lights, a battery, a controller and a 12V outlet, are technically very well suited to meet this distributed stand-alone demand. "Solar homes" based on this concept has become a worldwide phenomenon but continued satisfaction and expansion depends upon careful planning and institutional arrangements for their financing and maintenance.

5. Popular Choices for Renewable Energy

5.1 Solar Energy

Direct use of solar energy by converting it into electricity by the photovoltaic effect can be used for providing hot water and space heating using PV modules. Taken from [17] is the spectral response for solar cells given below.

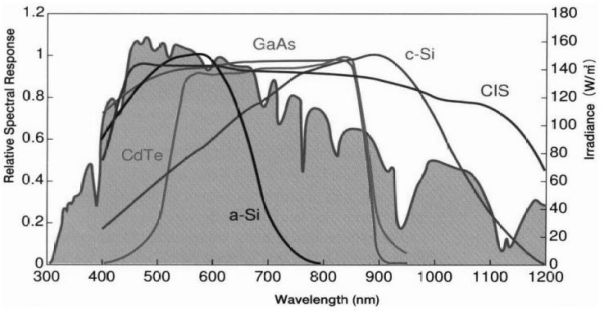

Figure 1: Spectral Response of Solar Cells

Solar energy can also be concentrated by mirrors to provide high temperature heat for generating electricity. Such solar thermal-electric power stations are in commercial operation in the USA [7]. Given below is the chart of materials used for making photovoltaic (PV) cells taken from [16].

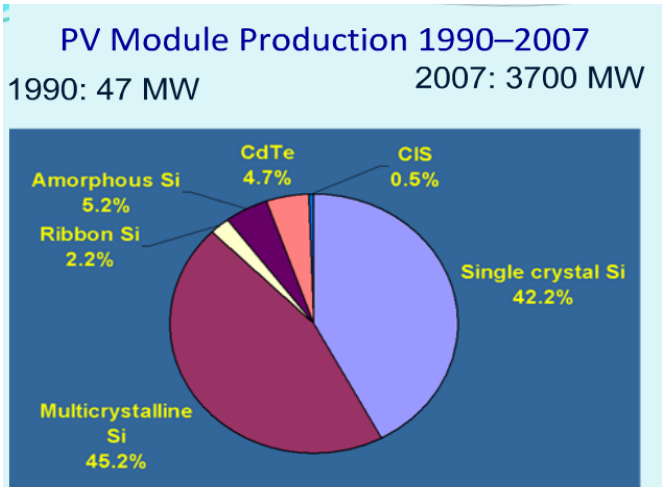

Figure 2: Material for PV cells

5.2 Hydro Electric Energy

Hydropower is an established technology that accounts for about 20% of global electricity from renewable energy sources. The energy of the water is either in the form of potential energy (reservoirs) or kinetic energy (e.g. rivers). In both cases electricity is generated by passing the water through large water turbines.

5.3 Tidal Energy

Tidal power is a special form of hydropower that exploits the bulk motion of the tides. Tidal barrage system trap sea water in a large basin and the water is drained through low-head water turbines.

Table 1: Existing Plants

Site	*Mean Tidal Range (m)*	*Basin (sq-km)*	*Installed Capacity (MW)*	*Approx Output (GWh/yr)*	*In service (year)*
La Rance (France)	8	17	240	540	1966
Kislaya Guba (Russia)	2.4	2	0.4	-	1968
Jingxia (China)	7.1	2	3.2	11	1980-86
Annapolis Royal (Canada)	6	6	17.8	30	1984

In recent years, rotors have been developed that can extract the kinetic energy of underwater currents. It is often confused with wave energy, but its origins are different. The power of the tides can be harnessed by building a low dam or barrage in which the rising waters are captured and then allowed to flow back through electricity-generating turbines [8].

5.4 Wave Energy

Places where wind blows over long stretches of ocean, they create waves, and a variety of devices can be used to extract that energy. Wave power is a huge resource is largely untapped. It is attracting new funding for research, development and demonstration in several countries particularly in the United Kingdom (UK).

5.5 Ocean Thermal Energy Conversion (OTEC)

The ocean is the world's largest solar collector. In tropical seas, temperature differences of about 20-25°C may occur between the warm, solar-absorbing near surface water and the cooler 500-1000m depth the warm, solar absorbing near surface sea water and the cooler 500-1000 m depth "deep" water at and below the thermocline [9]. Taken from [15], given here is the animation of how a closed cycle OTEC power plant would look like.

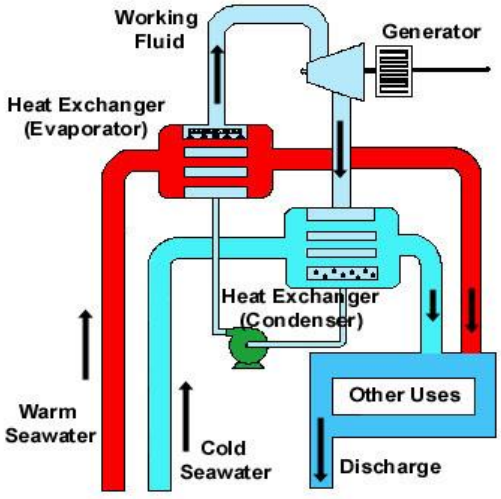

Figure 3: The OTEC cycle

Using the laws of thermodynamics, heat engines can operate using this temperature gradient. OTEC systems convert some of this thermal energy into useful work for electricity generation.

5.6 Wind Energy

The international oil crisis of the 1970s and recent concern over global warming have renewed interest in wind power. The wind power is a carbon-free and pollution free source of energy and wind power could produce globally 10-20% of the electrical power currently used. Growth of this sector is given in the figure below taken from [18].

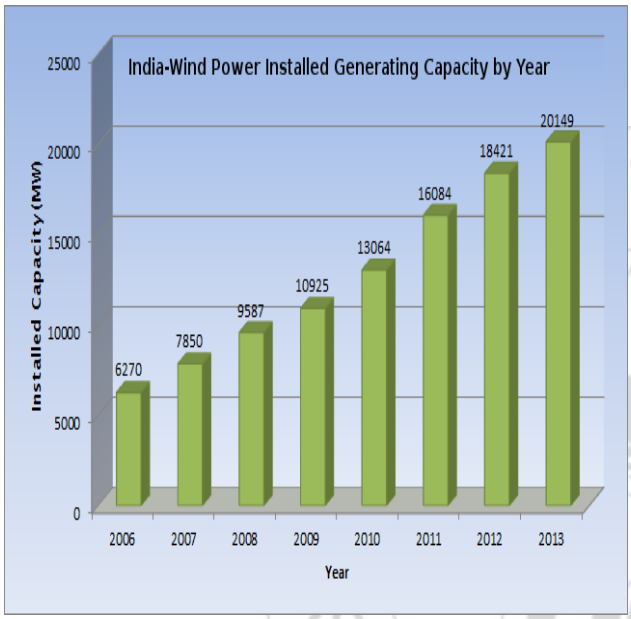

Figure 4: Progress in India's installed wind power generating capacity since 2006

The modern wind turbine is some hundred times more powerful than the traditional windmills of the seventeenth and eighteenth centuries and wind farms already produce significant amounts of energy in some parts of the world [10].

5.7 Bioenergy

The process of photosynthesis in plants with the help of solar radiation coverts water and atmospheric carbon dioxide into carbohydrates, which forms the basis of more complex molecules; Biomass, in the form of wood or other biofuels is a major world energy source, especially in the developing world.

5.7.1 Biodiesel

Ethanol contains oxygen and when used an auto-fuel mixed with petrol, improves combustion efficiency and reduces air pollution significantly. Ten percent ethanol blended with petrol cuts particulate matter in half and reduces smog producing emissions by as much as 25 percent [11]. Ethanol blended petrol is being used in Brazil for nearly 28 years now. In November 2004, it introduced two percent soya based bio-diesel blends in petro-diesel for diesel vehicle. Nowadays, biodiesel is a popular choice in Europe and Canada. In China biodiesel is produced from date expired food grains unfit for human consumption [12]. Thailand, Malaysia and Indonesia are planning palm oil based bio-diesel facilities.

5.8 Hydrogen & Fuel Cells

Hydrogen is the most abundant element in the Universe which makes it an attractive alternative and fuel cells can be the machines where hydrogen is fed to produce energy. The overall chemistry for fuel cells is given in Figure 5 [19].

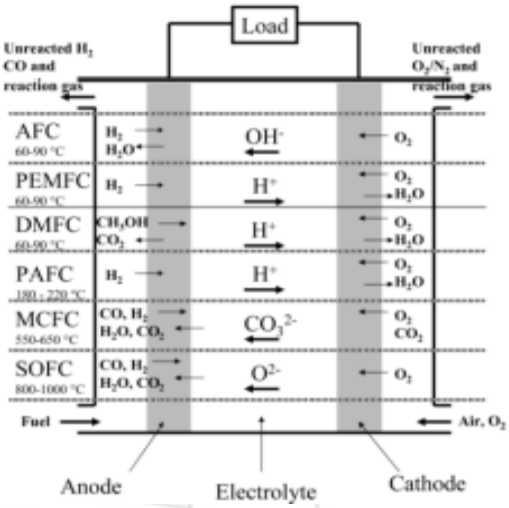

Figure 5: Types of Fuel Cells

Fuel cells technology covers stationary, transportation and consumer electronics.

6. Integration and Sustainability

After the 1973 oil shock, many countries looked towards renewable energy technologies. India has invested more on hydel, thermal, nuclear energy earlier. Today the paradigm shifts towards wind, solar and biofuels. As with all renewables the initial capital cost will be relatively large compared with regular income, and so beyond the means of most potential customers. Micro-financing is widely practiced in Africa, Sri Lanka, the pacific Islands and elsewhere. Grants and other mechanisms are adopted by industrialized nations in such regard. Integrated resource planning will lead to energy security of renewables for a healthy environment.

6.1 Concerns pertaining to sustainability

6.1.1 Financial Costs & Benefits

Assessment in terms of benefit for the owner, the end-users or the nation itself has to be considered. For example, the actual cost of damage from pollution emitted by a centralized coal-burning electricity power station (corrosion from acid rain, climate change from greenhouse gases, cleaning contaminated effluents, etc.) are mostly not included in the internal financial accounts of the electricity generating company, or its customers, but are paid by others [13]. Issues like loss of biodiversity are also not considered. If we consider a PV (photovoltaic) system for that matter external

costs relating to such are very low. However high initial capital cost for PV system makes it less preferable to fossil fuel based power stations, as its many issues are not considered in financial accounting.

6.1.2 Analyzing the system & related Parameters

Identification is to be made between the energy source and the end use service. For example, householders lighting house are interested in amount of illumination and tariff rates i.e. end use service. However, the cost of a clock battery is never considered in terms of Watt-hour delivered but in terms of how long the service is provided.

6.1.3 Relative Application

Intermittent nature of renewable energy systems are well known fact and it being site-specific is also another issue. Since they are designed to tap into natural flows of energy, it is obvious that a particular system would be cheapest where appropriate flow exists [14]. Thus hydroelectric systems are feasible where there is a flow of water. Biomass dependent systems depend on cost and availability of the biomass feedstock.

6.1.4 The Payback Period

Renewable energy systems generally have small operational costs and large initial, capital cost. A fossil fuel plant has the reverse, especially if there is no emissions prevention [3]. Some policy tools may help resolve this dilemma.

7. Conclusion

Energy and environment has unfolded an entirely different platform to humans in the contemporary world, where once the much in demand fossil fuels are now being termed destructive. Renewable energy in the form of solar, wind and others can be a salvation for it. Intermittent nature of renewables is an issue of concern but fuel cells and hydrogen seem to have that covered. Where once we began with coal, to petroleum, to natural gas, to methane and an eventual shift towards the hydrogen economy now seems inevitable.

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