A short Outline

"WORLD NEEDS NEW ENERGY SYSTEMS

Low Carbon, Carbon-Neutral & Renewable Energy Systems"

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Till recently the energy needs of the world were being met by burning fossil fuels like coal and oil. That has given rise to huge emission of greenhouse gases leading to anthropogenic global warming with apprehension of catastrophic climate anomalies. Hence time has come to switch over to newer benign fuels with least or no carbon emission.

		Table 1			Table 2		
12.4% Hydro 21.6% Nuclear	World Major Electrical Energy			World Renewable Electrical Energy			
	Sources			Power	Energy	%	
	Power Source	Energy	%	Source	(GW-h)	Total	
		(GW-h)	Total	Biomass	151,651	1.45	
				Waste	62,949	0.6	
	Coal	3,925,766	37.5	Geothermal	29,228	0.28	
	Gas	2,181,239	20.8		,		
	Oil	3,181,239	3.7	Solar PV	3,911	0.04	
3.7% 20.8 Gas oil	Nuclear	2,262,217	21.6	Solar Th	681	0.01	
Fig. 1	Hydro	1,296,291	12.4	Wind	149,405	1.43	
	Renewable & Non-Carbon Energy Systems	402,034	4.0	Tide	550	0.01	
				Other	3,659	0.03	
	Total	10,449,059	100	Total	402,034	3.85	
	Sou	rce: EIA 2007		IUtal	402,034	5.65	

Current World Energy Scenario & It's Changeover in 21st Century

Two major fossil fuels, coal and petroleum gas dominate the world electrical energy scenario today. The transportation sector – automobile, railways, aviation and shipping are all generally served by the petroleum fuel. The coal serves mostly the world electrical power sector. Both these fossil fuels heavily pollute the atmosphere with GHG emissions.

From the Table 1 and the Pie diagram, we see coal power constitutes 37.5 per cent and oil 3.7 per cent, two together combine over 40 per cent of total fuel consumption. The only redeeming feature is that natural gas constitutes 20.8 per cent, for gas fuel emit very much less GHGs.

Even today carbon-free renewable energy contributes about 4 per cent of electrical power (see Table 2)

I. Proven Low Carbon Energy Systems – Clean Coal and Gas

Clean Coal: The coal is the dominant fuel for large power plants, the fuel that is readily available till alternative non-carbon fuel source is technologically and commercially established. Hence, an emerging nation like India has no option but to commission coal-based power plants to meet the energy needs of its growing economy. But to limit the carbon emission, the Government of India has promulgated an order that all new coal thermal or even NG power system must have the above supercritical technology. Accordingly this is the dominant system under implementation nationally today with ten nos. ultra Mega Power Projects (UMPP), 10x4000 MW and all other power projects of NTPC and other private sector projects are being executed with the above technology for the first time in the country. These huge steam Power projects will attain 40-45% efficiency, unheard of in this country before and will substantially bring down the carbon emission per MW energy unit.

Further to contain and control the emission of carbon dioxide, CCS (carbon capture and Sequestration) technology is under development which separates out the CO_2 from the emission gases and compresses and stores it in the various voids and caverns underground.

Natural Gas: Secondly, Natural Gas (NG) which, of all the fossil fuels, has the least carbon content at 15.3 kg/GJ compared to 26.8 of coal and 20.0 of oil. Besides, natural gas has wide and efficient applications as transport energy, domestic heating and also as power plant energy. Hence pending the evolution of universal non-carbon energy, both clean coal and natural gas supported by CNG/LNG have yet to play important roles for at least two ensuing decades.

II. Carbon-Neutral Energy System

The Hydropower and Nuclear power, the two prominent well-developed non-carbon energy sources, are already fulfilling a large part of the present global power needs.

Hydropower: But the hydropower is capital intensive and its availability is likely to fall short of the world's needs.

India is already producing nearly 40,000 MW hydropower at 25% of the total power generation. The Indian potential hydropower is 150, 000 MW. The expansion programme is getting halted from the environmental consideration in the execution of mega Hydro Projects. Even then the target has been fixed at 64,000 MW to be reached by around 2022 with medium sized hydro-station.

Nuclear Power: Nuclear energy is also capital intensive and it poses safety hazards as presented lately by tsunami-hit Fukushima nuclear plant. In spite of the repeated assertion of the majority scientific community of its tremendous progress in nuclear safety, the public fear persists at the national and international levels. Though for large countries like China and India, the nuclear energy can meet a large part of its enormous future power needs.

That India has achieved high level of technological expertise in nuclear technology is now well-recognised worldwide. However, the Nuclear power capacity is a modest 7280 MW with 23 Reactors to be commissioned by about 2012. But with the signing of Nuclear Power Treaty, an ambitious target has been set at 63,000 MW by 2022, aided by import LW Reactors in four major sites in Mitha Virdee, Gujarat, Jaitapur in Maharastra, in Kundakulam in Chennai and Andhra Pradesh. One sites in Orissa and one in Haridaspur in West Bengal are presently stalled.

III. Renewable Energy Systems

Next we have the basket of renewable sources like biomass (bio-ethanol, bio-diesel & bio-gas), wind and solar energies which are now under intense study and development for large scale power applications. The world is looking forward to them to save the earth of the catastrophe of the intractable problems of carbon emissions and the consequent global warming. There would be really two huge beneficial contributions of the renewable energy sources. Firstly they are inexhaustible sources of energy as long as total demand is within the earth's capacity to renew them over a crop season or year. Secondly, they do not contribute to the global stock of carbon emission. The bio-fuels do emit carbon dioxide, but they are reabsorbed back into the biomasses that are regenerated continuously. Therefore there is no cumulative carbon accumulation in the atmosphere.

Thus in India, leaving out the Hydropower, we have three types of Renewable energies sources in plentiful:

1. **Bio-Energy:** Two main programmes under this scheme pertain to **Bio-ethanol** and **Bio-diesel.** We cannot say the progress is commendable, though a lot of support was extended by the former President of India Dr. Abdul Kalam.

A third form of bio-energy is **Biogas**, which can be produced from solid biowaste or from fresh plantation, eminently suitable for smaller power plants.

- **2. Solar Energy:** Here there is a strong Jawaharlal Nehru Solar Energy Mission targeting a stiff target of 20,000 MW capacities by 2020, of which rooftop system to amount to 10,000 MW. There are now heightened programmes under the mission.
- **3. Wind Energy:** India has already achieved a remarkable target of 9,000 NW, being placed at the 5th position globally. The wind energy is a growing sector in India. The Indian company SUZLON, which has bought over the German company RE Power, which makes it a world's major company

IV. Futuristic Hydrogen Fuel & Fuel Cell Power

Hydrogen Fuel: We will now shift our attention to a futuristic non-carbon fuel Hydrogen which has immense potentiality. As and when the hydrogen energy technology is fully developed with proven economic and commercial viability, it will impact the world in such a fundamental way that a whole new Hydrogen Economy will open up.

Hydrogen is enormously energy-rich, one kilogram of hydrogen contains 120 MJ of energy compared to 45 MJ of gasoline or petrol. The problem with hydrogen is that it is the lightest material that exists and hence storage of high volume hydrogen raises yet unresolved logistic problem. Secondly, though an unlimited amount of hydrogen is available in the ocean waters, hydrogen does not exist in free form; extracting hydrogen from water requires energy expenditure which makes it costly; further net energy recovery from hydrogen goes down substantially; thus the economic viability is affected too. This loss is largely compensated by the high energy conversion efficiency of Fuel Cell, which is the engine of conversion of hydrogen into electricity, which we describe briefly now.

Fuel Cells: A Fuel Cell (FC) is an open electrochemical conversion device, generating electricity at much high efficiency (above 70%) than the electromechanical engine-generator device. During operation, a fuel, hydrogen or hydrocarbon, and an oxidant are fed separately at two electrodes anode and cathode respectively of a FC continuously. An electrolyte offers a path for ions to migrate, proton from anode to cathode in case of PEMC Fuel Cell or cation from cathode to anode in case of a SOFC (Solid Oxide Fuel Cell), thus allowing electrons to flow through the anode to the external circuit. An SOFC Fuel Cell is shown in Fig.2.

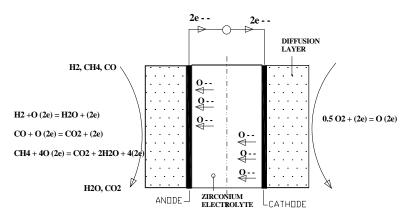


Fig. 2 SOFC (Solid Oxide Cation Exchange FC)

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