

Integrated Knowledge Partnership Workout

For Center of Excellence on Clean Energy Indonesia

Current Status and Policy Framework of PV in China

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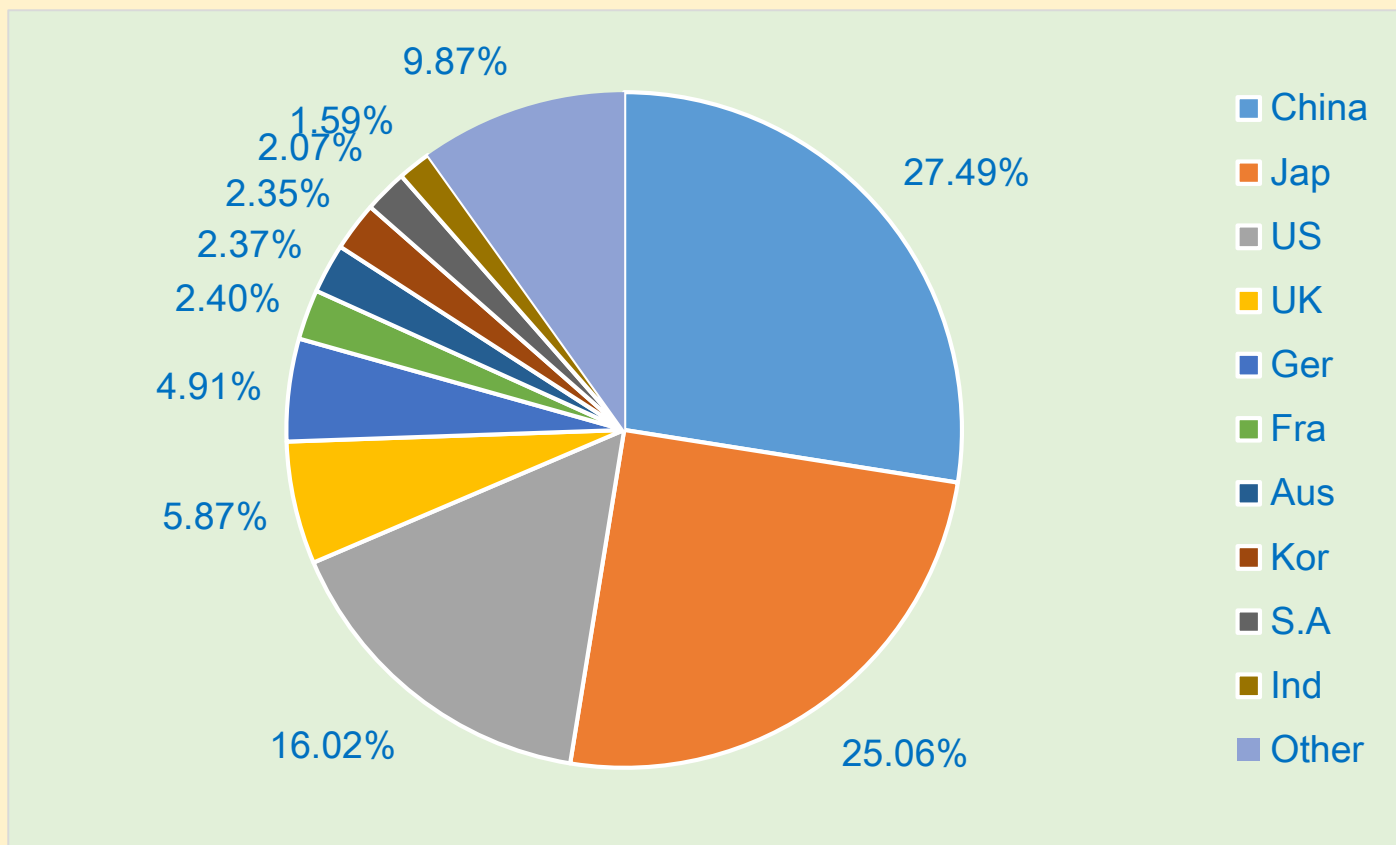


Wang Sicheng, CNECC

Dec. 17th, 2015, Jakarta, Indonesia

PV Market in China

World PV Annual Installation by Countries (2014)























Country	China	Jap	US	UK	Ger	Fra	Aus	Kor	S.A	Ind	Other	Total
2013 (GW)	9.50	6.90	4.50	1.70	3.30	0.60	1.20	0.44	0.30	0.44	9.47	38.35
2014 (GW)	10.64	9.70	6.20	2.27	1.90	0.93	0.92	0.91	0.80	0.62	3.82	38.70
2014 Share (%)	27.49	25.06	16.02	5.87	4.91	2.40	2.37	2.35	2.07	1.59	9.87	100.00
Cumulative (GW)	28.38	23.30	18.28	5.10	38.20	5.66	4.13	2.38	0.92	2.94	47.70	177.00

Source: IEA PVPS 2015

World PV Cumulative Installation by Countries (2014)

TABLE 1: TOP 10 COUNTRIES FOR INSTALLATIONS AND TOTAL INSTALLED CAPACITY IN 2014

	TOP 10 COUNTRIES IN 2014 FOR ANNUAL INSTALLED CAPACITY				TOP 10 COUNTRIES IN 2014 FOR CUMULATIVE INSTALLED CAPACITY			
1 st		China	10,6 GW			Germany	38,2 GW	
2 nd		Japan	9,7 GW			China	28,1 GW	
3 rd		USA	6,2 GW			Japan	23,3 GW	
4 th		UK	2,3 GW			Italy	18,5 GW	
5 th		Germany	1,9 GW			USA	18,3 GW	
6 th		France	0,9 GW			France	5,7 GW	
7 th		Australia	0,9 GW			Spain	5,4 GW	
8 th		Korea	0,9 GW			UK	5,1 GW	
9 th		South Africa	0,8 GW			Australia	4,1 GW	
10 th		India	0,6 GW			Belgium	3,1 GW	

NUMBERS HAVE BEEN ROUNDED

Source: IEA PVPS

PV Market in China

- Rural Electrification
- Communication and Industry
- PV Commercial Products
- Building Integration PV
- Large Scale Ground Mounted PV

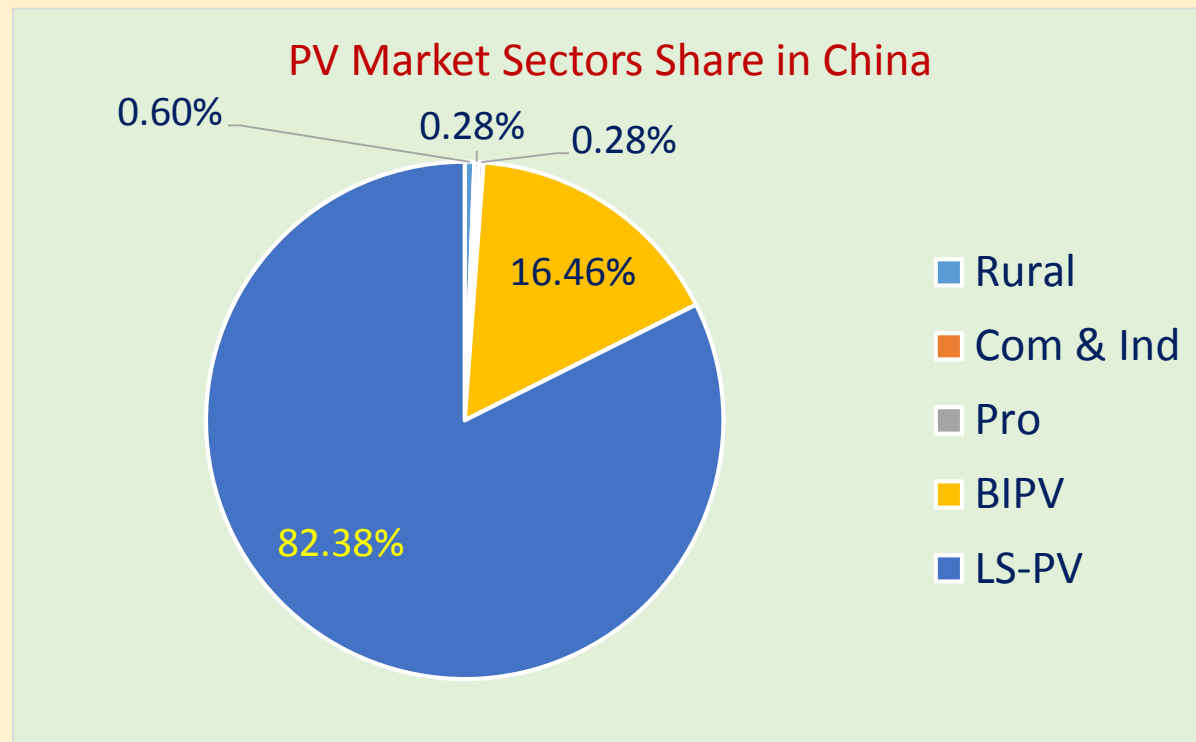


Commercial Products



2014 Domestic PV Market by Sectors

2014 Domestic PV Market by Sectors			
No.	Market Sector	Annu.Ins.	Cumm. Ins.
		(MWp)	(MWp)
1	Rural Electrification	20	170
2	Comm.& Indus.	10	80
3	PV Products	10	80
4	Building PV	2050	4670
5	Ground Mounted LS-PV	8550	23380
	Total	10640	28380



Source: National Energy Administration (NEA) , Feb. 15, 2015

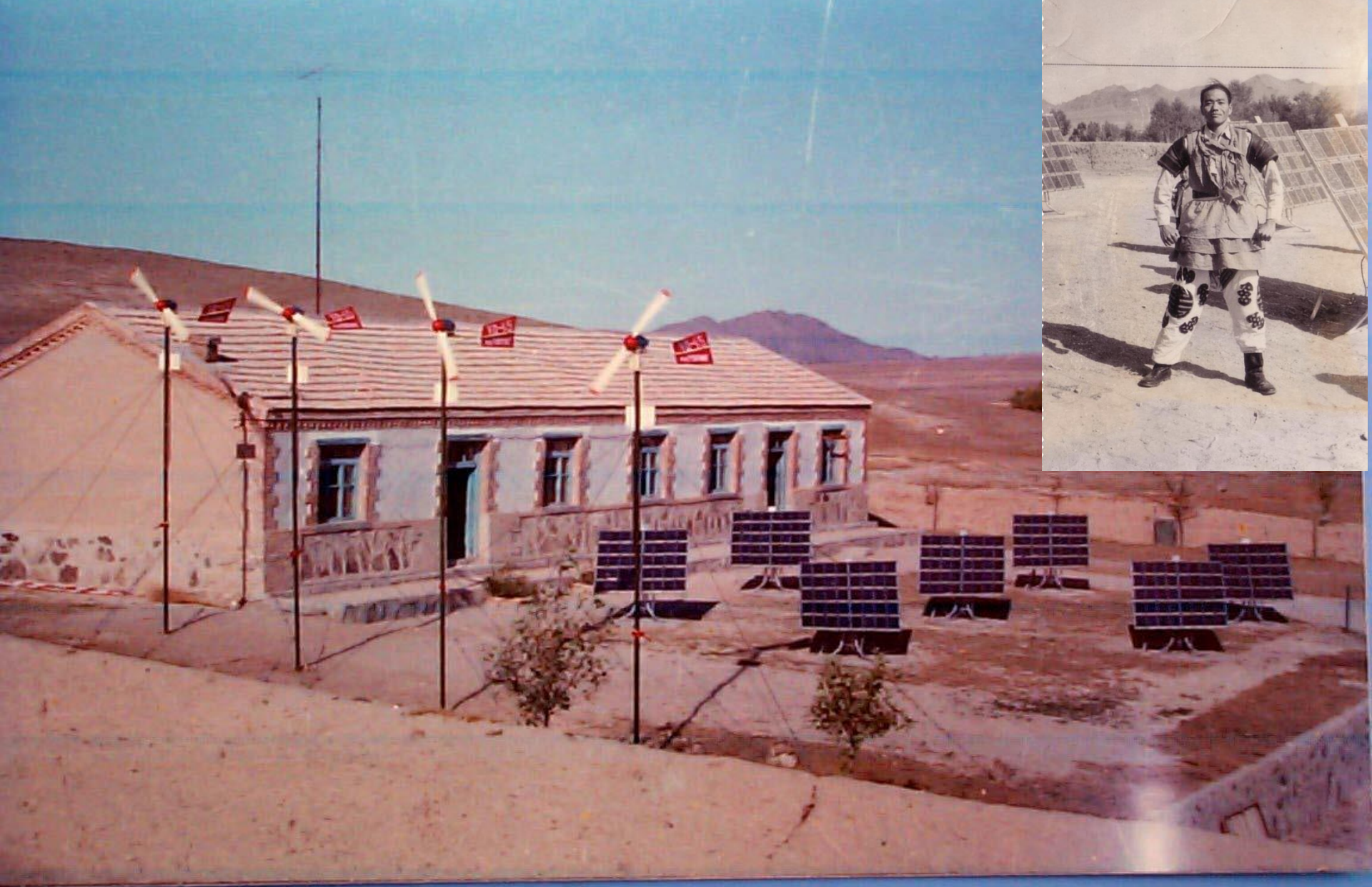


Rural Electrification



总装机容量500kW
北京华公司2002.2

18 3.18



560Wp of PV plus 200W wind turbines, Guligutai village, Inno-Mongolia, 1982

1990



Wang Sicheng together with Tibetan operator Mr. Luoxiu.

Largest PV Power Plant in the World



850MW PV Power Plant in Longyangxia, combined with **1.28GW** hydro-power plant, 2015-06-20

(Invested by Yellow River Power Co.)

PV Industry in China

PV Industry in China (2014)

1. World Poly-Si production 320,000 Tons, China 138,000 Tons, shares 43%;
2. World PV wafers production 50GW, China 38GW, shares 76%;
3. World PV cells production 56GW, China 33GW, shares 59%;
4. World PV module production 50GW, China 35GW, shares 70%。

China now is a Giant of PV Manufacturing in the world

Top 16 PV Module Manufacturers in the World and China (2014)

Company	Capacity	Production
Trina Solar	3600	3600
Yingli	4200	3400
Canadian Solar	3000	3000
JA Solar	3000	2500
Jinko	3200	2300
First Solar	2300	1846
Hanwha Solar One	2200	1700
Sharp Solar	1550	1400
Sun Power	1300	1233
Kyocera	1400	1200
REC	1000	954
Hareon Solar	1200	900
Solarworld	1230	900
Solar Frontier	980	900
ReneSolar	1200	820
Changzhou Yijing	1000	847
Others	54640	24490
Total	87000	52000

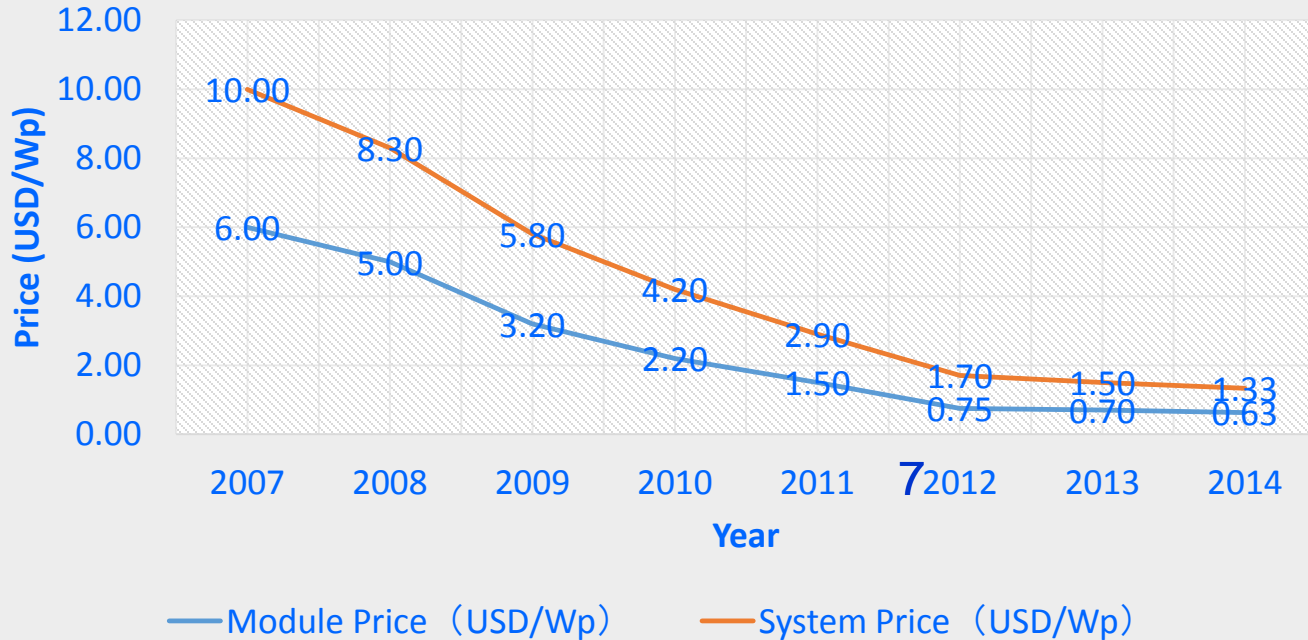
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Jinko	3200	2300
Hanwha Solar One	2200	1700
Hareon Solar	1200	900
Changzhou Yijing	1000	847
Astronergy	900	830
ReneSolar	1200	820
SunTech	1500	800
CECEP	650	610
BYD	1000	600
Risen Energy Co.	850	590
ORISI New Energy	600	570
ZNShine Solar	1000	560
Others	33900	11973
Total	63000	35600

PV module production made in China (main land) shared 70% of total world PV module production.

Source China PV Industry Association (CPIA)

PV Module and System Price Reduction

China PV Module and System Price 2007-2014



During Last 7 Years:

- **86.4% of module price decreased;**
- **86.7% of system price decreased;**
- **76.2% of PV FIT decreased**
- **4 Yuan/kWh was set for PV in 2008 (for the 1MW PV project in Shanghai).**

Year	2007	2008	2009	2010	2011	2012	2013	2014
Cumulative Installation (GWp)	0.10	0.14	0.30	0.80	3.20	6.70	16.28	26.84
Module Price (USD/Wp)	6.00	5.00	3.20	2.20	1.50	0.75	0.70	0.63
System Price (USD/Wp)	10.00	8.30	5.80	4.20	2.90	1.70	1.50	1.33
Feed-In Tariff of PV (Yuan/kWh)	4.0	Set through Bidding			1.15	1.00	0.9-1.0	0.9-1.0

State Council – Going Out Strategy (2015) No. 30

Encourage Overseas Investment and Win-Win Policy

《国务院关于推进国际产能和装备制造合作的指导意见》
国发〔2015〕30号

**Anti-dumping and Local Content
(US, EU, Canada, Australia, India....)**

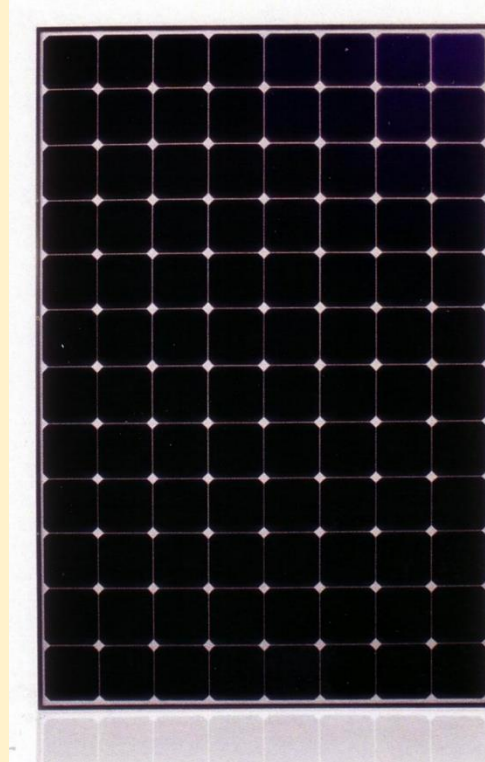
- ◆ **Trina Solar**: 1GW solar cell line and 1GW module line in India;
- ◆ **GCL**: Cooperate with India Ardani Group to set up PV manufacturing base with whole chain.
- ◆ **CSUN** 100MW Solar Cell line and 300MW Module line in Turkey;
- ◆ **Jinko** built a PV module line in South Africa
- ◆ **ReneSolar** built OEM lines in 7 countries
- ◆ **Yingli Green Energy** plan to build module line in Thailand
- ◆ **Comtech Solar** built 300MW wafer line in Malaysia
- ◆ **Zhongli Talesun Solar** invested in South-East Asia

PV Technologies in China

Trina Solar Developed High Efficiency IBC PV Cells



**Trina Solar's
N-type IBC PV
modules
21%.**



E20
SERIES

**SunPower's
IBC PV Modules
Efficiency
24%**



**Solar Powered
Airplane: Solar Impulse
2 used SunPower's IBC
PV modules.**



Silevo (Hangzhou) N-Type HIT PV Module:

- Cell Efficiency **21%**;
- Module Efficiency **18.4%**;
- Temperature Coff. **-0.22%/°C**

Triex™ R-Series

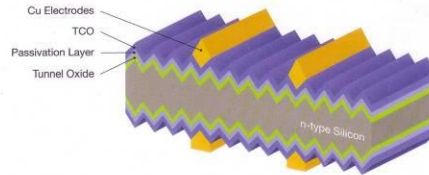


Triex™ modules utilize a hybrid cell technology which couples the best attributes of 3 different materials 1) N-type crystalline substrate, 2) Thin Film Passivation, 3) Semiconductor oxide to optimize cell and module performance while limiting costs. Silevo's breakthrough cell innovation coupled with traditional crystalline silicon (c-Si) package techniques enable Silevo's Triex modules to optimize all three performance indicators (efficiency, harvest, and cost) in order to deliver the industry's best value.

Triex 235 Watt, 18.4% Module

Triex Product Features

- **Best Performance/Cost Ratio:** Tunneling Junction cell technology with efficiencies up to 21% coupled with low cost manufacturing process optimizes end user value.
- **High Efficiency:** Total Area Module Efficiency up to 18.4% which lowers balance of system costs. Less panels, mounting structure, cabling required per given area.
- **Energy Harvest:** Tunneling Junction cell technology with $-0.22\%/C$ temperature coefficients enables up to +12% additional energy harvest in arid climates.
- **Manufactured Quality:** Highly automated advanced cell manufacturing coupled with industry proven and repeatable standard packaging techniques.



Warranties & Certification

- **10 Year Limited Product Warranty**
- **25 Year Limited Power Warranty:** 10 Year at 90% off the minimum rated power output, 25 years at 80% of the minimal rated power output.
- **IEC, UL, CEC, CE, ISO9001:** Pending TUV Rheinland Certification for IEC 61215, IEC 61730, UL 1703, TUV Safety Class II



Yingli Green Energy and Canadian Solar have developed new **MWT** PV moduls.

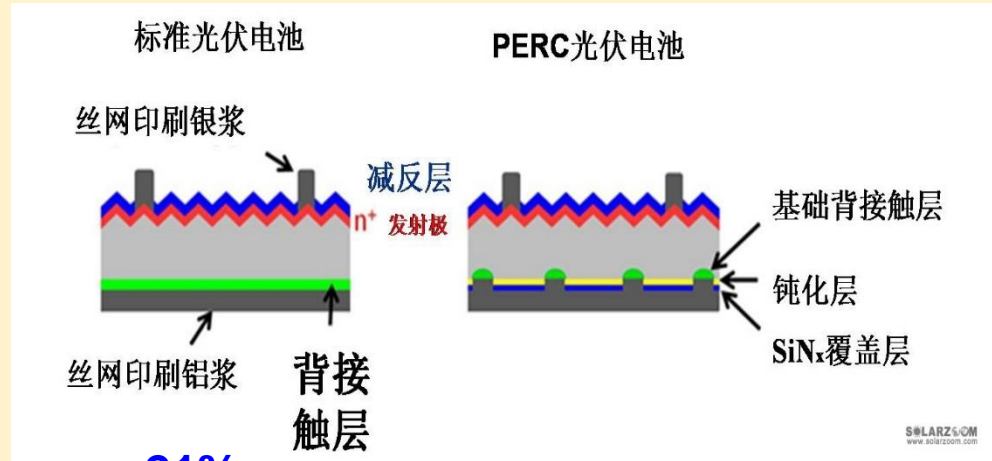


Canadian Solar efficiency **21%**



YGE efficiency **20.4%**

Csun, JA Solar and Jinneng Solar Developed PERC PV Modules



21%

PERC is a P-type low-cost and high efficiency technology. Current in China several companies are producing PERC PV modules and the cost is only around \$0.6USD.

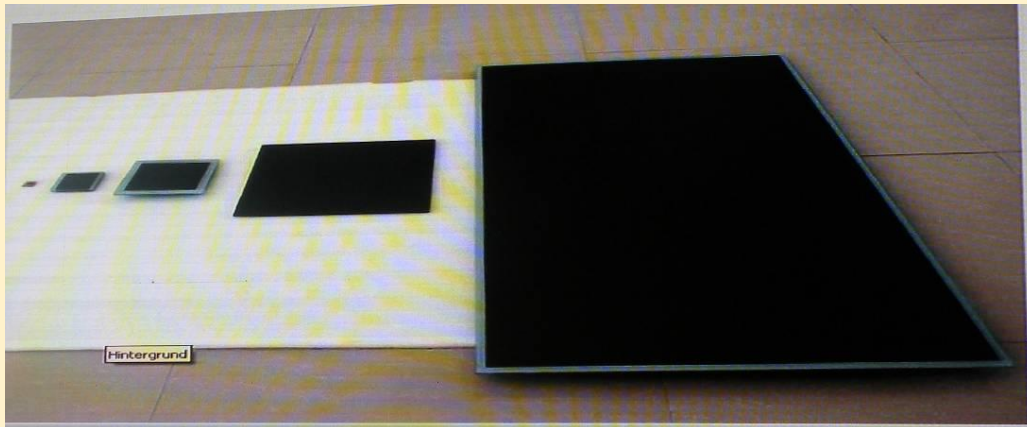
P-Type PERC
Module. Cell
efficiency 21%.

30MW CdTe manufacturing line by Advanced Solar Power (ASP)



ects. with...
de (S2) and BIPV module...
ding to customer' s requirements. The table...

S1 Series	ASP-S1-65	ASP-S1-70	ASP-S1-75	ASP-S1-80
Nominal Power(Pm)	65W	70W	75W	80W
Open Circuit Voltage(Voc)	110V	113V	115V	118V
Short Circuit Current (Isc)	0.92A	0.92A	0.94A	0.96A
Voltage at Max. Power(Vm)	83V	88V	92V	92V
Current at Max. Power (Im)	0.8A	0.8A	0.82A	0.84A
Module Dimension	L 1200×W 600×Dk 8mm			
Weight	11.8kg			
Temperature Coefficients of Pm	-0.214%/°C			
Temperature Coefficients of Voc	-0.321%/°C			
Temperature Coefficients of Isc	0.060%/°C			
Warranty	※ 10 years materials and workmanship; ※ 25 years power output guarantee for 90% of nominal output during first 10 years and 80% over 25 years.			



**1200 × 600 mm Standard
Module, 65W-80W,
Efficiency: 9.0% - 11.5%
Highest: >12%.**

**30MW Manufacturing Line
Developed by Self. (Cost: about \$0.5/Wp)**



**All manufacturing Facilities are developed by self
Catch-up First Solar in future?**

Hanergy: the largest a-Si and CIGS Producer



8 Manufacturing base in China and total a-Si capacity 3 GW .

Hanergy now is the largest CIGS manufacturer in the world.

Question:
are a-Si and CIGS modules really competitive or not?



Hanergy has unveiled plans to add new CIGS manufacturing capacity totalling 5.25GW.

15.5% CIGS module efficiency has been reached.

**Suncore Co. purchased
Emcore, US Co., in 2013, and
became the World Leading
CPV company.**

**The highest efficiency of GaAs
is 42.3% (500x and three
junctions).**



**60MW
in 2014**



PV Policies and Future Forecast

PV Incentive Policies

Released by NDRC on Aug. 26, 2013: NDRC [2013] No.1638

Solar Resources	FIT for LS-PV	Self-Consumption for Distributed PV	
	FIT (Yuan/kWh)	For self-consumed PV (Yuan/kWh)	Excess PV Feed-Back to Grid (Yuan/kWh)
I	0.90 (¢0.145)	Retail Price of Grid Electricity+0.42 Yuan (+ ¢0.068)	Whole-sell Coal-Fire Tariff + 0.42 Yuan (+ ¢0.068)
II	0.95 (¢0.153)		
III	1.00 (¢0.161)		

Key Points:

- (1) 3 level of FIT for LS-PV based on local solar resources;
- (2) For distributed PV, 0.42 Yuan/kWh will be subsidized to PV electricity;
- (4) Subsidy duration: 20 Years;
- (5) PV developers can choose either FIT or Self-Consumption.

The subsidy money is come from the surcharge, which is 1.5 cents/kWh charge to the end users. About 50 billion Yuan (\$8 billion USD) per year can be collected to support RE power supply.

Innovative Business Model for PV



Green House Covered by PV

PV-Fish Pool



PV- Vegetable Field



PV- Farm Land



PV Tunnel – Railway & Highway



国家能源局文件

国能新能[2015]265号

国家能源局关于推进新能源微电网 示范项目建设的指导意见

各省（区、市）发展改革委（能源局）、新疆生产建设兵团发展改革委，国家电网公司、南方电网公司，各主要发电投资企业，中国电建集团、中国能建集团、水电水利规划设计总院，中科院：

可再生能源发展“十二五”规划把新能源微电网作为可再生能源和分布式能源发展机制创新的重要方向。近年来，有关研究机构和企业开展新能源微电网技术研究和应用探索，具备了建设新能源微电网示范工程的工作基础。为加快推进新能源微电网示范工程建设，探索适应新能源发展的微电网技术及运营管理体制，现提出以下指导意见：

一、充分认识新能源微电网建设的重要意义

新能源微电网代表了未来能源发展趋势，是贯彻落实习近平总书记关于能源生产和消费革命的重要措施，是推进能源发展及经营管理方式变革的重要载

New Energy Micro-Grid Demonstration:

Guideline for Promoting RE Microgrid Demonstrations, issued by NEA (National Energy Administration) on July 13th, NEA (2015) No.265.

国家能源局文件

国能新能[2015]265号

July 13, 2015

国家能源局关于推进新能源微电网

示范项目建设的指导意见

Micro-grid Demonstrations

In Next 5 years, China plan to build 30-50 Micro-Grid Demonstration Projects

To reach the following purposes:

- ◆ *Going forward to reach **High-penetration of Distributed RE (>50%)** ;*
- ◆ *To make fluctuant RE power become **grid-friendly dispatchable power sources**;*
- ◆ *To start new market for **energy storage**;*
- ◆ *Institutional Innovation and hoping to have **independent distributors of power supply**.*

◆ 离网微电网 (Isolated Micro-Grid)

- Micro-Grid for Islands
- Micro-Grid for Remote Villages

◆ 联网微电网 (Grid-connected Micro-Grid)

- Grid-friendly Micro-Grid
- Self-Balanced Micro-Grid
- Service-Type Micro-Grid

Micro-Grid:

Dongfushan Island



(a) 东福山电站



(b) 980kWh 阀控式铅酸蓄电池



0kW 风电机组



(d) 100kW 光伏电站

- 地面光伏电站: 100kW
- 柴油机组: 250kW
- 风电机组: 7 台 30kW
- 蓄电池组: 980kWh, 阀控式铅酸蓄电池
- 海水淡化装置: 50 吨/天

- 电力负荷: 部队负荷、东福村和海水淡化装置
- 中心变电站: 0.38/10kV
- 设备层通讯采用 RS485, 电站层通信为工业以太网
- 具有能量管理系统

Micro-Grid: Nanji Island, Zhejiang

Integration of the microgrid(1)

南麂微电网系统组成 System structure of the microgrid on Nanji Island



光伏发电 solar generation
660kW

后隆站550kWp, 专线接入
special line
办事处站: 110kWp, 线路T接
T-connection



储能系统 storage system

4×500kW×2h 锂电池储能
lithium battery
2×500kW×15s 超级电容储能
supercapacitor



风力发电 wind
generation

10×100kW 永磁直驱
permanent magnet
synchronous generator



电动汽车充换电站
EV filling station
120个充电工位
charging units



柴油机发电 1.7MW
diesel generator

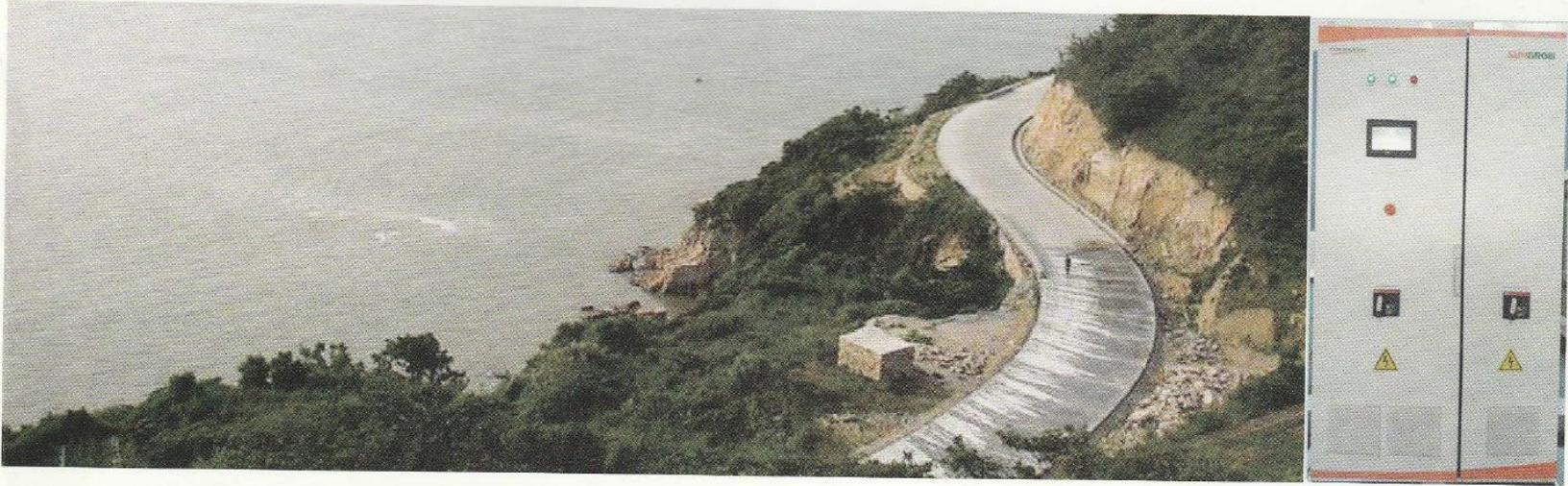
1×500kW
4×300kW
1×200kW

Micro-Grid: Donggao Island



Micro-Grid: 10kV , Include: 1.04MWp of PV, 50kW Wind-Power, 1220kW Diesel Generators, 2000kWh Lead-Acid Battery and EMS. Built by Xingye Company

Micro-Grid for Islands



Chengshan Island, Zhejiang Provinces: PV-Wind-Ocean Flow-Battery Hybrid System



三沙市永兴岛0.5MW独立光伏微电网发电示范项目（2013年）

Yongxing Island: 500kW PV + Diesel Generator + Storage Batteries 2013

0.5MW PV + Diesel Generator + Storage Batteries 2013

Micro-Grid for Remote Rural Area: Hydro + PV **Qinghai Province**



Location: Yushu District, Qinghai Province

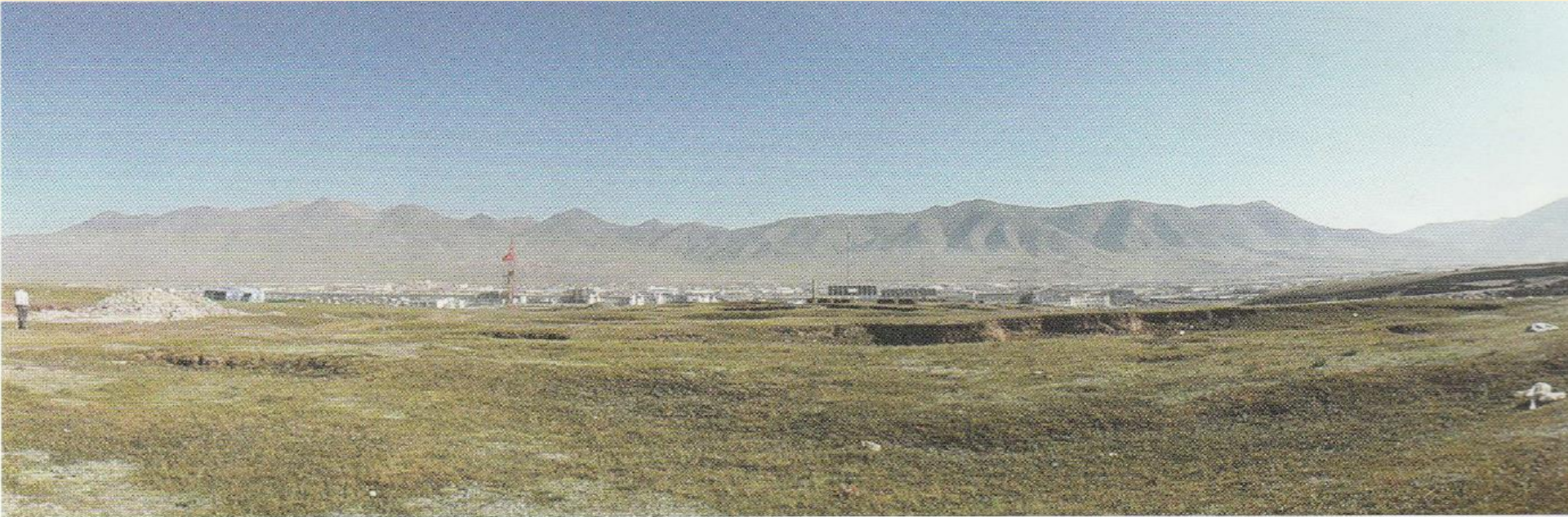
System:

- (1) Hydro-Power: 12MW;
- (2) PV : 2.0MW;
- (3) Battery: 15.2MWh.

Completed:

Dec., 2011

Micro-Grid for Rural Area: Zhiduo County, Qinghai Province



中节能青海治多县2.4MW微电网项目（2013年）

系统说明：项目位于青海治多县，海拔4300米，采用集中式光伏+储能微网运行方式，10KV建网，为全县5000多户人口供电，解决当地用电问题。系统配置方式灵活，并具备与水电、电网运行接口。

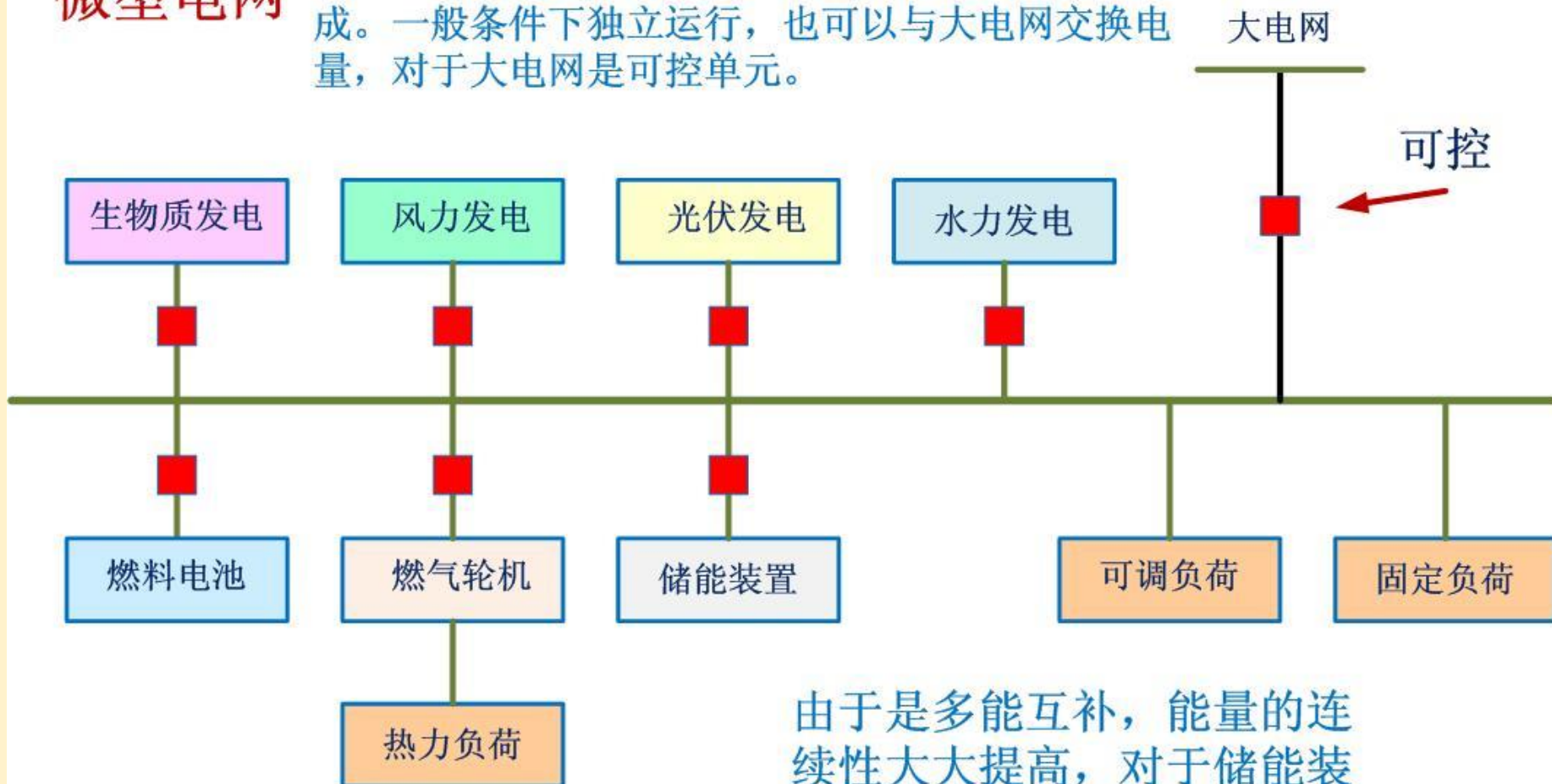
2.5MW Micro-Grid（2013年）

2.5MW of PV + Battery Storage for 5000 households;

微电网 (Micro Grid)

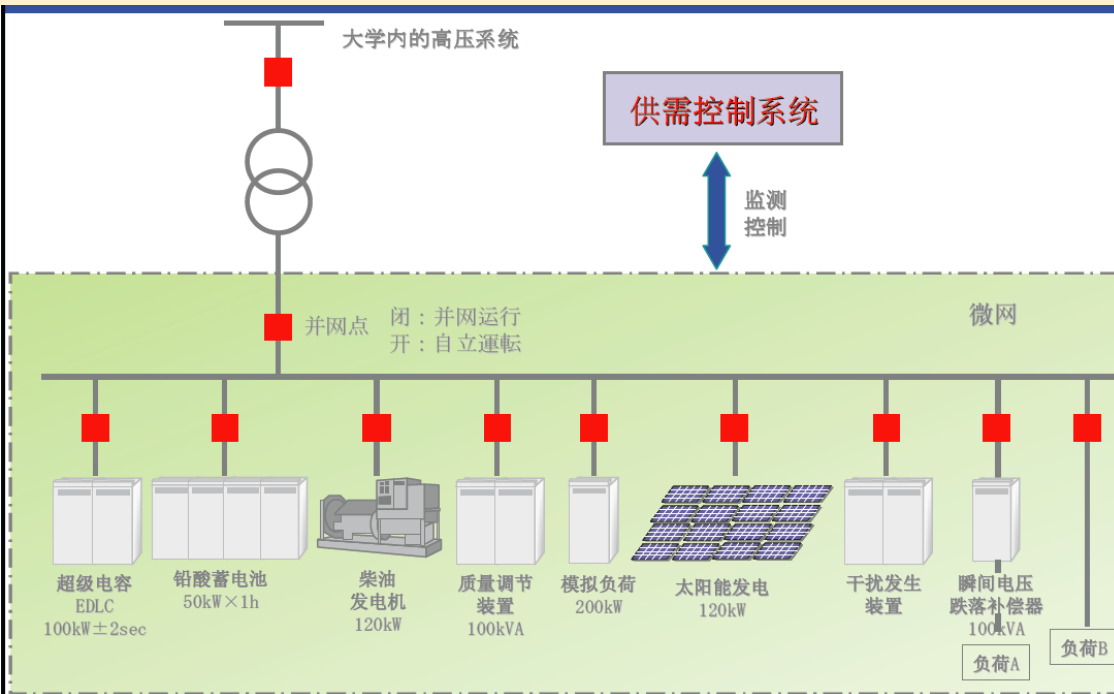
微型电网

由多种能源、储能装置、固定负荷和可调节负荷构成。一般条件下独立运行，也可以与大电网交换电量，对于大电网是可控单元。



由于是多能互补，能量的连续性大大提高，对于储能装置的要求则大大降低，很容易实现。

Grid-Connected Micro-Grid: Electronic Tech Univ.



Presented by Japan Gov.:

(1) 120kW of PV, Diesel Generator 120kW, 50kWh Battery Bank;

(2) Stable-Power Output

(3) Grid-Connected and Islanded working models.



Micro-Grid for Small Cities: Tulufan, Xinjiang Province



The penetration of RE reach to more than 30% , to satisfy power supply for 7000 households with 20,000 people.

- 1、 The small city managed by the developer of Micro-Grid;
- 2、 PV capacity: 13.5MW ;
- 3、 Central Control of EMS;
- 4、 Electric-Vehicles and charging stations.

China Now is Facing Pressure in Energy Supply and GHG Emission



Serious Air Pollution

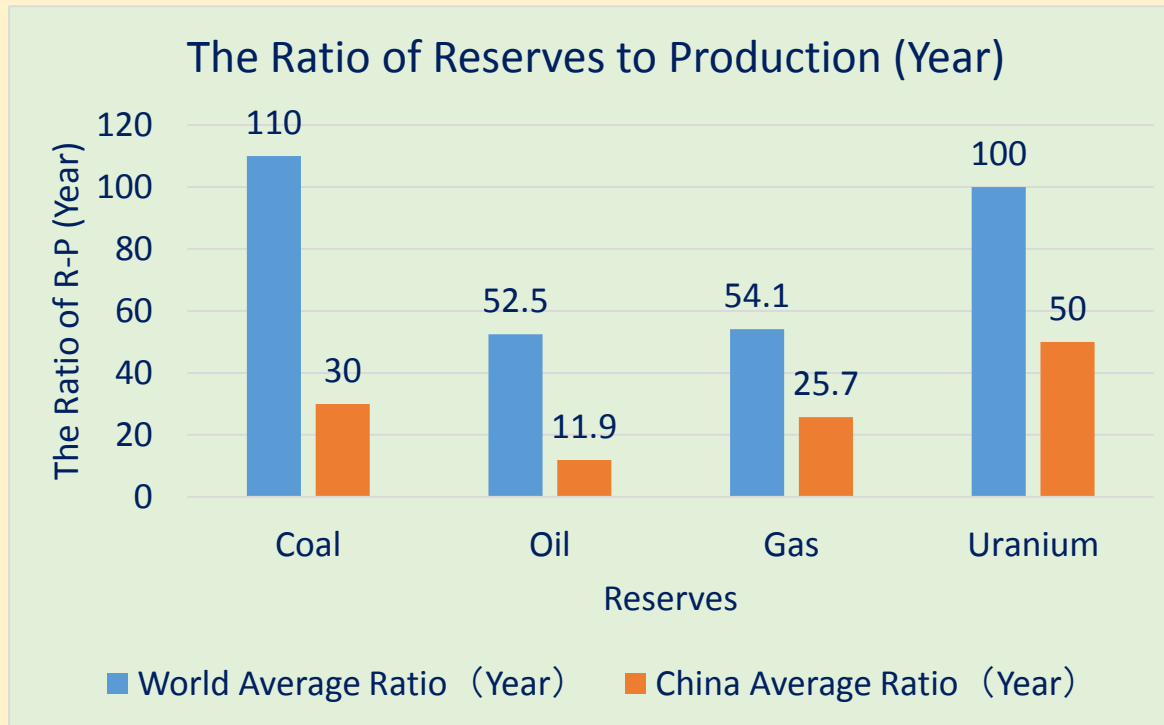
Dirty Fog in Beijing



China is Facing Serious Problems in Energy Supply and Air Pollution

- 1、 The largest country in GHG emission since 2007;
- 2、 The Largest country in energy consumption;
- 2、 The largest producer and consumer of electricity;
- 3、 The largest importer and user of coal;
- 4、 The largest importer of oil and 60% of oil was imported from other countries;
- 5、 Serious shortage in energy supply and serious pollution in environment.

The Ratio of Reserves to Production of China

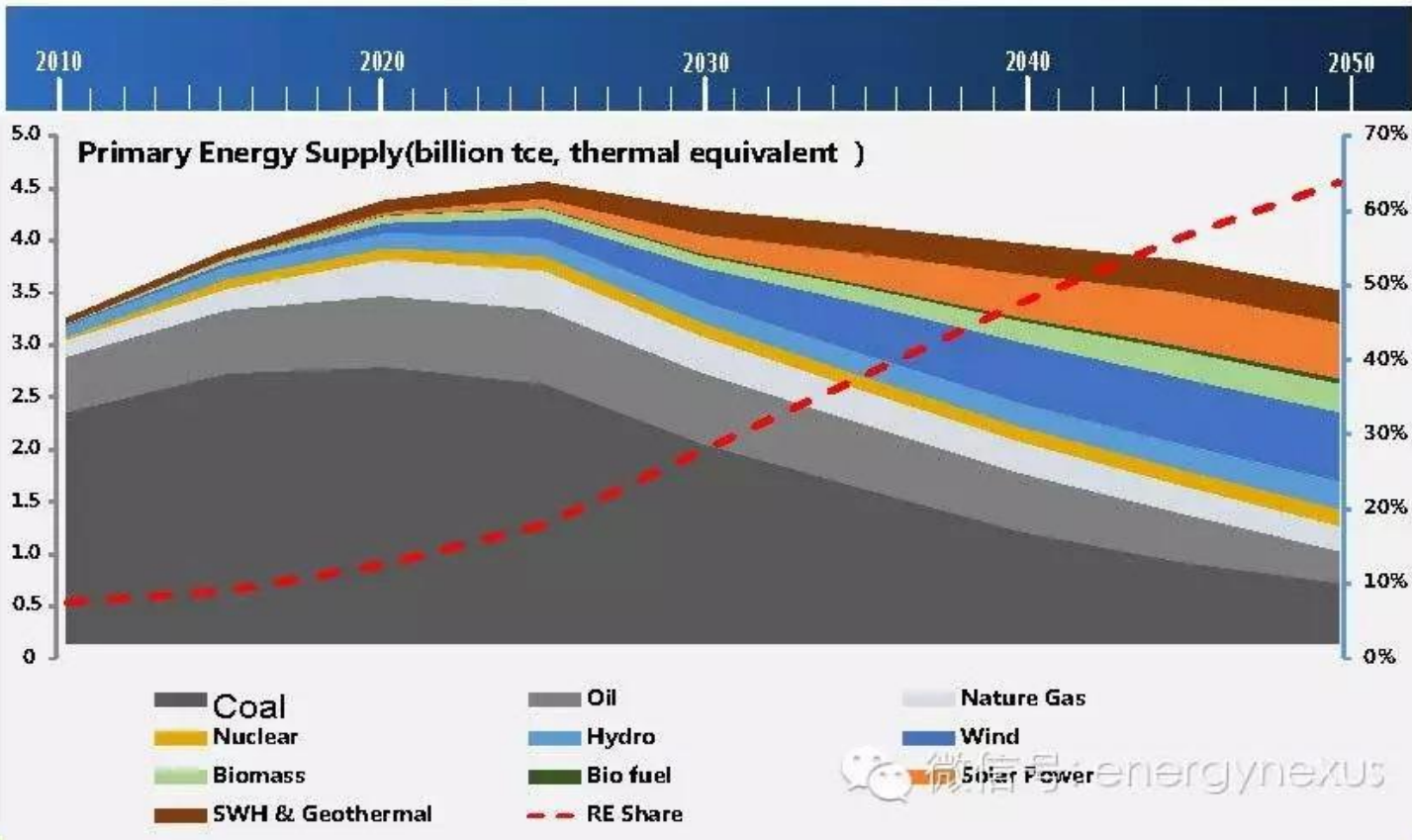


In another 30 years, there will be no coal, no oil and no gas in China!

China must complete the transforming of energy structure within next 20-30 years, and based on solar and other RE.

Reserves	Coal	Oil	Gas	Uranium
World	110	52.5	54.1	100
China	30	11.9	25.7	50

BY 2050, RENEWABLE ENERGY COULD MEET MORE THAN 60% OF PRIMARY ENERGY DEMAND

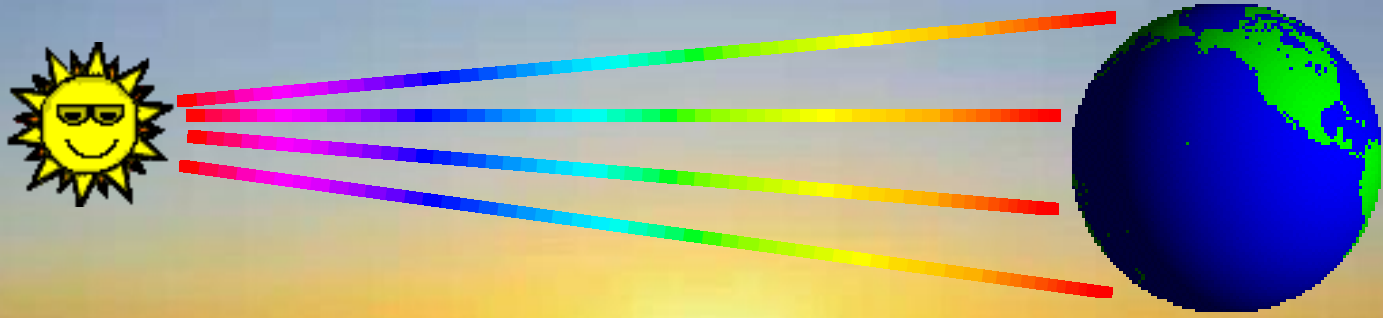


Coal consumption will reach to the peak by 2020; primary energy consumption will reach to the peak by 2025 (4.5 billion Tce) and the CO₂ emission will reach to the peak by 2030. By 2050, China primary energy consumption will be 3.4 billion Tce, 60% will come from renewable energy, 90% of electricity consumption will come from the non-fossil fuels, the share of electricity from total energy consumption will be raised from less than 30% today to more than 60%.

To Meet the Target of Energy Transition

Total PV installed capacity should be 2000 GW by the Year of 2050.

- 1、 By the year of **2020**,PV cumulative installation must be **150GW**, annual average installation should be **20GW** during **2015-2020**;
- 2、 By the year of **2030**,PV cumulative installation must be **400GW**, annual average installation should be **25GW** during **2021-2030**;
- 3、 By the year of **2050**,PV cumulative installation will reach to **2000GW**, annual average installation should be **80GW** during **2031-2050**.



Thank You !

Question ?

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