Feasibility Study

For a

PV Solar System

Located at

586 Manley Street
West Bridgewater, MA

December 8, 2024

Prepared by: **General Solar, Inc.**
Mark Braconnier
Nawfal Labzae
Tariq Melethil
Daniel Pinto

Executive Summary

This feasibility study was commissioned to assist National Development in evaluating the viability of installing a solar PV system on a warehouse building roof located at 586 Manley Street, West Bridgewater, MA. The potential for energy production is evaluated for the location based on a review of building specifications and plans provided by National Development, an on-site survey, available solar irradiance data for the site and utility provider information. The energy evaluation, along with National Development's motivations and goals for the system, are incorporated into a system design and cost estimate. A net present value financial model is then used to evaluate the potential financial benefits of the system.

The building's flat roof, which is not adversely impacted by shading and is mostly unencumbered by any obstructions, is ideal for the installation of a PV system. The roof has sufficient south-east facing sun exposure and has been specifically designed with extra load bearing capacity for the addition of a solar system. The recommended PV system design was determined to be a 513.4 kWdc rated system, comprised of 828 Canadian Solar 620W modules, 18 SMA string inverters, 36 DC combiner/disconnects and a PanelClaw 10-degree, fixed-tilt, ballasted racking system which eliminates the need for any roof penetrations. The system is projected to generate about 671,300 kWh per year, which represents 52.4% of the expected on-site electricity use of 1,281,000 kWh/year.

The system is estimated to cost about $1,133,000 (about $2.21/kWdc) and qualifies for a Federal Investment Tax Credit of $339,900 (30% of system cost), resulting in a net system cost of $793,100. The NPV model results are significantly positive, indicating that the system would be a good financial investment. It is therefore recommended that the owner proceed with installation of the PV system.

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1. Background Information

National Development ("ND") is one of the largest real estate investment, development, construction and asset management firms in New England, with corporate offices located in Newton Lower Falls, Massachusetts. Over the past 40 years, ND has developed a diverse portfolio of mixed-use, hotel, retail, life science, office, multifamily, senior housing and industrial projects totaling over 30 million square feet. ND has also been a leader in sustainability efforts for many different asset types, including development of several projects with PV solar arrays. [National Development] [1]

1.1 Project Location

The proposed project is located on an ND property at 586 Manley Street in West Bridgewater, Massachusetts, which is located at latitude 42°2'47" North, longitude 71°3'38" West [Google Earth] [2], at elevation 119.9 feet above sea level. [Map developers] [3]

1.2 Site Description

The site is located on the periphery of an area that is predominantly developed with industrial/warehouse buildings. Property uses in the immediate vicinity include a mix of industrial/warehouse, residential, religious organizations, conservation land as well as an adjoining ground-mounted solar array. A satellite view map of the site during construction of a new industrial/warehouse building is shown below in Figure 1.

Figure 1: Map of 586 Manley Street, West Bridgewater, MA [Mapquest] [4]

National Development recently completed construction of a 210,000 square foot (700 feet x 300 feet) industrial/warehouse building on the site, which is not yet leased. The building's flat roof is an ideal location to mount a solar PV array as the roof is unencumbered by obstructions and is not adversely impacted by any shading.

ND provided the new building site plan with building specifications shown below in Figure 2 and a potential multi-tenant building plan shown below in Figure 3. The building has a 2,500 amp electrical service as shown in the building specifications listed in Figure 2. The electrical service, which is located in the electrical room shown in the upper right corner of the building plan in Figure 3, can be split into multiple electrical panels if

the building is leased to more than one tenant. During a site visit to the project location by Group 2 team members on October 29, 2024, pictures were taken of the south-facing building facade, the building interior, and the electrical load center which are provided below in Figures 4, 5 and 6, respectively.

Figure 2: New Building Site Plan and Specifications - 586 Manley Street [National Development]

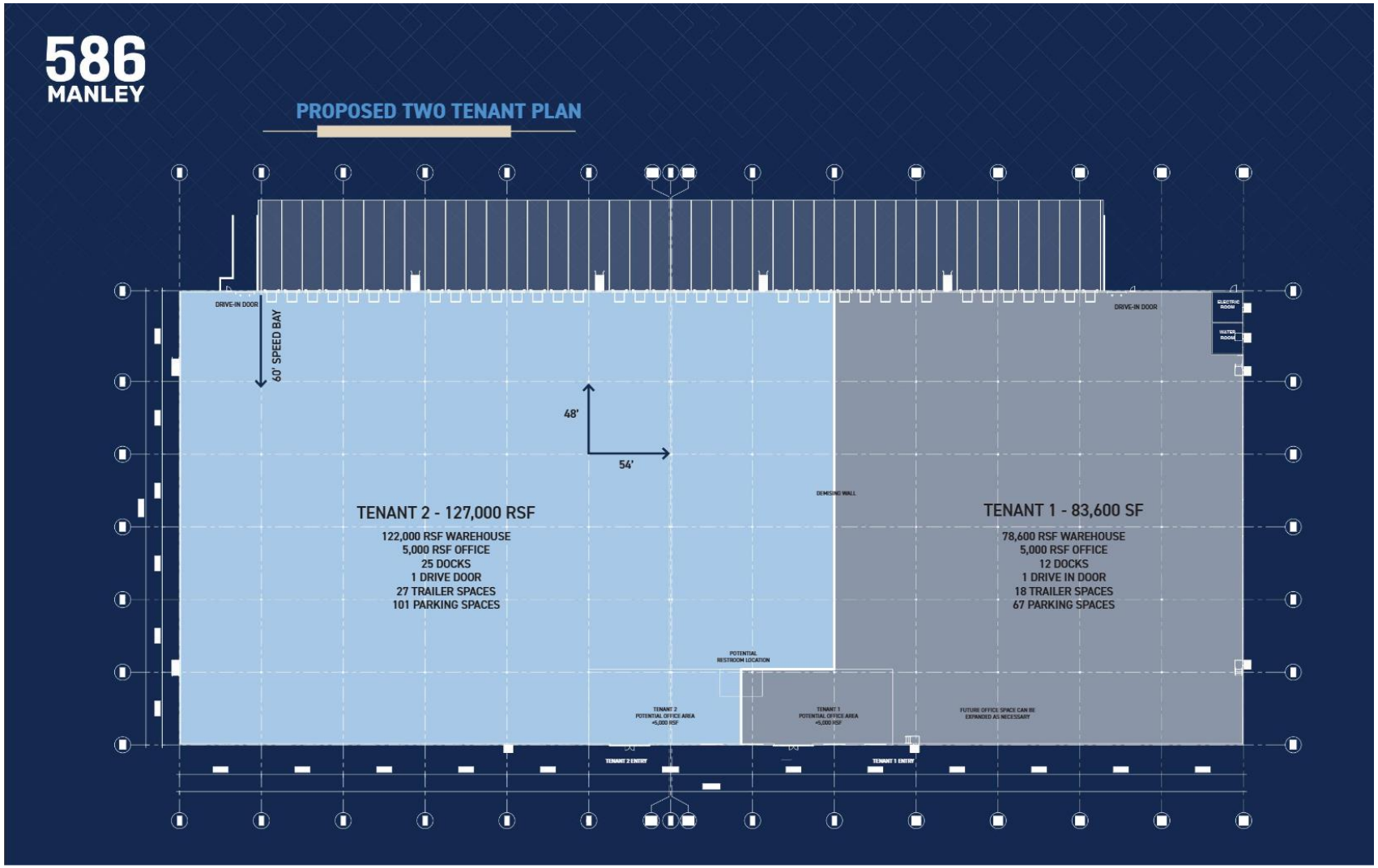

Figure 3: Possible Multi-Tenant Building Plan (the Electrical Room is located in the upper right corner) - 586 Manley Street [National Development]

Figure 4: South-Facing Building Facade - 586 Manley Street [from site visit on 10/29/24]

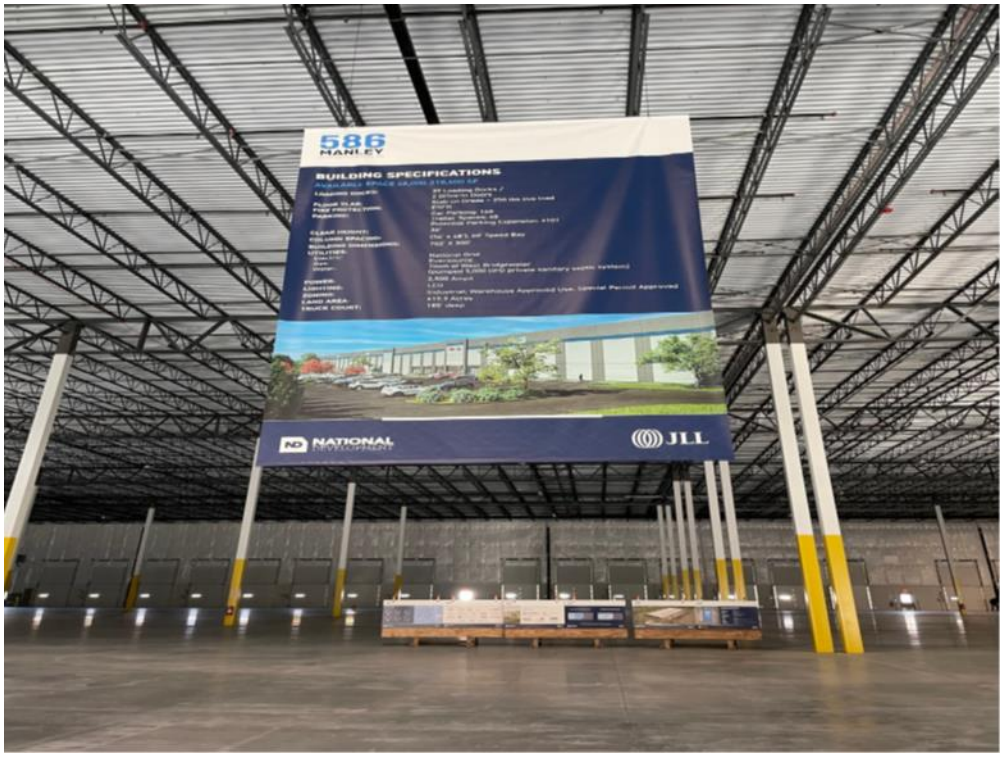

Figure 5: Building Interior - 586 Manley Street [from site visit on 10/29/24]

Figure 6: Electrical Load Center - 586 Manley Street [from site visit on 10/29/24]

1.3 Owner's rationale for installing a PV system

The owner would like to install a PV system on the building roof sized to supply 50% of the projected electricity demand from on-site uses, with net metering of any unused, excess electricity back to National Grid throughout a given day. In addition to energy cost savings, the PV system would also serve to enhance the owner's green initiative goals and marketplace image.

1.4 Owner's maximum budget for the PV system

The owner has a budget of $1,200,000 for the upfront PV system costs, before consideration of any tax incentive benefits. As such, the PV system is projected to be sized around 525 kWdc based on conservatively estimated upfront system costs of approximately $2.25 per Wdc. [SEIA] [5]

1.5 Owner's Electrical Demand and Utility Information

Since there is not any actual history of electricity use for the building, the average electricity use for a future non-refrigerated warehouse tenant is estimated to be about 6.1 kilowatt-hours (kWh) per square foot annually. [Esource.bizenergyadvisor] [6] This would equate to an electricity use of approximately 1,281,000 kWh/year or 106,750 kWh/month for the entire 210,000 sq. ft. building. Using the PVWatts Calculator, a preliminary estimate of annual energy production for a 525kWdc system size (using standard modules, fixed open racking, 14.08% system losses, an array tilt angle of 10 degrees, and a system azimuth angle of 165 degrees true, and an average of 3% soiling losses) indicated the system should generate around 634,000 kWh/year of AC energy, or about half of the annual energy demand for a fully-occupied building. [PVWatts] [7]

A 525kWdc solar system located at 586 Manley Street, which is in the National Grid SEMA service area, and which primarily serves on-site load is eligible to participate as a Cap-Exempt, Class II Net Metering Facility (for systems between 60 kW and 1,000 kW in size) as per the Code of Massachusetts Regulations (220 CMR 18:00). The net metering program allows for the export of any excess on-site solar-generated energy throughout a particular day to the electric grid in exchange for credits that are close to the fully-loaded retail rates charged by National Grid. [MA 220 CMR 18.00] [8] The net metering credits will be automatically applied against the tenant's monthly charges for electricity used when the solar system is not generating electricity or rolled forward to the next month if the credits exceed the monthly charges. [MA Net Metering] [9]

With projected average monthly electrical usage of 106,750 kWh and Demand estimated to be less than 200 kW [National Grid] [10], the electrical rates would fall under

National Grid's General Service – Demand G-2 rate structure [National Grid] [11]. A summary of the rates for the G-2 Delivery Service are provided below in Table 1.

Table 1: National Grid's G-2 Delivery Service Rate Structure [11]

Customer Charge ($ per month)	45.00
Distribution Demand Charge, measured at Peak 15-miunte monthly use period ($ per kW)	14.76
Distribution Energy Charge ($ per kWh)	0.01388
Transition Charge ($ per kWh)	0.03105
Transition Energy Charge ($ per kWh)	(0.00049)
Energy Efficiency Charge ($ per kWh)	0.00886
Renewables Charge ($ per kWh)	0.00050
Net Metering Recovery Surcharge ($ per kWh)	0.01232
Distribution Solar Charge ($ per kWh)	0.00471
Electric Vehicle Program Charge ($ per kWh)	0.00027
Total G-2 Delivery Service Rate ($ per kWh):	0.07110

In addition, the tenant will also be charged for actual energy usage through either the National Grid Electric Supply Industrial fixed priced or variable priced rates for the SEMA service area. The fixed price electric supply rates for the period 2/1/2023 through 1/31/2025 vary from $0.10744/kWh to $0.22899/kWh. [National Grid] [12]

2. Technical Analysis

2.1 Site Characterization

The 700 feet long x 300 feet wide industrial/warehouse building constructed on the site has a flat roof that is not adversely impacted by any shading and is unencumbered by obstructions except for two heating units and a roof access hatch as noted on the recently taken picture of the building shown below in Figure 7.

Figure 7 – Roof of Warehouse Building at 586 Manley Street [ND] [13]

Based on building plan notes provided by ND, along with observations from the October 29, 2024 site visit, it was determined that the average roof height of the building is 41.25 feet above grade level and has a 3% slope from/to each of the building's 700 foot long side walls (elevation 39 feet) to/from the roof highpoint at the building center line (elevation 43.5 feet). The plan notes also indicate that the roof was designed with an 8 pounds per square foot dead load allowance to accommodate the addition of a PV system. A compass reading taken during the site visit indicates the orientation of the 700 feet long southern building facade to be facing about 165° True South after adjusting for the magnetic variation correction for West Bridgewater. [NOAA -NCEI] [14]

The average annual irradiance of the site is approximately 4.88 kWh/m^2/day based on the irradiance data provided for the bordering town of Brockton, MA. [Solar Energy Local] [15] The average monthly solar radiation values are displayed below in Figure 8.

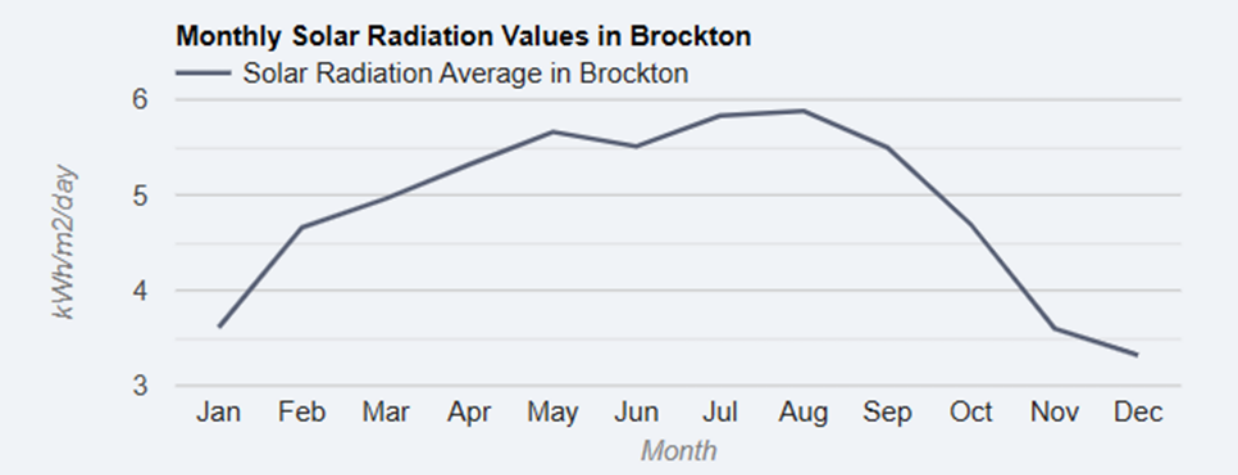

Figure 8 – Average Monthly Solar Radiation in Brockton, MA [Solar Energy Local] [15]

2.2 Recommended PV System Size

The recommended system size to achieve the owner's desired goal for a solar system that produces 50% of the expected annual on-site electricity use, with a maximum budget of $1,200,000, was determined to be a 513.4 kWdc rated system comprised of 828 modules rated at 620Wdc/module, 18 string inverters and a fixed-tilt ballasted racking system. [Helioscope] [16]

2.3 System Performance, Description, Design and Specifications

The 513.4 kWdc system is projected to generate about 671,300 kWh per year, which represents 52.4% of the expected on-site electricity use of 1,281,000 kWh/year. The system has a performance ratio of 84.0% and a system yield of 1,307.6 hours.

2.3.a System Description and Design

Updated satellite imagery of the newly constructed building was not available, however, Helioscope allows for simulation of the solar array placed at the location at the height of the building roof. The system modules are simulated to be located in two array areas on the eastern portion of the building roof closest to Manley Street to optimize system wiring requirements as shown below in Figure 9. The northeastern corner of the building was kept free of solar panels

due to the presence of the roof access hatch and to provide additional room for system electrical wiring to be brought down into the building electrical load center which is located directly below.

Figure 9 – Solar Module Location on Building Roof [Helioscope] [16]

The Building Commissioner for the Town of West Bridgewater indicated that the Town does not require a minimum setback from building side walls for commercial solar systems, however, a minimum perimeter setback of 3-1/2 feet was used to allow for ease of access for system installation and for future system and roof maintenance requirements. The system is designed with the solar modules in landscape position, facing toward the southern side of the building with a system azimuth of 164.7 degrees and a fixed racking tilt angle of 10 degrees. The 3% roof slope (which adds 1.72 degrees of tilt angle to the southern array section and subtracts 1.72 degrees of tilt angle from the northern array section) was also accounted for in the Helioscope modeling. The system is also designed with the fixed racking system's specified maximum row spacing of 1.45 feet and module to module spacing of 1/2 inch. The combination of the relatively

low system tilt angles and row spacing serve to minimize inter-row shading, allowing for the placement of more modules and overall higher system energy generation.

2.3.b Schedule of Components and Datasheets

The major system components, which include 828 Canadian Solar CS6.2-66TB-620W bifacial solar modules, PanelClaw-clawFR 10 degree fixed-tilt ballasted racking system, and 18 SMA Sunny Tripower 24000TL-US (1000V) inverters, are listed below in Table 2.

Table 2: Schedule of Major System Components for the Recommended PV System

Component	Description	Quantity
Modules	Canadian Solar , CS6.2-66TB- 620W (1000V)	828
Racking	PanelClaw-clawFR 10 degree fixed-tilt	828
Inverters	Sunny Tripower 24000TL-US (SMA)	18
AC Panels	6 input AC Panel	3
AC Home Runs from AC Panels to Utility Interconnect	1/0 AWG (Copper)	3 (2,596.4 ft.)
AC Home Runs from Inverters to AC Panels	1 AWG (Copper)	18 (4,127.0 ft.)
Home Runs from Combiners to Inverters	6 AWG (Copper)	36 (1,859.7 ft.)
Combiners	1 input Combiner	18
Combiners	2 input Combiner	18
Module Strings to Combiners	10 AWG (Copper)	54 (2,420.8 ft.)

The Canadian Solar CS6.2-66TB 620W bifacial module was selected to maximize system output with fewer panels and allow for a greater area for possible system expansion. The module datasheet is provided in Appendix 5.2. The module is rated for 1000V commercial-scale systems, has an efficiency rating of 23%, and is also bifacial which allows for increased system power gain with the capture of solar irradiance that will be reflected off the white building roof onto the back

of a module. The majority of all solar panels imported into the U.S. are now bifacial modules. [NREL] [17] Canadian Solar is also a leader in global panel manufacturing. [Statista] [18]

The PanelClaw-clawFR 10 degree fixed-tilt ballasted racking system was chosen as PanelClaw specializes in flat roof racking with a simple to install system that has a 25-year warranty, a ZAM coating that is 5 times more corrosion resistant than standard galvanized 90 coating, integrated roof protection pads, continuous system grounding and also allows for 90 degree module tilt-up with a clear walking path between module rows for ease of panel servicing. The clawFR system can be installed as a fully-ballasted system, without any mechanical fasteners penetrating the roof. The system is also designed for wind exposure category B with basic wind speed up to 190 mph, which meets or exceeds the wind design thresholds for the building roof. The ballast locations and density can also be easily adjusted for areas with expected higher wind pressures, such as along the roof edges closer to the parapet walls. [PanelClaw] [19]

The datasheet for the SMA Sunny Tripower 24000TL-US inverter is provided in Appendix 5.3. The SMA inverter has a peak efficiency above 98% and comes with integrated shading management software, full grid management functionality, and online communications and monitoring at no extra costs. [SMA] [20] Since the recommended solar system is not adversely impacted by any shading other than minimal inter-row module shading, the integrated SMA shading software is deemed sufficient to optimize each of the 54 module strings, eliminating the requirement and corresponding expense of providing optimizers for each of the 828 modules.

2.3.c System Electrical Design and 1-Line Drawing

The 54 strings of modules are arranged in 18 strings with 18 modules/string and 36 strings with 14 modules/string. There are 18 inverters, each capturing DC current output from two combined 14-module strings and one 18-module string. The 18 inverters are divided equally to feed AC current into 3 separate outdoor panels, which then feed into the northeast corner of the

roof and down to the interconnection panel in the building electrical room. The system electrical design is shown below in Figure 10 with the described components noted. The system 1-line drawing is included in Section 5.4.

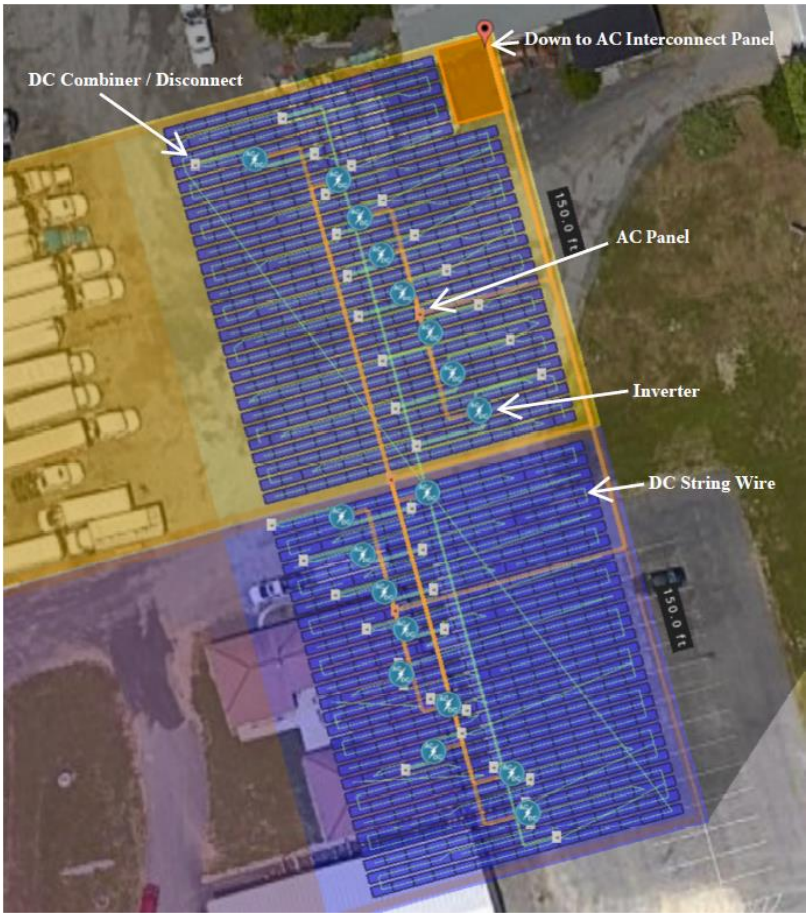

Figure 10 – System Electrical Design [Helioscope] [16]

2.3.d NEC Compliance for PV System

Article 690 of the NFPA-70 National Electric Code (NEC) specifies mandatory requirements for electrical components of PV systems. The maximum DC voltage and current for the system string and combined system circuits are listed below in Table 3, with details of how these values were calculated provided in Section 5.5.

Table 3: Maximum NEC Specified System Voltage and Current

Requirement	Source (String Circuit)	Combiner/System Output
Max Voltage (690.7)	53.72 V	967 V
Max Current (690.8)	20.1 A	40.2 A
Max Ampacity per (690.8(B)(1))	25.125 A	50.25 A
Max Ampacity per (690.8(B)(2))	20.94 A	41.88 A

The maximum voltage allowed by NEC 690.7 for a commercial system is 1000V, and the system meets this requirement. The NEC specifies the required conductor (690.8) and circuit breaker (690.9) sizing based on the maximum calculated current and ampacity values in Table 3 to ensure safe system operation under all conditions. The minimum copper conductor and breaker size for the string (source) circuits is 10 AWG and 30A, respectively. The minimum copper conductor and breaker size for the 2-string combiner circuits is 6 AWG and 60A, respectively.

In addition to the minimum NEC wire sizing requirements, the expected voltage losses for each of the system circuit conductors were also considered in making the conductor selection. The expected voltage losses as calculated by Helioscope for the chosen conductors are listed below in Table 4. The estimated combined conductor voltage loss of 3.6% is deemed as a favorable result and is below our targeted maximum acceptable voltage loss of 4.0%. The system DC/AC load ratio is noted as 1.19, which is also acceptable considering the expected seasonal irradiance in West Bridgewater.

Table 4: System Conductor Sizes and Expected Voltage Loss

Circuit	Wire Size	Voltage Loss
String to Combiner / DC Disconnect	10 AWG (Copper)	0.70%
Combiner / DC Disconnect to Inverter	6 AWG (Copper)	0.10%
Inverter to 6 Circuit AC Panel	1 AWG (Copper))	0.10%
6 Circuit AC Panel to the load center	1/0 AWG (Copper)	2.70%
Combined Expected Voltage Loss:		3.60%

2.3.d System Shading and Soiling Analysis

The system is not adversely impacted by any shading from trees or structures and was designed to avoid any shading concerns from the limited rooftop obstructions, which was confirmed through the Helioscope shading analysis feature. However, there is a 1.5% system shading loss estimated due to the inter-row module spacing, which is deemed to be acceptable. Additional consideration was included for increased snow soiling losses during the winter months of December through March, resulting in an average system soiling loss of 2.8%.

3. Financial Analysis

The financial analysis to follow reviews and confirms that the expected system costs are within the owner's budget of $1,200,000 and provides analysis of available incentives, operations and maintenance costs, projected energy savings and a net present value analysis.

3.1.a Installation - Hard Costs Estimates (all system components)

Hard costs are tangible costs directly related to the installation and operation of a PV system, which include costs for the system modules, racking, inverters, and wire listed above in Table 3. Pricing for the system components was determined through digital marketplaces and detailed discussions with solar industry supplier representatives from Greentech Renewables, Clear Energy Partners and Wholesale Solar Warehouse. Hard costs for the recommended 513.4

kWdc system are estimated to be about $453,000 ($0.88/W), including a 5% contingency allowance of $21,500, and are provided in estimate details in Section 5.6.

The NREL Fall 2023 Solar Industry Update report [17], the SEIA Solar Industry Research Data [5] and the actual installed system cost data from The Massachusetts Clean Energy Center [21] were also reviewed for solar system pricing metrics. The data indicates that hard costs for larger non-residential systems would potentially be below the estimate of $0.88/watt, particularly for flat roof-top systems with relatively simple racking requirements. However, the more conservative hard cost estimate was used in determining the total system costs.

3.1.b Installation - Soft Costs

Soft costs are comprised of all other non-hard costs items, including installation, permits, interconnection fees and developer expenses for overhead, administrative, sales & marketing, and profit margin which are listed below in Table 5.

Table 5: Soft Costs Estimate

Item	Estimated Cost	Comments
Installation Cost	$333,710	$0.65/Watt, Similar estimates provided by Greentech Renewables and Wholesale Solar
Building Permit Fee	$12,586	West Bridgewater, $16 per $1,000 of construction costs (hard cost plus installation)
Electrical Wiring Permit	$2,500	West Bridgewater (2% of wiring construction costs)
Pre-Application Report Fee	$750	National Grid
Interconnection Fee	$1,949	National Grid ($4.5/kWac)
General Overhead, Administrative, Sales & Marketing, and Profit	$328,364	Estimated at 29% of the Total System for a large commercial system
Total Soft Cost:	$679,859	

Installation cost estimates of $0.60/Wdc to $0.65/Wdc were provided by both Greentech Renewables and Wholesale Solar Warehouse. The other major soft cost category combining

developer expenses for overhead, administrative, sales & marketing, and profit margin is estimated to be about 29% of the total system costs, or about $0.64/Wdc. Both of these estimated expenses are more conservative than the installation and developer expense cost categories contained in the NREL Fall 2023 Solar Industry Update report for larger systems. The solar soft costs breakdown chart provided by the U.S. Department of Energy [22], that lists combined developer expenses as 38% of total system costs for smaller scale systems, was also considered when estimating the 29% for other developer expenses. The permit and interconnection fee amounts are sourced from West Bridgewater and National Grid websites.

3.1.c. Available Incentives that Offset Installation Cost

Massachusetts transitioned from a solar renewable energy credit (SREC) program to the Solar Massachusetts Renewable Target (SMART) incentive program at the end of 2018. The SMART incentives have recently been suspended for new projects in the National Grid services areas according to a notice on the SMART program website, therefore, the incentives are assumed to be unavailable for the recommended system. [23]

The available Federal solar incentive programs are the Solar Investment Tax Credit (ITC) or, as an alternative, the Production Tax Credit (PTC), but not both. The ITC allows businesses to deduct 30% of the cost of a solar energy system from the company's Federal taxes. Alternatively, the company can receive a Production Tax Credit for a ten year period based on $0.026/kWh of energy produced each year. [DOE] [24]

3.1.d Net System Costs

The combined system hard cost and soft costs are estimated to total $1,133,000 (about $2.21/kWdc), leaving an additional $67,000 in contingency under the $1,200,000 system budget.

The Federal ITC of 30% would result in a tax credit of $339,900. This compares more favorably than the alternative option to elect the PTC for the system which equates at most to about $174,540 in tax credits over 10 years (calculated as 671,300 kWh x $0.026/kWh = $17,454/year x 10 years, before adjustment for anticipated solar module degradation). The net system cost after applying the benefit of the ITC would be about $793,100.

3.2 Operations & Maintenance Costs

The solar panels and racking are manufactured for a useful service life of at least 25 years. However, the inverters and combiner boxes are expected to be replaced around year 12 at a cost of about $166,400, which is based on the initial cost for these components escalated by an average of 2.0%/year plus an additional allowance for future installation cost. There is not expected to be a need for frequent solar panel cleaning or regular snow removal based on typical weather patterns and air quality in West Bridgewater. However, an allowance of $6,000/year should be budgeted for an annual solar panel cleaning and/or possible snow removal expense during excessive snow events.

3.3 Estimated Savings Due to Energy Generated

As described in Section 1.5, the system will be eligible to participate in the Massachusetts Net Metering program since the energy generated will primarily serve on-site load. The net metering program allows for the export of any excess on-site solar-generated energy throughout a particular day to the electric grid in exchange for credits that are close to the fully-loaded retail rates charged by National Grid. Therefore, the estimated energy savings are calculated by multiplying the first-year energy generation of 671,300 kWh times a weighted National Grid average electricity rate of $0.2108/kWh, resulting in projected first-year energy savings of about $146,375 through energy cost avoidance. The calculation of the $0.2108/kWh weighted average electricity rate takes into consideration that about 86% of the expected annual solar irradiance,

and the corresponding PV system energy, is projected to be generated in the nine months from February through October. The weighted average electricity rate calculation details are provided in Section 5.7.

3.4 Net Present Value Model

The net present value (NPV) calculations are derived using an NPV model provided by UMass Lowell [Prof. Thomas], input values calculated from the recommended system and assumptions as described below in Table 6. Three different scenarios were modeled using conservative, likely and optimistic case assumptions as shown below in Table 7 along with the resultant NPV calculations for each scenario. Each of the 3 scenarios has a significantly positive NPV, indicating a decision to move forward with the system would be a good investment. The NPV model yearly cash flows results for each of the 3 scenarios are provided in Section 5.7.

Table 6: Input Variables for NPV Model Scenarios

Input Variable	Value	Source Reference
System Costs	$1,133,000	
Incentives	$339,900	Federal ITC (30%)
Net System Cost	$793,100	
Expected Annual Energy Production	671.3 MWh	
Market Discount Rate	4.60%	Federal Reserve
Loan Term Amortization	25 Years	Cambridge Savings Bank
Loan Interest Rate	7.00%	Cambridge Savings Bank
Average Value of Electricity	$0.2108/kWh	National Grid
Inflation Rate	2.50%	CPI
Tax Increase on System Costs after MA Exemption through Year 20	$28,733	MA.gov and West Bridgewater Tax Assessor

Table 7: Variable Assumptions for NPV Models and NPV Results

Input Variable	Conservative	Likely	Optimistic
Loan Interest Rate	8.40%	7.00%	5.90%
Annual Maintenance	$12,000	$6,000	$3,000
System Degradation Factor	6.00%	4.00%	3.00%
Market Discount Rate	6.00%	4.60%	3.50%
Property Tax Increase Rate	2.50%	2.00%	1.00%
Inverter and Combiner Replacement - YR12	$207,995	$166,396	$124,797
Inflation Rate	2.00%	2.50%	3.50%
NPV Results	$1,083,423	$1,639,199	$2,405,829

4. Recommendation

The location, which is not adversely impacted by any shading and is mostly unencumbered by any obstructions, is ideal for the installation of a PV system. The system is therefore relatively efficient and meets the owner's desired goals for energy cost savings and the promotion of green initiatives and an enhanced marketplace image. The system also does not have any significant ongoing operating or maintenance costs. The system is projected to generate annual electricity cost savings, and Investment Tax Credit value, that will likely result in a simple payback of the initial system cost investment in about five and one-half years. The significantly positive NPV results also indicate that the system would be a good investment. It is therefore recommended that the owner proceed with installation of the PV system.

5. Appendices

5.1 References

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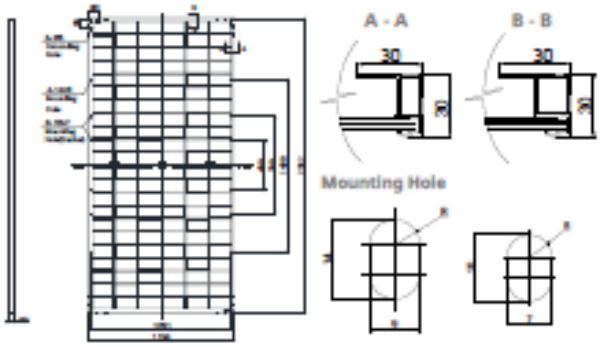
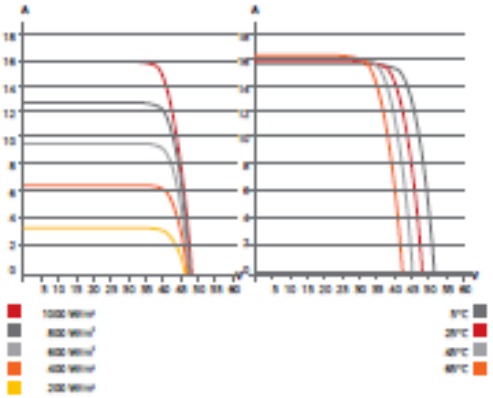
5.2 Canadian Solar CS6.2-66TB-620W Module Datasheet

ENGINEERING DRAWING (mm)



CS6.2-66TB-610 / I-V CURVES



ELECTRICAL DATA | STC*

		Nominal Max. Power (Pmax)	Opt. Operating Voltage (Vmp)	Opt. Operating Current (Imp)	Open Circuit Voltage (Voc)	Short Circuit Current (Isc)	Module Efficiency
CS6.2-66TB-600		600 W	40.4 V	14.86 A	47.6 V	15.85 A	22.2%
Bifacial Gain**	5%	630 W	40.4 V	15.60 A	47.6 V	16.64 A	23.3%
	10%	660 W	40.4 V	16.35 A	47.6 V	17.44 A	24.4%
	20%	720 W	40.4 V	17.83 A	47.6 V	19.02 A	26.7%
CS6.2-66TB-605		605 W	40.6 V	14.91 A	47.8 V	15.91 A	22.4%
Bifacial Gain**	5%	635 W	40.6 V	15.66 A	47.8 V	16.71 A	23.5%
	10%	666 W	40.6 V	16.40 A	47.8 V	17.50 A	24.7%
	20%	726 W	40.6 V	17.89 A	47.8 V	19.09 A	26.9%
CS6.2-66TB-610		610 W	40.8 V	14.96 A	48.0 V	15.97 A	22.6%
Bifacial Gain**	5%	641 W	40.8 V	15.71 A	48.0 V	16.77 A	23.7%
	10%	671 W	40.8 V	16.46 A	48.0 V	17.57 A	24.8%
	20%	732 W	40.8 V	17.95 A	48.0 V	19.16 A	27.1%
CS6.2-66TB-615		615 W	41.0 V	15.01 A	48.2 V	16.02 A	22.8%
Bifacial Gain**	5%	646 W	41.0 V	15.76 A	48.2 V	16.82 A	23.9%
	10%	677 W	41.0 V	16.51 A	48.2 V	17.62 A	25.1%
	20%	738 W	41.0 V	18.01 A	48.2 V	19.22 A	27.3%
CS6.2-66TB-620		620 W	41.2 V	15.06 A	48.4 V	16.08 A	23.0%
Bifacial Gain**	5%	651 W	41.2 V	15.81 A	48.4 V	16.88 A	24.1%
	10%	682 W	41.2 V	16.57 A	48.4 V	17.69 A	25.2%
	20%	744 W	41.2 V	18.07 A	48.4 V	19.30 A	27.5%
CS6.2-66TB-625		625 W	41.4 V	15.11 A	48.6 V	16.14 A	23.1%
Bifacial Gain**	5%	656 W	41.4 V	15.87 A	48.6 V	16.95 A	24.3%
	10%	688 W	41.4 V	16.62 A	48.6 V	17.75 A	25.5%
	20%	750 W	41.4 V	18.13 A	48.6 V	19.37 A	27.8%
CS6.2-66TB-630		630 W	41.6 V	15.16 A	48.8 V	16.20 A	23.3%
Bifacial Gain**	5%	662 W	41.6 V	15.92 A	48.8 V	17.01 A	24.5%
	10%	693 W	41.6 V	16.68 A	48.8 V	17.82 A	25.7%
	20%	756 W	41.6 V	18.19 A	48.8 V	19.44 A	28.0%

* Under Standard Test Conditions (STC) of irradiance of 1000 W/m², spectrum AM 1.5 and cell temperature of 25°C.
** Bifacial Gain: The additional gain from the back side compared to the power of the front side at the standard test condition. It depends on mounting (structure, height, tilt angle etc.) and albedo of the ground.

ELECTRICAL DATA | NMOT*

	Nominal Max. Power (Pmax)	Opt. Operating Voltage (Vmp)	Opt. Operating Current (Imp)	Open Circuit Voltage (Voc)	Short Circuit Current (Isc)
CS6.2-66TB-600	454 W	38.2 V	11.88 A	45.1 V	12.77 A
CS6.2-66TB-605	458 W	38.4 V	11.92 A	45.3 V	12.82 A
CS6.2-66TB-610	461 W	38.6 V	11.96 A	45.4 V	12.87 A
CS6.2-66TB-615	465 W	38.8 V	12.00 A	45.6 V	12.91 A
CS6.2-66TB-620	469 W	38.9 V	12.04 A	45.8 V	12.96 A
CS6.2-66TB-625	473 W	39.1 V	12.08 A	46.0 V	13.00 A
CS6.2-66TB-630	477 W	39.3 V	12.12 A	46.2 V	13.05 A

* Under Nominal Module Operating Temperature (NMOT), irradiance of 800 W/m² spectrum AM 1.5, ambient temperature 20°C, wind speed 1 m/s.

MECHANICAL DATA

Specification	Data
Cell Type	TOPCon cells
Cell Arrangement	132 [2 x (11 x 6)]
Dimensions	2382 × 1134 × 30 mm (93.8 × 44.6 × 1.18 in)
Weight	32.8 kg (72.3 lbs)
Front Glass	2.0 mm heat strengthened glass with anti-reflective coating
Back Glass	2.0 mm heat strengthened glass
Frame	Anodized aluminium alloy
J-Box	IP68, 3 bypass diodes
Cable	4.0 mm² (IEC), 12 AWG (UL)
Cable Length (Including Connector)	300 mm (11.8 in) (+) / 200 mm (7.9 in) (-) or customized length*
Connector	T6 or MC4-EVO2 or MC4-EVO2A
Per Pallet	36 pieces
Per Container (40' HQ)	720 pieces

* For detailed information, please contact your local Canadian Solar sales and technical representatives.

ELECTRICAL DATA

Operating Temperature	-40°C ~ +85°C
Max. System Voltage	1500 V (IEC/UL)
Module Fire Performance	TYPE 29 (UL 61730) or CLASS C (IEC61730)
Max. Series Fuse Rating	35 A
Protection Class	Class II
Power Tolerance	0 ~ + 10 W
Power Bifaciality*	80 %

* Power Bifaciality = $P_{max_{rear}}$ / $P_{max_{front}}$, both $P_{max_{rear}}$ and $P_{max_{front}}$ are tested under STC, Bifaciality Tolerance: ± 5 %.

TEMPERATURE CHARACTERISTICS

Specification	Data
Temperature Coefficient (Pmax)	-0.29 % / °C
Temperature Coefficient (Voc)	-0.25 % / °C
Temperature Coefficient (Isc)	0.045 % / °C
Nominal Module Operating Temperature	41 ± 3°C

* The specifications and key features contained in this datasheet may deviate slightly from our actual products due to the on-going innovation and product enhancement. CSI Solar Co., Ltd. reserves the right to make necessary adjustment to the information described herein at any time without further notice.
Please be kindly advised that PV modules should be handled and installed by qualified people who have professional skills and please carefully read the safety and installation instructions before using our PV modules.

PARTNER SECTION

CSI Solar Co., Ltd.
199 Lushan Road, SND, Suzhou, Jiangsu, China, 215129, www.csisolar.com, support@csisolar.com

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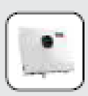
5.3 SMA Sunny Tripower 24000TL-US Inverter Datasheet

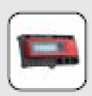
Technical data	Sunny Tripower 12000TL-US	Sunny Tripower 15000TL-US	Sunny Tripower 20000TL-US	Sunny Tripower 24000TL-US	Sunny Tripower 30000TL-US
Input (DC)					
Max. array power	18000 Wp STC	22500 Wp STC	30000 Wp STC	36000 Wp STC	45000 Wp STC
Max. DC voltage	*1000 V				1000 V
Rated MPPT voltage range	300 V...800 V	300 V...800 V	380 V...800 V	450 V...800 V	500 V...800 V
MPPT operating voltage range	150 V...1000 V				
Min. DC voltage / start voltage	150 V / 188 V				
Number of MPP tracker inputs	2				
Max. operating input current / per MPP tracker	66 A / 33 A				
Max. short circuit current per MPPT / string input	53 A / 53 A				
Output (AC)					
AC nominal power	12000 W	15000 W	20000 W	24000 W	30000 W
Max. AC apparent power	12000 VA	15000 VA	20000 VA	24000 VA	30000 VA
Output phases / line connections	3 / 3-N-PE				3 / 3-N-PE, 3-PE
Nominal AC voltage	480 / 277 V WYE				480 / 277 V WYE, 480 V Delta
AC voltage range	244 V...305 V				
Rated AC grid frequency	60 Hz				
AC grid frequency / range	50 Hz, 60 Hz / -6 Hz...+5 Hz				
Max. output current	14.4 A	18 A	24 A	29 A	36.2 A
Power factor at rated power / adjustable displacement	1 / 0.0 leading...0.0 lagging				
Harmonics	< 3%				
Efficiency					
Max. efficiency / CEC efficiency	98.2% / 97.5%	98.2% / 97.5%	98.5% / 97.5%	98.5% / 98.0%	98.6% / 98.0%
Protection devices					
DC reverse polarity protection	●				
Ground fault monitoring / grid monitoring	●				
All-pole sensitive residual current monitoring unit	●				
DC AFCI compliant to UL 1699B	●				
AC short circuit protection	●				
Protection class / overvoltage category	I / IV				
General data					
Dimensions (W / H / D) in mm (in)	665 / 650 / 265 (26.2 / 25.6 / 10.4)				
Packing dimensions (W / H / D) in mm (in)	780 / 790 / 380 (30.7 / 31.1 / 15.0)				
Weight	55 kg (121 lbs)				
Packing weight	61 kg (134.5 lbs)				
Operating temperature range	-25°C...+60°C				
Noise emission (typical) / internal consumption at night	51 dB(A) / 1 W				
Topology	Transformerless				
Cooling concept / electronics protection rating	OptiCool / NEMA 3R				
Features					
Display / LED indicators (Status / Fault / Communication)	— / ●				
Interface: RS485 / Speedwire, WebConnect	○/●				
Data interface: SMA Modbus / SunSpec ModBus	●/●				
Mounting angle range	15°...90°				
Warranty: 10 / 15 / 20 years	●/○/○				
Certifications and approvals	UL 1741, UL 1741SA, CA Rule 21, UL 1998, UL 1699B, IEEE 1547, FCC Part 15 (Class A & B), CAN/CSA C22.2 107.1-1				
NOTE: US inverters ship with gray lids.	Data at nominal conditions, August 2017. *Suitable for 600 V DC max. systems				
● Standard features ○ Optional features — Not available					
Type designation	STP 12000TL-US-10	STP 15000TL-US-10	STP 20000TL-US-10	STP 24000TL-US-10	STP 30000TL-US-10

Accessories

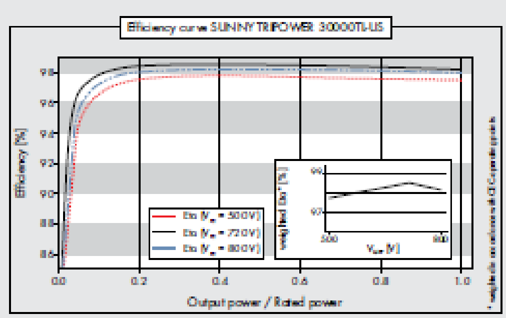
RS485 interface
DM-485CB-US-10



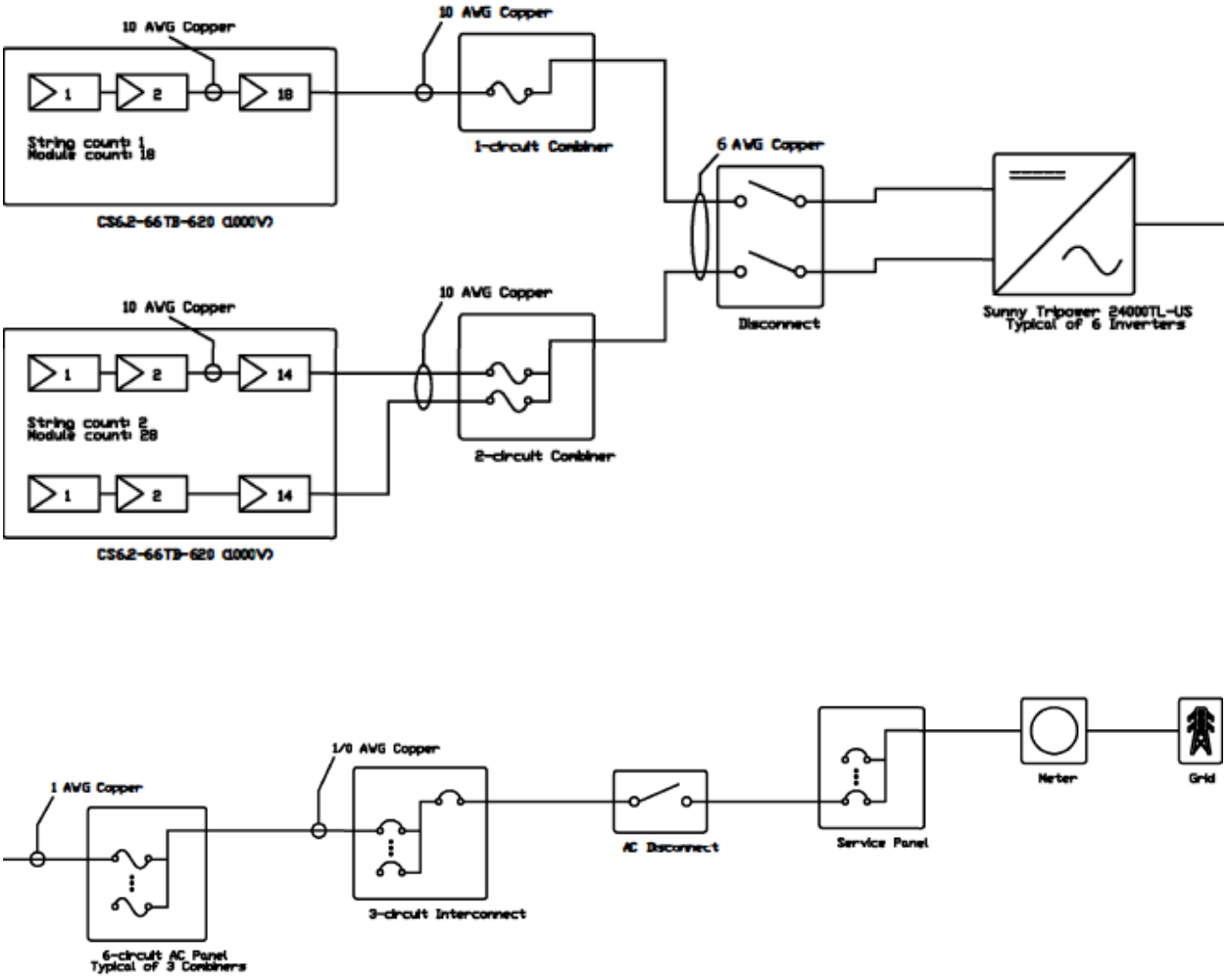
Connection Unit
CU 1000-US-11



SMA Cluster Controller
CLCON-10



5.4 PV System 1-Line Diagram



Module Specifications	
828x Canadian Solar CS6.2-66TB-620 (1000V)	
STC Rating	620 W
Vmp	41.2 V
Imp	15.06 A
Voc	48.4 V
Isc	16.08 A

Inverter Specifications	
18x SMA Sunny Tripower 24000TL-US	
Max AC Power Rating	24.06 kW
Max Input Voltage	1,000 V

Wire Schedule		
Tier	Wire	Length
Bus	36x 6 AWG	1860ft
String	54x 10 AWG	2818ft

5.5 NEC Compliance Calculations

Maximum Voltage, Circuit Sizing and Current (dc circuits)

Temperature Value for South Weymouth, MA determined from ASHPRAE

$T_{extreme} = -19℃$ $T_{2\%\ average} = 32℃$ $Voc = 48.4V$ $Isc = 16.08A$

System Max Voltage:

$$dT = T_{extreme} - 25℃ = -44℃$$

Voltage increases due to temp below STC:

$$= dT \text{ x } T\text{Cvoc x VOC} = -44℃ \times -0.25/100 \text{ x } 48.4 = 5.324V$$

$$Vmax = 48.4 + 5.32 = 53.724V$$

$$V\text{max } system = 53.724 \text{ x } 18 = 967V$$

Max Source Current:

$$Imax1 = 1.25\ Isc = 1.25 \text{ x } 16.08A = 20.1A$$

Max Output Current:

$Imax2 = 1.25$ x Isc x with 2 $strings\ in\ parallel = 1.25$ x $16.08A$ x $2 = 40.2A$

Max Ampacity Current: **Method I**

Source Circuit: $Imax1 = 1.25 \text{ x } 1.25 \text{ x } Isc = 25.125A$

Combiner Output Circuit:

$Imax2 = 1.25 \text{ x } 1.25 \text{ x } Isc \text{ x } 2\ strings\ in\ parallel = 25.125A \text{ x } 2 = 50.25A$

Method II

$T2\%\ average = 32$ (Conductor not on the ground)

$f\ (32) = 0.96$ *NEC 310.15(B)(1).*

Source Circuit: $Imax1 = 20.1 / 0.96 = 20.94A$

Combiner Output Circuit: $Imax2 = 40.2/0.96 = 41.88A$

As per NEC – Tables 310.16 & 310.17,

For 10 AWG (Copper) wire, Ampacity = 40 at 90° ambient temperature.

6 AWG (Copper) - Ampacity = 75 at 90° ambient temperature.

Per *NEC 310.15(C))(1),* (with 4-6 cables in a raceway) ampacity is adjusted to 80% of value.

Ampacity for 10 AWG (Copper) = 40 x 0.8 = 32 > 25.125A, with 30A breaker (in compliance)

Ampacity for 6 AWG (Copper) = 75 x 0.8 = 60A > 50.25A, with 60A breaker (in compliance)

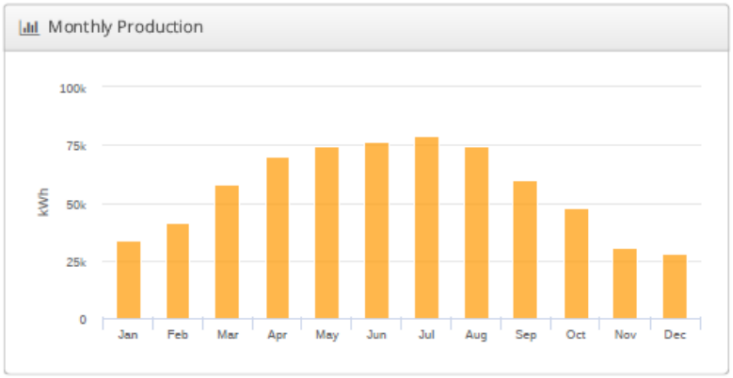
5.6 PV System Hard Cost Estimate Details

PV System Hardware Cost							
Item	Description	Actual Amount	Package Amount	Cost/Unit	Total	Vendor	Comments
Solar Panel	Canadian Solar , CS6.2-66TB- 620W (1000V)	828	828	$205	$169,409	Greentech Renewables	$0.33/Wdc, Clear Energy Partners quoted similar price
Inverter	Sunny Tripower 24000TL-US (SMA)	18	18	$4,100	$73,800	Greentech Renewables	
Racking (including racking, pads, fasteners, trays, clips, and ballast blocks)	PanelClaw-clawFR	828	828	$143	$118,073	Greentech Renewables	$0.23/Wdc
AC Home Runs from AC Panels to Utility Interconnect	1/0 AWG (Copper) (100 ft.)	27	27	$560	$15,120	Greentech Renewables	4% waste allowance added
AC Home Runs from Inverters to AC Panels	1 AWG (Copper) (1000 ft.)	4.34	5	$2,400	$12,000	Greentech Renewables	5% or more waste allowance added
Home Runs from Combiners to Inverters	6 AWG (Copper) (1000 ft.)	1.95	2	$2,000	$4,000	Greentech Renewables	3% waste allowance added
Module Strings to Combiners	10 AWG (Copper) (1000 ft.)	3	3	$400	$1,200	Greentech Renewables	5% or more waste allowance added
Grounding Wire	10 AWG (Copper, solid) (1000 ft.)	6	6	$700	$4,200	Greentech Renewables	4% waste allowance added
Racking Wire Management and AC Conduits	Combination of conduits and block supports	828.00	828	$12	$10,267	Greentech Renewables	$0.02/Wdc
DC Circuit Combiners	1 and 2 input Combiner Boxes, with DC disconnects	36.00	36	$80	$2,880	Greentech Renewables	
AC Panel - From Inverters	6 input AC Panel (200 A)	3	3	$2,500	$7,500	Greentech Renewables	
AC Disconnect	AC Disconnect - (200 A)	3	3	$700	$2,100	Greentech Renewables	
AC Panel - Main	3 input AC Panel (600 A)	1	1	$6,000	$6,000	Greentech Renewables	
AC Disconnect	AC Disconnect - (600 A)	1	1	$4,500	$4,500	Greentech Renewables	
Electric Service Meter		1	1	$300	$300	Greentech Renewables	
				Sub-Total:	$431,349		
			MA Sales Tax Exempt:		$0		
				Shipping:	Included		
				Contingency (5%):	$21,567		
			Total Hardware Costs:		$452,916		$0.88/Watt

5.7 Weighted Average Electricity Rate Calculation Details

Average National Grid Rates for 2 Years 2/1/23-1/31/25				Comments
Average SEMA Rates 3 Months Nov-Jan ($/kWh)		Average SEMA Rates 9 Months Feb-Oct ($/kWh)		
Fixed	Variable	Fixed	Variable	
0.191345	0.190	0.140	0.139	G-2 Supply Rates
0.07110	0.07110	0.07110	0.07110	G-2 Delivery Service
0.26245	0.26104	0.21106	0.21047	Combined Rates ($/kWh)
13.60%		86.40%		% of Annual PV System Production
0.03569		0.18235	0.21805	Average Anuual Electric Rate ($/kWh)
			$146,375	Average Annual Energy Savings - Cost Avoidance - 671,300 kWh

Annual Solar System Production: 671300 KWh			
Month	Approximate Production (kWh)	Nov-Jan (kWh)	Feb-Oct (kWh)
1	36000	36000	
2	42000		42000
3	57000		57000
4	71000		71000
5	74000		74000
6	75000		75000
7	78000		78000
8	75000		75000
9	59000		59000
10	49000		49000
11	28000	28000	
12	27300	27300	
Annual	671300	91300	580000
	100.00%	13.60%	86.40%



5.8 NPV Model Yearly Cash Flows – Conservative Scenario

Year	Unit Energy Cost	Avoided Energy Savings	Extra Mortgage Payment	Maintenance Costs	Extra Property Tax	Interest Payment	Principle Payment	Principle Balance	Income tax savings	Annual Savings	PW of Annual Savings
n											
0	0.21805							$ 793,100.00		$ -	$ -
1	0.2224	$ 146,376.97	$ (76,851.44)	$ (12,000.00)	$ -	$ 66,620.40	$ 10,231.04	$ 782,868.96	$ 26,648.16	$ 84,173.68	$ 79,409.13
2	0.2269	$ 147,512.85	$ (76,851.44)	$ (12,240.00)	$ -	$ 65,760.99	$ 11,090.45	$ 771,778.50	$ 26,304.40	$ 84,725.80	$ 75,405.66
3	0.2314	$ 149,549.36	$ (76,851.44)	$ (12,484.80)	$ -	$ 64,829.39	$ 12,022.05	$ 759,756.45	$ 25,931.76	$ 86,144.88	$ 72,328.90
4	0.2360	$ 151,608.33	$ (76,851.44)	$ (12,734.50)	$ -	$ 63,819.54	$ 13,031.90	$ 746,724.55	$ 25,527.82	$ 87,550.21	$ 69,347.97
5	0.2407	$ 153,689.84	$ (76,851.44)	$ (12,989.19)	$ -	$ 62,724.86	$ 14,126.58	$ 732,597.97	$ 25,089.94	$ 88,939.15	$ 66,460.51
6	0.2456	$ 155,793.97	$ (76,851.44)	$ (13,248.97)	$ -	$ 61,538.23	$ 15,313.22	$ 717,284.75	$ 24,615.29	$ 90,308.84	$ 63,664.17
7	0.2505	$ 157,920.78	$ (76,851.44)	$ (13,513.95)	$ -	$ 60,251.92	$ 16,599.53	$ 700,685.23	$ 24,100.77	$ 91,656.15	$ 60,956.58
8	0.2555	$ 160,070.35	$ (76,851.44)	$ (13,784.23)	$ -	$ 58,857.56	$ 17,993.89	$ 682,691.34	$ 23,543.02	$ 92,977.70	$ 58,335.36
9	0.2606	$ 162,242.73	$ (76,851.44)	$ (14,059.91)	$ -	$ 57,346.07	$ 19,505.37	$ 663,185.97	$ 22,938.43	$ 94,269.80	$ 55,798.15
10	0.2658	$ 164,437.98	$ (76,851.44)	$ (14,341.11)	$ -	$ 55,707.62	$ 21,143.82	$ 642,042.15	$ 22,283.05	$ 95,528.47	$ 53,342.60
11	0.2711	$ 166,656.15	$ (76,851.44)	$ (14,627.93)	$ -	$ 53,931.54	$ 22,919.90	$ 619,122.24	$ 21,572.62	$ 96,749.38	$ 50,966.37
12	0.2765	$ 168,897.26	$ (76,851.44)	$ (14,920.49)	$ -	$ 52,006.27	$ 24,845.18	$ 594,277.06	$ 20,802.51	$ 97,927.83	$ 48,667.13
13	0.2821	$ 171,161.36	$ (76,851.44)	$ (15,218.90)	$ -	$ 49,919.27	$ 26,932.17	$ 567,344.89	$ 19,967.71	$ 99,058.72	$ 46,442.59
14	0.2877	$ 173,448.46	$ (76,851.44)	$ (15,523.28)	$ -	$ 47,656.97	$ 29,194.47	$ 538,150.42	$ 19,062.79	$ 100,136.52	$ 44,290.48
15	0.2935	$ 175,758.58	$ (76,851.44)	$ (223,828.25)	$ -	$ 45,204.64	$ 31,646.81	$ 506,503.61	$ 18,081.85	$ (106,839.26)	$ (44,580.29)
16	0.2993	$ 178,091.73	$ (76,851.44)	$ (16,150.42)	$ -	$ 42,546.30	$ 34,305.14	$ 472,198.47	$ 17,018.52	$ 102,108.38	$ 40,194.59
17	0.3053	$ 180,447.90	$ (76,851.44)	$ (16,473.43)	$ -	$ 39,664.67	$ 37,186.77	$ 435,011.70	$ 15,865.87	$ 102,988.89	$ 38,246.41
18	0.3114	$ 182,827.08	$ (76,851.44)	$ (16,802.90)	$ -	$ 36,540.98	$ 40,310.46	$ 394,701.23	$ 14,616.39	$ 103,789.13	$ 36,361.88
19	0.3177	$ 185,229.24	$ (76,851.44)	$ (17,138.95)	$ -	$ 33,154.90	$ 43,696.54	$ 351,004.69	$ 13,261.96	$ 104,500.80	$ 34,538.88
20	0.3240	$ 187,654.37	$ (76,851.44)	$ (17,481.73)	$ -	$ 29,484.39	$ 47,367.05	$ 303,637.64	$ 11,793.76	$ 105,114.95	$ 32,775.34
21	0.3305	$ 190,102.40	$ (76,851.44)	$ (17,831.37)	$ (47,082.37)	$ 25,505.56	$ 51,345.88	$ 252,291.76	$ 29,035.17	$ 77,372.39	$ 22,759.51
22	0.3371	$ 192,573.30	$ (76,851.44)	$ (18,188.00)	$ (48,259.43)	$ 21,192.51	$ 55,658.94	$ 196,632.82	$ 27,780.77	$ 77,055.21	$ 21,383.21
23	0.3438	$ 195,066.99	$ (76,851.44)	$ (18,551.76)	$ (49,465.91)	$ 16,517.16	$ 60,334.29	$ 136,298.53	$ 26,393.23	$ 76,591.11	$ 20,051.34
24	0.3507	$ 197,583.40	$ (76,851.44)	$ (18,922.79)	$ (50,702.56)	$ 11,449.08	$ 65,402.37	$ 70,896.17	$ 24,860.65	$ 75,967.26	$ 18,762.28
25	0.3577	$ 200,122.44	$ (76,851.44)	$ (19,301.25)	$ (51,970.12)	$ 5,955.28	$ 70,896.17	$ (0.00)	$ 23,170.16	$ 75,169.78	$ 17,514.46
										$2,083,965.80	**$ 1,083,423.20**

5.8 NPV Model Yearly Cash Flows – Likely Scenario

Year	Unit Energy Cost	Avoided Energy Savings	Extra Mortgage Payment	Maintenance Costs	Extra Property Tax	Interest Payment	Principle Payment	Principle Balance	Income tax savings	Annual Savings	PW of Annual Savings
n											
0	0.21805							$ 793,100.00		$ -	$ -
1	0.2235	$ 146,376.97	$ (68,056.32)	$ (6,000.00)	$ -	$ 55,517.00	$ 12,539.32	$ 780,560.68	$ 22,206.80	$ 94,527.44	$ 90,387.69
2	0.2291	$ 148,836.10	$ (68,056.32)	$ (6,150.00)	$ -	$ 54,639.25	$ 13,417.07	$ 767,143.61	$ 21,855.70	$ 96,485.48	$ 88,219.52
3	0.2348	$ 151,941.85	$ (68,056.32)	$ (6,303.75)	$ -	$ 53,700.05	$ 14,356.27	$ 752,787.34	$ 21,480.02	$ 99,061.80	$ 86,608.46
4	0.2407	$ 155,109.87	$ (68,056.32)	$ (6,461.34)	$ -	$ 52,695.11	$ 15,361.21	$ 737,426.13	$ 21,078.05	$ 101,670.25	$ 84,996.17
5	0.2467	$ 158,341.33	$ (68,056.32)	$ (6,622.88)	$ -	$ 51,619.83	$ 16,436.49	$ 720,989.64	$ 20,647.93	$ 104,310.06	$ 83,384.05
6	0.2529	$ 161,637.41	$ (68,056.32)	$ (6,788.45)	$ -	$ 50,469.27	$ 17,587.05	$ 703,402.59	$ 20,187.71	$ 106,980.35	$ 81,773.42
7	0.2592	$ 164,999.34	$ (68,056.32)	$ (6,958.16)	$ -	$ 49,238.18	$ 18,818.14	$ 684,584.45	$ 19,695.27	$ 109,680.13	$ 80,165.50
8	0.2657	$ 168,428.33	$ (68,056.32)	$ (7,132.11)	$ -	$ 47,920.91	$ 20,135.41	$ 664,449.04	$ 19,168.36	$ 112,408.26	$ 78,561.39
9	0.2723	$ 171,925.66	$ (68,056.32)	$ (7,310.42)	$ -	$ 46,511.43	$ 21,544.89	$ 642,904.15	$ 18,604.57	$ 115,163.49	$ 76,962.13
10	0.2791	$ 175,492.58	$ (68,056.32)	$ (7,493.18)	$ -	$ 45,003.29	$ 23,053.03	$ 619,851.12	$ 18,001.32	$ 117,944.40	$ 75,368.69
11	0.2861	$ 179,130.40	$ (68,056.32)	$ (7,680.51)	$ -	$ 43,389.58	$ 24,666.74	$ 595,184.38	$ 17,355.83	$ 120,749.40	$ 73,781.92
12	0.2933	$ 182,840.42	$ (68,056.32)	$ (7,872.52)	$ -	$ 41,662.91	$ 26,393.41	$ 568,790.96	$ 16,665.16	$ 123,576.74	$ 72,202.64
13	0.3006	$ 186,623.99	$ (68,056.32)	$ (8,069.33)	$ -	$ 39,815.37	$ 28,240.95	$ 540,550.01	$ 15,926.15	$ 126,424.48	$ 70,631.57
14	0.3081	$ 190,482.46	$ (68,056.32)	$ (8,271.07)	$ -	$ 37,838.50	$ 30,217.82	$ 510,332.19	$ 15,135.40	$ 129,290.47	$ 69,069.38
15	0.3158	$ 194,417.21	$ (68,056.32)	$ (174,870.78)	$ -	$ 35,723.25	$ 32,333.07	$ 477,999.12	$ 14,289.30	$ (34,220.59)	$ (17,480.67)
16	0.3237	$ 198,429.65	$ (68,056.32)	$ (8,689.79)	$ -	$ 33,459.94	$ 34,596.38	$ 443,402.74	$ 13,383.98	$ 135,067.52	$ 65,973.98
17	0.3318	$ 202,521.20	$ (68,056.32)	$ (8,907.03)	$ -	$ 31,038.19	$ 37,018.13	$ 406,384.61	$ 12,415.28	$ 137,973.12	$ 64,441.80
18	0.3401	$ 206,693.31	$ (68,056.32)	$ (9,129.71)	$ -	$ 28,446.92	$ 39,609.40	$ 366,775.21	$ 11,378.77	$ 140,886.05	$ 62,920.55
19	0.3486	$ 210,947.45	$ (68,056.32)	$ (9,357.95)	$ -	$ 25,674.26	$ 42,382.06	$ 324,393.15	$ 10,269.71	$ 143,802.89	$ 61,410.62
20	0.3573	$ 215,285.12	$ (68,056.32)	$ (9,591.90)	$ -	$ 22,707.52	$ 45,348.80	$ 279,044.35	$ 9,083.01	$ 146,719.90	$ 59,912.34
21	0.3662	$ 219,707.82	$ (68,056.32)	$ (9,831.70)	$ (42,695.73)	$ 19,533.10	$ 48,523.22	$ 230,521.14	$ 24,891.53	$ 124,015.61	$ 48,423.36
22	0.3754	$ 224,217.11	$ (68,056.32)	$ (10,077.49)	$ (43,549.64)	$ 16,136.48	$ 51,919.84	$ 178,601.30	$ 23,874.45	$ 126,408.10	$ 47,195.97
23	0.3848	$ 228,814.54	$ (68,056.32)	$ (10,329.43)	$ (44,420.63)	$ 12,502.09	$ 55,554.23	$ 123,047.07	$ 22,769.09	$ 128,777.25	$ 45,974.87
24	0.3944	$ 233,501.71	$ (68,056.32)	$ (10,587.66)	$ (45,309.05)	$ 8,613.29	$ 59,443.03	$ 63,604.04	$ 21,568.94	$ 131,117.62	$ 44,760.38
25	0.4043	$ 238,280.23	$ (68,056.32)	$ (10,852.36)	$ (46,215.23)	$ 4,452.28	$ 63,604.04	$ (0.00)	$ 20,267.00	$ 133,423.33	$ 43,552.78
										$2,872,243.55	**$ 1,639,198.51**

5.8 NPV Model Yearly Cash Flows – Optimistic Scenario

Year	Unit Energy Cost	Avoided Energy Savings	Extra Mortgage Payment	Maintenance Costs	Extra Property Tax	Interest Payment	Principle Payment	Principle Balance	Income tax savings	Annual Savings	PW of Annual Savings
n											
0	0.21805							$ 793,100.00		$ -	$ -
1	0.2257	$ 146,376.97	$ (61,453.32)	$ (3,000.00)	$ -	$ 46,792.90	$ 14,660.42	$ 778,439.58	$ 18,717.16	$ 100,640.81	$ 97,237.50
2	0.2336	$ 150,591.16	$ (61,453.32)	$ (3,105.00)	$ -	$ 45,927.94	$ 15,525.38	$ 762,914.20	$ 18,371.17	$ 104,404.01	$ 97,462.27
3	0.2418	$ 155,391.44	$ (61,453.32)	$ (3,213.68)	$ -	$ 45,011.94	$ 16,441.38	$ 746,472.82	$ 18,004.78	$ 108,729.22	$ 98,067.53
4	0.2502	$ 160,343.27	$ (61,453.32)	$ (3,326.15)	$ -	$ 44,041.90	$ 17,411.42	$ 729,061.40	$ 17,616.76	$ 113,180.56	$ 98,630.32
5	0.2590	$ 165,451.37	$ (61,453.32)	$ (3,442.57)	$ -	$ 43,014.62	$ 18,438.69	$ 710,622.71	$ 17,205.85	$ 117,761.33	$ 99,151.88
6	0.2680	$ 170,720.62	$ (61,453.32)	$ (3,563.06)	$ -	$ 41,926.74	$ 19,526.58	$ 691,096.13	$ 16,770.70	$ 122,474.94	$ 99,633.44
7	0.2774	$ 176,156.04	$ (61,453.32)	$ (3,687.77)	$ -	$ 40,774.67	$ 20,678.65	$ 670,417.48	$ 16,309.87	$ 127,324.82	$ 100,076.16
8	0.2871	$ 181,762.80	$ (61,453.32)	$ (3,816.84)	$ -	$ 39,554.63	$ 21,898.69	$ 648,518.80	$ 15,821.85	$ 132,314.50	$ 100,481.16
9	0.2972	$ 187,546.25	$ (61,453.32)	$ (3,950.43)	$ -	$ 38,262.61	$ 23,190.71	$ 625,328.09	$ 15,305.04	$ 137,447.55	$ 100,849.52
10	0.3076	$ 193,511.87	$ (61,453.32)	$ (4,088.69)	$ -	$ 36,894.36	$ 24,558.96	$ 600,769.13	$ 14,757.74	$ 142,727.61	$ 101,182.29
11	0.3183	$ 199,665.35	$ (61,453.32)	$ (4,231.80)	$ -	$ 35,445.38	$ 26,007.94	$ 574,761.19	$ 14,178.15	$ 148,158.39	$ 101,480.45
12	0.3295	$ 206,012.52	$ (61,453.32)	$ (4,379.91)	$ -	$ 33,910.91	$ 27,542.41	$ 547,218.79	$ 13,564.36	$ 153,743.66	$ 101,744.99
13	0.3410	$ 212,559.40	$ (61,453.32)	$ (4,533.21)	$ -	$ 32,285.91	$ 29,167.41	$ 518,051.38	$ 12,914.36	$ 159,487.24	$ 101,976.81
14	0.3530	$ 219,312.20	$ (61,453.32)	$ (4,691.87)	$ -	$ 30,565.03	$ 30,888.29	$ 487,163.09	$ 12,226.01	$ 165,393.03	$ 102,176.80
15	0.3653	$ 226,277.31	$ (61,453.32)	$ (129,652.78)	$ -	$ 28,742.62	$ 32,710.69	$ 454,452.40	$ 11,497.05	$ 46,668.26	$ 27,855.85
16	0.3781	$ 233,461.32	$ (61,453.32)	$ (5,026.05)	$ -	$ 26,812.69	$ 34,640.63	$ 419,811.77	$ 10,725.08	$ 177,707.03	$ 102,484.70
17	0.3913	$ 240,871.02	$ (61,453.32)	$ (5,201.96)	$ -	$ 24,768.89	$ 36,684.42	$ 383,127.35	$ 9,907.56	$ 184,123.30	$ 102,594.20
18	0.4050	$ 248,513.41	$ (61,453.32)	$ (5,384.03)	$ -	$ 22,604.51	$ 38,848.80	$ 344,278.54	$ 9,041.81	$ 190,717.87	$ 102,675.09
19	0.4192	$ 256,395.69	$ (61,453.32)	$ (5,572.47)	$ -	$ 20,312.43	$ 41,140.88	$ 303,137.66	$ 8,124.97	$ 197,494.88	$ 102,728.09
20	0.4339	$ 264,525.31	$ (61,453.32)	$ (5,767.50)	$ -	$ 17,885.12	$ 43,568.20	$ 259,569.47	$ 7,154.05	$ 204,458.54	$ 102,753.89
21	0.4491	$ 272,909.92	$ (61,453.32)	$ (5,969.37)	$ (35,059.72)	$ 15,314.60	$ 46,138.72	$ 213,430.75	$ 20,149.73	$ 190,577.25	$ 92,538.76
22	0.4648	$ 281,557.41	$ (61,453.32)	$ (6,178.29)	$ (35,410.32)	$ 12,592.41	$ 48,860.90	$ 164,569.84	$ 19,201.09	$ 197,716.57	$ 92,758.85
23	0.4810	$ 290,475.91	$ (61,453.32)	$ (6,394.53)	$ (35,764.42)	$ 9,709.62	$ 51,743.70	$ 112,826.15	$ 18,189.62	$ 205,053.25	$ 92,947.69
24	0.4979	$ 299,673.79	$ (61,453.32)	$ (6,618.34)	$ (36,122.07)	$ 6,656.74	$ 54,796.57	$ 58,029.57	$ 17,111.52	$ 212,591.59	$ 93,106.00
25	0.5153	$ 309,159.69	$ (61,453.32)	$ (6,849.99)	$ (36,483.29)	$ 3,423.74	$ 58,029.57	$ 0.00	$ 15,962.81	$ 220,335.92	$ 93,234.48
										$3,861,232.12	**$ 2,405,828.70**