Sustainable Energy and Environment: The Roles of Technology and Ethics

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ABSTRACT

The earth ecosystem and its ecological future is at stake because the humankind has so far consumed energy and resources without paying careful attention to resource limits and degradation of nature. This anthropocentric way of economic life disrupted ecological food chains and natural circulation or cycles of earth's basic elements such as carbon, water (hydrogen and oxygen), nitrogen, and minerals. Sitting on top of chains, and armed with technologies, the humankind destabilized the cycles to the breaking point. For an example, the disruption of carbon cycle has led to climate change, water cycle to freshwater shortage, and nitrogen cycle to pollution.

Ironically the only tools we have for the sustainable development are also technologies, which may be called "Paradox of Technology". Perfection of technology ethics, which will complete natural cycles and the circle of God-Human-Nature relationship, is the only hope we have.

The energy and environment future depends on remediation of food chains and natural cycles damaged by the human technological activities. Since technology is a product of human intelligence, only our ethical mind can guide the role of technology. The humankind ought to use technologies to enhance the harmony of human and nature as dictated by his ethics of technology.

Christian ethics is now reshaped to establish the horizontally linear relationship between God, Human, and Nature from the old vertically linear one. On the other hand the Asian view of the nature makes the relationship between Heaven-Earth-Human to be a full circle, and regards the circle itself the Nature.

The Asian view may prevail for the perfection of cycles so that we can preserve our only habitat the Earth better for our coming generations, and also for generations of biospecies.

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1. The Ecological Future at Stake

Nobody could have foreseen today's technological society, and it becomes more definite we cannot figure out with confidence the change in the coming years. As a typical example, though the report "Limits to Growth" of the Club of Rome was sensational at its publication, it has been buried as a past monument. We only know that there are two groups of optimistic and pessimistic futurists. As an advocate of the pessimistic view, Bill Joy of Sun Microsystems, Inc. warned that new technologies could cause something akin to extinction of humankind within the next two generations. He meant to be reminiscent of Albert Einstein's famous 1939 letter to President Franklin Roosevelt alarming him to the possibility of an atomic bomb. He views that by 2030, computers will be a million times more powerful than they are today, and he fears robots may exceed humans in intelligence and eventually they may conquer human species.

Biological foresights are more convincing than physical ones since it is based on natural facts in the evolutionary process before our own eyes. Paleontologists recognize six previous mass-extinction events during the past half-billion years of Earth's life. The last one caused by a giant meteorite strike 65 million years ago ended the age of dinosaurs. After that life as a whole evolved again to its full variety across 2 million to 5 million years, then has gone through full evolutionary process in which Homo Sapiens appeared on Earth[1].

Throughout Earth's history, species, or members of Habitat Earth, disappeared naturally at the rate of about one species per million per year, and newly evolved species replaced them at the same rate, maintaining a rough equilibrium. Now biologists

generally agree that the rate of species extinction is 100 to 1,000 times as great as it was before the coming of humanity. Not only has the extinction rate soared, but also the birthrate of new species has declined as the natural environment is polluted. For example, it is estimated that 20% freshwater species have vanished or been driven toward extinction in recent decades.

E. O. Wilson warns that we are in the midst of the seventh mass extinction. If the current rate of habitat destruction were to continue in forests and coral reefs alone, half the species of plants and animals would be gone by the end of the 21st century. Our descendants would inherit a biologically impoverished and homogenized world. Not only would there be fewer life forms, but also faunas and floras would look much the same over large parts of the world. Humanity would then have to wait millions of years for natural evolution to replace what was lost in a single century. The sustainability of nature is at stake.

Furthermore we are not even aware of the full dimensions of the problem. As for biodiversity, fewer than 2 million species of animals, plants and microorganisms have been identified so far. Yet tens of millions more may exist in oceans, rain forests and everybody's gardens.

UNDP, UNEP, World Bank, and World Resources Institute jointly published "World Resources 2000~2001, People and Ecosystem, The Fraying Web of Life". It is the first report of their project Pilot Analysis of Global Ecosystems (PAGE). which can be acclaimed as the first global attempt to assess the ecological problems in real terms. The report confirms that half the world's wetlands have been lost in the past century; 58% of coral reefs are imperiled by human activity; 80% of grasslands are suffering from soil degradation; 20% of drylands are in danger of becoming deserts; and groundwater is being depleted almost everywhere[2〕

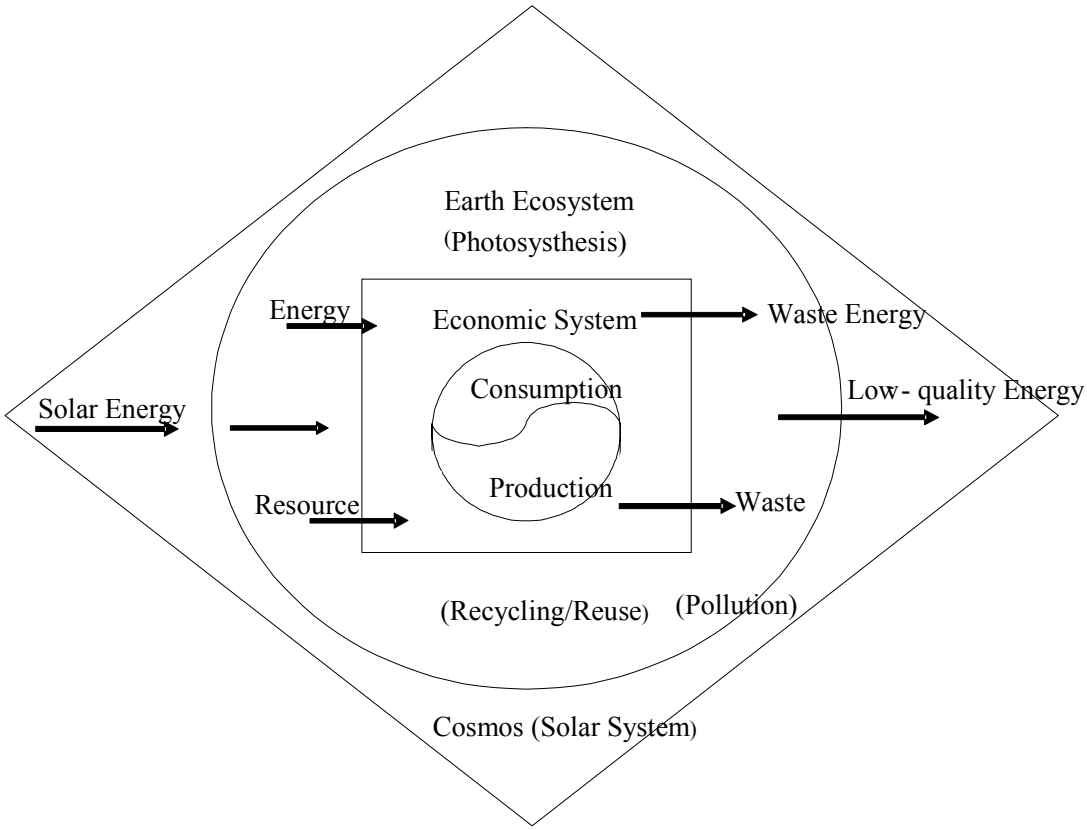
The report warns that we might already pass the possible turning point of avoiding a crisis of earth ecology. PAGE concludes that our planet's carrying capacity of

supporting natural ecosystem and human civilization is beginning to diminish, threatening our economic well-being and ultimately our survival.

2. The Earth System of 3E

The present cosmos has evolved from the beginning "Big Bang", an outburst of infinite energy and mass. The solar system and its planet Earth appeared later as an infinitesimal portion of cosmos, and we may designate it as the initial condition of Earth's mass and energy. From then on Earth's physical and biological system, namely ecosystem, has evolved with solar energy input and sporadic cosmic rain of mass such as meteorites.

Since earth ecology has been sustained by photosynthesis of carbon dioxide and water under solar energy, solar energy is the sole backbone of life support system, and thence the ecological food chains. Even fossil fuels, which fired our modern civilization, are nothing more than a storage form of solar energy, since fossil fuels are remains of death of biospecies. Without solar energy all forms of life and human civilization cease to exist.



Now what is the real cause of environmental degradation? The humankind, to maintain their lives, has to extract energy and resources from the surrounding natural environment, and recycle to it whatever is left after their use. This is an economic activity. When human population was scarce and dispersed, the nature's self-rehabilitating capacity were so large that limitations of available resources and environmental pollution did not pose a problem. So anthropocentric way of life prevailed and the ultimate economic goal was to utilize natural resources without any limit to the satisfaction of the humankind as the owner of nature.

In later history, however, population grew to fill cities and to accelerate men's needs. Industrial production was increased to meet these ever growing human requirements, and which began to pollute the environment so extensively and destructively that nature's self-rehabilitating capacities have long been overburdened. This was the beginning of today's environmental tragedy.

It is noteworthy that economic system is contained as a subsystem of the earth ecosystem. The input and output of the economic system are energy and resources, etc., and these can be called "resources in a broader sense". On the other hand, if we conceptually extend the famous Einstein's equation $E=mc^2$ for the micro-world to the macro-world to state E□m, the input to and output from the economic system can be lumped as "energy in a broader sense." If energy is used, the environment is destined to be polluted. lf energy is used less, the environment is more protected. So minimization of energy and resources use, or waste minimization, is the basic principle of sustainable development.

3. Food Chains and Natural Cycles

Disruptions in earth ecosystem can be diagnosed due to break-up of food chains in the ecosystem and natural cycles of earth system. When chains and cycles are broken, the system loses its present stability and moves in transition until it reattains another stability. The law of conservation of matters governs the earth system. The basic elements of biosystem such as carbon, water (hydrogen and oxygen), nitrogen, and minerals are conserved in the circulation through the system. This circulation flow has coevolved with the evolutionary system of biosphere, so a small leakage or a gap in the circulation causes the beginning of unstability of the whole ecosystem.

The material throughput of the biosphere always remains at the approximately same state of biomass by complete recirculation. For example, the sun maintains the production of this biosphere factory, in which oxygen is released from CO_2 by photosynthesis and food (sugar) is created. In these manufacturing process, no toxic emission is produced other than the air (oxygen) that we all breathe, and water vapour which is the source of our life. All processes and products are interlinked.

The consumption and destructive processes (e.g. food chains) are organised in a similar manner. The organic mass is used to build up higher forms of life and organisation, and their destruction lies in the decay of the organic substance into the original building blocks CO_2 , H_2O and minerals, with which the circulation ends in a completion for a new start.

3.1. Carbon Cycle and Climate Change

The "carbon cycle" designates the carbon exchange between four carbon reservoirs of atmosphere, terrestrial biosphere, marine biosphere, and the oceans. In the atmosphere, carbon exists as CO_2. In terrestrial and marine biospheres, it is bound in the most diverse forms of organic carbon. In the oceans, carbon is found as dissolved CO_2 and carbonates. The carbon cycle is interlinked in many ways with other circulatory systems. If, for example, the CO_2 content of the air fluctuates, the climate, the growth of plants and thus oxygen production change.

If we pump carbon dioxide into the atmosphere much faster than land and seas can reabsorb it by burning fossil fuels, the accumulating CO_2 is trapping heat to cause global warming and upsetting the climate. The result is not only rising seas and fiercer storms but also a possible repositioning of the world's ecosystems as the boundaries of forests or grassland shift. Many animal and plant species may not be able to adjust to sudden changes in their habitats.

United Nations Framework Convention on Climate Change (1992), the Kyoto Protocol (1997), and subsequent global meetings basically aim to control the carbon cycle of earth ecosystem by burning less carbons (fossil fuels) and by sequestering more airborne carbons. This is why new and renewable sources of energy, which contain no carbon at all, come under the spotlight.

3.2. Water Cycle and Freshwater Shortage

Three quarters of earth's surface is covered with water(H_2O). Quantitatively 94% of earth's water is saltwater, and the remaining 6% is freshwater. Freshwater resources consist of 27% glaciers in North pole and Antarctica, 73% underground waters, and remaining 1% rivers, lakes and water vapor in the atmostphere. The water cycle maintains its balance between them by rain or snow precipitation.

Furthermore the distribution of precipitation is not so even that Middle East, vast regions of North Africa, part of Middle America and Western USA suffer from freshwater shortage. Freshwater securement is closely linked with national security as has been from the old history. Desertification is a symptom of ground water shortage and draught. Disruptions in carbon cycle and consequent climate change are aggravating the freshwater distribution.

Human demand for freshwater is so large that many great rivers are diverted to cities and industrial parks. When diverted water is returned to waterways, it often comes bank laden with noxious chemicals and sewage. Moreover, the building of large dams and many more smaller obstructions has converted most of the world's rivers into a series of interconnected lakes. Such a water system, like nothing seen since the end of the last ice age, has dire consequences for thousands of species adapted to free-flowing water. Human alteration of the water cycle also extends underground as farms and cities overtax aquifers. Our only solace is that we have technologies to make freshwater out of plentiful seawater if we have cheap and abundant energy sources.

3.3. Nitrogen Cycle and Pollution

Nitrogen is found mostly in the atmosphere. Nitrogen is an essential element in the production of proteins and DNA : nitrogen fixation by micro-organisms leads to a constant supply of nitrogen to the seas and land, where denitrifying bacteria ensure that the organic substance decays, returning the nitrogen to the atmosphere.

However, through the use of fertilizers, the burning of fossil fuels and land clearing, humanity has doubled the levels of nitrogen compounds. These levels are more than can be efficiently absorbed by plants and animals, and recycled into the atmosphere. These excess nitrogen compounds wash into fresh- and saltwater systems, where they produce dead zones by stimulating suffocating growths of algae. Since the global food supply is based on aggressive use of fertilizer, restoring the balance of the nitrogen cycle poses a daunting challenge. Though limited to mostly metropolitan areas, urban NO_X pollution from automobile exhaust gases imposes heavy death toll all over the world.

4. The Roles of Technology and Ethics

4.1. Technology and Sustainability

The humankind sits at the top of food chains and governs the ecosystem at will. It also interferes the naturally circulating earth system. Since earth ecology is disrupted by break-up of evolutionary process of these circulation, the humankind is solely responsible for forging an ecological crisis. Homo Sapiens Sapiens should be blamed as the villain in the biogeosphere. Humans, as the sole possessor of technologies, have destroyed the system by utilizing them only for their own sake, knowingly and unknowingly.

The past history of humankind, as Arnulf Gruebler documented well in his book "Technology and Global Change", can be said a succession of agricultural revolution, then industrial revolution, and now services revolution. And today the humankind enjoys prosperity more than ever even though there are as much warnings to the continuation of this trend[3].

Arnulf Gruebler emphasizes that productivity gains through technological innovation do not always lead to reduction of environmental impacts. Technological development has helped to overcome resource (input) constraints in one hand, but in the other hand it has induced total output growth to such an extent as to face another resource limitation. Thus far, technology development, in a sense, forms a vicious cycle of producing other problems such as global environmental degradation.

Clive Ponting rewrote the history with green eyes, and from his book "A Green History of the World" we can quote many examples which illustrate a small step of technology innovation caused a giant step of human development[4]. One typical example is the chlorination of water to supply sanitary city water. The chlorine became available by electrolysis of sodium salt, and later chlorination became a major chemical reaction to manufacture useful chemicals. Even though we realize today that widespread use of carcinogenic chlorine induces health hazards, we understand chlorine served well to the humankind.

We have also experienced negative effects of recent technology development. Nuclear weapons, CFC, and DDT are only a few examples. DDT had been a wonderful invention until Rachel Carson's "Silent Spring" listed the demerits or "badness" of DDT. CFC had been a perfect chemical until ozone depletion was confirmed as warned by Rowland and Molina. All of a sudden, the "good" CFC was declared "bad". Nuclear technology is both good(nuclear medicine) and bad (nuclear weapons). Paul Gray eloquently expressed this double-edgedness of technology as "Paradox of Technology Development"[5]

The goodness of technology is judged according to the prevalent knowledges at the time of introduction of that technology. DDT was good when we had not yet realized its harmful ecological effects. CFC was good when we had not known at all of its possible chemical reaction with stratospheric ozone. DDT is now banned in most parts of the world, and CFCs have been gradually replaced by HFCs. The chlorination process in the production of city water was gradually replaced with other technologies or reinforced by adding another process to it. These examples manifest that technology development could be controlled in a way that the global environment could be preserved. In other words, technology innovation can become the basis of sustainable development, and is the key to sustainability.

Of course, many people hold pessimistic views about "technology-fix." But the humankind is better off than in the past due to technological change. This trend should be maintained and elevated further. We can achieve it because we now have "Ethics of Technology" to judge the goodness of technology innovation. And sustainability (eco-efficiency) is a major keyword for ethical guidelines of technology development[6]

4.2. The Circle of Technology Ethics

We now understand that the energy and environment future, hence the ecological future, depends on remediation of food chains and natural cycles damaged by the human technological activities.

Since technology is a product of human intelligence, our intellectual mind can reshape the role of technology in the harmonization between human and nature. The

humankind may use technologies to enhance the harmony of human and nature, as dictated by his bioethics and environmental ethics.

William Temple's early book "Nature, Man and God" tried to explain humankind's ethical responsibility in his relationship with the nature [7]. But it was Lynn White, Jr. who provoked the renewal of discussions by denouncing the Christian ethics in his 1967 essay "The Historical Roots of Our Ecological Crisis" [8].

Christianity has so far upheld the vertical relationship of God → Human → Nature. However, Christian responsibility for the ecological integrity is now advocated by many to establish the horizontal relationship between God ↔ Human ↔ Nature. The humankind (anthropos) is one of family members living in a habitat called Earth(oikos) with other creations, in which God (theos) resides as well [9].

It is very interesting that Lao-tsu said "Human be Earth, Earth be Heaven, Heaven be Tao, Tao be the Nature." This teching may be said to represent Asian philosophy of nature such as Taoism, Buddhism, and Hinduism. Graphically the Asian view of the nature makes the relationship between Heaven-Earth-Human to be a full circle, and the circle itself is the Nature. In the circle Heaven (God, theos), Earth(oikos), and Human (anthropos) coexists, and they share the beginning and the end of the circle altogether.

Won Buddhism originated in Korea enshrines a circle called Ilwon-sang(meaning unitary circular symbol) as the symbol of the object of religious worship and the standard of religious practice and moral cultivation. Is it only a coincidence? No. Deep

in our pure minds, we pray for the perfection of cycles so that we can preserve our Habitat the Earth better for our coming generations, and also generations of biospecies.

UNDP, UNEP, The World Bank, and World Resources Institute Published in 2003 the second report of their joint project “World Resources 2002-2004” with subtitle of "Decisions for the Earth: Balance, Voice, and Power"[10]. In the report they

emphasized the importance of environmental governance, for which I believe the circular conception of ethics should play the governing role.(01)

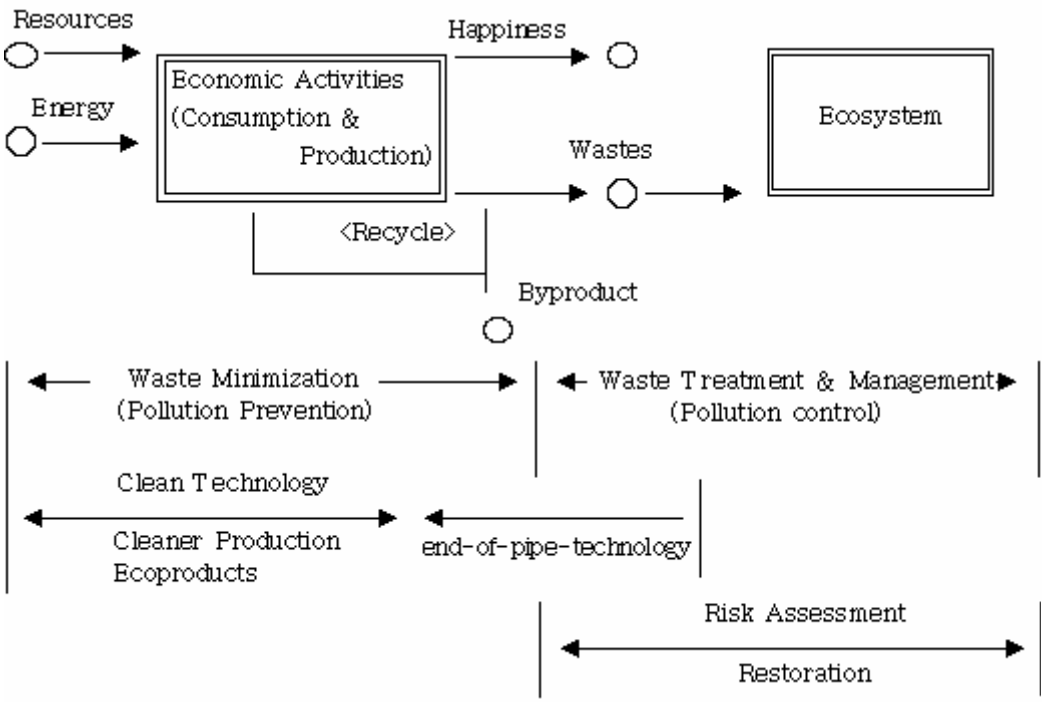
5. Sustainable Energy and Environment Future

It is evident from the above discussions that the Earth's sustainability will mostly depend on the eco-efficiency of energy and environment future. In order to preserve, and recreate, our only Habitat the Earth, technologies for economic development have to be cleaner ever, and the energy system based upon the carbon economy has to be replaced by the hydrogen economy.

5.1. Cleaner Technologies

As mentioned previously, all human economic activities, which can be divided into consumption process for keeping the human life and the production process for maintaining and enhancing the standard of living, cause environmental pollution.

In the consumption process we return household wastes to nature. On the other hand, in the production process, we produce industrial wastes. Environmental technology used to deal with the end-of-pipe technology, treating wastes only after they were produced. Now, it is evident that the first principle of solving the pollution problem is pollution prevention, and cleaner technologies (cleantech) carry the flag of this paradigm shift.



The established end-of-pipe technology cannot even meet the strengthening environmental standards. It also has demerits or impossibility of reduction of energy and resources consumption at the source and of high cost of installation and maintenance. Cleantech may be characterized into three groups;

(1) Reuse and recycling of wastes : Energy, useful components, and water is recovered from the outgoing process streams to recycle to the process or to be further processed into byproducts.

-Recovery of intermediate water from waste water
-Recovery of precious metals from used catalytic converters
-Recovery and destruction of CFC's
-Sulfer production by deSOx of flue gases

(2) Cleaner process and improved use of resources : Energy, raw materials, water etc. are conserved or consumed less by applying new process or by innovation of existing processes.

-IGCC (Integrated Gasification Combined Cycle)
-Process redesign, control, and optimization
-Fuel cells

(3) Ecoproducts and cleaner energy : Ecoproducts and cleaner energy which are non-toxic and less hazardous to the environment.

-Substitutes of CFC's
-Non-toxic agricultural chemicals
-Biodegradable plastics
-Renewable sources of energy
-Hydrogen energy

5.2. Hydrogen Economy

Imagine now you live long enough to have your birthday party in the year 2050. What do you think the shape and style of your dwelling, and energy type and sources for your lighting, heating & cooling, cooking, etc? And what kind of appliances and equipments for your habitat?

Energy foresights tell us that, in 2050, most of electricity will come from fossil fuels and nuclear fission, and nuclear fusion may be in the commercialization stage. New technology breakthroughs in photovoltaics and solar thermal will enhance merits of renewable energies, but overall contribution will remain less than 10% of the global energy requirement. Except coal, fossil fuels become scarce and expensive, and they are more needed as chemical feedstocks. Cheaper and safer nuclear power, and pollution-free hydrogen will be energy kingpin. Fuel cells and hydrogen cars will be ubiquitous on the globe.

Revolutionary energy technology innovation will surely provide cheap enough energy to produce hydrogen sources, and the carbon-based economy will converge into hydrogen-based economy. Non-toxic water cycle will replace toxic carbon cycle. Environment-minded nations are following suit of the United States program to give us a firm belief in brighter energy and environment future. USA has already set aside US$1.7 billion for Climate Change Science Program, another US$1.7 billion for Freedom Car and Hydrogen Fuel Initiative, US$1.0 billion for FutureGen Project, and huge sum of budget for Carbon Sequestration Leadership Program, new fission reactor and ITER fusion program. After Johannesburg World Summit on Sustainable Development in 2002, the Clean Energy Initiative is also launched.

On its way to hydrogen economy following hydrogen technologies are in the agenda of hydrogen RDDD.

(1) Production Method

- -Electrolysis
- -Direct thermal (>3,000 C)
- -Thermochemical (>750 C)
- -Biological
- -Photochemical

(2) Primary Energy Sources

- -Fossil fuels: natural gas, heavy oil, naphtha, coal
- -Nuclear: fission, fusion
- -Renewable energy: phtovoltaic, wind, etc.

(3) Storage and Transportation

- -Hydrides
- -Liquid hydrogen
- -Distribution infrastructure

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