



COMMITTENTE:

ASELLUS S.R.L.  
via Mercato, 3, 20121 - Milano (MI)

NOME COMMESSA:

COSTRUZIONE ED ESERCIZIO IMPIANTO  
AGROVOLTAICO AVENTE POTENZA IN  
IMMISSIONE PARI A 15.3 MW E POTENZA  
MODULI PARI A 19.97 MW<sub>p</sub> CON RELATIVO  
COLLEGAMENTO ALLA RETE ELETTRICA  
IMPIANTO 03

STATO DI AVANZAMENTO COMMESSA:

PROGETTO DEFINITIVO PER AUTORIZZAZIONE UNICA

CODICE COMMESSA:

HE.18.0019

PROGETTISTA:

ORDINE DEGLI INGEGNERI  
DELLA PROV. DI TRENTO

dott. ing. ALBERTO ALBUZZI  
ISCRIZIONE ALBO N. 2435

COLLABORATORE:

CONSULENTI:

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OGGETTO:

09 IMPIANTO DI PRODUZIONE DI ENERGIA  
Analisi della risorsa solare e stima di produzione energia

SCALA:

-

DATA:

APRILE 2021

NOME FILE:

6UJG3T7\_Elaborato\_09\_01.pdf

TAVOLA:

DPE.RE01

N. REV.	DATA	REVISIONE
0	04.2021	Emissione

ELABORATO

A.Albuzzi

VERIFICATO

responsabile commessa  
A.Albuzzi

VALIDATO

direttore tecnico  
N.Zuech

## Grid-Connected System: Simulation parameters

**Project :** **20191129 HE180019\_CSC\_Avetrana\_3**

<b>Geographical Site</b>	<b>Avetrana</b>	Country	<b>Italy</b>
<b>Situation</b>	Latitude	Longitude	17.79° E
Time defined as	Legal Time	Altitude	56 m
	Albedo		0.20
<b>Meteo data:</b>	<b>Avetrana</b>	Meteonorm 7.2, Sat=100% - Synthetic	

**Simulation variant :** **BR Tracker mono CS3W-420W 2P 10m Avetrana 3 1698 stringhe**

Simulation date 17/01/20 15h55

<b>Simulation parameters</b>	System type	<b>Trackers single array, with backtracking</b>	
<b>Tracking plane, tilted Axis</b>	Axis Tilt	Axis Azimuth	0°
Rotation Limitations	Minimum Phi	Maximum Phi	60°
	Tracking algorithm	Astronomic calculation	
<b>Backtracking strategy</b>	Nb. of trackers	Single array	
	Tracker Spacing	Collector width	4.24 m
Inactive band	Left	Right	0.02 m
Backtracking limit angle	Phi limits	Ground cov. Ratio (GCR)	42.4 %
<b>Models used</b>	Transposition	Perez	Diffuse Perez, Meteonorm
<b>Horizon</b>	Free Horizon		
<b>Near Shadings</b>	Linear shadings		
<b>User's needs :</b>	Unlimited load (grid)		

### PV Arrays Characteristics (4 kinds of array defined)

<b>PV module</b>	Si-poly	Model	<b>CS3W-420P 1500V SE</b>	
Custom parameters definition	Manufacturer	Canadian Solar Inc.		
<b>Sub-array "Sub-array #1"</b>				
Number of PV modules	In series	28 modules	In parallel	646 strings
Total number of PV modules	Nb. modules	18088	Unit Nom. Power	420 Wp
Array global power	Nominal (STC)	<b>7597 kWp</b>	At operating cond.	6896 kWp (50°C)
Array operating characteristics (50°C)	U mpp	996 V	I mpp	6922 A
<b>Sub-array "Sub-array #2"</b>				
Number of PV modules	In series	28 modules	In parallel	646 strings
Total number of PV modules	Nb. modules	18088	Unit Nom. Power	420 Wp
Array global power	Nominal (STC)	<b>7597 kWp</b>	At operating cond.	6896 kWp (50°C)
Array operating characteristics (50°C)	U mpp	996 V	I mpp	6922 A
<b>Sub-array "Sub-array #3a"</b>				
Number of PV modules	In series	28 modules	In parallel	95 strings
Total number of PV modules	Nb. modules	2660	Unit Nom. Power	420 Wp
Array global power	Nominal (STC)	<b>1117 kWp</b>	At operating cond.	1014 kWp (50°C)
Array operating characteristics (50°C)	U mpp	996 V	I mpp	1018 A
<b>Sub-array "Sub-array #3b"</b>				
Number of PV modules	In series	28 modules	In parallel	311 strings
Total number of PV modules	Nb. modules	8708	Unit Nom. Power	420 Wp
Array global power	Nominal (STC)	<b>3657 kWp</b>	At operating cond.	3320 kWp (50°C)
Array operating characteristics (50°C)	U mpp	996 V	I mpp	3332 A
<b>Total</b>	Arrays global power	Nominal (STC)	<b>19968 kWp</b>	Total
		Module area	<b>105033 m<sup>2</sup></b>	Cell area
				47544 modules
				94343 m <sup>2</sup>

### Grid-Connected System: Simulation parameters

<b>Inverter</b>	Model	<b>SUN2000-185KTL-H1-40C-Preliminary-v0.2</b>		
Custom parameters definition	Manufacturer	Huawei Technologies		
Characteristics	Operating Voltage	500-1500 V	Unit Nom. Power	175 kWac
			Max. power (=>30°C)	185 kWac
<b>Sub-array "Sub-array #1"</b>	Nb. of inverters	36 units	Total Power	6300 kWac
			Pnom ratio	1.21
<b>Sub-array "Sub-array #2"</b>	Nb. of inverters	36 units	Total Power	6300 kWac
			Pnom ratio	1.21
<b>Sub-array "Sub-array #3a"</b>	Nb. of inverters	5 units	Total Power	875 kWac
			Pnom ratio	1.28
<b>Sub-array "Sub-array #3b"</b>	Nb. of inverters	16 units	Total Power	2800 kWac
			Pnom ratio	1.31
<b>Total</b>	Nb. of inverters	93	Total Power	16275 kWac

**PV Array loss factors**

Array Soiling Losses		Loss Fraction	2.0 %
Thermal Loss factor	Uc (const) 37.7 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Array#1	2.4 mOhm	Loss Fraction 1.5 % at STC
	Array#2	2.4 mOhm	Loss Fraction 1.5 % at STC
	Array#3	16 mOhm	Loss Fraction 1.5 % at STC
	Array#4	5.0 mOhm	Loss Fraction 1.5 % at STC
	Global		Loss Fraction 1.5 % at STC
LID - Light Induced Degradation		Loss Fraction	0.8 %
Module Quality Loss		Loss Fraction	-0.1 %
Module Mismatch Losses		Loss Fraction	1.0 % at MPP
Strings Mismatch loss		Loss Fraction	0.10 %
Incidence effect (IAM): User defined profile			

10°	20°	30°	40°	50°	60°	70°	80°	90°
1.000	1.000	1.000	1.000	1.000	0.990	0.930	0.740	0.000

**System loss factors**

AC wire loss inverter to transfo	Inverter voltage	800 Vac tri		
	Wires: 3x10000.0 mm²	173 m	Loss Fraction	1.0 % at STC
External transformer	Iron loss (24H connexion)	19724 W	Loss Fraction	0.1 % at STC
	Resistive/Inductive losses	0.324 mOhm	Loss Fraction	1.0 % at STC
Unavailability of the system	3.6 days, 3 periods		Time fraction	1.0 %
Auxiliaries loss	Proportionnal to Power	4.0 W/kW ... from Power thresh.		0.0 kW

## Grid-Connected System: Near shading definition

**Project :** 20191129 HE180019\_CSC\_Avetrana\_3  
**Simulation variant :** BR Tracker mono CS3W-420W 2P 10m Avetrana 3 1698 stringhe

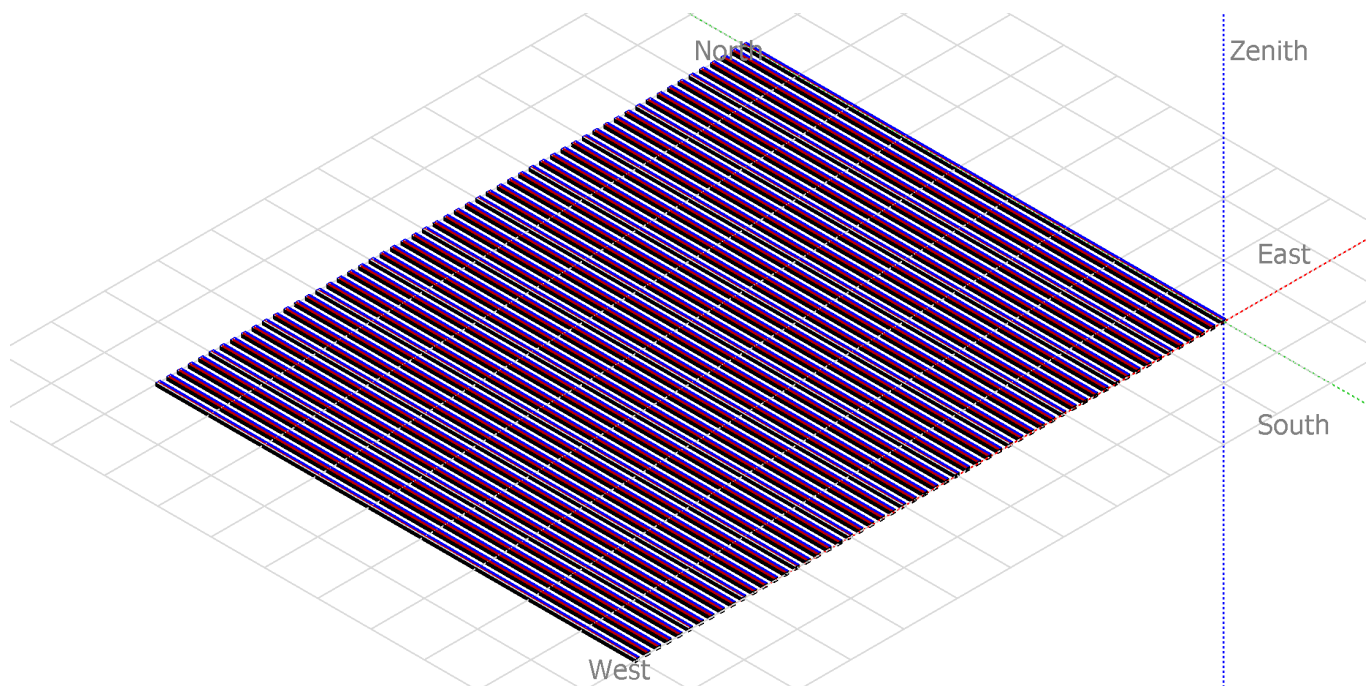
**Main system parameters**

System type **Trackers single array, with backtracking**

**Near Shadings**

PV Field Orientation	tracking, tilted axis, Axis Tilt	0°	Axis Azimuth	0°
PV modules	Model	CS3W-420P 1500V SE	Pnom	420 Wp
PV Array	Nb. of modules	47544	Pnom total	<b>19968 kWp</b>
Inverter	SUN2000-185KTL-H1-40C-Preliminary-v0.2		Pnom	175 kW ac
Inverter pack	Nb. of units	93.0	Pnom total	<b>16275 kW ac</b>
User's needs	Unlimited load (grid)			

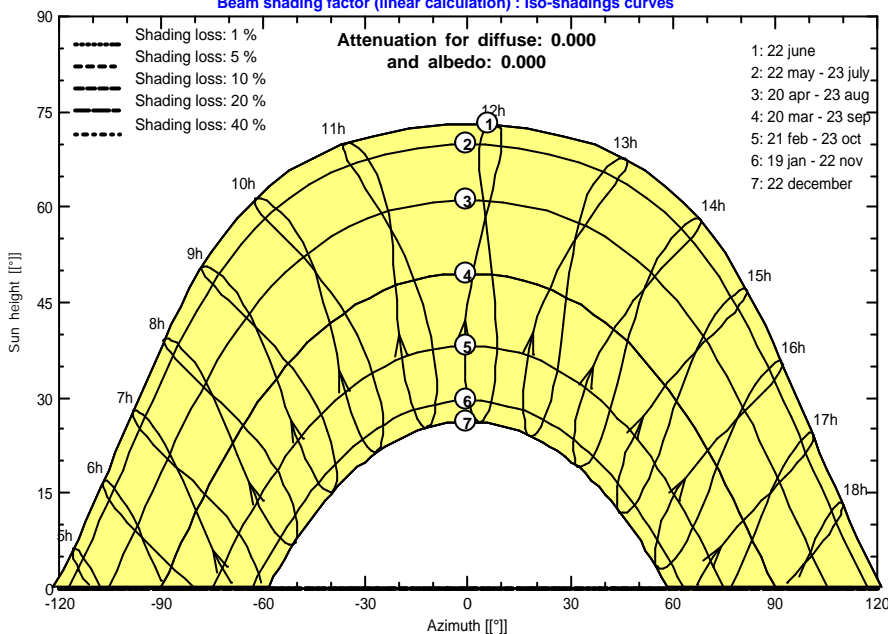
**Perspective of the PV-field and surrounding shading scene**



### Iso-shadings diagram

20191129 HE180019\_CSC\_Avetrana\_3

Beam shading factor (linear calculation) : Iso-shadings curves



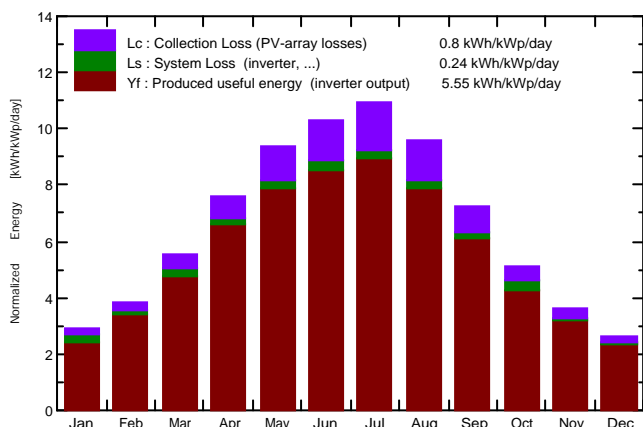
## Grid-Connected System: Main results

**Project :** 20191129 HE180019\_CSC\_Avetrana\_3  
**Simulation variant :** BR Tracker mono CS3W-420W 2P 10m Avetrana 3 1698 stringhe

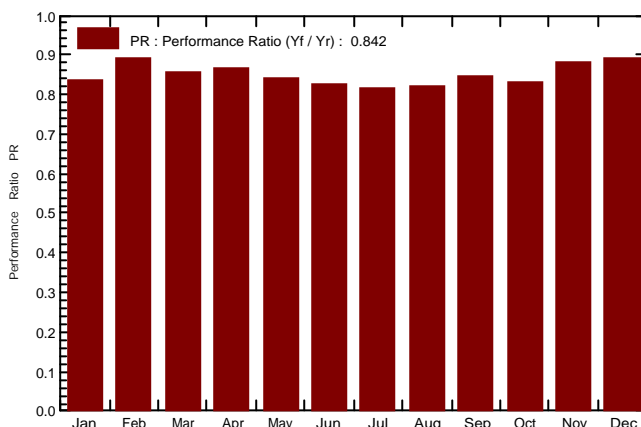
<b>Main system parameters</b>		System type	<b>Trackers single array, with backtracking</b>	
<b>Near Shadings</b>		Linear shadings		
PV Field Orientation	tracking, tilted axis, Axis Tilt	0°	Axis Azimuth	0°
PV modules	Model	CS3W-420P 1500V SE	Pnom	420 Wp
PV Array	Nb. of modules	47544	Pnom total	<b>19968 kWp</b>
Inverter	SUN2000-185KTL-H1-40C-Preliminary-v0.2		Pnom	175 kW ac
Inverter pack	Nb. of units	93.0	Pnom total	<b>16275 kW ac</b>
User's needs	Unlimited load (grid)			

**Main simulation results**  
 System Production **Produced Energy 40458 MWh/year** Specific prod. 2026 kWh/kWp/year  
 Performance Ratio PR **84.23 %**

**Normalized productions (per installed kWp): Nominal power 19968 kWp**



**Performance Ratio PR**



### BR Tracker mono CS3W-420W 2P 10m Avetrana 3 1698 stringhe Balances and main results

	GlobHor	DiffHor	T_Amb	GlobInc	GlobEff	EArray	E_Grid	PR
	kWh/m <sup>2</sup>	kWh/m <sup>2</sup>	°C	kWh/m <sup>2</sup>	kWh/m <sup>2</sup>	MWh	MWh	
January	67.2	23.30	9.81	91.4	86.0	1694	1522	0.834
February	81.9	35.50	10.20	107.9	101.3	1987	1925	0.893
March	130.6	49.30	13.11	171.9	162.2	3113	2945	0.858
April	172.9	59.40	15.80	228.5	216.4	4085	3949	0.866
May	219.3	67.20	21.55	291.5	276.7	5066	4893	0.840
June	234.9	66.10	25.74	309.7	294.4	5300	5118	0.828
July	251.5	49.90	28.84	339.3	324.1	5732	5529	0.816
August	219.1	49.20	28.42	297.4	283.5	5058	4882	0.822
September	160.8	45.90	22.78	217.8	206.9	3810	3682	0.847
October	117.0	38.90	19.24	159.3	150.6	2849	2636	0.829
November	78.4	28.50	14.50	108.2	101.7	1970	1909	0.883
December	60.7	23.90	11.11	82.6	77.3	1517	1468	0.890
<b>Year</b>	<b>1794.3</b>	<b>537.10</b>	<b>18.48</b>	<b>2405.5</b>	<b>2281.0</b>	<b>42181</b>	<b>40458</b>	<b>0.842</b>

Legends:

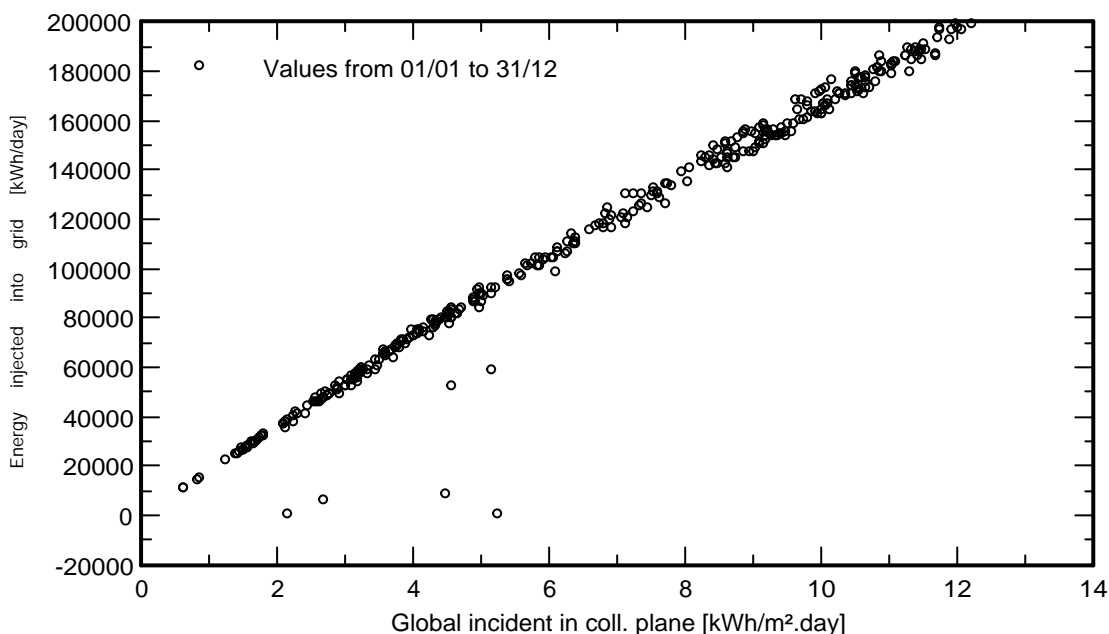
GlobHor	Horizontal global irradiation	GlobEff	Effective Global, corr. for IAM and shadings
DiffHor	Horizontal diffuse irradiation	EArray	Effective energy at the output of the array
T_Amb	T amb.	E_Grid	Energy injected into grid
GlobInc	Global incident in coll. plane	PR	Performance Ratio

### Grid-Connected System: Special graphs

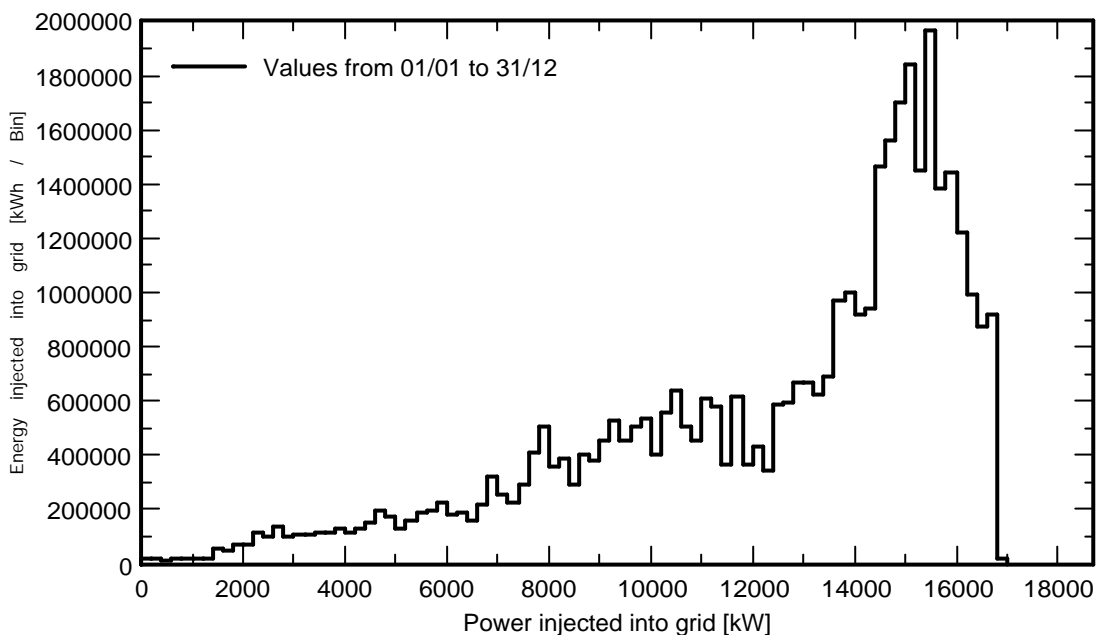
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<b>Main system parameters</b>	System type	<b>Trackers single array, with backtracking</b>		
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Inverter	SUN2000-185KTL-H1-40C-Preliminary-v0.2		Pnom	175 kW ac
Inverter pack	Nb. of units	93.0	Pnom total	<b>16275 kW ac</b>
User's needs	Unlimited load (grid)			

#### Daily Input/Output diagram



#### Distribuzione potenza in uscita sistema



## Grid-Connected System: Loss diagram

**Project :** 20191129 HE180019\_CSC\_Avetrana\_3  
**Simulation variant :** BR Tracker mono CS3W-420W 2P 10m Avetrana 3 1698 stringhe

<b>Main system parameters</b>	System type	<b>Trackers single array, with backtracking</b>	
<b>Near Shadings</b>	Linear shadings		
PV Field Orientation	tracking, tilted axis, Axis Tilt	0°	Axis Azimuth 0°
PV modules	Model	CS3W-420P 1500V SE	Pnom 420 Wp
PV Array	Nb. of modules	47544	Pnom total <b>19968 kWp</b>
Inverter	SUN2000-185KTL-H1-40C-Preliminary-v0.2		Pnom 175 kW ac
Inverter pack	Nb. of units	93.0	Pnom total <b>16275 kW ac</b>
User's needs	Unlimited load (grid)		

**Loss diagram over the whole year**

