LIMES
RENEWABLE ENERGY

REGIONE SICILIA
COMUNE DI MONREALE (PA)

PROGETTO

IMPIANTO AGRIVOLTAICO DI POTENZA DI PICCO
PARI A 20,5 MWp DENOMINATO " LIMES 21"
NEL COMUNE DI MONREALE (PA)

TITOLO

Rel. 05 - Rapporto di producibilità

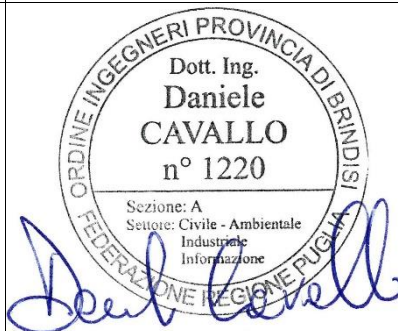| PROGETTISTA	PROPONENTE	VISTI
Progettista **SCM** INGEGNERIA SCM ingegneria S.r.l. Via Carlo del Croix, 55 Tel.: +39 0831-728955 72022 Latiano (BR) Mail: info@scmingegneria.com Dott. Ing. Daniele Cavallo	**LIMES 21 S.r.l.** **Sede legale e Amministrativa:** Via Giuseppe Giardina, 22 96018 PACHINO (SR) PEC: limes21@pec.it	Dott. Ing. Daniele CAVALLO n° 1220 ORDINE INGEGNERI PROVINCIA DI BRINDISI Sezione: A Settore: Civile - Ambientale Industriale Informazione FEDERAZIONE REGIONE PUGLIA

PROGETTAZIONE

Scala	Formato Stampa	Cod.Elaborato	Rev.	Nome File	Foglio
	A4	FV-LIME-MRL-PD-REL05	00	FV-LIME-MRL-PD-REL05-Rapporto di producibilità	1 di 17

Rev.	Data	Descrizione		Elaborato	Controllato	Approvato
00	07/12/2022	Prima Emissione		L. Maculan	D. Cavallo	D. Cavallo

INDICE

1   INTRODUZIONE

Il progetto prevede la realizzazione di un impianto fotovoltaico con tracker monoassiale per la produzione di energia della potenza nominale 20500 kW, da realizzarsi nel comune di Monreale (PA).

2   DATI GENERALI

2.1   DATI DEL PROPONENTE

Di seguito i dati anagrafici del soggetto proponente:

SOCIETA' PROPONENTE	
Denominazione	LIMES 21 S.R.L.
Indirizzo sede legale	Via Giuseppe Giardina, 22 - 96018 Pachino (SR)
Codice Fiscale/Partita IVA	01974980896
Capitale Sociale	10000 €
PEC	limes21@pec.it

Tabella 2-1 – Informazioni principali della Società Proponente

2.2   LOCALITÀ DI REALIZZAZIONE DELL'INTERVENTO

L'impianto fotovoltaico oggetto del presente documento sarà realizzato nel comune di Monreale (PA).

2.3   DESTINAZIONE D'USO

L'area oggetto dell'intervento ha una destinazione d'uso agricolo, come da Certificati di Destinazione Urbanistica allegati alla documentazione di progetto.

2.4   DATI CATASTALI

I terreni interessati dall'intervento, così come individuati al catasto terreni del Comune di Monreale (PA) sono particelle al foglio 146, part. 21-22-31-32-49-54-55-111-119, e al foglio 147, part. 56-147-154-194-195-280-282-283

Tutti i terreni su cui saranno installati i moduli fotovoltaici e realizzate le infrastrutture necessarie, risultano di proprietà privata e corrispondono a terreni ad uso prevalentemente agricolo o in ogni caso lasciati incolti.

Luogo di installazione	Comune di Monreale (PA)
Potenza di Picco (kWp)	20500 kWp

Potenza Nominale (kW)	20500 kWp
Potenza massima in immissione	20500 kW
Informazioni generali del sito	Sito collinare ben raggiungibile da strade provinciali/comunali
Tipo di strutture di sostegno	Inseguitore monoassiale
Coordinate area Nord	Latitudine 37°54'36.26"N Longitudine 13°13'53.04"E
Coordinate area Centro	Latitudine 37°53'53.21"N Longitudine 13°12'46.47"E
Coordinate area Sud	Latitudine 37°52'56.38"N Longitudine 13°12'51.65"E
Coordinate Cabina Utente 36 kV	Latitudine 37°54'0.45"N Longitudine 13°18'0.12"E

Tabella 2-2 – Dati catastali

2.5   CONNESSIONE

Il progetto di connessione, associato al codice pratica 202100063 prevede che la centrale venga collegata in antenna a 36 kV con una nuova stazione elettrica di trasformazione della RTN a 220/36 kV in doppia sbarra, denominata "Monreale 3", da collegare in entra - esce sulla linea a 220 kV della RTN "Partinico - Ciminna".

3 STIMA PRODUZIONE IMPIANTO FOTOVOLTAICO

L'impianto, come detto, sarà installato nel comune di Monreale (PA) e sarà diviso in tre aree, per le quali si possono considerare le coordinate baricentriche identificate nel precedente paragrafo 2.4.

Nella località di progetto si può considerare un irraggiamento medio annuo su superficie del modulo fotovoltaico installato su tracker di circa 2.107 kWh/m^2.

La potenza alle condizioni STC (irraggiamento dei moduli di 1000 W/m² a 25°C di temperatura) risulta essere:

$$PSTC = PMODULO \times N°MODULI = 580 \times 34632 = 20086 \text{ kWp}$$

Di seguito viene riportato il rapporto relativo alla simulazione della producibilità del sito.

LIMES
RENEWABLE ENERGY

Version 7.2.21

PVsyst
PHOTOVOLTAIC SOFTWARE

PVsyst - Simulation report

Grid-Connected System

Project: Limes 21

Variant: Nuova variante di simulazione
Unlimited Trackers with backtracking
System power: 20.09 MWp
Perciata - Italy

Author
Ing Daniele Cavallo (Italy)

PVsyst V7.2.21
VC0, Simulation date:
07/12/22 10:41
with v7.2.21

Project: Limes 21

Variant: Nuova variante di simulazione

Ing Daniele Cavallo (Italy)

Project summary

Geographical Site
Perciata
Italy

Situation
Latitude	37.90 °N
Longitude	13.21 °E
Altitude	395 m
Time zone	UTC+1

Project settings
Albedo   0.20

Meteo data
Perciata
Meteonorm 8.0 (1986-2005), Sat=100% - Sintetico

System summary

Grid-Connected System

Unlimited Trackers with backtracking

PV Field Orientation
Orientation
Tracking horizontal axis

Tracking algorithm
Astronomic calculation
Backtracking activated

Near Shadings
No Shadings

System information

PV Array		**Inverters**	
Nb. of modules	34632 units	Nb. of units	5 units
Pnom total	20.09 MWp	Pnom total	19.67 MWac
		Pnom ratio	1.021

User's needs
Unlimited load (grid)

Results summary

Produced Energy	37.26 GWh/year	Specific production	1855 kWh/kWp/year	Perf. Ratio PR	88.02 %

Table of contents

LIMES 21 S.R.L
Sede legale e Amministrativa: Via Giuseppe Giardina, 22 - 96018 Pachino (SR)
PEC: limes21@pec.it

PVsyst V7.2.21
VC0, Simulation date:
07/12/22 10:41
with v7.2.21

Project: Limes 21

Variant: Nuova variante di simulazione

Ing Daniele Cavallo (Italy)

General parameters

Grid-Connected System

Unlimited Trackers with backtracking

PV Field Orientation

Orientation	**Tracking algorithm**	**Backtracking array**	
Tracking horizontal axis	Astronomic calculation	Nb. of trackers	30 units
	Backtracking activated	Unlimited trackers	
		Sizes	
		Tracker Spacing	11.2 m
		Collector width	4.85 m
		Ground Cov. Ratio (GCR)	43.3 %
		Phi min / max.	-/+ 55.0 °
		Backtracking strategy	
		Phi limits	+/- 64.2 °
		Backtracking pitch	11.2 m
		Backtracking width	4.85 m

Models used
Transposition   Perez
Diffuse   Perez, Meteonorm
Circumsolar   separate

Horizon		**Near Shadings**	**User's needs**
Average Height	4.0 °	No Shadings	Unlimited load (grid)

Bifacial system
Model   2D Calculation
              unlimited trackers

Bifacial model geometry		**Bifacial model definitions**	
Tracker Spacing	11.20 m	Ground albedo	0.30
Tracker width	4.85 m	Bifaciality factor	71 %
GCR	43.3 %	Rear shading factor	5.0 %
Axis height above ground	2.70 m	Rear mismatch loss	10.0 %
		Shed transparent fraction	0.0 %

PV Array Characteristics

Array #1 - C01

PV module		**Inverter**	
Manufacturer	Jinkosolar	Manufacturer	SMA
Model	JKM580M-7RL4-TV	Model	Sunny Central 4400 UP
(Custom parameters definition)		(Original PVsyst database)	
Unit Nom. Power	580 Wp	Unit Nom. Power	4400 kWac
Number of PV modules	7722 units	Number of inverters	1 unit
Nominal (STC)	4479 kWp	Total power	4400 kWac
Modules	297 Strings x 26 In series	Operating voltage	962-1325 V
At operating cond. (50°C)		Pnom ratio (DC:AC)	1.02
Pmpp	4087 kWp		
U mpp	1050 V		
I mpp	3894 A		

PV module		**Inverter**	
Manufacturer	Jinkosolar	Manufacturer	SMA
Model	JKM580M-7RL4-TV	Model	Sunny Central 4200 UP
(Custom parameters definition)		(Original PVsyst database)	
Unit Nom. Power	580 Wp	Unit Nom. Power	4200 kWac
Number of PV modules	22256 units	Number of inverters	3 units
Nominal (STC)	12.91 MWp	Total power	12600 kWac

07/12/22   PVsyst Licensed to Ing Daniele Cavallo (Italy)   Page 3/13

PVsyst V7.2.21
VC0, Simulation date:
07/12/22 10:41
with v7.2.21

Project: Limes 21

Variant: Nuova variante di simulazione

Ing Daniele Cavallo (Italy)

PV Array Characteristics

Array #2 - C02

Number of PV modules	7384 units	Number of inverters	1 unit
Nominal (STC)	4283 kWp	Total power	4200 kWac
Modules	284 Strings x 26 In series		
At operating cond. (50°C)		Operating voltage	921-1325 V
Pmpp	3908 kWp	Pnom ratio (DC:AC)	1.02
U mpp	1050 V		
I mpp	3724 A		

Array #3 - C03

Number of PV modules	7436 units	Number of inverters	1 unit
Nominal (STC)	4313 kWp	Total power	4200 kWac
Modules	286 Strings x 26 In series		
At operating cond. (50°C)		Operating voltage	921-1325 V
Pmpp	3936 kWp	Pnom ratio (DC:AC)	1.03
U mpp	1050 V		
I mpp	3750 A		

Array #5 - C05

Number of PV modules	7436 units	Number of inverters	1 unit
Nominal (STC)	4313 kWp	Total power	4200 kWac
Modules	286 Strings x 26 In series		
At operating cond. (50°C)		Operating voltage	921-1325 V
Pmpp	3936 kWp	Pnom ratio (DC:AC)	1.03
U mpp	1050 V		
I mpp	3750 A		

Array #4 - C04

PV module		Inverter	
Manufacturer	Jinkosolar	Manufacturer	SMA
Model	JKM580M-7RL4-TV	Model	Sunny Central 2660 UP_1.2_prelim
(Custom parameters definition)		(Custom parameters definition)	
Unit Nom. Power	580 Wp	Unit Nom. Power	2667 kWac
Number of PV modules	4654 units	Number of inverters	1 unit
Nominal (STC)	2699 kWp	Total power	2667 kWac
Modules	179 Strings x 26 In series	Operating voltage	880-1325 V
At operating cond. (50°C)		Pnom ratio (DC:AC)	1.01
Pmpp	2463 kWp		
U mpp	1050 V		
I mpp	2347 A		

Total PV power		Total inverter power	
Nominal (STC)	20087 kWp	Total power	19667 kWac
Total	34632 modules	Number of inverters	5 units
Module area	94686 m²	Pnom ratio	1.02
Cell area	89197 m²		

Array losses

Array Soiling Losses		Thermal Loss factor		Serie Diode Loss	
Loss Fraction	1.5 %	Module temperature according to irradiance		Voltage drop	0.7 V
		Uc (const)	29.0 W/m²K	Loss Fraction	0.1 % at STC
		Uv (wind)	0.0 W/m²K/m/s		

LID - Light Induced Degradation		Module Quality Loss		Module mismatch losses	
Loss Fraction	2.0 %	Loss Fraction	-0.8 %	Loss Fraction	2.0 % at MPP

Impianto agrivoltaico di potenza di picco pari a 20,5 MWp
denominato "*LIMES 21*" da realizzarsi nel comune di Monreale (PA)

LIMES
RENEWABLE ENERGY

Project: Limes 21

Variant: Nuova variante di simulazione

PVsyst V7.2.21
VC0, Simulation date:
07/12/22 10:41
with v7.2.21

Ing Daniele Cavallo (Italy)

Array losses

Strings Mismatch loss
Loss Fraction   0.1 %

IAM loss factor
Incidence effect (IAM): User defined profile

0°	32°	56°	60°	66°	72°	75°	80°	90°
1.000	1.000	1.000	0.999	0.997	0.991	0.965	0.923	0.000

DC wiring losses

Global wiring resistance   0.99 mΩ
Loss Fraction   1.5 % at STC

Array #1 - C01		**Array #2 - C02**	
Global array res.	4.4 mΩ	Global array res.	4.7 mΩ
Loss Fraction	1.5 % at STC	Loss Fraction	1.5 % at STC
Array #3 - C03		**Array #4 - C04**	
Global array res.	4.6 mΩ	Global array res.	7.4 mΩ
Loss Fraction	1.5 % at STC	Loss Fraction	1.5 % at STC
Array #5 - C05			
Global array res.	4.6 mΩ		
Loss Fraction	1.5 % at STC		

System losses

Unavailability of the system   **Auxiliaries loss**
Time fraction   1.0 %   constant (fans)   10.00 kW
                    3.7 days,   10.0 kW from Power thresh.
                    3 periods

AC wiring losses

Inv. output line up to MV transfo
Inverter voltage   660 Vac tri
Loss Fraction   0.02 % at STC

Inverters: Sunny Central 4400 UP, Sunny Central 4200 UP		**Inverter: Sunny Central 2660 UP_1.2_prelim**	
Wire section (4 Inv.)	Alu 4 x 3 x 4000 mm²	Wire section (1 Inv.)	Alu 1 x 3 x 2500 mm²
Average wires length	3 m	Wires length	0 m

MV line up to Injection
MV Voltage   36 kV
Average loss Fraction   0.10 % at STC

Array #1 - C01		**Array #2 - C02**	
Wires	Alu 3 x 185 mm²	Wires	Alu 3 x 185 mm²
Length	10000 m	Length	0 m
Array #3 - C03		**Array #4 - C04**	
Wires	Alu 3 x 185 mm²	Wires	Alu 3 x 185 mm²
Length	0 m	Length	0 m
Array #5 - C05			
Wires	Alu 3 x 185 mm²		
Length	0 m		

PVsyst V7.2.21
VC0, Simulation date:
07/12/22 10:41
with v7.2.21

Project: Limes 21

Variant: Nuova variante di simulazione

Ing Daniele Cavallo (Italy)

AC losses in transformers

MV transfo

Grid voltage	36 kV
Operating losses at STC	
Nominal power at STC	4401 kVA
Iron loss (night disconnect)	0.88 kW/Inv.
Loss Fraction	0.10 % at STC
Coils equivalent resistance	3 x 4.95 mΩ/inv.
Loss Fraction	1.00 % at STC

LIMES 21 S.R.L
Sede legale e Amministrativa: Via Giuseppe Giardina, 22 - 96018 Pachino (SR)
PEC: limes21@pec.it

LIMES
RENEWABLE ENERGY

PVsyst V7.2.21
VC0, Simulation date:
07/12/22 10:41
with v7.2.21

Project: Limes 21

Variant: Nuova variante di simulazione

Ing Daniele Cavallo (Italy)

Horizon definition

Horizon from PVGIS website API, Lat=37°53"50', Long=13°12"50', Alt=395m

Average Height	4.0 °		Albedo Factor	0.72
Diffuse Factor	0.94		Albedo Fraction	100 %

Horizon profile

Azimuth [°]	-180	-173	-143	-135	-128	-120	-113	-105	-90	-83	-75	-68	-53
Height [°]	6.5	5.0	5.0	2.7	2.7	2.3	2.3	1.9	1.9	1.5	3.8	1.9	1.9
Azimuth [°]	-45	-38	-30	-23	-15	-8	8	15	23	30	38	45	68
Height [°]	1.5	2.7	2.3	1.9	1.9	0.8	1.5	1.1	1.5	1.9	1.1	3.8	3.8
Azimuth [°]	75	98	105	120	128	143	150	158	165	173	180		
Height [°]	4.6	4.6	7.3	7.3	8.8	9.9	9.2	7.6	6.5	7.3	6.5		

Sun Paths (Height / Azimuth diagram)

1: 22 June
2: 22 May and 23 July
3: 20 Apr and 23 Aug
4: 20 Mar and 23 Sep
5: 21 Feb and 23 Oct
6: 19 Jan and 22 Nov
7: 22 December

LIMES 21 S.R.L
Sede legale e Amministrativa: Via Giuseppe Giardina, 22 - 96018 Pachino (SR)
PEC: limes21@pec.it

LIMES RENEWABLE ENERGY

PVsyst V7.2.21
VC0, Simulation date:
07/12/22 10:41
with v7.2.21

Project: Limes 21

Variant: Nuova variante di simulazione

Ing Daniele Cavallo (Italy)

Main results
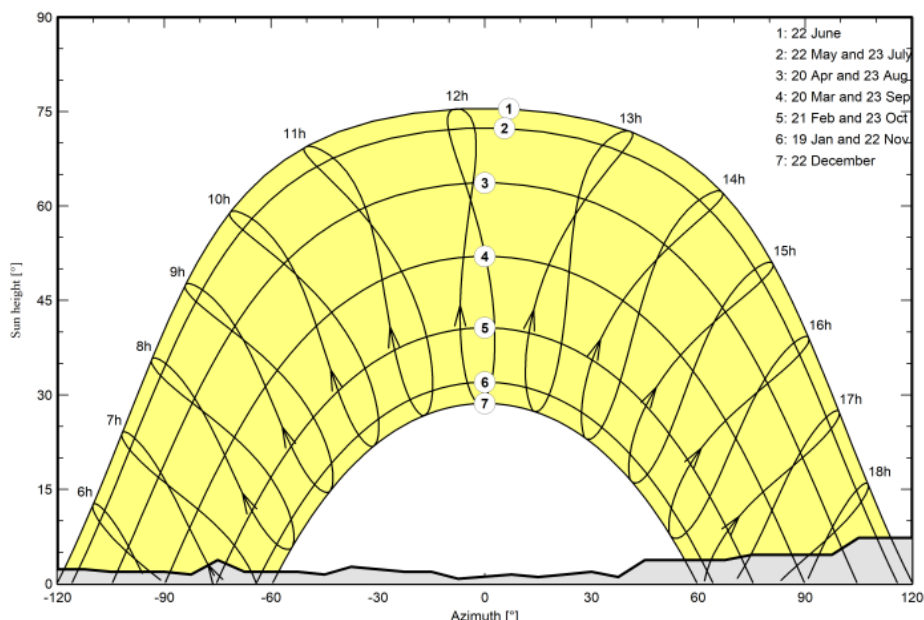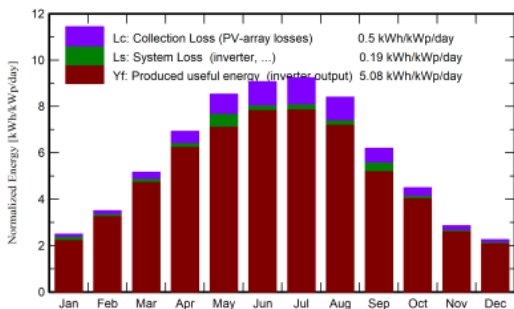
System Production

Produced Energy	37.26 GWh/year

Specific production	1855 kWh/kWp/year
Performance Ratio PR	88.02 %

Normalized productions (per installed kWp)

Lc: Collection Loss (PV-array losses) 0.5 kWh/kWp/day
Ls: System Loss (inverter, ...) 0.19 kWh/kWp/day
Yf: Produced useful energy (inverter output) 5.08 kWh/kWp/day

Performance Ratio PR

PR: Performance Ratio (Yf / Yr) : 0.880
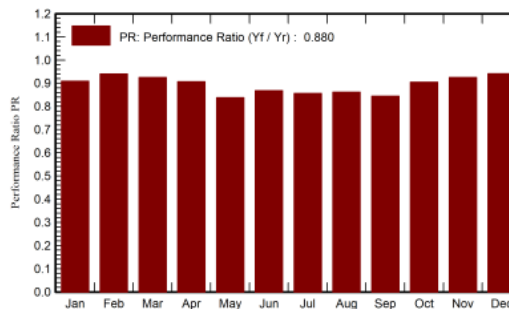
Balances and main results

	GlobHor	DiffHor	T_Amb	GlobInc	GlobEff	EArray	E_Grid	PR
	kWh/m²	kWh/m²	°C	kWh/m²	kWh/m²	GWh	GWh	ratio
January	59.5	26.90	11.58	77.3	73.9	1.496	1.412	0.909
February	77.3	36.28	11.38	98.2	94.2	1.903	1.854	0.940
March	127.2	61.86	13.68	160.0	153.4	3.051	2.974	0.925
April	163.4	67.63	15.91	207.8	200.4	3.885	3.784	0.907
May	205.3	75.15	20.49	264.5	254.7	4.803	4.452	0.838
June	210.2	78.51	24.26	272.0	261.7	4.868	4.744	0.868
July	221.7	76.07	27.32	286.4	275.8	5.055	4.927	0.856
August	199.6	73.34	27.60	260.4	251.4	4.625	4.510	0.862
September	145.7	62.10	23.69	186.0	178.8	3.386	3.156	0.845
October	108.0	48.26	21.08	139.5	133.9	2.597	2.534	0.905
November	66.9	32.21	16.63	85.6	82.0	1.634	1.592	0.926
December	55.0	28.67	13.05	70.0	66.9	1.358	1.324	0.942
Year	1639.8	666.97	18.94	2107.7	2027.0	38.660	37.263	0.880

Legends

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

LIMES RENEWABLE ENERGY

Project: Limes 21

Variant: Nuova variante di simulazione

Ing Daniele Cavallo (Italy)

PVsyst V7.2.21
VC0, Simulation date:
07/12/22 10:41
with v7.2.21

Loss diagram

1640 kWh/m²   **Global horizontal irradiation**
              +28.5%   **Global incident in coll. plane**

              -1.06%   Far Shadings / Horizon
              -1.59%   Near Shadings: irradiance loss
              -0.16%   IAM factor on global
              -1.50%   Soiling loss factor
              +0.44%   Ground reflection on front side

Bifacial

Global incident on ground
748 kWh/m² on 218657 m²

              -70.00% (0.30 Gnd. albedo)
                        Ground reflection loss

              -73.87%   View Factor for rear side

              +16.56%   Sky diffuse on the rear side
              +0.00%   Beam effective on the rear side
              -5.00%   Shadings loss on rear side
7.39% Global Irradiance on rear side (150 kWh/m²)

2027 kWh/m² * 94686 m² coll.   **Effective irradiation on collectors**

efficiency at STC = 21.21%   PV conversion, Bifaciality factor = 0.71

42.85 GWh   **Array nominal energy (at STC effic.)**
              +0.20%   PV loss due to irradiance level
              -5.11%   PV loss due to temperature
              +0.75%   Module quality loss
              -2.00%   LID - Light induced degradation
              -2.10%   Mismatch loss, modules and strings
              -0.70%   Mismatch for back irradiance
              -1.13%   Ohmic wiring loss
38.66 GWh   **Array virtual energy at MPP**
              -1.52%   Inverter Loss during operation (efficiency)
              0.00%   Inverter Loss over nominal inv. power
              0.00%   Inverter Loss due to max. input current
              0.00%   Inverter Loss over nominal inv. voltage
              0.00%   Inverter Loss due to power threshold
              0.00%   Inverter Loss due to voltage threshold
              0.00%   Night consumption
38.07 GWh   **Available Energy at Inverter Output**
              -0.11%   Auxiliaries (fans, other)
              -0.01%   AC ohmic loss
              -0.84%   Medium voltage transfo loss
              -0.06%   MV line ohmic loss
              -1.12%   System unavailability
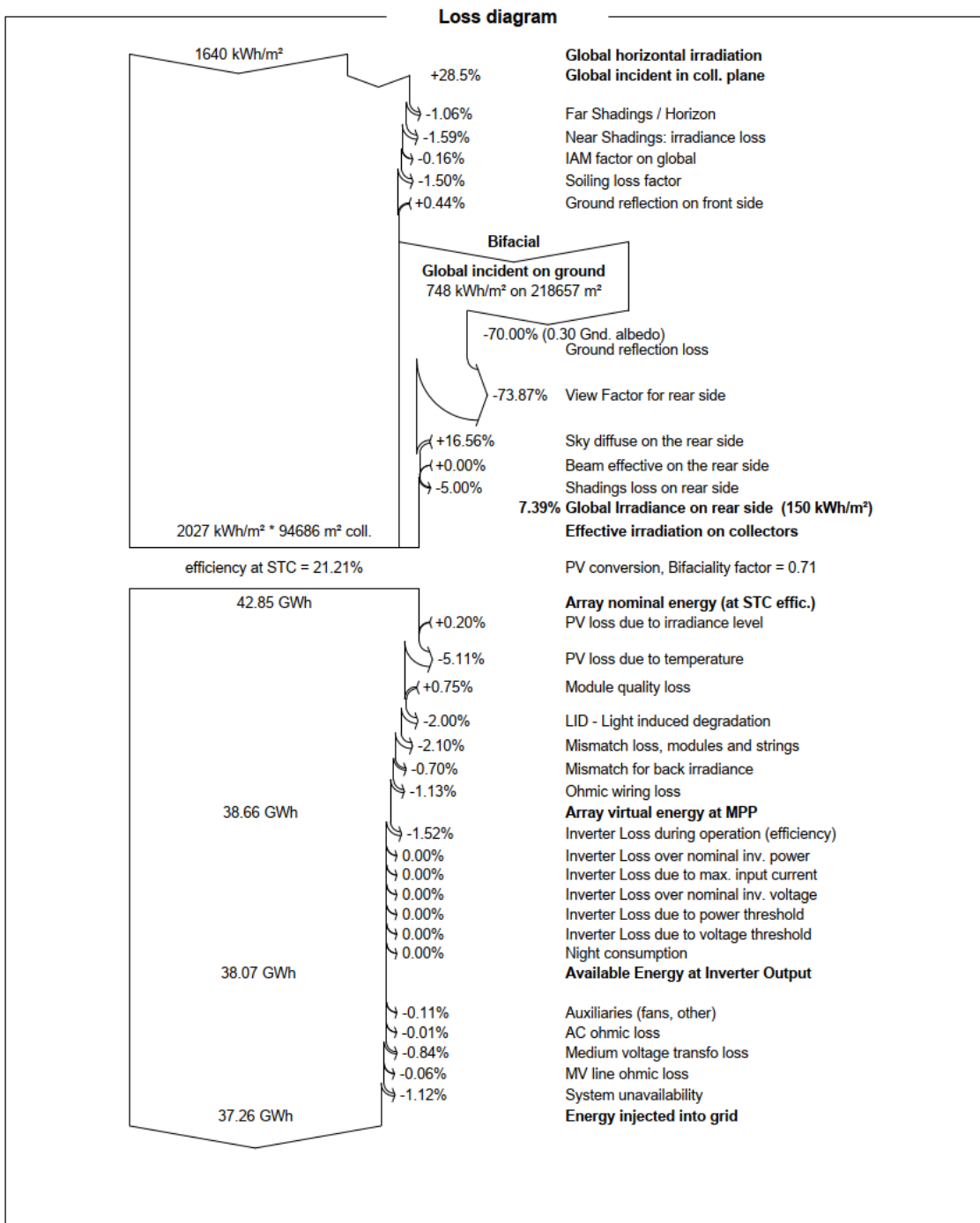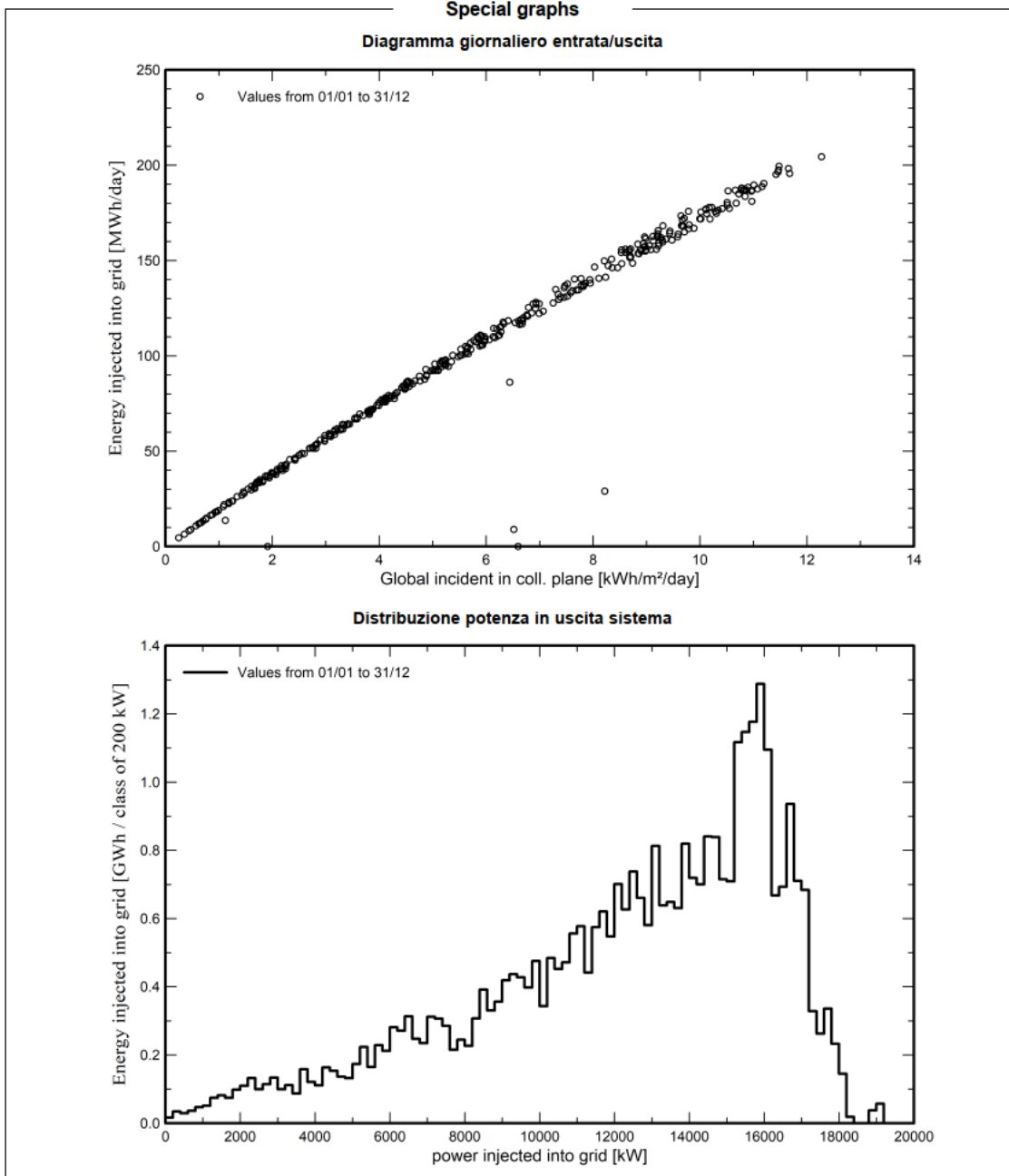37.26 GWh   **Energy injected into grid**

PVsyst V7.2.21
VC0, Simulation date:
07/12/22 10:41
with v7.2.21

Project: Limes 21

Variant: Nuova variante di simulazione

Ing Daniele Cavallo (Italy)

Special graphs

Diagramma giornaliero entrata/uscita

Distribuzione potenza in uscita sistema

pag. 15

LIMES
RENEWABLE ENERGY

PVsyst V7.2.21
VC0, Simulation date:
07/12/22 10:41
with v7.2.21

Project: Limes 21

Variant: Nuova variante di simulazione

Ing Daniele Cavallo (Italy)

P50 - P90 evaluation

Meteo data

Source	Meteonorm 8.0 (1986-2005), Sat=100%	
Kind	TMY, multi-year	
Year-to-year variability(Variance)		4.4 %

Specified Deviation

Climate change	0.0 %

Global variability (meteo + system)

Variability (Quadratic sum)	4.8 %

Simulation and parameters uncertainties

PV module modelling/parameters	1.0 %
Inverter efficiency uncertainty	0.5 %
Soiling and mismatch uncertainties	1.0 %
Degradation uncertainty	1.0 %

Annual production probability

Variability	1.77 GWh
P50	37.26 GWh
P90	34.99 GWh
P70	36.33 GWh

Probability distribution
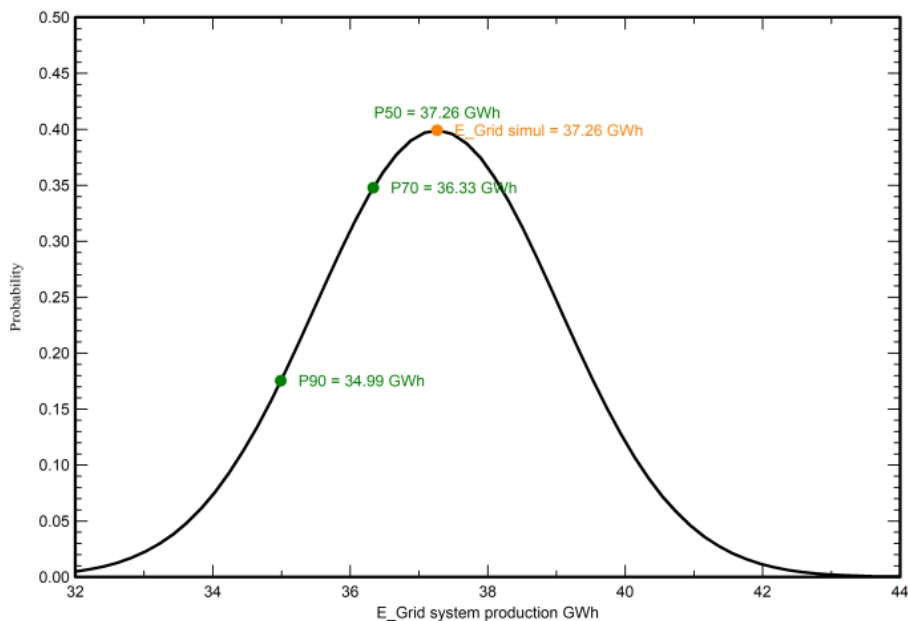
P50 = 37.26 GWh
E_Grid simul = 37.26 GWh
P70 = 36.33 GWh
P90 = 34.99 GWh

LIMES 21 S.R.L
Sede legale e Amministrativa: Via Giuseppe Giardina, 22 - 96018 Pachino (SR)
PEC: limes21@pec.it

PVsyst V7.2.21
VC0, Simulation date:
07/12/22 10:41
with v7.2.21

Project: Limes 21

Variant: Nuova variante di simulazione

Ing Daniele Cavallo (Italy)

CO_2 Emission Balance

Total:	371003.1 tCO_2
Generated emissions	
Total:	39289.60 tCO_2
Source: Detailed calculation from table below:	
Replaced Emissions	
Total:	472869.8 tCO_2
System production:	37263.18 MWh/yr
Grid Lifecycle Emissions:	423 gCO_2/kWh
Source:	IEA List
Country:	Italy
Lifetime:	30 years
Annual degradation:	1.0 %

Saved CO_2 Emission vs. Time
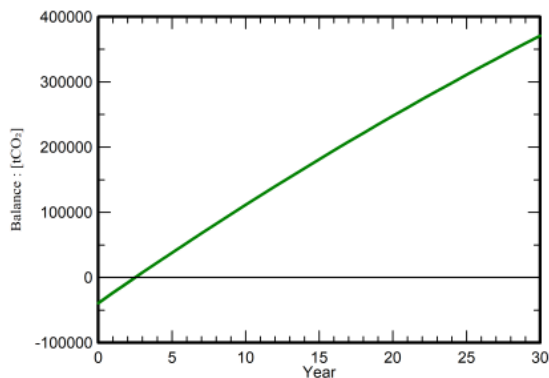
System Lifecycle Emissions Details

Item	LCE	Quantity	Subtotal
			[$kgCO_2$]
Modules	1713 kgCO2/kWp	20087 kWp	34402653
Supports	2.82 kgCO2/kg	1731600 kg	4885554
Inverters	280 kgCO2/units	5.00 units	1398