PVsyst - Simulation report

Grid-Connected System

Project: PV independencia 200MW

Variant: New simulation rentable

No 3D scene defined, no shadings

System power: 245.1 MWp

Salinas; Barahona - Dominican Republic

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Project summary

Geographical Site
Salinas; Barahona
Dominican Republic

Situation

Latitude	18.23 °N
Longitude	-71.35 °W
Altitude	114 m
Time zone	UTC-4

Project settings
Albedo 0.20

Weather data
Salinas, Barahona
Meteonorm 8.1 (1996-2015), Sat=100% - Synthetic

System summary

Grid-Connected System
Simulation for year no 10

No 3D scene defined, no shadings

PV Field Orientation
Fixed plane
Tilt/Azimuth 20 / 0 °

Near Shadings
No Shadings

User's needs
Unlimited load (grid)

System information

PV Array

Nb. of modules	368592 units
Pnom total	245.1 MWp

Inverters

Nb. of units	50 units
Pnom total	200.0 MWac
Grid power limit	184.7 MWac
Grid lim. Pnom ratio	1.327

Battery pack
Storage strategy: Peak shaving

Nb. of units	212 units
Voltage	1210 V
Capacity	367608 Ah

Results summary

Produced Energy	415496516 kWh/year	Specific production	1695 kWh/kWp/year	Perf. Ratio PR	75.87 %

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General parameters

Grid-Connected System — **No 3D scene defined, no shadings**

PV Field Orientation

Orientation	Sheds configuration	Models used
Fixed plane	No 3D scene defined	Transposition Perez
Tilt/Azimuth 20 / 0 °		Diffuse Perez, Meteonorm
		Circumsolar separate

Horizon
Free Horizon

Near Shadings
No Shadings

User's needs
Unlimited load (grid)

Storage

Kind	Peak shaving
Charging strategy	**Discharging strategy**
Available power over Grid	184.7 kW — As soon as power is needed

Grid power limitation

Active power	184.7 MWac
Pnom ratio	1.327

PV Array Characteristics

PV module

Manufacturer	Generic
Model	TSM-DEG21C-20-665Wp Vertex
(Original PVsyst database)	
Unit Nom. Power	665 Wp
Number of PV modules	368592 units
Nominal (STC)	245.1 MWp
Modules	13164 string x 28 In series
At operating cond. (50°C)	
Pmpp	224.6 MWp
U mpp	973 V
I mpp	230893 A

Inverter

Manufacturer	Generic
Model	Sunny Central 4000 UP
(Original PVsyst database)	
Unit Nom. Power	4000 kWac
Number of inverters	50 units
Total power	200000 kWac
Operating voltage	880-1325 V
Pnom ratio (DC:AC)	1.23

Total PV power

Nominal (STC)	245114 kWp
Total	368592 modules
Module area	1144976 m²

Total inverter power

Total power	200000 kWac
Number of inverters	50 units
Pnom ratio	1.23

Battery Storage

Battery

Manufacturer	Generic
Model	Luna2000 - 2.0 MWh - 2H0

Battery pack

Nb. of units	212 in parallel
Discharging min. SOC	10.0 %
Stored energy	400192.8 kWh

Battery Pack Characteristics

Voltage	1210 V
Nominal Capacity	367608 Ah (C10)
Temperature	External ambient temperature

Battery input charger

Model	Generic
Max. charg. power	101.0 MWdc
Max./Euro effic.	97.0/95.0 %

Battery to Grid inverter

Model	Generic
Max. disch. power	100.0 MWac
Max./Euro effic.	97.0/95.0 %

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Array losses

Array Soiling Losses
Loss Fraction 3.0 %

Thermal Loss factor
Module temperature according to irradiance
Uc (const) 20.0 W/m²K
Uv (wind) 2.0 W/m²K/m/s

DC wiring losses
Global array res. 0.069 mΩ
Loss Fraction 1.5 % at STC

Serie Diode Loss
Voltage drop 0.7 V
Loss Fraction 0.1 % at STC

LID - Light Induced Degradation
Loss Fraction 2.0 %

Module Quality Loss
Loss Fraction -0.4 %

Module mismatch losses
Loss Fraction 2.0 % at MPP

Strings Mismatch loss
Loss Fraction 0.2 %

Module average degradation
Year no 10
Loss factor 0.4 %/year

Mismatch due to degradation
Imp RMS dispersion 0.4 %/year
Vmp RMS dispersion 0.4 %/year

IAM loss factor
Incidence effect (IAM): Fresnel, AR coating, n(glass)=1.526, n(AR)=1.290

0°	30°	50°	60°	70°	75°	80°	85°	90°
1.000	0.999	0.987	0.962	0.892	0.816	0.681	0.440	0.000

Spectral correction
FirstSolar model
Precipitable water estimated from relative humidity

Coefficient Set	C0	C1	C2	C3	C4	C5
Monocrystalline Si	0.85914	-0.02088	-0.0058853	0.12029	0.026814	-0.001781

System losses

Unavailability of the system
Time fraction 2.0 %
7.3 days,
3 periods

Auxiliaries loss
constant (fans) 180.0 kW
180.0 kW from Power thresh.

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Main results

System Production

Produced Energy	415496516 kWh/year	Specific production	1695 kWh/kWp/year
		Perf. Ratio PR	75.87 %

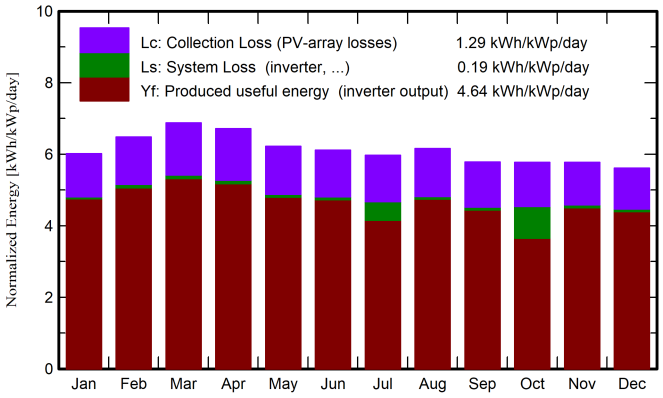
Battery aging (State of Wear)

Cycles SOW	99.0 to 99.0 %
Static SOW	99.0 to 86.1 %
Battery lifetime	7.7 years

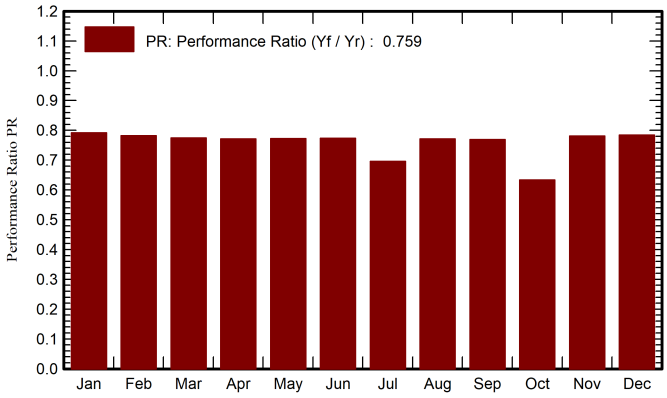
Economic evaluation

Investment		Yearly cost		LCOE	
Global	250,014,889.60 USD	Annuities	37,259,591.16 USD/yr	Energy cost	0.15 USD/kWh
Specific	1.02 USD/Wp	Run. costs	47,683,107.79 USD/yr		
		Payback period	14.9 years		

Normalized productions (per installed kWp)



Performance Ratio PR



Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	EBatDis kWh	PR ratio
January	151.0	50.21	26.86	186.6	178.0	36592408	36190378	236371	0.791
February	157.1	52.26	26.94	181.5	173.4	35442659	34786301	137856	0.782
March	198.8	65.27	27.54	213.1	203.3	41239154	40475988	116478	0.775
April	203.7	68.85	27.81	201.4	191.3	38817095	38088783	169639	0.772
May	208.3	84.40	28.63	192.9	182.4	37138347	36510149	0	0.772
June	202.7	86.27	28.92	183.4	173.5	35371058	34778637	0	0.774
July	202.4	85.06	29.97	185.2	175.0	35539860	31588888	0	0.696
August	197.9	90.73	30.15	190.8	181.0	36671571	36063214	0	0.771
September	168.1	71.26	29.22	173.4	164.7	33292138	32694436	66552	0.769
October	160.8	65.91	28.89	178.8	170.1	34549368	27760585	15613	0.633
November	144.0	53.67	27.78	173.3	164.8	33747591	33156059	41120	0.781
December	138.2	43.86	27.41	173.9	165.8	33982513	33403100	4445	0.784
Year	2133.0	817.76	28.35	2234.2	2123.4	432383762	415496516	788074	0.759

Legends

GlobHor	Global horizontal irradiation
DiffHor	Horizontal diffuse irradiation
T_Amb	Ambient Temperature
GlobInc	Global incident in coll. plane
GlobEff	Effective Global, corr. for IAM and shadings
EArray	Effective energy at the output of the array
E_Grid	Energy injected into grid
EBatDis	Battery Discharging Energy
PR	Performance Ratio

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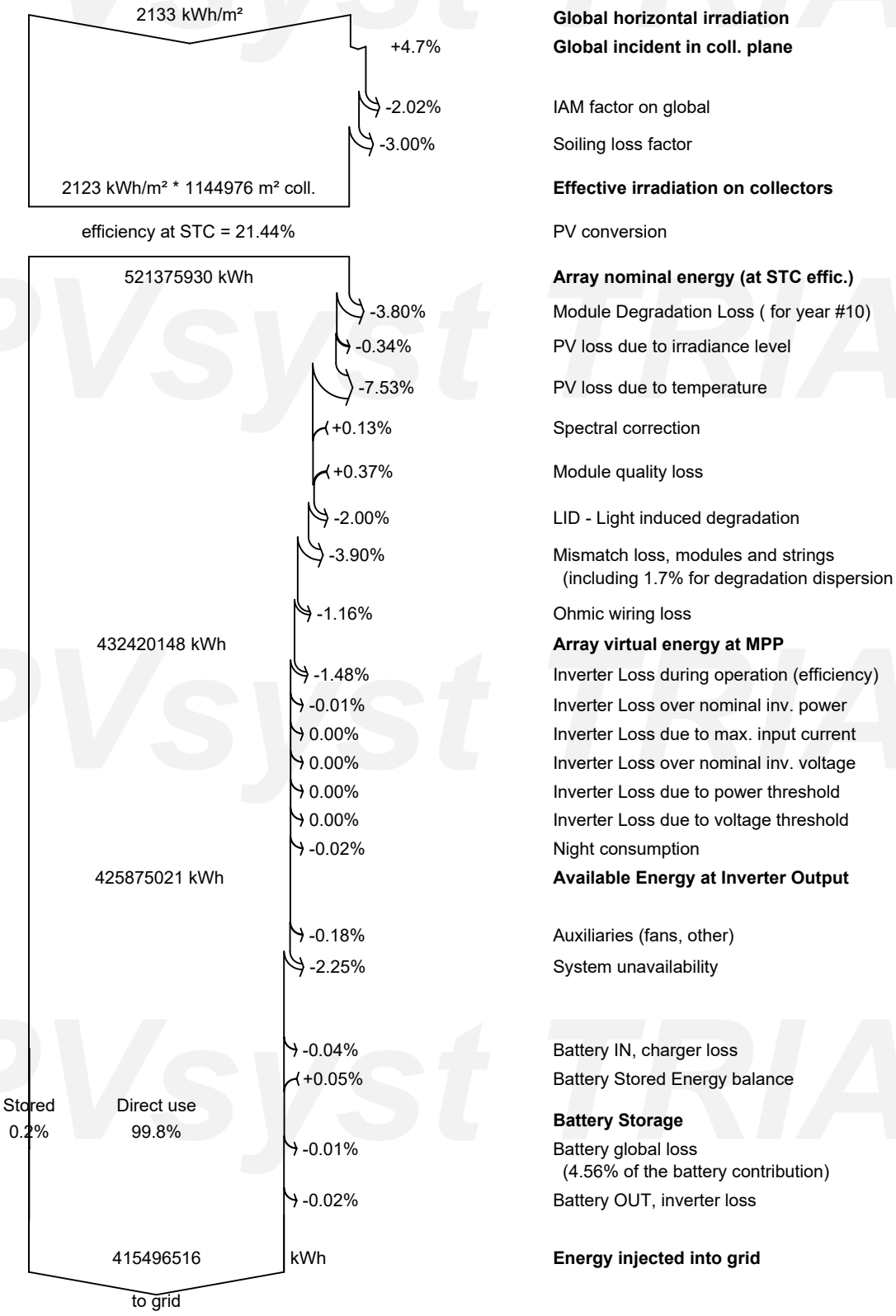
Loss diagram



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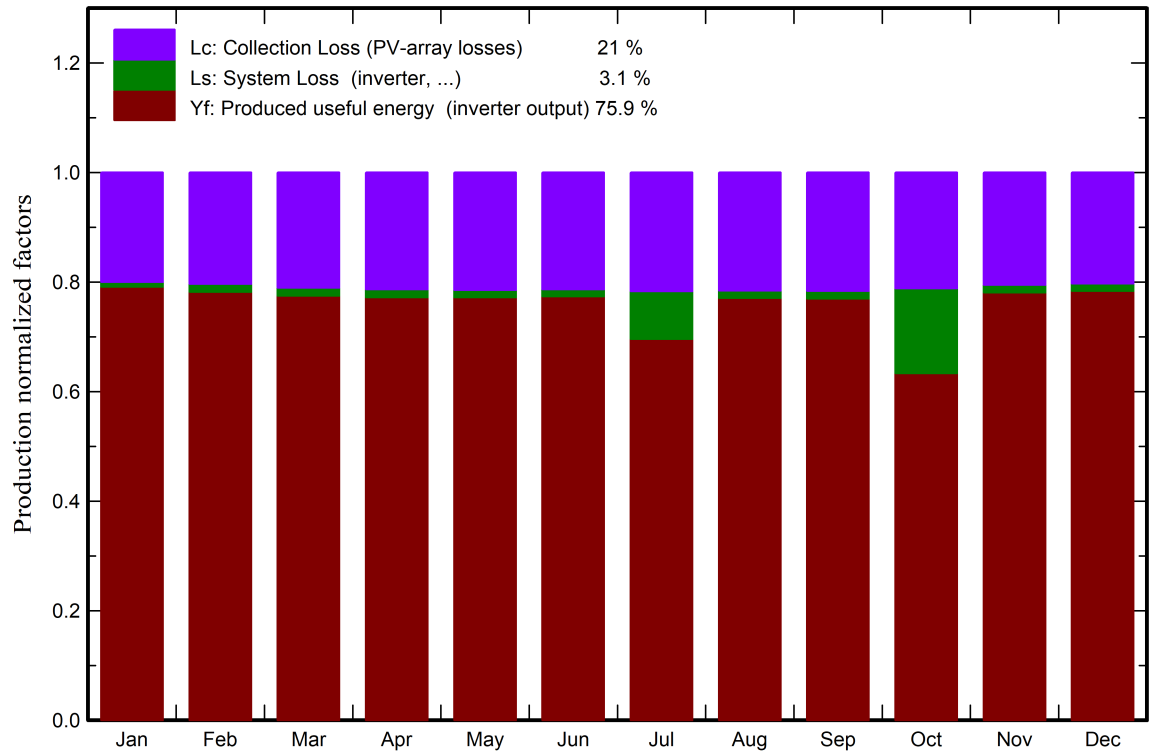
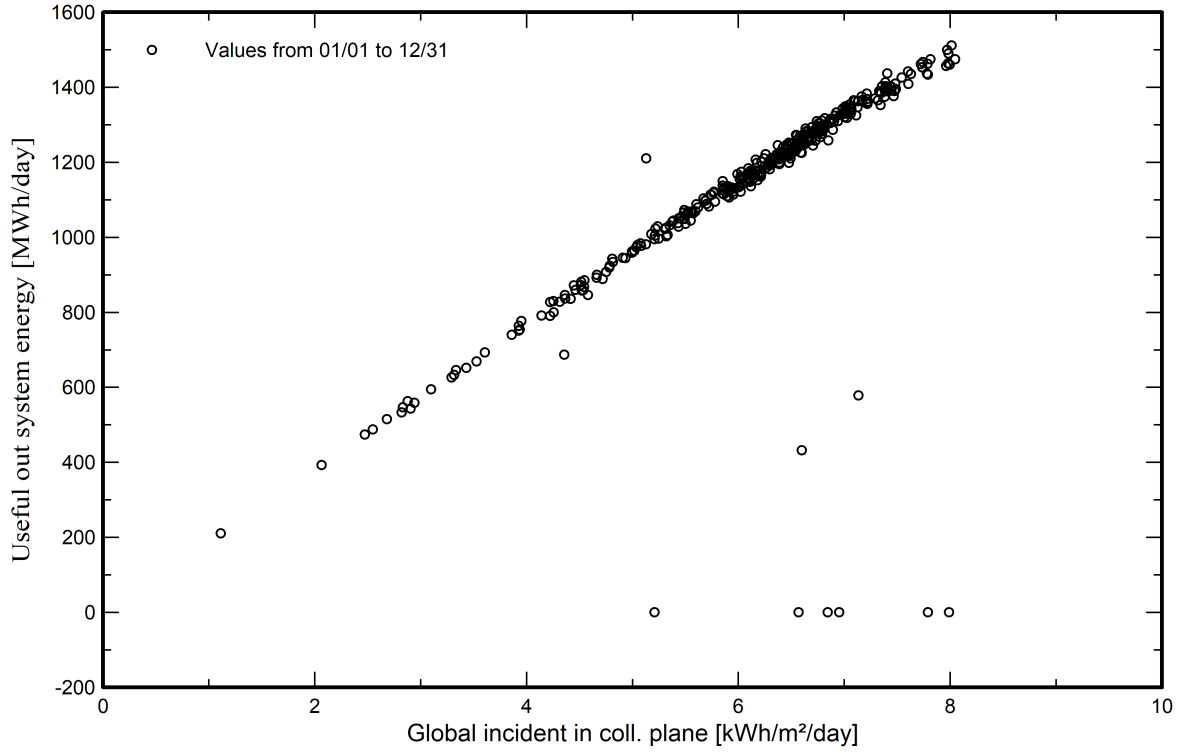
Predef. graphs

Normalized Production and Loss Factors



Daily Input/Output diagram



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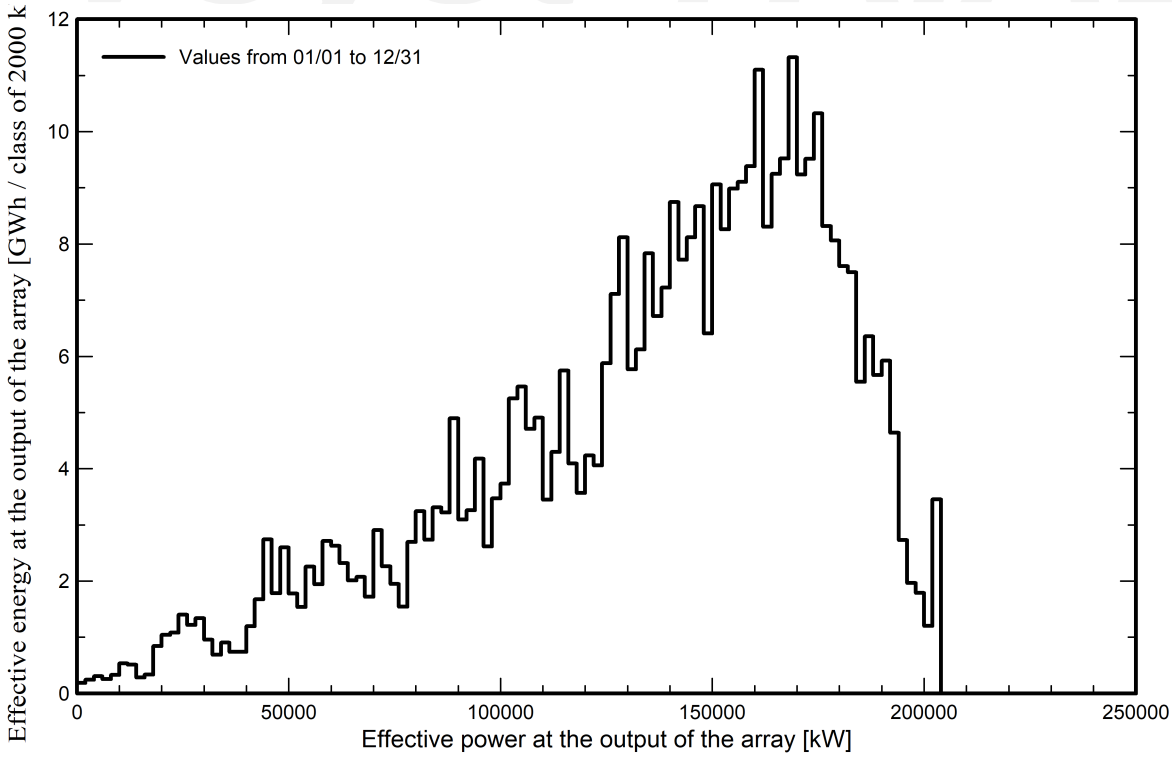
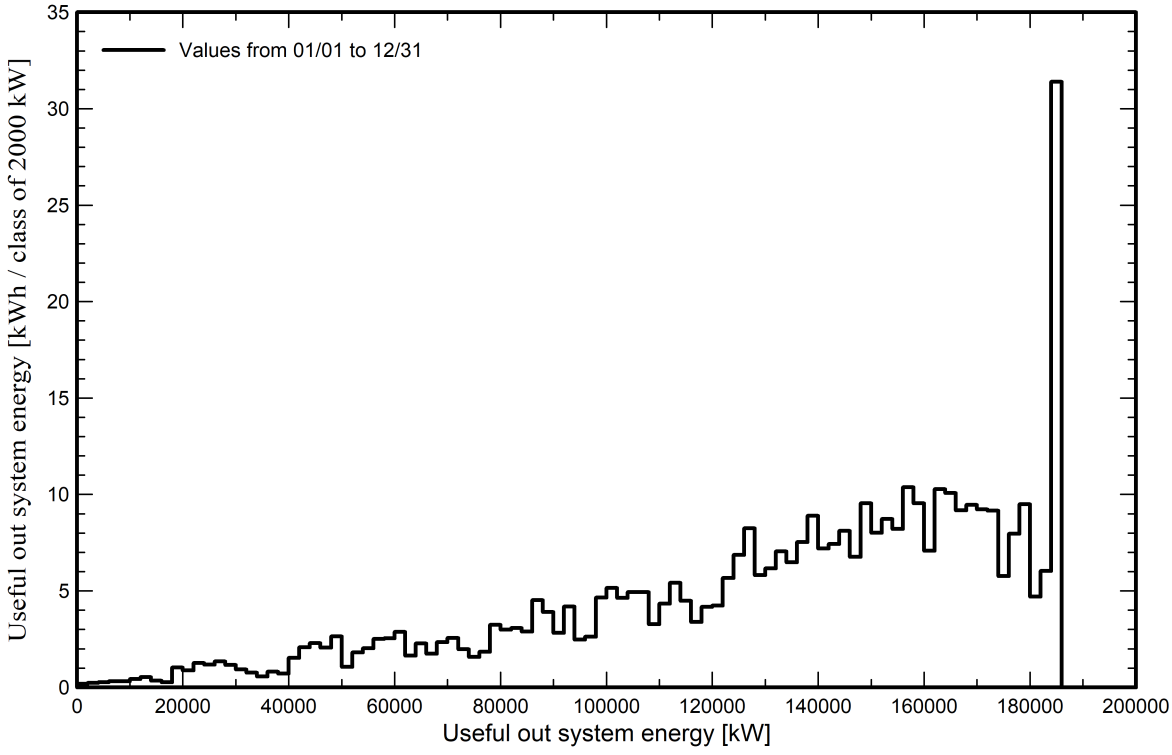
Predef. graphs

Array Power Distribution



System Output Power Distribution



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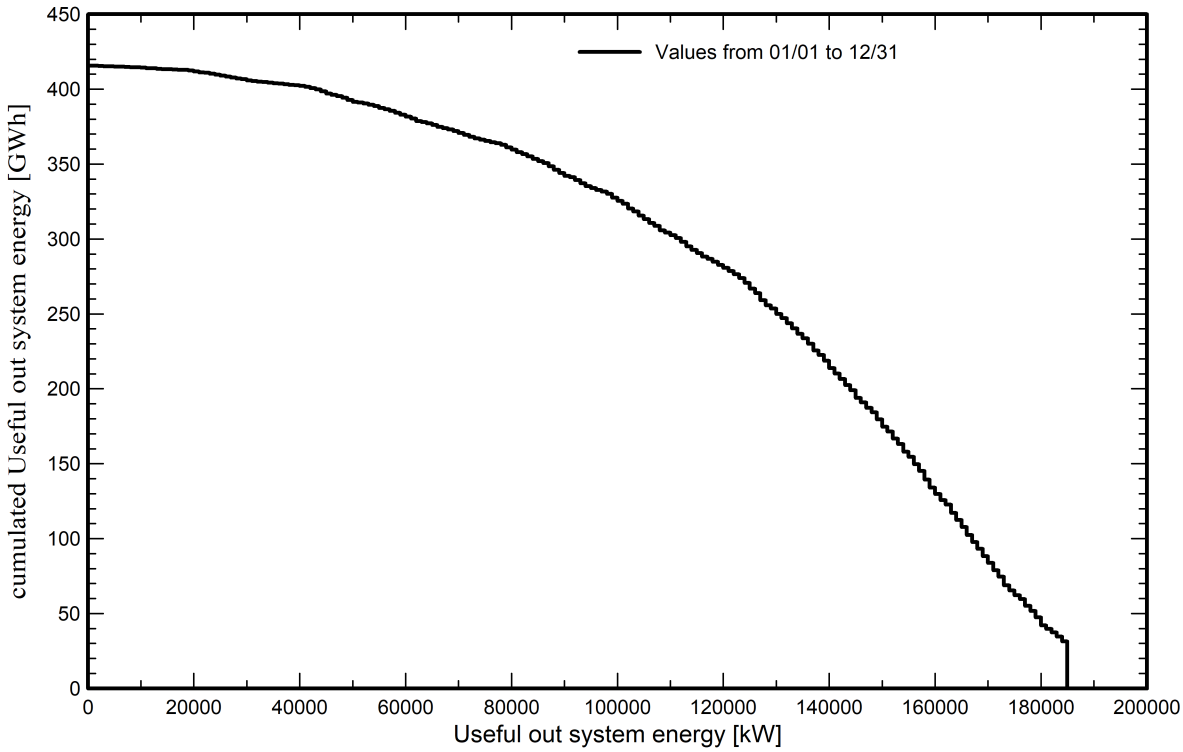
Predef. graphs

System Output Power cumulative distribution



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Single-line diagram

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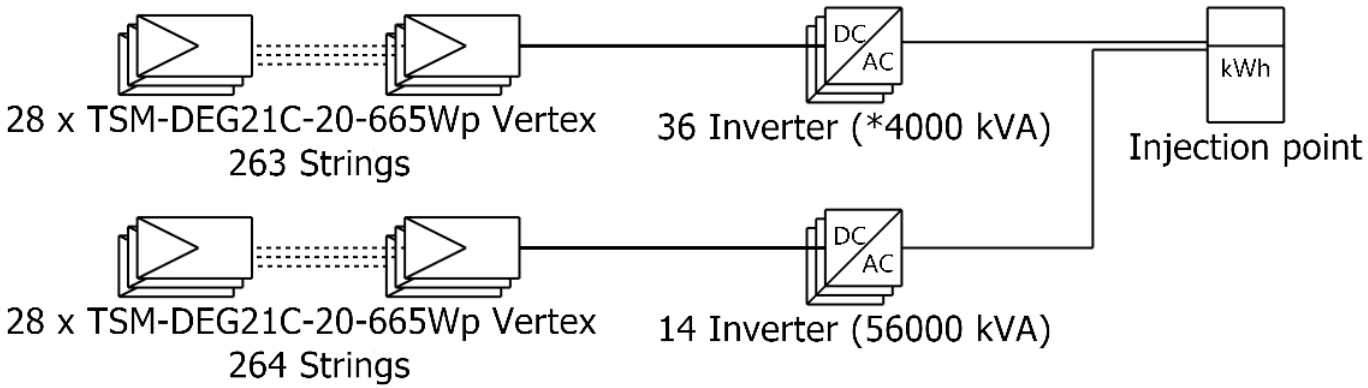

PV module	TSM-DEG21C-20-665Wp Vertex
Inverter	Sunny Central 4000 UP
String	28 x TSM-DEG21C-20-665Wp Vertex

	PV independencia 200MW	
	VC5 : New simulation rentable	09/10/24

Cost of the system

Installation costs

Item	Quantity units	Cost USD	Total USD
PV modules			
TSM-DEG21C-20-665Wp Vertex	368592	79.80	29,413,641.60
Supports for modules	359600	46.55	16,739,380.00
Inverters			
Sunny Central 4000 UP	50	478,268.00	23,913,400.00
Batteries	212	394,796.70	83,696,900.00
Studies and analysis			
Engineering	1	2,391,340.00	2,391,340.00
Installation			
Global installation cost per module	368592	66.50	24,511,368.00
Transport	1	23,913,400.00	23,913,400.00
Insurance			
Building insurance	1	11,956,700.00	11,956,700.00
Land costs			
Land purchase	1	7,174,020.00	7,174,020.00
Land preparation	1	2,391,340.00	2,391,340.00
Loan bank charges			23,913,400.00
		Total	250,014,889.60
		Depreciable asset	153,763,321.60

Operating costs

Item	Total USD/year
Maintenance	
Provision for inverter replacement	4,782,680.00
Salaries	500,000.00
Repairs	1,000,000.00
Cleaning	500,000.00
Provision for battery replacement	10,813,552.97
Bank charges	24,511,368.00
Administrative, accounting	100,000.00
Total (OPEX)	42,207,600.97
Including inflation (1.00%)	47,683,107.79

System summary

Total installation cost	250,014,889.60 USD
Operating costs (incl. inflation 1.00%/year)	47,683,107.79 USD/year
Produced Energy	415579 MWh/year
Cost of produced energy (LCOE)	0.1484 USD/kWh

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Financial analysis

Simulation period

Project lifetime	25 years	Start year	2025

Income variation over time

Inflation	1.00 %/year
Production variation (aging)	0.25 %/year
Discount rate	1.00 %/year

Income dependent expenses

Income tax rate	10.00 %/year
Other income tax	0.00 %/year
Dividends	5.00 %/year

Depreciable assets

Asset	Depreciation method	Depreciation period (years)	Salvage value (USD)	Depreciable (USD)
PV modules				
TSM-DEG21C-20-665Wp Vertex	Straight-line	20	0.00	29,413,641.60
Supports for modules	Straight-line	20	0.00	16,739,380.00
Inverters				
Sunny Central 4000 UP	Straight-line	20	0.00	23,913,400.00
Batteries	Straight-line	20	0.00	83,696,900.00
		Total	0.00	153,763,321.60

Financing

Loan - Redeemable with fixed annuity - 10 years 250,014,889.60 USD Interest rate: 8.00%/year

Electricity sale

Feed-in tariff	0.17000 USD/kWh
Duration of tariff warranty	20 years
Annual connection tax	0.00 USD/kWh
Annual tariff variation	0.0 %/year
Feed-in tariff decrease after warranty	0.00 %

Return on investment

Payback period	14.9 years
Net present value (NPV)	173,742,817.96 USD
Internal rate of return (IRR)	10.31 %
Return on investment (ROI)	69.5 %
Paid dividends	16,370,638.11 USD

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Financial analysis

Detailed economic results (kUSD)

Year	Electricity sale	Loan principal	Loan interest	Run. costs	Deprec. allow.	Taxable income	Taxes	After-tax profit	Divid. 5.00%	Cumul. profit	% amorti.
0	0	0 0	0	0	0	0	0	0	0	0	0.0%
1	70,648,498	0 17,258,400	20,001,191	42,207,601	7,688,166	751,540	75,154	-8,893,848	0	-8,805,790	3.4%
2	70,825,119	0 18,639,072	18,620,519	42,629,677	7,688,166	1,886,757	188,676	-9,252,825	0	-17,876,298	7.2%
3	71,002,182	0 20,130,198	17,129,393	43,055,974	7,688,166	3,128,649	312,865	-9,626,248	0	-27,219,439	11.5%
4	71,179,688	0 21,740,614	15,518,978	43,486,533	7,688,166	4,486,010	448,601	-10,015,038	0	-36,843,693	16.4%
5	71,357,637	0 23,479,863	13,779,729	43,921,399	7,688,166	5,968,343	596,834	-10,420,188	0	-46,758,144	21.8%
6	71,536,031	0 25,358,252	11,901,339	44,360,613	7,688,166	7,585,912	758,591	-10,842,764	0	-56,972,519	27.9%
7	71,714,871	0 27,386,912	9,872,679	44,804,219	7,688,166	9,349,807	934,981	-11,283,920	0	-67,497,235	34.6%
8	71,894,158	0 29,577,865	7,681,726	45,252,261	7,688,166	11,272,005	1,127,200	-11,744,895	0	-78,343,448	42.1%
9	72,073,894	0 31,944,094	5,315,497	45,704,784	7,688,166	13,365,446	1,336,545	-12,227,026	0	-89,523,105	50.4%
10	72,254,078	0 34,499,621	2,759,970	46,161,832	7,688,166	15,644,111	1,564,411	-12,731,756	0	-101,048,997	59.6%
11	72,434,713	0 0	0	46,623,450	7,688,166	18,123,097	1,812,310	23,998,954	1,199,948	-79,538,165	68.2%
12	72,615,800	0 0	0	47,089,684	7,688,166	17,837,950	1,783,795	23,742,321	1,187,116	-58,468,061	76.6%
13	72,797,340	0 0	0	47,560,581	7,688,166	17,548,592	1,754,859	23,481,899	1,174,095	-37,835,394	84.9%
14	72,979,333	0 0	0	48,036,187	7,688,166	17,254,980	1,725,498	23,217,648	1,160,882	-17,636,900	92.9%
15	73,161,781	0 0	0	48,516,549	7,688,166	16,957,066	1,695,707	22,949,526	1,147,476	2,130,662	100.9%
16	73,344,686	0 0	0	49,001,714	7,688,166	16,654,805	1,665,481	22,677,491	1,133,875	21,470,508	108.6%
17	73,528,048	0 0	0	49,491,732	7,688,166	16,348,150	1,634,815	22,401,501	1,120,075	40,385,831	116.2%
18	73,711,868	0 0	0	49,986,649	7,688,166	16,037,053	1,603,705	22,121,514	1,106,076	58,879,800	123.6%
19	73,896,147	0 0	0	50,486,515	7,688,166	15,721,466	1,572,147	21,837,485	1,091,874	76,955,558	130.8%
20	74,080,888	0 0	0	50,991,381	7,688,166	15,401,341	1,540,134	21,549,373	1,077,469	94,616,227	137.8%
21	74,266,090	0 0	0	51,501,294	0	22,764,796	2,276,480	20,488,316	1,024,416	111,241,065	144.5%
22	74,451,755	0 0	0	52,016,307	0	22,435,448	2,243,545	20,191,903	1,009,595	127,463,164	151.0%
23	74,637,885	0 0	0	52,536,470	0	22,101,414	2,210,141	19,891,273	994,564	143,285,513	157.3%
24	74,824,479	0 0	0	53,061,835	0	21,762,644	2,176,264	19,586,380	979,319	158,711,083	163.5%
25	75,011,540	0 0	0	53,592,453	0	21,419,087	2,141,909	19,277,178	963,859	173,742,818	169.5%
Total	**1,820,228,509**	**250,014,890**	**122,581,022**	**1,192,077,695**	**153,763,322**	**351,806,471**	**35,180,647**	**220,374,256**	**16,370,638**	**173,742,818**	**169.5%**

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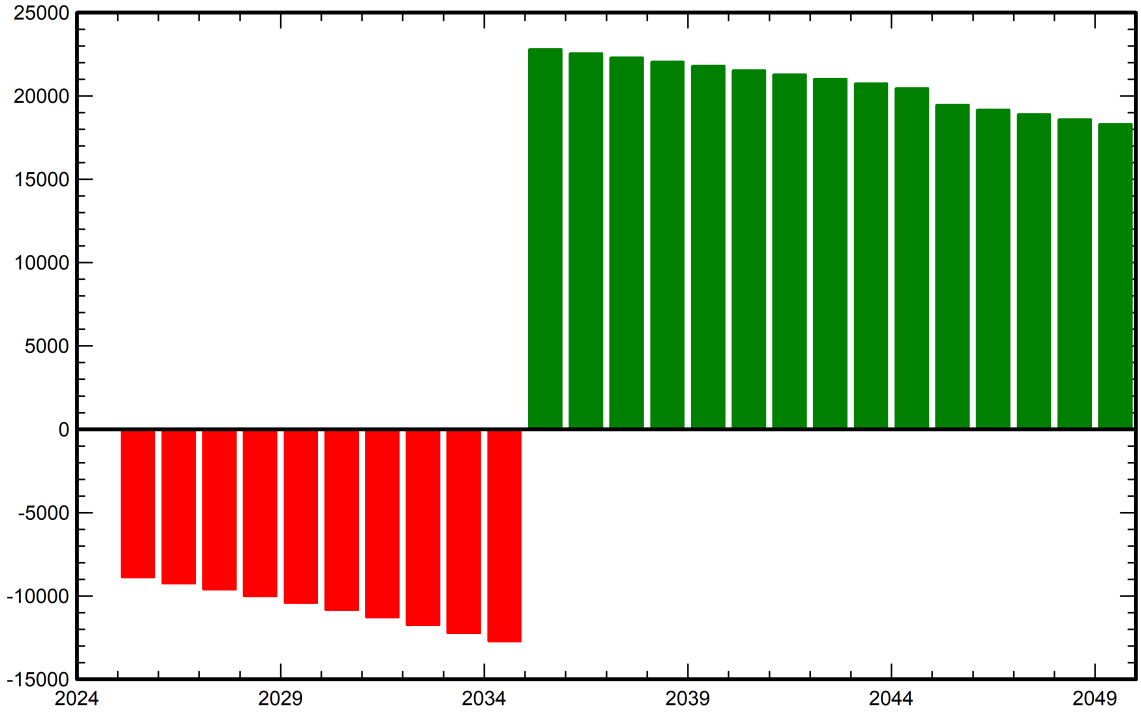
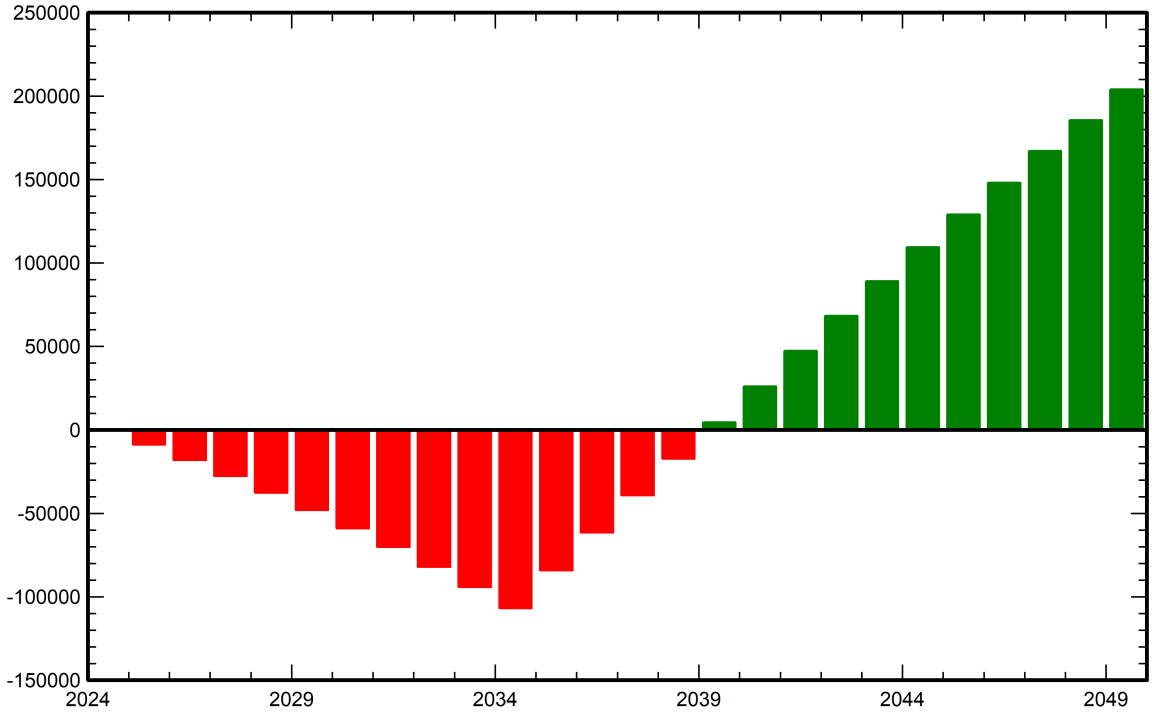
Financial analysis

Yearly net profit (kUSD)



Cumulative cashflow (kUSD)



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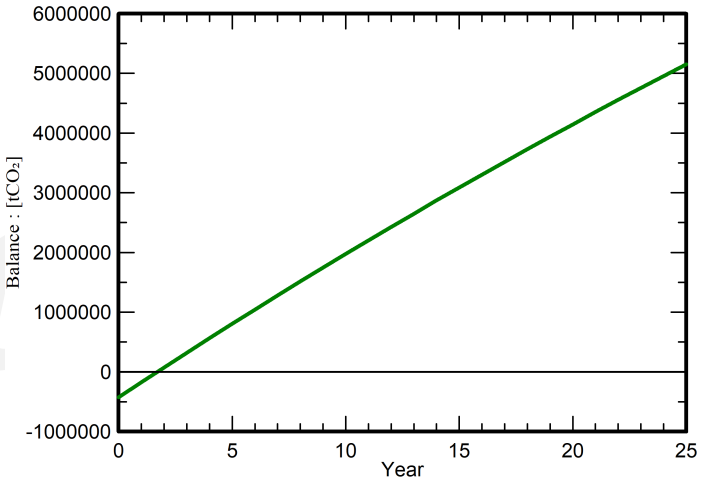
CO_2 Emission Balance

Total: 5152548.8 tCO_2

Generated emissions
Total: 424076.67 tCO_2
Source: Detailed calculation from table below

Replaced Emissions
Total: 6274934.3 tCO_2
System production: 415558.56 MWh/yr
Grid Lifecycle Emissions: 604 gCO_2/kWh
Source: IEA List
Country: Dominican Republic
Lifetime: 25 years
Annual degradation: 1.0 %

Saved CO_2 Emission vs. Time



System Lifecycle Emissions Details

Item	LCE	Quantity	Subtotal
			[$kgCO_2$]
Modules	1713 kgCO2/kWp	239134 kWp	409569584
Supports	4.03 kgCO2/kg	3596000 kg	14487133
Inverters	399 kgCO2/units	50.0 units	19956

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