



PV Solar Power for the Santo Domingo Tribe's Community Water Pump and Treatment Facility

Deployment of Clean Energy and Energy Efficiency Projects on Indian Lands, DE-FOA-0001021

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Santo Domingo

- The Santo Domingo Tribe (traditionally known as the Kewa Pueblo) is a federally recognized tribe with a reservation located between Albuquerque and Santa Fe, New Mexico.
- 5th largest tribe of the 19 New Mexico Pueblos
- The Pueblo is home to approximately 5,027 tribal members and residents.
- The Tribe has no Casino,
- In 2012, 45 percent of the Pueblo community lived below the government's poverty level and unemployment was 41 percent.
- It is one of the most traditional Pueblo Tribes





Economic Context

- Traditionally, the Tribe prospered from the irrigated cultivation of maize, squash, and beans, jewelry making and pottery.
- Sale of jewelry and pottery, while economically important to Tribal members, not as lucrative as one would like to support a family and the necessities of life.
- The primary business of the Tribe is the Kewa gas station with modest returns.





Opportunity in the Sun

- Although the Tribe is economically disadvantaged, the Tribe recognizes that it is rich in natural resources, in particular, sunlight.
- The Tribe has more than 800 acres of tribal Trust lands rich with solar energy potential and ready access to regional energy markets with lines on and near the Pueblo.
- The Tribe has an interest in exploring alternative (solar) energy production as a keystone for economic development.
- A good first step is to implement a “small-scale” system:
 - Produce financial benefits to the Tribe in the near term
 - Reduce GHG/carbon footprint
 - Training and development of institutional capacity for larger projects.

Overview

- The Tribe was awarded DOE implementation Grant to use solar for the Pueblo's largest energy needs and generate savings in GHG emissions and energy costs.
- The community water pump and treatment facility (WPT facility) is one of the largest electrical demands on the reservation. Small building near Route 25 and Route 22.
- The WPT facility provides potable water to the Pueblo community of approximately 5,027 tribal members and residents.
- The PV power system planned for the community WPT facility will be connected to the Public Service of New Mexico (PNM) electrical grid.

Project Objectives and Benefits

- Reduced reliance on fossil fuels and environmental impacts and cost savings
- Reduce tribal energy costs
 - The community WPT facility has one of the highest electrical bills of the buildings on the reservation
 - Over the life of the project, the WTP facility PV power system is estimated to save the Tribe approximately **\$20,000** per year in electricity costs. It is expected to lower the average cost of electricity from the current **\$0.1265/kWh** to a levelized cost of **\$0.0713/kWh**. 6 year return on investment with DOE match.



An Important Step

As the Tribe's first renewable energy project, the Project will serve as a model for future renewable development on the reservation and potential economic development for Tribe.



Competitive Procurement

- Developed list of potential bidders for distribution of RFP.
- Distributed RFP to 18 firms and trade groups
- Also published the RFP in local newspaper for 2 week period and solicited offers
- Site visits: requested by 3 firms
 - 2 firms actually conducted site visit, third firm satisfied with pictures
- Received 5 offers within 2 week period



Competitive Procurement

Request for Procurement Key Elements

Design PV system that best fits two key objectives:

- Maximize the financial “income” from the PNM net-metering and Renewable Energy Credit (REC) programs
- Off-set the maximum amount of electricity taken from the power grid.

Install the system and ensure meeting operational goals.

Train tribal staff in O&M

Evaluation Process

Technical qualifications

- Ability of the contractor to meet the project objectives
- Ability of the contractor to meet project specifications
- Experience in PV system design and installation
- Ability and/or prior experience working with PNM

Price

- Bidder availability and ability to complete the project according to the project schedule; and
- Efficacy of the project approach

Evaluation based on consideration of factors providing “best value” to Santo Domingo

Award Selection



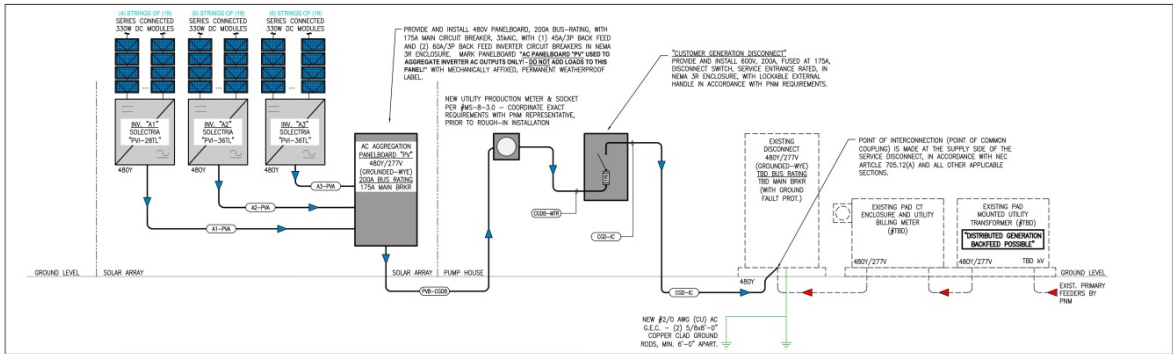
- Affordable Solar selected
- Best Value – qualified contractor with lowest price
 - Lowest cost with greatest benefit
- Pricing: \$2.83/W installed



Design Specifications

- 100 kW DC system determined to be best approach
- 25-year warranty
- Net-metering available on a month-to-month basis allows customer to offset solar power produced during peak hours with electricity used during peak hours
- System produces ~70% of its power during on-peak time and ~30% during off-peak times.
- The WTP currently uses about 37% of its electricity during on-peak time and the majority of electricity during off-peak.
 - PNM compensates any overproduction at the rate of avoided cost, which varies depending on the time of year and time of day, but averages about \$0.0284/kWh.

Design



1-LINE WIRING DIAGRAM (PRELIMINARY)
SCALE: 1" = 16'

SYSTEM "A" - INTERCONNECTION SUMMARY

MAIN FEATURES:
 Nominal AC Power: 100.00 kWac
 Peak DC Power: 100.32 kWp
 Module technology: Poly-Crystalline
 Inverter Topology: 3Ø String - UL1741

PV MODULES:
 Manufacturer: Hyundai
 Model: HIS-M330T1
 Peak Power: 330 Wp (Each)
 Quantity: 304 Modules

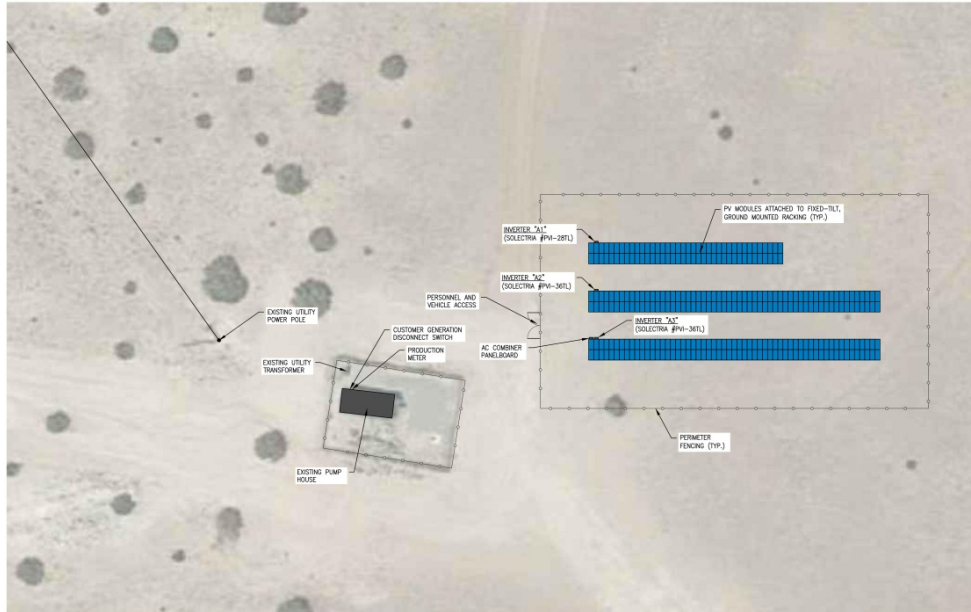
ELECTRICAL CONFIGURATION:
 Modules per string: 19 Modules
 Max DC Voltage: 1000 v (UL)
 Total Qty. of Strings: 16 Strings

INVERTER CONFIGURATION:
 Manufacturer: Solacrista
 Model: (2) PVI-36TL (1) PVI-28TL
 Nominal power: 100.0KW AC
 Quantity: (3) Inverters
 Inverter Output Voltage: 480Y (3Ø/4W)
 Array Combiner: Integrated/Fused
 DC Disconnect: Integral/Lockable (Off)
 AC Disconnect: Integral/Lockable (Off)

ENGINEER:
 - PRELIMINARY -
 NOT FOR CONSTRUCTION!

GENERAL NOTES:

- THE ELECTRICAL CONTRACTOR IS RESPONSIBLE FOR INSTALLING ALL EQUIPMENT AND FOLLOWING ALL MANUFACTURER'S OR ENGINEER'S DIRECTIONS AND INSTRUCTIONS SHOWN HERE.
- THE ELECTRICAL CONTRACTOR IS ADVISED THAT ALL DRAWINGS, EQUIPMENT MANUALS, ESPECIALLY THE INVERTER MANUALS, ARE TO BE READ AND UNDERSTOOD PRIOR TO INSTALLATION OF ANY EQUIPMENT. THE CONTRACTOR IS ALSO ADVISED TO HAVE ALL COMPONENTS SHOWN IN THE OFF-GRID PORTION OF THIS DRAWING READY PRIOR TO INSTALLATION OF THE INVERTER COMPONENTS.
- INSULATION CHECK IS TO HAVE A MINIMUM OF ONE GUARANTEE LEVEL ELECTRODE ON SITE AT ALL TIMES WHEN ELECTRICAL WORK IS BEING PERFORMED.
- THIS SOLAR PHOTOVOLTAIC SYSTEM IS TO BE INSTALLED FOLLOWING THE CONVENTIONS OF THE NATIONAL ELECTRIC CODE, ANY LOCAL CODE WHICH MAY SUPERSEDE THE NEC SHALL GOVERN.
- ALL COMPONENTS TO BE INSTALLED WITH THIS SYSTEM ARE TO BE INSTALLED BY A THIRD PARTY TESTING AGENCY (EUL, ETL, ETC). EQUIPMENT SHALL BE KEPT IN AN OUTDOOR RAINED OR BETTER, UNLESS LOCKED MODES.
- THE CONTRACTOR IS RESPONSIBLE FOR SELECTING AND PURCHASING EQUIPMENT THAT WILL MEET THE REQUIREMENTS OF THIS SYSTEM. ALL ENCLOSURES, CONDUIT, TUBING, PIPES, WELDED METAL SURFACES, CONCRETE, CHANGING EQUIPMENT AND OTHER PRODUCTS SHALL BE SELECTED TO LAST THE LIFETIME OF THE PV SYSTEM. THE INVERTER CONTRACTOR SHALL BE RESPONSIBLE FOR THE SELECTION OF THE WIRING MATERIALS AND THE ELECTRICAL CONTRACTOR IS RESPONSIBLE TO ENSURE THAT THESE INSTALLATIONS ARE IN ACCORDANCE WITH GOOD QUALITY EQUIPMENT, WORKMANSHIP AND SHALL.
- NO WORK FROM THE WORK IS ALLOWED PROCEED AT THE DISCONNECT ENCLOSURE AND THE DC TERMINALS OF THE INVERTER DURING SERVICE. ALL DISCONNECTS BEING OR INVOLVED WITH THIS PHOTOVOLTAIC SYSTEM MUST BE MAINTAINED IN THE OPEN POSITION. THE USE AND LOCK TERMINALS OF THE DISCONNECTS MAY BE ENDED IN THE OPEN POSITION AND THE SWITCH IS TO BE KEPT TO COMPLY WITH ARTICLE 690.11 OF THE NEC REFLECTING THIS.
- ALL PORTIONS OF THIS SOLAR ELECTRIC SYSTEM SHALL BE CLEAN AND NEAT IN ACCORDANCE WITH THE NATIONAL ELECTRIC CODE.
- THE ELECTRICAL CONTRACTOR SHALL PERFORM WITH WORKMANSHIP CHECKS AND P/WIRING CONDUCTIVITY CHECKS PRIOR TO TERMINATING ANY WIRING.
- FOR PROPER MAINTENANCE AND SOLUTION OF PROBLEMS, REFER TO SOLARSAFETY PROCEDURE IN INVERTER OPERATION MANUAL. CONTRACTOR PERFORMING THE MAINTENANCE IS RESPONSIBLE TO FOLLOW ALL LOCKOUT/TAGOUT PROCEDURES.
- THIS PHOTOVOLTAIC SYSTEM'S UTILITY INTERCONNECTION POINT SHALL MEET THE SPECIFIC REQUIREMENTS OF ARTICLE 690.14, NATIONAL ELECTRIC CODE. PLEASE FOLLOW THE SPECIFIC INSTRUCTIONS IN THE DRAWING SET TO MEET THIS CODE REQUIREMENT.
- THE OBTAINING OF THE PHOTOVOLTAIC SYSTEM SHALL COMPLY WITH NEC 690.14 AND NEC 690.41 IF THE REQUIREMENTS DESCRIBED IN THIS DRAWING SET ARE CLOSELY FOLLOWED. THE OBTAINING WILL BE MET. ANY CHANGES WILL NEED TO BE REVIEWED AND APPROVED BY THE CONTRACTOR, MANUFACTURER AND DESIGN AGENT FOR PROTECT SAFETY.
- THE CONTRACTOR IS RESPONSIBLE FOR MARKING ALL EQUIPMENT FOR THE ENGINEER'S REPORT OF MANUFACTURERS' SPECIFICATIONS AND THE CONTRACTOR SHALL USE ALL EFFORTS TO MEANT LEAST EQUIPMENT SUCH THAT IT WILL BE CLEAN, LEVEL, AND SOLID IN ORDER TO GET THE LIFETIME OF THIS SOLAR ELECTRIC SYSTEM.



ENLARGED SITE PLAN - SYSTEM "A"
SCALE: 1" = 30'



FIXED-TILT RACKING SYSTEM (TYPICAL)
OR APPROVED EQUIPMENT

THIS PLAN IS NOT A BIDDING DOCUMENT. IT DOES NOT DEFINE EXISTING UTILITIES AND IS NOT FOR CONSTRUCTION BY AFFORDABLE SOLAR. THE ENGINEER'S STAMP IS ONLY FOR THE INSTALLATION OF THIS DESIGN BY ANYONE OTHER THAN AFFORDABLE SOLAR. AFFORDABLE SOLAR EXPRESSLY RESERVES THE RIGHT TO MAKE ANY CHANGES TO THIS DESIGN. THESE PLANS ARE NOT TO BE REPRODUCED, COPIED, OR COPIED IN ANY MANNER WITHOUT THE WRITTEN CONSENT OF AFFORDABLE SOLAR.

NO.	REVISION	DATE	BY	CHKD. BY
1	REVISED STRING CONFIG	08/14/18	BY	BY
2	REVISED STRING CONFIG	08/14/18	BY	BY

affordable solar
 4840 Pan American East Fwy NE
 Albuquerque, New Mexico 87109-2220
 (505) 944-4220 - www.affordable-solar.com

CONTRACT FILE NO.: SANTO DOMINGO THREE GROUND MOUNT PV SYSTEM
 CONSULTANT FILE NO.: SANTO DOMINGO PV SYSTEM NEW REV

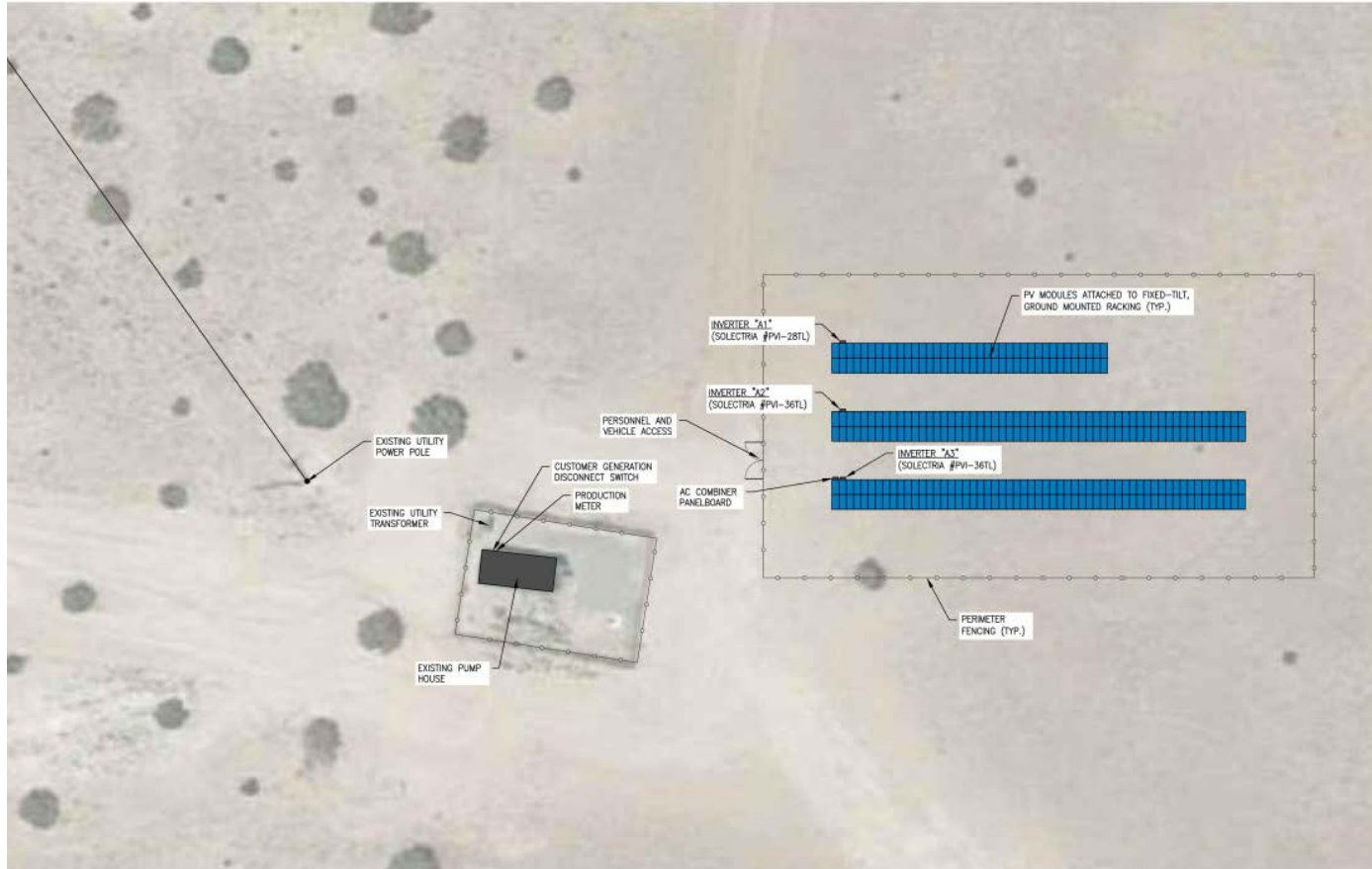
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PROJECT NAME: SANTO DOMINGO PV SYSTEM
 FACILITY LOCATION: (SANTO DOMINGO) PUEBLO
 PROJECT NO.: INTERCONNECTION DOCUMENTS

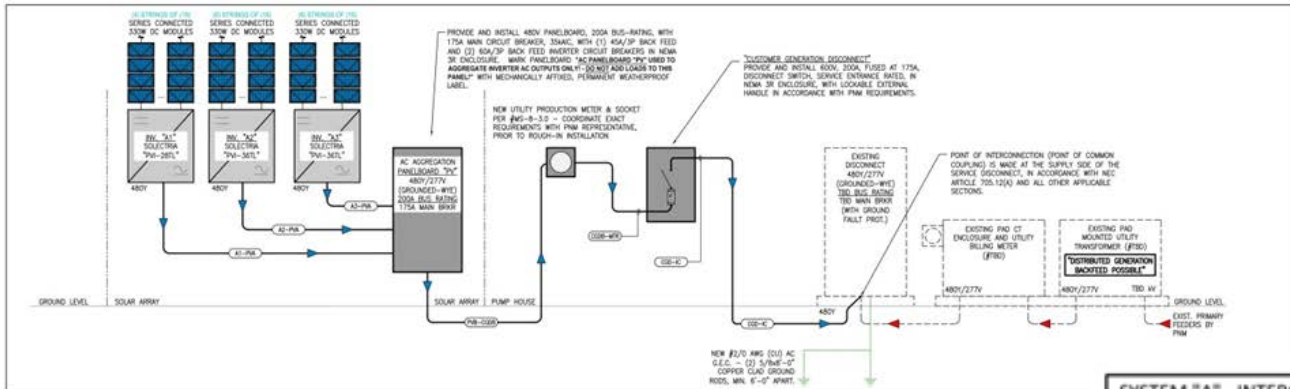
SANTO DOMINGO PUEBLO SOLAR PHOTOVOLTAIC SYSTEM ENLARGED SITE PLAN

DATE:	REVISED BY:	BY:
D	PV-1.00	01
PRELIMINARY:	SCALE AS INDICATED	SHEET 1 OF 1

Enlarged Site Plan – System A



System A 1-Line Wiring Diagram



SYSTEM "A" - INTERCONNECTION SUMMARY

MAIN FEATURES:

Nominal AC Power:	100.00 kWac
Peak DC Power:	100.32 kWp
Module technology:	Poly-Crystalline
Inverter Topology:	3Ø String - UL1741

PV MODULES:

Manufacturer:	Hyundai
Model:	HiS-M330TI
Peak Power:	330 Wp (Each)
Quantity:	304 Modules

ELECTRICAL CONFIGURATION:

Modules per string:	19 Modules
Max DC Voltage:	1000 V (UL)
Total Qty. of Strings:	16 Strings

INVERTER CONFIGURATION:

Manufacturer:	Solectria
Model:	(2) PVI-36TL, (1) PVI-28TL
Nominal power:	100.0kW AC
Quantity:	(3) Inverters
Inverter Output Voltage:	480Y (3Ø/4W)
Array Combiner:	Integrated/Fused
DC Disconnect:	Integral/Lockable (Off)
AC Disconnect:	Integral/Lockable (Off)

Solar Panels



FIXED-TILT RACKING SYSTEM (TYPICAL)

OR APPROVED EQUIVALENT

Where are we now?

- Project specifications submitted to Public Service Co-New Mexico (PNM) for Review
- Applied and received approval from PNM for project's tie-in
- Expect to receive approval from the U.S. Department of Energy (DOE) to move ahead
- Implementation to begin **1st Quarter 2017**



Questions?

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Grid-Connected System: Simulation Parameters

Santo Domingo WTP Facility

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Grid-Connected System: Simulation parameters			
Project :	Santo Domingo WTP Facility		
Geographical Site	Albuquerque Intl Arpt [isis]	Country	United States
Situation	Latitude 35.0°N	Longitude	106.6°W
Time defined as	Legal Time	Time zone	UT-7
	Albedo	Altitude	1619 m
Meteo data:	Santo Domingo WTP Facility NREL NSRD : TMY2 - TMY		
Simulation variant :	New simulation variant		
	Simulation date	10/06/16 10h36	
Simulation parameters			
Collector Plane Orientation	Tilt	30°	Azimuth 0°
Models used	Transposition	Perez	Diffuse Imported
Horizon	Free Horizon		
Near Shadings	No Shadings		
PV Arrays Characteristics (2 kinds of array defined)			
PV module	Model	HIS-S330T1	
<small>Custom parameters definition</small>	Si-mono	Manufacturer	Hyundai Heavy Industries
Sub-array "Sub-array #1"	In series	19 modules	In parallel 4 strings
Number of PV modules	Nb. modules	76	Unit Nom. Power 330 Wp
Total number of PV modules	Nominal (STC)	25.08 kWp	At operating cond. 22.57 kWp (50°C)
Array global power	U mpp	644 V	I mpp 35 A
Array operating characteristics (50°C)			
Sub-array "Sub-array #2"	In series	19 modules	In parallel 12 strings
Number of PV modules	Nb. modules	228	Unit Nom. Power 330 Wp
Total number of PV modules	Nominal (STC)	75.2 kWp	At operating cond. 67.7 kWp (50°C)
Array global power	U mpp	644 V	I mpp 105 A
Array operating characteristics (50°C)			
Total	Nominal (STC)	100 kWp	Total 304 modules
Arrays global power	Module area	595 m²	
Sub-array "Sub-array #1" : Inverter			
<small>Custom parameters definition</small>	Model	PVI 28TL	
Characteristics	Manufacturer	Solectria Renewables, LLC	
Inverter pack	Operating Voltage	450-800 V	Unit Nom. Power 28.0 kWac
	Nb. of inverters	2 * MPPT 50 %	Total Power 28 kWac
Sub-array "Sub-array #2" : Inverter			
<small>Custom parameters definition</small>	Model	PVI 36TL	
Characteristics	Manufacturer	Solectria Renewables, LLC	
Inverter pack	Operating Voltage	540-800 V	Unit Nom. Power 36.0 kWac
	Nb. of inverters	4 * MPPT 50 %	Total Power 72 kWac
Total	Nb. of inverters	3	Total Power 100 kWac
PV Array loss factors			

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Grid-Connected System: Simulation parameters (continued)																					
Array Soiling Losses		Loss Fraction	3.0 %																		
Thermal Loss factor	Uc (const) 29.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s																		
Wiring Ohmic Loss	Array#1 308 mOhm	Loss Fraction	1.5 % at STC																		
	Array#2 103 mOhm	Loss Fraction	1.5 % at STC																		
	Global	Loss Fraction	1.5 % at STC																		
LID - Light Induced Degradation		Loss Fraction	1.8 %																		
Module Quality Loss		Loss Fraction	-0.8 %																		
Module Mismatch Losses		Loss Fraction	1.0 % at MPP																		
Incidence effect, user defined profile	<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th>0°</th> <th>30°</th> <th>50°</th> <th>60°</th> <th>65°</th> <th>70°</th> <th>75°</th> <th>80°</th> <th>90°</th> </tr> </thead> <tbody> <tr> <td>1.00</td> <td>1.00</td> <td>1.00</td> <td>0.99</td> <td>0.98</td> <td>0.95</td> <td>0.89</td> <td>0.76</td> <td>0.00</td> </tr> </tbody> </table>			0°	30°	50°	60°	65°	70°	75°	80°	90°	1.00	1.00	1.00	0.99	0.98	0.95	0.89	0.76	0.00
0°	30°	50°	60°	65°	70°	75°	80°	90°													
1.00	1.00	1.00	0.99	0.98	0.95	0.89	0.76	0.00													
System loss factors																					
Unavailability of the system	Wires: 3x35.0 mm² 64 m	Loss Fraction	1.5 % at STC																		
	5.5 days, 3 periods	Time fraction	1.5 %																		
User's needs :																					
	Unlimited load (grid)																				

Grid-Connected System: Simulation Parameters

Santo Domingo WTP Facility

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Grid-Connected System: Main results

Project : Santo Domingo WTP Facility
Simulation variant : New simulation variant

Main system parameters

System type	Grid-Connected		
PV Field Orientation	tilt	30°	azimuth 0°
PV modules	Model	HIS-S330T1	Pnom 330 Wp
PV Array	Nb. of modules	304	Pnom total 100 kWp
Inverter	Model	PVI 28TL	Pnom 28.00 kW ac
Inverter	Model	PVI 36TL	Pnom 36.0 kW ac
Inverter pack	Nb. of units	3.0	Pnom total 100 kW ac
User's needs	Unlimited load (grid)		

Main simulation results

System Production **Produced Energy 205173 kWh/year** Specific prod. 2045 kWh/kWp/year
 Performance Ratio PR **85.8 %**

Normalized productions (per installed kWp): Normal power 100 kWp

Performance Ratio PR

New simulation variant

Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEfl kWh/m²	EArray kWh	E_Grid kWh	EflAnR %	ERfSysR %
January	99.9	-0.17	165.5	159.4	15840	15104	16.11	15.35
February	118.6	1.77	172.3	165.8	16260	15786	15.88	15.41
March	173.4	6.48	213.6	205.1	19546	18959	15.38	14.92
April	202.0	9.95	213.9	204.6	19204	18637	15.10	14.65
May	243.0	16.73	233.0	222.9	20437	19813	14.75	14.30
June	247.7	20.90	226.2	216.4	19505	17784	14.50	13.22
July	224.8	23.43	212.4	203.5	18176	17635	14.39	13.97
August	203.7	21.57	208.3	199.4	17939	17418	14.48	14.06
September	174.0	19.31	201.6	193.4	17523	17009	14.62	14.19
October	149.2	12.59	205.0	197.3	18405	18039	15.10	13.85
November	107.0	5.25	171.7	165.5	16029	15668	15.70	15.25
December	91.4	0.44	159.5	153.7	15255	14821	16.08	15.63
Year	2034.9	11.58	2383.0	2286.9	214136	205173	15.11	14.48

Legends: GlobHor Horizontal global irradiation, T Amb Ambient Temperature, GlobInc Global incident in coll. plane, GlobEfl Effective Global, corr. for IAM and shadings, EArray Effective energy at the output of the array, E_Grid Energy injected into grid, EflAnR Effc. East array / rough area, ERfSysR Effc. East system / rough area

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Grid-Connected System: Loss diagram

Project : Santo Domingo WTP Facility
Simulation variant : New simulation variant

Main system parameters

System type	Grid-Connected		
PV Field Orientation	tilt	30°	azimuth 0°
PV modules	Model	HIS-S330T1	Pnom 330 Wp
PV Array	Nb. of modules	304	Pnom total 100 kWp
Inverter	Model	PVI 28TL	Pnom 28.00 kW ac
Inverter	Model	PVI 36TL	Pnom 36.0 kW ac
Inverter pack	Nb. of units	3.0	Pnom total 100 kW ac
User's needs	Unlimited load (grid)		

Loss diagram over the whole year

Horizontal global irradiation: 2035 kWh/m²
 Global incident in coll. plane: 2287 kWh/m² * 595 m² coll. efficiency at STC = 16.87%

Losses: +17.1% IAM factor on global, -3.0% Soiling loss factor, -0.5% PV conversion, -3.1% Array nominal energy (at STC effc.), -0.7% PV loss due to irradiance level, -0.5% PV loss due to temperature, +0.7% Module quality loss, -1.8% LID - Light induced degradation, -1.0% Module array mismatch loss, -1.2% Chitic wiring loss, -1.9% Array virtual energy at MPP, -1.9% Inverter Loss during operation (efficiency), 0.0% Inverter Loss due to nominal inv. power, 0.0% Inverter Loss due to nominal inv. voltage, 0.0% Inverter Loss due to voltage threshold, -1.3% Available Energy at Inverter Output, -1.0% System unavailability, -1.0% AC chitic loss

Energy injected into grid: 205173 kWh

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