

SOLAR ENERGY TECHNOLOGIES

Solar & wind energy technologies

- Photovoltaics
 - Off-grid
 - Grid-tied
- Solar thermal
 - Solar water heating
 - Solar thermal power
- Passive solar
- Other renewable technologies
- Why renewable energy?
 - Climate change
 - Economic trends
 - Peak oil?
 - Energy security

Range of solar technologies ...



Electricity from light (PV)



Hot water



Electricity from heat

Other renewable energy technologies ...



Electricity from wind



Pumping with wind

Electricity from water



Solar energy - overview

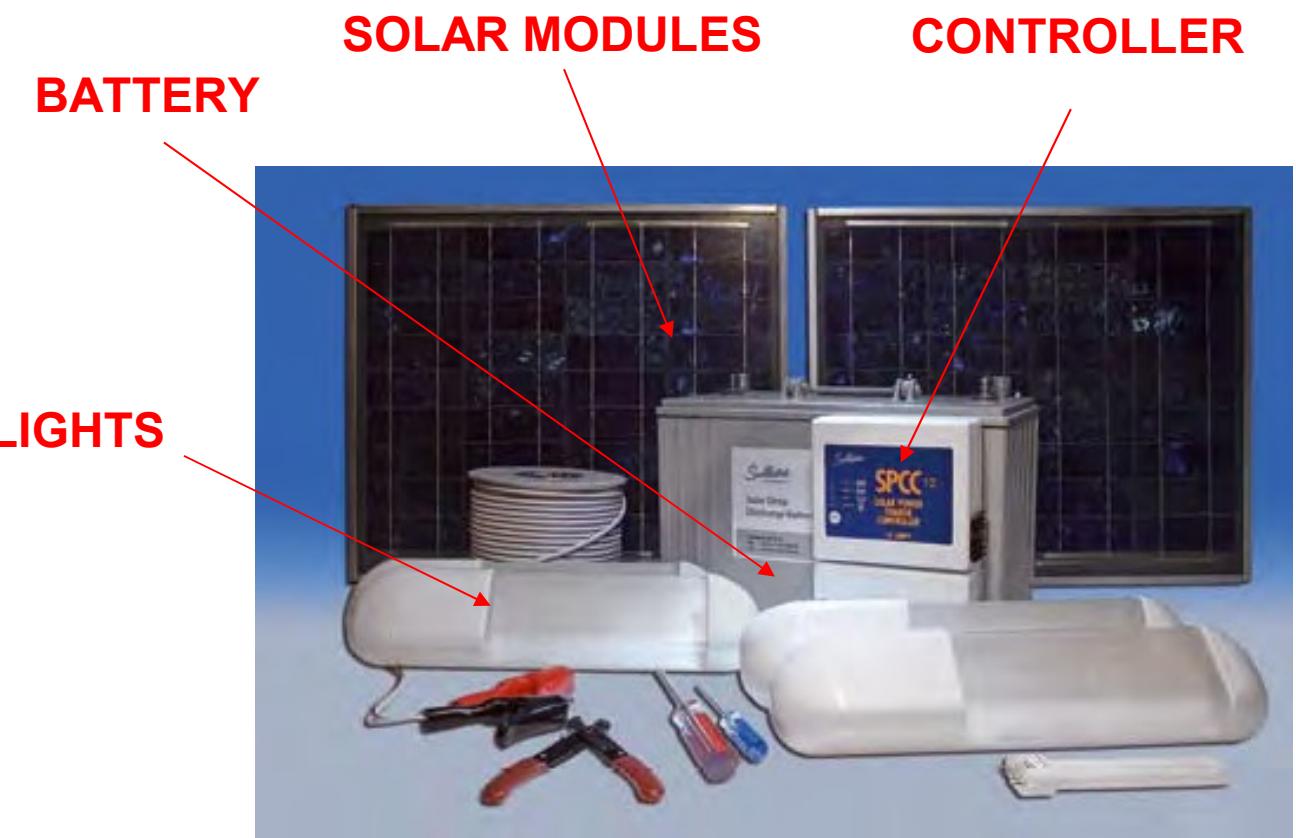
- Photovoltaics (PV)
(stand-alone)
 - Electricity, charging batteries, water pumping
 - Photovoltaics (PV)
(grid-tied)
- Passive solar
 - Space heating & cooling
- Solar thermal
 - Heating water, cooling, space heating, cooking
- Solar thermal power / electric



Solar water heating on a school in Berlin

Solar electricity - stand-alone

- Telecom
- Rural electrification
- Remote locations
- Bus shelters
- Street furniture
- Satellites
- Hybrid systems
- 2,000,000,000 people are without electricity world-wide, at least
- 2006 – installed globally 2.2 GW



Sollatek™
solar systems

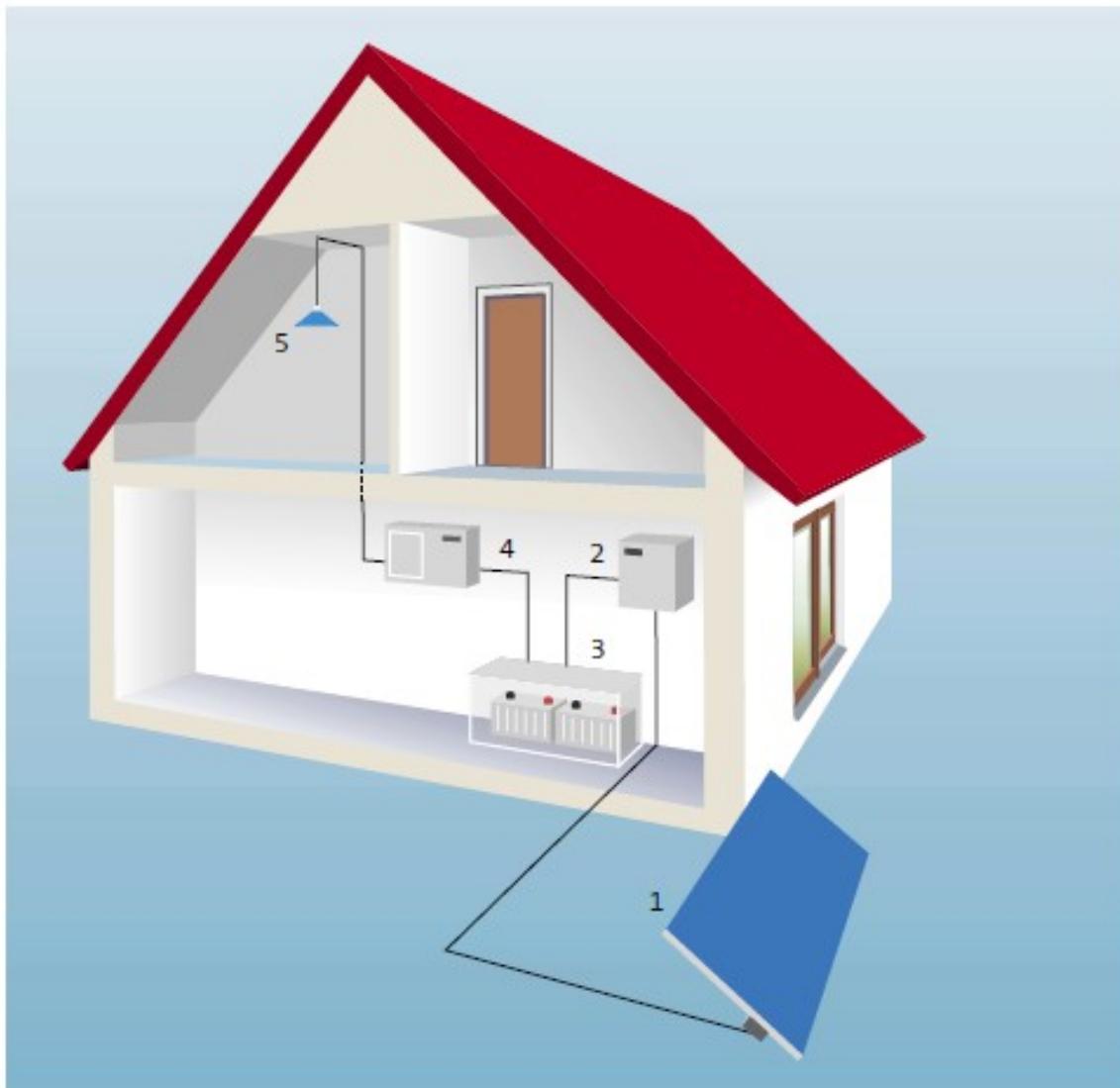
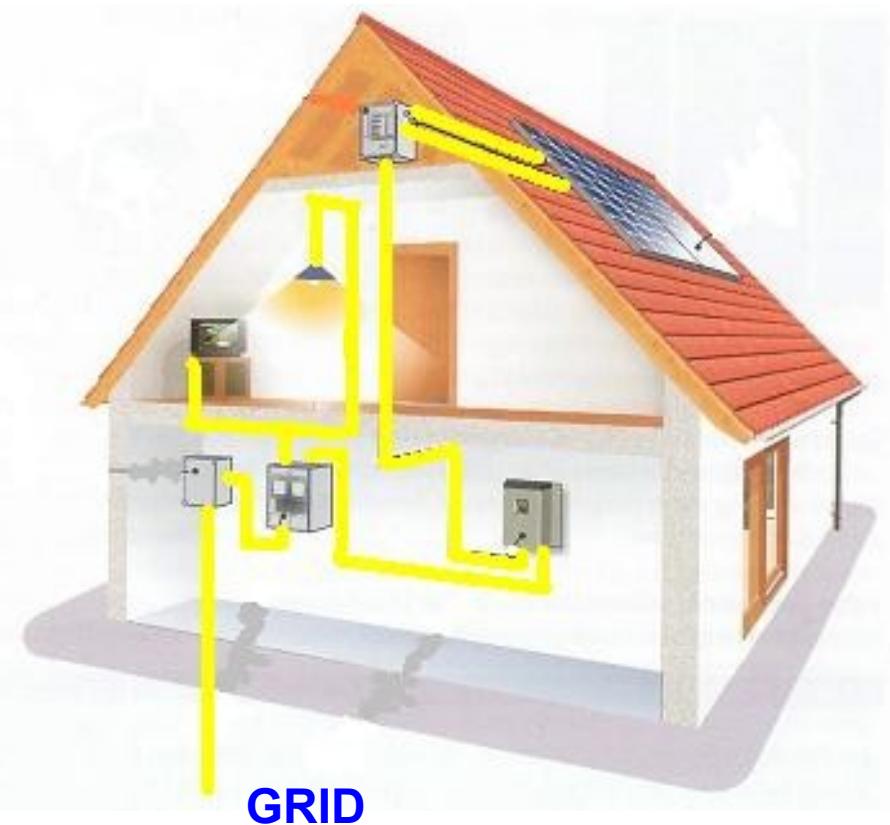


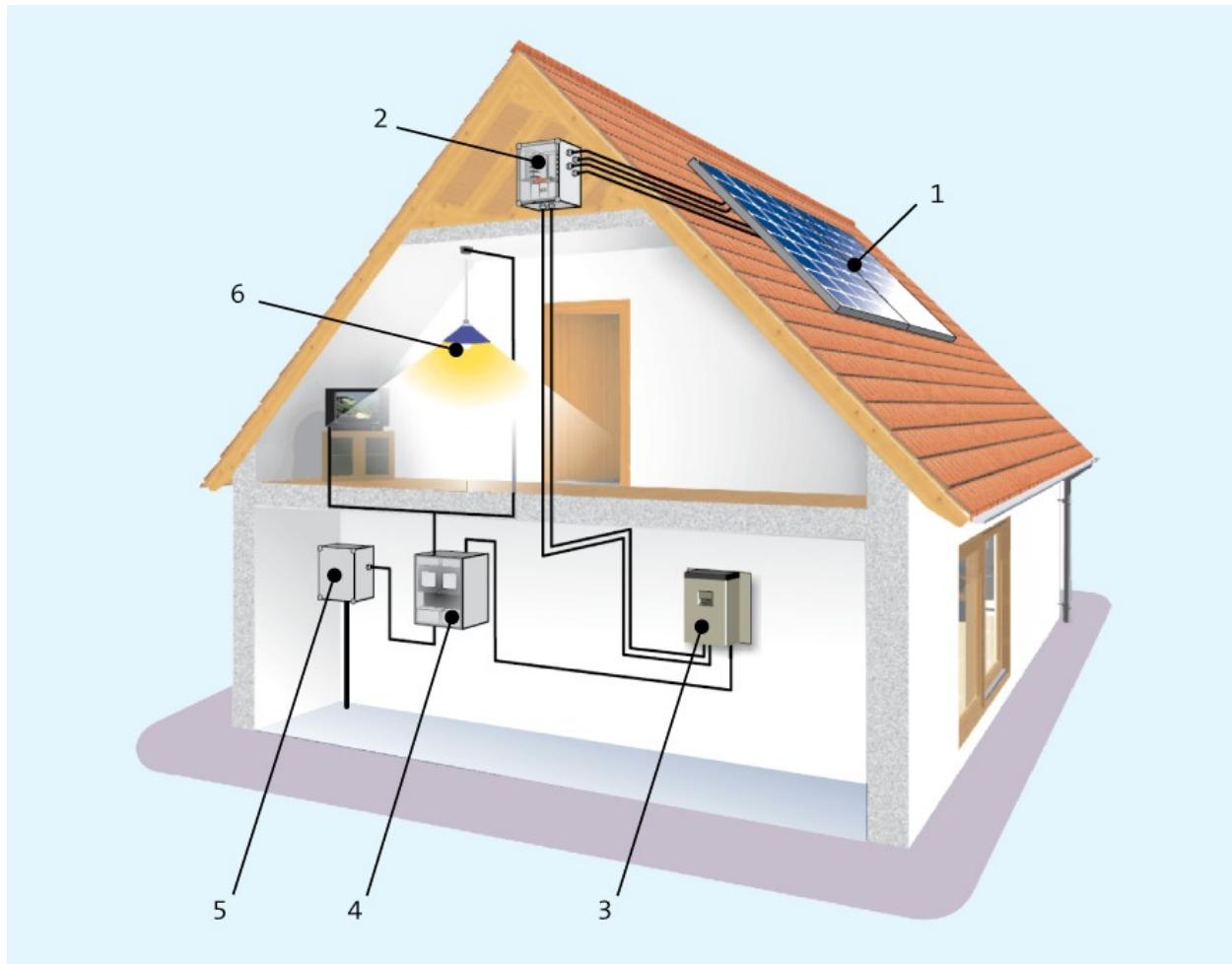
Figure 6.1: 1 PV array, 2 Charge controller, 3 Batteries, 4 Inverter, 5 Loads. Though a common configuration, many others are possible



Photovoltaics - grid-tied

- Electricity generated during the day and exported into the grid
- Electricity needed at night imported from the grid
- Fully automatic
- 2006 – installed globally 1.8 GW





1 PV array, 2 PV array combiner/junction box, 3 Grid-tied inverter,
4 Import/export meter, 5 Connection to grid, 6 Loads.
Other configurations are possible

PV – mobile and portable applications

- PV is modular
- Large and small systems are possible
- Works nearly everywhere
- But most expense of the renewable energy technologies



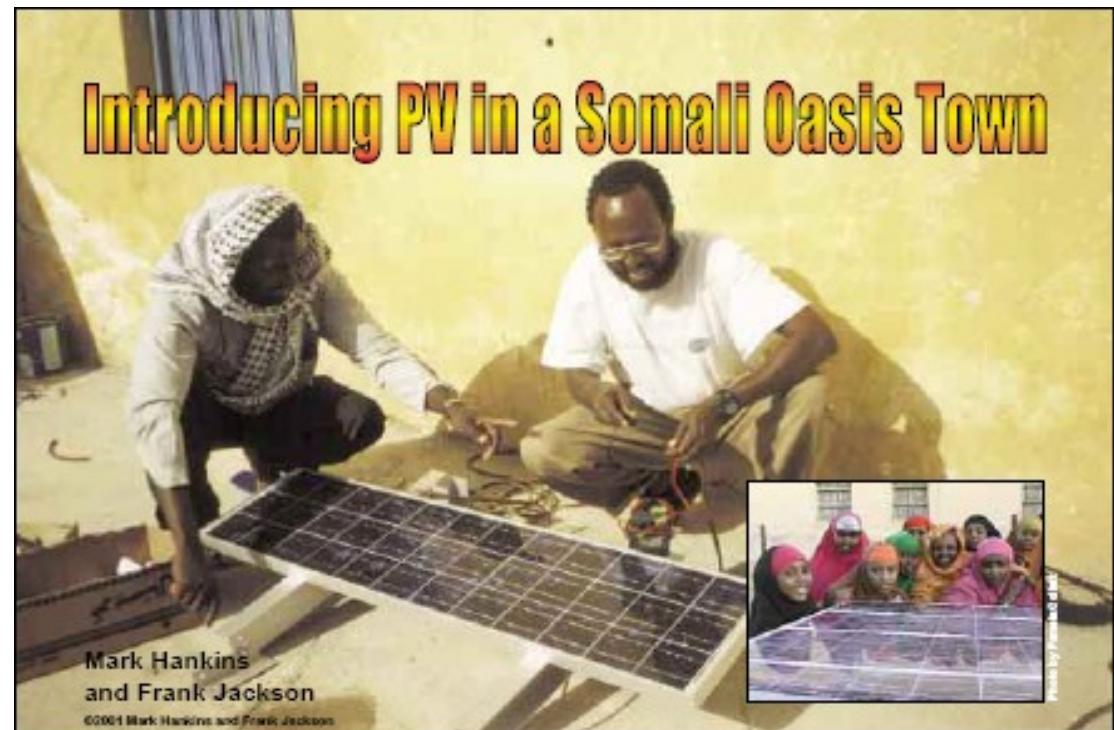
NASA Helios, 75 metre wingspan

PV – stand-alone in developing world

2,000,000,000
people are without
electricity world-
wide

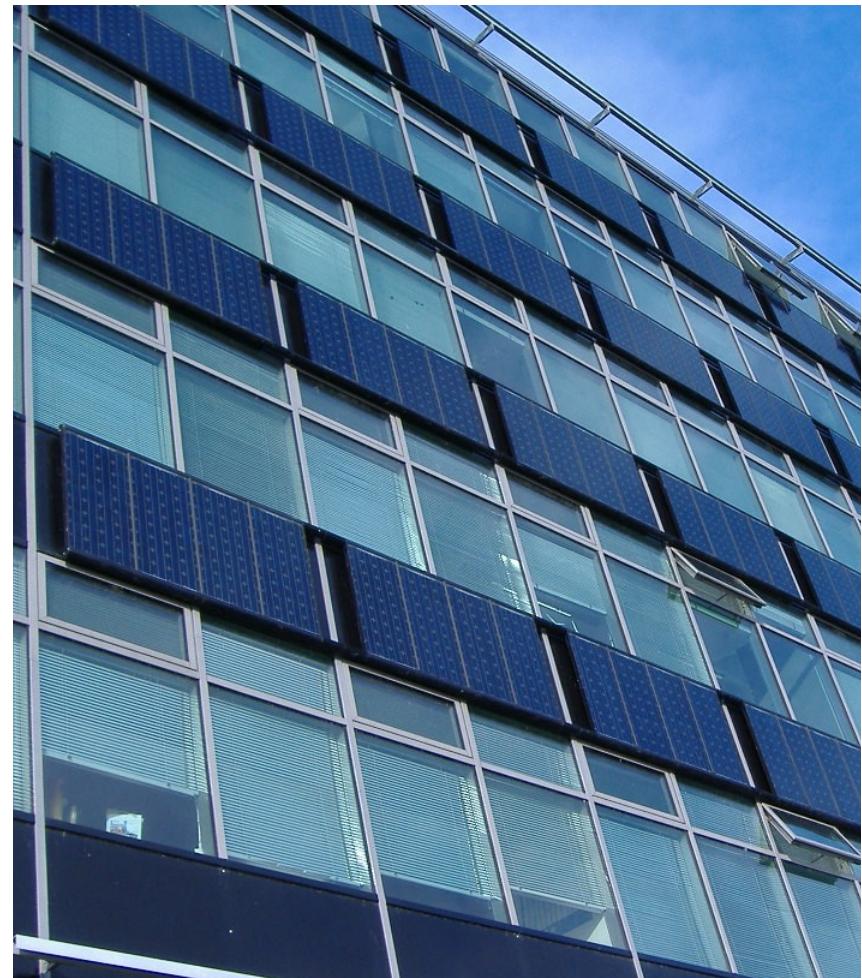
Stand-alone PV is
often the most cost
effective solution

Mainly small single
module systems for
lighting, radio & TV



Building Integrated Photovoltaics (BIPV)

- PV modules & laminates used to replace expensive facade cladding
- Electricity used during the day mainly
- Energy security
- Corporate projects
- Looks good



PV – urban environment



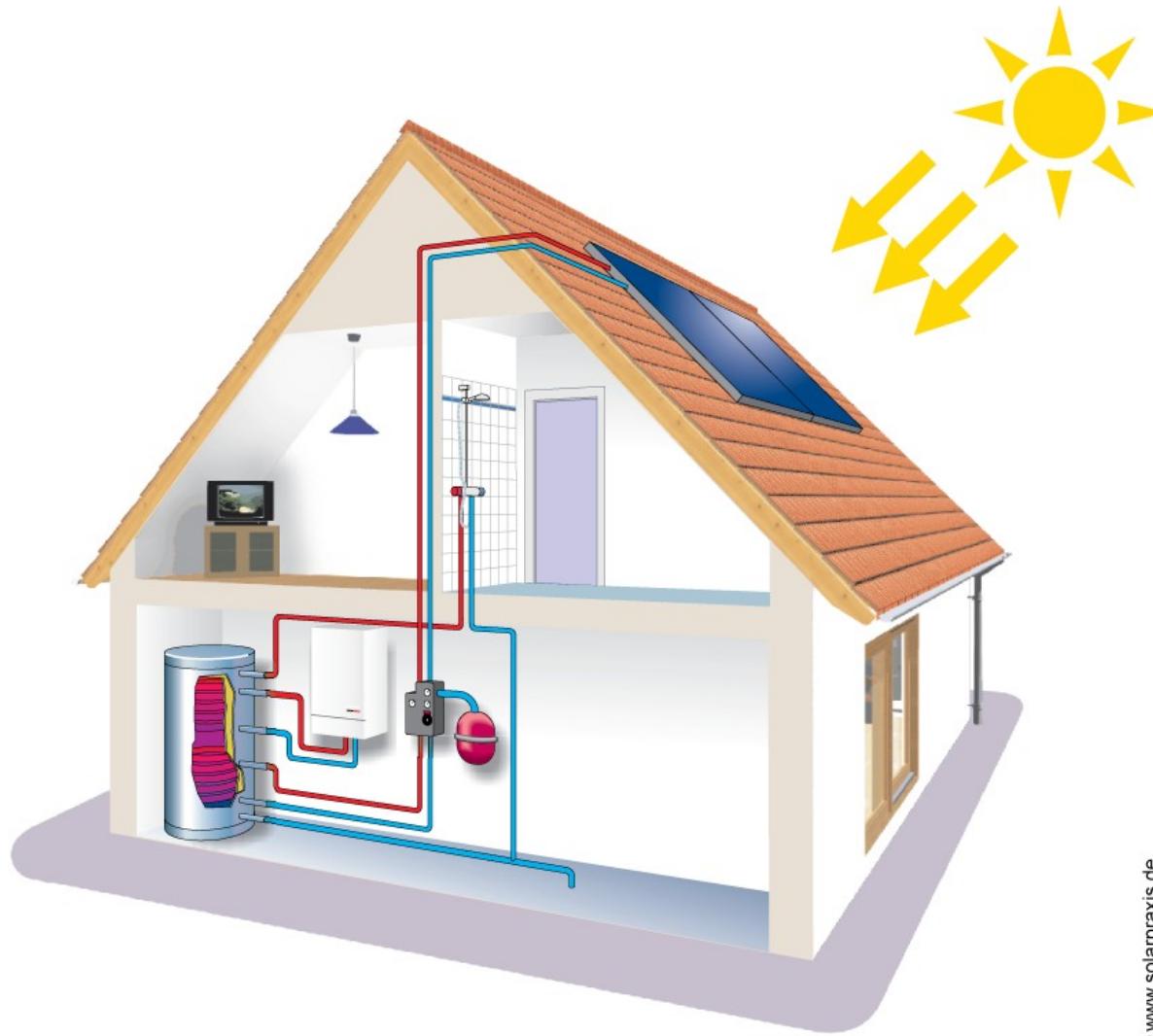
*Parking
meter*



*Solar
street
light,
Sollatek*

There are many applications for stand-alone PV even in urban environments - bus shelters, parking meters, sign illumination, park lighting

Solar-thermal system for heating domestic water



© www.solarpraxis.de

Solar water heating

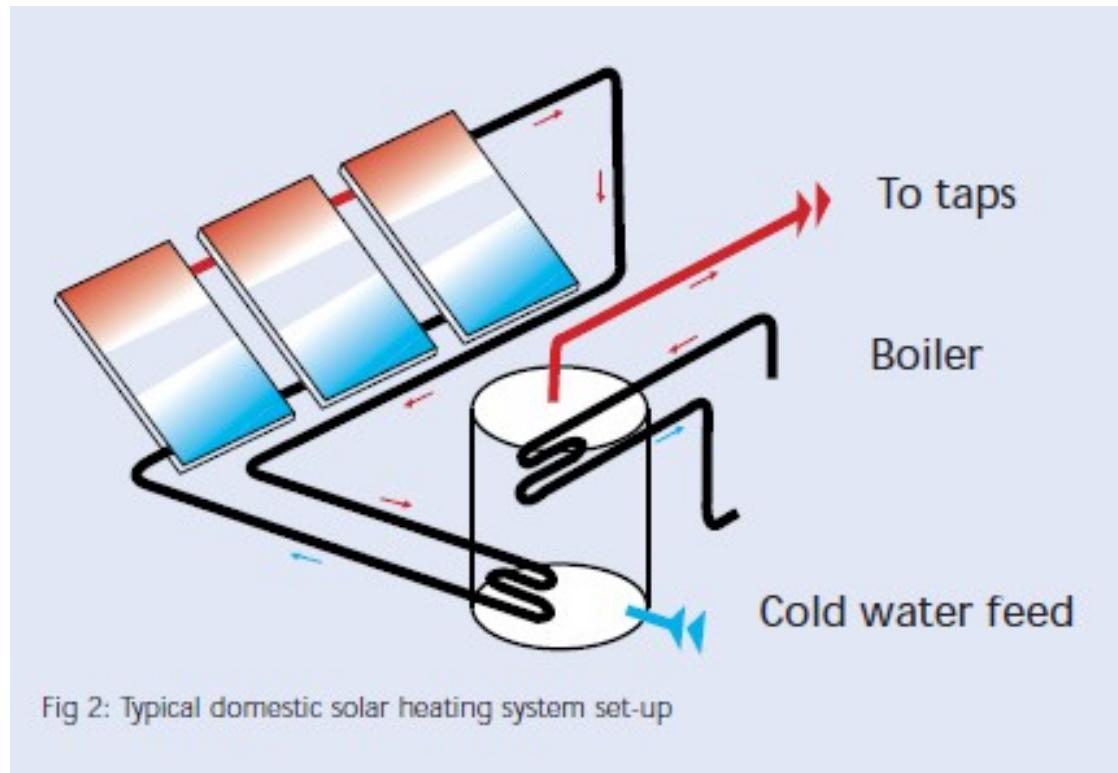
- Domestic systems can produce 40-60% of hot water annually
- Even outdoor swimming pool systems in warm countries can extend period of pool use
- 2006 – installed global capacity 77 GW_t (glazed)
- 2006 – households with solar hot water, 4 million globally



DIY, with clipfins

Solar water heating – the basic idea

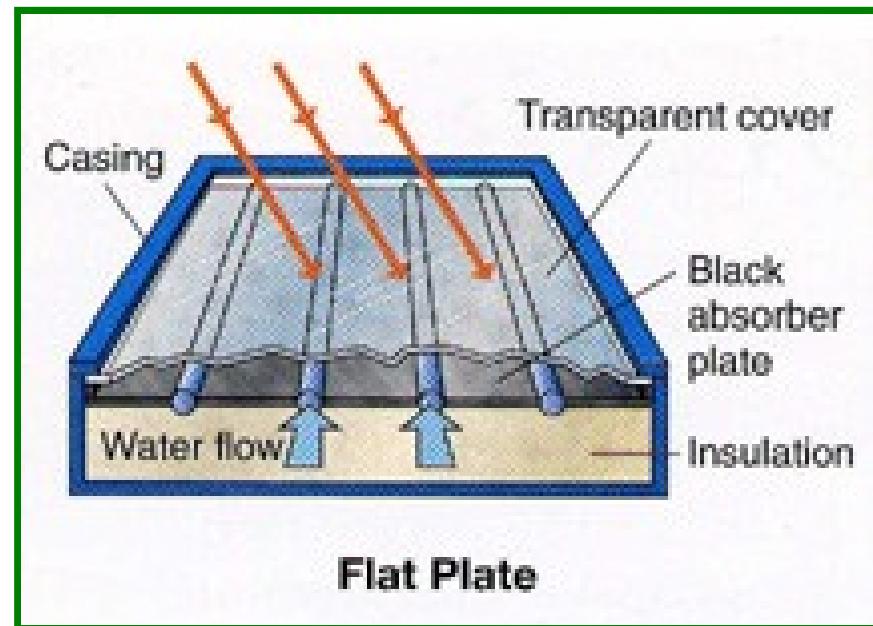
- Solar panels heat water which flows to the tank
- When the sun shines the water is heated by solar
- When not, by the boiler or electric element
- Thermostat controlled



Energy Savings Trust

Solar water heating – flat plate collectors

- With selective surface
- Without selective surface
- Domestic installations generally



Solar water heating – evacuated tubes

- Large installations
- Hospitals
- Hotels
- Domestic
- Most efficient type
- Needs less roof space
- Most expensive
- Space heating
- Space cooling



Solar water heating – plastic collectors

- Unglazed plastic collectors
- Used for swimming pools
- Extends period of use



Plastic collectors for pool, Spain
Source: www.re-solutions.org

Solar cookers

- Parabolic cookers
- Box cookers
- Parabolic is excellent demonstration of power of the sun
- In practice rarely used unless no other alternative available



Solar dryers

- Fruit
- Mushrooms
- Coffee
- Chilli
- Etc.
- Further information from
Tropical Whole Foods (UK)

*Home Power article
on solar drying*

Homebrew

The Design, Construction, and Use of an

Indirect, Through-Pass, Solar Food Dryer

Dennis Scanlin

©1997 Dennis Scanlin

Drying is our oldest method of food preservation. For several thousand years people have been preserving dates, figs, apricots, grapes, herbs, potatoes, corn, milk, meat, and fish by drying. Until canning was developed at the end of the 18th century, drying was virtually the only method of food preservation. It is still the most widely used method. Drying is an excellent way to preserve food and solar food dryers are an appropriate food preservation technology for a sustainable world.

Food scientists have found that by reducing the moisture content of food to between 10 and 20%, bacteria, yeast, mold and enzymes are all prevented from spoiling it. The flavor and most of the nutritional value is preserved and concentrated. Vegetables, fruits, meat, fish and herbs can all be dried and can be preserved for several years in many cases. They only have 1/3 to 1/6 the bulk of raw, canned or frozen foods and only weigh about 1/6 of that of the fresh food product. They don't require any special storage equipment and are easy to transport.

The solar dryer which will be described in this article is easy to build with locally available tools and materials (for the most part) for about \$150 and operates simply by natural convection. It can dry a full load of fruit or vegetables (7-10 lbs) thinly sliced in two sunny to partly sunny days in our humid Appalachian climate or a smaller load in one good sunny day. Obviously the amount of sunshine and humidity will affect performance, with better performance on clear, sunny and less humid days. However, some drying does take



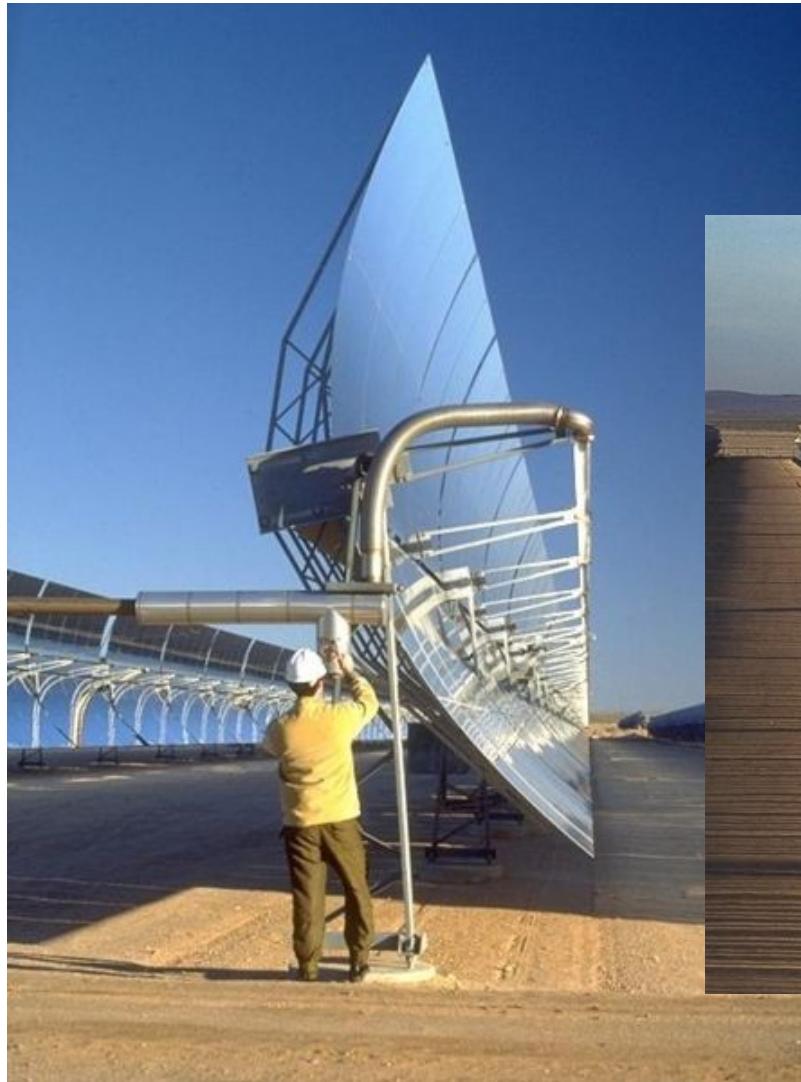
place on partly cloudy days and food can be dried in humid climates. The dryer was developed at Appalachian State University in the Department of Technology's Appropriate Technology Program. Over the last 12 years we have designed, built, and tested quite a few dryers and this one has been our best. It was originally developed for the Honduras Solar Education Project, which Appalachian State implemented several years ago. The prototype for that project was constructed by Chuck Smith, a graduate student in the Technology Department. Amy Martin, another Appalachian student, constructed the modified and improved version depicted in this article. Solar dryers are a good way to introduce students to solar thermal energy technology. They have the same basic components as do all low temperature solar thermal energy conversion systems. They can be easily constructed at the school for small sums of money and in a fairly short amount of time, and they work very well. While conceptually a simple technology, solar drying is more complex than one might imagine and much still needs to be learned about it. Perfecting this technology

Solar thermal electric – example

- **STM's *SunDish™* prototype**
- Runs on sun during the day, on other fuels at night
- 25kWe - 200MWe
- Hot water



Krammer's Junction, USA

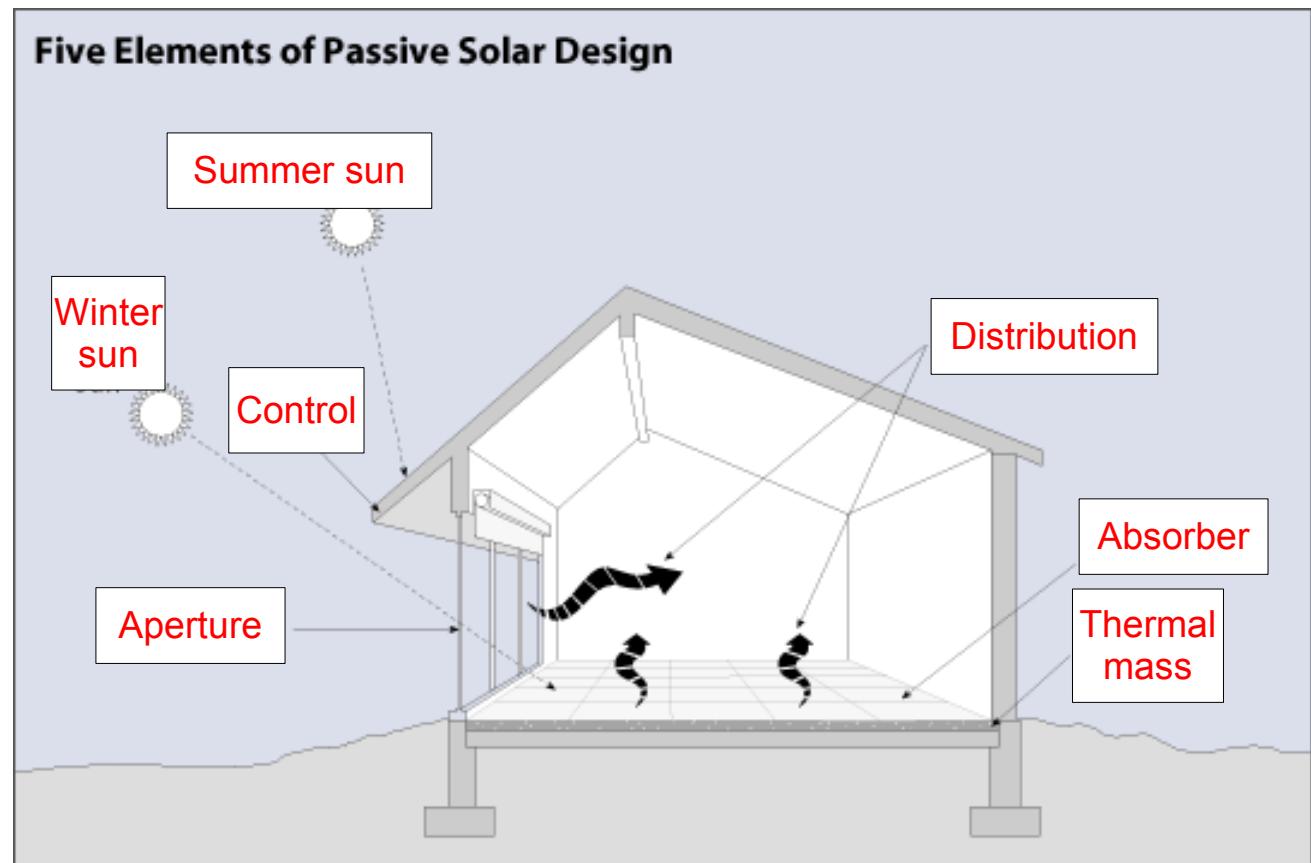


Solar tower



Passive solar

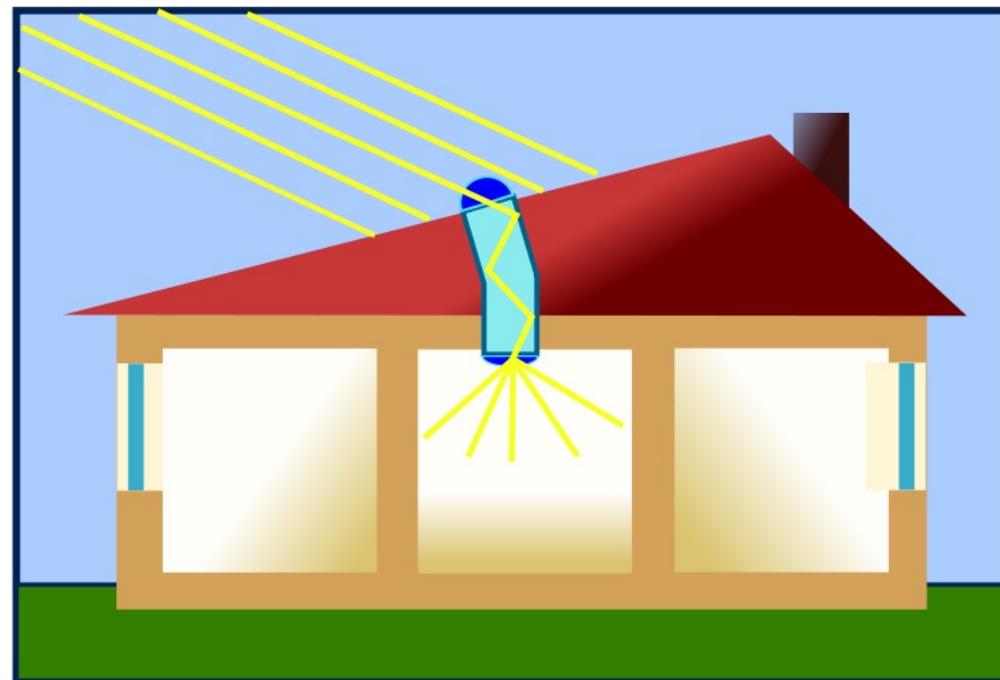
- Lower energy needs
- Cool in summer
- Warm in winter
- Orientation
- Window sizes
- Insulation
- Very site specific



Light tubes

Light tubes
channel
daylight directly
into buildings

Can be used
with movement
detectors on
electric lights



Wind energy - overview

Traditional wind mill

- milling corn, sawing wood, carding wool, pumping water

Wind pumps

Wind generators (stand-alone)

- electricity, some heat sometimes, charging batteries
- can now be connected to grid

Wind generators (large grid-tied)

- wind farms
- off shore

Wind pumps



- 100,000s installed in the mid-West of USA in 19th century
- Also used in Australia and South Africa extensively
- Water is pumped and stored when wind blows
- Need to be above borehole
- Small wind-electric water pumps are also now available

Wind generators - off-grid

- 2 to 6 blades
- Variable speed
- Usually used for charging batteries
- Off-grid
 - Good wind resource needed
 - Battery banks
- Some can now be connected up to the grid



Wind generators – large grid-tied

- Constant speed
- No free-wheeling – computer/remote controlled



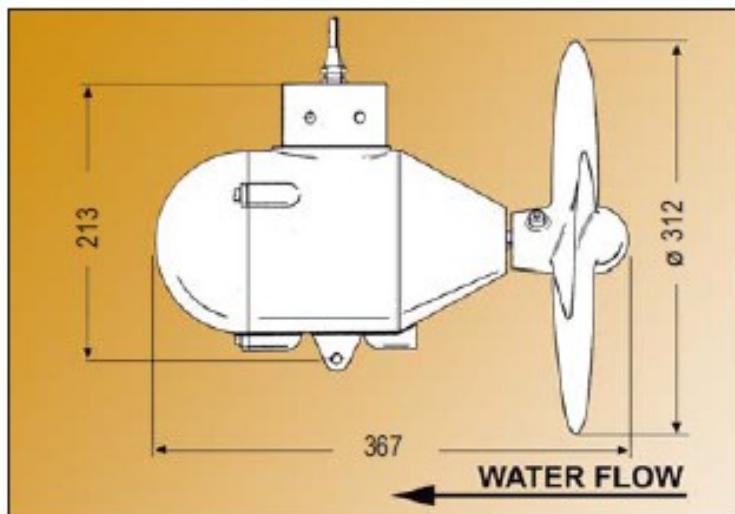
Wind farm near Berlin
Photo: Clare Maynard

Hydro-power - overview

- Water wheels
 - milling corn, sawing wood, etc.
- Hydraulic ram
- Mini-hydro (stand-alone)
 - charging batteries
- Micro-hydro (stand-alone)
 - charging batteries, some heat
- Micro-hydro (grid-tied)
- Large hydro electric

Mini-hydro

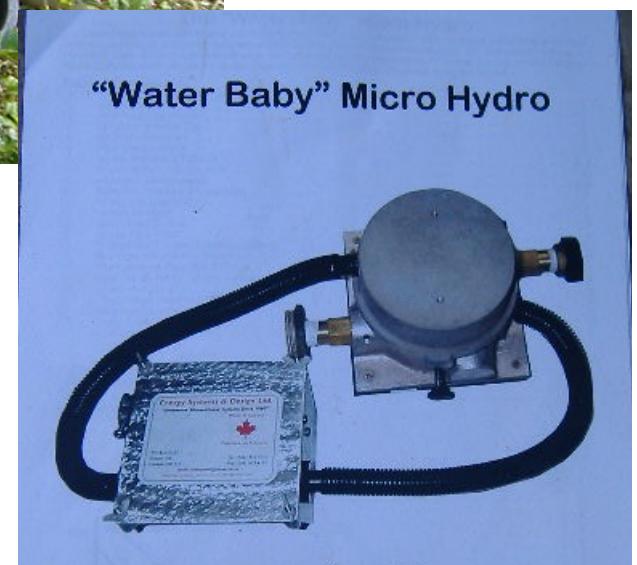
- Small systems
- Charging batteries
- Fast flowing streams



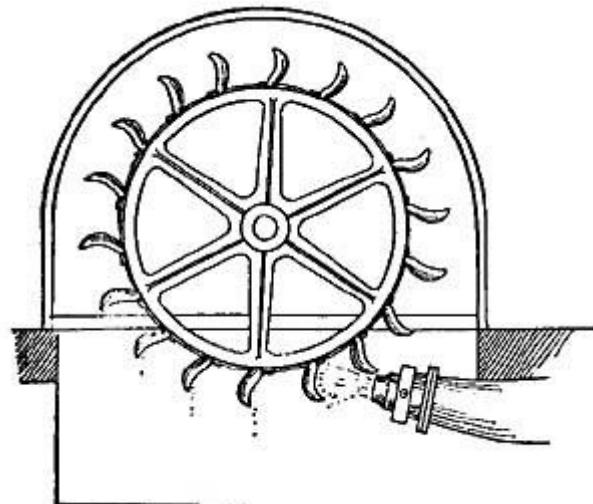
www.ampair.com



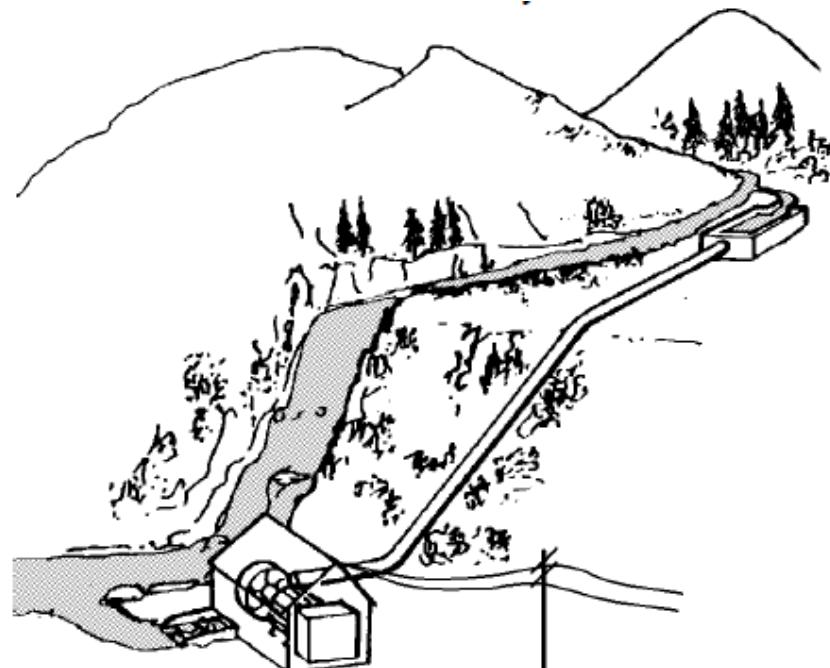
“Water Baby” Micro Hydro



Micro-hydro – common system configuration



From General Science, 1912
www.gutenberg.org



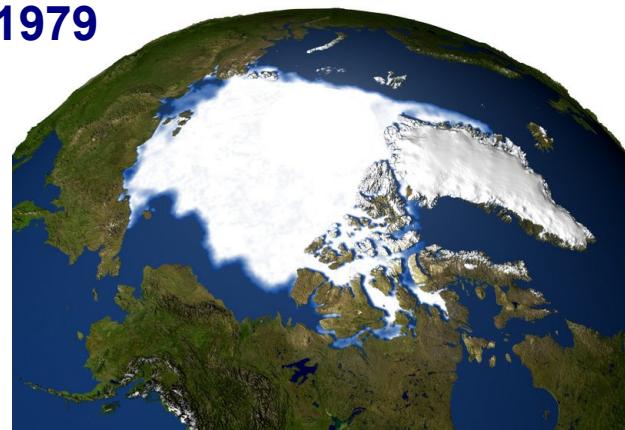
British Hydropower Association

- Typical micro-hydro system
- Pelton wheel – minimum head of 20m required
- First electricity power stations were micro-hydro

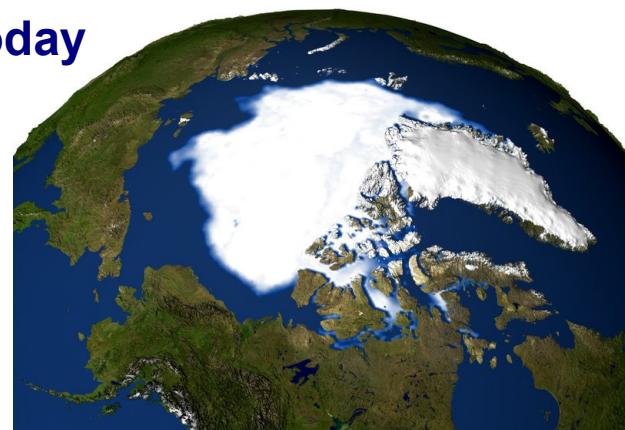
Renewable energy - why?

- Climate change
- Rising fossil fuel prices
- Energy security issues
- Peak oil
- Why off-grid?

1979



Today



Project assessment

- Why?
 - to save money?
 - to make green statement
 - to ensure energy security
- Which technologies are viable?
- Which technologies are impracticable/too expensive?
- What is the available budget?

7.5 Site survey form – stand-alone PV system

Sample site survey form for stand-alone PV systems

Customer details

Name

Address

.....

.....

.....

Tel (landline):

Tel (cell/mobile):

Email

Customer requirements

Potential budget:

System purpose (to provide all power? seasonal use? hybrid system? any power back-up needs etc.?)
.....

*From Photovoltaics for Professionals,
Solarpraxis, Berlin*

The future?

- Will there be more or less interest in renewable energy in five years time?
- Will there be more or less renewable energy systems being installed in five years time?
- Will renewable energy be more or less economically viable in five years time?
- In ten years time?

