

## Grid-Connected System: Simulation parameters

**Project :** **kaptai 78.8MW pumped hydro project2**

**Geographical Situation** **kaptai 78.8MW pumped hydro project2** Country **Bangladesh**

**Situation** Latitude 22.49° N Longitude 92.23° E  
Time defined as Legal Time Time zone UT+6 Altitude 16 m  
Albedo 0.20

**Meteo data:** **kaptai 78.8MW pumped hydro project2** Meteororm 7.2 (1981-2000), Sat=100% - Synthetic

**Simulation variant :** **New simulation variant**

Simulation date 04/02/21 02h04  
**Simulation for the 10th year of operation**

**Simulation parameters** System type **No 3D scene defined, no shadings**

**Collector Plane Orientation** Tilt 20° Azimuth 0°

**Models used** Transposition Perez Diffuse Perez, Meteororm

**Horizon** Free Horizon

**Near Shadings** No Shadings

**User's needs :** Unlimited load (grid)

**Grid power limitation** Active Power 50.0 MW Pnom ratio 1.576

**Power factor** Cos(phi) 1.000 leading Phi 0.0°

### PV Array Characteristics

**PV module** Si-mono Model **LR4-72 HBD 450 M G2 Bifacial**

Original PVsyst database Manufacturer Longi Solar

Number of PV modules In series 16 modules In parallel 10944 strings

Total number of PV modules Nb. modules 175104 Unit Nom. Power 450 Wp

Array global power Nominal (STC) **78797 kWp** At operating cond. 71893 kWp (50°C)

Array operating characteristics (50°C) U mpp 598 V I mpp 120316 A

Total area Module area **380601 m²** Cell area 347462 m²

### Inverter

Original PVsyst database Model **Sunny Central 2200**

Characteristics Manufacturer SMA

Operating Voltage 570-950 V Unit Nom. Power 2200 kWac

Inverter pack Nb. of inverters 28 units Total Power 61600 kWac

Pnom ratio 1.28

### PV Array loss factors

Array Soiling Losses Loss Fraction 3.0 %

Thermal Loss factor U<sub>c</sub> (const) 20.0 W/m²K U<sub>v</sub> (wind) 0.0 W/m²K / m/s

Wiring Ohmic Loss Global array res. 0.055 mOhm Loss Fraction 1.0 % at STC

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

LID - Light Induced Degradation Loss Fraction 1.5 %

Module Quality Loss Loss Fraction -0.5 %

Module Mismatch Losses Loss Fraction 1.0 % at MPP

Strings Mismatch loss Loss Fraction 0.10 %

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

## Grid-Connected System: Simulation parameters

Incidence effect (IAM): User defined profile

0°	25°	45°	60°	65°	70°	75°	80°	90°
1.000	1.000	0.995	0.962	0.936	0.903	0.851	0.754	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 loss factors

AC wire loss inverter to transfo	Inverter voltage	385 Vac tri		
	Wires: 3x30000.0 mm <sup>2</sup>	61 m	Loss Fraction	2.0 % at STC
External transformer	Iron loss (Night disconnect)	77128 W	Loss Fraction	0.1 % at STC
	Resistive/Inductive losses	0.019 mOhm	Loss Fraction	1.0 % at STC
Unavailability of the system	10.0 days, 3 periods		Time fraction	2.7 %
Auxiliaries loss	constant (fans)	40.0 kW	... from Power thresh.	0.0 kW

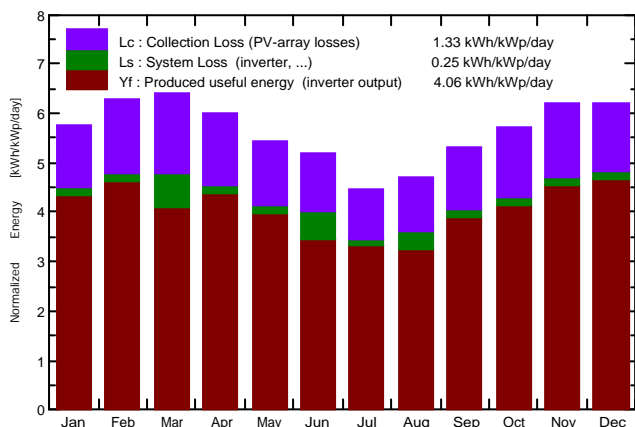
## Grid-Connected System: Main results

**Project :** kaptai 78.8MW pumped hydro project2  
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 Simulation for the 10th year of operation

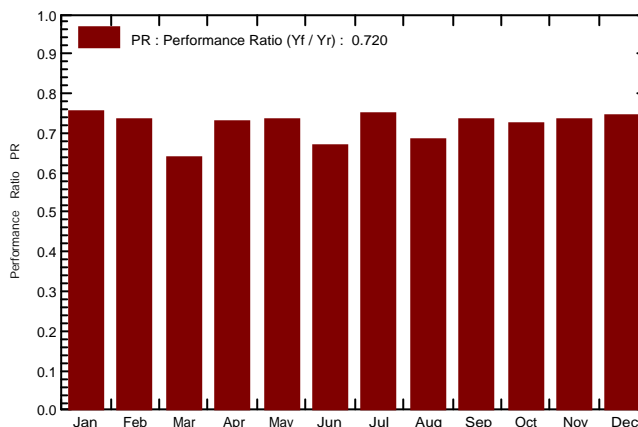
<b>Main system parameters</b>		System type	<b>No 3D scene defined, no shadings</b>	
PV Field Orientation		tilt	20°	azimuth 0°
PV modules		Model	LR4-72 HBD 450 M G2 Bifacial	450 Wp
PV Array		Nb. of modules	175104	Pnom total <b>78797 kWp</b>
Inverter		Model	Sunny Central 2200	Pnom 2200 kW ac
Inverter pack		Nb. of units	28.0	Pnom total <b>61600 kW ac</b>
User's needs		Unlimited load (grid)		Cos(Phi) 1.000 leading

<b>Main simulation results</b>		System Production	<b>Produced Energy 116635 MWh/year</b>	Specific prod.	1480 kWh/kWp/year
			Apparent energy 116635 MVAh	Perf. Ratio PR	71.96 %

**Normalized productions (per installed kWp): Nominal power 78797 kWp**



**Performance Ratio PR**



### New simulation variant Balances and main results

	GlobHor kWh/m <sup>2</sup>	DiffHor kWh/m <sup>2</sup>	T_Amb °C	GlobInc kWh/m <sup>2</sup>	GlobEff kWh/m <sup>2</sup>	EArray MWh	E_Grid MWh	PR
January	139.7	41.58	21.33	178.8	170.4	11036	10646	0.756
February	148.2	46.22	23.62	176.3	168.1	10602	10220	0.736
March	182.0	66.55	26.59	197.9	188.3	11670	9982	0.640
April	179.3	78.96	28.23	180.6	170.9	10738	10361	0.728
May	177.5	83.96	28.99	168.4	159.3	10075	9722	0.733
June	168.3	84.27	28.09	155.6	146.9	9470	8185	0.668
July	147.2	84.19	28.08	137.8	130.0	8427	8139	0.749
August	149.3	79.68	28.26	146.0	138.0	8805	7896	0.686
September	151.8	75.41	28.05	159.2	150.8	9581	9250	0.737
October	155.8	59.33	28.17	177.6	168.8	10524	10155	0.726
November	146.9	36.00	25.57	185.7	177.2	11129	10727	0.733
December	143.8	27.93	22.93	192.9	184.1	11775	11352	0.747
Year	1889.6	764.07	26.51	2056.9	1952.8	123832	116635	0.720

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

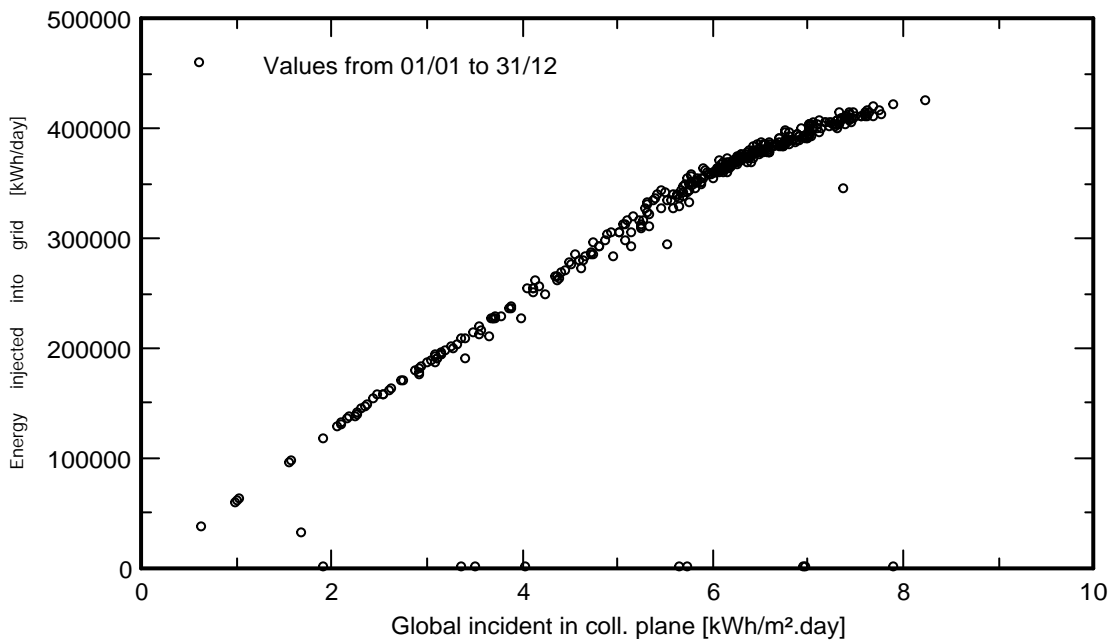
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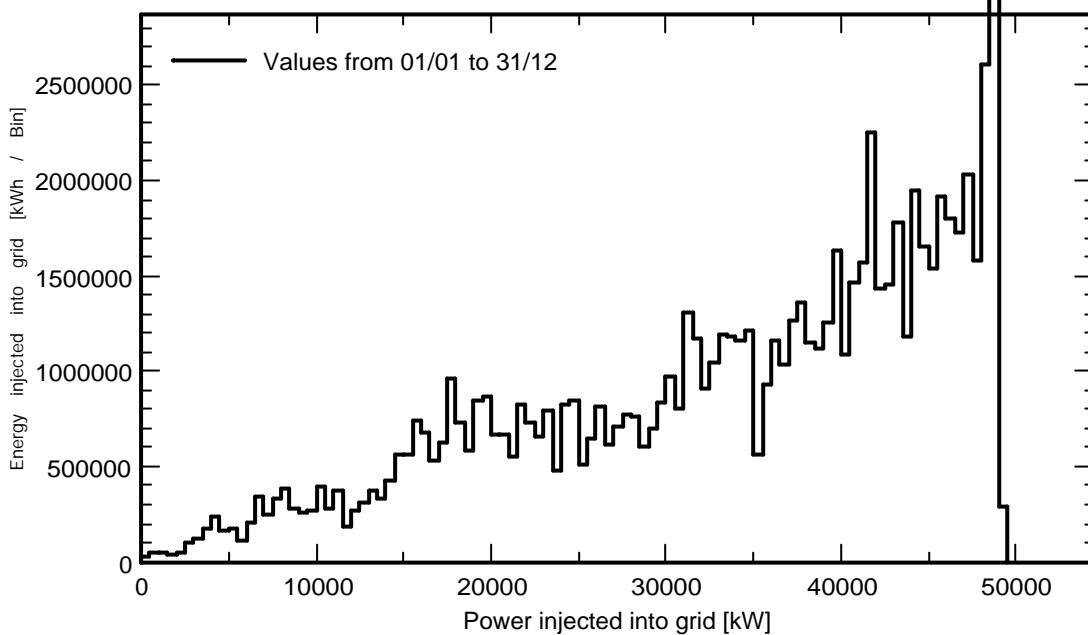
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### Daily Input/Output diagram



### System Output Power Distribution

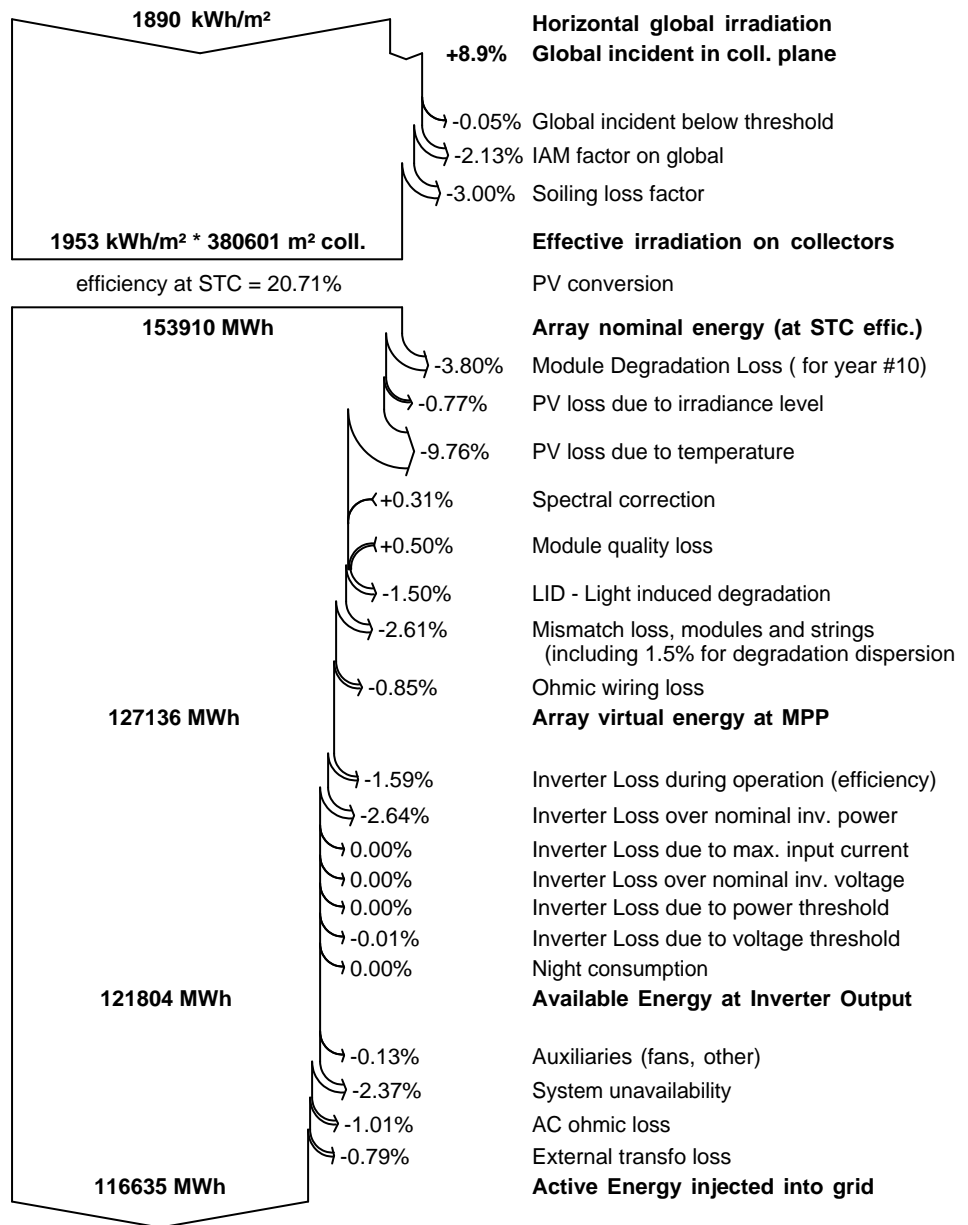


## Grid-Connected System: Loss diagram

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### Loss diagram over the whole year



0 MVAR  
 116635 MVA

Reactive energy to the grid: Cos(Phi) = 1.000  
**Apparent energy to the grid**

## Grid-Connected System: P50 - P90 evaluation

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### Evaluation of the Production probability forecast

The probability distribution of the system production forecast for different years is mainly dependent on the meteo data used for the simulation, and depends on the following choices:

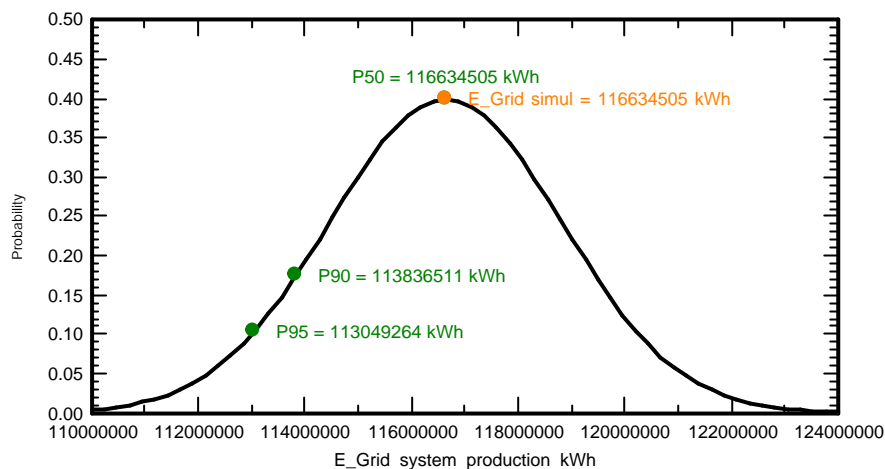
Meteo data source		Meteonorm 7.2 (1981-2000), Sat=100%
Meteo data	Kind	Not defined
Specified Deviation	Year deviation from aver.	3 %
Year-to-year variability	Variance	0.5 %
		Year 1995

The probability distribution variance is also depending on some system parameters uncertainties

Specified Deviation	PV module modelling/parameters	1.0 %	
	Inverter efficiency uncertainty	0.5 %	
	Soiling and mismatch uncertainties	1.0 %	
	Degradation uncertainty	1.0 %	
Global variability (meteo + system)	Variance	1.9 %	(quadratic sum)

Annual production probability	<b>Variability</b>	<b>2182 MWh</b>
	<b>P50</b>	<b>116635 MWh</b>
	<b>P90</b>	<b>113837 MWh</b>
	<b>P95</b>	<b>113049 MWh</b>

**Probability distribution**



## Grid-Connected System: CO2 Balance

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**Produced Emissions** **Total: 141777.65 tCO2**  
 Source: Detailed calculation from table below

**Replaced Emissions** **Total: 2043436.5 tCO2**  
 System production: 116634.51 MWh/yr Lifetime: 30 years  
Annual Degradation: 1.0 %  
 Grid Lifecycle Emissions: 584 gCO2/kWh  
 Source: IEA List Country: Bangladesh

**CO2 Emission Balance** **Total: 1631241.6 tCO2**

**System Lifecycle Emissions Details:**

Item	Modules	Supports
LCE	1713 kgCO2/kWp	3.90 kgCO2/kg
Quantity	78797 kWp	1751040 kg
Subtotal [kgCO2]	134956855	6820791

