



中国微网示范现状及面临挑战

Status and Challenges of Micro-grid Demonstration in China

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2015.05.19

提纲 Outline



1. 中国发展微网的意义及分类
MG Significance and Classification
2. 独立型微网案例分析
Case study for Isolated MG
3. 联网型微网案例分析
Case study for On-Grid MG
4. 面临挑战
Challenges

1.1 微网意义/ Significance of MG

微电网的意义 / MG Significances

□ 解决边远地区的可靠供电问题

to supply energy demand in a stable and reliable way in remote area, including inhabited island and rural area. Mostly depend on renewable energy such as PV, wind, small hydro power, etc. And some micro-grids supply both heat and electricity.

□ 提高可再生能源发电的渗透率

to present a controlled profile to the wider power system, e.g. to damp the variability of a local renewable resource and buffer the grid from it.

□ 提高本地供电质量和供电可靠性

to provide power quality and/or reliability (PQR) different from the local standard of service, e.g. to serve particularly sensitive loads such as emergency services



1.2 微网分类 /Classification of MG

独立型微网 Isolated MG

不和常规电网相连接，利用自身的分布式能源满足微网内负荷的需求。当网内存在可再生分布式能源时，常常需要配置储能系统以保持电源与负荷间的功率平衡，并充分利用可再生能源。**这类微网更加适合在海岛、边远地区等地为用户供电。**

Off grid, to meet the demand of MG load with distributed energy. When the existence of distributed renewable energy (RE), the MG system often needs to configure the storage system to keep the power balance between power supply and load, and make full use of RE. **This MG type fits for the island and remote areas.**

联网型微网 On-grid MG

具有并网和独立两种运行模式。在并网工作模式下，一般与中、低压配电网并网运行，实现能量的双向交换。在外部电网故障情况下，可转为独立运行模式，继续为微网内重要负荷供电，提高重要负荷的供电可靠性。通过采取先进的控制策略和控制手段，可保证微网**高电能质量**供电，也可以实现两种运行模式的**无缝切换**。

Two operation modes with isolation and on grid; In on-grid mode, MG grid-connected operation with middle and low voltage network can realize the energy two-way exchange. In isolated mode, MG can go on to supply power to important loads. By the advanced control strategy and method, **high quality of electric energy supply** is guaranteed, and **the seamless switching** of two operation modes can be realized.

提纲 Outline

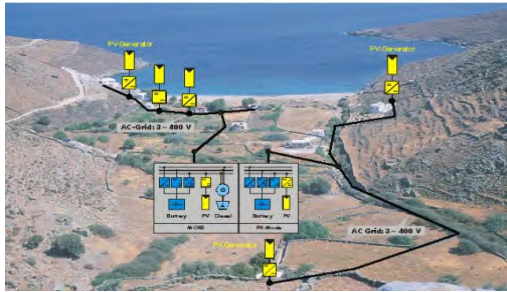


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2.1 独立微网典型特征

2.1 Typical Characteristics of Isolated MG

□ 示范系统 / Demonstration system



希腊基斯诺斯岛、浙江东福山岛、青海玉树、广东大万山岛等

Kythnos island in Greece, Dong Fushan Island of Zhejiang, Yu Shu of Qinghai, Dong'ao island of Guangdong

□ 典型特征 / Typical Characteristic

- **电网**：没有大电网连接，电压等级不高，结构薄弱
Grid：No large and strong grid to connect, voltage level is not high, the structure is weak;
- **分布式电源**：能源“因地制宜”，可再生发电渗透率较高
Distributed generators: Energy “right crop for right land”, high penetration of renewable energy
- **负荷**：生活用电为主，波动大，峰谷差、季节差大
Loads：Residential electricity consumption, large fluctuations and difference in season
- **供电质量**：电能质量要求不高，可以短时间停电
Power Quality: low quest for power quality, the temporary power failure is ok

2.2 典型案例分析(1) / Case Study (1)

— 青海玉树水/光/储微网 / Hydro/PV/Battery MG in Yu Shu, Qing Hai

- ◆ 玉树概况：远离青海电网，人口31万，水电冬季运行受限，电力紧缺

Overview: Far from power grid, Hydropower limited operation in winter, Lack of electricity

- ◆ 电力装机（震后）：2座小水电12MW，冬季电力缺口 $\geq 2\text{MW}$ (震前缺12.6MW)

Power capacity (After earthquake): Hydropower 12MW, Lack of electricity $\geq 2\text{MW}$

- ◆ 解决方案：建设10MW_p光电（带储能）+12MW水电，形成水/光/储互补微网

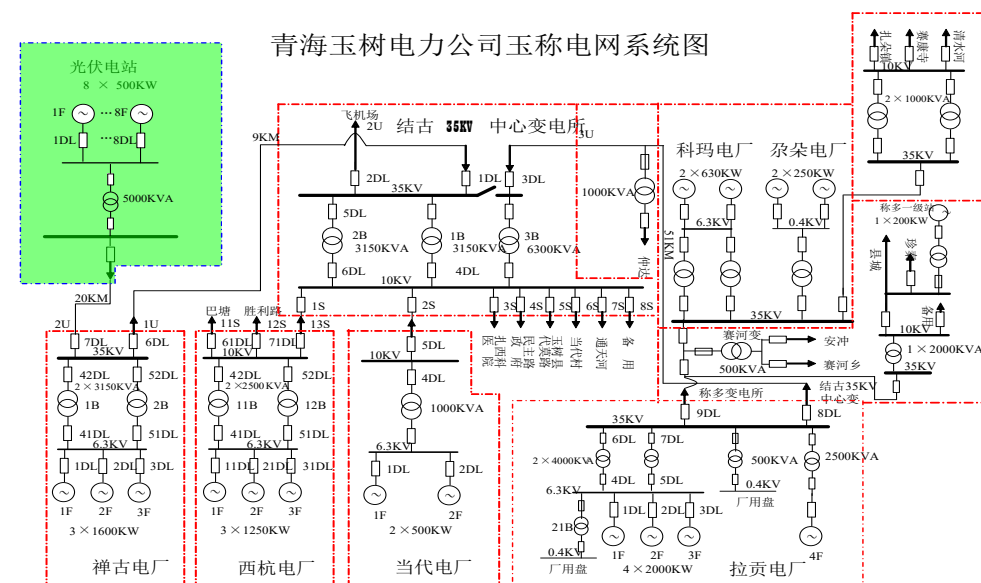
Solution: 10MW PV+12MW Hydropower, Complementary micro-grid

- ◆ 项目需求：一期建设2MW_p光伏电站，支撑晚高峰4小时，并可带重要负荷

Recent demand: 2MW PV for the evening peak period of 4 hours power supply, With heavy load



青海玉树州(地震前)/Yu Shu City (Before Earthquake 2010)



玉树电网结构图/Power system of Yu Shu City

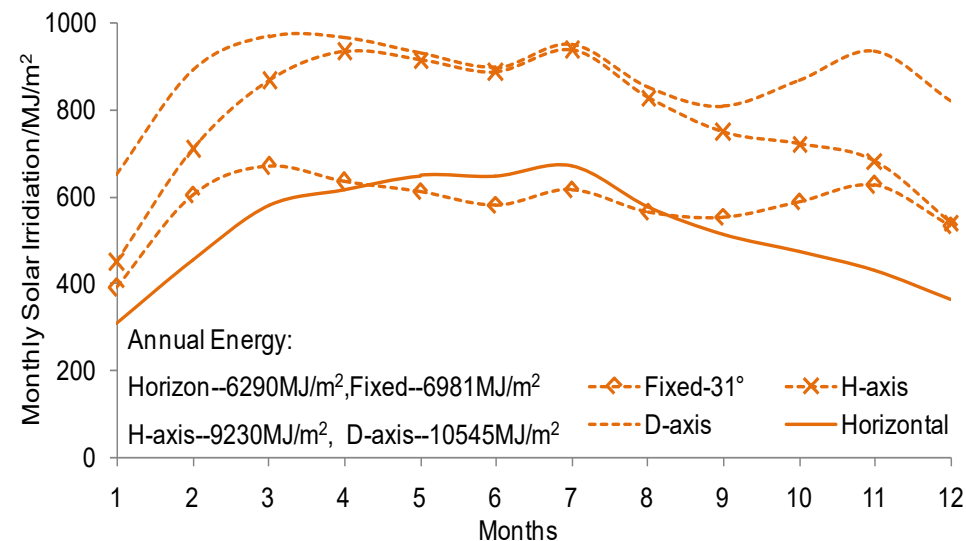
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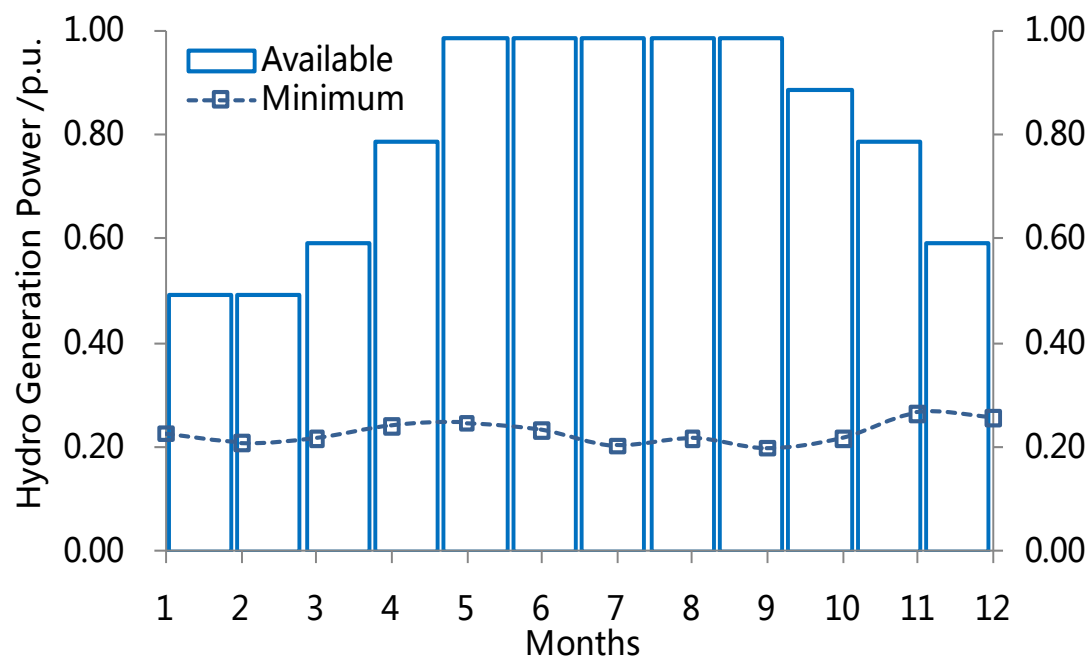
资源情况与负荷需求 / Resource and Load

◆ 玉树地区太阳能资源比较丰富，日照时数2600~3600h，年辐射量6500MJ/m²以上。

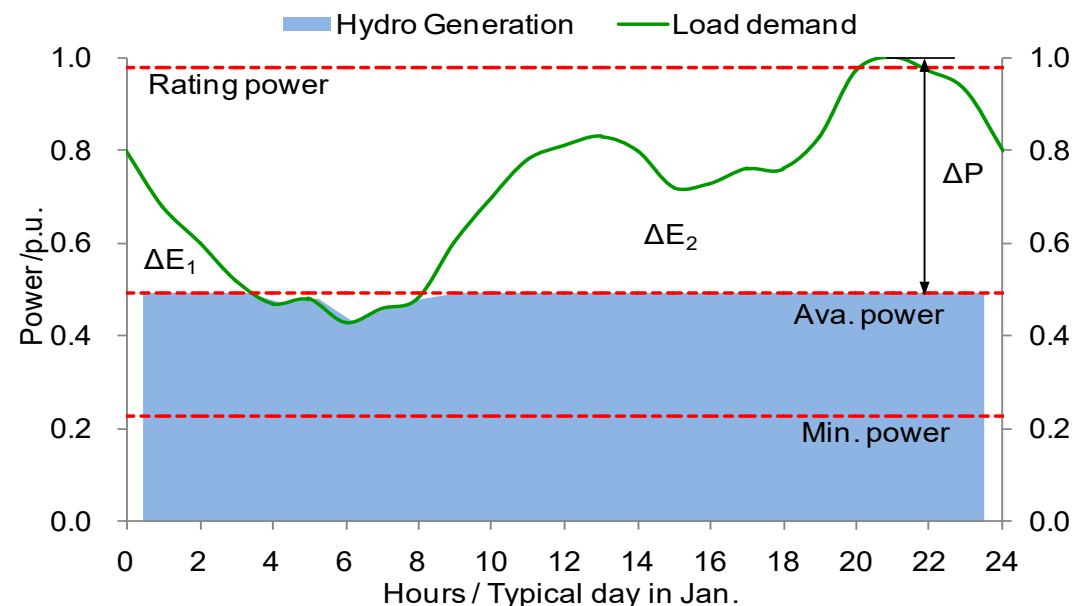
Solar energy resources are relatively abundant, sunshine is 2600 ~ 3600h, the amount of radiation is above 6500MJ / m²



玉树州太阳辐照曲线/Monthly solar irradiation in Yu Shu



玉树州水电机组发电曲线/Monthly hydro generation power in Yu Shu

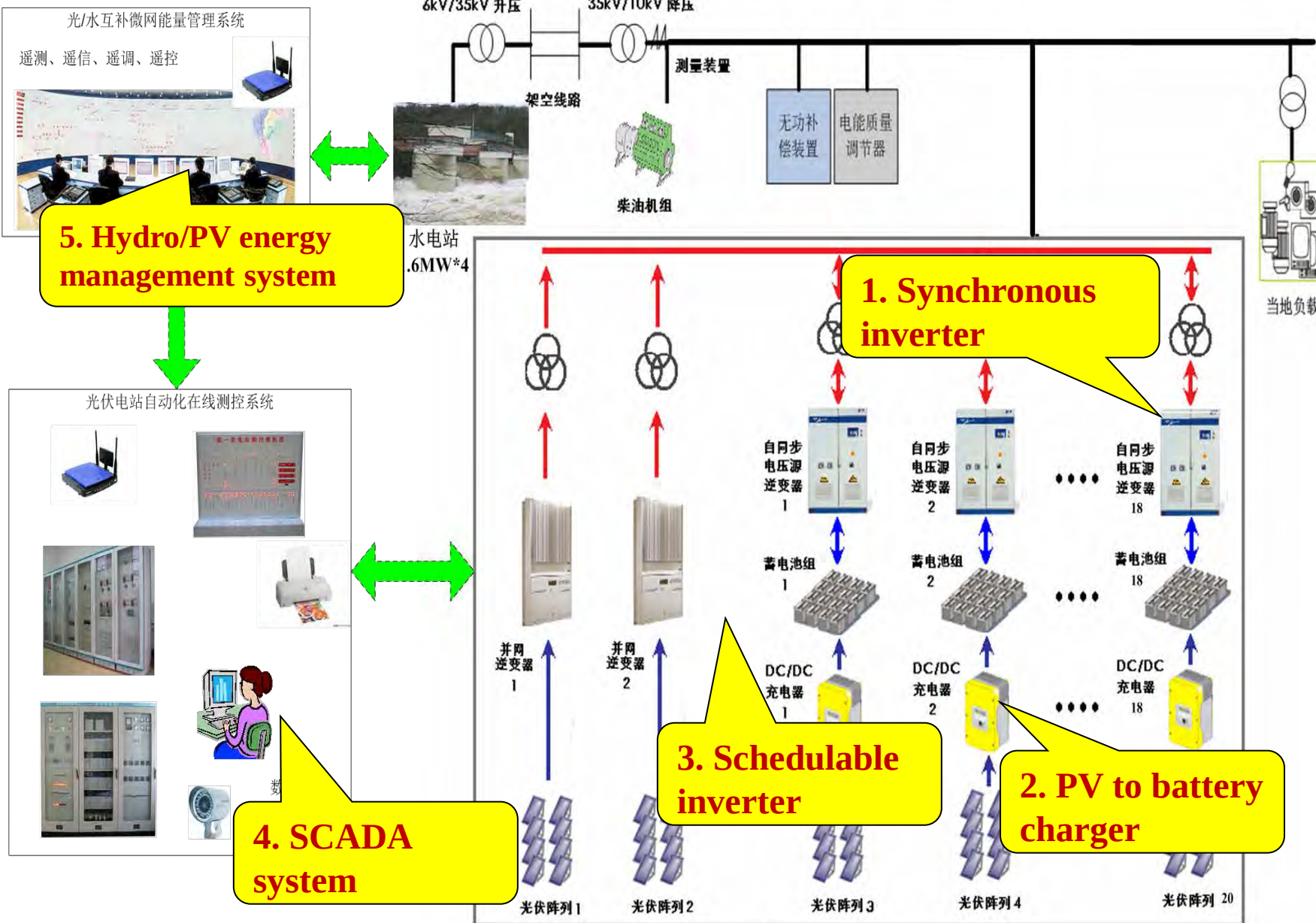


典型月水电机组发电和负荷曲线/ hydro generation power and load in Jan

2.2 典型案例分析(1) / Case Study (1)

— 青海玉树水/光/储微网 / Hydro/PV/Battery MG in Yu Shu, Qing Hai

关键技术 / Key technologies



◆ 系统组成

水电机组:12MW

光伏阵列:2MW

蓄电池组:15.2MWh

负载: 17MW

◆ 电压等级

直流400V, 并网点35kV

System composition:
Hydro Station 12MW
+PV 2MW + Battery
Station 15.2MWh+
Load 17MW.
Dispatch Center 35kV.

2.2 典型案例分析(1) / Case Study (1)

— 青海玉树水/光/储微网 / Hydro/PV/Battery MG in Yu Shu, Qing Hai



青海玉树光伏/储能电站（2011年建成）

PV/battery station in Yushu County finished by Nov. 2011



2MW平单轴+15.2MWh铅酸

2 MW PV array + 15.2 MWh Battery



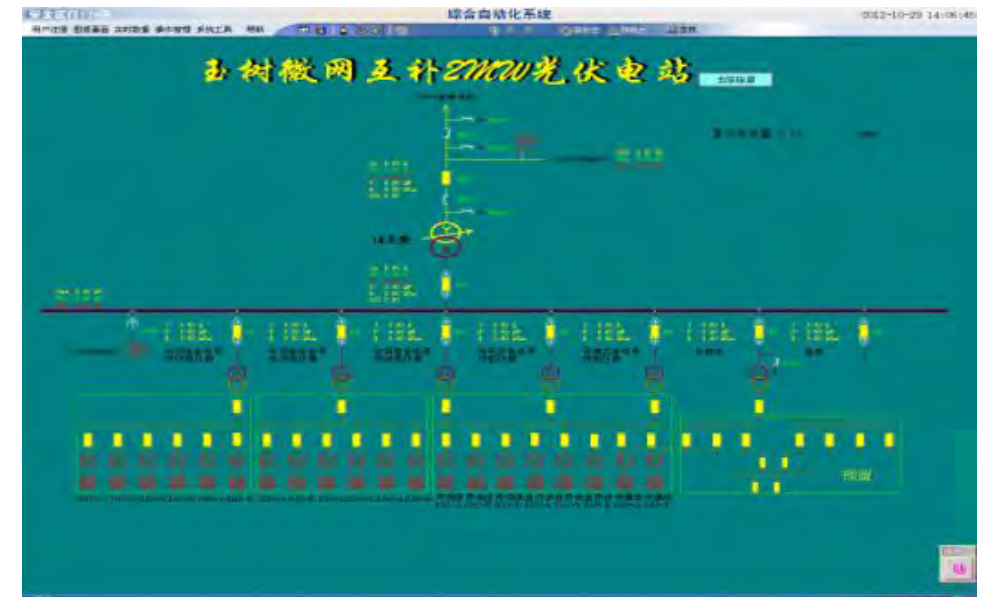
200kVA逆变器（下垂控制）

200kVA Inverter with Droop Control



150kW DC/DC 充电控制器

150kW DC-DC Charger

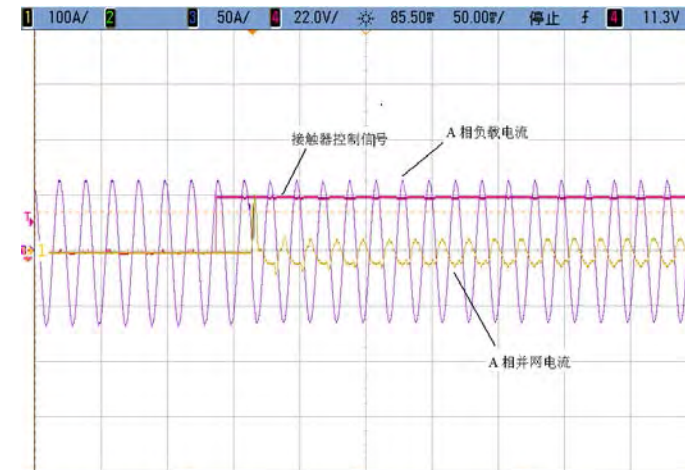
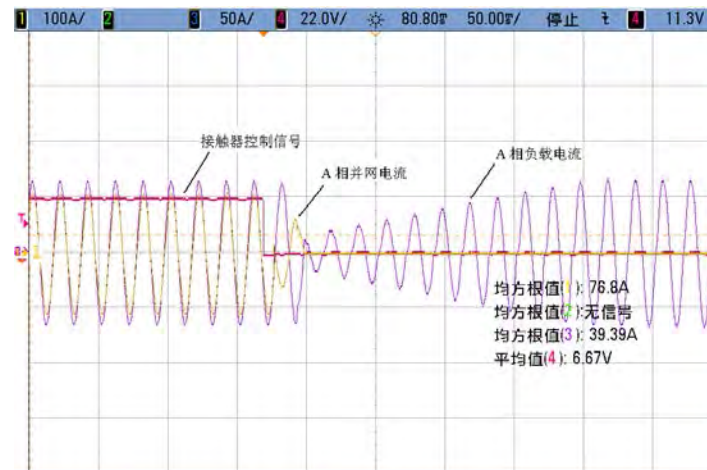
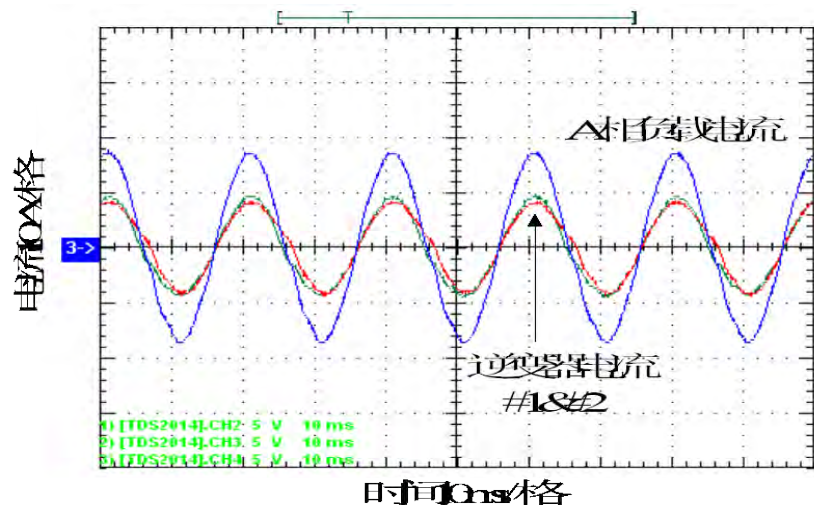


综合自动化系统

Software HMI of automation system

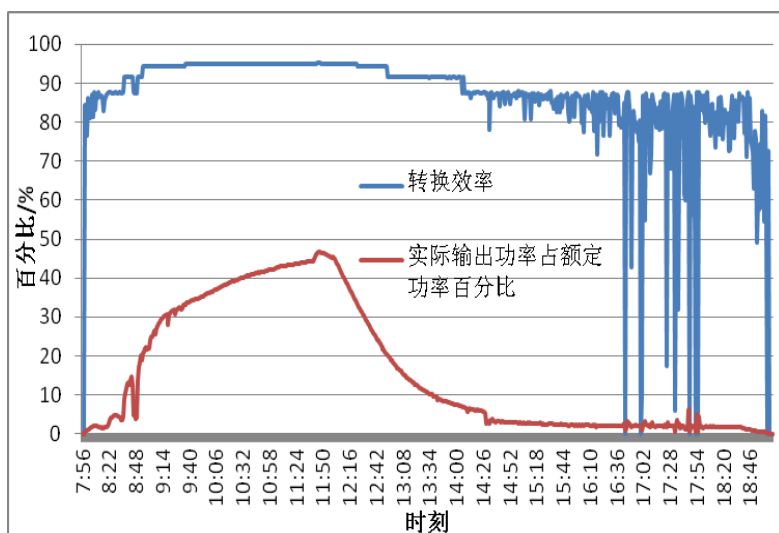
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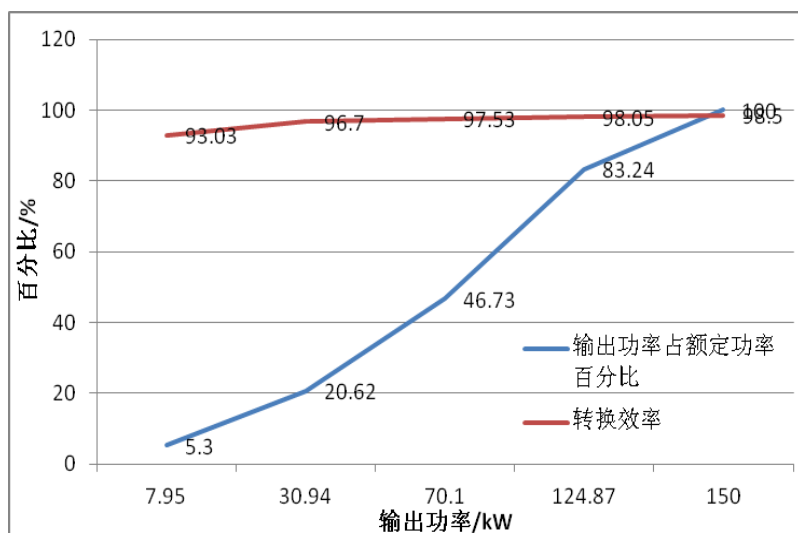


逆变器采用下垂控制技术，模拟同步机组，实现多台逆变器自并联，最大效率95.7%，THD <3%.

The inverter used droop control strategy, simulated synchronous generators, achieved multi-inverter parallel, maximum efficiency 95.7%, THD <3%.



光伏阵列输出功率曲线
Output power of PV array



充电控制器转换效率曲线
Charge controller efficiency curve

充电控制器采用MPPT与三段式充电协调控制技术，最大效率98.5%，输出电压400V.

The charger used MPPT and three-stage coordinated control strategy, maximum efficiency 98.5%, Output voltage 400V.

2.2 典型案例分析(1) / Case Study (1)

— 青海玉树水/光/储微网 / Hydro/PV/Battery MG in Yu Shu, Qing Hai



新华网等媒体报道“中国最大规模水光互补微网电站在青海玉树并网发电”

China's largest micro grid power plant in Yushu reported by Xinhuanet.



可再生能源学会二等奖和青海省成果鉴定证书 Award certificates



强卫书记视察2012年2月

Leader inspected the station in February, 2012



徐福顺副省长视察2011年7月

Leader inspected the station in February, 2011

2.3 典型案例分析(2) / Case Study (2)

— 广东大万山岛网 / Island MG in Da Wanshan, Guangdong Province

- ◆ 岛屿概况：大万山岛位于香洲东南部39km，珠江口外最南端，面积约8.1km²，主峰大万顶海拔443.13m，人口约300人；

Overview: Da Wanshan Island located in south east of HongKong, 39km. the area is 8.1km², and the current population is about 300.

- ◆ 经济现状：该地区经济发展以渔业和旅游业为主；

Current economic situation: The fishing and tourism is the main industry.

- ◆ 供电现状：主要依赖柴油机组供电，发电成本较高，约3~4元/kWh，且可靠性较差。

Power supply situation: Power supply mainly dependent on the diesel generator, the cost of power generation is about ¥ 3~4 yuan /kWh (¥ 0.5 yuan in Guangdong), and low reliability.



2.3 典型案例分析(2) / Case Study (2)

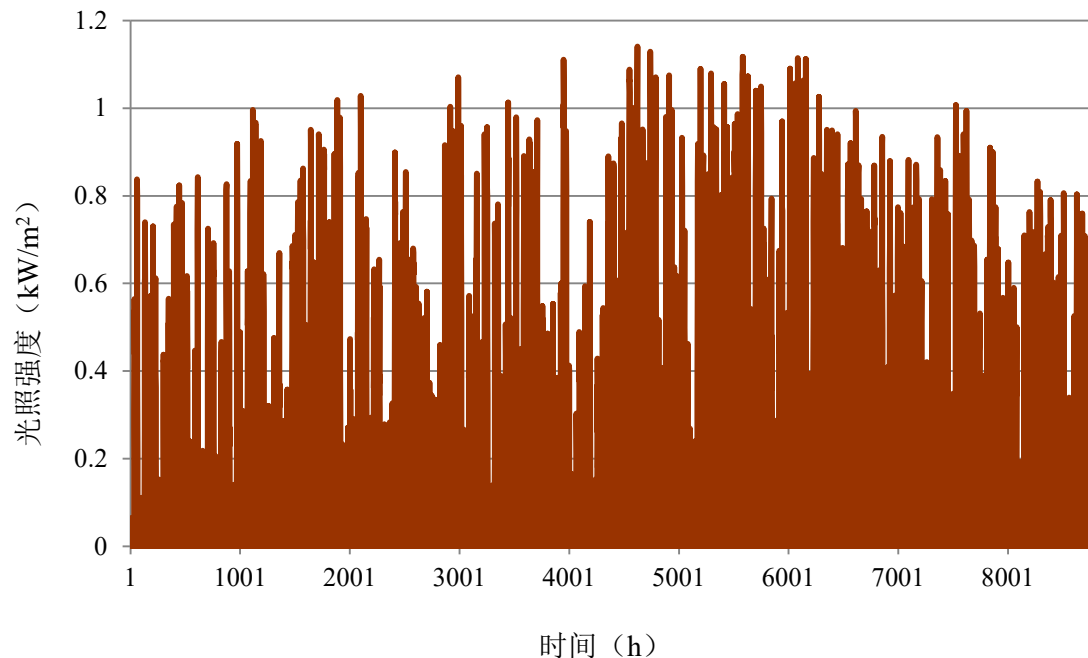
— 广东大万山岛网 / Island MG in Da Wanshan, Guangdong Province

资源情况与负荷需求 / Resource and Load

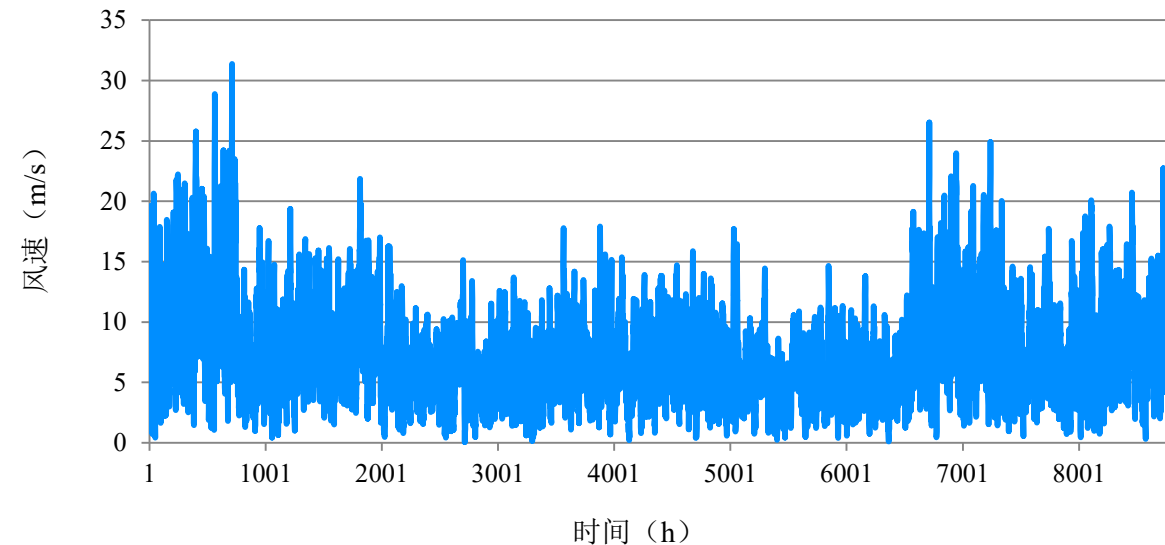
◆ 风/光/负荷数据 / Data curve

根据当地风速、光照及负荷参数，利用HOMER软件拟合得到全年8760小时的风速、光照以及负荷数据。

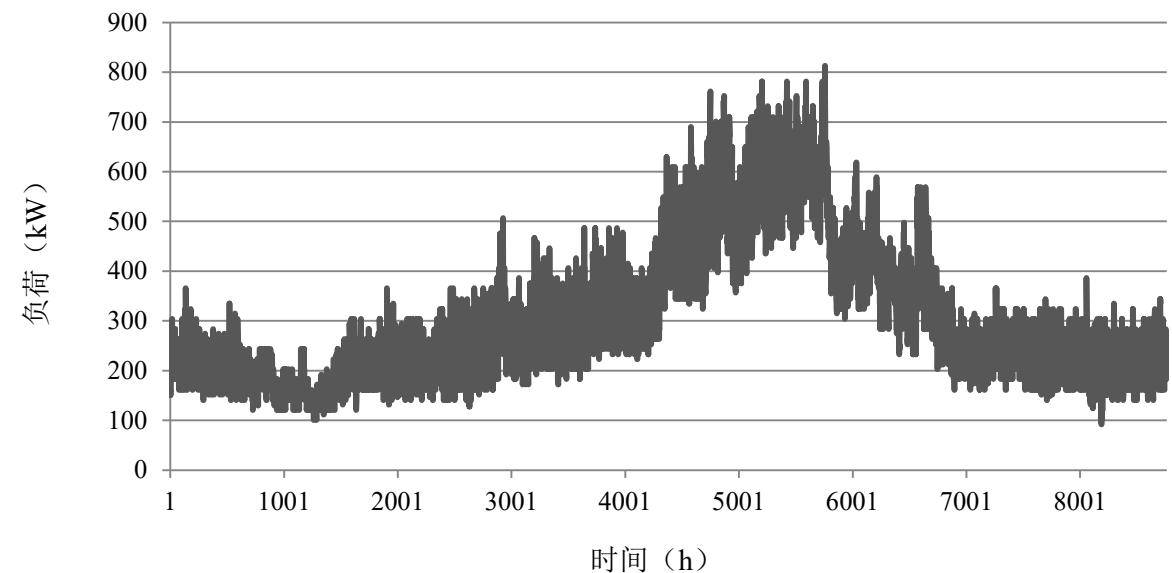
According to the data of investigation (wind, solar, load), curve fitting by HOMER.



光照强度数据 / Irradiance intensity



风速数据 / Wind data



负荷数据 / Load data

2.3 典型案例案例分析 (2) / Case Study (2)

— 广东大万山岛网 / Island MG in Da Wanshan, Guangdong Province

➤ 配置方案 Configuration

设备名称/Equipment	配置方案/Configuration
风电机组/wind	1台850kW
光伏/PV	200kWp
蓄电池/Battery	2000kWh
PCS	1000kW
柴油机/Diesel	2台500kW

➤ 初投资 Initial Investment

设备名称/Equipment	费用/cost (元)
风电机组/wind	8,500,000
光伏/PV	2,000,000
柴油发电机组/Diesel	800,000
电池组/Battery	3,600,000
PCS	2,000,000
初始总投资/Total	16,900,000

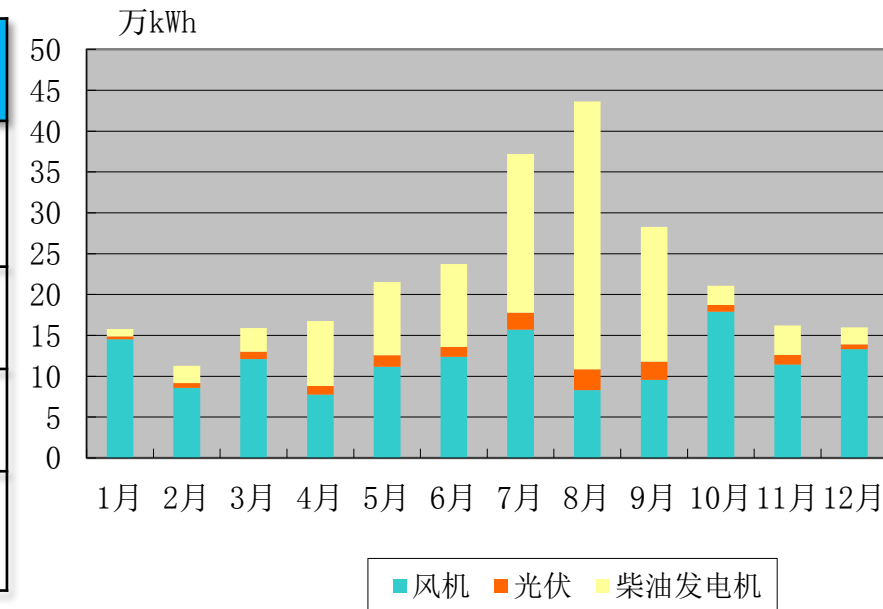
2.3 典型案例分析 (2) / Case Study (2)

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运行效果评估 / Evaluation of operation effect

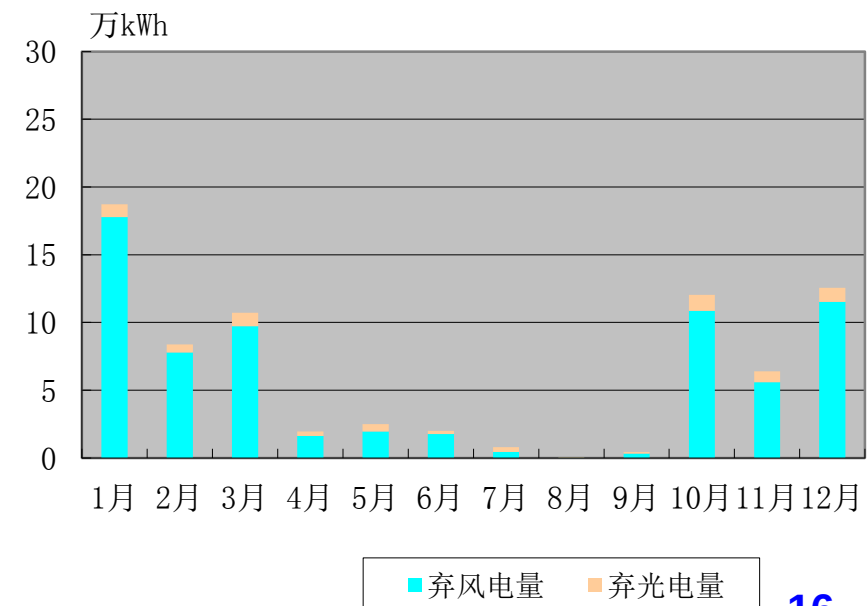
各种源的发电量 / The amount of power generation

		年发电量 (10 ⁴ kWh)	年发电比例 (%)	年平均满发小时 数 (h)
负荷水平 Load (810kW)	风电/wind	142.7	53.35	1680
	光伏/PV	15	5.61	750
	柴油机/diesel	109.8	41.05	\



可再生能源丢弃情况 / discard renewable energy

		年丢弃量 (kWh) Total discard/Year	年丢弃比例 (%) proportion
负荷水平 Load (810kW)	风电机/wind	69.4万	32.72
	光伏/PV	7.2万	32.43



2.3 典型案例分析(2) / Case Study (2)

— 广东大万山岛网 / Island MG in Da Wanshan, Guangdong Province

经济性评估 / Economic Evaluation

经济指标 / economic indicators	单位/ unit	指标值/ index value
项目周期	年	25
初始投资	万元	1690
折现率	%	8
用户电价	yuan/kWh	2.00
原有电价（仅依靠柴油机组供电）	yuan/kWh	3.15
安装，运输、人工等费用	万元/年	6.15
资本金比例（自有金/贷款）		0.3/0.7
投资回收期 / payback period	年 (Year)	>25
内部收益率 / <u>internal rate of return</u>	%	5.925%
储能寿命	年	6.33
储能更换次数	次	3
柴油机1更换次数	次	4
柴油机2更换次数	次	0

经济性分析小结 / Brief summary of economic

◆ 由经济分析结果可以看出，目前该项目的内部收益率较小，整个项目周期内都不能收回成本，故在没有政府补贴的前提下无法商业化运行和推广；

Without government subsidies, hard to commercial operation and popularize.

◆ 对于独立型微电网，延续国家“无电地区电力建设”项目的政策，初投资由中央和地方政府解决；为了更为有效地保证电站的后期运营管理和服务，也可以考虑电价补贴方式。

For the isolated MG, the initial investment should be offered by the central and local government.

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3.1 典型案例分析 (3) / Case Study (3)

— 青海兔儿干新村 / New Village, Qing Hai Province

区域介绍 / Introduction

- ◆ **地理位置**：青藏高原，青海湖必经之路，日月山下第一镇，3100米，年均气温3.0℃（严寒）
Geography：Located in Qinhai-Tibet Plateau, altitude 3100m, temperature 3 °C
- ◆ **新村建设**：省政府重点支持的新型农村社区示范工程,批复建设经费2.2亿元，2014年4月开工
New village：Demonstration of new village in Qin Hai province



现有村庄 / Existing village



新村规划 / New town plan

3.1 典型案例分析 (3) / Case Study (3)

— 青海兔儿干新村 / New Village, Qing Hai Province

常规能源情况/ Conventional energy situation

- ◆ **电网**：35/10kV变电站一座，容量2MVA，电网末端，薄弱

Grid: 35/10kV substation, capacitor is 2MVA, weak grid

- ◆ **化石能源**：煤、燃气要长距离运输，成本高；高原缺氧，化石燃料能效低(75%)

Fossil energy: short of coal/oil/gas, low efficiency because anoxia (75%)

- ◆ **薪柴能源**：牛粪、木柴等，供暖效果差，对环境和生态破坏大，妇女线虫病多发

Firewood energy: cow dung, wood, damage environment, result in disease



薄弱电网 / Weak grid



牛粪 / Cow dung



空气污染 / Pollution

3.1 典型案例分析 (3) / Case Study (3)

— 青海兔儿干新村 / New Village, Qing Hai Province



原有住宅
Existing house
380户

公共事业
Public
services and
facilities

在建住宅
Building house
700户



社区全年用电统计 / Statistics

- ◆ 全年用电量：367.4万kWh
Annual electric energy consumption
- ◆ 采暖季用电量：268.1万kWh(73%)
The heating season shares 73%
- ◆ 非采暖季用电量：99.3万kWh(27%)
Other season shares 27%

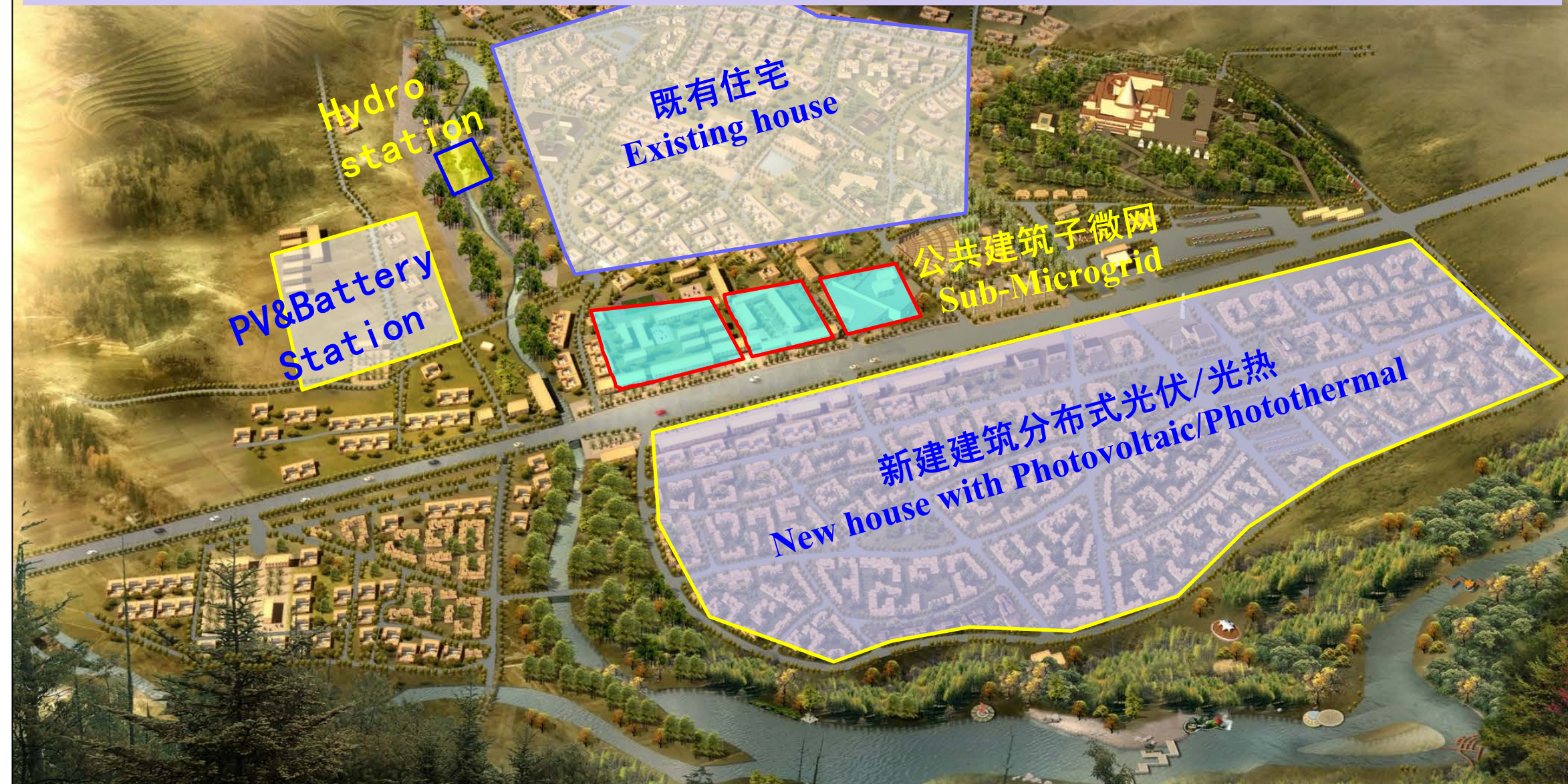
- ◆ 太阳资源丰富，1700kWh/m²/Year；
Solar energy is rich
- ◆ 风电资源条件好(日月山)；
Wind power resource condition
- ◆ 水电资源好(已建电站)。
Existing small hydro power station

3.1 典型案例分析 (3) / Case Study (3)

— 青海兔儿干新村 / New Village, Qing Hai Province

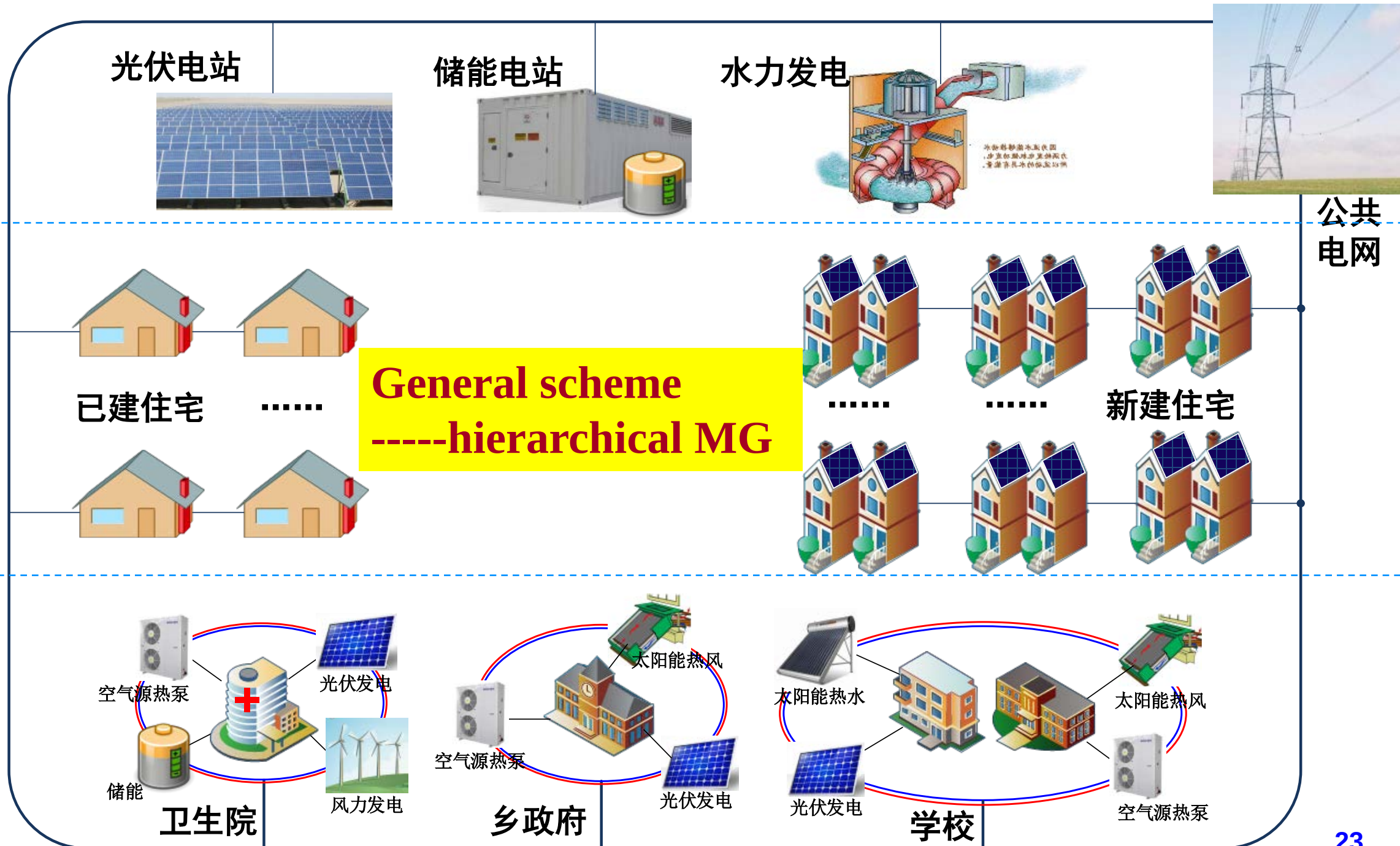
◆ 总体方案：以可再生能源为主多种能源综合利用微网示范系统

General scheme : Village MG, which renewable energy based and comprehensive utilization of energy



3.1 典型案例分析 (3) / Case Study (3)

— 青海兔儿干新村 / New Village, Qing Hai Province



3.1 典型案例分析 (3) / Case Study (3)

— 青海兔儿干新村 / New Village, Qing Hai Province

运行效果评估 / Evaluation of operation effect

系统	发电量 kWh	供暖面积 m ²	年耗电量 kWh	电量渗透率 采暖季	电量渗透率 非采暖季	电量渗透率 全年
新建住宅 700户	92.2万	110	293.3万	20%	75%	27%
既有住宅 380户	0	100	48.2万	0	0	0
卫生院	2.65万	700	2.4万	62%	381%	110%
乡政府	3.1万	1890	2.18万	101%	225%	143%
学校	4.65万	教 5803 宿 1416	5.39万	61%	137%	165%
整个社区	551.6万	/	367.4万	100%	278%	150%

Penetration of renewable energy

3.1 典型案例分析 (3) / Case Study (3)

— 青海兔儿干新村 / New Village, Qing Hai Province

经济性评估 / Economic Evaluation

系统分类	商业装机容量	初投资 Initial investment		年运维费 (万元)		年均收入 (万元)	内部收益率 IRR	投资回收期 Payback
新建住宅 House	700户屋顶光伏 525kW	525		9.0		电：70	10.6%	9.68
卫生院微网 Sub-MG	10kW光+10kW风 空气源热泵系统 15kW/4h铅酸	25 29 12	66	0.25 0.5 1.2	1.95	电：2.66 暖：1.72	4.38	<0 /
乡政府微网 Sub-MG	20kW光伏 太阳能热风供暖系统 15kW/2h储能	20 47 6	73	0.23 0.95 0.6	1.78	电：2.66 暖：4.63	7.29	2.5% 28
学校微网 Sub-MG	30kW光伏 宿舍/教室供暖系统 30kW/4h	30 247 24	301	0.3 30.1 2.4	32.8	电：3.99 暖：17.93	21.92	<0 /
集中式光伏 PV station	2.9MW	2610		20		电：386	16.28%	6.90
集中储能站 Battery	1MWh铅酸储能站	200		12		0	<0	/
合计	/	3775		77.53		489.59	9.77%	10.27

提纲 Outline

1. 中国发展微网的意义及分类
MG Significance and Classification
2. 独立型微网案例分析
Case study for Isolated MG
3. 联网型微网案例分析
Case study for On-Grid MG
4. 面临挑战
Challenges



面临挑战 / Challenges

系统集成研究
与示范
System
integration

关键装备研
发与产业化
Critical
equipment

实证研究
Demonstr-
ation

市场化研
究
market-
ization

研究与开发
Research and development

商业化模式探讨
Business mode
discussion

实施方案的制定
Execute solution

国家投资方案确定
National investment
plan

政策制定与实施
Policy formulation
and implementation

支撑体系建设
Supporting system
construction

国家实验室与中心
National laboratory

检测认证与标准
Detection&identific-
ation&standard

专业人才体系
professional talents
system

Thank you for your attention!

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