

Putting a circular economy into practice in China

Feng Zhijun · Yan Nailing

Received: 24 June 2006 / Accepted: 11 October 2006 / Published online: 12 January 2007
© Integrated Research System for Sustainability Science and Springer 2007

Abstract Promoting a circular economy has been identified as China's basic national policy, according to the recently enacted 11th five-year plan for China's economic and social development. Because of the importance of the development strategy used for this purpose, an implementation framework is proposed in this paper. First, a program is suggested for practically implementing a circular economy in China to serve as a demonstration, beginning at the level of enterprises, then industrial parks, then expanding to cities and regions, thus enabling accumulation of experience to facilitate reasonable decision-making at each successive step. Legislation is also urgent. Certain issues involving legislation, for example the rules the law requires, maneuverability, public involvement, and referencing of developed countries' experiences, must be effectively addressed. Finally, a scientific and effective assessment system should be developed to obtain accurate information and improve guidance. Assessment indices should include an economic development index, a green development index, and a human development index.

Keywords Circular economy · Practice in China · Legislation

Introduction

The recently enacted 11th five-year plan identifies economical use of resources as China's basic national policy to promote a circular economy, preserve the environment, establish a resource-saving and environmentally friendly society, and achieve a harmonious balance of economic growth, population, resources, and the environment.

The circular economy, which is a mode of economic development based on ecological circulation of natural materials, requires compliance with ecological laws and sound utilization of natural resources to achieve economic development. It is, essentially, an ecological economy that follows the principles of "reducing resource use, reusing, and recycling", with the objectives of reducing the resources that enter the production process, effecting multiple use of the same resources in different ways, and reusing waste from one facility as a resource for other facilities. In this mode, with materials going through a feedback process of "resource-product-renewed resource", the ultimate objective of optimum production, optimized consumption and minimum waste can be achieved in production (Feng 2004).

"Reducing resource use" means achieving the objectives set for production and consumption by using minimal raw materials and energy and by cutting pollution at the very outset of economic activity. In production, this principle tends to be reflected in compact and lightweight products, simplified packaging, and maximization of product functions, all with a view to reducing waste discharge. "Reusing" refers to the reuse of a product at other facilities after its initial consumption rather than letting it become toxic waste.

F. Zhijun
National People's Congress, Environment and Resource
Commission, Beijing, People's Republic of China

Y. Nailing (✉)
China Executive Leadership Academy, Pudong,
Shanghai 201204, People's Republic of China
e-mail: nlyan@celap.org.cn

Recycling, the third principle of the circular economy, means the use of a product many times in its primary state rather than one-off use. Meanwhile, products and components in a product series and their packaging must be compatible with one another to enable their reuse when they are upgraded. These principles, as parts of the whole, occupy different places in terms of importance, with reduction of resource use as the leading principle within a circular economy system.

As the largest developing nation in the world, China, with its low per-capita resources and environmental capacity, still has a long way to go before it can be called a generally well-off society. To achieve harmonious relationships between human beings and the environment, it is essential for China to further reform its economic structure and even to shift to a new growth model. Otherwise, natural resources, the environment, and the national competitiveness and security of China will all be threatened. Under these conditions, China must prepare itself for a long and narrow road that adheres to circular economy practices now and for many years to come.

The importance of a development strategy

People's opinions of development are very important. Different opinions of development determine different development paths, models, and strategies.

In the five decades since World War II, humanity gained much insight into development. In the 1950s, some economists (e.g. Lewis 1954) equated development with economic growth. Some developing countries, for example Brazil, Mexico, and South Africa, replicated this theory in their own development, resulting in such phenomena as “growth without development” and “negative development”. In the late 1960s, Gunnar Myrdal (1968) pointed out that growth does not equal development and that economic development is a combination of economic growth and social reform. In the 1980s, the United Nations introduced the concept of “holistic, endogenous and overall” development by French economist Francois Perroux (1983). The UN also introduced the Human Development Index (United Nations Development Programme 1990), which takes into account not only economic factors, but also such factors as social advancement and environmental harmony. As a result, the HDI incorporates a per-capita life expectancy index, education index, and income index. This work demonstrated that the UN advocates balanced and harmonious relations between the economy and ethics,

efficiency and equality, immediate interest and long-term welfare, the parts and the whole.

Nations in the twenty-first century, whether developed or developing, are faced with significant problems regarding development. China, the largest developing nation on earth, needs to answer some fundamental questions about development. There is, in fact, a movement away from the creed that “development is of overriding importance” to one that “development is the top priority” and thence to “overall, balanced and sustainable development”; this trend is gradually giving birth to a scientific philosophy of development specific to China. That is indeed the reasonable choice for China, facing as it does several problems including resource and energy shortages, environmental issues, and how to boost national competitiveness and safeguard national security.

Resource problems

With severe shortages in aggregate and per-capita resources, the growing demand for resource consumption in China is breathtaking. In terms of aggregate resources, China has 1.8% of the world's total oil reserves, 0.7% of natural gas, 9% of iron ore, 5% of copper ore, and 2% of aluminum. With regard to per-capita resources, one Chinese owns half the world average in mineral resources, one-third in arable land and grassland, one-fourth in water resources, one-fifth in forest, one-seventh in energy, and only one-tenth in oil (Information Office of the State Council 2006).

In terms of resource use in China, from 1990 to 2001 oil consumption increased by 100%, natural gas by 92%, steel by 143%, copper by 189%, aluminum by 380%, zinc by 311%, and ten non-ferrous metals by 276%. Steel consumption is currently 250 million tons, equal to the combined total of the USA, the European Union, and Japan, and accounting for 40% of the world's total; cement use has reached 800 million tons, almost half the world total, and electric power use is now second only to the USA. Current known reserves of oil and natural gas in China can last ten years only. All in all, domestic resources simply cannot sustain industrial growth at a traditional pace (Information Office of the State Council 2006).

Environmental issues

China faces daunting environmental challenges. Desertification affects 2.674 million km² of land, 27.9% of the nation's total land area, and is increasing at an annual rate of 10,000 km²; 471 counties in 18 provinces

or 400 million people are threatened by desertification. China discharges 43.95 billion tons of wastewater, more than 82% of the environmental capacity; 40.9% of the water in seven major rivers is seriously polluted and 75% of lakes suffer from eutrophication. Of 600 cities, 400 have insufficient water supplies, and 360 million rural people have no access to clean and safe water. Annual discharges of sulfur dioxide amount to 19.27 million tons, smog 10.13 million tons, and industrial dust 9.41 million tons, severely damaging human health. China's environment simply cannot afford to continue on the current industrial course (Information Office of the State Council 2006). Mitigation of pressures on the environment and reversal of environmental degradation have become urgent necessities.

National competitiveness

With WTO membership come demands to adhere to strict international rules and standards. Trade barriers stand in the way of efforts by China's businesses to go global. In recent years environmental considerations have gained increasing prominence in international trade, resulting in a situation in which China faces many "green barriers" leading to reduced competitiveness. For Chinese firms to go global, there is a need to adopt technical standards and rules in compliance with environmental requirements, and to introduce "green passport" documentation including energy-saving certificates, energy efficiency marking, compulsory recycling of packaging, and mutual certificate systems.

National security

Energy is the basis for human survival and development, and energy issues concern national security. In China, high-energy-consuming industries still have a major role to play in the near future, but shortages of domestic resources make energy conservation the only choice for China's energy and economic security.

Sound development in China will also add impetus to and have an effect on world development. Reduced energy and resource consumption resulting from China's sound development will contribute to healthy development of the world at large. Sound development in China will also hasten overall development of other developing countries, thereby helping to narrow the north-south gap. China's scientific development philosophy, based on a variety of development theories, also serves as example for those striving for overall

development and will expand the world's selection of development theories.

Developing a circular economy is a shift of growth models and a new road to industrialization, and a guarantee for bringing about an overall well-off society and a nation's modernization. Achieving such an economy requires practical implementation of a scientific development philosophy.

Pilot and demonstration programs

Practical implementation of a circular economy has many aspects. Vertically it involves enterprises, industrial parks, cities, and regions; horizontally it involves industries, urban infrastructures, the cultural environment, and the social consumption system. To put a circular economy into practice, there is a need for expanded pilot and demonstration programs and for exploration of effective circular economy models that ultimately facilitate the overall development of such an economy.

The circular economy should be implemented first at the level of enterprises, then in industrial parks, then in cities and regions, moving from the micro to the macro level. Each of these levels serves as the basis for the next level above, and as a platform for the level immediately below.

At the enterprise level, firms set up ecological industrial chains by in-house circulation of materials and energy, and yield profits by endogenous growth and intensive operations that maximize resource use and minimize pollution. In production, stress is on economy of raw materials and energy, on phasing out of toxic materials, and in reduction of the quantity and toxicity of waste; for products, the emphasis is on minimization of adverse effects resulting from a product's entire life cycle, from extraction of raw materials to its disposal; for services, environmental considerations should be integrated into service design and delivery.

At the industrial park level, material flow and energy flow must be redesigned in line with the principles of the circular economy. Within a park, wastes or by-products of one facility should become raw material or input for another by means of waste exchange, clean production, and other measures, achieving the closed-circuit circulation of materials and the multi-level use of energy, forming an interdependent ecological industrial system, maximizing use of materials and energy, and minimizing discharge of wastes, all adding value to the overall resources and energy within the park. Such parks feature horizontal coupling, vertical

closeness, regional integration, flexible structures, sharing of infrastructure, and smooth information exchange.

At the city or regional (provincial) level, pollution prevention becomes paramount; this is characterized by material and energy circulation and has, as its ultimate objective, sustainable social, economic, and environmental development, including maximum energy and resource use and reduction of waste discharge.

Circular-economy cities and provinces involve four systems: the industrial system, the infrastructure, the cultural setting, and social consumption; the infrastructure serves as the basis for the rest, with the industrial system affecting social consumption, and social consumption affecting the human habitation environment. Thus the four systems together constitute a larger complex system.

First, there is a need to build a circular economy-based industrial system featuring industrial symbiosis and material circulation. In such a system people use resources from the ecological system to manufacture, distribute, and deliver products. The system provides material and funding support for regional development with its production functions, covering primary, secondary, and tertiary industries.

Second, infrastructure development is indispensable. This includes the building of water-recycling systems, clean energy systems, and clean mass transit systems. A sound urban infrastructure guarantees circular economic development. A circular economy-oriented urban infrastructure is based on circulation of materials, efficient use of energy, and information sharing within the system, on integration of clean production, eco-industry and eco-agriculture, and on formulation of a holistic strategy.

Third, a commitment to “green” planning, landscaping, and architecture is also needed. An eco-friendly human habitation environment helps to restore the ecosystem in cities and boost the quality of life. To sustain the long-term health of ecosystems requires that resource use, production, and waste disposal be conducted below the ecological threshold.

Fourth, green distribution and consumption should be encouraged and practiced. Within the framework of a circular economy, consumption should be based on harmony between humanity and nature, ensuring that consumption by current and future generations can move from simple to sophisticated levels. Consumer preferences, behavior, and patterns should be oriented toward environmental protection, ecological balance, and sustainable social development, with governments adopting policy measures to ensure the formation of a

circular consumption mechanism. In this way, human demand for materials, ecological health, and mental health can be satisfied while establishing a virtuous cycle in the environment and in the social consumption system, thus enriching the content of circular economy practice.

Indices and indicators for assessment

Successful development of a circular economy requires a system of indicators for assessment; formulation of these is a basis for quantifying economic development and providing key criteria for evaluating the soundness of economic development.

GDP, the traditional indicator of economic development, plays a key role in showing the economic strength of a nation. It fails to indicate changes in the wealth of a nation and in the welfare of its people, however, or the negative impact of economic growth on the environment. With the emergence of environmental protections and sustainable development in the 1960s, some economists and statisticians therefore attempted to integrate environmental considerations into the national economic accounting system, leading to the term “green GDP”. As a modification of GDP, it represents the value of GDP after deducting capital depreciation of products, loss of natural resources, and losses caused by pollution. Despite progress in green GDP research, controversy remains. Currently, no calculating system for green GDP is recognized across the globe, and no government ever releases official green GDP figures, despite trials by some states.

Scholars around the world have made attempts to establish a new system of national accounting, proposing indicators that stress balanced economic, social, and environmental development, for example the human development index (United Nations Development Programme 1990), the index for sustainable economic welfare (Daly and Cobb 1989), the genuine progress index (Daly 1996), subjective well-being (SWB) (Schwarz and Strack 1999), measure of domestic progress (MDP) (Jackson 2004), the UN system of integrated environmental and economic accounting (SEEA) (United Nations 2000), and the net economic welfare indices (Nordhaus and Tobin 1972) among others. The objective of most of these is to determine a genuine growth rate after deducting ecological loss from economic growth. The price to be paid during economic development must be noted.

Because a circular economy stresses harmonized economic, social, and ecological relationships, an index system for assessment should embody these three

dimensions by including an economic development index, a green development index, and a human development index. Of the three, the economic development index should include economic strength indices, for example per-capita GDP and growth rate of GDP, and economic efficiency indices, for example CPI, the industrial mix Index, and the ratio of investment in fixed assets to GDP. The green development index should include:

1. reduction indicators, for example land-output ratio, annual reduction ratio of material consumption per 10,000 output value, energy consumption per ten thousand output value, water consumption per 10,000 output value, and waste discharge per 10,000 output value;
2. reuse indicators, for example reuse ratio of water for industrial purposes, reuse ratios of products and energy, and urban sewage-treatment ratio; and
3. resource indices, for example utilization ratios of waste industrial gases, solid wastes, and urban domestic wastes.

The human development index should encompass:

1. a human habitation environment index, including urban air pollution indicators, sanitation indicators for drinking water, per-capita green space, and per-capita road space; and
2. a social index, including unemployment rate, social security coverage, and Engel coefficient.

These circular economy indices and indicators should also be incorporated into performance evaluation systems for government officials.

Proprietary technological innovation as backup

Technology is a key factor in the development of a circular economy. Each of the three circular economy principles already mentioned requires advanced technology and the development and updating of facilities and equipment.

The government needs to continue its support for the major technologies necessary for a circular economy, identifying key technological areas and projects in line with current and long-term requirements for the economy and lending support to research into energy saving, alternatives, and recycling, thus boosting the nation's capacity in proprietary technological innovation. Enterprises, the key players in this respect, need to incorporate circular economy philosophies and

approaches into their R&D of new products and processes, to boost their innovative capacity.

Research attention and governmental input should be devoted to (Xie 2002):

- processes that feature energy saving, material saving, and reduced or no pollution, including clean production processes;
- technologies that boost the lifespan of materials;
- research into new materials as alternatives to toxic and polluting materials;
- resource-renewing technologies to boost energy efficiency, for example those that recover resources from used household electrical appliances, batteries, and computers;
- development of forecasting models to determine the correlation among such factors as economic gains, recycling rates, costs for renewing resources and pricing for products;
- development of new cost-benefit analysis methods; and
- development of sound and steady eco-chains among enterprises and industries.

Promoting legislation

Barriers exist at the initial stage of China's attempts to achieve a circular economy, barriers that require administrative and legal means to remove. Legal measures are formal, consistent, compulsory, open, and authoritative, thus playing an indispensable and irreplaceable role. Legislation is therefore needed for circular economy development.

In July 2006, the Standing Committee of the National People's Congress of China initiated legislation procedures to draft a proposal concerning the circular economy. The drafting group is now in operation. The outline of the 11th Five-Year Plan for the economic and social development of China also suggests and supports legislation regarding a circular economy. It seems the government is committed to a circular economy by legislation.

Legislative principles

Circular economy legislation must take the principles below into account.

Compliance with a scientific development philosophy

According to the scientific development philosophy of China, which focuses on overall, coordinated, and

sustainable development, economic growth is just one part of development. Development also stresses harmony between humans and nature and seeks to bring about balanced regional, urban and rural, social, and economic development by use of domestic and foreign resources. A circular economy helps to integrate populations, resources, and the environment, prevent environmental poverty, promote social justice at a higher level, and narrow the income gap, and is thus in line with the scientific approach to development. Circular economy legislation therefore requires the scientific approach to development as a guideline.

Due attention to the circular economy in other legislation

To enhance circular economy legislation, attention must be paid to the circular economy in other legislation also. This is also a case in point for decision-making based on considerations of all the relative factors advocated in Agenda 21 China.

Consideration of economic measures

International practices reveal that economic measures remain one of the most effective means of conserving the environment and resources. In view of this, the application of economic measures must be promoted by inclusion in circular economy legislation. In addition to current measures, for example pricing, interest rates, and credit and loans, new measures must be explored, for example environmental taxes, financial incentives, insurance for liability resulting from environmental damage, and environmental labeling, all of which should be included in legislation, when appropriate, to better facilitate circular economy development.

Issues to address

Enforceability

Poor enforceability has been a serious problem in Chinese legislation that must be solved. Clauses must be specific, well-defined, and unambiguous, and when necessary, quantified terms should be included to avoid generalization and abstractness. This requires responsibility on the part of legislators, with legal clauses drafted and examined on the basis of responsible and scientific research. When legislators are confronted with tough problems, consultation with experts and the public is essential to solving them. Only in this way can quality legislation be guaranteed.

Drawing on foreign experience

Environmental problems in one nation may have something in common with those in others. China's lack of experience in circular economy legislation makes it necessary to draw on foreign experience. Whatever works should be taken into account. For example, the Chinese tendency toward generalized legal clauses makes legislation difficult to enforce. China can learn from developed nations in taking a more concrete and specific approach to drafting legal clauses, taking into consideration expected problems and countermeasures.

Public participation

Practices in many countries indicate that public participation is indispensable to development of a circular economy. In circular economy legislation, public voices must be heard, their wisdom absorbed, and their motivation and creativity retained. The current problem is that despite hearings held by legislatures that produce sound suggestions from experts and the public, legislators will ignore these suggestions when a conflict with departmental interests arises, making such hearings nothing more than formalities. It is high time to change course in this regard.

Vital clauses

Circular economy legislation mainly consists of defining the duties and responsibilities of the governments and parties concerned, compulsory administrative measures, economic measures and incentives, and measures to encourage public participation. The elements listed below are vital to circular economy legislation:

1. The legislation must be implemented in coordination with environmental planning, incorporated into economic and social planning at national and regional levels, and provided with budgetary support.
2. The legislation should stipulate the responsibilities of central and local government. In enacting and implementing supportive regulations, governments and departments must identify the responsibilities of concerned parties so that the circular economy can be implemented meaningfully.
3. The legislation must also force major polluting enterprises to adopt circular economic practices. Such enterprises should be listed and required to adopt such practices with relevant penalties and incentives in place.

4. The legislation should encourage the application of energy-efficient and resource-efficient processes and technology that are non-hazardous or less hazardous. Governments at all levels should put more resources into supporting businesses in creative attempts to develop these processes and technology.
5. The legislation should encourage the establishment of diversified investing mechanisms, reward recycling, and reuse efforts, and readjust corresponding taxes, credit and loans, and financial policies.
6. The legislation should explicitly stipulate the recycling and reuse of products and associated rewards and accountability. In the design and production of a product, the enterprise should view the possibility of reusing that product after consumption as a key indicator of its business performance.
7. The legislation should reflect intermediary service regulations. Organizations of an intermediary nature should build up a network of businesses interested in recycling products and their packaging, with release and exchange of information, thus connecting individuals, enterprises, and governments.
8. Consumers should be partially responsible for recycling of consumed products. This will encourage the public to acquire attitudes and habits about consumption in keeping with environmental protection. In this way, resources can be fully exploited and the discharge of hazardous waste can be minimized.
9. The legislation should provide the content, channels, and means for public participation in the establishment of a resource-circulating society. It should also encourage and support the public in creative endeavors that help to build an ecological environment of the people, by the people, and for the people.

Conclusion

The proposed objective of building an overall well-off society within the next two decades of the century encompasses enhanced sustainability, an improved natural environment, increased efficiency of resource use, and harmonious relationships between humans and nature, putting our entire society on a path of

development characterized by good productivity, quality of life, and an eco-friendly environment. To that end, China must alter its development philosophy and approaches, generate new development models, boost the quality of development, take the scientific approach to development as a guideline for overall economic and social progress, and reflect this approach in all aspects of the 11th five-year plan. Development of a circular economy offers a path toward solving environmental problems affecting human health and social development, fostering a growth model characterized by resource conservation, and encouraging healthy consumption behavior, all via a shift in growth models and protection of the natural environment. To build a resource-conserving, environment-friendly, economically efficient, and harmonious society, China needs to be active in its practice of a circular economy.

References

- Daly HE (1996) *Beyond growth: the economics of sustainable development*. Beacon Press, Boston
- Daly HE, Cobb JB Jr (1989) *For the common good: redirecting the economy toward community, the environment, and a sustainable future*. Beacon Press, Boston
- Feng Z (2004) *An introduction to the circular economy*. People's Press, Beijing
- Information Office of the State Council (2006) *Environmental protection in China 1996–2005*. http://www.gov.cn/zwgk/2006-06/05/content_300288.htm
- Jackson T (2004) *Chasing progress: beyond measuring economic growth*. UK
- Lewis WA (1954) Economic development with unlimited supplies of labor. *Manchester School* (3):139–191
- Myrdal G (1968) *Asian drama: an inquiry into the poverty of nations*. The Capital University of Economics & Business Press, Beijing, 2001
- Nordhaus WD, Tobin J (1972) *Economic growth*. NBER, New York
- Perroux F (1983) *A new concept of development*. Basic tenets. UNESCO, Paris
- Schwarz N, Strack F (1999) Reports of subjective well-being: judgmental processes and their methodological implications. In: Kahneman D, Diener E, Schwarz N (eds) *Well-being: the foundations of hedonic psychology*. Russell Sage Foundation, New York, pp 61–84
- United Nations Development Programme (1990) *Human development report 1990*. Oxford University Press, New York, Oxford
- United Nations (2000) *System of integrated economic and environmental accounting (SEEA) draft manual*. Revised 1 May 2000
- Xie Z (2002) *Ecological industry: theory and practice*. China Environmental Protection Press, Beijing