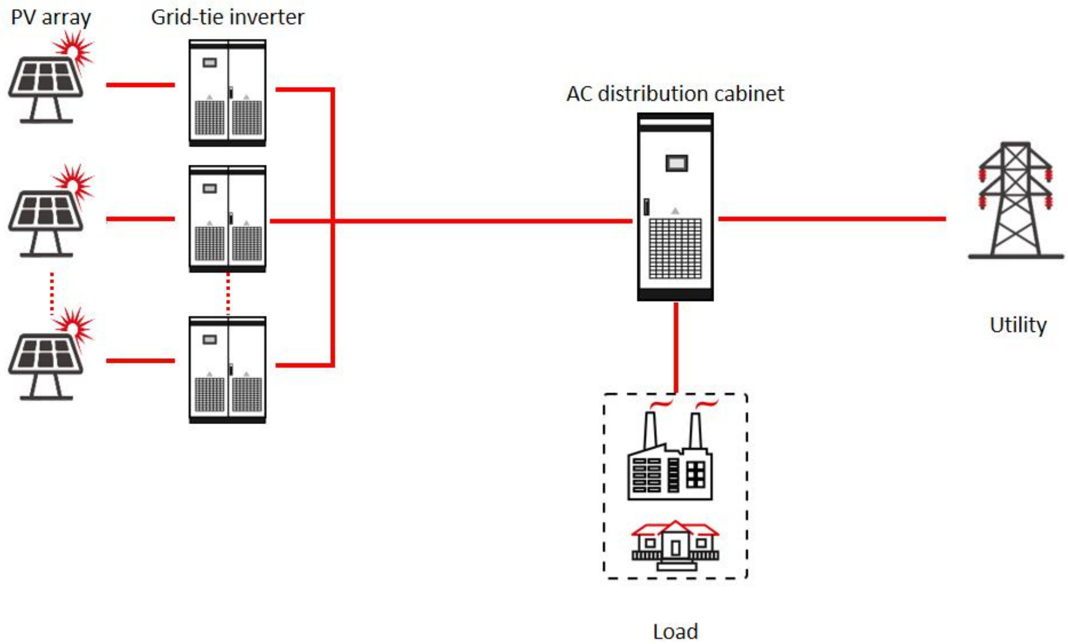
Data speaks louder, upgrade grid-tie system to storage makes more money?

In recent years with the popularization of new energy, the scale of grid-tie system has increased significantly. However, due to the primitive power grid construction in a lot of areas, decreased or canceled Feed-in-Tariff, and low PV self-consumption rate, the phenomenon of feed-in power limitation and solar station abandonment has frequently occurred, resulting in resource waste, investment return reduction or even deficit. In view of this situation, our company put forward the energy storage AC-couple retrofit scheme and has been widely applied. Grid connected energy storage system can store the surplus power and improve the self-consumption ratio. It is applicable to the scenarios that PV power cannot be sold to utility grid, and self-use electricity price is higher than the feed-in price, or solar power generation and consumption are not in the same period.

For the owner, what can be done to improve the power generation revenue?

Now it's going to be introduced with a real case.

It is a grid-tie PV project located in an industrial park in Zhengzhou, PV installed capacity is 520kwp with 100 kW grid connected inverter CP100X5 units in parallel, the system is to supply loads in the factory.



Original equipment list

Item	Model	Qty.
PV panel	LR6-60	1764 pcs
Central inverter	Growatt CP100	5 units
AC distribution cabinet	Growatt AC cabinet	1 unit

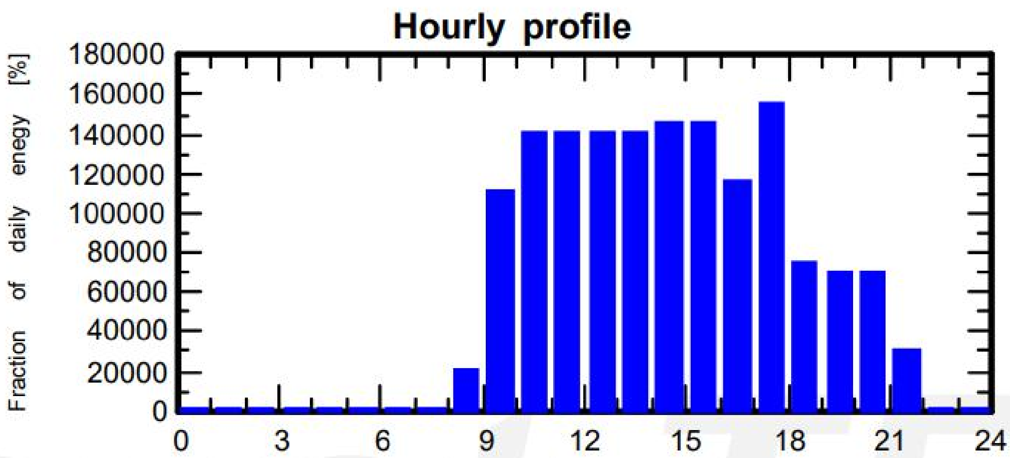
According to the owner's description, the original design purpose is mainly for the factory self-consumption plus earning feed-in subsidy. As the policy changes, turns out the feed-in price gets too low, which resulted in a plunge in investment profit.

The load list and service time of the factory are as follows:

Daily household consumers, Constant over the year, average = 1515 kWh/day

Annual values

	Number	Power	Use	Energy
Lamps (LED or fluo)	90	1000 W/lamp	9 h/day	810000 Wh/day
TV / PC / Mobile	20	1000 W/app	10 h/day	200000 Wh/day
Domestic appliances	10	3000 W/app	6 h/day	180000 Wh/day
Fridge / Deep-freeze	10		24 Wh/day	19992 Wh/day
Dish- & Cloth-washers	1		5 Wh/day	25000 Wh/day
machine 1	1	40000 W tot	4 h/day	160000 Wh/day
machine 2	1	30000 W tot	4 h/day	120000 Wh/day
Stand-by consumers			24 h/day	24 Wh/day
Total daily energy				1515016 Wh/day



We use the software PVSYST to simulate the system output：

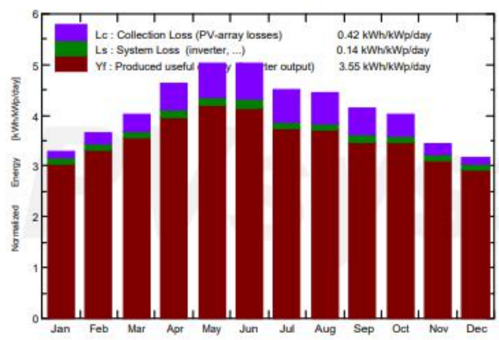
Grid-Connected System: Main results

Project : **connected-grid Project at Zhengzhou**

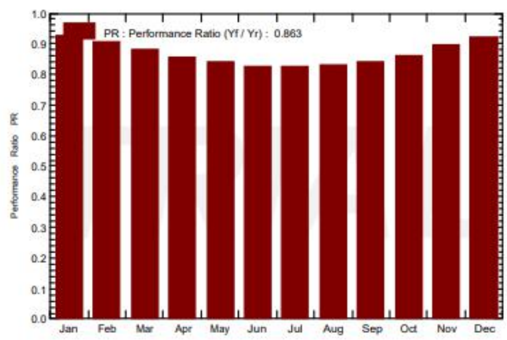
Simulation variant : **zhengzhou simulation variant**

Main system parameters	System type	**No 3D scene defined, no shadings**		
PV Field Orientation	tilt	30°	azimuth	0°
PV modules	Model	LR6-60 BP 295 M Bifacial	Pnom	295 Wp
PV Array	Nb. of modules	1764	Pnom total	**520 kWp**
Inverter	Model	Growatt CP100	Pnom	100 kW ac
Inverter pack	Nb. of units	5.0	Pnom total	**500 kW ac**
User's needs	Daily household consumers	Constant over the year	Global	553 MWh/year
Main simulation results				
System Production	**Produced Energy**	**674.2 MWh/year**	Specific prod.	1296 kWh/kWp/year
	Performance Ratio PR	86.33 %	Solar Fraction SF	67.17 %

Normalized productions (per installed kWp): Nominal power 520 kWp



Performance Ratio PR



zhengzhou simulation variant
Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_User MWh	E_Solar MWh	E_Grid MWh	EFrGrid MWh
January	72.8	41.7	0.90	102.2	100.3	51.30	46.97	29.27	20.08	17.70
February	81.7	48.5	4.60	102.2	100.1	50.14	42.42	27.21	21.01	15.21
March	112.2	72.1	10.00	124.8	122.1	59.50	46.97	31.65	25.57	15.31
April	135.1	81.9	16.60	138.5	135.4	64.07	45.45	32.16	29.49	13.29
May	161.8	96.0	21.70	155.0	151.2	70.36	46.97	34.50	33.27	12.46
June	161.7	101.9	26.30	150.3	146.6	67.30	45.45	34.42	30.34	11.03
July	148.7	99.5	27.20	139.8	136.3	62.55	46.97	34.41	25.75	12.56
August	139.8	88.7	25.70	137.7	134.3	62.03	46.97	33.99	25.70	12.97
September	112.9	67.4	21.60	123.9	121.2	56.31	45.45	29.31	24.80	16.14
October	99.6	54.7	15.60	124.5	122.1	58.10	46.97	29.63	26.26	17.33
November	74.0	40.0	8.70	103.5	101.6	50.20	45.45	27.10	21.17	18.35
December	66.5	36.5	2.80	98.2	96.4	49.00	46.97	27.76	19.34	19.21
Year	1366.7	828.9	15.19	1500.7	1467.5	700.86	552.98	371.41	302.79	181.57

Legends:
- GlobHor: Horizontal global irradiation
- DiffHor: Horizontal diffuse irradiation
- T_Amb: T amb.
- GlobInc: Global incident in coll. plane
- GlobEff: Effective Global, corr. for IAM and shadings
- EArray: Effective energy at the output of the array
- E_User: Energy supplied to the user
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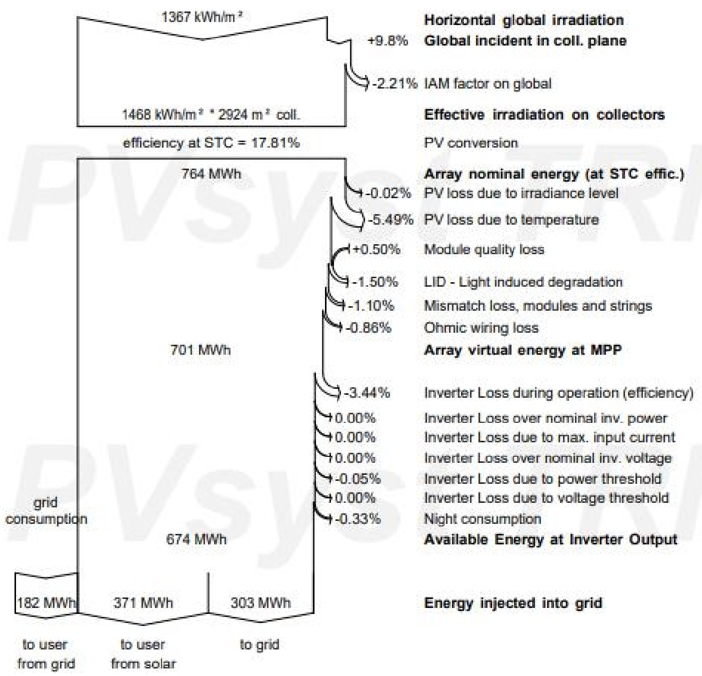
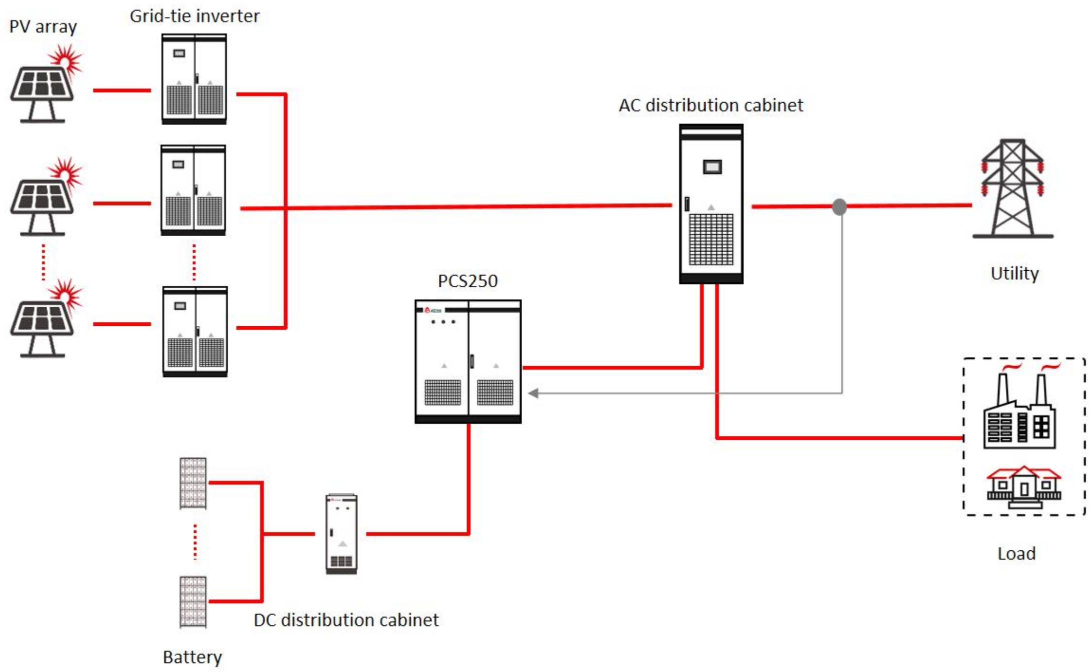
Loss diagram over the whole year



From above we can see that the annual active power generation is 700.86MWh, load power consumption is 552.98MWh, and PV has supplied 371MWh to the load, 302.79MWh PV power has been sent to the grid and 181.57MWh taken from grid. Annual PV self-consumption rate is 67.17%.

If the feed-in price is 0.1USD/kWh, electricity price is 0.3USD/kWh. In a year, the owner will have to pay 182000 * 0.3-303000 * 0.1 = 42500 US dollars for electricity.

In order to improve the self-consumption rate and save electricity cost, we designed the following retrofit solution for the owner:



Added equipment list

Item	Model	Qty.
Bidirectional battery inverter	ATESS PCS250	1 unit
Battery module	ATESS 7.68kWh battery	14 packs in series X 6 strings in parallel

In this case, BYD battery B-box bro 13.819 packs in series X 6 strings in parallel is used for simulation.

System operation mode: the output of PCS500, grid inverter, load, and grid common AC BUS input and output are in dynamic balance. The grid inverter and PCS500 operate independently. PCS detects the power on the grid side, judges the power size and flow direction to decide whether to charge or discharge. When the PV power is greater than load power, PCS will detect the power transmission to the grid, so as to start charging mode and absorb the remaining PV power to charge battery; otherwise, when the PV power is insufficient for the load, PCS will detect the power flows from the grid to the load, so as to discharge to offset the power deficiency, to ensure that the load preferentially uses the PV and battery energy, minimize power draw from grid, and improve the PV self-consumption.

After the retrofit, the simulation results from PVSYST are as follows:

Main system parameters	System type	**No 3D scene defined, no shadings**		
PV Field Orientation	tilt	30°	azimuth	0°
PV modules	Model	LR6-60 BP 295 M Bifacial	Pnom	295 Wp
PV Array	Nb. of modules	1764	Pnom total	**520 kWp**
Inverter	Model	Growatt CP100	Pnom	100 kW ac
Inverter pack	Nb. of units	5.0	Pnom total	**500 kW ac**
User's needs	Daily household consumers	Constant over the year	Global	553 MWh/year
Main simulation results				
System Production	**Produced Energy**	**674.2 MWh/year**	Specific prod.	1296 kWh/kWp/year
	Performance Ratio PR	82.44 %	Solar Fraction SF	92.26 %
Battery ageing (State of Wear)	Cycles SOW	97.7%	Static SOW	90.0%
	Battery lifetime	10.0 years		

PV Array Characteristics					
PV module	Si-mono	Model	**LR6-60 BP 295 M Bifacial**		
Original PVsyst database		Manufacturer	Longi Solar		
Number of PV modules		In series	21 modules	In parallel	84 strings
Total number of PV modules		Nb. modules	1764	Unit Nom. Power	295 Wp
Array global power		Nominal (STC)	**520 kWp**	At operating cond.	472 kWp (50°C)
Array operating characteristics (50°C)		U mpp	612 V	I mpp	772 A
Total area		Module area	**2924 m²**	Cell area	2593 m²
Inverter		Model	**Growatt CP100**		
Original PVsyst database		Manufacturer	Growatt New Energy		
Characteristics		Operating Voltage	450-820 V	Unit Nom. Power	100 kWac
Inverter pack		Nb. of inverters	5 units	Total Power	500 kWac
				Pnom ratio	1.04
Battery		Model	**B-Box PRO 13.8**		
		Manufacturer	BYD		
Battery Pack Characteristics		Nb. of units	14 in series x 6 in parallel		
		Voltage	717 V	Nominal Capacity	1560 Ah (C10)
		Discharging min. SOC	20.0 %	Stored energy	894.6 kWh
		Temperature	Fixed (20°C)		
Battery input charger		Model	Generic		
		Max. charging power	250.0 kWdc	Max./ Euro efficiency	97.3/95.0 %
Battery to Grid inverter		Model	Generic		
		Max. discharging power	250.0 kWac	Max./ Euro efficiency	97.3/95.0 %

zhengzhou simulation variant

Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_User MWh	E_Solar MWh	E_Grid MWh	EFrGrid MWh
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April	135.1	81.9	16.60	138.5	135.4	64.07	45.45	43.03	16.23	2.420
May	161.8	96.0	21.70	155.0	151.2	70.36	46.97	45.31	19.72	1.659
June	161.7	101.9	26.30	150.3	146.6	67.30	45.45	45.45	16.71	0.000
July	148.7	99.5	27.20	139.8	136.3	62.55	46.97	46.29	11.24	0.674
August	139.8	88.7	25.70	137.7	134.3	62.03	46.97	44.44	12.52	2.527
September	112.9	67.4	21.60	123.9	121.2	56.31	45.45	40.18	11.50	5.266
October	99.6	54.7	15.60	124.5	122.1	58.10	46.97	41.33	12.15	5.631
November	74.0	40.0	8.70	103.5	101.6	50.20	45.45	38.99	6.88	6.463
December	66.5	36.5	2.80	98.2	96.4	49.00	46.97	41.78	2.59	5.184
Year	1366.7	828.9	15.19	1500.7	1467.5	700.86	552.98	510.19	133.37	42.794

Legends:
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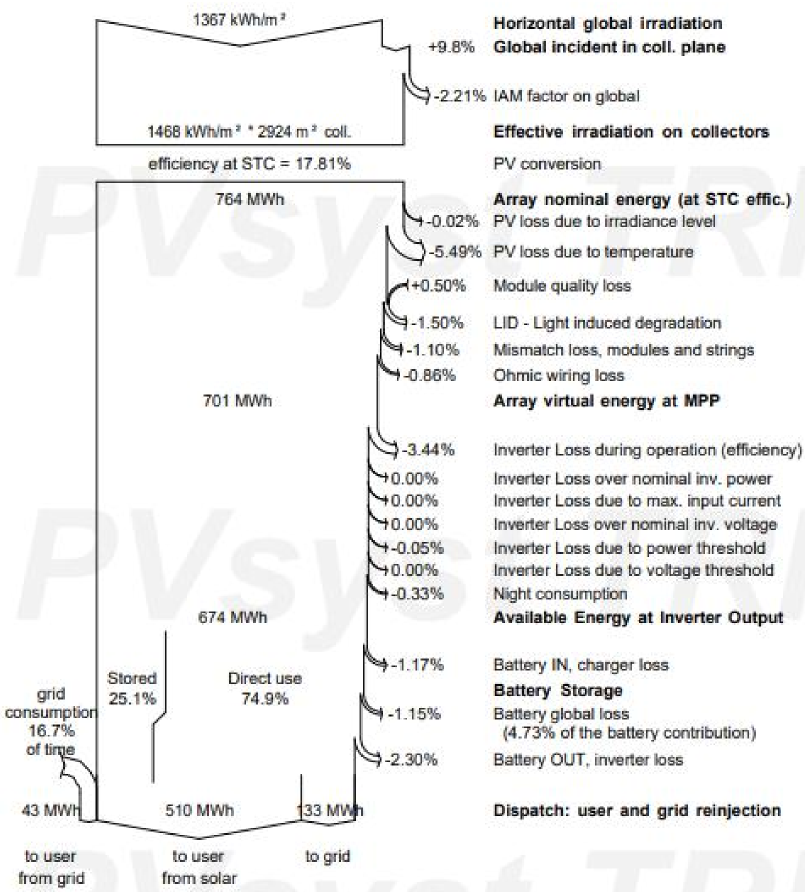
Loss diagram over the whole year



We can see that the annual PV active power generation is 700.86MWh, the load power consumption is 552.98MWh, PV-to-load power raises to 510.19MWh, sent to grid 133.37MWh, taken from grid 42.794MWh, and annual PV utilize rate increases to 92.26%. Assume the feed-in price is 0.1USD/kWh, the electricity is 0.3USD/kWh. In the first year, it will be 43000 * 0.4-133000 * 0.1 = 392000 US dollars on the electricity bill.

What are the bonuses this retrofit brings?

1. Before the retrofit, the annual electricity cost is US $42500. After the retrofit, only 3900 US dollars to be paid, almost realize "free use of electricity" , $38600 can be saved annually.

2. The annual PV utilization rate increased from 67.17% to 92.26%.

3. 181.57MWh power taken from gird reduced to 43MWh per year, the grid power supply pressure can be greatly relieved.

4. 303MWh feed-in power reduced to 133MWh per year, significantly reduces operation and maintenance pressure on the grid.

5. According to relative policy, it can be incorporated into the smart dispatch for large grid to participate in power grid regulation, and can put on the welfare of energy storage subsidy.

6. It is a good demonstration to reduce emissions and achieve good ecological benefits.

Then, how about the earnings the owner can actually get?

From the simulation results, it can be seen that in a year, 700.86MWh of active PV power is generated , among which the load consumes 552.98MWh. Suppose the load is constant, and the PV capacity attenuation won't be less than 80% after 25 years. Then 700.86MWh * 0.8 = 560.688MWh, which is still greater than load power consumption, thus the annual revenue can be estimated to be constant.

Inverter + battery cost = 25700+214000≈240000US dollars

$38600 electricity cost can be saved annually. (based on China's electricity price)

The energy storage subsidy is $0.078 per kWh discharged for participating in smart dispatch and peak regulation of large grid. Assuming there is 60 times of dispatching and 100 kWh discharged each year, the annual subsidy will be about US $470 (Based on China's subsidy)

Then the investment recovery period = 240000 / (38600 + 470) = 6.14 years

To sum up, the investment recovery period for the retrofit is about 6 years and 2 months, the life of lithium battery is normally about 10 years, so the money earned in the rest nearly 4 years will be net profit. Due to the continuous progress of battery technology, the cost of battery will reduce substantially in the following years, and by contrary the electric charge rises every year. After the battery is scrapped, it can be replaced by new battery with higher performance, lower price and continue to run the storage system.

The above is a typical case of grid-tie to storage retrofit. The ATESS PCS series model does not need to communicate with the existing grid inverter, so it can be applied with the inverter of any brand in the market, saving investment for EMS, and at the same time realizing the function of energy flow regulation and management.

Now there are countless grid-tie PV power stations running in operation. Due to unsatisfactory self-consumption rate, limitation of grid power consumption and transformer capacity, many more owners tend to choose this scheme to upgrade their system. On one hand, it's because it doesn't require to change or replace the original equipment, on the other hand, it brings considerable economic benefits compared with continuous use of the pure grid connected system.