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Circular Economy Model - Taking Fuel Ethanol and Bio-gas as its core

Du Feng-guang / Jia Hao
Henan Tianguan Group Co. Ltd
16 East Jianshe Road, Nanyang, Henan, 473000, China
Email: ny00174@public.nyptt.ha.cn

Circular economy is a new concept which started more than ten years ago. It is the abbreviation of the closed material circular economy. Essentially, it is a kind of zoological economy and it requires people to use ecological rules but not mechanistic rules to instruct human economic activities. Since the industrial Revolution in 1712, people have developed in such a traditional way:

mass-exploiting resources → producing mass → consuming mass → Producing mass waste.

Its characteristics are high exploitation, low utilization and high discharge and it is a kind of one-way-flow linear economy. It uses resources carelessly and it achieves increase in quantity through changing resources into waste continuously. This economic model has lasted for about 300 years. In the late 20th century, resource shortage and environment pollution, the two major obstacles, appeared and became a great threat to human life and development.

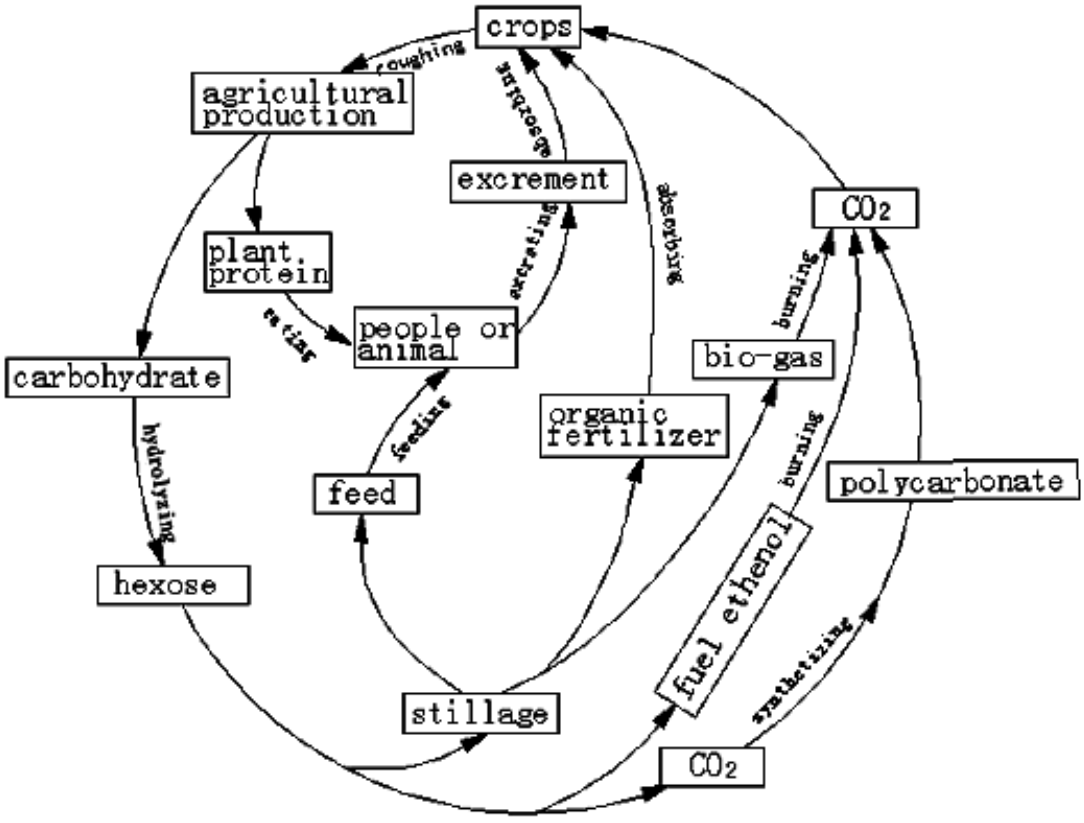
On the opposite, circular economy proposes a kind of economic development pattern, which is in harmony with the environment. It demands organizing economic activities into a feedback flow 'resources — products — renewable resources'. Its characteristics are low exploitation, high utilization and low discharge. All the materials and resources will be used reasonably and continuously in the economy circulation in order to reduce the impact produced by economic activities to the lowest degree. In this way, we can save a lot of natural resources for our descendants. At the same time, we can reduce the discharge of waste and lighten the burden on environment. That is to say, circular economy is realized by continuous circulation of materials, which is also called sustainable development. For a producing enterprise, circular economy is realized by the continuous circulation of its products. Circular economy provides a strategic canonical form of theory to change traditional economy into sustainable economy and eliminates the long-lasting and acute conflict between environment and development.

In the late 1990s the primary resources of energy were in shortage and oil price rose quickly. Human living environment suffered serious destruction from industrial waste. Meanwhile, China's grain production experiences continuous and substantial growth. Due to its over-production the government has to pay a lot of money for storage and deposition. The yield has increased but the farmers' income did not increase. As a result, their production initiative is greatly frustrated.

Henan Tianguan Group is a large enterprise for grain processing. Through internal and external market research, we think that in order to realize the development of national economy and sustainable development of the enterprise, we must choose the way of sustainable development and make a plan for the exploitation of fuel ethanol. This project can solve the three central issues: surplus of grain, oil shortage and environment deterioration. This project gains high attention of the national officials and govenrment departments. With support of officials on different levels, the 200,000 tons per year fuel ethanol plant rebuilding project of Tianguan was completed and put into production in April 2001. A new 300,000 tons per year fuel ethanol project was started in November 2002. Tianguan takes the comprehensive processing of grain and bio-energy as the cut-in point and realizes sustainable development of the enterprise, striding toward the realization of a circular economy.

In the early 1990s, facing fierce competition in the markets, we initiated the strategy of 'alcohol production as a base, deep processing of alcohol as a guideline and comprehensive utilization as well as comprehensive development as the two wings (one base and two wings)'. We carry out clean production, exploit deep processing and comprehensively utilize products, such as acetic acid, ethyl acetate, carbon dioxide, bio-gas and feed and we proceed the way of sustainable development. These items free the enterprise from difficulties in the weak periods of the ethanol market and enable the company to face the fierce competition. Based on the deep processing and comprehensive utilization we realize plural product patterns led by alcohol and clean production models of producing alcohol from sweet potatoes. The exploitation of fuel ethanol combines the development of the enterprise with grain transformation and makes the enterprise stride forward to a higher level and a broader field. It raises the strategy of 'one base and two wings' to the green concept and sustainable development strategy in the best harmony with nature, society and economy. It forms sustainable development and good circulation of production, environmental protection and reuse of resources.

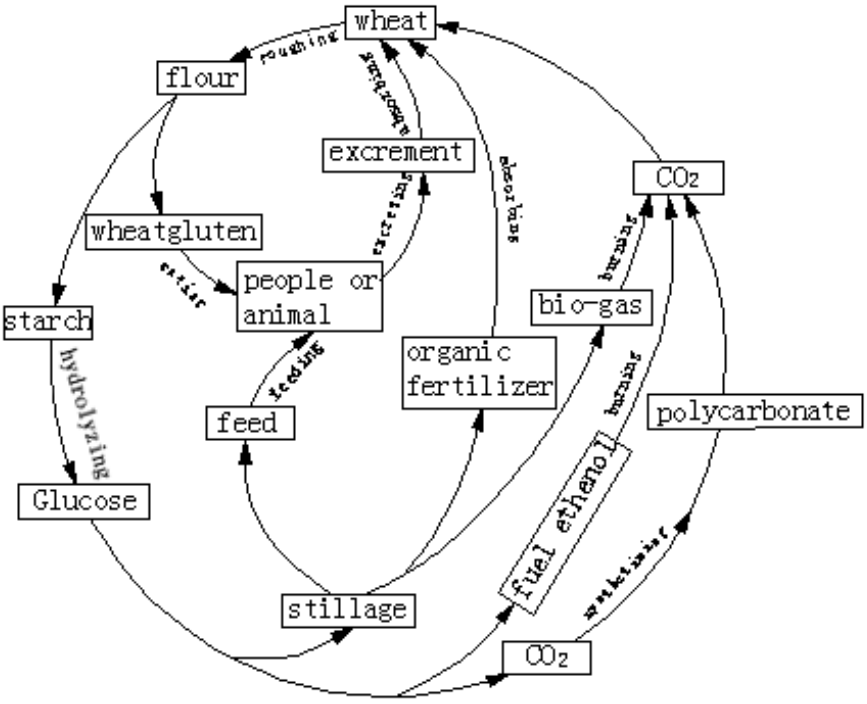
The circular economy product model proposed by Tianguan group is shown in the following picture.



Circulation diagram for sustainable development by the Tianguan Group

From the above scheme, we can see clearly that the discharge of one step is the raw material of the next step. No waste is produced in the whole course and zero discharge is realized. Resources are utilized effectively and the natural environment is protected to the highest degree. We realize the best combination of economic, social and environmental interests. The circular reuse and the utilization of waste products are necessary conditions for the realisation of a circular economy.

Fuel ethanol is a new industry which is in accordance with the state industrial policies and helps to solve the three central issues — resources shortage, comparative surplus of grain and environment deterioration. Through appropriate design, its production course is in line with the requirements of a sustainable circular economy. Besides the main product (fuel ethanol), by-products such as wheat bran, wheat gluten, bio-gas, CO_2, etc. add high economic interests to the enterprise.



Circulation diagram for the production of fuel ethanol from wheat by the Tianguan Group

From the picture we can see clearly that wheat is transformed to flour and bran by milling. Through extraction, we can get wheat gluten and starch, which raise the economic value of wheat. After gluten and bran are used as food for people and animals, the excrement are used as fertilizer for wheat or other plants. (For large breeding farms, the mud after the bio-gas fermentation can be used as fertilizer.) During the whole course, no industrial waste is discharged and no harm is done to the environment. After extracting wheat gluten the remaining starch mash is transformed to glucose by hydrolysis. Through fermentation of *saccharomyces cererisiae* glucose can be converted into ethanol and carbon dioxide. Through purifying and dehydrating, fuel ethanol is gained which can be used as transport fuel for vehicles. After burning, fuel ethanol is transformed into carbon dioxide and water returning to nature and are used again in photosynthesis by wheat or other plants. The purified and compressed carbon dioxide from fermentation can be used in the beverage industry and in other industries. It can also be used for the production of polycarbonate together with propylene oxide.

After fuel ethanol is produced, the stillage contains much organic material, which will cause great pollution to environment if discharged. Of course, controlling pollution requires large investment, but we realize its urgency and necessity. Looking at the strategic height of sustainable development, we invest money and accelerate the speed of pollution research. After continuous experiments and studies, we found the best solution — producing bio-gas by stillage.

First, the stillage is separated into filter cake and filtrate. The filter cake can be converted into DDG protein feed by drying. The filtrate is transformed into bio-gas by anaerobic fermentation. After filtering the fermentation mash, we get a filter cake, which can be used as organic fertilizer and its filtrate contains only little organic material. It can be used as process-water after aerobic fermentation. After burning, bio-gas changes into carbon dioxide and water, which will be used in photosynthesis. Organic fertilizer can be produced from the residue (without the micro-organism fermentation). Finally, all of the products become nutrition for wheat or other plants, and we realize a complete circulation of material under natural conditions. During the course of controlling pollution, we realize the secondary exploitation of all products, leading to significant economic gains. It proves that our way of controlling pollution is reasonable, effective and we can make sustainable development possible.

In the whole course, fuel ethanol and bio-gas are the main products and there is no waste discharged. We realize circulation under natural conditions and also realize the 'resources → products → resources reproduction' circulation flow model of material that is proposed by circular economy.

The proposal of the above model clarifies the concepts of circular economy and sustainable development. Of course, it may not be so simply and perfect in practice. However, it clarifies the development scheme of our enterprise and proposes an aim. We believe that Tianguan Group will be the model of circular economy in practice.

Henan Tianguan Group is a large state-owned enterprise reorganized by some companies with the former Nanyang alcohol factory as its core. It is one of the 520 key enterprises in China and is one of the 50 key enterprises in Henan. It is the first enterprise, which has passed the ISO 9002 attestation and it is the only one that has post-doctorate working stations in China's alcohol industry. Tianguan has more than 5000 employees, more than 900 technicians and 12.8 billion yuan assets. There are 12 productive enterprises, 6 subsidiary companies and 1 institute of the Henan province under the supervision of the group. It has the largest fuel ethanol production line in China, which is 200,000 ton/year, the largest xanthan gum production line and bio-gas projects in China. Its products involve organic chemistry, fine chemistry, biochemistry, distilled liquor, industrial gases and electric power. The main products are food-grade ethanol, fuel ethanol, distilled spirits, beer, acetic acid, and xanthan gum, DDG feed, wheat gluten, bio-gas and more than 40 other products. The total production per year is 500,000 tons with 1 billion yuan sales income and 100 million yuan of tax and profits. At present, the 300,000 ton/year fuel ethanol project sustained by the state is under construction. After it is put into production, the total production will be more than one million ton and the sales income will achieve 2.38 billion yuan and the tax and profits will be 2,800 million yuan.

Reference:

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