PV Autonomous Systems and Mini-Grids

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Fraunhofer Institute

for Solar Energy Systems

"Off-grid and mini grid PV systems for electrification: advantages and challenges"

Accra, 2th of November 2012

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Outline

- Off-Grid Systems
- The PV Hybrid Systems and the Island Grid Concept
- Advantages and challenges
- Further advantages based on applications
- Conclusions

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Rural electrification with renewable energies
Off-Grid Systems

Small PV systems

Hydroelectric power stations

Hybrid PV systems

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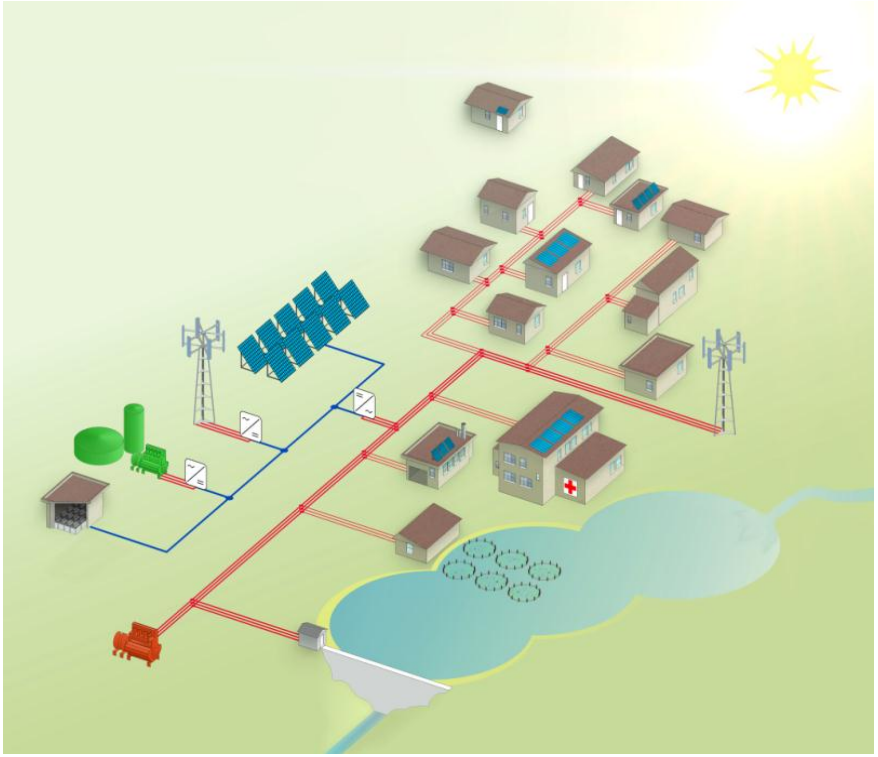
PV Hybrid Systems and the Island Grid Concept

- **Access to energy services** and option to the grid and to SHS
  - Bringing electricity and adapting
  - Extending services
  - Cost-effective option
- Use of local resources & promotion of **local development**
  - Human and financial capital
  - Renewable local resources
  - Financial resources
- **Automation** becomes a “Turn Key” for local operation transparency and sustainability
  - Offer different electricity services
  - Use of tariff structures
  - Guarantees long-run term operation of PV-Hybrid system



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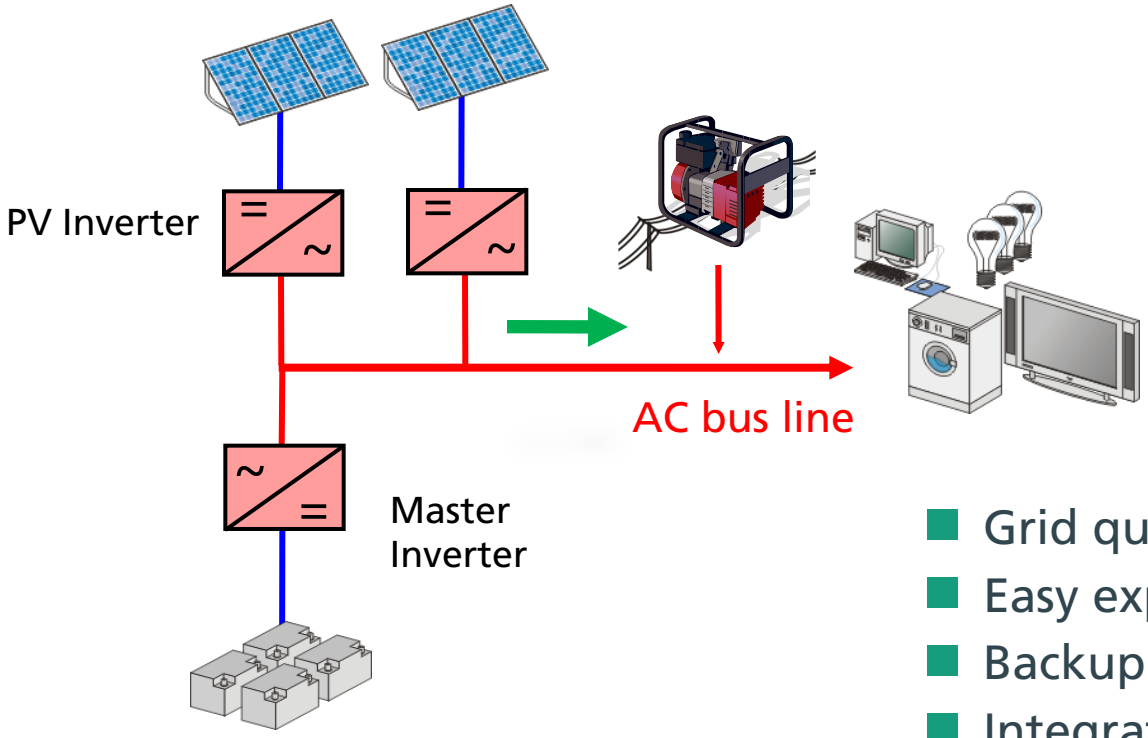
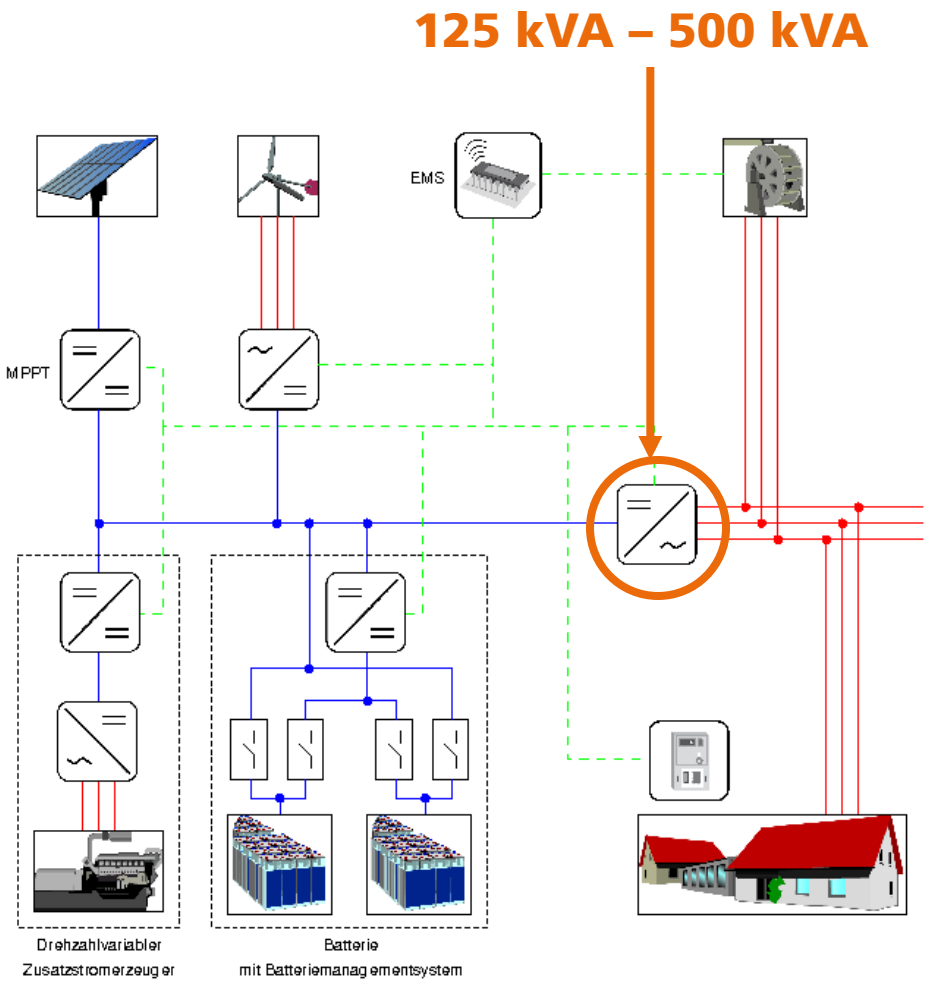
PV Hybrid Mini Grids and the modular concept



- Grid quality electricity
- Easy expandability
- Backup solution
- Integration of PV Power
- Standard components

Next generation of PV Hybrid Mini-grids

- Hybrid battery system (lead acid and lithium) with integrated battery management system
- Development of an Energy management system
- Standardized communication infrastructure
- Suitable for isolated mini-grids and grid connect applications



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Advantages Status Quo:
100% commercial available technology solutions

- 5 KW – 300 kW **towards 1 MW based PV** Hybrid systems
- **Modular concepts** to adapt to the local energy demand
- **Simple integration** of different energy generators:
  (wind turbines, fuel cells, biogas/biomass, hydropower, concentrating photovoltaic CPV, Diesel engines, and others)
- Development of new technologies for **secondary storage**
- Automation of the operation via **SCADA Systems,** metering and monitoring

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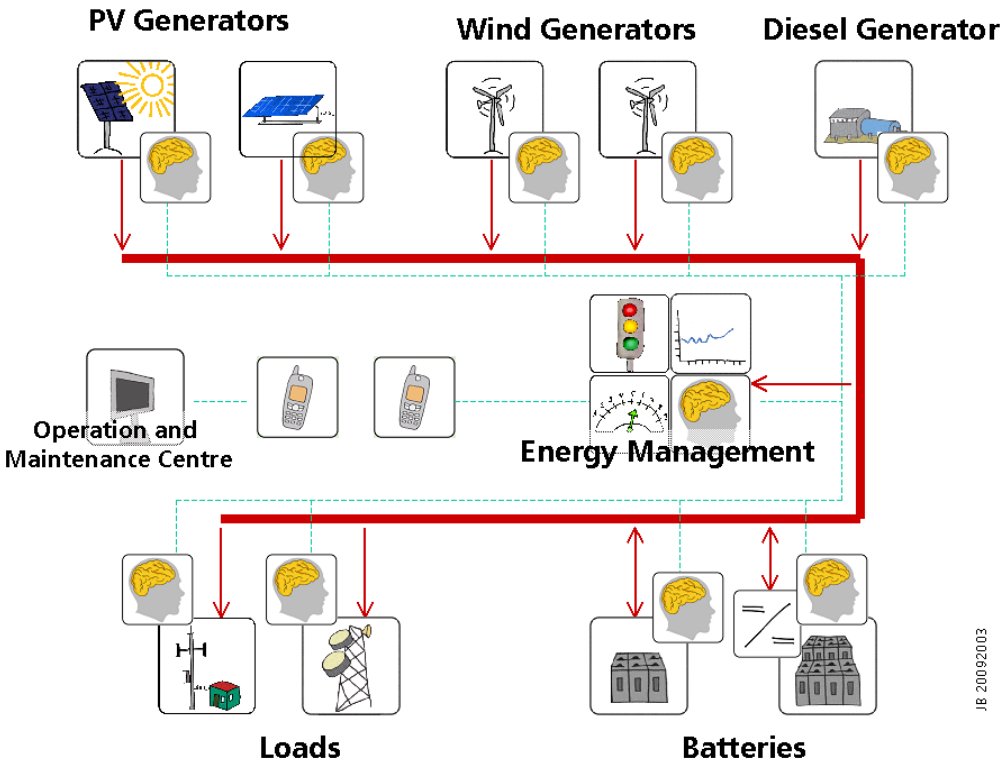
Challenge
Automation/Standardization among system components

- Integration Higher level **of Energy Management System**
  - EMS stage of development
- Integration of **Intelligent components**
  - Generators
  - Battery management
  - Load management
- **Communication** bus based on an Standardized Universal Energy Supply Protocol
- Use of **Monitoring**, **metering and billing** system components



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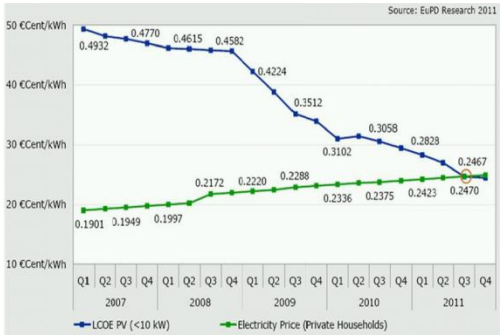
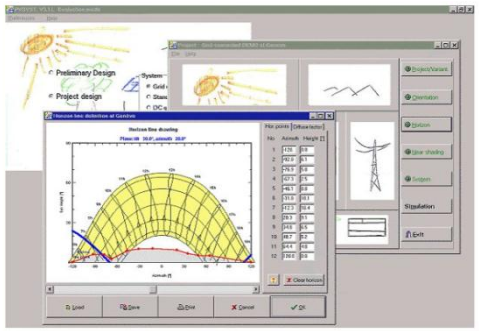
Advantages
Economic feasibility and worldwide information access

- **Low Prices** of PV modules: less than 1 Euro/Wp
- Feasible solutions while sizing and dimensioning considering **cost-effective improvements** based on simulation tools are possible
- Information gather trough **Performance evaluation** with help of monitoring systems
- Vast experiences on off-grid PV systems trough involvement of different **local stakeholders**, entrepreneurs and governments Institutions promoting PV Systems
- Promotion **High education programs** at international level





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Challenges
local implementation and adaptation

- Need for Suited **Knowledge and Technology Transfer models**
  - Lack of local capacity building specially on human capital missing the chain of economic value added (fro shipping to operation)
- No access to **local financing and business markets**
  - Leverage on Capital with high risk left to the private sector
  - socio-economic conditions of the end users
- Development of local content
  - **Import barriers** and lack of own technology development
  - No local conditions for high market penetration

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Advantages of System applications: Substitution of Diesel generators with PV systems

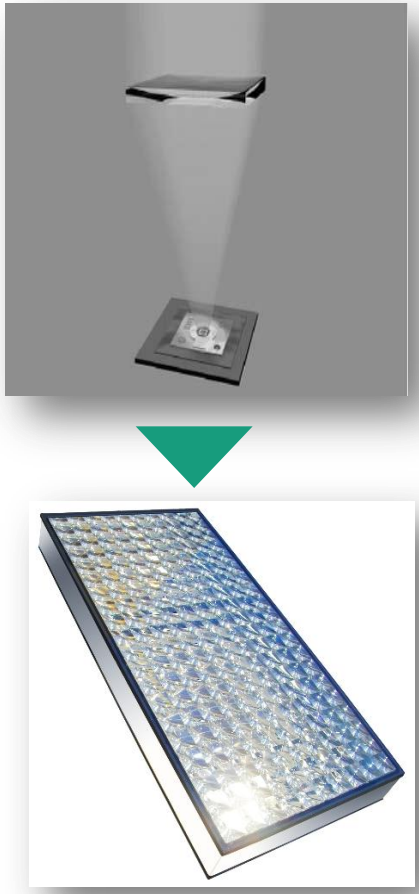
PV is already economic attractive, depending on local conditions

- Example of Brazil: a 21 kWp PV, 60 kVA Diesel generator and no storage
  - Only 10 % of annual electricity consumption can be covered by PV
  - Need for improvement

Source R. Rüther

Advantages R&D
New technology developments CPV off-grid for water pumping, desalination and irrigation

- CPV trackers: 5 x 6 kWp
- CPV inverter: 5 x 6 kW
- Island inverters: 3 x 5 kW
- Flat plate PV with charge controller as backup: 1 kWp
- Submersible Pump: 9-15 kW, ~ 65 m³/h
- Irrigation Pump: 5.5 kW
- Desalination 1.5 kW
- Air conditioning 0.5 kW
- Dump Load 6 kW
- Battery (48 V) 900 Ah (C10)



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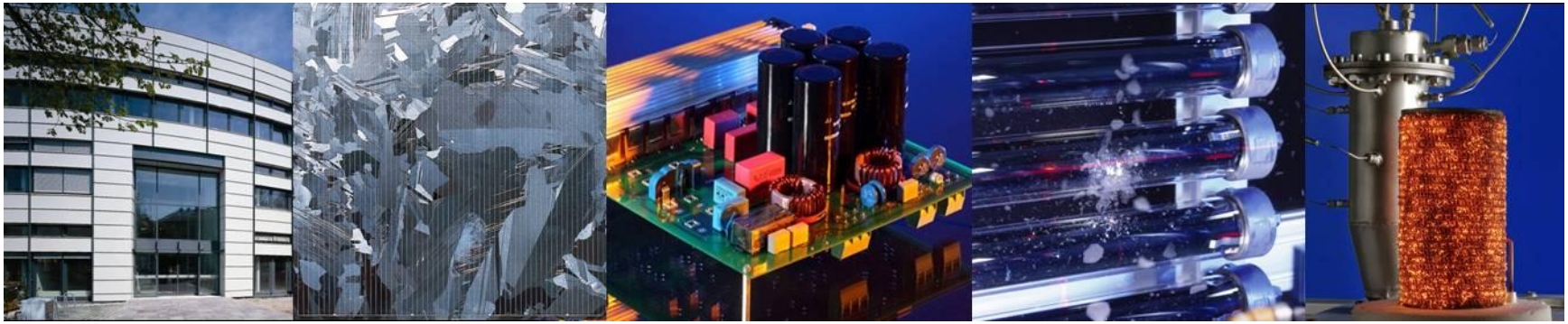
Conclusions

- Off-Grid PV Mini-Grids are already worldwide implemented and are an economic-effective technology solution
  - Today complete PV based commercial technologies are available in the market
- Hybridization of system technology and system components is not a trend but a reality
  - Tendency is to go for 100% renewable
- Integration of automation is required to improve efficiency, energy services, life cycle, operation and maintenance costs
- New technology developments have to be pushed-up from north-south countries

Trends

- Improve local capacity and access to services
  - Power and distribution (voltage, phases, Grid quality, etc.)
  - Availability (24 hours, day-time only, etc.)
  - Capability for demand-side management
  - Human and financing resources
- Operation and maintenance programs for the long-term
- To achieve overall "acceptance" and overcome regulatory hurdles
- Need to develop further compelling "best practices" for rural autonomous PV Hybrid Island Grids

Thank you for your attention!



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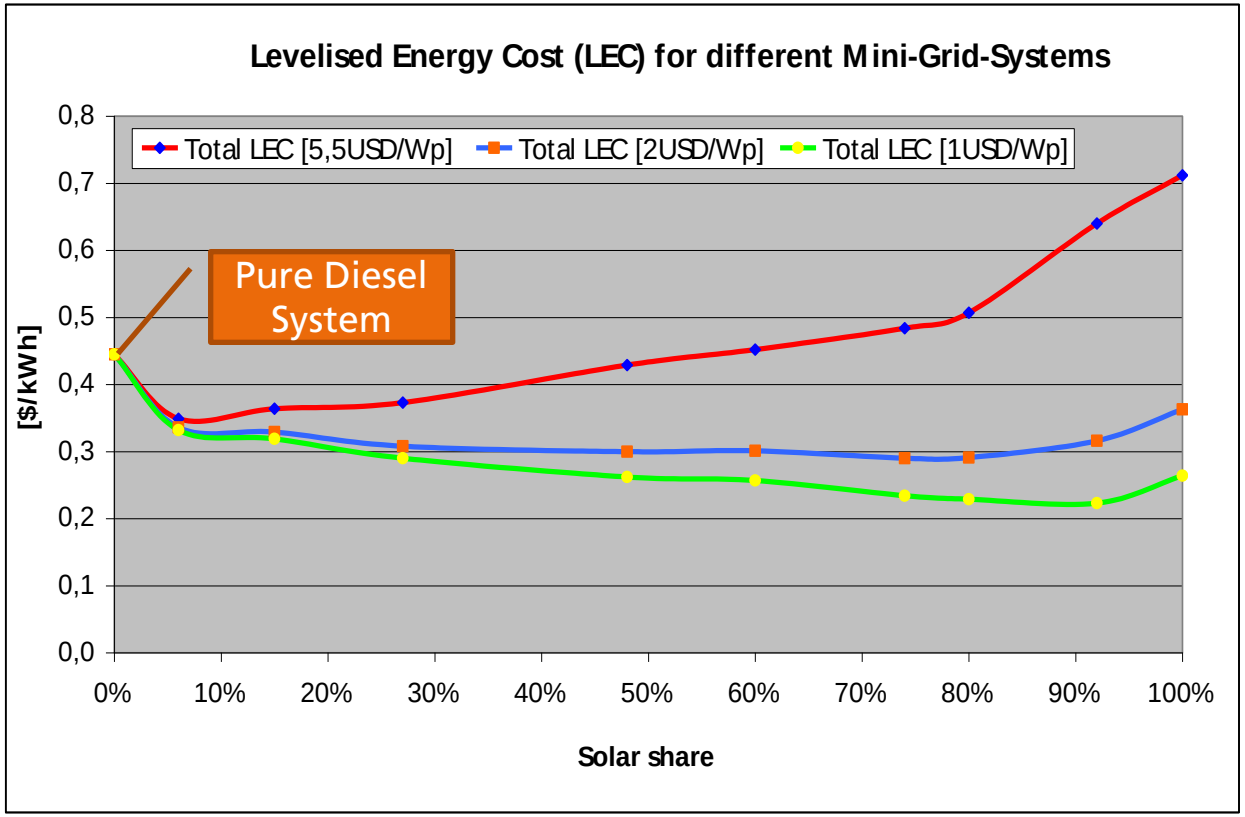
Knowledge and Technology transfer

Transfer	Characteristics
Contract research	Organizations hire certain research institutions with a specific research contract to specified conditions. The research findings are the exclusive property of the company.
Advice and consultancy	Experts, specialists advise inventors economic institutions. The advice is usually billed at fixed daily rates and extends over a few days.
Licensing	When licensing a right is acquired by a research institutions to use a particular research result.
Assisted projects	In publicly funded research projects, several partners from science and industry to a common problem, such as craft and technical colleges. The project results will be made public.
Graduate student research	Research and development issues can be scientifically processed through graduate study or work longer. In addition to the scientific knowledge of the students, the company can establish initial contacts with scientists.
Internships	In longer internships of students can research questions are addressed. Here is a very intensive supervision by the company especially with younger students semester necessary

Mini-grids: Substitution of Diesel generators with renewable energies

Life cycle cost analysis – Example Mexico

- 99 households, a rural clinic and a fish factory
- Daily consumption: 2849 kWh
- Peak load: 200 kW
- Variation of PV module prices [5.50, 2.00, 1.00 USD/Wp]



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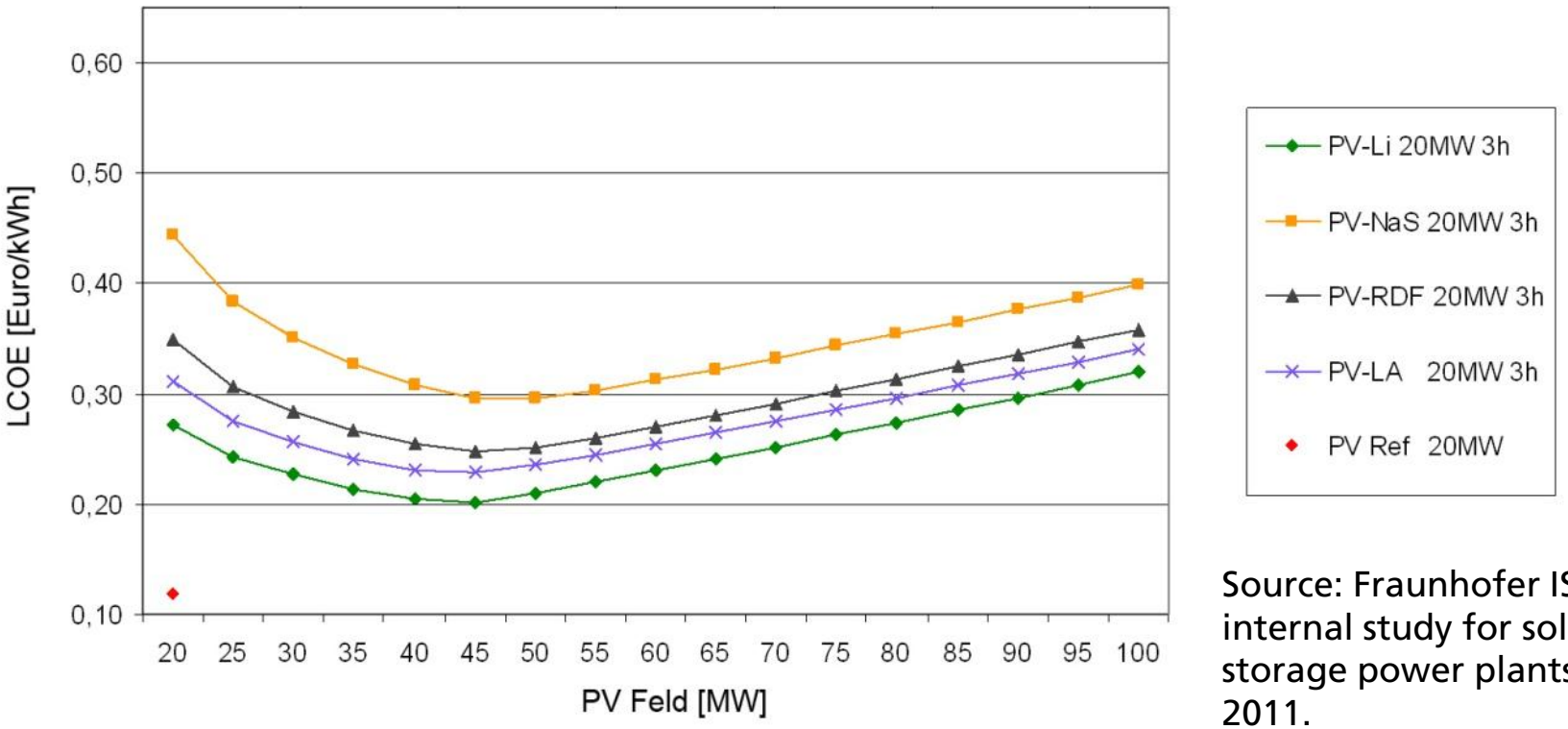
Simulation study – PV power plant in Aswan:
2452 kWh/(m²year) !!!

- Starting point:

  PV power plant should provide 20 MW up to 3 hours via the battery system

- Battery parameters: Manufacturer information !!!



Source: Fraunhofer ISE internal study for solar storage power plants, 2011.

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