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international centre for theoretical physics

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**College on Evaluation of Energy Technologies  
and Policies for Implementation of Agenda-21**

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**Renewable Energy Sources, Technologies and  
Potential**

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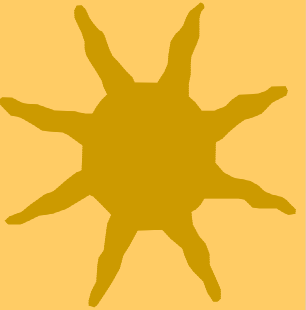
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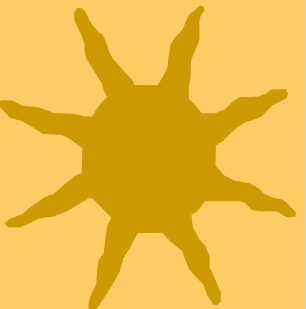




*Colleague on Evaluation of Energy Technologies  
and Policies for Implementation of Agenda 21*



*Renewable Energy Sources  
Technologies and Potential  
by*



**NAJWA GADAHELDAM**

*Mary Kobusingye (Intern)*

**PTC/ECB/UNIDO**

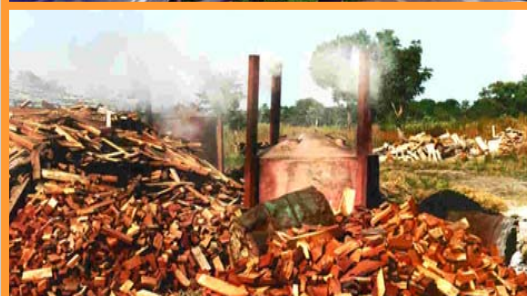
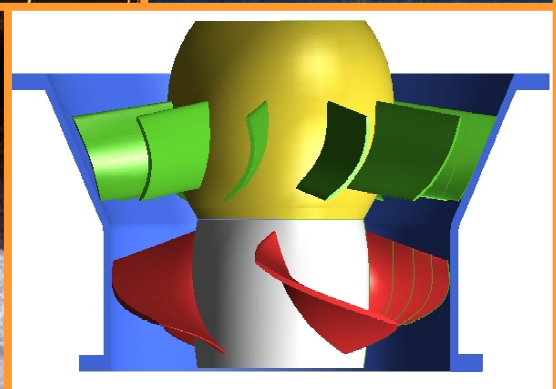
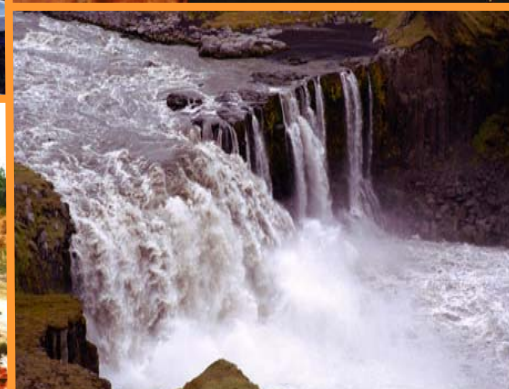
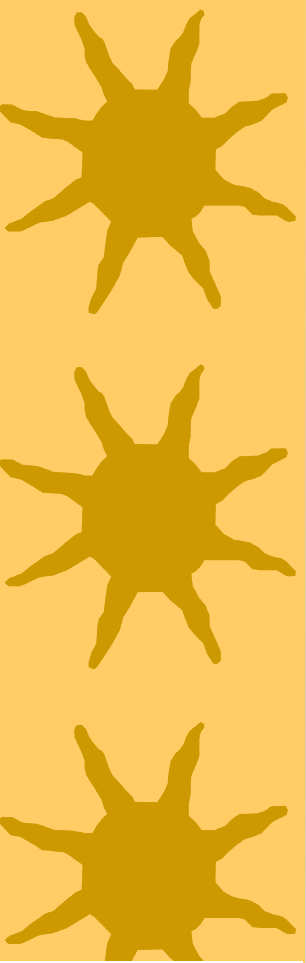


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# *Renewable Energy Sources Technologies and Potential*

NAJWA GADAHELDAM PTC/ECB/UNIDO



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# *Renewable Energy Sources Technologies and Potential*



## Problem:

- Almost 2 billion very poor people are without access to a modern energy service.
- 2.8 billion people live on less than US\$ 2/day and 1.2 bP on less than 1 US\$ /day.
- People in developing countries without access to modern fuels actually spend a higher fraction of their income on energy than those who have access (WB-2000a).



No energy means no development

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# WORLD SUMMIT ON SUSTAINABLE DEVELOPMENT PLAN OF IMPLEMENTATION, 4 September 2002

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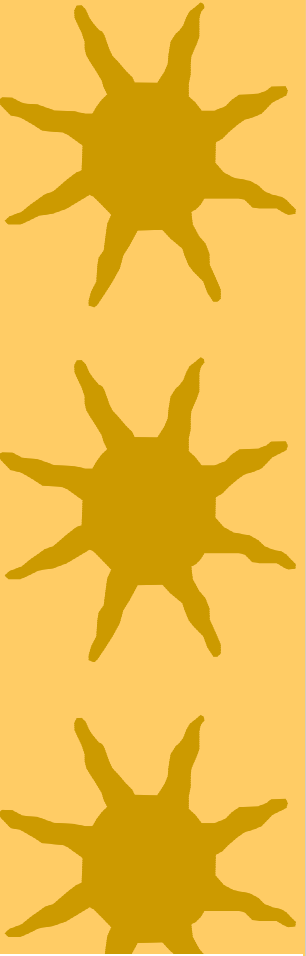
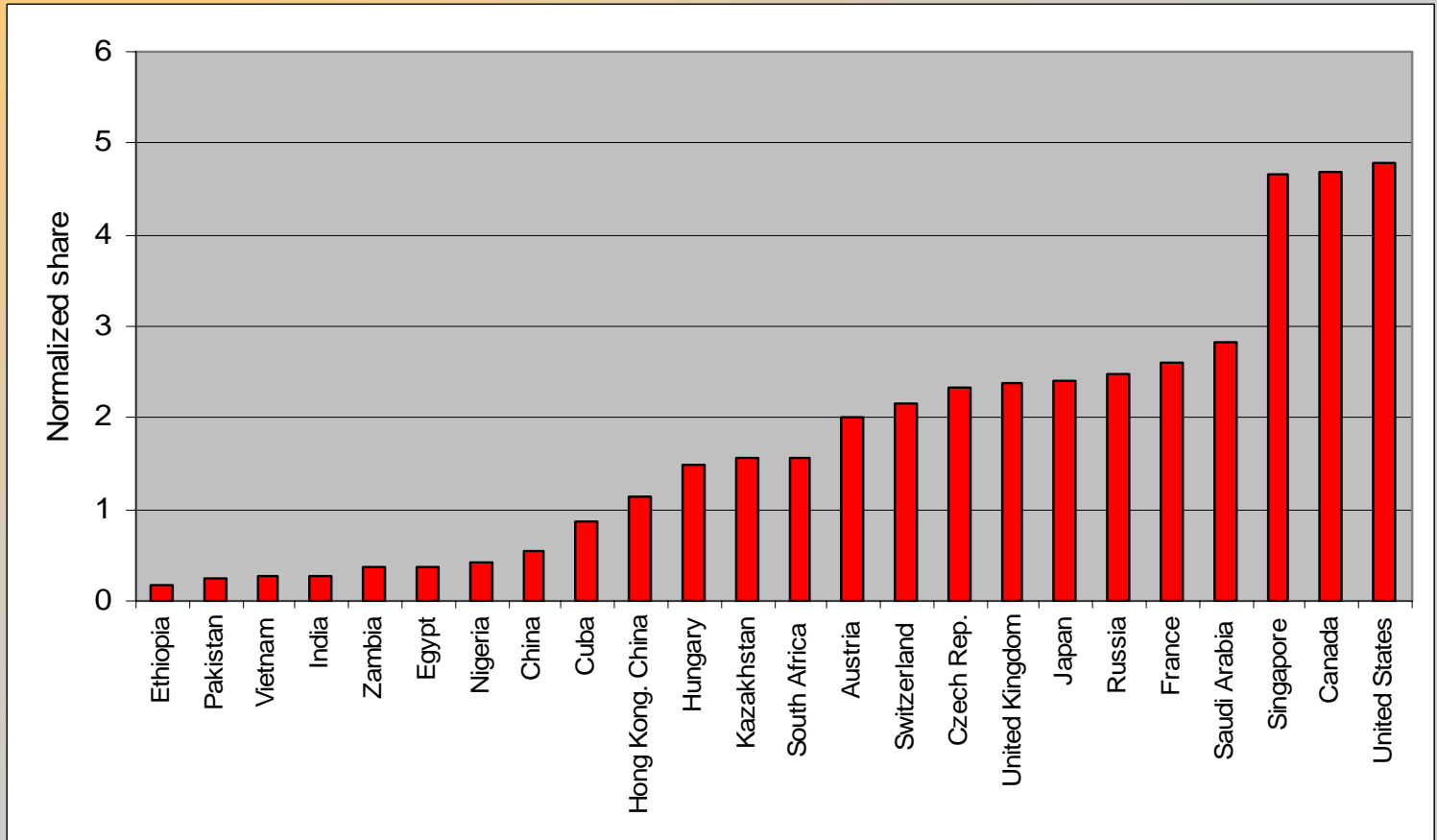
8. Take joint actions and improve efforts to work together at all levels to improve **access to reliable and affordable energy services for sustainable development** sufficient to facilitate the achievement of the millennium development goals, including the goal of **halving the proportion of people in poverty by 2015**, and as a means to generate other important services that mitigate poverty, bearing in mind that access to energy facilitates the eradication of poverty. ...

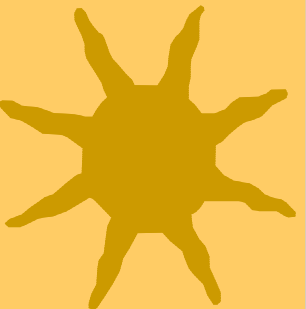
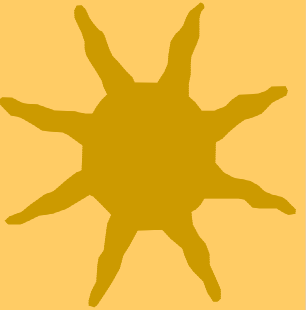




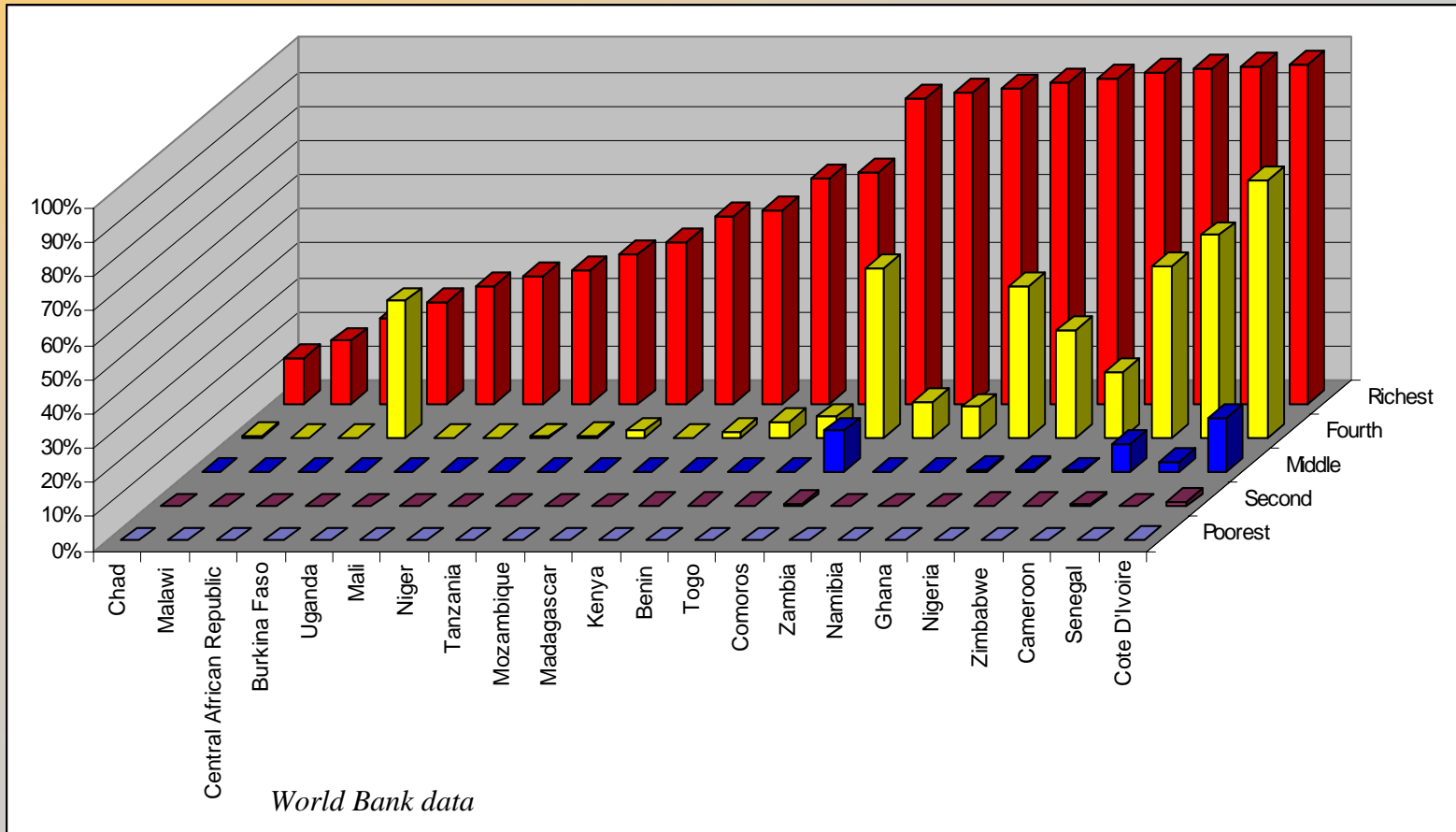
# Share in the global energy use

$$\text{Energy SHARE} = \frac{\frac{(\text{Total energy consumption of the country})}{(\text{Total energy consumption of the World})} \times 100}{\frac{(\text{Population of the country})}{(\text{Total population of the World})} \times 100}$$





# Percent distribution of households with access to electricity







# Options for Rural Energy project design

- ***The public service concept:***

Energy is a service of the Government to its citizens financed from a combination of taxes, grants, loans, etc. similar to roads, sewerage systems, etc.

- ***The “washing machine” concept:***

Energy investment is basically an expenditure. Like a washing machine, it frees the women from tedious domestic work, but in itself it does not generate additional income.

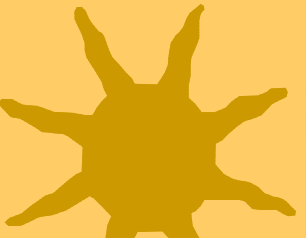
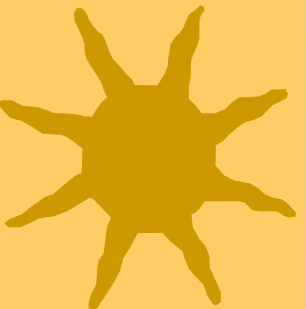
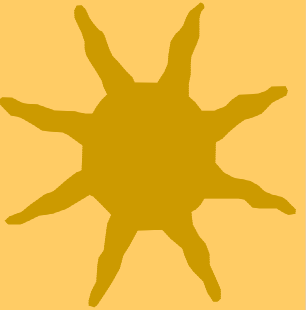
- ***The enterprise concept:***

Energy generation and use are for creating profit and require investments by an individual or a group in order to develop an enterprise. The profit may be derived from two separate means: (a) the services provided by the generation facility are sold and/or (b) other productive activities are promoted (food processing, textiles, metal working, water pumping, etc.)





# *Main Elements of UNIDO's Energy Programme*



- Access of the poor to energy (particularly renewable energy)
- Promotion of RET
- Rational energy use
- Cleaner production Technologies
- Climate Convention/ Kyoto Protocol





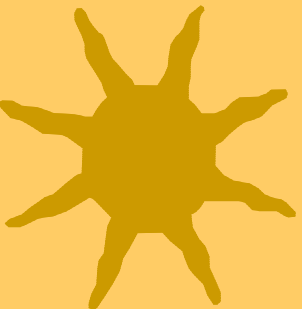
# *Renewable Energy Sources*

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## ★ Solar Radiation

- wind energy
- water power
- biomass

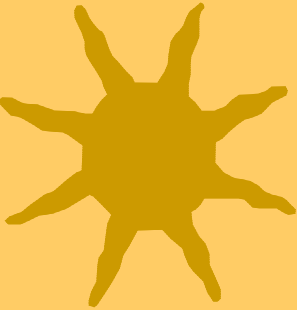


❖ geothermal heat





# Conversion Technologies



## Solar Radiation into

- Electricity by Photovoltaic
- Heat (low, medium, high) by Solar Thermal Collectors



## Wind into

- Electricity
- Mechanical drive for pumping etc.



## Water Power into

- Electricity
- Mechanical drive for milling, grinding, manufacturing

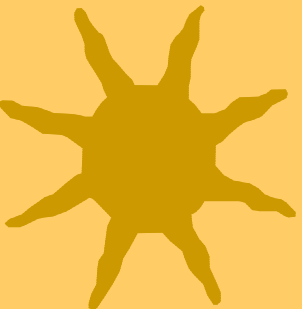
## Biomass into

- Heat (cooking, lighting, processing)
- Electricity (gas fuelling combustion engines).





# *Conversion of Solar Radiation*



## **Photovoltaic (PV)** for electricity generation.

- Time distribution of demand pattern have to be matched by storage (normally lead acid batteries, recently hydrogen technology is under development).

## **Solar Thermal Applications** (Solar Thermal Collectors)

- Low temperature applications (green houses, glas covered flat plate collectors) for crop drying, preparation of warm water ( $T < 70$  degC)
- Medium temperature (process heat) for agro processing (tea, coffee, tobacco, etc.)  $T < 120$  degC
- High temperature applications (sun tracking concentrating systems) for steam production for sterilization and cooking, power generation in hybrid steam turbine plants.  $120$  degC  $< T < 600$  degC.

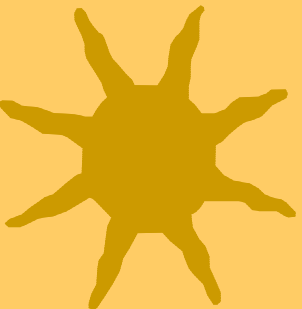




# *Conversion of Wind Power*



## Wind Energy Converters WEC



- Electricity Generation (grid connected wind parks, and off grid stand alone WEC,).  $P_{\text{rated}}$  up to 2 to 3 MW per machine, up to 15 MW per wind park (2 to 3 blade high turning speed machines)
- Water pumping for irrigation of farms etc. Direct mechanical drive of a pump by multiblade low turning speed machines





# Conversion of Water Flow

- Small Hydro Power Plants (HPP) (without storage dams) for electricity generation and use of mechanical shaft power. Pelton-, Cross Flow Turbines,  $P_{\text{rated}}$  up to 0.5 MW
- Medium HPP with small storage dams, for electricity generation. E.g. Pelton-, Francis Turbines  $P_{\text{rated}}$  up to 2 MW
- Water hammer (hydraulic ram) for water lifting up to 100 m
- **Big scale HPP including dams covering large areas ( $P$  more than some hundred MW) are not considered as RET, because of the big changes of environment and society**





# *Conversion of Biomass*



- Improved efficiency in burning of fire wood,
- Use of organic agricultural residues for heat production, briquetting.
- Gasification technology
- Gas production (biogas, generator gas) for combustion engines (electricity generation, shaft power), from agro and municipal waste



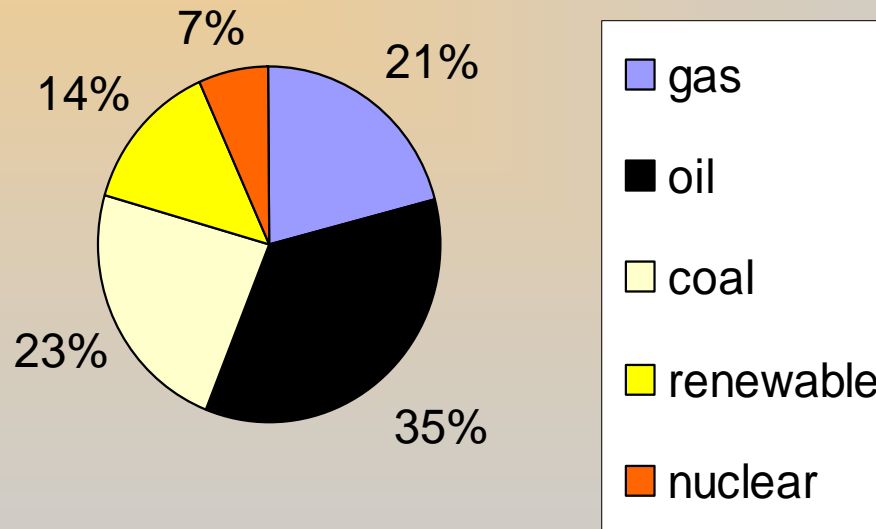


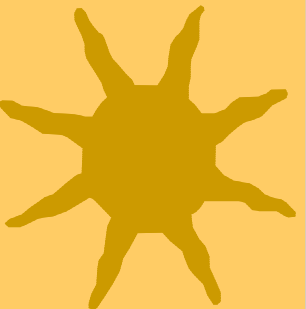
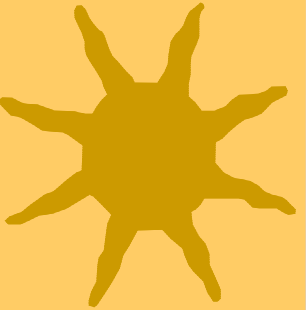


# *Present World Energy Distribution*



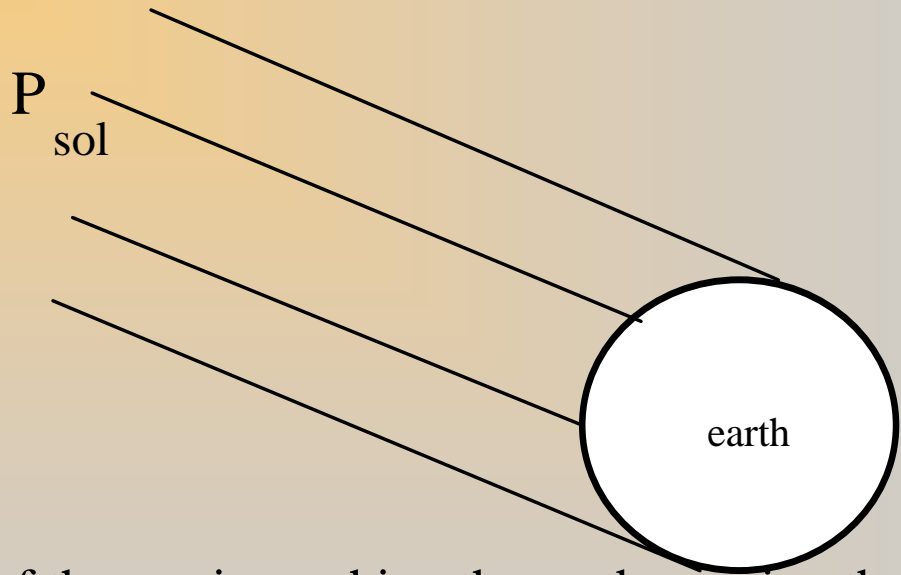
**fuel share in world total primary energy supply**





# Renewable Energy Potential

## General Potential



- ★ Radiation of the sun is reaching the earth, passing through the atmosphere (gases, water vapor, clouds, dust, etc.), losing energy by reflection and absorption



# *Renewable Energy General Potential*



- $P_{\text{solar}} = 10^{17}$  W permanent global solar power input to the earth outside the atmosphere
- $\text{Eff} = 2\%$  available (after atmospheric and conversion losses)
- $A = 5\%$  surface area of the earth used for conversion
- $N = 10^{10}$  future world population.



➤ **1 kW/cap solar power consumption available per person.** (about 4 times more than used in e.g. Europe)

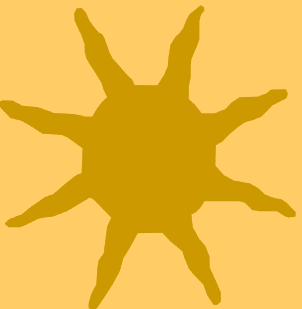
### **Problems:**

- **geographical and time distribution of availability and demand (storage)**
- **technical conversion and financing**



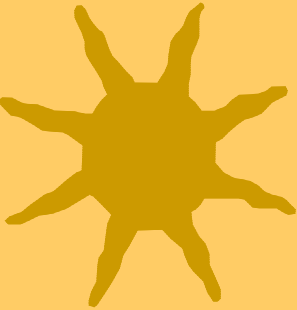


# *Potential Application of RET*



- ★ RET can cover demand not yet provided for by grid service and other energy infrastructure without further GHG emissions
- ★ RET can amend and complement existing energy service infrastructure based on fossil and nuclear technologies
- ★ RET can provide energy service on small scale and to areas far/long distance from utility grids
  
- **Thus, RET can be used as an instrument for income generation and poverty alleviation mainly in developing countries**

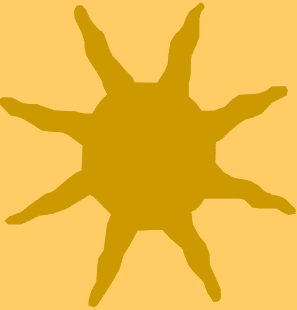




# *Barriers to RET implementation*

- Low energy flow density in RE inputs (radiation, wind) normally is not allowing for high peak load supply
- High investment capital demand increases capital costs. However, low operative capital is compensating, if financing schemes are available
- “from the shelf solutions “ are normally not matching a given demand; on site demand and supply analysis has to be done
- Human capacity and awareness of RET options are not as common as needed for sustainable operation.
- **Market economic and financial constrains**
- **Policy and regulatory frame work barriers**
- **Lack of consultation, co-ordination and co-operation as institutional barriers**





# *Barriers to RET implementation*

- **Luck of Business and Technical infrastructure**
- The provision for energy is often perceived from the comfort of living point of view, neglecting its role as a facilitator in rural and economic development-both by consumers and decision makers
- Little imperial knowledge of the costs and benefits of the range of technologies available for providing RET based modern energy services exist, and thus it has not been extended to policy and decisions makers
- Limited in-country capacity for renewable energy data collection and analysis is an important barrier for project development and implementation.
- **Information exchange, awareness and human resources limitations**

