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Non-Conventional Energy Sources: Current Scenario and Future Trends – A Key-Note Address

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Introduction

Today the energy sources are dominated by fossil fuels contributing 88% of the total world energy consumption, while hydroelectricity and nuclear energy contribute only about 5% each, as seen in Table 1: (BP Statistical review 2010)

	MTOE	% of Total
World Energy Consumption	**11164**	
Oil	3882	35
Coal	3278	29
Gas	2653	24
Hydroelectricity	740	7
Nuclear	610	5

Table 1: Total world energy consumption in 2010

In comparison all the renewable energy sources contribute about 1% and the break up is:

	MTOE
Bio Fuels	
Ethanol	44
Biodiesel	14
Other Renewables	
Wind	89
Geothermal	13
Solar	4

Table 2: Consumption of renewable energy during 2010

The introduction of new unconventional energy source undergoes several transition stages. Initially it is unproven dream of a few pioneers. It is uncertain and unreliable. However, if it can generate about equivalent of 500bopd (25000TOE per annum) then it is a **promising** new energy source. By the time the source supplies 1% of the total world energy it is a **potent** unconventional energy source likely to graduate further into **significant** source supplying 5% of total energy consumption or gain a place even as a **Major** energy source contributing more than 25% of the total energy.

We need to appreciate if the new source requires non renewable natural resource like mineral or ore, then its development in first place depends on the nature's endowment. Maturing of the technology for scales and safety, development of niche applications, social We shall attempt and classify the various unconventional sources on these lines. Generally, it takes three to four decades for the energy source to progress from **Promising** to **Potent.** Therefore, in the time frame from now to 2050 only the promising energy sources of today may contribute significantly to the energy mix.

Oil is the most versatile and highly concentrated energy source. Today adequate infrastructure exists for exploiting this from one corner of the world and utilizing it at any other place. The transport sector heavily and almost entirely (nearly 95%) depends on this source. Therefore, any unconventional source augmenting oil will naturally have advantage of having a ready and huge infrastructure, like upstream technology, downstream refining capacity, pipeline and tanker transportation, retail delivery points and above all close to billion vehicles and tens of thousands of airliners critically depending on the fuel.

Therefore, in the face of all geo-political, logistic and technological difficulties, the unconventional energy sources promising oil will be at the top of priority list.

Oil sands, heavy oil, deepwater exploration, tight oil (shale oil), coal to liquid (CTL), gas to liquid (GTL), arctic exploration, oil shale and bio-fuels fall in this category. Energy from these sources is expensive and therefore development depends on the oil price.

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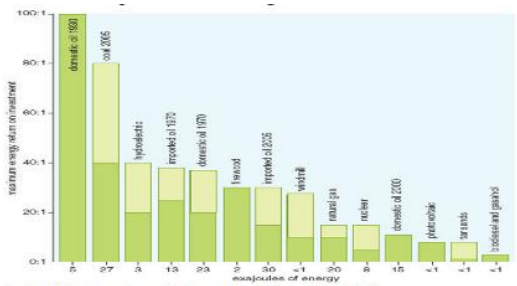
Oil sand, heavy oil and deep water exploration (>500mts.) are already **potent** technologies. Coal to liquid and gas to liquid contribute to oil production significantly in South Africa (160,000BOPD) and Qatar (140,000BOPD) respectively.

Some of these sources like oil sands require considerable energy input. Oil sand also requires water. CTL and GTL are transformations of energy sources in their own right and have energy penalty.

But the major problem for expansion of oil sands, extra heavy oil, CTL and GTL is the CO2 penalty. Oil sourced from these contributes to green house gas emission in the processing stage. Therefore, the fate of these technologies depends on the future stand on the issue of global warming.

Arctic exploration is yet in nascent phase and work on exploitation of oil shale has not begun except for some use of shale as a fuel directly in thermal power plants.

Bio-fuel is altogether a different issue. The production contribution is already a million barrels per day. The driving force here is its appeal as a green fuel to fight global warming. As to the energy source the amplification factor (EROEI) is at the best 1.4:1. With 1 unit input of fossil fuel energy, we get back 1.4 units of bio fuel. What it means is 70% of the energy generated is required or is consumed in producing it. For comparison, EROEI ranges for various conventional and non conventional energy sources are plotted in the figure below.



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Biofuels directly compete with food for inputs like land, irrigation, fertilizers and so on. Fertile lands are already under pressure for accommodating the ever growing population. Further, in case of palm plantation, clearing of jungles contribute so heavily to CO2 emissions that it will take decades of CO2 saving to compensate the initial GHG emissions. It is highly doubtful that in the face of demographic pressure, this source will ever expand.

Next unconventional source, which has many advantages of oil as a source, is natural gas. There is a well established infrastructure of pipelines. Natural gas is a cleaner source for power generation. It has already replaced oil as heating source and it is substituting oil in transport sector as a cleaner alternative. The next big development in this direction is the expansion of LNG infrastructure for liquefaction, transportation and gasification, which makes it possible to transport gas across the continents. Also the very first large offshore floating liquefaction facility will revolutionize the exploitation of offshore stranded resources.

CBM and Shale gas are potent sources contributing ~ 7TCF to the energy production. Huge resource bas is available for shale gas as well as CBM. The well established machinery of seismic surveys, logging, geochemistry and all other upstream tools are of great utility along with the drill data of large number of oil and gas well or shale gas exploration and exploitation. Shale, being source rocks of natural gas, their locations geographically coincide with the conventional gas fields and can share the infrastructure for evacuation. Horizontal drilling, multilateral drilling and massive hydro-fracturing are the technologies, which have brought this resource on the stream. There are problems on the environmental front, like sourcing large quantities of water for fracturing, disposing off the effluent loaded with chemicals, possible contamination of shallow water reservoirs and also suspected link between tremors and massive hydro-fracturing. All these problems are crucial because of demographic pressure in highly populated areas. Shale Gas will certainly graduate to Significant energy source category. This will more than compensate the decline in the established gas fields. Last year shale gas contributed 23% of US gas production. It was ~5 TCF, just shy of 5% of global gas production. Safe and clean fracturing fluid is necessary for making this source socially acceptable. Outside North America, shale gas exploration has just begun. The proven gas provinces are likely to prove rich in this resource.

Finally, we consider the renewable energy sources of non-fossil nature. Their renewable nature is of immense

importance for sustainability. The modern complex industrialized world with very large population requires increasing input of energy to keep it going. The Earth no more has the capacity to absorb and digest the huge waste generated from the use of fossil energy. The symptoms of accumulated toxic waste are seen everywhere. The deteriorating environment and natural dynamic balance of various cycles like carbon and nitrogen are disturbed. Some major consequences are global warming, acidification of oceans and dying coral reefs. Since the easily accessible and easily refined hydrocarbons are already exploited, exploitation of dirtier alternatives is required to meet the demand, making the problem more acute. The famous climate scientist James Hansen thinks that the window of opportunity to avoid catastrophe is closing fast and we have to wean ourselves away from fossil fuels.

It must be clearly understood, that if we treat the climate change problem seriously, then renewable alternative energy source must **replace and displace** fossil fuels and not augment them. Therefore, the crucial question is whether by drastically reducing the energy consumption, we can de-fossilize our energy sources? The alternatives at various stages of development are:

- Hydro
- Wind
- Solar PV
- Concentrating solar thermal
- Passive solar
- Geothermal
- Wave
- Tidal
- New generation nuclear

Hydroelectric power as renewable energy source is very well established. Today worldwide there are around 28000 dams and all large ones have hydro power stations. There are very few suitable sites left for development. There are many social problems at new sites. The submergence of habited area is the main problem giving rise to large number of displaced people. But for micro hydro project, the expansion is not possible as a result of saturation.

Wind is the most successful renewable energy. It has been growing very fast over last two decades and especially, in the last ten years, there has been a ten-fold growth. It is envisaged that by 2020, wind energy would achieve the goal of installed capacity of one terawatt. There have been spectacular progress in the technology and also the prices have been coming down. For on land installations, it is close to achieving grid parity in the cost of electricity. In fact, it is a **potent** technology and would soon be **significant**. But it is evident that as the base widens and highly favorable sites are saturated, the current high growth rate is unlikely to continue. None the less, with expansion in offshore wind farms, we can expect that impressive growth will still continue.

In terms of growth, Solar PV is not far behind Wind. Solar PV has increased at the rate of factor of ten in little over five years. Installed capacity at the end of 2010 was 50 Gigawatts and by the end of this decade, it is also likely to achieve the impressive one terawatt installed capacity mark. Strides in technology and entry of China in this field have led to steep fall in prices. China already has installed capacity to manufacture 50 million panels per annum. Solar PV is not constrained by limited sites. There is virtually no limit on its expansion.

The capacity factor of wind and Solar PV are smaller than the conventional sources, one terawatt installed capacity generates much less power than the same capacity thermal power plant. Then there is intermittent nature of these sources. Robust and cheap adequate storage is necessary to solve this problem. Several technologies are under consideration and development for storage of power.

Solar thermal plants of 50MW and more are under construction at a few places. The centralized large scale nature of the project requires high investments. In some experiments, the problem of storage has been addressed and heat storage is in-built to make the plant run round the clock. Solar thermal is a **promising** source of energy.

Geothermal energy as of now is a **niche** technology for hot spots and contributes more than 10 MTOE or 200,000 bopd. There are several agencies carrying out research and experimentation in Engineered or Extended Geothermal Systems. Two deep wells are drilled up to hot igneous rocks. The rock is then fractured in both the wells to make hydraulic connection between the wells. Through one of the wells water is injected which exchanges heat with the hot rock and is produced through the other well. A turbine is run on the produced steam and the water is re-injected.

When developed successfully, this will enhance the scope of geothermal energy practically without limits.

There are many other nascent technologies on the experimental stage. However, as noted earlier in case of successful energy sources, it takes about three decades for the technology to mature and start delivering about 1% of total energy consumption. Therefore, in next thirty years our options are limited to the unconventional resources discussed above

Several professional organizations like IEA, EIA, BP, and Exxon Mobil generate world energy outlook every year. In almost all of them the future is very similar to scaled up present with contribution of renewables increasing to about 5% or so. The unconventional hydrocarbon sources are expected to take care of the increasing demand of 1 to 2%. In almost all of these, the climate change has a passing mention but BAU reigns. Seldom, if ever there is a mention of PPOD (Post Peak Oil Decline).