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Ahmet Aksoy · Muhammad Sajid Aqeel  
Ahmad *Editors*

# Phytoremediation for Green Energy

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Editors

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 Springer

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# Contents

<b>1 Energy, Environment and the Future of Mankind .....</b>	<b>1</b>
Yuan Tseh Lee	
<b>2 Bio-fuels: A Blessing in Disguise .....</b>	<b>11</b>
O. Surriya, Syeda Sarah Saleem, K. Waqar, A. Gul Kazi and M. Öztürk	
<b>3 Engineered Phyto-Covers as Natural Caps for Containment of Hazardous Mine and Municipal Solid Waste Dump Sites– Possible Energy Sources .....</b>	<b>55</b>
M. N. V. Prasad	
<b>4 Chromium and Nickel Phytotoxicity and Genotoxicity.....</b>	<b>69</b>
Agáta Fargašová, Bernd Markert and Karol Mičieta	
<b>5 Physio-Anatomical Responses of Plants to Heavy Metals.....</b>	<b>79</b>
Riffat Batool, Mansoor Hameed, Muhammad Ashraf, Muhammad Sajid Aqeel Ahmad and Sana Fatima	
<b>6 Integration of Different Bioindication Methods for Chemical Elements: The Multi-Markered-Bioindication-Concept (MMBC) .....</b>	<b>97</b>
Bernd Markert, Agáta Fargašová, Stefan Fraenzle and Simone Wuenschmann	
<b>7 Interaction Between Plants and Biosurfactant Producing Microorganisms in Petroleum Contaminated Absheron Soils.....</b>	<b>115</b>
Elmira Akhundova and Yamen Atakishiyeva	
<b>8 Phytoremediation of Crude Oil-Contaminated Soil by <i>Medicago sativa</i> (Alfalfa) and the Effect of Oil on its Growth .....</b>	<b>123</b>
Saeed Minoui, Dariush Minai-Tehrani and Malak Hossein Shahriari	

<b>9 Bioremediation of Petroleum Polluted Soils using <i>Amaranthus retroflexus</i> L. and its Rhizospheral Funji.....</b>	<b>131</b>
Fariba Mohsenzadeh and Abdolkarim Chehregani Rad	
<b>10 Reciprocal Effects of Oil-contaminated Soil and <i>Festuca</i> (Tall fescue).....</b>	<b>141</b>
Dariush Minai-Tehrani, Saeed Minoui and Malak Hossein Shahriari	
<b>11 Fundamentals of Hydrogen Production via Biotechnology (Bio-H<sub>2</sub>)....</b>	<b>149</b>
Nuri Azbar	
<b>12 Evaluation of <i>Senecio glaucus</i> L. and its Root-Associated Fungi for Bioremediation of Crude Oil Polluted Soils .....</b>	<b>175</b>
Fariba Mohsenzadeh and Abdolkarim Chehregani Rad	
<b>13 Root and Shoot Peroxidase Activity in <i>Festuca arundinacea</i> in Light Oil-Contaminated Soil .....</b>	<b>185</b>
Zahra Ghaffari, Sahar Shademan, Zahra Sobhani-Damavandifar and Dariush Minai-Tehrani	

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# Chapter 1

## Energy, Environment and the Future of Mankind

Yuan Tseh Lee

**Abstract** Charles Darwin who was born 200 years ago did remind us that “It is not the strongest of the species that will survive, or the most intelligent; it is the one most adaptable to change.” If the environment changes faster than the time required for a given species to evolve, the likely result will be extinction. With the fast changing climate and rapidly deteriorating ecosystem today, human species, with a life cycle of 30–40 years, are not likely to evolve and adapt as quickly. Unless humans manage to slow down the change of environment, the fate of extinction might be inevitable.

**Keywords** Energy crisis · Environmental degradation · Energy efficiency · Future of mankind

### 1 Recent Development of Human Society on Earth

After the appearance of our ancestor on the heavily forested planet a couple of million years ago, the development of the human society as a whole, was in harmony with nature. Mankind was indeed a part of nature, reliant on the sun for the creation of most of what was needed to survive. Since the population of mankind was small, for a long period of time their limited activities seemed to have affected neither the biosphere nor their living environment to any great extent.

The development of mankind took a new turn after the industrial revolution, which began about 250 years ago. As mankind learned to transform energy from one form to another—from chemical, thermal, electrical to mechanical—and invented various machines that could perform work thousands of times more powerfully, more precisely and more reliably than could be possibly done with human and animal labor, the productivity of mankind increased immensely and an unprecedented improvement of living standards was achieved. The success of mankind on the surface of the earth had been quite remarkable. But, during this process, mankind became addicted to the use of a large amount of energy, and since the energy from biomass created by sunshine no longer satisfied our need, we began to

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depend more and more on fossil fuels—coal, natural gas and petroleum—which were buried under the ground and took millions of years to accumulate. In USA in 1850, 90% of the energy depended on wood burning, but 80 years later, by 1930, 90% of the energy came from the combustion of fossil fuel. Fossil fuels also provided energy and feed stock needed for the production of various new materials, such as plastics, fertilizer, synthetic fibers, steel and cement, and regrettably man had drastically changed the intimate relation between man and the nature. Harmonious relations between man and the biosphere was disrupted, and the important role played by the sun in the development of mankind, or the philosophical view of Confucius: “Man and Nature are but one”, somehow seemed to have been forgotten.

As we entered the twenty-first century, we began to realize that the current development patterns of human society are not sustainable. Problems related to population explosion, natural resource depletion and the damage done to the living environment have become quite serious. In a sense, the earth was once regarded as “infinite” or “unlimited” for mankind, not only because of the resources available, but also due to the ability of the earth to digest all the waste produced by mankind. However, from the point of view of the damage done to the ecosystem or the living environment, the earth as a whole should be considered “limited” and “overdeveloped” at present. For example, carbon dioxide produced by human activities is far exceeding the capacity of the earth to absorb through the growth of the forest or coral reefs and other mechanism, and the global warming trend is threatening the very existence of human beings on earth. It is quite ironic that during the twentieth century, not only are the “developed” countries overdeveloped, the so-called “developing” countries are also overdeveloped. It is unfortunate that the so-called “developing” countries are following in the footsteps of the “developed” countries, and marching along the unsustainable path established by “developed countries” in the past, when the earth was still “unlimited”.

It is extremely important for mankind to wake up immediately and accede to the fact that human society as a whole is living beyond its means. We must learn to work together as a community to find new, sustainable ways to re-establish an intimate relation with the biosphere, live in harmony with nature, and to return to a more direct relationship with the mighty power of the sun. After all, it was the sun that brought us altogether here on the surface of the earth.

## 2 Issues on Energy and Environment

One of the most urgent problems man faces today is the problem related to the relationship between energy and the environment, especially the global warming trends caused by the emission of greenhouse gases, and the energy crises caused by the widening gap between the limited supply and rapidly growing demand for petroleum and other fossil fuels. The other problem, which menaces to wipe out large portions of humanity in a short time, is the spread of infectious diseases, like those caused by virus  $H_5N_1$ .

It is comforting to know that, at present, energy received by the surface of the earth in one hour is approximately equal to the total energy consumption of the entire world in a year. In other words, the amount of energy the surface of the earth receives is approximately ten thousand times the energy consumed by human society. It means that if we were clever enough, we can depend entirely on solar energy. For example, if an inexpensive and practical photovoltaic cell, that converts 10% of solar energy to electricity becomes available, it will only take 1% of the planet's land area to generate enough electric energy to satisfy the energy needs of the entire world. If the electrical energy generated by a photovoltaic cell could be effectively stored or used to electrolyze water into hydrogen and oxygen—or to even more directly dissociate water by using a combination of photovoltaic cells—it is not inconceivable that countries with large land masses could become energy exporting countries, nor that hydrogen gas might then become a major energy source as we enter the age of the “hydrogen economy”. If we learn to develop biofuel more efficiently, or to invent efficient “artificial leaf”, photosynthesis might provide enough biomass on earth to satisfy the need for liquid fuel and other chemical feed stocks now provided by petroleum.

To make it possible for the world to achieve sustainable development, we must do the following things to reduce our dependence on fossil fuel.

1. Increase of our energy efficiency, and improve the recyclable usage of materials.
2. Develop efficient renewable energy sources, e.g. photovoltaic cells, wind power generators, geothermal, ocean current and thermal energy conversion, and various biofuels.
3. Develop a new generation of safe nuclear reactors and appropriate waste disposal technology and fusion reactors.
4. Examine our population policies and the way of life. We need to learn to live simpler and more frugal lives.
5. Protect our living environment and ecosystems, and maintain biodiversity.

Although our current scientific knowledge and technology enables us to get it started, there are many challenging scientific problems awaiting a solution. For example, in photosynthetic processes, most of the solar energy is stored in the fiber plants rather than carbohydrates. Although the production of alcohol from sugar cane or corn has been effective and successful, the challenge lies in the effective production of alcohol from fiber through hydrolysis and fermentation. For harvesting energy from geothermal, ocean flow and thermal energy conversion, new engineering technologies need to be developed.

With concerted efforts, which include the development of various renewable energies, changes to our way of life and social structure, 40–50 years from now, we could become largely free from the use of fossil fuels. We will be again like our ancestors, directly reliant on the power of the sun; perhaps supplemented by new generations of nuclear fission reactors or micro suns, in the form of fusion reactors.

But during the transition period of the next 30 years, especially before fusion reactor becomes successful, while nuclear fission reactors still play a role, we

probably will continue to depend on coal to a great extent, and the sequestering of  $\text{CO}_2$  will remain a problem in need of a solution.

In recent years, the long neglected development of vaccine for infectious disease is finally picking up some momentum with international efforts. The race lies between the perfection of  $\text{H}_5\text{N}_1$  vaccine and the mutation of  $\text{H}_5\text{N}_1$  virus, which initiate the transmission from people to people. More research works need to be carried out in this area. However, we do have to pay attention to the fact that in the past, the funds spent for medical research globally has only been targeted at problems related to 10% of the population. It is quite obvious that if we do not pay more attention to the deteriorating situation in developing countries, there is no way we can combat infectious disease effectively.

### 3 The St James's Palace Memorandum

In May 2009, after the St James's Palace Symposium of Nobel Laureates in London, a memorandum was issued which calls for "Action for a Low Carbon and Equitable Future", with the following content.

The St James's Palace Memorandum calls for a global deal on climate change that matches the scale and urgency of the human, ecological and economic crises facing the world today. It urges governments at all levels, as well as the scientific community, to join with business and civil Society to seize hold of this historic opportunity to transform our carbon-intensive economies into sustainable and equitable systems. We must recognize the fierce urgency of now.

#### 3.1 *The Fierce Urgency of Now*

Climate risk avoidance, energy security, sustainable land use, population growth and equitable economic development constitute a key set of interacting challenges for humankind in the twenty-first century. The evidence is increasingly compelling for the range and scale of climate impacts that must be avoided, such as droughts, sea level rise and flooding, leading to mass migration and conflict. The robust scientific process, by which this evidence has been gathered, should be used as a clear mandate to accelerate the actions that need to be taken. Political leaders cannot possibly ask for a more robust, evidence-based call for action.

In a time of financial and economic crisis, the participants of the St James's Palace Symposium emphasize that without directing current economic recovery resources wisely, and embarking on a path towards a low carbon economy, the world will have lost the opportunity to meet the global sustainability challenge. Decarbonising our economy offers a multitude of benefits, from addressing energy security to stimulating unprecedented technological innovation. A zero carbon economy is an ultimate necessity and must be seriously explored *now*.

## 3.2 *Milestones of the Great Transformation*

Building on the Potsdam Memorandum and recent advances in the scientific understanding of climate change, the participants of the St James's Symposium identified as key requirements **an effective and just global agreement on climate change, low-carbon energy infrastructure and tropical forest protection, conservation and restoration.**

### 3.2.1 **Delivering an Effective and Just Global Agreement on Climate Change**

Firm political leadership is *now* crucial. Leadership is primarily required from developed countries, acknowledging their historical responsibility as well as their financial and technological capacity. However, all countries will need to implement low carbon development strategies. *In this spirit of trust, every country must act on the firm assumption that all others will also act.*

A long-term commitment under the United Nation Framework Convention on Climate Change (UNFCCC) is now urgently required. The global agreement in Copenhagen must include the following elements:

1. Acknowledging the compelling evidence of science, we should confine temperature rise to 2 degrees Celsius to avoid unmanageable climate risks. This can only be achieved with a peak of global emissions of all greenhouse gases by 2015, and at least a 50% emission reduction by 2050 on a 1990 baseline. This in turn means that developed countries have to aim for a 25–40% reduction by 2020. A robust measure of assessing the necessary emission reductions is a total carbon budget, which should be accepted as the base for measuring the effectiveness of short-term (2020) and long-term (2050) targets;
2. The creation of carbon prices adopted across large parts of the global economy combined with measures to lower the price of low carbon energy, especially in developing countries. Funds raised should be used to provide the necessary financial support for adaptation;
3. The agreement must acknowledge the priority of developing countries to overcome poverty while ensuring sustainable development.

### 3.2.2 **Delivering a Low Carbon Energy Infrastructure**

Decarbonising our society requires an increase in energy conservation and efficiency, and a revolution in our energy infrastructure *now*. *“The required technological innovations will not be achieved without an unprecedented partnership between government and business”.*

Actions in the following areas are needed:

1. Clear policy frameworks aimed at fostering innovation and the demonstration, scale up and roll out of low carbon technologies, including globally coordinated investment frameworks linked to economic recovery, with the emphasis on ‘green growth’;
2. Developed countries should commit to a significant increase in investments for research, development and deployment;
3. Technology sharing and financial support, through mechanisms such as globally supported feed-in-tariffs for renewable energy, are required to help developing countries leapfrog to a low carbon economy;
4. The establishment of “smart grids”—connecting renewable energy sources over large areas and implementing novel energy storage technologies.

### **3.2.3 Delivering Tropical Forest Protection, Conservation and Restoration**

Tropical forests provide the ecosystem services essential for human well-being and poverty alleviation. In addition, deforestation and forest degradation are substantially contributing to climate change and global biodiversity loss at the genetic, species and landscape level. Both locally and globally, protecting boreal and tropical forest cover is an essential tool for mitigation of, and adaptation to, climate change. *Without a solution to rainforest protection, there is no solution to tackling climate change.*

An emergency package is needed *now* to provide substantial funding to tropical forest nations to help them halt deforestation and embark on alternative economic development paths, including:

1. Accelerating a long-term UNFCCC agreement on halting deforestation and on forest restoration, including innovative financing mechanisms from public and private sources;
2. Building capacity as well as mechanisms for verification and national governance structures that can support and reward the maintenance of rainforest regions. Developing countries need to take their own responsibility in tropical forest protection, conservation and restoration.

## **3.3 The Contribution of Science**

The solutions to the extraordinary environmental, economic and human crises of this century will not be found in the political arena alone. Stimulated by the manifesto of Bertrand Russell and Albert Einstein, the first Pugwash gathering of 1957 united scientists of all political persuasions to discuss the threat posed to civilization by the advent of thermonuclear weapons. Global climate change represents a threat of similar proportions, and should be addressed in a similar manner. There should be an acceleration and integration of global sustainability studies, to encourage the

active involvement of *all* scientists in these matters, championing the process of robust scientific study. All scientists should be urged to contribute to raising levels of public knowledge on these threats to civilization, and engage in a massive education effort to popularize the principles in this Memorandum.

We know what need to be done. We cannot wait until it is too late.

We cannot wait until what we value most is lost.

What is stated in this Memorandum is extremely important and worth paying great attention to by all.

## 4 Dilemma of Living in a Partially-Globalized World

Although we have witnessed the globalization of human society during the last few decades, the process is only half complete, and because of this, we are suffering from the consequences. Owing to highly-developed transportation and communication technologies, our world is relatively shrunken than it once was, and it appears that the concept of global village is slowly taking root as a number of human activities, most notably in the economic sphere, become globalized. The spread of disease around the world is another example. With thousands of airplanes daily crossing oceans and continents, loaded with people and goods, disease causing bacteria, viruses, and other microbes certainly will not be confined to specific locations. Similarly, environmental problems such as the depletion of the ozone layer by chlorofluorocarbons, and global warming trends caused by greenhouse gases, are problems that must be addressed on a global scale. On the other hand, in spite of the increased international collaboration in the areas of science and technology, high-tech based economic competition is still largely carried out on a national basis. Currently, in the partially globalized world, it is quite clear that only those people who are able to stage their activities on a global scale are benefiting enormously. For that reason it is not surprising that we will have to tackle such problems as the widening gap between rich and poor, both among countries and people in a country, nor that threats to solve problems by military force have not disappeared. These problems might be avoided if the entire world were to become “one community”.

We should also realize that, though the globalization of the world economy is driving us toward a borderless society, it will not reduce the differences among peoples in various regions overnight. The establishment of a new, common global culture, together with more effective ways of communicating among all peoples, will certainly take time. The differences among cultural heritages, languages, and religions that make this world so rich and colorful will not, and should not, be made to disappear. As the world shrinks in relative terms, and contact between peoples becomes more frequent, whether or not the difference in civilization are likely to cause an inevitable crash (as suggested by the well-known scholar Huntington), would seem to be entirely dependent on how well people around the world learn to communicate and to understand, appreciate, and respect cultural heritage. To



become good citizens of the global village, we need to learn quickly and also to teach our young people to take a global view and to respect, appreciate, and understand the different cultures of different peoples. In this aspect, scientists certainly can lead the way.

## 5 Science and Technology in Society Forum in Kyoto

In the fall of 2004, Mr. Koji Omi, the former Minister of Finance of Japan, organized a very important annual forum in Kyoto, with the title of “Science and Technology in Society forum”. More than six hundred leading scientists, business leaders and policy makers were invited every year from all over the world to discuss problems related to the subject matter of the forum. The forum aroused great enthusiasm among participants, and has since become a very successful and important annual event. During the past October, the fifth forum was held with more than 600 attendees.

Mr. Omi made two important points when he described the fundamental concept of this forum in the opening ceremony of the first forum. He mentioned positive and negative aspects of the rapid progress of science and technology, and noted that the benefits of science and technology have not yet reached everyone equally, which, as he said, “is really what symbolizes the lights and shadows of science and technology.” While the negative aspects must be properly controlled, the positive features of science and technology should be promoted.

Mr. Omi’s other important point was stated thus: “Today’s problems are global and can not be solved by any single country or by scientists alone.” He went on saying that “Boundaries between nations are merely lines on a map; nature makes no such distinctions. We should think of ourselves as members of humankind, whose very existence will be at risk if we do not live in accordance with the principles of Mother Nature.” Indeed, as an astronaut observes the beautiful earth from the spacecraft, the astronaut will not find any national boundaries.

I believe most of us sitting in this room would support this idea without hesitation. However, if we do not try to answer some other questions related to the fact that the earth is “limited” and the world is only “partially globalized”, our efforts to find solutions might encounter some difficulties. For example, we must also ask, “How many people can the planet support if we were to extend the living standard of the people in the so called “developed countries” to everyone on earth?” It is interesting to note that when India became independent, in response to the question of how the people in that country could catch up with the living standard of the people in Great Britain, Gandhi, rightfully recognized that it would take the natural resources of many Planet Earths, if the people in India were to have the British way of life. It is just impossible.

If we do not fully appreciate and understand the boundary conditions of the earth, the rules of the game and the consequences of competition in a globalized market-driven economy, practicing the so called “good sciences” for the greater

good can still produce miserable losers among us, when these “good sciences” are used mainly as a tool for global economic competition, especially when science and technology are used for the domination of some countries over others. Scientists as a whole should take full responsibility to ensure that science and technology bring benefits to everyone equally. If we are not careful, we might predict that, even if science and technology were to advance in faster pace along with excellent material comforts and improvement in healthcare, the continuing population explosion and excessive usage of natural resources might overload the planet, and then sustainable development might not be possible.

## 6 Concluding Remarks

Many of the problems we face today are problems that cannot be solved with current scientific knowledge and technologies—they await the accumulation of new knowledge and the development of new technologies. That is why it is so important to continue our efforts for the advancement of science and technology, and for the education of a new generation of creative scientists.

During the long history of mankind, our ancestors invented various technologies in order to survive better or to improve the quality of life. Their curiosity and their desire to understand natural phenomena were the basis of the advancement of science. Until about one hundred years ago, the advancement of science was driven by the available technology; only during the last century have technological advances been led by the results of scientific research.

In recent years, we have observed encouraging improvement in international scientific collaboration. Many projects were initiated, many agreements were signed. Year after year, we have discussed the “capacity building” of science, technology and education for developing countries, but the worsening situation of the entire world has yet to find its turning point. For example, the rain forest, which is often compared with the lung of a human body, is continuing to disappear from the surface of the earth. For the past decade, every summer we witnessed the thick dark smog generated by the forest fire in Indonesia contaminate not only the air in Indonesia, but also their neighboring countries. It is not realistic to blame or to expect Indonesia to be able to keep their rain forest from disappearing. Unless we consider the protection of the rain forest in Indonesia as “our responsibility”, and raise enough funds to help Indonesia establish a protected “global rain forest”, no matter how serious we engage in international scientific collaboration, the rain forest will continue to disappear.

We should all recognize the fact that the increasingly interconnected world cannot be a safe place if a large portion of its population still suffers from grinding poverty, disease stricken, illiteracy, derived of education, unemployment, and other barriers to survival. Scientists can play key roles in finding solutions to these problems. Especially if we learn to solve problems together, learn to share knowledge, new technological options and the limited resources available, learn to respect and

understand different cultural heritages, then it will be possible to realize the establishment of a genuine global village that enables sustainable development for all.

In order for science and technology to solve the problems man faces in the twenty-first century, it is not enough to advance science and technology at a faster pace. The advancement of science and technology certainly will solve many problems we are facing today and will also shape the development of human society of the future. However, unless we pay special attention to the roles play by science and technology in this “finite” and “half-globalized” world, and learn to work together beyond the national boundaries, and pay more attention to our “global competitiveness” for solving problems of the entire world, rather than continue to worry about “national competitiveness” for their own countries, the serious problems related to the sustainable development will not be solved.

At present, the entire world consists of more than one hundred nation-states. One of the duties of the government of a nation-state is to collect taxes from their citizen and business to solve their problems and redistribute wealth. As the world became more and more globalized, it became obvious that there is a need to have some sort of a “global government”, which can resolve conflicts between the interests of nation-states, and the interest of the entire world.

The best way to work together beyond national boundaries is to make national boundaries disappear all together. Although it might take a long time, our future certainly will depend on how soon all of us in different countries learn to operate as “one community” for the entire world, and we do not have much time to waste. Perhaps the European Union is a step toward that direction, and half way through the twenty-first Century, the formation of the “Global Union of the Planet of Earth” might become a reality, then the sustainable development of the entire world might become possible. Otherwise, the solar system might send a farewell message to mankind on earth in the not too distant future.

## Chapter 2

# Bio-fuels: A Blessing in Disguise

O. Surriya, Syeda Sarah Saleem, K. Waqar, A. Gul Kazi and M. Öztürk

**Abstract** Biofuels are part of the bio energy family that can be transformed into fuels for both mobile as well as stationary incentives. Bio-fuels obtained from various forms of bio-mass are considered environmentally safe and economically efficient candidates for complete replacement of natural oil in the twenty-first century. Depending on their future accessibility, geologists categorize bio-fuels into three generations, namely; first, second and third. According to research analysts, energy demand will increase with alarming celerity until late 2020–2030, up to more than 50%. Because of the emerging economies of the developing countries in recent years, energy consumption will directly enhance the demand for renewable, cost effective energy generation sources. The depleting life expectancy of natural fossil fuels in the world market has led research institutes, policy makers and enterprises to discover alternative means of generating transportation fuel. One such prominent and promising alternative is “Biofuels” which not only contributes to diminishing the increasing bubble of global warming but also generates substantial amount of energy in a less cumbersome manner.

**Keywords** Biofuel · Biodiesel · Bioethanol · Biomethanol · Biohydrogen · Algae biofuels

## 1 Introduction

Biofuels refer to combustible materials which are directly or indirectly derived from biomass. Most common biomass includes wood, agricultural crops, aquatic plants, forestry products and animal wastes (Keck 2001; Öztürk et al. 2006, 2007, 2010; Öztürk 2010; Abideen et al. 2011). Biofuels are part of the bio energy family that can be transformed into fuels for both mobile as well as stationary incentives. These

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