Wind Power and Seawater, Save Corn from Ethanol Production

Marine resources recovery and offshore integrated plant for sodium fuel, fresh water, ethanol, vegetable, and fish production with wind energy and seawater

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Abstract

The "Offshore Integrated Manufacturing Plant" is proposed to prevent an artificial collapse in prices for corns, to solve the problems of food crisis and global warming simultaneously, and to make a peace loving, sustainable society without resource wars. This on-site manufacturing plant is located on the raw material called "seawater" and is equipped with a wind power station. Utilizing offshore wind energy and seawater, sodium is produced as a solid fuel on site by molten-salt electrolysis and transported to a power consumption place on land, where the sodium will be made to react with water to produce hydrogen for power generation. The sodium hydroxide, a by-product, is used as a raw material for the soda industry.

Along with the electrolysis factory described above, the ethanol factory, the vegetable farm, and the fish-raising farm on mega-float are designed to accommodate each other with chemicals such as fresh water, magnesium, calcium, chlorine, carbon dioxide, oxygen, hydrogen, hydrochloric acid, sodium hydroxide, and sulfuric acid, as well as wastes produced and use them efficiently, to attain "Zero Waste", to decrease the energy loss in production, storage, and transportation, and to improve the efficiency of the whole system.

Introduction

The major cause of global warming is fossil fuel. It is oil, among the fuels, that most easily generates energy. Life in society fails if either of energy and food is lacking; therefore, we heavily reply on oil. When the price of oil soars, it is not only the price of gasoline to rise but also those of tuna, tomatoes, bread, air tickets, butter, pork, and beef. President Bush of the United States of America mapped out their course of making corn a raw material for fuel ethanol and decreasing the gasoline consumption by 20% in ten years in the autumn of 2006 (Baker and Zahniser, 2006). The corn price rose as soon as it was announced, and the act of the corn/ethanol special procurements kicked off in the United States; which triggered acceleration of converting soybean fields to corn fields, and the price of land became doubled as much as ten years ago (Kirchhoff, 2007). The plan originally made to reduce the oil dependency changed agriculture to speculative ventures, and the abrupt change in cultivated crops is destroying the ecosystems that have been kept to date. The corn producing countries can stop the price rise of oil, and its economic effect is enormous (Patzek, 2004); however, the importing countries suffer from the repercussions directly and fall into the difficulty of obtaining food. As a matter of fact, even if ethanol fuel is produced from corn, the oil dominance cannot be changed fundamentally by merely mixing gasoline with the ethanol (Murahara and Seki, 2007). Is there any method of getting rid of the fossil fuel age (the oil age) without fueling food crisis? The reserve production ratio of fossil fuel is limited (Dresselhaus and Thomas, 2001): 41 years for oil, 67 years for natural gas, and 165 years for coal. Nuclear power generation is reviewed as a fuel that does not release CO_2, but uranium is also short, 85 years, in reserve production ratio. Fuel resources whose depletion are worried about and whose mining places are unevenly distributed. The depletion and uneven distribution of the fuel resources create a resource power, and it rules the world economy; which destroys the economic balance and causes fuel and food crisis. Is there any energy resource that is evenly distributed and is not depleted?

Seawater is distributed evenly in the world, and it contains water most and sodium second. If the seawater gathered then and there is electrolyzed by offshore wind power generation to produce sodium metal, and the sodium is transported to a power consumption place on land and made to react with water, the hydrogen generated can be supplied as electric power to a thermal power station, and the sodium hydroxide, a by-product, supplied as a raw material to the soda industry for almost nothing. There is no fuel except sodium that discharges neither CO_2 nor radioactivity and is depletion-free (Murahara and Seki, 2007). By the offshore electrolysis, fresh water, magnesium, calcium, hydrochloric acid, sulfuric acid, hydrogen, chlorine, and oxygen are produced as by-products; by using the surplus power, rare metals are also collected from the hydrothermal deposits or the manganese crusts lying at the bottom of the sea. Moreover, the "Offshore Integrated Manufacturing Plant" produces fuel ethanol, vegetable, and fish by utilizing these chemicals of by-products; which is considered to solve the problems of energy and food crisis simultaneously, to prevent the artificial collapse in prices for corn and energy, and to make the world environmentally friendly with renewable energy and without resources wars that can ensure stable supplies of water, agricultural and marine food, energy, and mineral resources, while maintaining the form of the modern industry (Murahara and Seki, 2007). In this paper, the plan of having wind power and seawater be the support and driving force of this task is described.

Offshore On-Site Integrated Manufacturing Plant

The offshore integrated manufacturing plant is located on the raw material called "seawater" and is equipped with a power station for renewable energy resources such as wind, ocean current, and the sun; which has an electrolysis factory, ethanol factory, vegetable farm, and fish-raising farm that produce fuel, fresh water, chemicals, vegetables, and fish. It is exactly letter-perfect, "the Offshore On-Site Integrated Manufacturing Plant" (Murahara and Seki, 2007; Fig. 1).

Offshore Electrolysis Factory. The offshore electrolysis factory is mainly designed for producing an alternative energy for oil [Fig. 1(a)]. Figure 2 illustrates the flow of the sodium production process at the electrolysis factory. The seawater of approximately 3% salinity is firstly filtered through the reverse osmotic membrane (film) by giving pressures around 50 atmospheres in order to freshen. To separate Ca from the 6% saline sprinkling water containing NaCl, $MgCl_2$, $MgSO_4$, $CaSO_4$, and KCl that have not permeated the membrane, the oxalic soda [$(COONa)_2$] produced at the ethanol factory is poured in the sprinkling water so that oxalic calcium (CaC_2O_4) is precipitated and removed. On the other hand, sodium hydroxide (NaOH) is poured into the filtrate (NaCl, Na_2SO_4, $MgCl_2$, and $MgSO_4$) of 6% saline sprinkling water without Ca in order to liberate magnesium; magnesium hydroxide [$Mg(OH)_2$] is precipitated and separated from the saline solution. The precipitate is turned into magnesium metal (Mg) and chlorine gas (Cl_2). Meanwhile, the 20% saline water is further concentrated to 30% by heat, and then is electrolyzed to produce sodium hydroxide. The sodium hydroxide (NaOH) is electrolyzed to produce sodium metal (Na). In addition to sodium, fresh water, sodium hydroxide, magnesium, calcium, chlorine, hydrogen, hydrochloric acid, oxygen, and sulfuric acid are isolated and recovered as by-products by the seawater electrolysis (Murahara and Seki, 2007; Murahara and Seki, 2008).

Offshore Ethanol Factory. The offshore ethanol factory mainly designed for producing fuel bio-ethanol plays two big roles: a producer of fuel and alcoholic drinks and a provider of carbon dioxide, which is essential for photosynthesis, to the vegetable farm [Fig. 1(b)]. For beer and sake production, the deep-sea water pumped up at the electrolysis factory is freshened by the reverse osmotic membrane to use. Grain such as malt, rice, seed malt, and corn that have been uploaded are fermented with brewer's yeast to produce "the deep-sea water beer" at the beer brewery and "the deep-sea water sake" at the sake brewery as well. The carbon dioxide generated with this alcohol fermentation is supplied to the vegetable farm for photosynthesis. On the other hand, for producing fuel bio-ethanol, wood, sawdust, branches, and strained lees of sugar cane those have been uploaded, woody biomass (cellulose) such as lees of malt and hops wasted at the beer brewery, or seaweeds collected from the seabed are solubilized with the concentrated sulfuric acid produced at the electrolysis factory and added to the fresh water also produced at the electrolysis factory. And, it is resolved into sugars with the diluted sulfuric acid. Inducing alcohol fermentation by the alcoholic dialytic ferment secreted from yeast, bio-ethanol is manufactured through the processes of distillation and dehydration. Sulfuric acid is collected and recycled here. Again, the carbon dioxide generated is used for photosynthesis at the vegetable farm. At the ethanol factory, furthermore, a part of cellulose that is a raw material for fuel alcohol is poured in sodium hydroxide to produce sodium nitrate, which is used for removing calcium in the seawater and facilitating the molten-salt electrolysis of sodium or magnesium (Murahara and Seki, 2007).

Offshore Vegetable Farm. It is a proper temperature, water, light, carbon dioxide, and fertilizer to support successful photosynthesis for producing vegetables [Fig. 1(c)]. The characteristic of the offshore vegetable farm is to grow highlands vegetables by using the nourishing, desalinated deep-sea water and an artificial sunlight, and utilizing the low-temperature of the deep-sea water. The carbon dioxide produced by the alcohol fermentation at the ethanol factory, the fresh water produced from the nourishing deep-sea water collected at the electrolysis factory, and the artificial light such as the visible light rays removed by the band-pass filter and not supplied to the photovoltaic generation, fluorescent lamps, or light emitting diodes (LED) carry out photosynthesis. And, the oxygen generated by the photosynthesis is provided to the fish-raising farm.

Offshore Fish-Raising Farm. A leading aim of the offshore fish-raising farm is to promote fish and shellfish growth by adding the oxygen generated at the vegetable farm into the seawater pumped up at the electrolysis factory [Fig. 1(d)]. Deep-sea water is generally rich in nourishment but low in oxygen concentration. If adding oxygen in the deep-sea water and draining the water off to the sea surface, its surroundings will become a sea area rich in both nourishment and oxygen concentration; where migrating fish will swarm, and it can be a natural fishing place or fish-breeding ground. In addition, replenishing the surface seawater with oxygen can control an outbreak of red tide and/or solve the Dead Zone that is spreading in coastal waters.

Submarine Resources Mining Factory. The offshore mining factory designed for rare metals collection can also be operated to mine hydrothermal deposits and manganese crusts distributed in the shallow sea or manganese nodule in the deep-sea of the exclusive economic zone (EEZ), and collect mineral resources such as gold, silver, copper, zinc, lead, cobalt, manganese, molybdenum, titanium, tin, antimony, bismuth, mercury, uranium, fluorite, tungsten, chromium, and nickel (Murahara and Seki, 2007). Many of these resources are in EEZ or the open sea area, and it requires high power to mine them. There is no method so far except the electric power converted by diesel generation using light oil, which is not profitable. If using wind or ocean current power available on site, however, the energy does not cost. Furthermore, if using electric generation by temperature difference between the hot water in a submarine volcano or hot spring and the cold deep-sea water in the neighborhood, it is not necessary to transmit the power to the mining site, and accordingly, no power loss in transmission.

Electric Power Consumption Place on Land

A hydrogen power station needs a large amount of hydrogen. The sodium metal produced at the offshore electrolysis factory is, therefore, delivered to the hydrogen power stations on land and is there made to react with water to generate a large amount of hydrogen instantaneously on demand (Fig. 3). The by-product (sodium hydroxide) generated by the reaction is the primary raw material for the soda industry. So, it is considered that this is a very economical, efficient method. If oversupplied, the sodium hydroxide is again melted and electrolyzed to reproduce sodium metal (Fig. 4). This is exactly the sodium fuel cycle. As seawater exists in the sea, there are rock salt and saline lakes on the Continents; where renewable energy resources such as wind and sunlight are also available. Thus, the method described above can also be used on land.

The sodium fuel cycle is a recycling system that endlessly produces and reuses the fuel, same as the nuclear fuel cycle that manufactures uranium and plutonium by reprocessing the used nuclear fuel at the power plant. However, this cycle does not generate high-level nuclear wastes as the nuclear fuel cycle does. Sodium unlimitedly exists as salt in seawater and abundantly as rock salt on the Continents, whereas uranium is deposited in the limited region only in the world and its reserves is limited as fossil fuel (Fig. 4). It is the sodium fuel that is rich in natural resources and can be supplied all over the world (Murahara and Seki, 2007; Murahara and Seki, 2008).

Estimates of Power Required by Electrolysis Factory

An amount of power required at the electrolysis factory is estimated. In general, the reverse osmotic membrane (film) method requires 3.5 kWh per ton of seawater and the ion-exchange membrane method (electrodialysis), 8 kWh per ton to collect fresh water. The electrolysis of sodium hydroxide needs 2,500 kWh to produce one ton of sodium hydroxide; the molten-salt electrolysis of sodium, 9,700 kWh to produce one of sodium metal; and the molten-salt electrolysis of magnesium, 16,500 kWh to produce one ton of magnesium metal. When assuming that the offshore electrolysis factory treats one ton of the seawater per hour, 0.9 ton of fresh water, 10.8 kg of sodium, 1.3 kg of magnesium, 2.8 kg of sulfuric acid, and 3.5 kg of hydrochloric acid are produced with the power consumption of 177 kWh. The sodium of 10.8 kg is transported to land and is added water there; then, hydrogen and sodium hydroxide are generated 5 kl and 17 kg, respectively. When the output of one wind turbine set up on the floating plant is assumed 5,000 to 10,000 kW, the gross generation of one floater with a few hundreds wind turbines becomes 1 to 2 million kW. And, if 100 to 200 floaters are built, it is not necessarily unreasonable to supply the home country, Japan, with the resource consumption and also to export to other countries ((Murahara and Seki, 2007; Murahara and Seki, 2008).

Formation of Protective Film with Heat, Cold, and High Electric Insulation Resistance Properties of Wind Turbine and Solar Thermal Power Generation Element

A water-repellent protective film is essential to prevent salt, snow, or ice sticking to the propellers of a wind turbine, and also a strong adhesive is needed not to crack by a thunderbolt.

For solar thermal power generation, a high temperature resistance adhesive is necessary to bond elements and a protective film to guard a solar cell against salt damage. It is, thus, proposed to use silicone oil for developing adhesion and coating (Murahara et al., 2005; Murahara, 2007). Silicone oil consists of siloxane bonds, while the chemical structure of quartz has siloxane bonds. The dimethylsiloxane silicone oil {[-O-Si(CH_2)-O-]n} coated on a sample surface is irradiated with the Xe_2 lamplight (172 nm) in the air, and the oxygen is excited by the UV-photon to generate a high active O atom. This active oxygen reacts with the silicone oil to generate (SiO_2)n (Murahara and Seki, 2008; Murahara and Seki, 2008), which will be a coating film or adhesive thin layer photo-oxidized. By this technique, an optical thin film can be made to transmit ultraviolet rays of wavelengths under 200 nm and enjoy the characteristics of homogeneity, high density, resistance to environment, resistance to water, anti-reflective in water, and hardness of 5 in Mohs' scale. In our previous study, the experimental results showed that the adhesion strength was 18MPa at room temperature, and the photo-oxidized silicone oil had 6.5MPa in bonding strength after heating at 500ºC (Murahara et al., 2005; Murahara, 2007).

Conclusions

"The Offshore On-Site Integrated Manufacturing Plant" that takes such important roles as described above has been designed for every factory to accommodate each other with the chemicals and wastes produced and use them efficiently, to attain "Zero Waste", to decrease the energy loss in production, storage, and transportation, and to improve the efficiency of the whole system. This concept is suggested to prevent an artificial collapse in prices for corns, to ensure a stable supply of water, agricultural and marine food, energy, and mineral resources, to solve the problems of food crisis and global warming simultaneously, to be environmentally friendly, and to make a peace-loving, sustainable society without resource wars.

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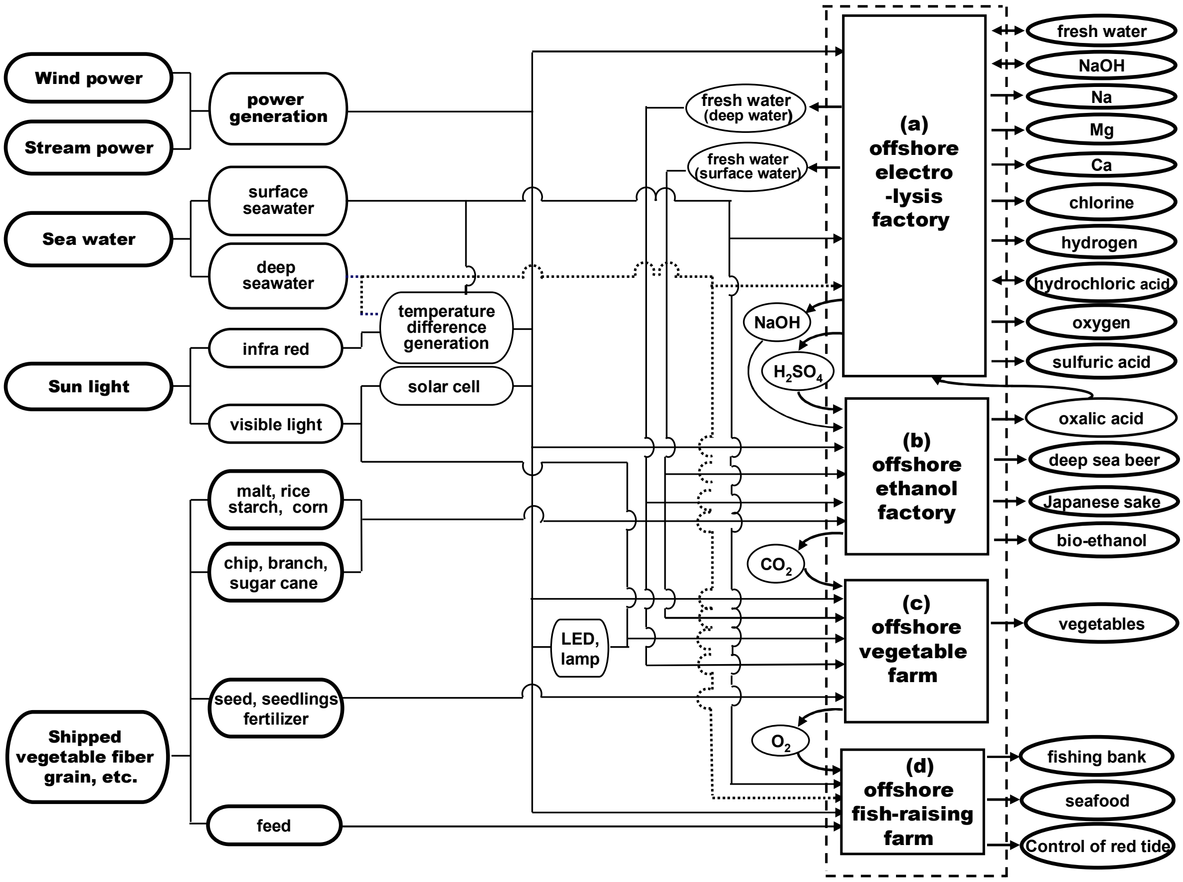

Figure 1. Flow-chart of Offshore On-Site Integrated Manufacturing Plant. The plant is equipped with a power station for renewable energy resources such as wind, ocean current, and the sun; which has an electrolysis factory(a), ethanol factory(b), vegetable farm(c), and fish-raising farm(d) that produce fuel, fresh water, chemicals, vegetables, and fish.

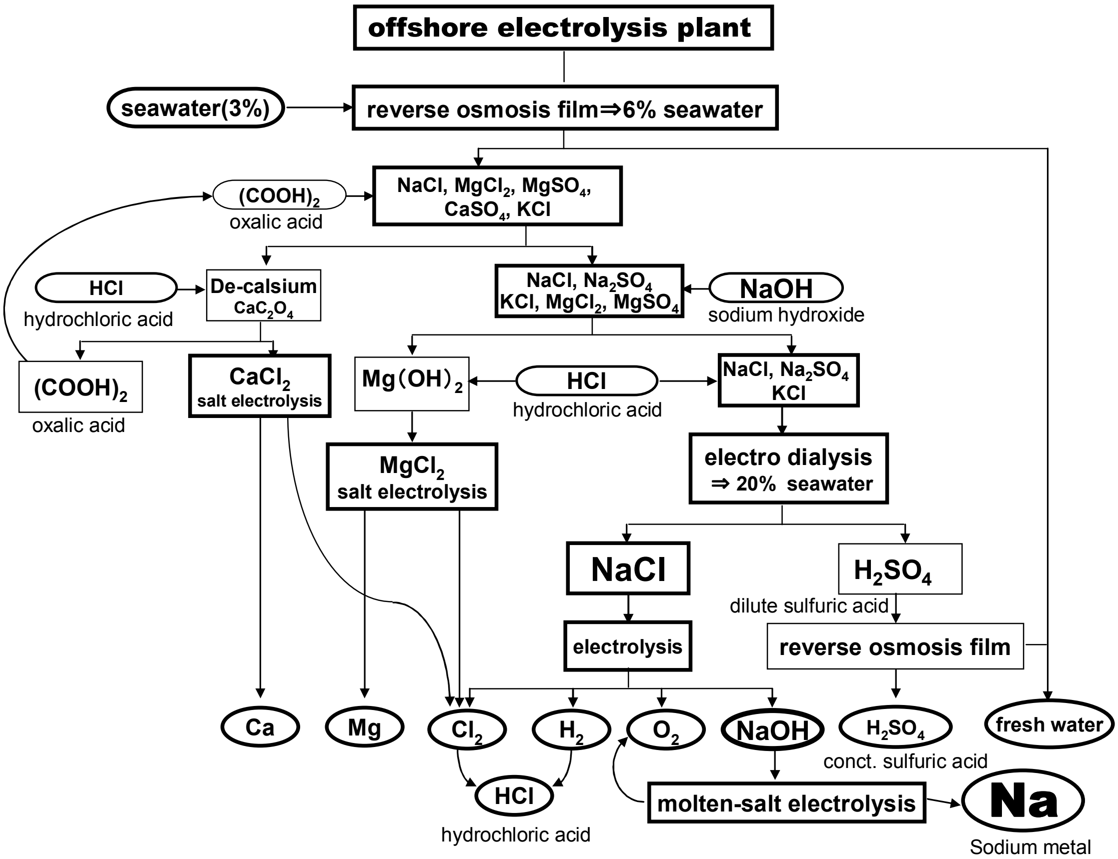

Figure 2. Flow-chart of Sodium Production by Seawater Electrolysis. The seawater is firstly filtered through the reverse osmotic membrane by giving pressures in order to freshen. The sodium hydroxide is poured into the filtrate (NaCl, Na_2SO_4, $MgCl_2$, and $MgSO_4$) of 6% saline sprinkling water in order to liberate the magnesium. The 20% saline water is further concentrated to 30% by heat, and then is electrolyzed to produce sodium hydroxide. The sodium hydroxide is molten-salt electrolyzed to produce sodium metal.

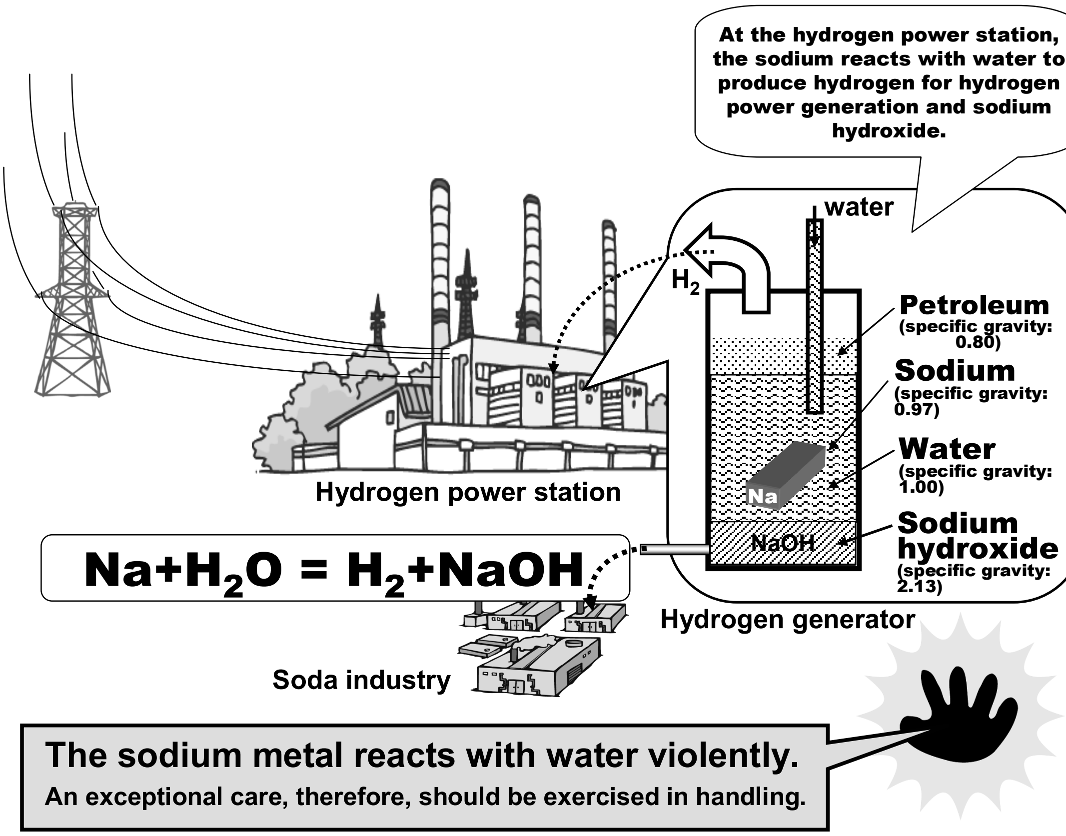

Figure 3. Concept of Hydrogen Power Generation. The sodium metal produced at the offshore electrolysis factory is delivered to the hydrogen power stations on land, where they make it react with water to generate hydrogen instantaneously. The sodium hydroxide, a by-product, is supplied to the soda industry as a raw material.

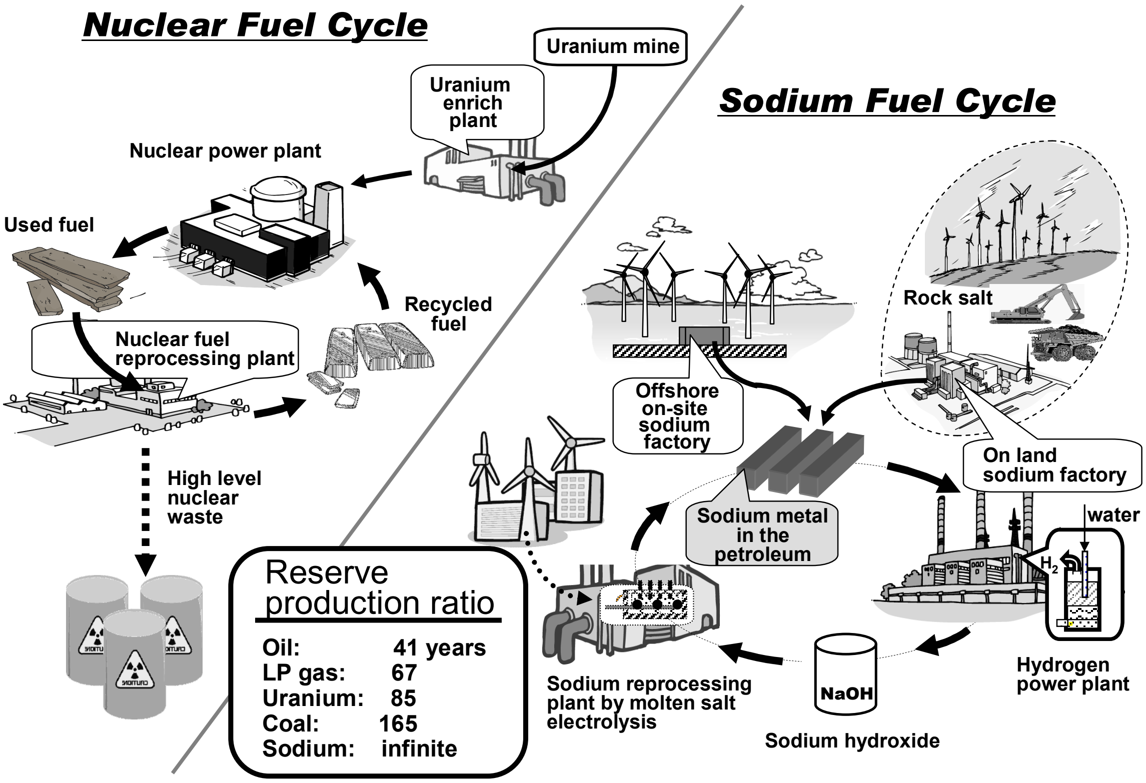

Figure 4. Comparison of Sodium Fuel Cycle and Nuclear Fuel Cycle. Fossil fuel and uranium are deposited only in the limited region in the world and its reserves are limited, whereas sodium unlimitedly exists as a salt in seawater and abundantly as a rock salt in the Continents. It is the sodium fuel that is rich in natural resources and can be supplied all over the world.