.07	335.4	66.22	66.22	674.24	N/A
Cost (PV)	\$347,655	\$374,745	\$1,509,300	\$297,990	\$297,990	\$2,827,680	N/A
Cost (Battery)						\$1,050,000	
kWh/year	113,338	122,970	381,746	75,372	65,413	758,839	793,030
Usage %	14.29%	15.51%	48.14%	9.50%	8.25%		95.69%



Building Only

	Group East Building	Group West Building	Total	Building Consumption per energy model
Panel QTY	231	249	480	N/A
kW	99.33	107.07	206.4	N/A
Cost	\$347,655.00	\$374,745.00	\$722,400.00	N/A
kWh/year	113,338	122,970	236,308	793,030
Usage %	14.29%	15.51%		29.80%



III. ECONOMIC EVALUATION

Under direct ownership the Town would pay for the design and installation of the photovoltaic system at an approximate cost of \$3.5/watt for roof top and \$4.5/watt canopy arrays. If a battery storage system is required, the Town would pay approximately \$1,050,000. Payback analysis takes into account initial investment, operation, maintenance and repair costs and utility rebate. See Table 1 and Appendix A for full life cycle analysis.

Table 1(Initial Cost)

	System Size	Investment Cost	Discounted Payback
Roof & Canopies (No SMART)	674.24 KW dc	\$2,827,680	17 years
Roof, Canopies, & Battery (SMART)	674.24 KW dc	\$3,907,680	17 years
Roof Only	206.4 KW dc	\$722,400	15 years
Roof Only (SMART)	206.4 KW dc	\$737,400	13 years

Table 2 (Inflation Reduction Act included)

	System Size	Investment Cost after IRA	Discounted Payback
Roof & Canopies (No SMART)	674.24 KW dc	\$1,979,379	12 years
Roof, Canopies, & Battery (SMART)	674.24 KW dc	\$2,744,386	12 years
Roof Only	206.4 KW dc	\$505,680	11 years
Roof Only (SMART)	206.4 KW dc	\$520,680	9 years

IV. APPENDIX

Appendix A

NIST BLCC 5.3-22: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology in OMB Circular A-94

Base Case: Baseline - No PV option 3

Alternative: Option 1 PV Roof and Canopies (No SMART)

General Information

File Name:	T:\Dore & Whittier - 894\117 Consentino MS\PV Study\Contentio PV Study BLCC5.xml
Date of Study:	Fri Oct 13 08:51:52 EDT 2023
Project Name:	Contentino Middle School
Project Location:	Massachusetts
Analysis Type:	OMB Analysis, Non-Energy Project
Analysis Purpose:	Public Investment or Regulatory Analysis
Analyst:	Jeff Bagdasarian
Base Date:	June 1, 2024
Service Date:	June 1, 2024
Study Period:	20 years 0 months (June 1, 2024 through May 31, 2044)
Discount Rate:	2.4%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	\$0	\$2,827,680	-\$2,827,680
Future Costs:			
Energy Consumption Costs	\$3,762,561	\$162,211	\$3,600,350
Energy Demand Charges	\$0	\$0	\$0
Energy Utility Rebates	\$0	\$0	\$0
Water Costs	\$0	\$0	\$0
Recurring and Non-Recurring OM&R Costs	\$0	\$143,999	-\$143,999
Capital Replacements	\$0	\$90,000	-\$90,000
Residual Value at End of Study Period	\$0	\$0	\$0
	-----	-----	-----
Subtotal (for Future Cost Items)	\$3,762,561	\$396,210	\$3,366,350
	-----	-----	-----
Total PV Life-Cycle Cost	\$3,762,561	\$3,223,890	\$538,670

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings \$3,456,350

- Increased Total Investment \$2,917,680

Net Savings \$538,670

Savings-to-Investment Ratio (SIR)

SIR = 1.18

Adjusted Internal Rate of Return

AIRR = 3.27%

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback occurs in year 15

Discounted Payback occurs in year 17

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	793,030.0 kWh	34,189.0 kWh	758,841.0 kWh	15,174,742.4 kWh

Energy Savings Summary (in MBtu)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	2,705.9 MBtu	116.7 MBtu	2,589.3 MBtu	51,778.4 MBtu

Emissions Reduction Summary

Energy Type	-----Average Base Case	Annual Alternative	Emissions----- Reduction	Life-Cycle Reduction
Electricity				
CO2	261,756.67 kg	11,284.82 kg	250,471.85 kg	5,008,751.27 kg
SO2	74.24 kg	3.20 kg	71.04 kg	1,420.55 kg
NOx	199.87 kg	8.62 kg	191.25 kg	3,824.56 kg
Total:				
CO2	261,756.67 kg	11,284.82 kg	250,471.85 kg	5,008,751.27 kg
SO2	74.24 kg	3.20 kg	71.04 kg	1,420.55 kg
NOx	199.87 kg	8.62 kg	191.25 kg	3,824.56 kg

NIST BLCC 5.3-22: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology in OMB Circular A-94

Base Case: Baseline - No PV option 3

Alternative: Option 1T PV Roof and Canopies Tax (No SMART)

General Information

File Name:	T:\Dore & Whittier - 894\117 Consentino MS\PV Study\Contentio PV Study BLCC5.xml
Date of Study:	Fri Oct 13 08:55:09 EDT 2023
Project Name:	Contentino Middle School
Project Location:	Massachusetts
Analysis Type:	OMB Analysis, Non-Energy Project
Analysis Purpose:	Public Investment or Regulatory Analysis
Analyst:	Jeff Bagdasarian
Base Date:	June 1, 2024
Service Date:	June 1, 2024
Study Period:	20 years 0 months (June 1, 2024 through May 31, 2044)
Discount Rate:	2.4%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	\$0	\$1,979,379	-\$1,979,379
Future Costs:			
Energy Consumption Costs	\$3,762,561	\$162,211	\$3,600,350
Energy Demand Charges	\$0	\$0	\$0
Energy Utility Rebates	\$0	\$0	\$0
Water Costs	\$0	\$0	\$0
Recurring and Non-Recurring OM&R Costs	\$0	\$143,999	-\$143,999
Capital Replacements	\$0	\$90,000	-\$90,000
Residual Value at End of Study Period	\$0	\$0	\$0
	-----	-----	-----
Subtotal (for Future Cost Items)	\$3,762,561	\$396,210	\$3,366,350
	-----	-----	-----
Total PV Life-Cycle Cost	\$3,762,561	\$2,375,589	\$1,386,971

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings \$3,456,350

- Increased Total Investment \$2,069,379

Net Savings \$1,386,971

Savings-to-Investment Ratio (SIR)

SIR = 1.67

Adjusted Internal Rate of Return

AIRR = 5.06%

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback occurs in year 11

Discounted Payback occurs in year 12

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	793,030.0 kWh	34,189.0 kWh	758,841.0 kWh	15,174,742.4 kWh

Energy Savings Summary (in MBtu)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	2,705.9 MBtu	116.7 MBtu	2,589.3 MBtu	51,778.4 MBtu

Emissions Reduction Summary

Energy Type	-----Average Base Case	Annual Alternative	Emissions----- Reduction	Life-Cycle Reduction
Electricity				
CO2	261,756.67 kg	11,284.82 kg	250,471.85 kg	5,008,751.27 kg
SO2	74.24 kg	3.20 kg	71.04 kg	1,420.55 kg
NOx	199.87 kg	8.62 kg	191.25 kg	3,824.56 kg
Total:				
CO2	261,756.67 kg	11,284.82 kg	250,471.85 kg	5,008,751.27 kg
SO2	74.24 kg	3.20 kg	71.04 kg	1,420.55 kg
NOx	199.87 kg	8.62 kg	191.25 kg	3,824.56 kg

NIST BLCC 5.3-22: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology in OMB Circular A-94

Base Case: Baseline - No PV option 3

Alternative: Option 2 PV Roof and Canopies (With SMART)

General Information

File Name: T:\Dore & Whittier - 894\117 Consentino MS\PV Study\Contentio PV Study BLCC5.xml

Date of Study: Fri Oct 13 08:53:04 EDT 2023

Project Name: Contentino Middle School

Project Location: Massachusetts

Analysis Type: OMB Analysis, Non-Energy Project

Analysis Purpose: Public Investment or Regulatory Analysis

Analyst: Jeff Bagdasarian

Base Date: June 1, 2024

Service Date: June 1, 2024

Study Period: 20 years 0 months (June 1, 2024 through May 31, 2044)

Discount Rate: 2.4%

Discounting Convention: End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	\$0	\$3,907,680	-\$3,907,680
Future Costs:			
Energy Consumption Costs	\$3,762,561	\$162,211	\$3,600,350
Energy Demand Charges	\$0	\$0	\$0
Energy Utility Rebates	\$0	-\$1,407,348	\$1,407,348
Water Costs	\$0	\$0	\$0
Recurring and Non-Recurring OM&R Costs	\$0	\$143,999	-\$143,999
Capital Replacements	\$0	\$90,000	-\$90,000
Residual Value at End of Study Period	\$0	\$0	\$0
	-----	-----	-----
Subtotal (for Future Cost Items)	\$3,762,561	-\$1,011,138	\$4,773,699
	-----	-----	-----
Total PV Life-Cycle Cost	\$3,762,561	\$2,896,542	\$866,019

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings \$4,863,699

- Increased Total Investment \$3,997,680

Net Savings \$866,019

Savings-to-Investment Ratio (SIR)

SIR = 1.22

Adjusted Internal Rate of Return

AIRR = 3.41%

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback occurs in year 14

Discounted Payback occurs in year 17

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	793,030.0 kWh	34,189.0 kWh	758,841.0 kWh	15,174,742.4 kWh

Energy Savings Summary (in MBtu)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	2,705.9 MBtu	116.7 MBtu	2,589.3 MBtu	51,778.4 MBtu

Emissions Reduction Summary

Energy Type	-----Average Base Case	Annual Alternative	Emissions----- Reduction	Life-Cycle Reduction
Electricity				
CO2	261,756.67 kg	11,284.82 kg	250,471.85 kg	5,008,751.27 kg
SO2	74.24 kg	3.20 kg	71.04 kg	1,420.55 kg
NOx	199.87 kg	8.62 kg	191.25 kg	3,824.56 kg
Total:				
CO2	261,756.67 kg	11,284.82 kg	250,471.85 kg	5,008,751.27 kg
SO2	74.24 kg	3.20 kg	71.04 kg	1,420.55 kg
NOx	199.87 kg	8.62 kg	191.25 kg	3,824.56 kg

NIST BLCC 5.3-22: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology in OMB Circular A-94

Base Case: Baseline - No PV option 3

Alternative: Option 2T PV Roof and Canopies Tax (SMART)

General Information

File Name:	T:\Dore & Whittier - 894\117 Consentino MS\PV Study\Contentio PV Study BLCC5.xml
Date of Study:	Fri Oct 13 08:54:17 EDT 2023
Project Name:	Contentino Middle School
Project Location:	Massachusetts
Analysis Type:	OMB Analysis, Non-Energy Project
Analysis Purpose:	Public Investment or Regulatory Analysis
Analyst:	Jeff Bagdasarian
Base Date:	June 1, 2024
Service Date:	June 1, 2024
Study Period:	20 years 0 months (June 1, 2024 through May 31, 2044)
Discount Rate:	2.4%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	\$0	\$2,744,340	-\$2,744,340
Future Costs:			
Energy Consumption Costs	\$3,762,561	\$162,211	\$3,600,350
Energy Demand Charges	\$0	\$0	\$0
Energy Utility Rebates	\$0	-\$1,407,348	\$1,407,348
Water Costs	\$0	\$0	\$0
Recurring and Non-Recurring OM&R Costs	\$0	\$143,999	-\$143,999
Capital Replacements	\$0	\$90,000	-\$90,000
Residual Value at End of Study Period	\$0	\$0	\$0
	-----	-----	-----
Subtotal (for Future Cost Items)	\$3,762,561	-\$1,011,138	\$4,773,699
	-----	-----	-----
Total PV Life-Cycle Cost	\$3,762,561	\$1,733,202	\$2,029,359

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	\$4,863,699
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- Increased Total Investment \$2,834,340

Net Savings \$2,029,359

Savings-to-Investment Ratio (SIR)

SIR = 1.72

Adjusted Internal Rate of Return

AIRR = 5.20%

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback occurs in year 11

Discounted Payback occurs in year 12

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	793,030.0 kWh	34,189.0 kWh	758,841.0 kWh	15,174,742.4 kWh

Energy Savings Summary (in MBtu)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	2,705.9 MBtu	116.7 MBtu	2,589.3 MBtu	51,778.4 MBtu

Emissions Reduction Summary

Energy Type	-----Average Base Case	Annual Alternative	Emissions----- Reduction	Life-Cycle Reduction
Electricity				
CO2	261,756.67 kg	11,284.82 kg	250,471.85 kg	5,008,751.27 kg
SO2	74.24 kg	3.20 kg	71.04 kg	1,420.55 kg
NOx	199.87 kg	8.62 kg	191.25 kg	3,824.56 kg
Total:				
CO2	261,756.67 kg	11,284.82 kg	250,471.85 kg	5,008,751.27 kg
SO2	74.24 kg	3.20 kg	71.04 kg	1,420.55 kg
NOx	199.87 kg	8.62 kg	191.25 kg	3,824.56 kg

NIST BLCC 5.3-22: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology in OMB Circular A-94

Base Case: Baseline - No PV option 3

Alternative: Option 3 PV Roof Only (No SMART)

General Information

File Name:	T:\Dore & Whittier - 894\117 Consentino MS\PV Study\Contentio PV Study BLCC5.xml
Date of Study:	Fri Oct 13 08:57:15 EDT 2023
Project Name:	Contentino Middle School
Project Location:	Massachusetts
Analysis Type:	OMB Analysis, Non-Energy Project
Analysis Purpose:	Public Investment or Regulatory Analysis
Analyst:	Jeff Bagdasarian
Base Date:	June 1, 2024
Service Date:	June 1, 2024
Study Period:	20 years 0 months (June 1, 2024 through May 31, 2044)
Discount Rate:	2.4%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	\$0	\$722,400	-\$722,400
Future Costs:			
Energy Consumption Costs	\$3,762,561	\$2,641,379	\$1,121,182
Energy Demand Charges	\$0	\$0	\$0
Energy Utility Rebates	\$0	\$0	\$0
Water Costs	\$0	\$0	\$0
Recurring and Non-Recurring OM&R Costs	\$0	\$115,200	-\$115,200
Capital Replacements	\$0	\$25,000	-\$25,000
Residual Value at End of Study Period	\$0	\$0	\$0
	-----	-----	-----
Subtotal (for Future Cost Items)	\$3,762,561	\$2,781,578	\$980,982
	-----	-----	-----
Total PV Life-Cycle Cost	\$3,762,561	\$3,503,978	\$258,582

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings \$1,005,982

- Increased Total Investment \$747,400

Net Savings \$258,582

Savings-to-Investment Ratio (SIR)

SIR = 1.35

Adjusted Internal Rate of Return

AIRR = 3.93%

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback occurs in year 13

Discounted Payback occurs in year 15

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	793,030.0 kWh	556,720.0 kWh	236,310.0 kWh	4,725,553.0 kWh

Energy Savings Summary (in MBtu)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	2,705.9 MBtu	1,899.6 MBtu	806.3 MBtu	16,124.3 MBtu

Emissions Reduction Summary

Energy Type	-----Average Base Case	Annual Alternative	Emissions----- Reduction	Life-Cycle Reduction
Electricity				
CO2	261,756.67 kg	183,757.45 kg	77,999.22 kg	1,559,770.77 kg
SO2	74.24 kg	52.12 kg	22.12 kg	442.37 kg
NOx	199.87 kg	140.31 kg	59.56 kg	1,191.00 kg
Total:				
CO2	261,756.67 kg	183,757.45 kg	77,999.22 kg	1,559,770.77 kg
SO2	74.24 kg	52.12 kg	22.12 kg	442.37 kg
NOx	199.87 kg	140.31 kg	59.56 kg	1,191.00 kg

NIST BLCC 5.3-22: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology in OMB Circular A-94

Base Case: Baseline - No PV option 3

Alternative: Option 3T PV Roof Only (Tax No SMART)

General Information

File Name:	T:\Dore & Whittier - 894\117 Consentino MS\PV Study\Contentio PV Study BLCC5.xml
Date of Study:	Fri Oct 13 08:58:07 EDT 2023
Project Name:	Contentino Middle School
Project Location:	Massachusetts
Analysis Type:	OMB Analysis, Non-Energy Project
Analysis Purpose:	Public Investment or Regulatory Analysis
Analyst:	Jeff Bagdasarian
Base Date:	June 1, 2024
Service Date:	June 1, 2024
Study Period:	20 years 0 months (June 1, 2024 through May 31, 2044)
Discount Rate:	2.4%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	\$0	\$505,680	-\$505,680
Future Costs:			
Energy Consumption Costs	\$3,762,561	\$2,641,379	\$1,121,182
Energy Demand Charges	\$0	\$0	\$0
Energy Utility Rebates	\$0	\$0	\$0
Water Costs	\$0	\$0	\$0
Recurring and Non-Recurring OM&R Costs	\$0	\$115,200	-\$115,200
Capital Replacements	\$0	\$25,000	-\$25,000
Residual Value at End of Study Period	\$0	\$0	\$0
	-----	-----	-----
Subtotal (for Future Cost Items)	\$3,762,561	\$2,781,578	\$980,982
	-----	-----	-----
Total PV Life-Cycle Cost	\$3,762,561	\$3,287,258	\$475,302

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings \$1,005,982

- Increased Total Investment \$530,680

Net Savings \$475,302

Savings-to-Investment Ratio (SIR)

SIR = 1.90

Adjusted Internal Rate of Return

AIRR = 5.73%

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback occurs in year 10

Discounted Payback occurs in year 11

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	793,030.0 kWh	556,720.0 kWh	236,310.0 kWh	4,725,553.0 kWh

Energy Savings Summary (in MBtu)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	2,705.9 MBtu	1,899.6 MBtu	806.3 MBtu	16,124.3 MBtu

Emissions Reduction Summary

Energy Type	-----Average Base Case	Annual Alternative	Emissions----- Reduction	Life-Cycle Reduction
Electricity				
CO2	261,756.67 kg	183,757.45 kg	77,999.22 kg	1,559,770.77 kg
SO2	74.24 kg	52.12 kg	22.12 kg	442.37 kg
NOx	199.87 kg	140.31 kg	59.56 kg	1,191.00 kg
Total:				
CO2	261,756.67 kg	183,757.45 kg	77,999.22 kg	1,559,770.77 kg
SO2	74.24 kg	52.12 kg	22.12 kg	442.37 kg
NOx	199.87 kg	140.31 kg	59.56 kg	1,191.00 kg

NIST BLCC 5.3-22: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology in OMB Circular A-94

Base Case: Baseline - No PV option 3

Alternative: Option 4 PV Roof Only (With SMART)

General Information

File Name:	T:\Dore & Whittier - 894\117 Consentino MS\PV Study\Contentio PV Study BLCC5.xml
Date of Study:	Fri Oct 13 08:56:05 EDT 2023
Project Name:	Contentino Middle School
Project Location:	Massachusetts
Analysis Type:	OMB Analysis, Non-Energy Project
Analysis Purpose:	Public Investment or Regulatory Analysis
Analyst:	Jeff Bagdasarian
Base Date:	June 1, 2024
Service Date:	June 1, 2024
Study Period:	20 years 0 months (June 1, 2024 through May 31, 2044)
Discount Rate:	2.4%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	\$0	\$737,400	-\$737,400
Future Costs:			
Energy Consumption Costs	\$3,762,561	\$2,641,379	\$1,121,182
Energy Demand Charges	\$0	\$0	\$0
Energy Utility Rebates	\$0	-\$206,980	\$206,980
Water Costs	\$0	\$0	\$0
Recurring and Non-Recurring OM&R Costs	\$0	\$115,200	-\$115,200
Capital Replacements	\$0	\$25,000	-\$25,000
Residual Value at End of Study Period	\$0	\$0	\$0
	-----	-----	-----
Subtotal (for Future Cost Items)	\$3,762,561	\$2,574,598	\$1,187,963
	-----	-----	-----
Total PV Life-Cycle Cost	\$3,762,561	\$3,311,998	\$450,563

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings \$1,212,963

- Increased Total Investment \$762,400

Net Savings \$450,563

Savings-to-Investment Ratio (SIR)

SIR = 1.59

Adjusted Internal Rate of Return

AIRR = 4.81%

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback occurs in year 11

Discounted Payback occurs in year 13

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	793,030.0 kWh	556,720.0 kWh	236,310.0 kWh	4,725,553.0 kWh

Energy Savings Summary (in MBtu)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	2,705.9 MBtu	1,899.6 MBtu	806.3 MBtu	16,124.3 MBtu

Emissions Reduction Summary

Energy Type	-----Average Base Case	Annual Alternative	Emissions----- Reduction	Life-Cycle Reduction
Electricity				
CO2	261,756.67 kg	183,757.45 kg	77,999.22 kg	1,559,770.77 kg
SO2	74.24 kg	52.12 kg	22.12 kg	442.37 kg
NOx	199.87 kg	140.31 kg	59.56 kg	1,191.00 kg
Total:				
CO2	261,756.67 kg	183,757.45 kg	77,999.22 kg	1,559,770.77 kg
SO2	74.24 kg	52.12 kg	22.12 kg	442.37 kg
NOx	199.87 kg	140.31 kg	59.56 kg	1,191.00 kg

NIST BLCC 5.3-22: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology in OMB Circular A-94

Base Case: Baseline - No PV option 3

Alternative: Option 4T PV Roof Only Tax (With SMART)

General Information

File Name: T:\Dore & Whittier - 894\117 Consentino MS\PV Study\Contentio PV Study BLCC5.xml

Date of Study: Fri Oct 13 08:58:58 EDT 2023

Project Name: Contentino Middle School

Project Location: Massachusetts

Analysis Type: OMB Analysis, Non-Energy Project

Analysis Purpose: Public Investment or Regulatory Analysis

Analyst: Jeff Bagdasarian

Base Date: June 1, 2024

Service Date: June 1, 2024

Study Period: 20 years 0 months (June 1, 2024 through May 31, 2044)

Discount Rate: 2.4%

Discounting Convention: End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	\$0	\$520,680	-\$520,680
Future Costs:			
Energy Consumption Costs	\$3,762,561	\$2,641,379	\$1,121,182
Energy Demand Charges	\$0	\$0	\$0
Energy Utility Rebates	\$0	-\$206,980	\$206,980
Water Costs	\$0	\$0	\$0
Recurring and Non-Recurring OM&R Costs	\$0	\$115,200	-\$115,200
Capital Replacements	\$0	\$25,000	-\$25,000
Residual Value at End of Study Period	\$0	\$0	\$0
	-----	-----	-----
Subtotal (for Future Cost Items)	\$3,762,561	\$2,574,598	\$1,187,963
	-----	-----	-----
Total PV Life-Cycle Cost	\$3,762,561	\$3,095,278	\$667,283

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings \$1,212,963

- Increased Total Investment \$545,680

Net Savings \$667,283

Savings-to-Investment Ratio (SIR)

SIR = 2.22

Adjusted Internal Rate of Return

AIRR = 6.57%

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback occurs in year 9

Discounted Payback occurs in year 9

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	793,030.0 kWh	556,720.0 kWh	236,310.0 kWh	4,725,553.0 kWh

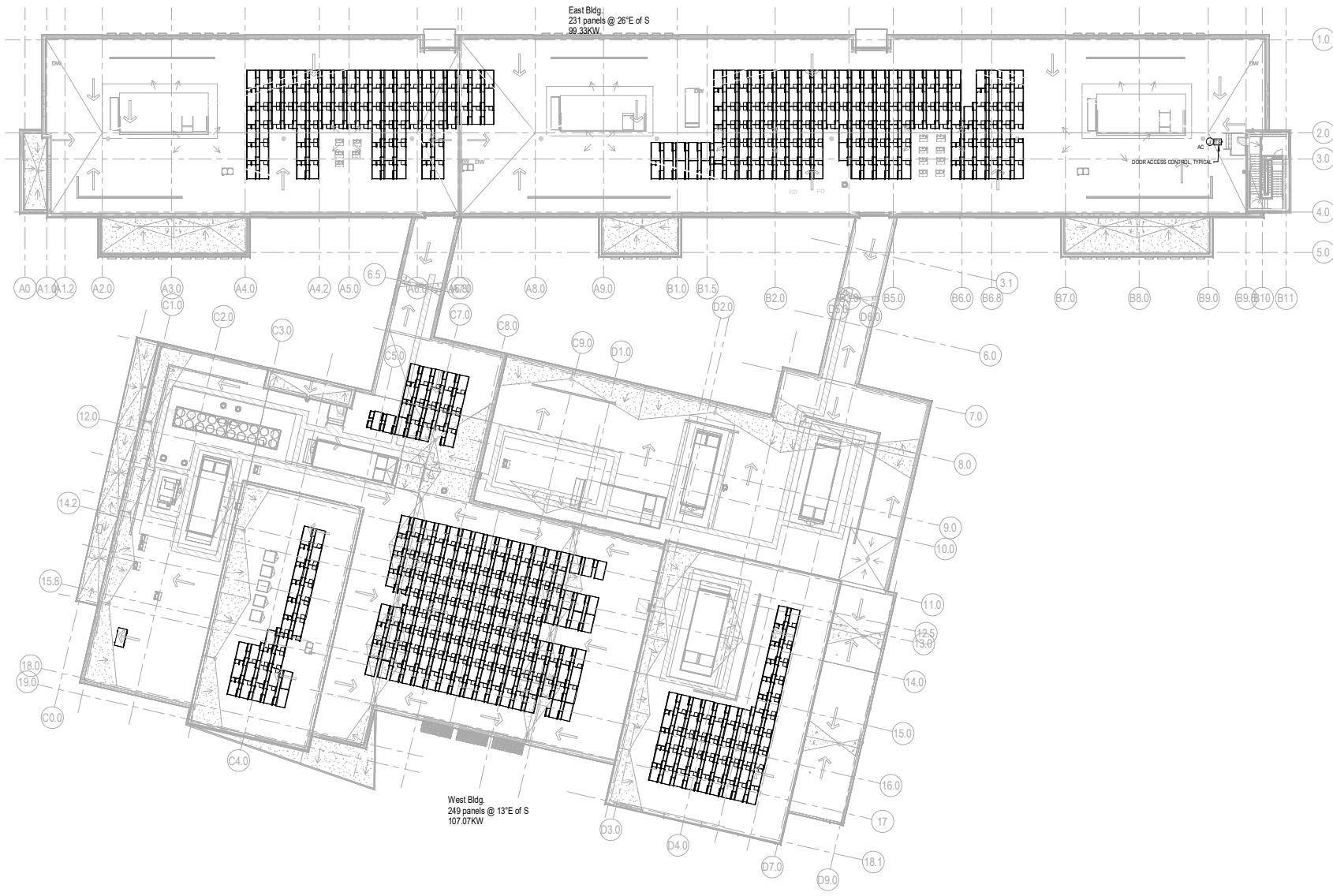
Energy Savings Summary (in MBtu)

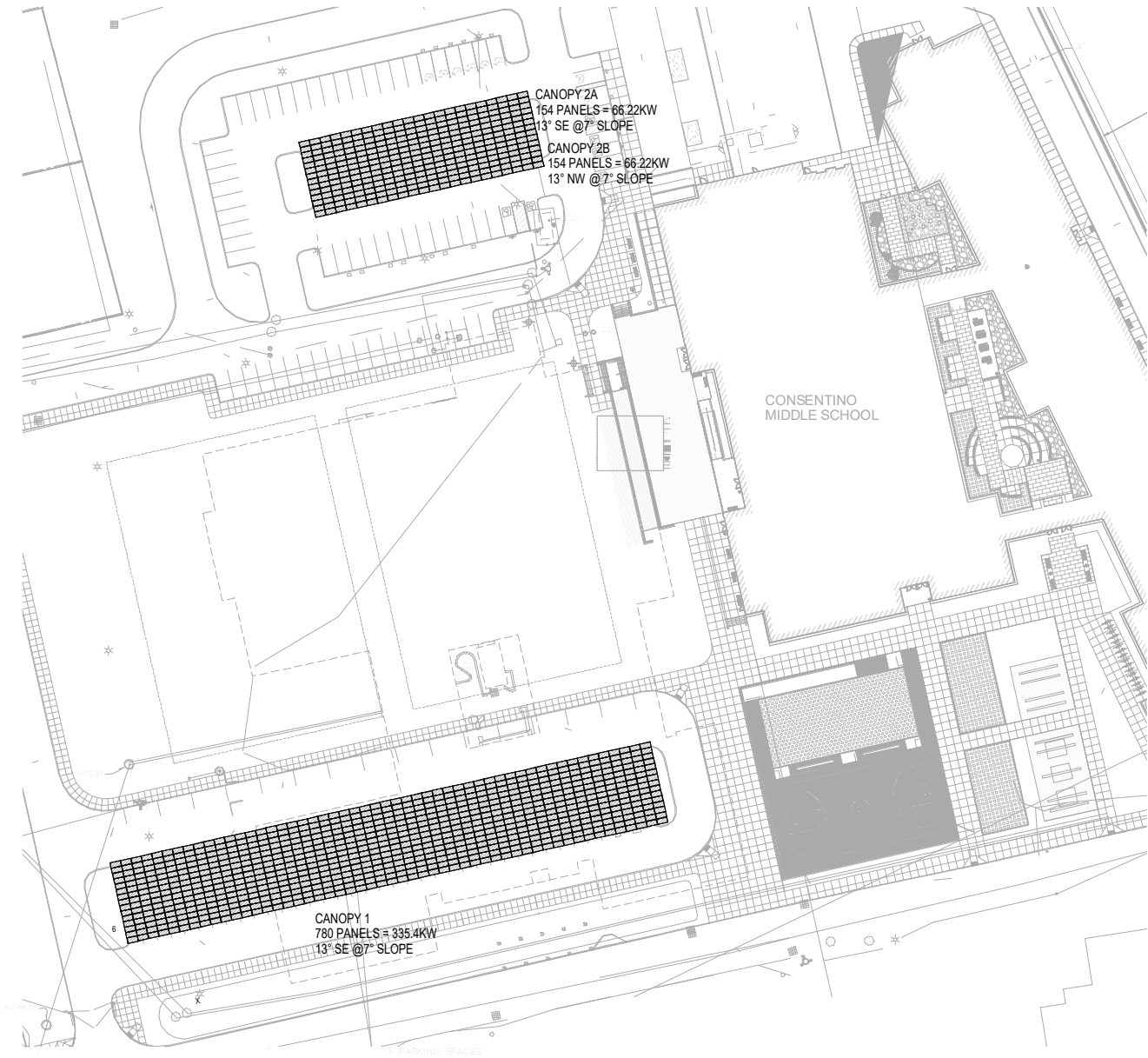
Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	2,705.9 MBtu	1,899.6 MBtu	806.3 MBtu	16,124.3 MBtu

Emissions Reduction Summary

Energy Type	-----Average Base Case	Annual Alternative	Emissions----- Reduction	Life-Cycle Reduction
Electricity				
CO2	261,756.67 kg	183,757.45 kg	77,999.22 kg	1,559,770.77 kg
SO2	74.24 kg	52.12 kg	22.12 kg	442.37 kg
NOx	199.87 kg	140.31 kg	59.56 kg	1,191.00 kg
Total:				
CO2	261,756.67 kg	183,757.45 kg	77,999.22 kg	1,559,770.77 kg
SO2	74.24 kg	52.12 kg	22.12 kg	442.37 kg
NOx	199.87 kg	140.31 kg	59.56 kg	1,191.00 kg

Appendix B





CANOPY 2A
164 PANELS = 66.22KW
13° SE @ 7° SLOPE

CANOPY 2B
154 PANELS = 66.22KW
13° NW @ 7° SLOPE

CONSENTINO
MIDDLE SCHOOL

CANOPY 1
780 PANELS = 335.4KW
13° SE @ 7° SLOPE

78 PARKING SPACES

Appendix C



RESULTS

381,745 kWh/Year*

System output may range from 366,399 to 395,641 kWh per year near this location.

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The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

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The energy output range is based on analysis of 30 years of historical weather data, and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

Month	Solar Radiation (kWh / m ² / day)	AC Energy (kWh)
January	2.00	17,457
February	2.33	18,290
March	3.99	33,454
April	5.30	40,958
May	5.80	45,240
June	5.91	43,496
July	6.17	46,409
August	5.68	42,907
September	4.68	35,038
October	3.29	26,335
November	2.11	17,050
December	1.78	15,112
Annual	4.09	381,746

Location and Station Identification

Requested Location	685 WASHINGTON STREET, HAVERHILL, MA
Weather Data Source	Lat, Lng: 42.77, -71.1 0.1 mi
Latitude	42.77° N
Longitude	71.10° W

PV System Specifications

DC System Size	335.4 kW
Module Type	Standard
Array Type	Fixed (open rack)
System Losses	14.08%
Array Tilt	7°
Array Azimuth	167°
DC to AC Size Ratio	1.25
Inverter Efficiency	96%
Ground Coverage Ratio	0.4
Albedo	From weather file
Bifacial	No (0)

	Jan	Feb	Mar	Apr	May	June
Monthly Irradiance Loss	16.4%	32.4%	6.8%	0%	0%	0%
	July	Aug	Sept	Oct	Nov	Dec
	0%	0%	0%	0%	6%	12.8%

Performance Metrics

DC Capacity Factor	13.0%
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RESULTS

75,371 kWh/Year*

System output may range from 72,341 to 78,114 kWh per year near this location.

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The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

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The energy output range is based on analysis of 30 years of historical weather data, and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

Month	Solar Radiation (kWh / m ² / day)	AC Energy (kWh)
January	2.00	3,447
February	2.33	3,611
March	3.99	6,605
April	5.30	8,087
May	5.80	8,932
June	5.91	8,588
July	6.17	9,163
August	5.68	8,471
September	4.68	6,918
October	3.29	5,200
November	2.11	3,366
December	1.78	2,984
Annual	4.09	75,372

Location and Station Identification

Requested Location	685 WASHINGTON STREET, HAVERHILL, MA
Weather Data Source	Lat, Lng: 42.77, -71.1 0.1 mi
Latitude	42.77° N
Longitude	71.10° W

PV System Specifications

DC System Size	66.22 kW
Module Type	Standard
Array Type	Fixed (open rack)
System Losses	14.08%
Array Tilt	7°
Array Azimuth	167°
DC to AC Size Ratio	1.25
Inverter Efficiency	96%
Ground Coverage Ratio	0.4
Albedo	From weather file
Bifacial	No (0)
Monthly Irradiance Loss	Jan Feb Mar Apr May June
	16.4% 32.4% 6.8% 0% 0% 0%
Monthly Irradiance Loss	July Aug Sept Oct Nov Dec
	0% 0% 0% 0% 6% 12.8%

Performance Metrics

DC Capacity Factor	13.0%
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RESULTS

65,415 kWh/Year*

System output may range from 62,785 to 67,796 kWh per year near this location.

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The energy output range is based on analysis of 30 years of historical weather data, and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

Month	Solar Radiation (kWh / m ² / day)	AC Energy (kWh)
January	1.34	2,112
February	1.74	2,594
March	3.32	5,492
April	4.80	7,386
May	5.56	8,631
June	5.76	8,447
July	5.96	8,926
August	5.26	7,914
September	4.05	6,012
October	2.57	4,009
November	1.47	2,195
December	1.12	1,695
Annual	3.58	65,413

Location and Station Identification

Requested Location	685 WASHINGTON STREET, HAVERHILL, MA
Weather Data Source	Lat, Lng: 42.77, -71.1 0.1 mi
Latitude	42.77° N
Longitude	71.10° W

PV System Specifications

DC System Size	66.22 kW
Module Type	Standard
Array Type	Fixed (open rack)
System Losses	14.08%
Array Tilt	7°
Array Azimuth	347°
DC to AC Size Ratio	1.25
Inverter Efficiency	96%
Ground Coverage Ratio	0.4
Albedo	From weather file
Bifacial	No (0)

	Jan	Feb	Mar	Apr	May	June
Monthly Irradiance Loss	16.4%	32.4%	6.8%	0%	0%	0%
	July	Aug	Sept	Oct	Nov	Dec
Monthly Irradiance Loss	0%	0%	0%	0%	6%	12.8%

Performance Metrics

DC Capacity Factor	11.3%
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The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

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The energy output range is based on analysis of 30 years of historical weather data, and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

113,340 kWh/Year*

System output may range from 108,784 to 117,466 kWh per year near this location.

Month	Solar Radiation (kWh / m ² / day)	AC Energy (kWh)
January	2.11	5,421
February	2.42	5,600
March	4.08	10,016
April	5.37	12,080
May	5.82	13,198
June	5.92	12,670
July	6.18	13,508
August	5.73	12,570
September	4.74	10,344
October	3.40	7,966
November	2.20	5,242
December	1.88	4,723
Annual	4.15	113,338

Location and Station Identification

Requested Location	685 WASHINGTON STREET, HAVERHILL, MA
Weather Data Source	Lat, Lng: 42.77, -71.1 0.1 mi
Latitude	42.77° N
Longitude	71.10° W

PV System Specifications

DC System Size	99.33 kW
Module Type	Standard
Array Type	Fixed (roof mount)
System Losses	14.08%
Array Tilt	10°
Array Azimuth	154°
DC to AC Size Ratio	1.25
Inverter Efficiency	96%
Ground Coverage Ratio	0.4
Albedo	From weather file
Bifacial	No (0)

	Jan	Feb	Mar	Apr	May	June
Monthly Irradiance Loss	16.4%	32.4%	6.8%	0%	0%	0%
	July	Aug	Sept	Oct	Nov	Dec
Monthly Irradiance Loss	0%	0%	0%	0%	6%	12.8%

Performance Metrics

DC Capacity Factor	13.0%
---------------------------	--------------



RESULTS

122,970 kWh/Year*

System output may range from 118,026 to 127,446 kWh per year near this location.

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The energy output range is based on analysis of 30 years of historical weather data, and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

Month	Solar Radiation (kWh / m ² / day)	AC Energy (kWh)
January	2.15	5,957
February	2.45	6,122
March	4.12	10,882
April	5.39	13,044
May	5.83	14,260
June	5.92	13,649
July	6.20	14,585
August	5.75	13,594
September	4.79	11,261
October	3.43	8,661
November	2.24	5,752
December	1.92	5,202
Annual	4.18	122,969

Location and Station Identification

Requested Location	685 WASHINGTON STREET, HAVERHILL, MA
Weather Data Source	Lat, Lng: 42.77, -71.1 0.1 mi
Latitude	42.77° N
Longitude	71.10° W

PV System Specifications

DC System Size	107.07 kW
Module Type	Standard
Array Type	Fixed (roof mount)
System Losses	14.08%
Array Tilt	10°
Array Azimuth	167°
DC to AC Size Ratio	1.25
Inverter Efficiency	96%
Ground Coverage Ratio	0.4
Albedo	From weather file
Bifacial	No (0)

Monthly Irradiance Loss	Jan	Feb	Mar	Apr	May	June
	16.4%	32.4%	6.8%	0%	0%	0%
Monthly Irradiance Loss	July	Aug	Sept	Oct	Nov	Dec
	0%	0%	0%	0%	6%	12.8%

Performance Metrics

DC Capacity Factor	13.1%
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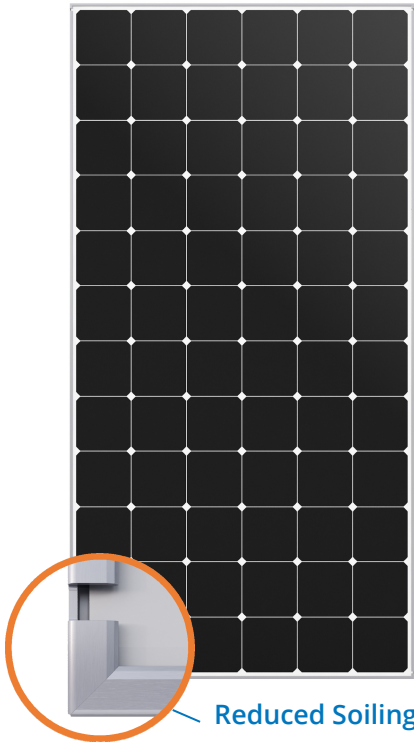
Appendix D



430–450 W Commercial A-Series Panels

SunPower® Maxeon® Technology

SunPower® Maxeon® cell-based panels maximize energy production and savings by combining industry-leading power, efficiency, and durability with the best power, product, and service warranty in the industry.^{1,2}



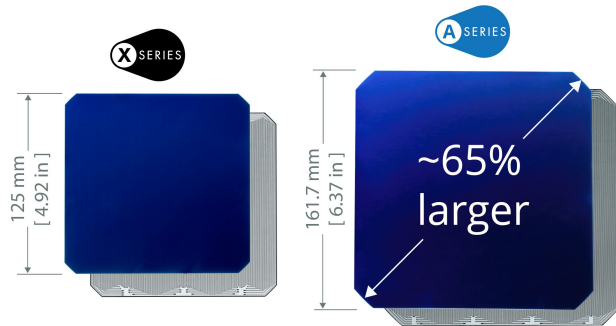
Reduced Soiling

NEW drainage notch improves performance



Highest Power Density Available

SunPower's new Maxeon® Gen 5 cell is 65% larger than prior generations, delivering the most powerful cell and highest efficiency panel in commercial solar. The result is more power per square meter than any commercially available solar.¹



SUNPOWER MAXEON SOLAR CELL TECHNOLOGY



Fundamentally Different. And Better.

- Most efficient cell in commercial solar²
- Delivers unmatched reliability³
- Patented solid metal foundation prevents breakage and corrosion

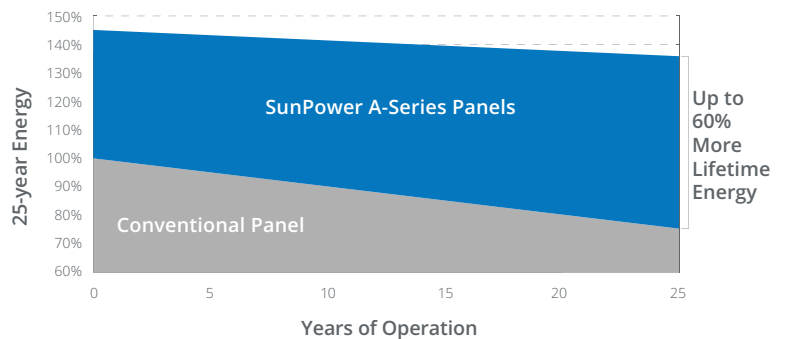
As sustainable as the energy it produces.

- Achieved the #1 ranking on the Silicon Valley Toxics Coalition's Solar Scorecard for 3 years running
- SunPower modules can contribute to your business's LEED certification⁴



Maximum Lifetime Energy and Savings

Designed to deliver up to 60% more energy from the same space over the first 25 years in real-world conditions like partial shade and high temperatures.¹



Best Reliability, Best Warranty

SunPower technology is proven to last and we stand behind our panels with the industry's best 25-year Combined Power, Product and Service Warranty.

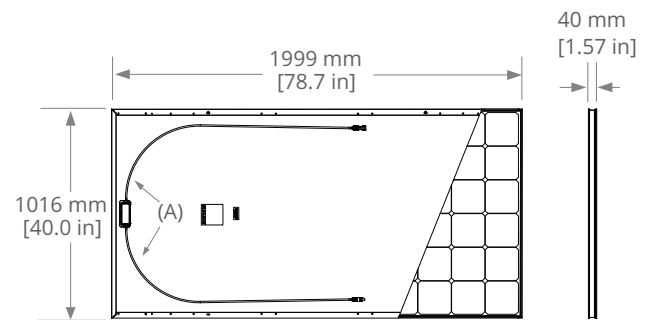


430–450 W Commercial A-Series Panels

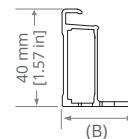
Electrical Data			
	SPR-A430-COM	SPR-A440-COM	SPR-A450-COM
Nominal Power (P _{nom}) ⁵	430 W	440 W	450 W
Power Tolerance	+5/0%	+5/0%	+5/0%
Panel Efficiency	21.2%	21.7%	22.2%
Rated Voltage (V _{mpp})	42.7 V	43.4 V	44.0 V
Rated Current (I _{mp})	10.1 A	10.2 A	10.2 A
Open-Circuit Voltage (V _{oc})	51.2 V	51.6 V	51.9 V
Short-Circuit Current (I _{sc})	10.9 A	10.9 A	11.0 A
Max. System Voltage	1500 V UL		
Maximum Series Fuse	20 A		
Power Temp Coef.	-0.29% / ° C		
Voltage Temp Coef.	-136 mV / ° C		
Current Temp Coef.	5.7 mA / ° C		

Tests And Certifications	
Standard Tests	UL1703
Quality Management Certs	ISO 9001:2015, ISO 14001:2015
EHS Compliance	OHSAS 18001:2007, lead free, Recycle Scheme
Ammonia Test	IEC 62716 (Pending)
Desert Test	MIL-STD-810G (Pending)
Salt Spray Test	IEC 61701 (maximum severity) (Pending)
PID Test	1500 V: IEC 62804
Available Listings	UL, CEC

Operating Condition And Mechanical Data	
Temperature	-40° F to +185° F (-40° C to +85° C)
Impact Resistance	1 inch (25 mm) diameter hail at 52 mph (23 m/s)
Appearance	Class A
Solar Cells	72 Monocrystalline IBC cells
Tempered Glass	High-transmission tempered anti-reflective
Junction Box	IP-68, TE (PV4S)
Weight	47.7 lbs (21.6 kg)
Max. Load	Wind: 75 psf, 3500 Pa, 357 kg/m ² front & back Snow: 125 psf, 6000 Pa, 612 kg/m ² front
Frame	Class 2 silver anodized



FRAME PROFILE



(A) Cable Length: 1320 mm +/-10 mm [52 in +/-0.4 in]

(B) Long Side: 32 mm [1.3 in]

Short Side: 24 mm [0.9 in]

Please read the safety and installation guide.

1 SunPower 450 W, 22.2% efficient, compared to a Conventional Panel on same-sized arrays (310 W, 16% efficient, approx. 2.0 m²), 4.9% more energy per watt (based on PVsyst pan files for avg US climate), 0.5%/yr slower degradation rate (Jordan, et. al. "Robust PV Degradation Methodology and Application." PVSC 2018).

2 Based on search of datasheet values from websites of top 20 manufacturers per IHS, as of January 2019.

3 #1 rank in "Fraunhofer PV Durability Initiative for Solar Modules: Part 3". PVTech Power Magazine, 2015. Campeau, Z. et al. "SunPower Module Degradation Rate," SunPower white paper, 2013.

4 A-Series panels additionally contribute to LEED Materials and Resources credit categories.

5 Standard Test Conditions (1000 W/m² irradiance, AM 1.5, 25° C). NREL calibration Standard: SOMS current, LACCS FF and Voltage.

See www.sunpower.com/company for more reference information.

For more details, see extended datasheet: www.sunpower.com/solar-resources. Specifications included in this datasheet are subject to change without notice.

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