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Energy plants in the coastal zone of China: Category, distribution and development

Guo Dong-Gang[a,d,1], Zhang Xiao-Yang[c,1], Shao Hong-Bo[b,c,*], Bai Zhong-Ke[d], Chu Li-Ye[c], Shangguan Tie-Liang[a,**], Yan Kun[b], Zhang Li-Hua[b], Xu Gang[b], Sun Jun-Na[b]

[a] College of Environment and Resources, Shanxi University, Taiyuan 030006, China
[b] The CAS/Shandong Provincial Key Laboratory of Coastal Environmental Processes, Yantai Institute of Costal Zone Research, Chinese Academy of Sciences, Yantai 264003, China
[c] Institute for Life Sciences, Qingdao University of Science & Technology, Qingdao 266042,China
[d] China University of Geosciences, Beijing 100083, China

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ABSTRACT

Fossil fuel is running out day by day and wide plantation of energy plants is very promising to solve future energy crisis. However, China has to feed 22% of the world population but occupies less than 10% global arable lands. Therefore exploiting 2,000,000 ha of non-agricultural coastal land is imperative. This article shows the category and unbalanced distribution of terrestrial and marine energy plants in the coastal zone, and points out five ways (biodiesel, bioethanol, methane, direct combustion and cell fuel) to utilize them. Also the development and progress made in each way is illustrated. At last, several practical suggestions are offered for the future exploitation of coastal energy plants for the globe.

Contents

* Corresponding author at: Institute for Life Sciences, Qingdao University of Science & Technology (QUST), Qingdao 266042, China. Tel.: +86 532 84023984.
** Corresponding author. Tel.: +86 532 84023984.
E-mail addresses: shaohongbochu@126.com (H.-B. Shao), sgtl-55@163.com (T.-L. Shangguan).
[1] Zhang Xiao-Yang and Guo Dong-Gang are the co-first authors for the article because of equal contribution.

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1. Introduction

Nowadays the development of global economy depends heavily on fossil fuel like petroleum, coal and methane. Excessive dependence upon fuel energy not only seriously pollutes our planet but also causes local wars and conflicts for the purpose of occupying energy resources since the storage and distribution of fossil fuel varies among countries [1]. As the world's third largest economy, China is consuming more and more fossil resources. In 2008 petroleum consumption of China reached 365 million tons, 200 tons of which were imported from other countries at a high price. What's worse, in 2008 CO_2 emission of China exceeds America and becomes the biggest discharger of both CO_2 and SO_2 [1,2]. Therefore developing new source of energy is highly imperative both economically and environmentally.

The energy plants refer to plants whose biomass can be used directly as an energy source. In a broad definition, this term designates any land-base or maritime plants since energy stored in any kind of life. Since China is of great biodiversity, the study of energy plants is feasible and promising. For example, 1554 species of oil plant have been found in China whose oil can be converted into biodiesel. Oil content of 154 species is greater than 40% in seed and 30 kinds of arbors or shrubs plants produce combustible components of biofuel richly [1].

Because of the large population and limited areas of arable farmland in China, it is impossible to grow energy plants in fertile inland farms extensively, which would cause nationwide famine. However, China has more than 2,000,000 ha of non-agricultural coastal land with extreme salinity and other adverse factors where normal crops cannot grow. And this number is rocketing in a rate of 13,300–20,000 ha per year. Therefore growing energy plants in these regions is a very practical approach, since it would not take any agricultural land and, if properly exploited, would partly solve energy crisis. To date, many kinds of coastal energy plants have been identified and improved, which grow not only on land but also in the sea. Alga is perhaps one of the most potential alternatives because of its astronomical amount, large specific surface area and amazing growth rate.

Exploitation of these energy plants is mainly in forms of biodiesel, bioethanol, methane, direct combustion and microbial cell fuel. The cell fuel is an unconventional way of directly utilizing energy stored inside energy plants, and deserves more attention and investigation.

2. Category of main coastal zone plants

2.1. Terrestrial plants

2.1.1. Hydrocarbon-rich species

This kind of plants is rich in hydrocarbons, which is easily converted into biodiesel or can be directly used as biofuel without any processes. Representative species of this type is listed as follows:

Euphorbia tirucalli Linn: Growing well in tropic coastal sand, *E. tirucalli Linn* usually have a trunk of 2.0–6.0 m and reach 10.0–25.0 cm in diameter. Its milky sap, rich in combustible hydrocarbon, can be used to produce biodiesel in the process of abstraction and conversion [2]. Besides liquid fuel, *E. tirucalli Linn* are also utilized to produce methane, and its output of CH_4 is 5–10 times more than normal plants. Belonging to the same genus with *E. tirucalli Linn*, another species, *E. 1athyrus* grow not only in coastal zone but also barren inland. Its sap contains a great amount of hydrocarbons resembling petroleum and produces 10–50 barrels of fuel per hectare per year.

Calotropis gigantean: This species grows in arid or semiarid coastal zone with milk-like but poisonous sap in its stem, branch and leaf. Ethane extractive of this sap contains high concentration of liquid hydrocarbon mixtures, whose carbon–hydrogen ratio is similar to petroleum [2]. As a new source of hydrocarbons energy, this fuel is expected to substitute petroleum in the future. Reportedly, in Australia one subspecies of *C. gigantean* can produce 10.64 thousand liters of light petroleum per hectare per year. In southern China, the perspective of *C. gigantean* is very bright because of its amazing growth rate of 30 cm per week and because of its ability to retain sand.

Sindora glabra: Nicknamed by local citizen as diesel-trees, *S. glabra* flow out yellowish or amber liquid when wounded. This kind of liquid owns a similar combustibility with diesel and thus is widely used by the local as kerosene. Typically, a plant with diameter of 30–50 cm can produce 2–4 kg biofuel each time [2].

2.1.2. Carbohydrate-rich species

This type of plants is mainly used to produce bioethanol. Carbohydrates mainly refer to sugar, stark and cellulose, and the former two can be converted into bioethanol more easily than cellulose.

2.1.2.1. Sugar-rich plants. Helianthus tuberous L: Belonging to Compositae family and Helianthus genus, this perennial herb evolves strong ability to resist salinity, cold, malnutrition and drought. Experiments have shown that irrigating *H. tuberous L* with salt seawater would not negatively affect its growth and sugar content. Typically 70% of its carbohydrate is synanthrin and fructose content is also high.

Sorghum dochna var. dochna: This annual herb also shows its ability to resist salt, drought and flood. Since people no longer eat its crop, its planting area shrinks dramatically.

Sugar beet: This is a very common sugar plant in the world which belongs to Chenopodiaceae family and Beta genus. It tolerates high level of salinity and alkalinity, but is sensitive to acid soil. So not only inland fertile farm but also coastal zone can be used for beet plantation.

Sugarcanes: Although some are planted near the sea, sugarcanes cannot strongly resist salinity as effectively as the above species such as sugar beet and *H. tuberous* [3]. As perennial C4 plants, sugarcanes have strong ability to absorb and fix CO_2 and can be harvested for more than 7 times a year. In the second largest bioethanol-producing country—Brazil, sugarcanes are widely grown and utilized to produce biofuel.

2.1.2.2. Stark-rich plants. Corn: Traditionally corns cannot tolerate salt effectively, and growing corn nearby coastal zone is risky for the future yield may drop dramatically. But some species of corn are more tolerant towards salt than others and technology such as cell engineering and genetic engineering has been employed to create new species that is suitable in coastal zone [17].

Potato: Like corns, traditional potatoes are not salt-tolerant, but some special species shows satisfying tolerance towards negative conditions in coastal zone. Investigations conducted by Liang et al.