European Experience with Large Scale Ground-Mounted PV Systems
欧洲大型地面光伏电站的经验

光伏并网及光电建筑技术研讨会

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Definition and Global Status of Large-Scale MW PV Systems
大规模光伏电站的分级与现状

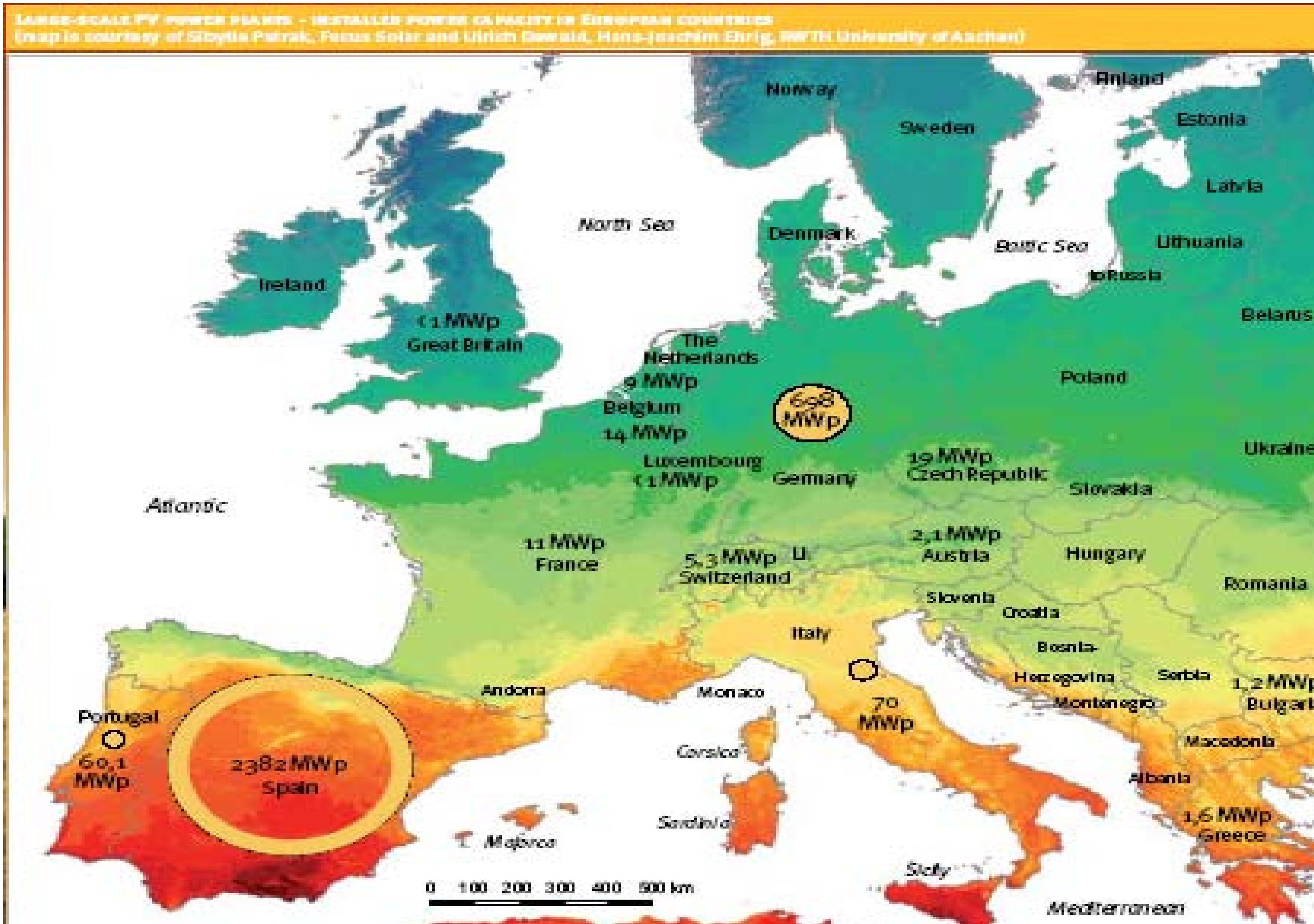
Definition of Large-Scale MW Systems分级

Class VII	> 20 MW
Class VI	10-20 MW
Class V	5-10 MW
Class IV	3-5 MW
Class III	1-3 MW
Class II	500 kW–1 MW
Class I	200-500 kW

Global Status Today 全球现状

- approx. 1900 sys
- Cumulative 3.6 GW
- Ø size 1.8 MW
- in 2008: 1000 sys
  - Spain 590 sys
  - Germany 120 sys
- 60 MW in Spain largest so far
- All >10 MW installed in the last two years

Geographical Distribution of MW-Class Systems in Europe在欧洲的地理分布



Construction Phases 建设阶段(1)

Geodesy, Geology, Micro Climate 测量，地质，微气候

- Basics for construction drawings & scheduling 施工图的基础
- Static Analyses (Wind Speed, Weight of Snow) influence material costs 静力分析（风速、雪重）影响材料成本
- Part of Energy Yield Calculation产电量计算

Earth Moving 平整土地

- If necessary, use of heavy machinery 如需要，使用重型机械
- No sealing/ coating needed不需覆盖土地
- Construction site needs storage place for equipment 施工地点需安排设备堆放场地

Source: Phoenix Solar

Construction Phases建设阶段(2)

Ramming打桩

- Deployment of environmentally friendly ramming technologies
  开发了环境友好的打桩技术
- Leveling off geological specialties
  按地质特性调整
- Ideally facilitates the exact alignment of support beams 使得桩基的对直非常方便

Source: Phoenix Solar

Construction Phases建设阶段(3)

Erection of Systems

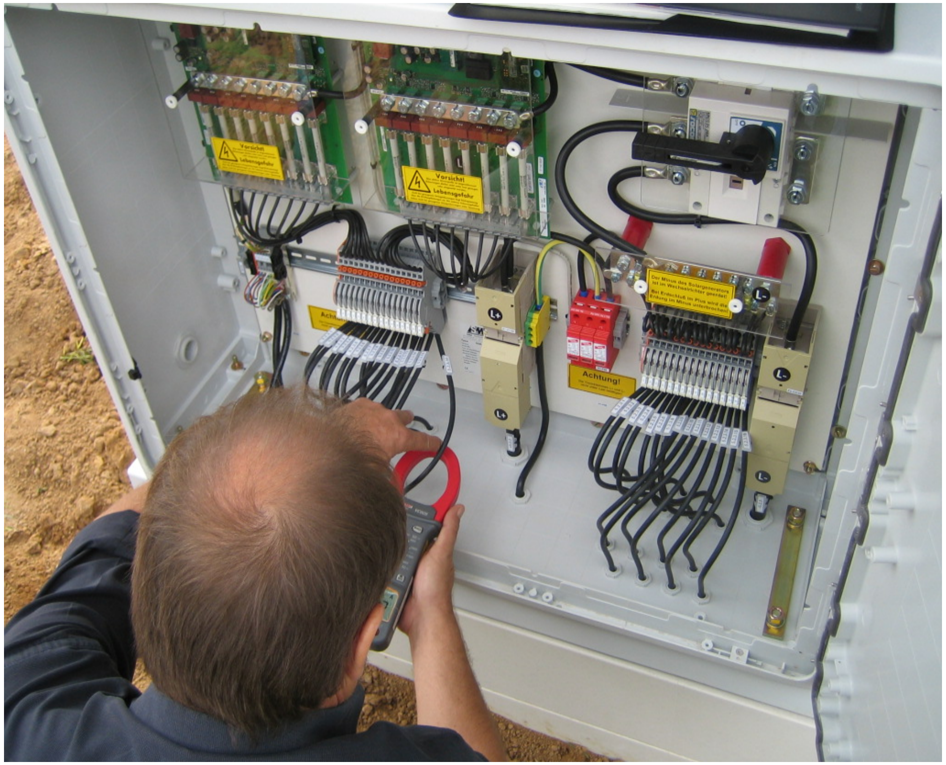
- Installation of angel-iron depending on geographical position
- Installation of crossbeams

Erection of Systems

- Installation of main beams

Source: Phoenix Solar

Construction Phases建设阶段(4)



Installation of Cables

敷设电缆

- Preparing final installation准备最后的安装
- Dig out earth cable channels开挖电缆沟
- Laying of Strings & Strapping放入电缆

Electrical-Technical Works

电气连接

- Construction and installation of distribution-, transformer, and inverters 安装配电箱、变压器和逆变器

Source: Phoenix Solar

Construction Phases建设阶段(5)

Installation of Modules and Securing of Plant

安装组件和防护

- Security Systems:安保系统,
  fences, cameras & motion detectors
- 栅栏、监视器、移动探头

Source: Phoenix Solar

Case Study案例:
1 MWp System in Germany & Spain

Characteristics 特性

- Suitable area without extensive area modification 无需大规模修整的适宜面积
- Site with no high wind speeds – standard mounting structure 风力不大-可使用标准支架
- Ground-based mounting system 落地安装系统
- Modules fixed (no tracking) 固定安装（不跟踪）
- Central inverter 中央逆变器
- Connection point to the grid <1km 接线点到电网不足1KM

Source: Phoenix Solar

Cost Categories 费用类别

- Investment for a 1 MWp turn-key PV plant 1MW 交钥匙光伏设备投资
- Land lease 土地租赁费
- Operation & Maintenance Services 运行维护费
- Inverter Service Contract 逆变器维护合同费
- Insurance 保险费
- Administration 管理费
- Security Services 安保服务费
- Removal/Dismantling and Recycling 拆除费及回收处理费

Source: Phoenix Solar

Operation & Maintenance 运行维护

- Monitoring of the System‘s Performance 监测系统状态
- 24/7 Stand-By Service 24/7 值班
- Data Analysis and Optimization Procedures 数据分析及优化程序
- Regular Site Inspections 场地定期巡检
- Fault Repair within Defined Timelines 在规定时间内修复故障
- Telephone Fees for Monitoring 监护电话费
- On-Site Power Supply 现场电源
  - Cooling of Inverters, Security Systems 逆变器冷却，安保
- Terrain Keeping 地面保护

Source: Phoenix Solar

Inverter Service Contract
逆变器维护合同费

- 20 years Contract with Inverter Supplier
  与逆变器供应商签20年合同
- Regular on-site Inspections 定期现场检查
- Defined Timelines for Fault Repair
  规定的故障维修时间
  - 24 hrs Response Time 24小时响应

Objective目的

- Limiting Potential Revenue Loss due to Inverter Malfunctioning 限制潜在的由于逆变器故障造成的收入损失
- 24/7 "Stand-By" Monitoring independent from Inverter Supplier 24/7 独立值班

Source: Phoenix Solar

Insurances 保险

- Theft 小偷
- Vandalism 故意破坏
- Injury Liability 伤害倾向
- Storm & Lightning Strike 风暴与电击

<u>Objective目的</u>

- Avoidance of Revenue Loss due to Operation Interruption
  避免由于中断运行造成的收入损失

Source: Phoenix Solar

Security 安保

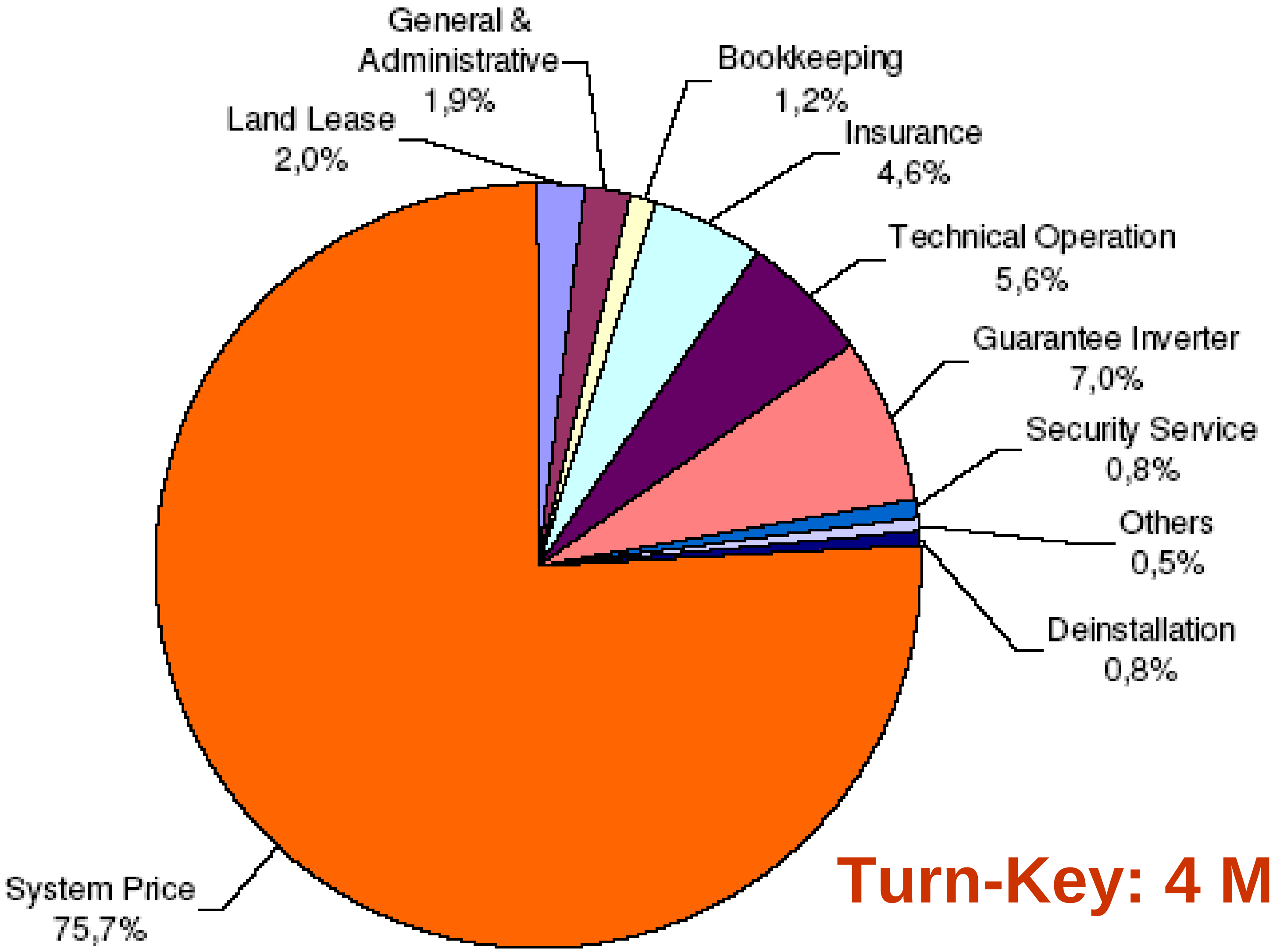
- Level and Sophistication determined by the Location and Accessibility 安保水平及复杂程度取决于电站位置及当地环境
- Roof-Top sys require lower level measures屋顶系统的要求较低
- Remote and ground mounted installations require higher level measures 边远地区和地面电站的要求较高

Removal & Recycling 拆除费及回收处理费

- Assumption: Dismantling after 20 years of operation 假设运行20年后需要拆除
- Assumption: Costs for dismantling of mounting system with no concrete foundations are lower 假设没有水泥基础的地面系统拆除费用较低

Source: Phoenix Solar

Case 1: Total Cost Ownership
案例1：总业主成本



Turn-Key: 4 Mio. /€ MWp

Sept. 2008 prices

Source: Phoenix Solar

Total Cost Ownership including Cost for Financing 包括融资的总业主成本

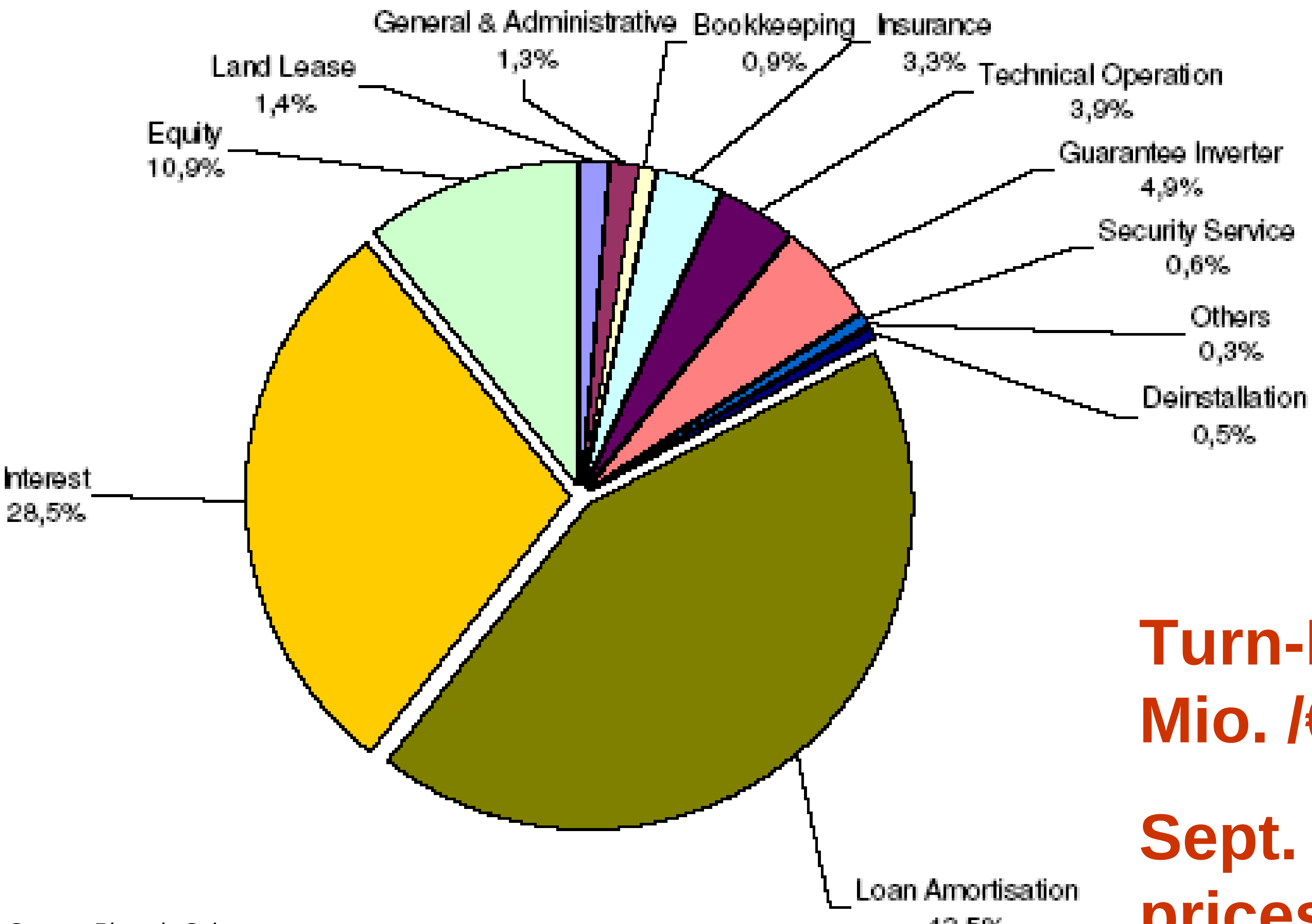
How does the Inclusion of Cost for Financing affect the Total Cost of Ownership?
融资如何影响总业主成本？

Financing Framework for 1 MWp turn-key PV sys:

- 20% equity权益, 80% debt负债
- Duration of debt贷款年限: 20 years年
- Interest Rate利率: 5.5%
- Inflation Rate通胀率: 2%
- Lost Interest on Equity for 20 years NOT considered 不考虑20年间权益损失的利息

Source: Phoenix Solar

Case 案例2: Total Cost of Ownership including Cost for Financing 包括融资的总业主成本



Turn-Key: 4 Mio. /€ MWp

Sept. 2008 prices

Source: Phoenix Solar

Cost Perspectives for Solar Electricity (Case 1 + 2)太阳能电力成本计算

Included cost for financing results in a significant increase of the TCO i.e. specific costs for solar electricity (€/kWh) 考虑融资成本后使总成本明显增加

Germany德国

(Turn-key sys price: 4 Mio.€/MWp // 1020 kWh/kWp)

- Due to financing costs the average cost per kWh increases from 0.27 €/kWh to 0.38 €/kWh
  由于融资成本，每千瓦时的平均成本由0.28增加到0.38欧元

Spain西班牙

(Turn-key sys price: 4 Mio.€/MWp // 1600 kWh/kWp)

- Due to financing costs the average cost per kWh increases from 0.17 €/kWh to 0.24 €/kWh
  由于融资成本，每千瓦时的平均成本由0.17增加到0.24欧元

Source: Phoenix Solar

General Experiences with Large-Scale MW PV Systems大型兆瓦光伏电站的一般经验

- Most LSPV sys are on-grid consisting of several sub-plants in parallel 大多数大型光伏系统是并网系统，包含若干个平行的子系统

- Most common system design mistakes: lack of experience which starts with the selection of components e.g. modules最常见的系统设计错误：缺乏经验，从选择光伏组件开始

- Reasons for reduced energy yields: Plant internal: module output lower, failure of inverters, miscalculation of size of cables, poor maintenance & spare part supply service.发电量下降的原因：电站内部：组件出力下降，逆变器故障，电缆容量计算错误，保养和备件供应不足Plant external: shut-down of grid, fluctuation of main frequency & voltage, lightning strike, burglary of modules 电站外部：电网关闭，主频和电压波动，雷击，组件被盗

- Transparency of plant results (yearly yield) is no more given, because owners are mainly private equity or financial investors therefore, actual plant results are kept confidential. Resulting in that assessing / comparing individual plants became difficult 电站的年发电量数据已难以得到。因为电站所有者通常是私人企业或金融投资商。电站的实际运行情况是保密的，使得评估和比较不同电站的效益很困难。

Source: Edwin Cunow, own research

General Experiences with Large-Scale MW PV Systems大型兆瓦光伏电站的一般经验

- Majority of financial institutions prefer wafer-based modules due to the long term existence in the market (minor risks) 大多数融资机构喜欢支持单晶和多晶组件电站，因为其市场化时间长，风险最小
- Tracking systems gaining momentum due to decreasing module prices, although high costs for trackers & maintenance, but higher energy yields off-set such additional costs由于组件价格增加，跟踪系统比例增加。尽管跟踪器及其维护成本高，但由于出力的增加可以抵消增加的成本
- Acceptance: Upon completion & sale a contract signed between EPC contractor and buyer governs the „acceptance“. Banks often require a „Technical Due Diligence“ conducted by independent institutions / consultants either after completion or during planning stage验收：一旦电站建成，工程总承包商和买家要共同验收。在项目计划阶段或工程完工后，银行通常要请一家独立机构进行"技术性精算"。

Source: Edwin Cunow, own research

Case Study Germany: 53 MW案例

- Location: Northern Germany 德国北部
- Investment 投资: € 160 Mio (20/80)
- Capacity 容量 53 MW // 162 hectares area公顷
- Module 组件: 700.000 Thin-Film (FSLR)
- Inverter逆变器: > 37 SMA SC 1250 / 1 SMA SC 900 MW
- Construction period 建设期: 8 months月
- Operational 投产: August 20, 2009
- FiT上网电价: €-cents 0.3194 / kWh for 20 years
- Supply 15.000 households
  供电15000户
- Owner: Private Investor
  私人投资者

Thank you for your attention !

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