Welcome to the SCHOTT Solar Presentation on Off-Grid PV Applications

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Basics of Solar Technology & Components of Stand-alone PV-Systems

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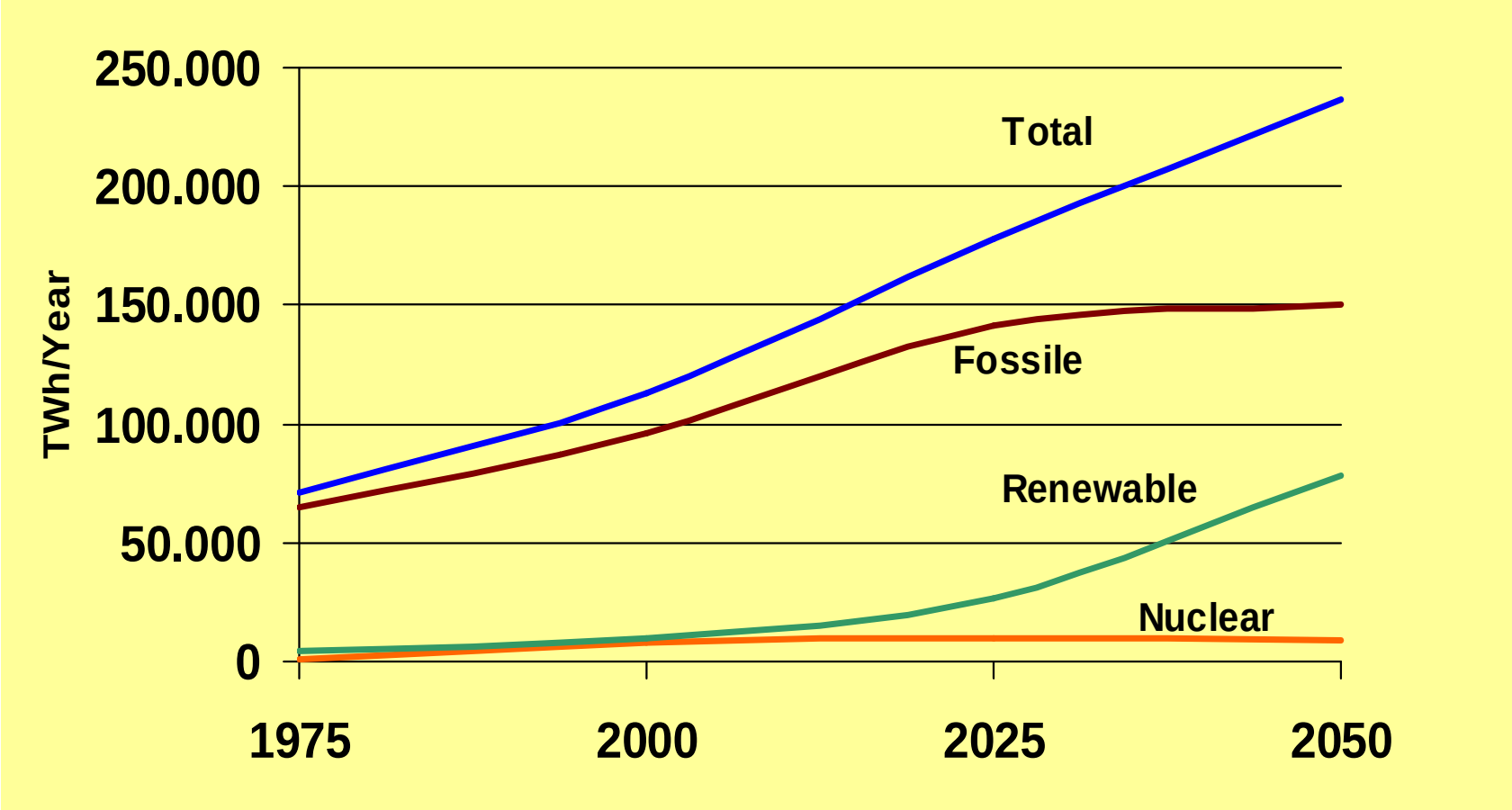
Shell Energy Scenario



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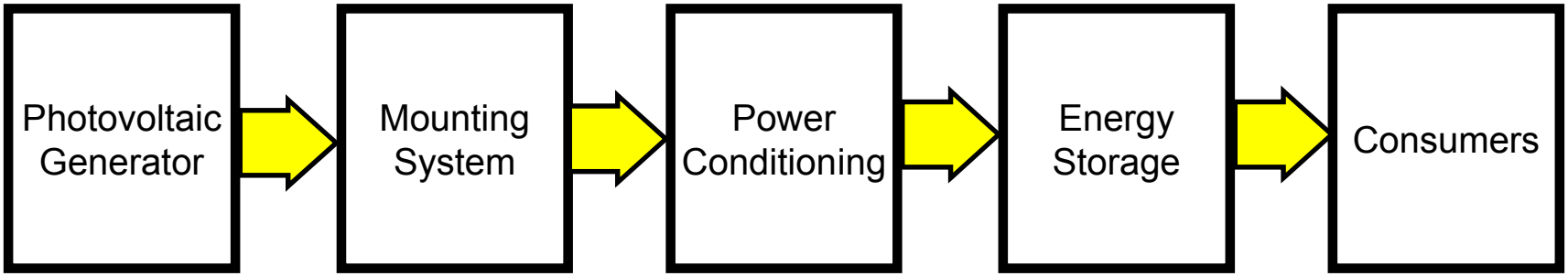
Components of Photovoltaic Systems



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The Energy in the Sunshine

- Every second, 50 billion kWh reach the earth‘s atmosphere
- The primary energy demand per second of the whole world is just 3 million kWh
- This is a very small fraction of 0.006 %
- A photovoltaic power plant covering an area of about 700 x 700 km could deliver enough energy to meet this global energy demand
- The main reason why this is not realized is that the costs would be out of reach
- It would take decades for the solar industry to produce the necessary solar cells

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DESERTEC Industrial Initiative – Just a vision or close to Reality ?

Desertec Map (Foundation Concept as of July 09)

Source: www.desertec.org

Key messages

- On the 13th of July 12 companies signed an MoU to establish a DESERTEC Industrial Initiative (DII) in order to analyse and develop the technical, economic, political, social and ecological framework for carbon-free power generation in the deserts of North Africa.
- Founding companies are ABB, ABENGOA Solar, Cevital, Deutsche Bank, E.ON, HSH Nordbank, MAN Solar Millennium, Munich Re, M+W Zander, RWE, SCHOTT Solar and SIEMENS
- The clean power initiative aims to supply 15% of Europe's electricity needs – predominantly through solar thermal power plants (CSP) in the MENA region
- Total project costs estimated to be around € 400bn
- Next steps include the drafting of concrete business plans, associated financing concepts, and industrial preparations for building a large number of solar thermal power plants in the MENA region

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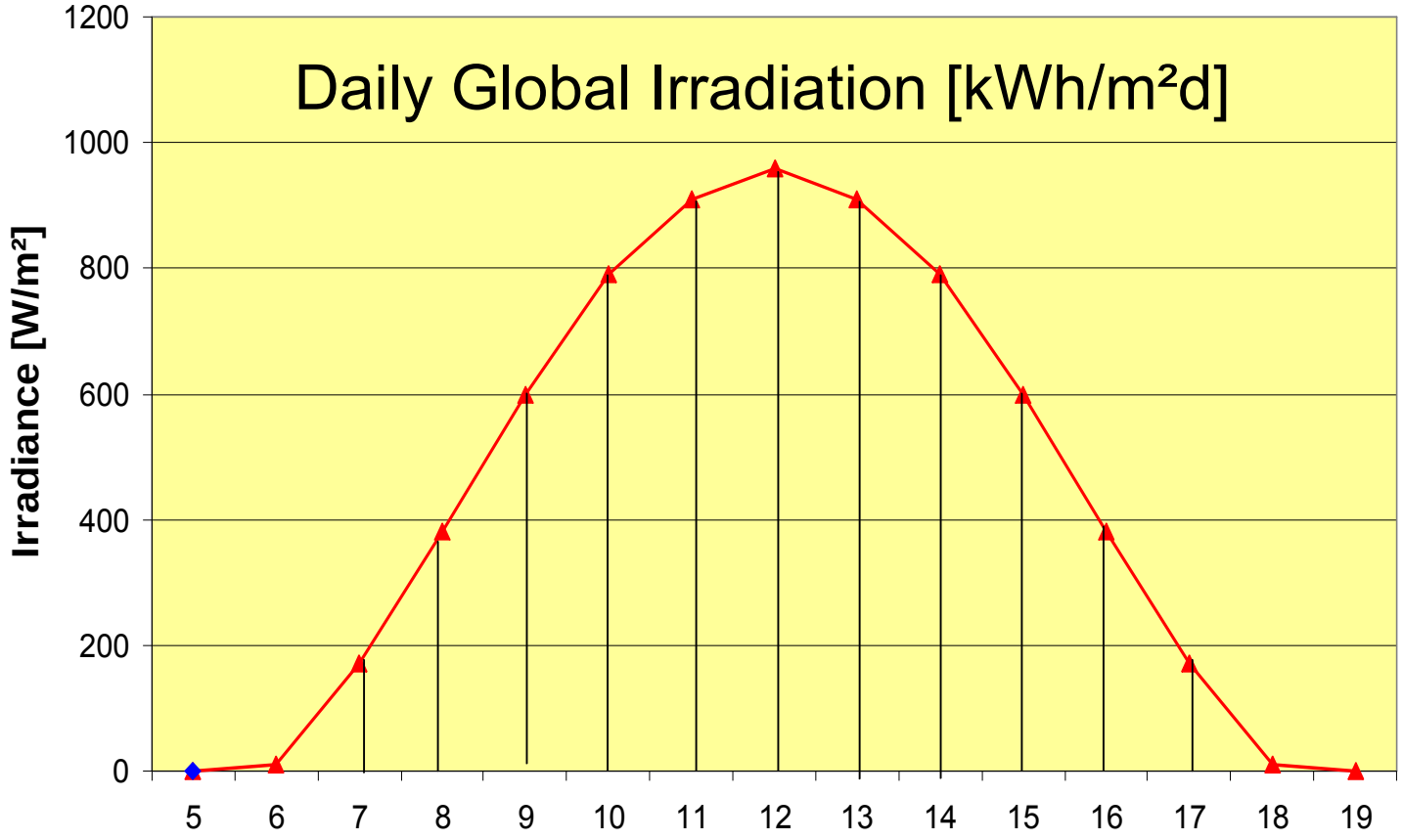
Solar Irradiance in the Course of a Sunny Day



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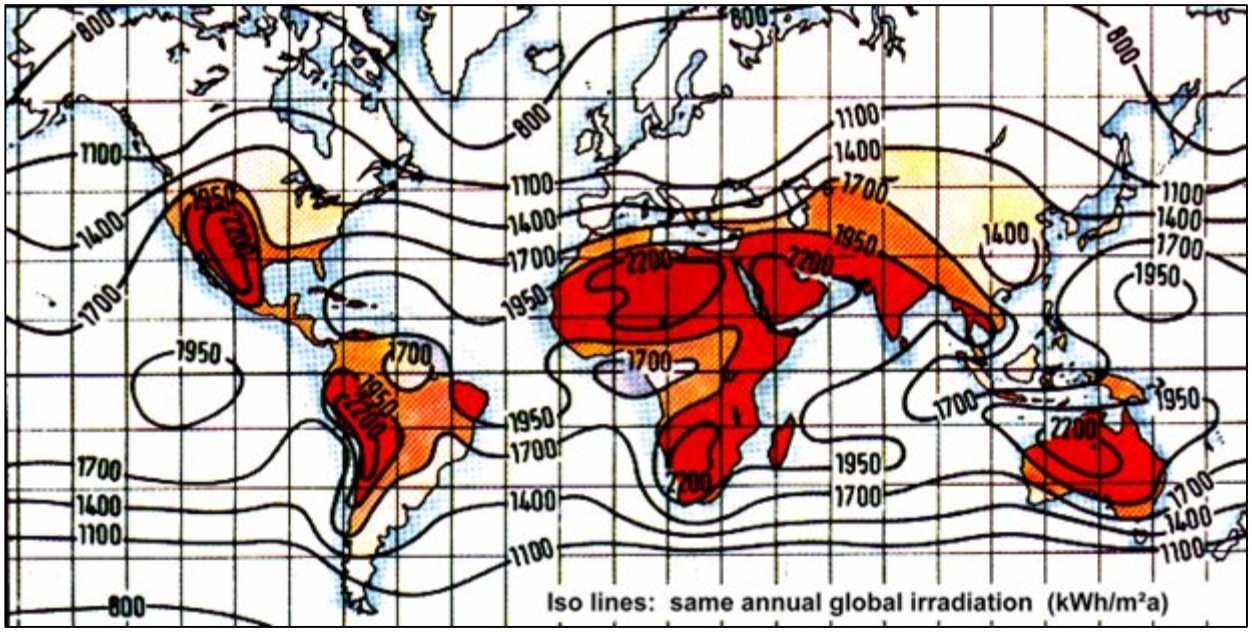
World Global Irradiation Distribution on a horizontal Surface [kWh/m²a]



- The daily global irradiation is measured by a network of meteorological stations all over the world
- The red areas indicate excellent possibilities for the utilization of solar energy
- In sunny areas like the Sahara, the typical yearly global irradiation on one square-meter is about 2200 kWh/m². This is twice the amount of energy compared to locations in Central Europe.

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How can I make use of solar energy ?

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Indirect and Direct Use of Solar Energy

Indirect use of solar energy

Wind, Biomass, Hydro Power

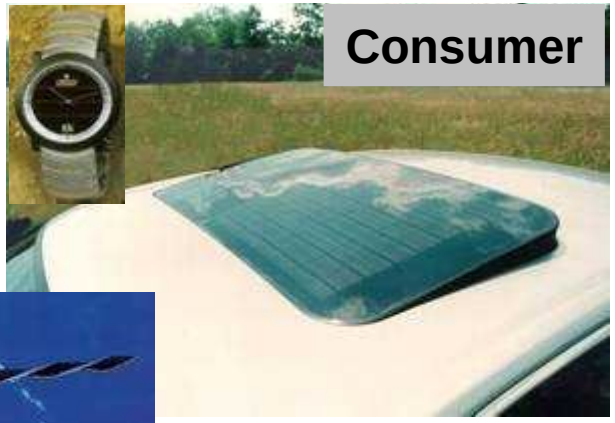
Direct use of solar energy

Photovoltaic and Solar Thermal Systems

Main Market Segments

Off-Grid Industrial

Consumer



Space

Off-Grid Residential

Grid-connected

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System Voltage in stand-alone PV Systems

- A solar generator generates electricity exclusively in daylight
- Many applications such as lights are usually operated at night
- Energy must be stored to balance supply and demand
- The only means of storage for electricity are batteries
- For charging 12 V batteries, modules with 36 cells connected in series are needed
- Modules with 36 cells have an nominal voltage of 17 V at the Maximum Power Point (MPP)
- The typical system voltage in small PV systems is 12 V or a multiple of that (typically 24 V, 48 V)

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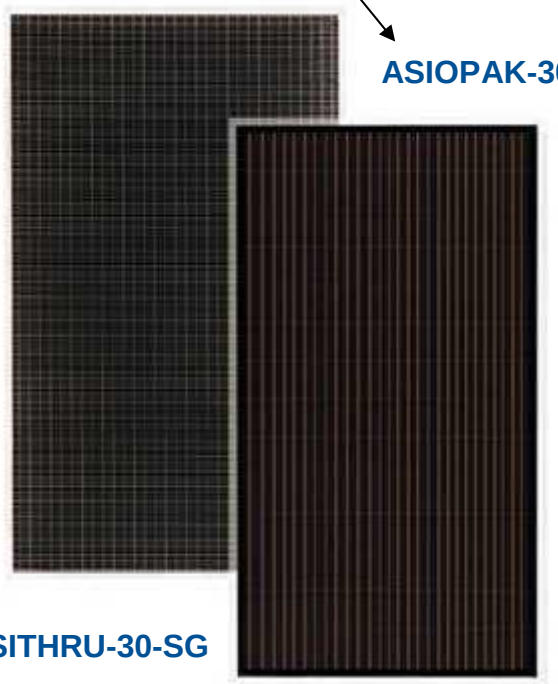
Amorphous Silicon Modules

24 V

ASIOPAK-30-SG



ASITHRU-30-SG

12 V

SCHOTT ASI 100

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Crystalline Silicon Modules

24 V

SCHOTT POLY 170

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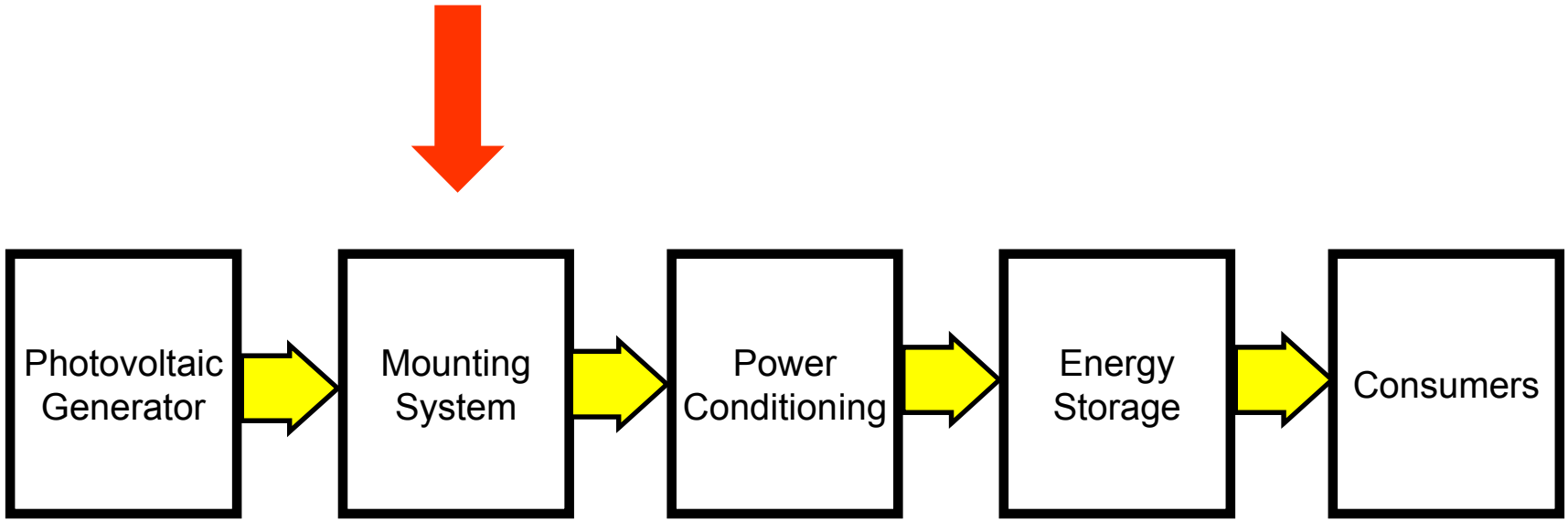
Components of Photovoltaic Systems



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Mounting Systems for stand-alone PV-Generators

Ground-mounted System

Pole System

Gabione System

Container System

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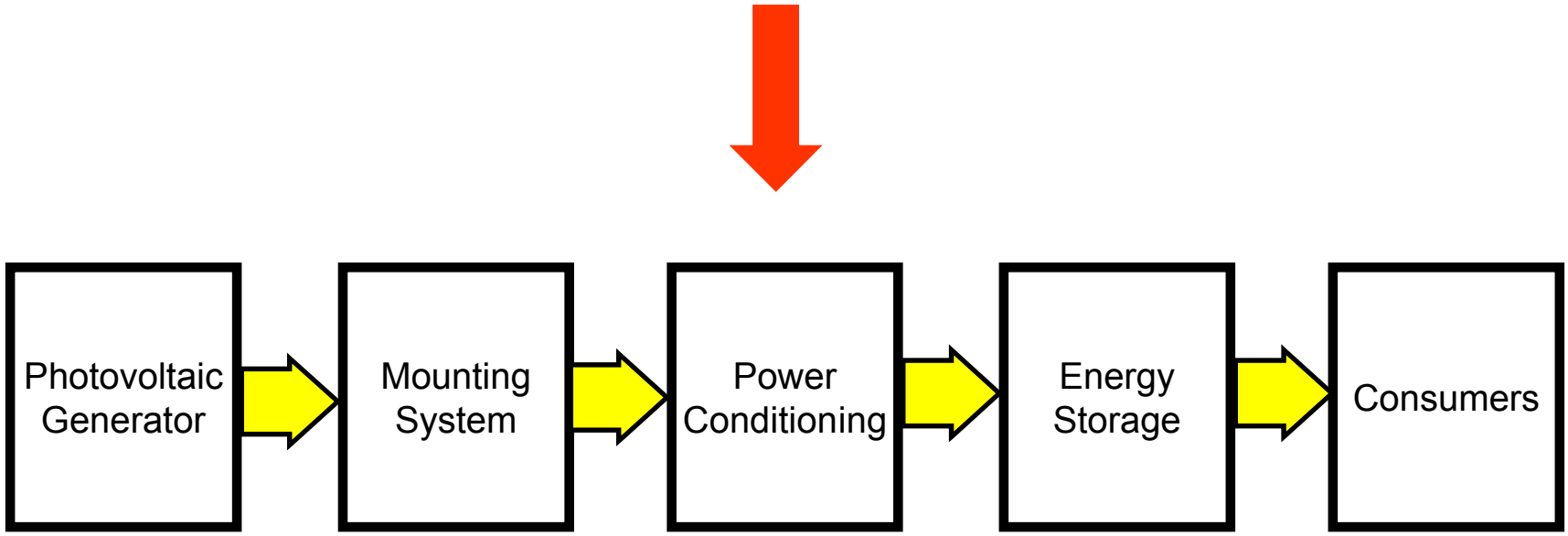
Components of Photovoltaic Systems



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Power Conditioning Devices

- **Direct Coupling**

  Direct connection of generator and load (no power conditioning)

- **Charge Regulator**

  Batteries are sensitive to overcharging as well as deep discharging. The battery is protected by charge regulators

- **DC/DC-Converter**

  If appliances with voltages other than 12 V have to be operated (e.g. Laptop), a DC/DC-converter will be applied to provide the required voltage

- **DC/AC-Inverter**

  Many electrical appliances are only avaliable for AC. An inverter transforms low-voltage DC supplied by a solar system into high voltage AC

- **MPP-Tracker**

  Matches the voltage characteristics of the PV-generator to those of the battery, improves efficiency by 10-20 %

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Advantages of Power Conditioning

- MPP-Tracking increases system efficiency
- Appropriate load management
- Increasing of battery life time
- Fault indication and verification through LEDs/LCDs
- Electronical data evaluation via interface
- Provision of high currents to start heavy loads

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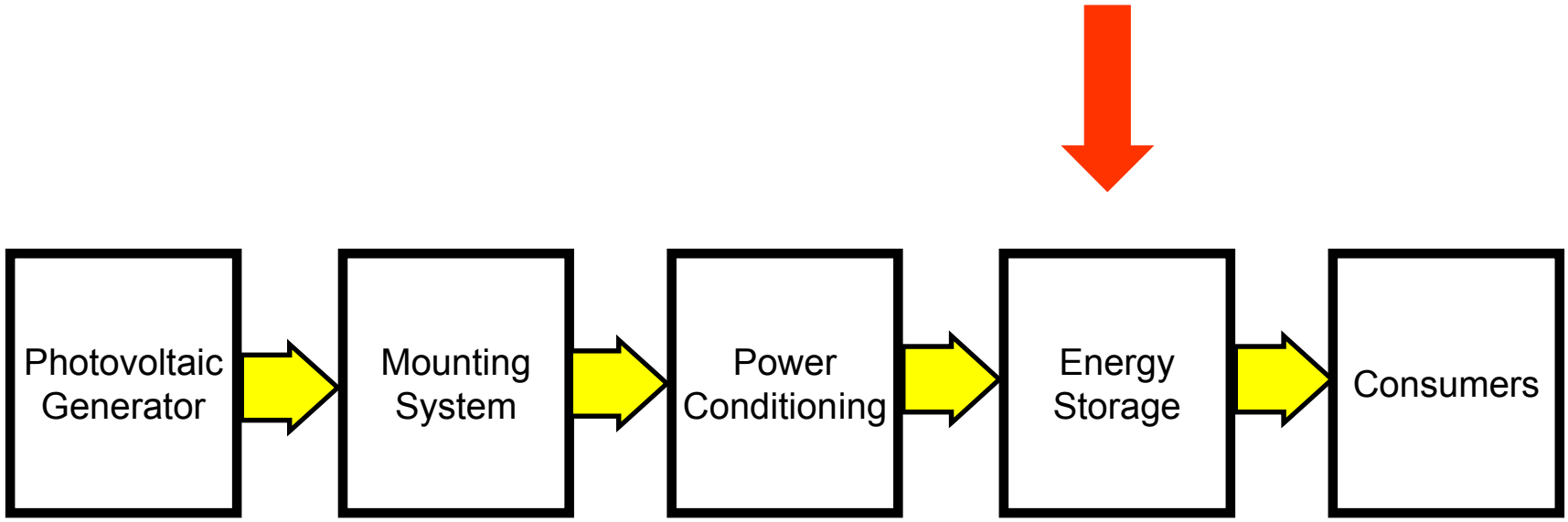
Components of Photovoltaic Systems



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Forms of Energy Storage

- **Condensators**

  Energy storage for very small appliances, e.g. solar watches, toys

- **Batteries**

  Electrochemical energy storage to equalize day-to-day fluctuations in supply and demand.

- **Electric Grid**

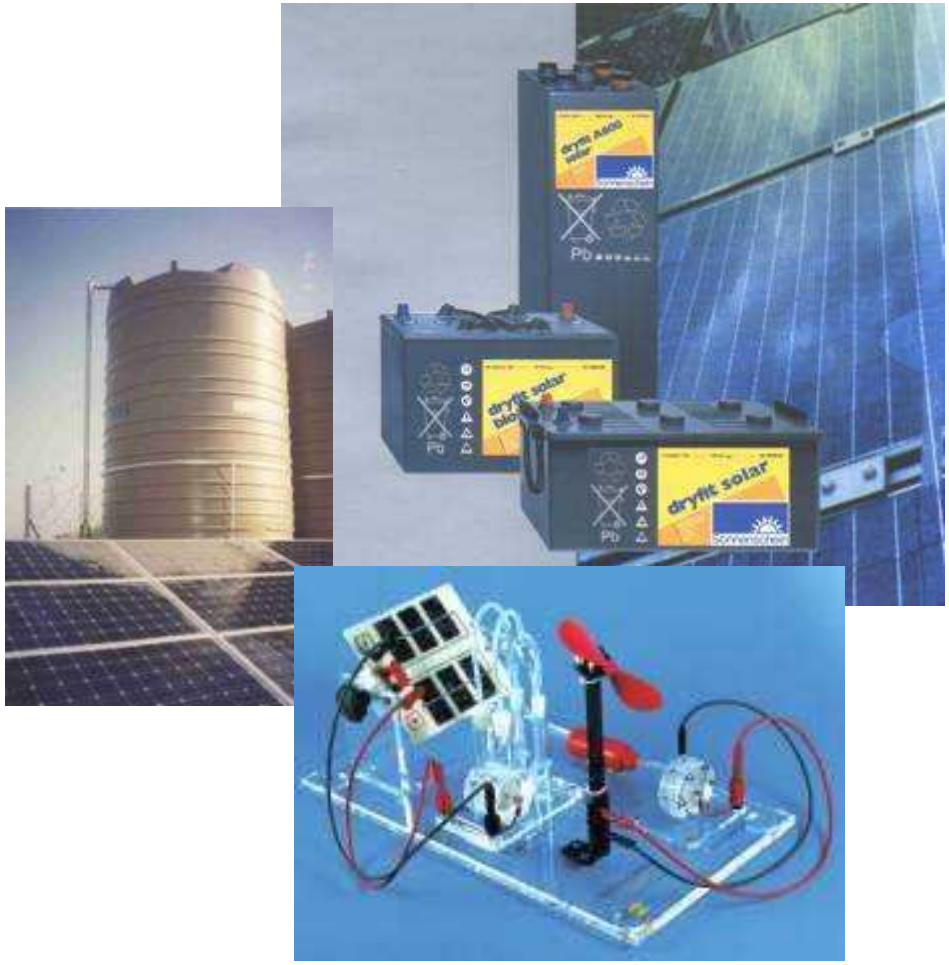
  Energy storage for grid-connected PV-systems

- **Water Tank**

  In case of photovoltaic pumping systems, the pumped water is stored in collection basins or water tanks.

- **Hydrogen**

  Hydrogen is the chemical energy storage of the future. Hydrogen, produced in solar powered water electrolysis plants, will be stored in tanks and used to generate electricity with fuel cells



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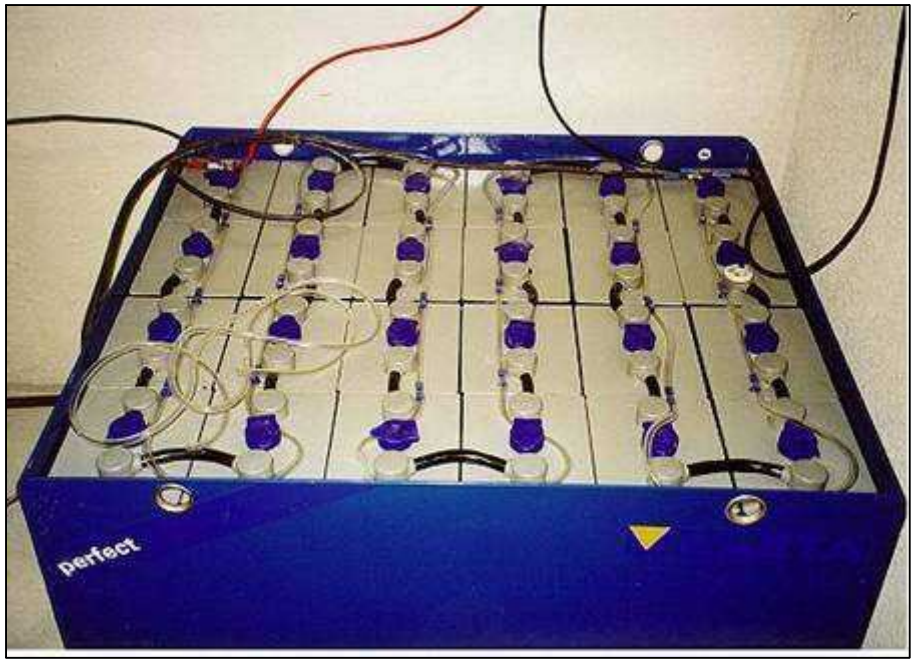
Batteries

- For off-grid systems a battery is used to provide energy storage for several days
- Nearly all batteries used for PV systems are of the lead-acid type (with a small quantity of antimony to reduce self-discharge)
- Nickel-cadmium batteries are also suitable and have the advantage that they cannot be overcharged or discharged, but are considerably more expensive
- All PV batteries are deep-cycle i.e. designed to be discharged down to 50% or more without damage so that they can supply power over a long period of time (in contrast to a car battery, for example, which is usually only discharged down to 3 to 5 %)
- The lifetime of a PV battery varies depending on factors such as how it is used, how it is maintained and charged, and temperature, but is typically between 5 and 8 years



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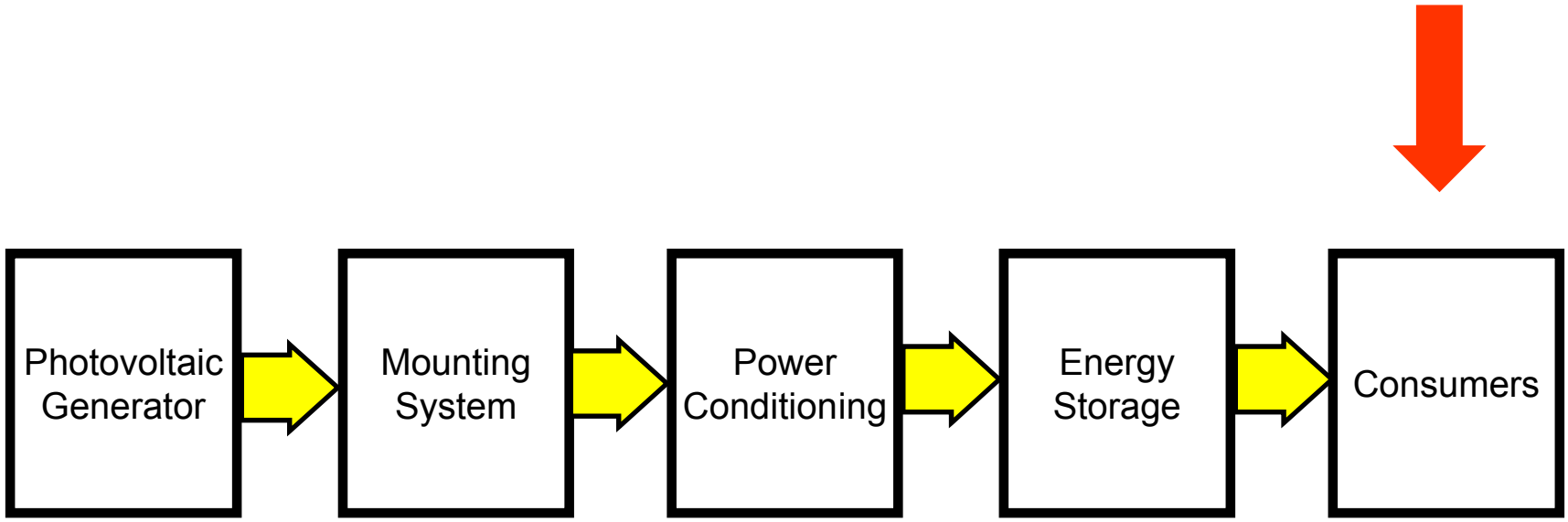

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Energy-Consumers

- Different types of electrical loads / consumers are available on the market but not all of them are suitable for PV-systems
- Energy is expensive. The best way to minimize energy costs is by saving energy
- Every kilowatt hour that is not consumed does not have to be paid for
- Therefore, before planning a PV-system, a careful selection of appliances is necessary
- Additionally, an effective load management by the operator and user of the photovoltaic system is necessary (e.g. switch-off light, if it is not needed), This is called rational use of energy

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What is a Hybrid Power System ?

- A hybrid power system has more than one type of generator - usually a conventional generator powered by a diesel engine and a renewable energy source such as PV, wind, or hydropower.
- A hybrid system is most often used for larger applications such as village power, residential systems where generators already exist, and in applications like telecommunications where availability requirements are near 100 percent.
- Almost all PV-generator hybrid systems include batteries for storage.

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Example: Suntainer-Concept in Australia

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Reference Applications

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Photovoltaic Water Pumps

Photovoltaic Water Pumping System (PVP) in Khedairia 1993

- 2,1kWp
- 42pcs PQ 10/40D
- Ground mounted installation
- Pumping head 65 m
- Pumping volume 17,5 m³/d
- Drinking water for approx. 700 people

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Telecommunications Applications and Rail Signalling Operations

Saudi Telecom Network Towers
Saudi Arabia
SCHOTT ASE-300-DG-FT

Saudi Rail Organisation
Saudi Arabia
SCHOTT Poly 175 Wp

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Centralised Power Supply for Remote Islands

Village power supply for 300 houses (Indonesia)
BIG SOL 2001

- Hybrid system with solar power generator, genset and battery backup
- 12kW ASE-300-DG-FT
- Ground mounted installation
- 25kVA Diesel Genset
- Battery: 220V, 420 Ah
- Hybrid inverter 15kVA
- **Award for best Hybrid System in South East Asia 2002**

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Solar Home Systems

Solar Boat Systems (Central Java, Indonesia) BIG SOL 1997-2001

- ASE-50-ETF/17
- Battery and charge controller
- 400 fishing boats
- Power supply for communication and lighting

Solar home systems for 300 houses (Kalimantan, Indonesia) BIG SOL

- ASE-50-ETF/17
- Battery and charge controller

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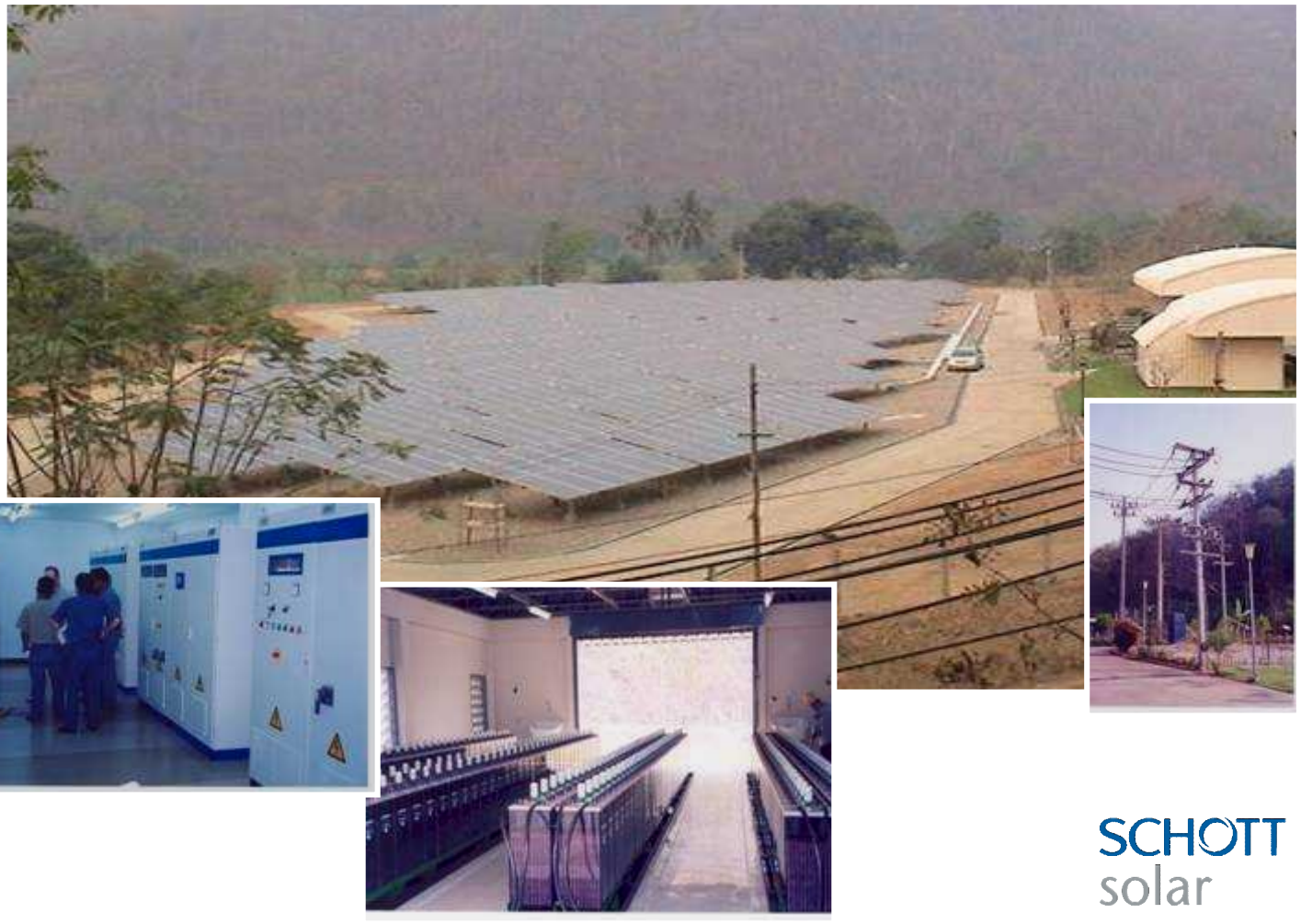
Grid-connected power supply with battery backup

EGAT – Mae Hong Son (Thailand) 2004

- 500kWp
- 1680 pcs ASE-300-DG-FT
- Ground mounted installation
- Inverter:
  2x 250kVA Sunny Central
  and
  2x 200kVA Battery inverter
- Battery:
  560V / 1200 Ah



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Village Power Supply

Central village electrification system with battery backup (Java, Indonesia) 1996 -1997

- 8kWp ASE-50-DG-FT

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Does Solar Technology make sense in the GCC countries?

- The global PV market in 2010 is estimated at 6 GWp (more than 80% grid-connected)
- Solar irradiation is among the highest in the world
- Abundance of lower cost non-irrigable land

→Government regulation a must for transition to a grid connected solar application market in this region

→Grid parity is being achieved in countries like Italy. Other countries are moving towards it too. Why not the Gulf countries?

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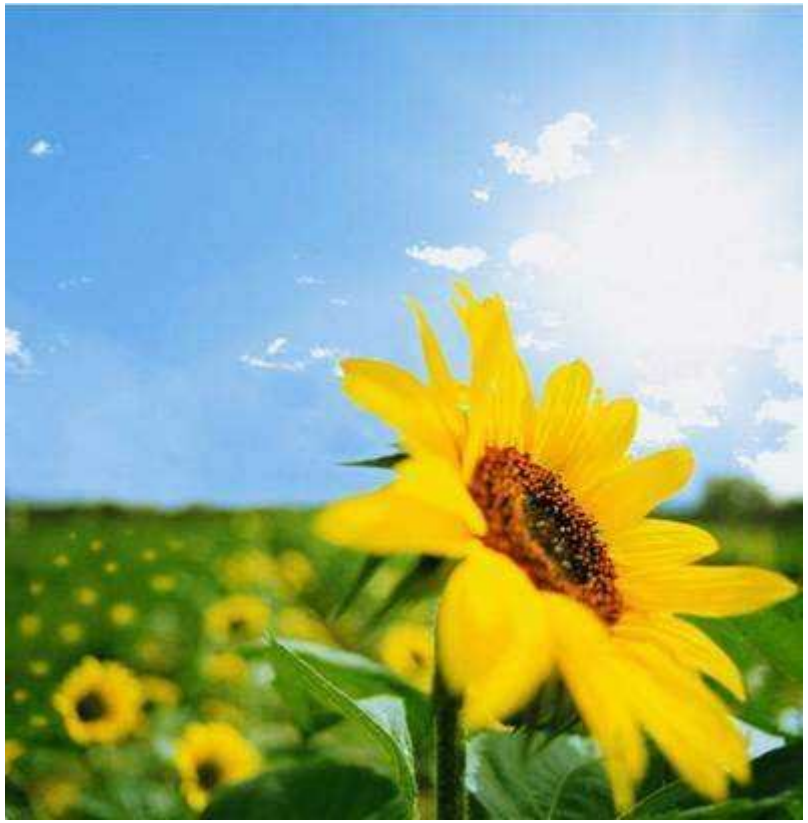
Thank you for your attention !



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