Grid-Connected System: Simulation parameters

Project : **6 megawatt**

Geographical Site	**Kaptai**		Country	**Bangladesh**
Situation	Latitude	22.49° N	Longitude	92.21° E
Time defined as	Legal Time	Time zone UT+6	Altitude	26 m
	Albedo	0.20		
Meteo data:	**kaptai**	Meteonorm 7.2 (1981-2000), Sat=100% - Synthetic		

Simulation variant : **New simulation variant**

	Simulation date	17/04/24 13h11		
	Simulation for the	**10th year of operation**		

Simulation parameters	System type	**Sheds on ground**		
Collector Plane Orientation	Tilt	22°	Azimuth	0°
Sheds configuration	Nb. of sheds	402	Identical arrays	
	Sheds spacing	5.00 m	Collector width	3.32 m
Shading limit angle	Limit profile angle	33.2°	Ground cov. Ratio (GCR)	66.5 %
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon	Free Horizon			
Near Shadings	Linear shadings			
User's needs :	Unlimited load (grid)			

PV Array Characteristics

PV module	Si-mono	Model	**Mono 440 Wp Twin 144 half-cells**	
Original PVsyst database		Manufacturer	Generic	
Number of PV modules		In series	14 modules	In parallel 974 strings
Total number of PV modules		Nb. modules	13636	Unit Nom. Power 440 Wp
Array global power		Nominal (STC)	**6000 kWp**	At operating cond. 5458 kWp (50°C)
Array operating characteristics (50°C)		U mpp	527 V	I mpp 10357 A
Total area		Module area	**30340 m²**	Cell area 27097 m²
Inverter		Model	**30 kWac inverter**	
Original PVsyst database		Manufacturer	Generic	
Characteristics		Operating Voltage	450-700 V	Unit Nom. Power 30.0 kWac
Inverter pack		Nb. of inverters	167 units	Total Power 5010 kWac
				Pnom ratio 1.20

PV Array loss factors

Array Soiling Losses			Loss Fraction	2.0 %
Thermal Loss factor	Uc (const)	29.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Global array res.	0.85 mOhm	Loss Fraction	1.5 % at STC
Module Quality Loss			Loss Fraction	-0.4 %
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

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

Auxiliaries loss	constant (fans)	0 W	... from Power thresh.	0.0 kW

Grid-Connected System: Near shading definition

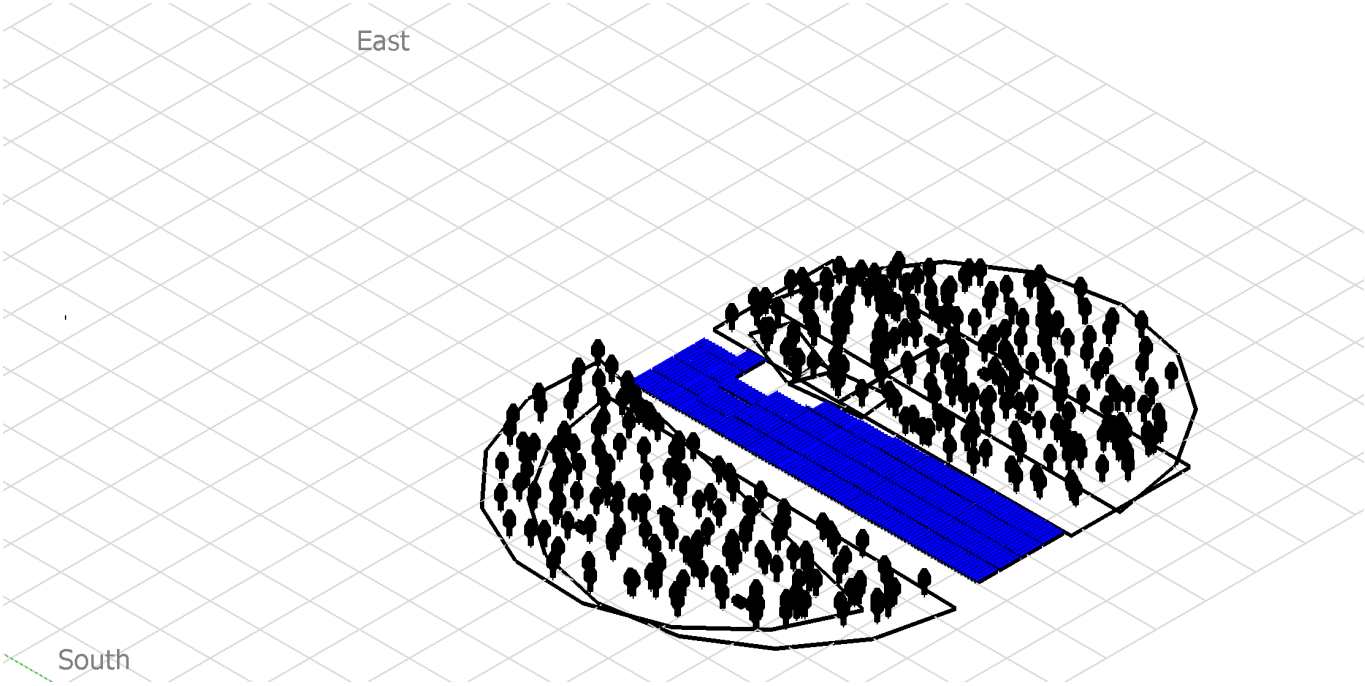
Project : **6 megawatt**

Simulation variant : **New simulation variant**

Simulation for the 10th year of operation

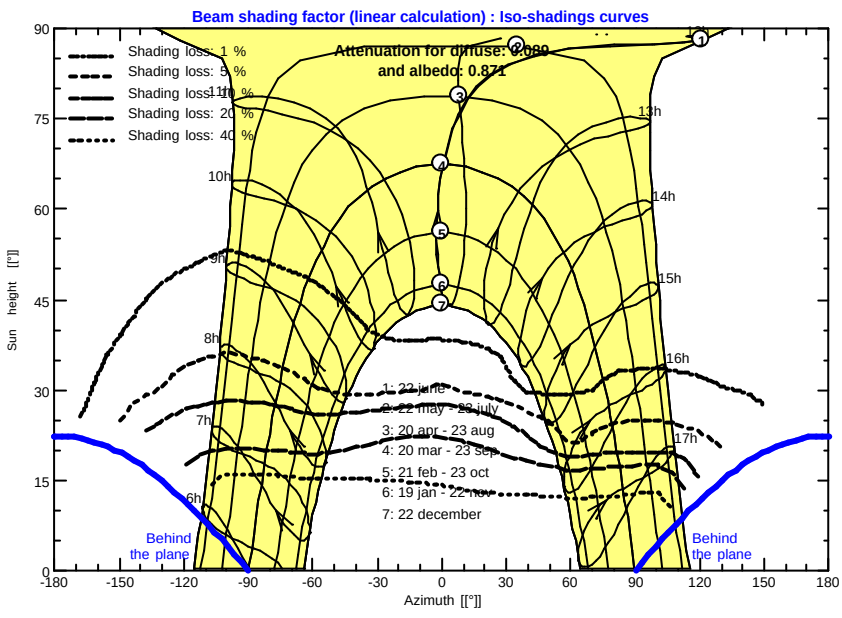
Main system parameters	System type	**Sheds on ground**		
Near Shadings	Linear shadings			
PV Field Orientation	tilt	22°	azimuth	0°
PV modules	Model	Mono 440 Wp Twin 144 half-cells		440 Wp
PV Array	Nb. of modules	13636	Pnom total	**6000 kWp**
Inverter	Model	30 kWac inverter	Pnom	30.0 kW ac
Inverter pack	Nb. of units	167.0	Pnom total	**5010 kW ac**
User's needs	Unlimited load (grid)			

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram

6 megawatt



Grid-Connected System: Main results

Project : **6 megawatt**

Simulation variant : **New simulation variant**

Simulation for the 10th year of operation

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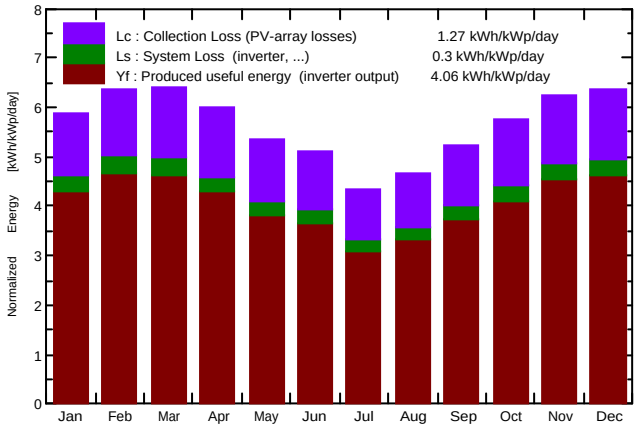
User's needs	Unlimited load (grid)			

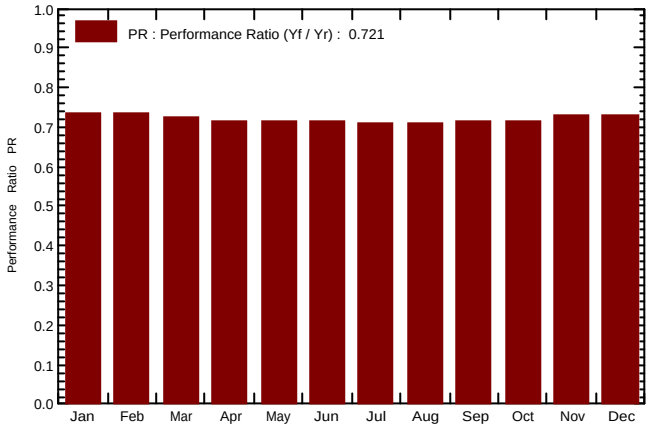
Main simulation results

System Production	**Produced Energy**	**8901 MWh/year**	Specific prod.	1484 kWh/kWp/year
	Performance Ratio PR	72.11 %		
Investment	Global incl. taxes	2139590.38 USD	Specific	0.36 USD/Wp
Yearly cost	Annuities (Loan 2.00%, 20 years)	130850.33 USD/yr	Running Costs	228966.47 USD/yr
Energy cost		**0.06 USD/kWh**	Payback period	**3.3 years**

Normalized productions (per installed kWp): Nominal power 6000 kWp



Performance Ratio PR



New simulation variant

Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR
January	139.5	41.71	21.33	181.8	164.0	858.7	801.0	0.734
February	148.0	46.37	23.62	178.3	162.8	842.2	785.4	0.734
March	181.9	66.69	26.59	198.3	181.3	927.6	863.7	0.726
April	179.3	78.97	28.23	179.6	162.1	828.9	771.4	0.716
May	177.4	84.09	28.99	166.3	149.8	765.6	711.0	0.713
June	168.2	84.36	28.09	153.1	137.4	709.0	658.3	0.717
July	146.4	81.80	28.08	134.9	120.3	620.7	574.4	0.709
August	149.1	76.46	28.26	144.7	129.9	666.4	617.4	0.711
September	151.5	72.56	28.05	156.9	141.3	724.2	672.8	0.715
October	155.7	58.61	28.17	178.8	161.6	823.6	766.4	0.714
November	146.9	38.56	25.57	187.7	171.4	879.3	819.3	0.727
December	143.8	27.82	22.93	197.0	177.8	922.5	860.2	0.728
Year	1887.5	758.00	26.51	2057.4	1859.8	9568.7	8901.4	0.721

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

Project : **6 megawatt**

Simulation variant : **New simulation variant**
Simulation for the 10th year of operation

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Near Shadings	Linear shadings			
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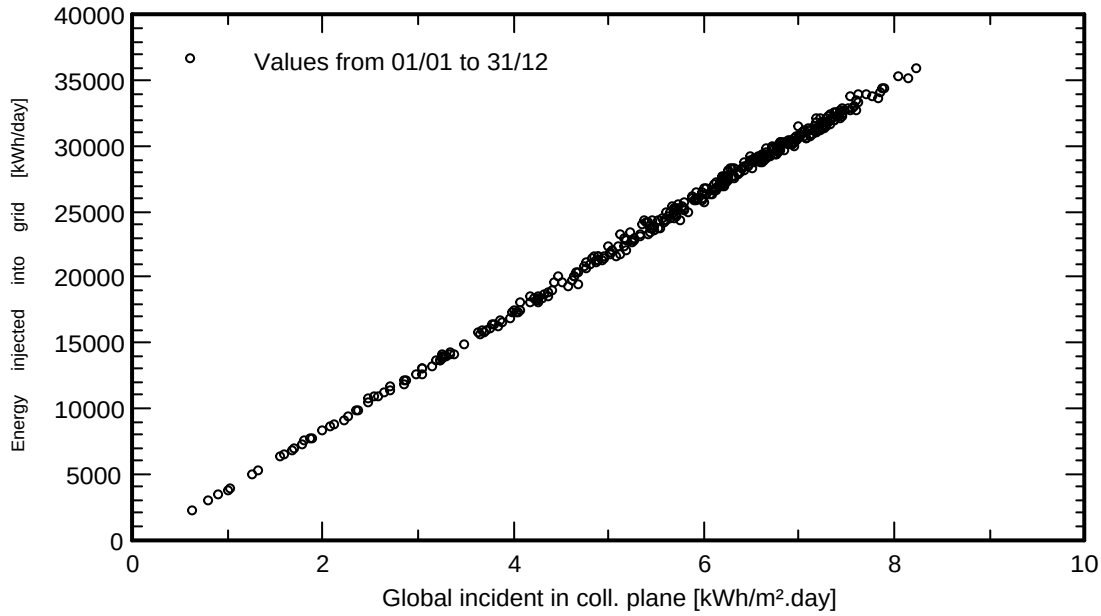
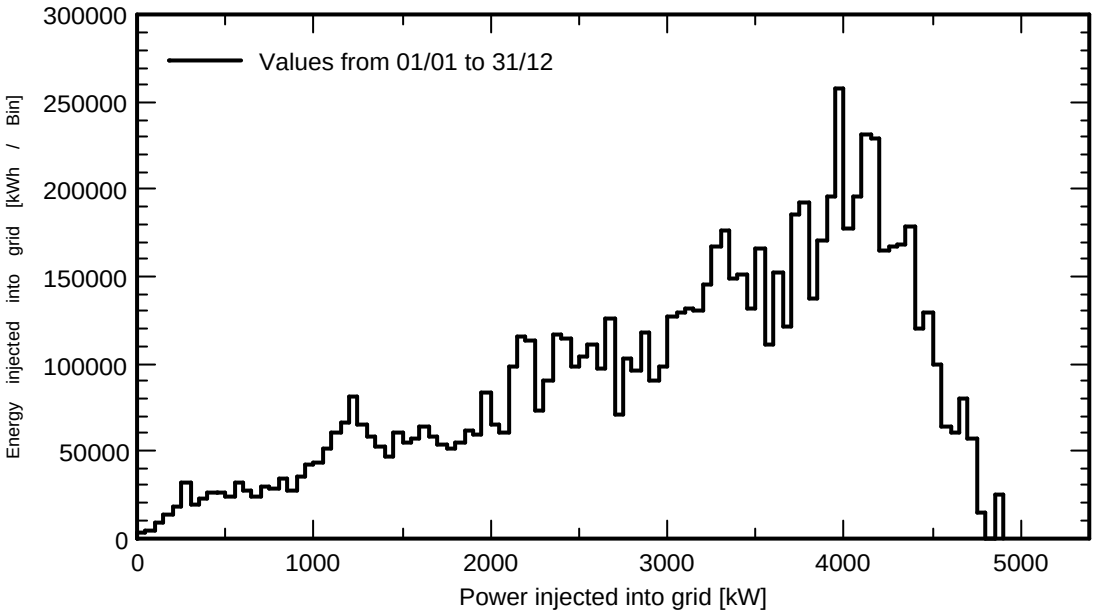
User's needs	Unlimited load (grid)			

Daily Input/Output diagram



System Output Power Distribution



Grid-Connected System: Loss diagram

Project : **6 megawatt**

Simulation variant : **New simulation variant**
Simulation for the 10th year of operation

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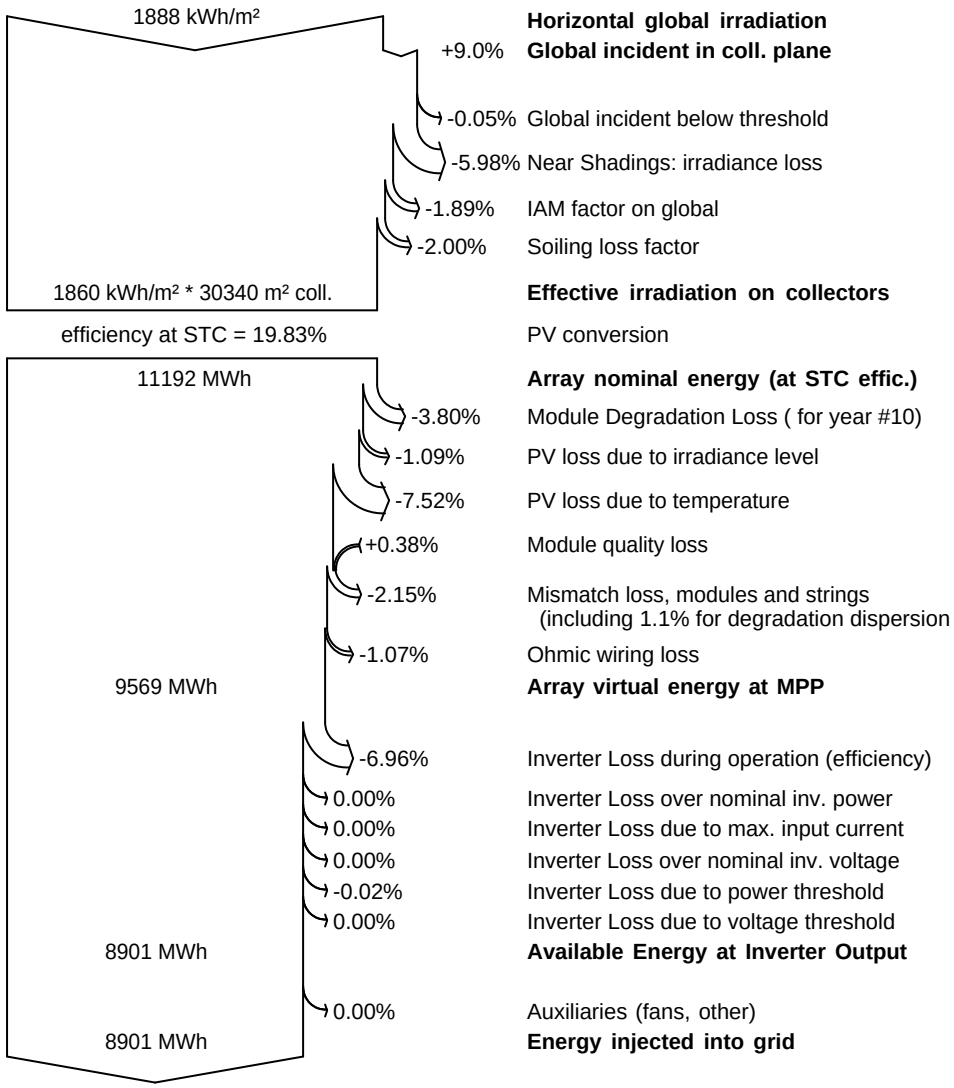
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



Grid-Connected System: Economic evaluation

Project : **6 megawatt**

Simulation variant : **New simulation variant**

Simulation for the 10th year of operation

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User's needs	Unlimited load (grid)			

Investment

Direct costs			
PV modules			
Mono 440 Wp Twin 144 half-cells	13636 units	21.50 USD / unit	293'174.00 USD
Supports for modules	13636 units	25.20 USD / unit	343'627.20 USD
Inverters			
30 kWac inverter	167 units	1'650.00 USD / unit	275'550.00 USD
Installation			
Transport			71'065.00 USD
Accessories, fasteners			737'086.34 USD
Wiring			36'438.84 USD
Settings			53'299.00 USD
Grid connection			314'350.00 USD
Insurance			
Liability insurance			15'000.00 USD
		Net investment (CAPEX)	**2'139'590.38 USD**

Operating costs

Maintenance		
Salaries		148'560.00 USD / year
Reparation		3'465.47 USD / year
Cleaning		1'272.00 USD / year
Security fund		44'416.00 USD / year
Taxes		
Other taxes		35'533.00 USD / year
Subsidies		-4'280.00 USD / year
	Total (OPEX)	**228'966.47 USD / year**
	Operating costs (OPEX) incl. Inflation (6.20%)	**405'847.89 USD / year**

System summary

Net investment				**2'139'590.38 USD**
Own funds				0.00 USD
Loan (20 years)	Rate 2.00 % / year	Annuities	130'850.33 USD / year	2'139'590.38 USD
Total yearly cost (inc. inflation 6.20 % / year)				**536'698.21 USD / year**
Produced Energy				**8901 MWh / year**
Cost of produced energy				**0.060 USD / kWh**
(sum of costs over lifetime / total production over lifetime)				

Grid-Connected System: Long Term Financial Balance

Project : **6 megawatt**

Simulation variant : **New simulation variant**

Simulation for the 10th year of operation

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User's needs	Unlimited load (grid)			

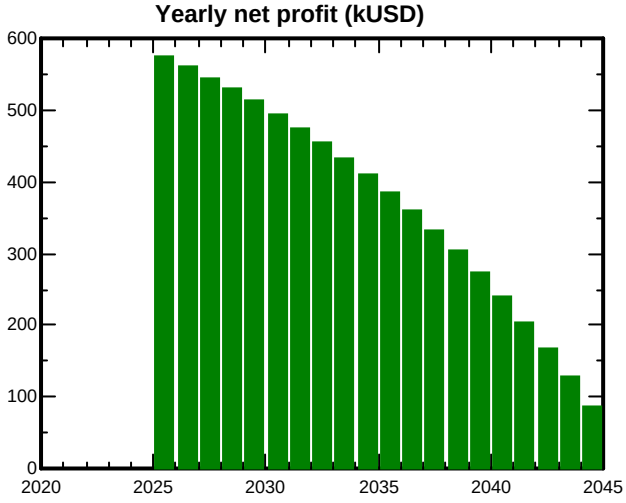
Electricity sale

Feed-in tariff	Peak tariff	**0.11**	**USD/kWh**	
	Off-peak tariff	**0.09**	**USD/kWh**	14:00-16:00, 20:00-08:00
Duration of tariff warranty		20	years	
Annual connection tax		0.00	USD	
Annual tariff variation		0.0	% / year	
Feed-in tariff variation after warranty		-50.00	%	

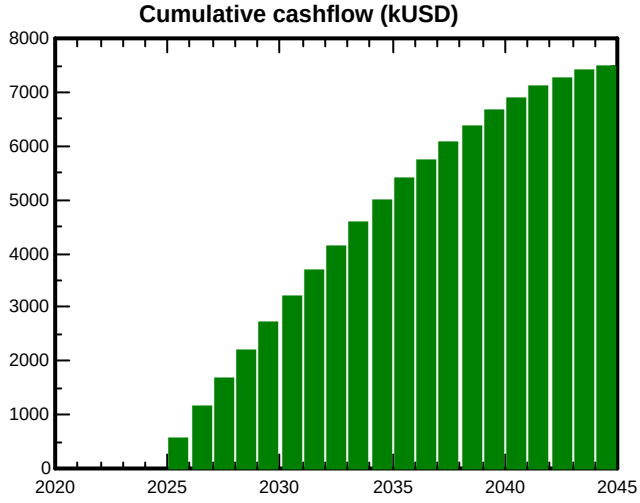
Return on investment

Project lifetime	**20**	**years**
Payback period	**3.3**	**years**
Net profit at end of lifetime	**7'480'510.04**	**USD**
Return on investment (ROI)	**349.6**	**%**

Yearly net profit (kUSD)



Cumulative cashflow (kUSD)



Grid-Connected System: Long Term Financial Balance

Project : **6 megawatt**

Simulation variant : **New simulation variant**

Simulation for the 10th year of operation

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User's needs	Unlimited load (grid)			

Detailed economic results (USD)

Year	Sold energy	Loan principal	Interest 2.00%	Run. costs	Deprec. allow.	Taxable income	Tax 0.00%	After-tax profit	Cumul. profit	% amorti.
2025	935'176	88'059	42'792	228'966	106'980	556'439	0	575'360	575'360	31.0%
2026	935'176	89'820	41'031	243'162	106'980	544'004	0	561'164	1'136'523	61.4%
2027	935'176	91'616	39'234	258'238	106'980	530'724	0	546'088	1'682'611	91.2%
2028	935'176	93'448	37'402	274'249	106'980	516'546	0	530'077	2'212'688	120.4%
2029	935'176	95'317	35'533	291'253	106'980	501'411	0	513'073	2'725'762	148.8%
2030	935'176	97'224	33'627	309'310	106'980	485'260	0	495'016	3'220'777	176.5%
2031	935'176	99'168	31'682	328'488	106'980	468'027	0	475'839	3'696'616	203.4%
2032	935'176	101'152	29'699	348'854	106'980	449'644	0	455'472	4'152'088	229.4%
2033	935'176	103'175	27'676	370'483	106'980	430'038	0	433'843	4'585'932	254.5%
2034	935'176	105'238	25'612	393'453	106'980	409'132	0	410'873	4'996'805	278.6%
2035	935'176	107'343	23'507	417'847	106'980	386'843	0	386'479	5'383'284	301.7%
2036	935'176	109'490	21'361	443'753	106'980	363'083	0	360'573	5'743'857	323.7%
2037	935'176	111'679	19'171	471'266	106'980	337'760	0	333'060	6'076'917	344.4%
2038	935'176	113'913	16'937	500'484	106'980	310'775	0	303'842	6'380'759	364.0%
2039	935'176	116'191	14'659	531'515	106'980	282'023	0	272'812	6'653'571	382.1%
2040	935'176	118'515	12'335	564'468	106'980	251'393	0	239'858	6'893'429	398.9%
2041	935'176	120'885	9'965	599'465	106'980	218'767	0	204'861	7'098'289	414.1%
2042	935'176	123'303	7'547	636'632	106'980	184'018	0	167'694	7'265'983	427.7%
2043	935'176	125'769	5'081	676'104	106'980	147'012	0	128'223	7'394'206	439.6%
2044	935'176	128'285	2'566	718'022	106'980	107'609	0	86'304	7'480'510	449.6%
Total	18'703'530	2'139'590	477'416	8'606'013	2'139'590	7'480'510	0	7'480'510	7'480'510	449.6%

Grid-Connected System: CO2 Balance

Project : **6 megawatt**

Simulation variant : **New simulation variant**
Simulation for the 10th year of operation

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User's needs	Unlimited load (grid)			

Produced Emissions	**Total:**	**9941.35 tCO2**		
	Source:	Detailed calculation from table below		
Replaced Emissions	**Total:**	**155952.2 tCO2**		
	System production:	8901.38 MWh/yr	Lifetime:	30 years
			Annual Degradation:	1.0 %
	Grid Lifecycle Emissions:	584 gCO2/kWh		
	Source:	IEA List	Country:	Bangladesh
CO2 Emission Balance	**Total:**	**125373.0 tCO2**		

System Lifecycle Emissions Details:

Item	Modules	Supports
LCE	837 kgCO2/kWp	3.90 kgCO2/kg
Quantity	10743 kWp	244160 kg
Subtotal [kgCO2]	8990281	951072