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Clean Energy Technology Approaches of Mitigating Greenhouse Gases

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This paper intended to overview on the present policies for the promotion of clean energy technologies. Many of the new technologies that harness renewable energy, including wind, solar, geothermal, and biofuels will be economically competitive with the fossil fuels. The supply of all fossil and nuclear fuel sources is finite and their efficient use in meeting our energy needs should be a part of an energy and CO_2 reduction strategy. Energy conservation can play an important role in future energy strategy, because it can mitigate adverse impacts on the environment rapidly and economically. Increased use of nuclear power presents the possibility of additional carbon free energy use and its consequent benefit for the environment. With the introduction of high power Compact Fusion Neutron Source (CFNS), nuclear power could be made cleaner at an affordable cost, and become a more viable replacement for carbon heavy sources like fossil fuel. Wind energy technology has progressed significantly over the last twenty five years. Solar thermal power using concentrating solar collectors was the first solar technology that demonstrated its grid power potential. These solar technologies will continue improving, thus bringing the cost down, especially with the economies of scale. The population of the world has woken up to the adverse effects of greenhouse emissions including a catastrophic impact of climate change due to global warming on the flora and fauna. The relevant key issues and condition which influence any individual country and its specific policy for promoting energy conservation and deployment of renewable energy technologies are determined by resources, targets, and constraints, the resources of renewable energies and their technical and economic exploitable potentials are one important issue.

1. Introduction

Energy is one of the essential needs of a functional society. Energy production or utilization is often intertwined with consumption of other precious natural resources, such as minerals, forests, water, food, and land. For a more sustainable energy future we need to develop a rich set of energy technology and technology-intensive policy options. These options include increased efficiency of energy production and use, reduced consumption, a new generation of renewable energy technologies, nuclear options that can win and retain public acceptance, and means to use fossil fuels in a climate friendly way. In fact, environmental considerations affect virtually all aspects of energy decision making by government, the private sector, and increasingly, by

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consumers. The adverse impacts from energy include a vast legacy of prior damage, current pollution, and real prospect of continued ecosystem degradation for decades or more to come. These energy derived pollutants include gases, liquids, solids, or mixed phases, and that they may adversely impact a host of environmental media and ecosystems. Further, energy derived pollutants may act over a wide range of length and time scales (Table 1).

Table 1. Approximate Length and Time Scales for Selected Known and Potential Environmental Effects of Energy Production and Utilisation

Local	0.001-10 km
	e.g.,- Air Pollutants
	- Acute Respiratory Episodes: <1 d
	- Lung Cancer: 10-50 y
	- Mutagenicity: 1-5 generations
Regional	100-500 km
	e.g., - Acid Rain
	- Forest and Aquifer Damage: 1-20 y
	- Particulate Pollution
Global	5,000-25,000 km
	e.g., Climate Modification
	-Sea Level Rise } 30-100 y
	- Desertification } or more

Source: (Tester et al., 2005)

2. Climate Impact and Energy Strategy Plan

The valuation of global warming damages is extremely complex. Not only is the task difficult because of the large number of different impacts in all countries of the world that should be taken into account, but also as these impacts will occur in future decades and centuries one needs to estimate how these costs will evolve into the distant future. On top of the resulting uncertainties there are controversial ethical issues related to the valuation of mortality in developing countries and the choice of the discount rate for intergenerational costs.

In combating the impact of global climate change, the world faces unprecedented environmental, social, and economic challenges. As the Intergovernmental Panel on Climate Change's Fourth Assessment Report, the Stern Review, and other recent reports emphasize, the world risks devastating threats to our climate if no dramatic action is taken to reduce—*not just stabilize*—the levels of greenhouse gas (GHG) emissions. To compound the challenge, the need to reduce emissions comes at a time when the global economy is expanding and the worldwide demand for energy, infrastructure, and transportation is increasing rapidly (Avato and Coony, 2008).

Low-carbon energy technologies offer developing countries the best way to expand energy use to fuel their economies while simultaneously reducing global emissions (Katoch et al., 2009). As new technologies become available, they can contribute to reconcile the choice between development and emissions reductions. Instead of following the same technological trajectories as industrialized countries, these countries can move directly to advanced clean technologies. Currently, however, most of the clean technologies available are too costly for widespread use.

Electricity sectors are organized around a model of large centralized power-generating stations that distribute electricity to end consumers along a vast network of transmission and distribution lines. With such a highly coordinated system, it is more difficult to introduce a new technology that does not fit well with the other existing components.

3. Clean Energy Technology Roadmap

According to some estimate the 13.3% of the world's total primary energy supply came from renewable energy in 2003. However, almost 80% of the renewable energy supply was from biomass, and in developing countries it is mostly converted by traditional open combustion, which is very inefficient. Because of its insufficient use, biomass resources presently supply only about 20% of what they could if converted by more efficient, already available technologies. As it stands, biomass provides only 11% of the world total primary energy, which is much less than its real potential. The total technologically sustainable biomass energy potential for the world is 3-4 TW_e, which is more than the entire present global electrical generating capacity of about 3 TW_e. In 2003, shares of biomass and hydropower in the total primary energy mix of the world were about 11% and 2%, respectively. All of the other renewables, including solar thermal, solar PV, wind, geothermal, and ocean combined, provided only about 0.5% of the total primary energy (Table 2).

Table 2. 2003 Fuel Shares in World Total Primary Energy Supply

Source	Share (%)
Oil	34.4
Natural Gas	21.2
Coal	24.4
Nuclear	6.5
Renewables	13.3

[Source: Kreith and Goswami, 2007]

The relevant key issues and condition which influence any individual country and its specific policy for promoting energy conservation and deployment of renewable energy technologies are determined by resources, targets and constraints, the resources of renewable energies and their technical and economic exploitable potentials are one important issue. These conditions and the sources of renewable energies differ in a wide range between continents, countries and even on a regional scale inside individual countries. Major changes from business as usual are needed to shift the energy sector onto a sustainable track. All major reports on climate change confirm that such a shift will require some mix of the following clean energy technologies:

- Increased energy efficiency in power supply, demand, and transport
- Renewable energy—including wind, hydro, solar, geothermal power and biofuels
- Nuclear energy
- Fuel switching to less carbon-intensive fuels (for example, from coal to natural gas)
- Carbon capture and storage (CCS).

3.1. Clean coal technology development

Coal is the most prevalent and least expensive fossil fuel available. The estimated global coal reserve to production ratio is more than 200, implying that coal can continue to be consumed at current rates for more than two centuries, much longer than oil or gas. Many of the countries with the largest and fastest growing energy demand have substantial coal reserves, such as China and India. As a result, virtually all future energy scenarios predict the increased use of coal for power generation, notably in developing countries. In this light, technologies that increase the efficiency of power generation from coal and/or facilitate CO_2 sequestration are of critical importance for reducing the carbon footprint of fossil fuels (Clean Air-Cool Planet, 2006; Chafee et al, 2007).

The innovations have been developed and tested during the last few years aimed at reducing emissions through improved combustion and environmental control in the near term and in the longer term by fundamental changes in the way coal is preprocessed before converting its chemical energy to electricity. Such technologies are referred to as "Clean Coal Technologies" described by a family of precombustion, combustion/conversion, and post-combustion technologies. They are designed to provide the coal user with added technical capabilities and flexibility, and the world with an opportunity to exploit out most abundant fossil sources. These can be categorised as:

- Pre-combustion, where sulphur and other impurities are removed from the fuel before it is burned.
- Combustion, where techniques to prevent pollutant emissions are applied in the boiler while the coal burns.
- Post-combustion, where the flue gas released from the boiler is treated to reduce its content of pollutants.
- Conversion, where coal, rather than being burned, is changed into a gas or liquid that can be cleaned and used as fuel.

3.2. Nuclear energy with minimum waste

Bhat and Katoch (2009) have reported that the world over nuclear reactors is of the fission type, in which uranium atoms are split to generate tremendous amount of energy. In these commercial 'light weight reactors', uranium atoms are split by bombarding them with neutrons. The trouble is that the fission reactors also generate lot of radioactive waste, disposing of which is a serious problem. Several types of nuclear waste are produced in the process. One variety is the 'daughter atoms', the left over bits of the split atoms. These itself remain radioactive for centuries. That is irksome, but manageable. The material may be stored and monitored above ground for a few hundred years till it becomes harmless. The bigger worry is the new transuranic elements which get produced during fission, because they can stay radioactive for hundreds of thousands of years. This waste involves those atoms which absorb the bombarding neutrons but don't split in the typical "light water reactor" the workhorse of nuclear industry. These highly toxic "transuranics" include several kinds of plutonium. The standard fission reactors cannot split these new elements except for a small portion of the plutonium and they remain radioactive for hundreds of thousands of years. No wonder environmentalists are dead set against them, making nuclear energy hard to sell to a large section of the populace.

Dwindling fossil fuel supplies and global warming have compelled scientists and technologists to explore alternative and clean energy sources. In such a scenario, the process of nuclear fusion seems to be the appropriate answer. Unlike nuclear fission reactions in which nuclei of heavy elements split apart to produce energy, in fusion process, the lighter nuclei such as hydrogen fuse together under tremendous pressure and temperature, releasing huge amount of energy. Hydrogen, the ingredient for fusion reactions, is among the most abundant elements available in the universe. Since its existence, the earth has been receiving this power from the fusion reaction taking place at the heart of the sun. Fusion reactors in which atoms combine in place of splitting are still decades away, but pose no such problem. As we wait for pure fusion reactors to become a reality, there is a great near term potential use of fusion; the fusion neutrons can be exploited to clean up the “transuranics” generated in fusion reactors. With the introduction of high power Compact Fusion Neutron Source (CFNS), nuclear power could be made cleaner at an affordable cost, and become a more viable replacement for carbon heavy sources like fossil fuel.

3.3. Bloom energy

BEC (2010) has stated that Bloom Energy Server provides continuous onsite electricity from wide range of renewable or traditional fuel sources. Founded in 2001, Bloom Energy can trace its roots to the NASA Mars space program. For NASA, Sridhar and his team were charged with building technology to help sustain life on Mars using solar energy and water to produce air to breath and fuel for transportation. They soon realized that their technology could have an even greater impact here on Earth and began work on what would become the Bloom Energy Server. The Bloom Energy Server converts air and nearly any fuel source – ranging from natural gas to a wide range of biogases – into electricity via a clean electrochemical process, rather than dirty combustion. Even running on a fossil fuel, the systems are approximately 67% cleaner than a typical coal-fired power plant. When powered by a renewable fuel, they can be 100% cleaner. Each Energy Server consists of thousands of Bloom's fuel cells – flat, solid ceramic squares made from a common sand-like "powder."

The Bloom box is a new kind of fuel cell that produces electricity by combining oxygen in the air with any fuel source, such as natural gas, bio-gas, and solar energy. Sridhar said the chemical reaction is efficient and clean, creating energy without burning or combustion. He said that two Bloom boxes - each the size of a grapefruit - could wirelessly power a US home, fully replacing the power grid; one box could power a European home, and two or three Asian homes could share a single box. Although currently a commercial unit costs $700,000-$800,000 each, Sridhar hopes to manufacture home units that cost less than $3,000 in 5 to 10 y.

Bloom Energy’s management team possesses expertise across a number of relevant industries, including aerospace, high volume manufacturing, semiconductors, automotive, naval nuclear, and Silicon Valley startups. In addition to CEO Sridhar, the company’s board members include John Doerr, partner, Kleiner Perkins Caulfield & Byers; General Colin Powell, former U.S. Secretary of State; Scott Sandell, general partner, New Enterprise Associates (NEA); T.J. Rodgers, chairman, SunPower; and Eddy Zervigon, managing director, Morgan Stanley. Bloom Energy’s investors include Kleiner Perkins Caufield & Byers, representing the firm’s first clean tech investment, as well as Morgan Stanley, NEA, and Northgate Capital.

4. Conclusions

Energy is the life hood of industry; it is used to convert fuels to thermal, electric, or motive energy to manufacture all the products of daily life. Nearly all aspects of energy production, transformation, and use result in CO_2 emissions that accumulate in the atmosphere. The magnitude and scope of any future carbon valuation is still subject to substantial political risk. Consequently, the future value of GHG emissions is discounted significantly in investment decisions and does not yet provide sufficient incentives for RD&D investments. Balancing climate change mitigation and increased energy needs in developing countries poses a serious dilemma that can only be reconciled with new and improved clean energy technologies. The development of new technologies is widely dispersed between different institutions and countries. Limited opportunities for information sharing about future demands and future technological possibilities between technology users and producers also reduce incentives for innovation. With the introduction of high power Compact Fusion Neutron Source (CFNS), nuclear power could be made cleaner at an affordable cost, and become a more viable replacement for carbon heavy sources like fossil fuel. Bloom Energy Server provides continuous onsite electricity from wide range of renewable or traditional fuel sources.

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