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Approaches towards Sustainable Development in China

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Abstract

China aims at quadrupling its real GDP by 2020 compared to the year 2000. Without any energy and environmental policy measures, this tremendous economic growth would be associated with a quadrupling of primary energy consumption up to 4.5 bn tons of standard coal equivalents (sce) and energy-related CO_2-emissions of 11.5 bn tons. Given these expectations, China is urgently searching for a way to ease these negative implications of economic growth and has committed itself to achieve a level of 3.0 bn t sce primary energy consumption in 2020. As a consequence, the macro-economic energy intensity has to be reduced by 35 percent by 2020. In 2000, however, the average energy intensity in terms of energy consumption per unit industrial output was about 50 percent higher in China than in industrialised countries. Coming from this level, a reduction of 35 percent by 2020 would lead to an energy intensity representing roughly the year-2000 level of developed countries. This is a very demanding goal: depending on the specific industrial process, the decrease of energy intensity in the forthcoming 20 years has to be two to five times higher than what was achieved during the past two decades. Yet, only this path may help to achieve a sustainable development in China.

1 Introduction

The term of sustainable development has no single, comprehensive definition: more than 100 definitions can be found for this abstract concept (GDRC 2005). The most frequently quoted definition is taken from the so called Brundtland Report "Our Common Future: Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (GDRC 2005). Along the lines of this definition, sustainable development implies improving the quality of life for all of the Earth's citizens without increasing the use of natural resources beyond the regeneration capacity of the environment.

Sustainable development is not a new idea. In human history, many cultures have recognized the need for harmony between the environment, society, and economy. In economics, this concept has been developed in the forestry sector, stating that not more wood shall be cut than the forest is able to grow again. Generally, sustainable development is seen having three pillars: economy, ecology and a social dimension (Klemmer 1994: 14-18). E.g., the economic development should not only pursue mere profit maximisation goals but should be integrated as a social market economy with income redistribution mechanisms where the market mechanisms fail to provide a socially fair outcome. Economic decisions also should internalise the external costs of their environmentally detrimental side effects. It is tried to measure or describe the level of sustainable development by certain indicators of efficiency in these fields such as energy efficiency, emission intensities etc.

China's sustainable development strategy is embedded in the country's efforts to transform China into a modern society with tremendous expectations of economic growth. Since 1980, the Chinese economy grew by about 8 percent per year by 2001. Real GDP quadrupled during this period. Although average per-capita income is still expected to more than triple by 2020 (Suding 2005: 2) to achieve a moderate wealth (*xiao kang*) for the people, there are further increasing regional gaps in income growth between the prospering East and South coastal provinces and the hinterland. To achieve these economic development goals without severe energy security problems, e.g. relating to mineral oil, China has to save energy specifically. Negative side effects of this substantial economic growth are increasing environmental degradation (e.g. forest degradation through acid rain) and growing social problems (e.g. educational shortfalls and increasing crime rates caused by migration). One instrument to ease the negative socio-economic and environmental implications of this growth pattern is to integrate economic, environmental and social policy into a national sustainable development strategy.

This paper is to set China's need to develop a sustainable development strategy and the current approaches to implement this strategy into the quantitative context of the countries economic development and subsequent economic growth related environmental problems.

After giving an introduction into the problem (Section 1), the empirical background for China's needs to formulate a national sustainable development strategy is analysed (Section 2): Economic development, energy consumption and natural resources implications as well as regional income disparities. Energy saving is a core feature of China's sustainable development strategy. Hence, in this section, specific macro-economic requirements for energy saving to achieve an energy consumption and emission level compatible with the Chinese development goals are derived. Section 3 provides for an overview of the current state of China's sustainable development strategy, generally and relating to specific sector policies. China is aiming at developing this strategy further. In order to give some input for a possible improvement of China's sustainable development strategy, critical success factors are described in Section 4. A summary concludes this paper.

2 Empirical background

One of the most important policy objectives in China is economic growth as the engine of growing wealth of the world's most populated country, which accommodates more than 1.3 bn people. This welfare goal has top priority for the Chinese government. The successful balance of the past 20 years shows a quintuplication of real Gross Domestic Product (GDP) from 1.8 bn Renminbi (RMB) in 1980 to 9.7 bn RMB[1] by 2001 (see Appendix, Table 1).

The remarkable growth of economy and welfare in China between 1980 and 2001 was accompanied by a 4.6 percent improvement of energy efficiency on average, leading to a moderate annual growth in primary energy consumption of 3.3 percent and only a doubling of energy use and related CO_2-emissions. *Inter alia*, as a result of the installation of desulphurisation devices, SO_2-emissions only grew by about 1.1 percent p.a. during this time. The most important emitter is the industrial sector with a high share of energy intensive production (iron and steel, chemical industry, building material etc.).

Despite the enormous efforts made – energy efficiency had increased by 20 percent during the 1990s – industrial energy efficiency is still very low. For example, to produce one ton of steel China still uses four times more energy than the US. A similar situation is found in the power sector, which is still dominated by coal fired power plants. Currently, the average energy efficiency of Chinese power plants is about 30 percent compared to 38 percent in Germany.

China's government again aims at quadrupling real GDP: up to about 40,000 RMB by 2020 against 2000 (Suding 2005: 2). This task represents an extrapolation of the macro-economic trend of about 8 percent p.a. between 1980 and 2001. Against this background, the realisation of the development goal described above is still associated with an enormous growth of energy consumption and related natural resources implications.

2.1 Economic growth and energy consumption

The relation between energy consumption and economic development can formally be expressed by the composition of the following factors: population, per-capita income, and the energy intensity of GDP (Equation 1).

(1) $$E_t = \eta_t \cdot Ycap_t \cdot P_t$$

with t = 1951 – 2001,
E_t = Primary energy consumption (m t sce),
η_t = energy intensity of GDP (t sce / 1,000 RMB GDP),
$Ycap_t$ = Gross Domestic Product per capita (RMB) in prices of 1998,
P_t = population.

The equation does not necessarily provide a causal relation as important factor such as energy prices or structural changes of the economy are not included. However, this ex-post identity can show the links between energy consumption and the most important macro-economic variables in China. The formulation as an equation can also efficiently structure the following sections.

GDP is a product of per-capita income and population. Assuming a constant per capita income, GDP would increase with the growth rate of population. As both, income (7.0 percent p.a.) and population (1.2 percent p.a.) levels grew between 1980 and 2001, the rise in GDP was 8.3 percent p.a.

The increase of per capita income led to a rising private household demand in every category of consumption. The growth of disposable income in China leads to an increase of consumption which has direct and indirect implications for energy demand. Directly, energy demand increases with a growth of motorisation, the use of electric appliances or the trend to larger apartments and an increasing number of single households. Indirectly, the rising demand for consumption goods increases the energy demand for their production. A growth of energy consumption is also associated with a rise in air-pollution.

According to their income elasticities, the demand for goods and services increased, both leading to a growth of energy consumption. As an example, between 1981

[1] In purchasing power parities, this already is a level of about 4,000 US$ per capita representing the income level of Japan in the 1960s and South Korea in the 1970s (Suding 2005: 1).

and 2001, average household income increased by 103 percent. In the same period of time, the average household living space grew by 105 percent leading to a rise in energy demand for cooling respectively heating purposes as well as for certain household appliances: especially, the demand for refrigerators, air-conditioning systems and colour TVs grew enormously (see Appendix, Table 2).

With an increase of income the demand for transportation and motorisation in China grew (see Appendix, Table 3) leading to an additional demand for transport fuels. Between 1990 and 2001, especially, the number of motor cycles (928 percent), other vehicles (922 percent), and passenger cars (671 percent) grew enormously.

During the same period of tine, the total number of vehicles increased by 520 percent. With China's WTO entry and subsequent lifts of import tariffs on passenger cars, the import of cars will increase. As the imported cars on average are larger than the domestic vehicles, it may lead to an additional growth of fuel demand in China.

As a result of the rise in per capita income, primary energy consumption per capita in China increased by 2.1 percent p.a. from 617 kg sce in 1980 to 949 kg sce in 2001. Compared to Germany (5,388 kg sce) or the US (10,329 kg sce), this is still a very low specific energy consumption.

Energy use in China will continue to rise in the future as production and income levels will increase. In their latest forecast, the International Energy Agency (IEA) estimated China's primary energy consumption by 3 bn t sce in 2020 and 3.6 bn t sce in 2030 in the reference case. Taking certain environmental policies and measures into account, in an alternative scenario primary energy consumption may only grow up to 2.7 bn t sce in 2020 and 3.15 bn t sce in 2030 (see Appendix, Table 4).

To achieve the economic development goals of quadrupling GDP by 2020 against 2000, China has to save energy specifically, otherwise a sustainable development cannot be reached in terms of realising an ecologically sound environment with a moderate resource utilisation. If GDP quadrupled from 2000 to 2020 with a constant-year-2000-energy intensity of 0.124 t sce/1,000 RMB real GDP, primary energy supply would reach about 4.5 bn t sce.

A quadrupling of 2000 primary energy supply would put a heavy burden on energy production and increase the demand for imports of mineral oil dramatically. Currently, about 40 percent of China's oil demand is satisfied with imports. As domestic oil reserves are starting to deplete, in 2020 almost all mineral oil will have to be imported.

To avoid huge negative environmental side effects of economic growth (e.g. CO_2-emissions would increase up to 11.5 bn t), the Chinese government aims at reducing the absolute amount of energy consumption to a reasonable degree of below 3.0 bn t sce in 2020 (Suding 2005: 5). This is about the amount of primary energy consumption, the IEA estimates in her reference scenario (see Appendix, Table 5). To reach this domestically acceptable level of primary energy supply, macro-economic energy-intensity has had to be reduced to 65 percent compared with the year 2000.

Up to the recent past, China decreased macro-economic energy intensity substantially: from 0.337 t sce/1,000 RMB GDP in 1980 to 0.134 t sce/1,000 RMB in 2002. Sectorally disaggregated, between 1980 and 2001, specific energy intensity of major industrial products in China had been reduced by between 12.1 percent (aluminium) and 45.9 percent (tiles). However, certain industrial processes such as cotton spinning, the production of sulphuric acids or the production of paper and paperboard even increased energy intensity (see Appendix, Table 6).

To achieve the 3.0 bn t sce goal, energy efficiency in 2020 has to reach the current value of the industrialised countries. In 2000, on the average, industrial energy intensity in China was about 50 percent higher than in industrialised countries (Suding 2005: 6). Coming from this degree in China, a reduction by 35 percent in 2020 would lead to an energy efficiency representing 98 percent of the current level in developed countries.

This is a demanding goal: a decrease in energy intensity by 35 percent against 2000 within the next 20 years would mean – depending on the process – an increase of two to five times more than what has been achieved during the past 20 years. During the past 20 years, most of the sectors have already reduced energy intensity. Nevertheless, in certain processes, energy intensity is still growing and specific reductions even have to be achieved until 2020. To reach an even lower level, e.g. of 2.7 bn t sce, which is the alternative scenario (Table 4) of the IEA, taking additional environmental policy measures in developing countries into account, macro-economic energy efficiency had to be reduced by 40 percent below the 2020 value.

2.2 Natural resources implications

Generally, the tremendous economic development in China has two different implications for the natural resources:

- increasing utilisation of the natural resources absorption capacity in terms of accumulating and processing emissions from anthropogenic sources, and
- decreasing domestic reserves and stock of resources due to the increasing extraction of fossil and other mineral substances. This development has implications for the Chinese import demand, e.g. for crude oil.

Utilisation of the absorption capacity of natural resources

Energy related environmental issues are closely associated with the reduction of local and regional air quality due to the emissions of air pollutants such as dust particulates and sulphur dioxide (SO_2).

China has set environmental standards for air quality measured by an Air Pollution Index (API) with five grades. The total API is constructed by sub-indices measured through the concentration of sulphur dioxide (SO_2), nitrogen dioxide (NO_2), dust particles with a diameter of less than 10 micrometers (PM_{10}), carbon monoxide (CO) and ozone (O_3) (see Appendix, Table 7). The total index value is the maximum of the single sub-index values.

The State Environmental Protection Administration (SEPA) has described the five API grades and has given out protection measures for the population. For instance, for a pollution of grade 5, where the exercise endurance of the healthy people drops down, some strong symptoms appear remarkably and some heart and lung diseases appear earlier, aged persons and patients should stay indoors and avoid strength training; the ordinary persons should avoid outdoor activities (see Appendix, Table 8).

In China, as an overall trend, air quality in cities tends to improve. However, in 2/3 of the cities, the air quality did not reach the air quality standard for Grade II.

Of the 343 cities and counties monitored by SEPA in 2002, 116 cities recorded urban air quality reaching National Air Quality Standard Grade II or better, accounting for 34.1 percent. Among these, 11 cities had air quality reaching Grade I standard (e.g. Haikou). 35.0 percent of the total or 120 cities had air quality reaching Grade III standard. 31.2 percent or 107 cities had air quality worse than Grade III. Compared to the previous year, the number of cities with air quality reaching Grade II standard increased slightly. The number of cities with air quality worse than Grade III decreased by 2 percent.

On the total, only 26.3 percent of the total urban population accounted for lived in areas reaching the environmental standards. Judged by air pollution situation, nearly 3/4 of the total urban population are still living in severely polluted environments.

Dust particulates were the main pollutants affecting urban air quality. In 63.2 percent of the cities, particulate concentration exceeded the national Grade II standard. In general, in China's northern cities, the particulate pollution was more serious than in the southern cities. North China, Northwest, Northeast, Central plains, and east part of Sichuan and Chongqing are regions having relatively severe particulate pollution. 22.4 percent of the cities had SO_2-emissions exceeding the standard (located in Shanxi, Hebei, Guizhou, Sichuan, Gansu and Chongqing). In all cities monitored by SEPA in 2002, the concentration of nitrogen dioxide reached the national Grade II standard, but its concentration in large cities was relatively high. 113 cities have been approved by the State Council as the key cities for air pollution prevention and control (SEPA 2004: 17), 30 cities of them having the air quality standard reached in 2002. In 44 cities, the air quality met the Grade III standard, in 39 cities, the air quality was worse than Grade III.

On the basis of the calculated API in 47 key environmental protection cities, in 2002, Lanzhou is still the worst polluted city in China, followed by Shijiazhuang and Urumqi. However, the situation in these cities improved compared to 2001. In almost half of the other cities, including Beijing, the pollution index increased (see Appendix, Figure 1), i.e. the situation deteriorated.

Due to the concentration of energy consumption in China, hot spots of SO_2-emissions occur. 73 percent of China's total SO_2-emissions can be found in only 13 of the 31 provinces and municipalities. The largest per-square-kilometer impact of the SO_2-emissions can be found in the large and booming cities of Shanghai (179.1 t), Tianjin (46.8 t) and Beijing (27.5 t) as well as in booming provinces like Jiangsu (17.8 t), Shandong (13.5 t) or Liaoning (12.5 t). Above average per-square-kilometer emissions are mainly in the cities and provinces along the eastern and southern coast such as Zhejiang and Guangdong. Hinterland regions with low economic growth and a higher share of non-fossil primary energy supply have lower SO_2-emissions per square-kilometer such as Qinghai (0.1 t) and Yunnan (0.6 t).

However, since 2000, the emissions of SO_2 are slowly decreasing. In 2002, the total emission of sulphur dioxide in China reached 19.3 million (m) t (15.6 m t from industrial sources and 3.6 m t from domestic sources). The emission of soot totalled 10.1 m t (industry: 8.0 m t; domestic: 2.1 m t). The total industrial dust emission was 9.4 m t (see Appendix, Table 9). Among the 47 most polluted cities, the SO_2 concentration in 11 cities exceeded the standard: Shijiazhuang, Taiyuan, Urumqi, Changsha, Guiyang, Lanzhou, Chongqing, Tianjin, Beijing, Shenyang and Nanchang.

During the past two decades, the emissions of greenhouse gases (GHGs) increased. Especially, carbon dioxide emissions (CO_2) grew by 46.5 percent from 2.4 bn t in 1990 to 3.5 bn t in 2002 (see Appendix, Table 10).

Coal combustion is still the largest source of CO_2-emissions. However, oil and gas play an increasing role. Methane (CH_4) and nitrous dioxide (N_2O) account for only 10 percent of the accounted GHGs. Methane emissions decreased, maybe due to a decrease of cattle against 1990.

Assuming a constant year 2000 CO_2 intensity of real GDP (0.291 t CO_2 per 1,000 RMB GDP), without energy and CO_2 saving measures, a quadrupling of real GDP in 2020 would lead to CO_2-emission of about 11.5 bn t. According to the IEA reference forecast, assuming a quintuplication of real GDP, China's CO_2-emissions would almost double from 2.9 bn t in 2000 to 5.7 bn t in 2020 (see Appendix, Table 11).

As coal is likely still to be the prominent source of power generation, CO_2-emissions in this sector will increase above average. This will lead to a ten percent increase in total CO_2-emissions in 2030. As coal efficiency will increase and natural gas co-generation will substitute a part of coal combustion in the industry sector, the industrial share of total CO_2-emissions will decrease. Due to increasing per-capita income and mobility, transport related CO_2-emissions will grow. The substitution of coal with natural gas in the household sector for heating and cooking reduced residential CO_2-emissions. This development will continue in the future.

Growing CO_2-emissions are having an impact on global climate change. A large part of the additional CO_2-emissions in the world will be from sources in China. Climate change is likely to affect the agricultural water cycle, agricultural water demand, potential for drought and surface run-off, and finally agricultural production in China. Especially, the rain-fed crops in North and Northwest China will face decreases in precipitation and moisture-soil deficits in the forthcoming decades leading to a growth of water demand, and a decrease in agricultural production, respectively, if the natural precipitation cannot be substituted by other measures (Tao et al., 2003: 204). Against this background, different climate change adaptation strategies have to be developed.

Energy security problems

Due to China's economic growth and the preference for using domestic resources, the domestic stocks of reserves decrease as the extraction of fossil and other mineral substances will increase. This development has implications for energy security regarding the provision of sufficient transport capacities (coal and natural gas), the availability of domestic reserves and imports (crude oil), and the provision of sufficient power generation capacities.

Although China's coal reserves are abundant and can be exploited at low cost, energy security issues occur: in a transport-related dimension. As China's main coal reserves are located in the North and Central provinces, but a huge and growing energy demand is generated in the prospering coastal East and South China regions, a huge transport demand is generated. However, as transport capacities are limited, serious energy supply security problems are existing and even growing in the future. China's future energy security strategy has to take this into account, considering measures in the field of improving transport volume on the supply side or the improvement of energy efficiency of coal use and possible substitution potentials to reduce the coal and coal transport demand.

Compared with other countries, China has considerable domestic oil reserves. But domestic oil production cannot satisfy the increasing oil demand, especially from transport and non-energy use. Since 1993, China is a net importer of mineral oil and oil products, since 1996 net importer of crude oil. Ever since, import demand of crude oil has been increasing. Assuming that no major fields can be explored in China, crude oil reserves will be depleted by the end of the year 2018 and crude oil has to be imported by 100 percent (see Appendix, Figure 2). Oil security has different dimensions, such as the building up of strategic oil reserves, the geographical diversification of oil supply including direct investment in energy production abroad, the improvement of energy efficiency in the consumption of oil as well as fuel substitution.

China has domestic gas reserves. However, they are also not sufficient to satisfy expected future gas demand, especially for power generation in peak load and residential use for heating, hot water and cooking. Energy security in this case is also mainly an issue of transport. The Chinese government already took measures to ensure energy supply security by building a large gas pipeline from Xinjiang to Shanghai. The sufficiency of additional transport capacities and energy security depends on the government strategy to what extent the use of natural gas is promoted.

As for electricity, the occurrence of power shortages is the most important challenge for energy security. Power shortages are the result of a fast growing energy demand, which cannot be met by the installation of new additional power generation capacity. To a large extent, maintaining energy security is dealt with by capacity additions of fossil fuelled power generation. The promotion of nuclear and renewable energy sources is to a large extent a reaction to the growing demand for the transport of coal associated with economic growth, especially in the coastal provinces with only limited own coal reserves. Energy security strategy has to take the capacity addition restrictions for large hydro-power projects resulting from geographical situations into account. It also has to consider the additional costs of new nuclear and renewable power generation production capacity. As for nuclear energy, nuclear safety is also an energy security problem including the final deposition of nuclear waste.

2.3 Regional income disparities

The macro-economic development described above only shows a part of the real situation in China because considerable regional income disparities can be found there. The highest per capita incomes are available in the big cities of Shanghai, Beijing and Tianjin as well as in the booming coastal provinces (Zhejiang, Guangdong, Fujian, Liaoning etc.).

Income in central and western China is much lower than in the coastal provinces (see Appendix, Figure 3). GDP per capita in Shanghai (30,543 RMB) is eleven times higher than in Guizhou (2,837 RMB).

The larger cities and coastal provinces have been developed much faster than the hinterland mainly because of China's export-oriented economic development strategy since the early 1980s. Deng Xiaoping's strategy to promote China's exports and building up special economic zones boosted the economic development of the coastal provinces. On the top of that, the costal provinces economic development attracted qualified and non-qualified labour from the hinterland, leading to an additional comparative disadvantage of China's West. The consequence is a regional concentration of GDP per capita. In 2001, 51 percent of the real GDP was created by the nine richest provinces accounting for only 32 percent of China's population (see Appendix, Figure 4).

Inequities in income distribution are measured by the Gini-coefficient. The coefficient is a number between 0 and 1, where 0 corresponds with perfect equality (where everyone has the same income) and 1 corresponds with perfect inequality (where one person has all the income, and everyone else has zero income).

Based on the relationship between the cumulated share of population and the cumulated share of GDP in the four income categories mentioned in Figure 4, China's Gini-coefficient is 0.7. The Gini-coefficient in Germany is 0.3, in the US 0.4.

There are several sources of income inequality in China, most importantly higher urban wages as compared to rural incomes. Urbanites and those working in government monopolistic sectors, for example telecommunication and banking, generally earn much more than farmers and city dwellers in non-monopolistic industries. Additionally, farmers seldom can gain an equal footing while competing with their urban counterparts in job-seeking. Such discrimination also further pushes farmers into a disadvantageous corner while they try to elevate themselves through other means, for instance education and vocational training (*People's Daily*, 16.8.02). Socially, these income disparities provide massive incentives to leave rural areas and generate masses of migrant workers in the large cities of Shanghai, Beijing and elsewhere and generate specific problems regarding accommodation, education etc.

Hence, according to Chua and Bauer (1996), differences in provincial urbanization rates, proportion of industrial employment can partly explain the regional income disparities. Later empirical work, such as Takahiro (2001) also takes foreign direct investment per capita into consideration.

The regional disparities of economic growth and welfare have different effects on the energy end environmental sector in China. The main impacts in China are:

- a regional concentration of energy use followed by
- a regional concentration of regional emissions, as well as
- a huge transport demand resulting from regional disparities of energy production and energy use.

The fast economic development, growing related energy and environmental disparities and the social problems are calling for an integrated policy taking all these factors and their interrelations into account. By establishing a national sustainable development strategy, the Chinese government is trying to do this.

3 Evolution of China's approach towards sustainable development

3.1 Formulation of a national strategy

Three milestones of formulating China's national strategy for sustainable development can be intensified by:

(a) China's Agenda 21: White Paper on China's Population, Environment, and Development in the 21st Century in 1994.

Following the outcome of the United Nations Conference on Environment and Development in Rio de Janeiro in 1992, in the same year China started to draft its national Agenda 21. In July 1994, the State Council promulgated "China's Agenda 21: White Paper on China's Population, Environment, and Development in the 21st Century". The white paper describes policies and measures that have been taken and shall be taken in the future to achieve a sustainable development in China (China's Agenda 21 1994). The Agenda contains general information about strategies and policies for sustainable development as well as specific sectoral development measures, e.g. in the fields of population, health, economic and environmental policies.

(b) Program of Action for Sustainable Development in China in the Early 21st Century

In 2002, the Chinese government took a further step to establish a national sustainable development strategy: the Leading Group for Promoting the Sustainable Development Strategy in China started to formulate the "Program of Action for Sustainable Development in China in the Early 21st Century" (Office of the Leading Group 2004). The programme was published in 2004 and includes

- *Achievements and problems.* *Inter alia*, main achievements are a rapid and healthy economic growth providing an improvement of people's livelihood and quality of life; the reduction of population growth and the narrowing of the East-West gap, the increase of government expenditures for ecological protection and a growing public awareness of sustainable development goals through capacity building. Among others, the greatest challenges are the conflict between rapid economic growth, intensive resource extraction and related ecological damages, regional socio-economic disparities, aging of population, pressure through unemployment and inconsistencies between existing law and requirements for sustainable development.
- *Guidelines, objectives and principles* of China's sustainable development strategy. Main guidelines are (1) human centeredness, (2) harmony between man and nature, (3) centering around economic growth and proceeding from the peoples needs, (3) seeking breakthroughs in institutional innovation, (4) promotion of harmony between socio-economic development, population, resources and environment, (5) enhancing China's competitiveness and laying a sound fundament to achieve a well-off society by 2020. Main objectives are (1) growing capacities for sustainable development, (2) a marked process in economic restructuring, (3) effective control of population growth, (4) improvement of the ecological environment, (5) increase of efficient resource utilisation, and (6) rising productivity, prosperous

livelihood and a well-preserved environment. Main principles are (1) achieving a well-balanced growth, (2) invigoration of the society through science and education, (3) allowing the government to regulate the macro-economy and the market to regulate the micro-economy, (4) increasing international participation and taking advantage of the domestic and international markets, and (5) achieving breakthroughs in key areas.
- *Priority areas of the action plan.* These are (1) economic development, especially industrial restructuring, regional development and poverty alleviation, urbanisation and small-town development, economic globalisation, (2) social development, especially population management, social security, health care, disaster management, (3) resource allocation, utilisation and protection, especially water resources, rational land use, energy efficiency, forest resources, grassland resources, mineral resources, marine resources, climate resources and strategic mineral resources, (4) ecological protection and build-up, especially ecological monitoring and security evaluation, key ecological projects, nature reserves. Ecological conservation zones, anti-desertification, soil conservation, green agriculture, scenic spot protection, urban environment, (5) environmental protection and pollution control, especially water pollution control, marine pollution control, air pollution control, urban traffic management, solid waste control and the environmental industry and (6) capacity building, especially legislation and enforcement, indicator systems, monitoring and evaluation, information sharing,
- *Safeguard measures to realise the goals set out in the programme.* These are (1) employment of administrative means to improve decision making, (2) creation of an investment regime that favours sustainable development through economic leverage, (3) provision of a strong support for promotion of sustainable development through scientific advances and advocacy, (4) improvement of legislation on sustainable development, (5) selection of key regions and field as model projects, and (6) strengthening international cooperation to create a sound external environment for sustainable development at home (Office of the Leading Group, 2004: 1-20).

(c) General strategy implementing a "New Scientific Development Concept" and a "Harmonious Society"

China's sustainable development strategy is embedded in the country's efforts to transform China into a modern state. In this light,

> the formation of the new scientific development concept is a major achievement of the Communist Party of China (CPC) to emancipate ideological work, seek truth from facts, keep pace with the changes of the time, and realize ideological innovation". (*People's Daily*, 22.2.04)

These remarks were made by Chinese Premier Wen Jiabao at a high-level seminar on the new concept of development held at the Party School of the Central Committee of the Communist Party of China for provincial and ministerial level officials on 21 February 2005 in Beijing.

The scientific concept of development, with the goal of building a well-off society by 2020 and the modernization of China by 2050, calls for

> people-centered development, which is comprehensive, coordinated and sustainable, for the promotion of overall harmonic development of economy, society and human beings. (*People's Daily*, 22.2.04)

It also stresses

> coordinated development between urban and rural areas, among different regions and between economic and social development, harmony between human beings and nature and coordination of domestic development and opening to the outside world"(*People's Daily*, 22.2.04)

as means of pushing forward reform and progress.

The concept of "harmonious socialist society" was first launched at the Fourth Plenary Session of the 16th Communist Party of China Central Committee and further interpreted by Chinese President Hu Jintao at a routine high-level Party seminar held prior to this year's sessions of NPC and the National Committee of the Chinese Political Consultative Conference (CPPCC) to set the keynote of this year's social and economic development. A harmonious society features democracy, the rule of law, equity, justice, sincerity, amity and vitality. It aims at giving full scope to people's talent and creativity, enables all the people to share the social wealth brought by reform and development, and forges an ever closer relationship between the people and government (Xinhua, 5.3.05).

3.2 Preliminary establishment of a legal system of the national strategy

To implement the policies and measures of China's Agenda 21, the government has enacted or revised about 120 laws and regulations on population, family planning, environmental protection, natural resource management etc. The legal measures include

- 13 natural resources protection laws
- 3 disaster preparedness and mitigation laws
- 6 environmental protection laws and
- more than 100 regulations concerning population, resources, environment and disasters.

Between 1998 and 2002, government expenditure for environmental protection amounted to 580 bn RMB or on the average 1.3 percent of GDP. This was about two times the total expenditures between 1950 and 1997 (Office of the Leading Group 2004: 45).

3.3 Establishment of an institutional framework

In order to implement the national strategy, already in 1992 under the former State Planning Commission (SPC) and State and Technology Commission (SSTC), Chinese government established a leading group and an affiliated office to instruct the inter-ministerial formulation of China's Agenda 21 and the associated priority programme. In 2000, the leading group was renamed to "Leading Group for Promoting Sustainable Development" (LGPSD) to further coordinate the implementation of the sustainable development strategy among the different ministerial offices. The LGPSD is consisting of representatives from the former State Development Planning Commission (SDPC), the Ministry of Foreign Affairs (MOFA), the Ministry of Science and Technology (MOST), the State Environment Protection Administration (SEPA) and other ministries and institutions in China. The group is lead by the Vice-Chairman of the National Development and Reform Commission (NDRC).

3.4 Implementation of the national strategy through a national development plan

The implementation of the national strategy is being set out through the national development plans. The Ninth Five-Year Plan (1996-2000) put forward that sustainable development is an important strategy for China to promote the countries modernisation. During this plan period, government spending on the environment increased by 1.8 percent against the Eighth Five-Year-Plan reaching 380 bn RMB.

Though economic development is the primary goal of Chinese policy, the Tenth Five-Year Plan (2001-2005) formulates quantitative environmental goals. By 2005:

- energy intensity of 10,000 RMB GDP is to be reduced to 2.2 t sce (in prices of 1990),
- energy conservation and utilization reduction are to be accumulated to 340 m t sce, the annual energy conservation ratio shall reach 4.5 percent,
- conservation and substitution of fuel oil and finished oil should reach 16 m t and 5 m t respectively.

For several sectors such as power generation, iron and steel industry, chemical industry or building material industry, the Chinese government set out individual goals for 2005. E.g., the coal consumption for power generation shall be reduced to 380 g sce/kWh in 2005 (see Appendix, Table 12).

To reduce emissions the Chinese government introduced several measures, including the ban of leaded gasoline since 2000 (*People's Daily*, 3.12.99). Key points of energy technology improvement are petroleum conservation and substitution technologies, clean coal technologies, electricity saving technologies including co-generation etc. The overall energy efficiency goal set by the Chinese government is demanding. In prices of 1990, the energy consumption per 10,000 GDP in 2001 is 2.62 t. A decrease to 2.20 t would represent a specific energy intensity reduction of 16.4 percent in 2005 against 2001.

The forthcoming Eleventh Five Year Plan (2006-2010) aims at enhancing economic strength, changing economic growth patterns, optimising industrial structure, improving the public service system, strengthening the capability for sustainable development, and accelerating reform so as to bring about sustained, fast and sound development of the national economy and the overall progress of the society. These goals shall be, *inter alia*, reached by following measures:

- Breaking the four major bottlenecks of sustainable development (resources, science and technology, talents and system),
- address the rural and west development problems,
- appropriately handle major socio-economic issues of economic growth patterns, industrial structure, balanced development between urban, rural areas and different regions, resources and eco-environment protection, talents and science and technology education, developing a harmonious society (Zhang 2005: 2).

4 Linking sustainable development to selected policies

China's current sustainable development strategy is linked to various sector policies. In the following, energy policy, environmental policy, selected economic policy measures and social policy are highlighted.

4.1 Energy policy

China's "Programme of Action for Sustainable Development" proposes the following measures to achieve a sustainable energy policy:

- paying attention to saving energy resources, increasing energy efficiency and promotion of clean coal technologies through the promotion of a resource saving society,
- adjusting the structure of energy resources and raising the ratio of clean energy resources, and development and exploitation of renewable and new energy sources.

At the meeting of academicians of the Chinese Academy of Sciences and the Chinese Academy of Engineering held in June 2004, President Hu Jintao emphasized the need to strengthen scientific progress and innovation in the field of energy resources, improve the utilization efficiency of China's resources, especially energy and water resources, reduce wastes of resources and develop renewable resources, so as to provide technical guarantee for the establishment of a resources-saving society. A resources-saving society integrates two concepts: One is a resources-saving national economic system; the other is a resources-saving society, which refers mainly to the field of consumption (*People's Daily*, 7.3.05).

Hu Jintao emphasized

> Establishing a resources-saving national economic system and a resources-saving society is the duty for the Chinese engineering and scientific circles. China is now in the stage of large-scale capital construction. Large public infrastructure projects, such as the construction of roads, power stations, energy facilities and public places need to consume huge amounts of materials. For the satisfaction of functional requirements of the society, security and reliability in the designing and construction process, efforts are made to ensure that the projects are simple and practical, and to reduce as much as possible the consumption of energy and other resources, and make the projects compatible with the ecological environment. To establish a resources-saving society is the common orientation for the sustainable development of various countries around the world. This common orientation is especially important and urgent for China. Along with rapid economic development, China has been sustaining increasingly heavy pressure of energy and other resources. Building up a resource saving society to reduce the consumption of energy sources per capita and to improve the utilisation efficiency per unit GDP is a precondition to obtain the economic goal of a well-off society. In this context, well-off means Gross Domestic Product is quadrupled against 2000 and the capability of sustainable development is kept enhancing by the year 2020. (*People's Daily*, 7.3.05)

There is a huge potential of energy saving in China. In industry, many sectors still have an energy intensity well above the industrialised country's level: iron and steel (+21 percent), ammonium (+31 percent), cement (+45 percent), copper (+65 percent), paper and paperboard (+120 percent). The energy intensity of industrial electro-motors and machinery, however, is only estimated to be 5-10 percent above the developed countries' average. The potentials in the household sector are substantial as well. The specific energy intensity for heating is 2-3 times higher than in comparable climatic zones in the western hemisphere. In transport, energy intensity is about 10 percent higher than in the US, and 20-25 percent higher than in Japan or Europe. The reason for this is that the transport of goods has a much larger share in China, where the shipping of goods has a dominant role (Suding 2005: 6).

To use this potential for energy saving, the Chinese government provided a legal and institutional framework (Office of the Leading Group 2004: 48):

- In 1995, China established a "National Leading Group for Promoting and Planning of Technology using Clean Coal". A large-scale demonstration power plant using fluidised bed combustion technology has been built with the assistance of a foreign joint venture.
- In 1997, the Law of the People's Republic of China on Energy Conservation was issued. The government also provided some taxation and other financial incentives to save energy.

The adjustment of primary energy structure is a central concern, as well. Currently, the Chinese energy consumption is dominated by coal, having a share of 57 percent, followed by oil (20 percent) and biomass/waste (17 percent). Gas (3 percent), hydro (2 percent), nuclear (1 percent) and other renewables (<0.5 percent) only play a minor role (see Appendix, Table 13).

In the IEA reference scenario, this structure will not change significantly in 2020. Coal will contribute 54 percent of total primary energy supply, oil (24 percent), gas (5 percent) and nuclear (2 percent) will have a slightly higher share. The use on non-commercial energy (biomass) will decrease to 11 percent of total primary energy supply. The other renewable and new energy sources will not increase their share above 0.5 percent.

To achieve a more sustainable energy structure from the environmental point of view, the share of renewable energy should be increased. In 2003, the installed renewable energy production capacity was:

- Grid-connected wind power: 568 MW;
- Solar photovoltaic (PV) systems: 50 MW;
- Solar-thermal water-heating systems: 50 m m^2.

In 2003, energy production from coal gasification reached 4.5 m m^3, from biogas 5 bn m^3 and from co-generation 1.7 bn kWh (Zhang 2005: 7).

China's "Medium- and Long-term Energy Development Strategy and Plan to 2020" contains specific targets for power generation from renewable sources. In 2010, the target is 60 GW (about 10 percent of China's total installed power generation capacity). The equivalent target for 2020 is 121 GW or 12 percent of total installed capacity (Zhang, 2005: 7). To achieve these ambitious targets, the Government has issued the Law of Renewable Energy which will be enforced from 1 January 2006. The objectives of this law are to:

- confirm the importance of renewable energy in China's national energy strategy;
- remove barriers to the development of an renewable energy market;
- create market opportunities for renewable energy;
- set up a financial guarantee system for renewable energy development;
- create a social atmosphere that encourages renewable energy (Zhang 2005: 7).

From the current point of view, these targets are not achievable by far. Even in the alternative scenario, the IEA expects only an increase of renewable energy sources sum up to about 2.5 percent in 2020 and 4 percent in 2030, including hydropower (Table 12).

4.2 Environmental policy

During the past 25 years, Chinese environmental policy developed thematically, instrumentally, institutionally and regionally (Oberheitmann 2005a). The political field of environmental policy broadened according to growing environmental problems in various sectors. Now, environmental policy covers all major fields including water, air, soil, flora and fauna as well as the radioactive environment. The degree of institutionalisation increased, e.g. by promoting the environmental protection agency to ministerial level. This has led to competition and conflicts with other policy fields, especially economic development policy. The instruments of environmental policy are economising, i.e. they are turning away from command and control measures to economic instruments giving incentives to the economic entities to change their behaviour. Environmental policy also internationalised. China increasingly engages itself in international environmental treaties and promised "Green Olympics" in 2008. This is resulting from China's increasing role in the world and the growing international responsibility attached to this (Oberheitmann 2005b).

According to the Programme of Action for Sustainable Development (2004), as for environmental policy a sustainable development should be pursued in the fields of

- water resources (working out a strategy plan for the development, exploitation and protection of water resources, prevention of water pollution, economisation of water utilisation, etc.),
- eco-environment construction and protection (improving the legal system, protection of endangered species, wetland protection, etc.),
- forest resources (improvement of the forest law system, protection of forest reserves and grasslands, etc.),
- marine resources (strengthen marine laws and regulations, prevention of marine pollution, protection of the marine eco-system, etc.),
- solid waste management (promotion of recycling, improvement of collection and disposal facilities, hazardous waste management, etc.),
- environmentally sound management of chemicals (improving the regulatory system, active participation in international conventions on chemicals, etc.),
- athmospheric protection (updating laws and regulations, SO_2-emissions and acid rain control, improvement of urban air quality, protection of the ozone layer, mitigation of global climate change).

For instance, as for water, Chinese government took resource saving measures. *Inter alia*, water saving irrigated areas in China reached more than 16 m hectares. The rate of recycled water-use for industries was increased from 53 percent in 1993 to 62.5 percent in 2000. Hence, from 1996 to 2000, the amount of water saved summed up to a total of 1.4 bn m^3 in all cities in China. Through restructuring of industry and measures adopted for water-saving, the water-use amount per 1,000 RMB was reduced from 19,200 m^3 in 1993 to 6,100 m^3 in 2000 (Office of the Leading Group 2004: 50-51).

Main instruments for a sustainable reduction of regional (SO_2) and global (CO_2) emissions in China are (a) increased energy efficiency of coal, (b) higher energy efficiency of mineral oil, (c) the increase of the share of natural gas as well as (d) the increase of the share of nuclear energy and renewable energy.

Macro-economically, the improvement of coal efficiency is the least-cost alternative for emission reduction in China. At the same time, it serves energy security goals as well. Reducing coal consumption on the one hand decreases the coal transport bottlenecks from the coal producing provinces in north and central China (Shanxi, Inner Mongolia, Shaanxi, etc.) to the booming coastal provinces (Guangdong, Zhejiang, Fujian, etc.). On the other hand, it reduces the probability of power shortages due to transport difficulties.

4.3 Selected economic policy measures

Implementing China's sustainable development strategy, the government currently undertakes two major policies and measures – the development of a circular economy as well as the calculation of a "Green GDP".

Since the 1980s, China has played an active roll in the implementation of the cleaner production plan established by UNEP, and gradually carried out cleaner production through out the country, which have had a sound effect. In late 1990s, China introduced the idea of circular economy from abroad, and was thought of highly by the top leaders. Recently, the Chinese government and German GTZ established a task force on circular economy within the China Council for International Cooperation and Development (CCICED). This task force aims at illustrating the concept of circular economy, gathering and sorting the experiences on circular economy in foreign countries, and providing related policy recommendations to promote the healthy progress of China's circular economy. Due to their definition,

> circular economy is the abbreviation of closing materials cycle economy. On the basis of material flow patterns, traditional industrial economy is a one-way linear economy consisted of "resource production + consumption – disposal". (CCICED 2003: 2)

In such a kind of open-loop linear economy, people extensively drain all kinds of materials and energy from the planet, then release them as pollutants and wastes to air, water and soil. On the contrary, circular economy, promotes an economy development pattern in line with the restricted accumulation capacities of natural environment. The main purpose of it is to organize the economic activities to a close-loop process of "resource-production – consumption – secondary resource". All materials and energy can be used rationally and continuously in sustained economy cycles, hence the harmful effect to natural environment can be reduced substantially. Circular economy is an imitation of the ecosystem, so it is essentially an eco-economy. The basic difference between circular and linear economy is that the latter is merely a superposition of separate linear material flows, so the trans-system material flows are much greater than those within the system. An ideal circular economy usually consists of these four major roles: miners, processors (manufacturers), consumers and waste disposers. Because of the retroactive and network interactions within the system, material flows between different roles can be much greater than trans-system flows (CCICED 2003: 3).

The 16th National Congress of the Communist Party of China, held in November 2002, pledged an ambitious blueprint for China's development in the next twenty years, i.e. to realize an overall well-off society by the year 2020. The characteristics of such industrialization will be focused on featuring high-technology products, good economic returns, low natural resource consumption and environmental pollution, and efficient deployment of manpower. Development based on the circular economy will be essential for China to reach an overall well-off society by sustaining fast-paced economic growth while mitigating negative ecological impact and creating more job opportunities. In less than three years, the concept of ecological industrial parks and circular economy was introduced into China and started to flourish.

In March 2002, the Government of Guiyang, capital of Guizhou Province, decided to develop Guiyang towards the first Circular Economy Ecological City in China. Soon after this, SEPA officially approved Guiyang as the first pilot city towards Circular Economy Ecological City in China. In July 2003, Guiyang Government entrusted Qinghua University to make a "Master Plan for Guiyang Circular Economy Eco-City Development", in order to effectively guide the efforts towards Guiyang Circular Economy Eco-City and consequently promote the sustainable development of Guiyang. The Master Plan was finished by mid-2004 (IMFM 2005: 4).

The planning goals of the Circular Economy Master Plan are as follows. Phase I of initial design, planning and pilot project phase will end late 2005. Phase II (2005 – 2010) brings about a first implementation and a system re-design phase. Phase III (2010 – 2020) has the final implementation of the projects and a compilation phase. In the Plan, the following relevant regional material flows are considered:

- municipal solid waste (MSW),
- commercial and industrial waste with emphasis on the organic fractions, organic residues from agriculture and livestock industry,
- residues from wastewater treatment plants with emphasis on sewage sludge,
- health care waste (HCW),
- tourism industry (Circular Economy Hotels).

One of the most promising pilot projects is the San Lian Milk Products Co.[2] project (see Appendix, Figure 5). The basic idea of this project is to install an industrial-agricultural biogas plant at San Lian Milk Products Co. By utilizing the energy content of (a) solid and liquid manure of the San Lian Milk Products Co., (b) organic residues of the Traditional Chinese Medicine (TCM) industry, (c) organic residues (residues of soya beans) of the Wei Chun Yuan Food Group, electrical and thermal energy as well as a high-quality organic fertilizer can be produced. For the technical design of the planned biogas plant, the liquid and solid manure of 1,600 milk cows at the company site and 3,400 contracted cows are taken in consideration. Considerable net benefits can be generated through combining several measures: The renewable energy provided by the biogas plant can be used to subsidize coal and electricity at the San Lian Milk Products Co. The fertilizer quality will be enhanced compared to the present composting system. The high-quality organic fertilizer can be sold on the Chinese fertilizer market. The harmful discharge of critical loads to the local wastewater treatment will be avoided. A cost-benefit analysis showed that the total investments of about 4.3 m EUR can be recovered by the annual net-benefits of the project within about seven years (IMFM 2005: 90).

Regarding the calculation of a "Green GDP", on 28 February 2005, 10 municipalities and provinces, including Beijing, have started work to take environmental costs into account when calculating their GDP. The first results of the pilot project governed by SEPA are expected to be released early next year and, it is hoped, will lay a good foundation for nationwide implementation of what has been called "Green GDP" calculation (*China Daily*, 1.3.05). To test run the system for the calculation of a "Green GDP", SEPA has issued a schedule comprising three phases:

- Phase 1: Oct 2004 to Dec 2004. This is the preparatory period, in which technical preparation, training and spot checks for pollution losses were carried out.
- Phase 2: Jan 2005 to Sept 2005. The cities and provinces will set up leading bodies and technical assurance system to carry out the GDP calculation and evaluation of loss caused by pollution.
- Phase 3: Oct 2005 to June 2006. Release of the evaluation and calculation report.

To cope with these shortcomings, the United Nations (UN) and the World Bank have developed alternative

[2]The company produces a wide range of high quality milk products. The live stock capital of the company encompasses 5,000 milk cows, whereas 1,600 milk cows are kept at the local stables of the company and 3,400 milk cows are contracted to small farmers in the near surrounding of the company site (up to 20 km). Actually, the liquid manure (24,000 t in 2003) of the livestock farming at the San Lian Milk Products Co. company site is discharged untreated in the wastewater system. The heavily polluted wastewater causes severe environmental and drinking water problems. The subcontracted farmers deliver fresh solid manure, which is composted in 18 greenhouses nearby the factory site. The solid manure is mixed with straw and dried (25 – 30 days) and then marketed as organic fertilizer. The actual selling price of the fertilizer is about 400 RMB per ton. For production, the San Lian company needs annually 7,203,280 kWh electrical energy and 40,500 KWh thermal energy, produced out of 5,111 t coal (energy content of coal: 7.92 kWh per t). The total energy costs amount up to 2.78 m RMB for electrical energy and 664,300 RMB for thermal energy (IMFM 2005: 85-90).

macro-indicators for environmentally adjusted and sustainable national revenue and products. In 1993, the UN provided, in an official document, a conceptual basis for the implementation of a System for Integrated Environmental and Economic Accounting (SEEA) and environmentally adjusted GDP (Green GDP). Since it is on a "conceptual" basis, the system has yet to provide applicable methods to direct world economies to calculate their respective green GDP statistics. In China, the calculation of resource consumption in economic activities, a prerequisite for establishing a green GDP system, started in the early 1980s. In 1994, the State Council put forward the idea of green accounting of economic activities (*China Daily*, 30.4.04). In April 2003, a high-ranking official from the Ministry of Land and Resources warned that two-thirds of the country's mines have reached their middle or old age, which means, many will be closed due to depletion of resources. The severe situation has prompted relevant departments, such as the NBS, the State Environmental Protection Administration, and the State Forestry Bureau, to quicken their pace in this aspect. The project involves the following calculation:

- First, the current prices of the mineral, water and forestry resources have been calculated in the market on the presumption that they are inexhaustible.
- Second, environmental degradation needs to be quantified to reflect the real green GDP figures.
- Third, the costs needed to redress environmental degradation should also be taken into account (*China Daily*, 30.4.04).

The country's economic boom has had a negative impact on its environment. Experts have been calling for GDP figures to include environmental costs to counter the ecological damage that GDP targets are thought by some to exacerbate. They estimated that when environmental costs are deducted, the average annual GDP growth rate in China will be cut by as much as 2 percentage points. The national GDP growth was 8 percent in 2002 and exceeded 9 percent for the past two years (*China Daily*, 1.3.05).

In an interview, SEPA Vice Minister Pan Yue stressed that "Green GDP" strives to unify economic growth with environmental protection so that it reflects achievements and costs of national economy activities (Liu 2004). Adoption of this system will certainly lead to a drastic fall in statistics of economic growth and bring about changes to the appraisal system for Chinese officials' performance. In the past, GDP growth served as the sole criterion for officials' performance. If economic growth, social development and environmental protection is taken into consideration for the appraisal of the performance of officials, many of them will not have a correct understanding of it, thus becoming a potential force of resistance to the system (Liu 2004).

The system will also have direct and far-reaching influence for enterprises. In actual economic activities, on the one hand, some enterprises only attach importance to direct costs related to their growth and added value, but turn a blind eye to the serious damage to resources and environment entailed by their activities. And on the other hand, the macro-control departments need to analyze the real economic operation. It is necessary for the departments to calculate the environmental cost in enterprises. "Green GDP" index system not only effectively restricts enterprises' impulse to expand but also provides them with an internal force for economic growth. Saving energy means reducing energy consumption, which contributes to saving costs used though the mitigation of pollution. In the long run, the "Green GDP" benefits for enterprises basically will outweigh the defects.

Setting price is the major technological problem when adopting the "Green GDP" system. As known, transaction in the market is the premise of GDP calculation. But it is difficult, even impossible to correctly determine the value of environment. The environment is not involved in transactions in the market. For instance, when a company cuts down a forest and sell the timbers, the price of timber can be added into the GDP statistics, but how much is the cost of the ensuing animal extinction and soil erosion? There is no market price for the wild animals, plants and soil. The environmental cost is hard to be figured out therefore. Secondly, so far there is no scientific calculation method for environmental costs in some projects. For instance, a thermo-power plant will discharge sulphur dioxide and carbon dioxide, which will affect air quality or even the climate. The loss as such is impossible to calculate.

Setting price in the "Green GDP" index system is a worldwide problem. Another challenge is the lack of related laws and regulations, i.e. laws on resources and statistics, evaluation criteria and sharing of information, etc. Vice Minister Pan Yue stated, China shall start the research regardless of how difficult the task is so as to gradually set up a "Green GDP" system that is in line with China's conditions. He assumed, it will take three to six years to establish an initial framework for the "Green GDP" (Liu 2004).

4.4 Social policy

As social policy is not the focus of this article, only a brief description can be given as to the specific fields in China's sustainable development strategy. The social dimension in China's sustainability strategy is developed in three major areas, i.e. (a) the development of science and technology, education, culture and health care, (b) creating more jobs, improving social security work and raising people's living standards, and (c) strengthening democracy and the legal system and safeguarding social stability (Wen 2005).

Core features of these measures are the acceleration of reform and development of science and technology, the promulgation of a national program for medium-to long-term scientific and technological development in 2005 and establishing a national innovation system. The Chinese government will strengthen basic research and research in strategic hi-tech fields and important technologies for non-profit application, continue to work on a set of major science and technology projects and devote more effort to tackling problems in key technologies.

In 2005, 10.9 bn RMB will be allocated from the central budget for reemployment work, 2.6 bn RMB more than in 2004. Local budgets will also increase reemployment allocations. Government will increase employment guidance, training and services. The development of the social security system will be speeded up. The Chinese government will improve the system of basic old age insurance for enterprise employees. While retaining the practice of combining contributions from various sources in society with personal employee retirement accounts, it will be ensured that personal retirement accounts are fully funded in more areas on a trial basis. Additionally, Chinese government will incorporate subsistence allowances for workers laid off from state-owned enterprises into the unemployment insurance system. The Chinese government aims at strengthening democracy and the legal system and safeguarding social stability, fully implement the Party's policies on ethnic minorities and paying close attention to social stability. It will develop a sound mechanism for mediating and settling social conflicts and disputes, improve the system of early warning and the mechanism for prompt response to emergencies to ensure social stability (Wen 2005).

5 Success factors of the national sustainable development strategy

Driving force behind the sustainable development strategy in China is the experienced and expected economic growth and the positive and negative side effects connected with it:

- Positive effects are the growth of public welfare through increasing disposable income and related consumption of private households, increasing agricultural and industrial production as well as growing provisions of services.
- These positive effects, however, are counterbalanced by an increase of energy and other resources utilisation which has impact on the domestic resources availability and the increasing demand to access international resources markets. Socio-economically, a certain amount of instability is produced by an increasing income gap both between regions and even within a region.

Hence, the national sustainable development strategy aims at balancing the Chinese society in different ways: (a) balancing urban and rural development, (b) balancing the development among regions, (c) balancing economic and social development, (d) balancing domestic development and opening wider to the outside world, and (e) balancing development of man and nature. Against this background, factors of success or failure are:

- In balancing urban and rural development and the development among regions, strategic factors are the success of measures to close the gap in income distribution. Currently, urban income is much higher, especially in the prospering coastal regions. These income disparities lead to huge migrations of rural inhabitants into the large cities of Shanghai, Beijing and elsewhere. As long as enough finance flows back to the provinces where the migrant workers come from, there is a tendency towards an equilibrium. However, the geo-strategical disadvantages of the western provinces without connection to harbours for exports and imports still remain. Some western regions are rich of natural resources. Here, the Chinese government should aim to promote the utilisation of these resources for economic purposes. This is not only the production of goods, but also natural parks and sites opened for tourism.
- In balancing economic and social development, factors of success and failure are the successful implementation of macro-economic reforms and the elimination of structural factors that impede economic development and cause economic instability to provide an institutional guarantee for universal, balanced and sustainable economic and social development. It is required to coordinate political restructuring and other reforms alongside with the ongoing economic restructuring. Economic restructuring also should take place in the energy sector. For this, a thorough energy system analysis is necessary. A good example how to undertake such an energy system analysis can be seen in Latin America (see OLADE et al. 2000). Promotion of reform and development takes place through opening up and opening up even wider to the outside world in all areas. Balancing economic and social development also means to reduce the negative implications of a sole reliance on market forces. In this sense, the German or Scandinavian social market economies are good examples as well.
- In balancing domestic development and opening wider to the outside world, critical factors of Chinese economic policy are maintaining the comparative cost advantages in production based on cheap labour and the requirements of opening up the domestic markets internationally based on China's obligations towards the WTO. One other critical point is monetary policy and the valuation of the Renminbi. A revaluation against the US-Dollar has to be considered carefully.

In balancing the development of man and nature, a national sustainability strategy has to take total welfare into account: welfare provided by the utility from consumption and welfare through the utility from a clean environment. Environmental policy is expensive. Hence, China should also further promote international cooperation, e.g. through projects under the Clean Development Mechanism of the Kyoto Protocol.

To integrate sustainable development and economic growth, appropriate policy measures such as the establishment of a circular economy and attempts to calculate a "Green GDP" as a part of implementing a national sustainable development strategy in China are crucial factors for success. As for these two specific measures, there is still scope for improvement.

It is often misunderstood that with the establishment of a circular econcomy, the practice of cleaner production may be put in the back seat. In fact, cleaner production is the first and most vital step for reaching the ultimate goal of circular econcomy, especially for industrial sectors. Without the implementation of cleaner production, a circular econcomy remains in the stage of conceptual framework. For a circular econcomy to prosper in China, it must not become merely the patent of the environmental community. Its acceptance and application by economic policymakers, urban planners, and industrial managers will be the decisive factor through capacity strengthening.

The calculation of a "Green GDP" is connected with various methodological problems (valuation, aggregation, imperfect information about cause and effect, regional disparities, etc.). Hence, these valuations should be made by scientific research institutes and not by the official statistics bureau, which are bound to certain requirements for accuracy. Thus, e.g., in Germany, there will be no official "Green GDP" in the official statistics. Against this background, the attempts to calculate a "Green GDP" in China should be integrated into a long-term development of a sustainability analysis. To avoid huge investments at once, additional pilot projects should be developed to assess the practicability and the financial input for this approach. If adopted, the results of the calculations have to be used intensively. The sustainability indicators collected, short-term can be used for integrated sustainability analysis and be published in designated environment or sustainability reports in China. From the medium and long-term perspective, they can be used in formulating and planning an integrated sustainability policy. Hence, not only the datasets of "Green GDP" accounts should be developed, but also the analysis tools. For this, additional working groups in universities and research institutes may be established.

6 Summary

China's government aims at quadrupling GDP by 2020. If this economic growth would be accompanied by a constant energy and CO_2-emission intensity, primary energy supply would also quadruple to a level of about 4.5 bn t sce. Energy-related CO_2-emissions would reach a level of about 11.5 bn t. This would induce severe energy security problems and, of course, negative environmental and social effects.

Based on China's Agenda 21 and the Programme of Action for Sustainable Development in the 21st Century, the government is thus implementing a national strategy for a sustainability development in different steps:

- formulation of a national strategy for sustainable development,
- preliminary establishment of a legal system of the national strategy,
- establishment of an institutional framework to drive the strategy implementation, and
- implementation of the national strategy through a national development plan.

To reach the overall goal of a sustainable development, the national strategy aims at balancing the Chinese society in different ways: urban and rural development, development among regions, economic and social development, domestic development and opening wider to the outside world, and the development of man and nature.

In the energy sector, Chinese government proposes to achieve a sustainable policy by paying attention to saving energy resources, increasing specific energy efficiency and promotion of clean coal technologies, and by adjusting the structure of energy resources and raising the ratio of clean energy resources, and development and exploitation of renewable and new energy sources. In the field of energy saving, to achieve a level of 3.0 bn t sce primary energy consumption in 2020, the energy efficiency has to decrease by 35 percent by 2020. This represents the year-2000 level of industrialised countries and is clearly a difficult task, as some industry sectors are still increasing the energy intensity rather improving their energy efficiency.

As for the natural resources, the tremendous economic development in China has two implications: an increasing utilisation of the natural resources absorption capacity and a decrease of domestic reserves and stocks of fossil resources, such as crude oil. Hence, a sustainable natural resource policy of saving energy serves different goals: maintaining energy security, reducing emissions, and preserving natural resources.

Appendix

Table 1: Development of selected macro-economic variables in China (1952-2001)

Variable	1952	1960	1970	1980	1990	2000	2001	2001 vs. 1980[a] (percent p.a.)
GDP[1] (bn RMB)	373	719	1,038	1,809	3,756	9,031	9,652	8.3
Population (m)	575	662	830	987	1,143	1,267	1,276	1.2
GDP per capita[1] (RMB)	650	1,087	1,251	1,833	3,286	7,126	7,563	7.0
Primary Energy Supply (m t sce)	48	295	306	609	990	1,115	1,212	3.3
CO_2 (m t)	137	835	822	1,573	2,565	2,629	2,906	3.0
SO_2 (m t)	1	9	8	16	19	20	19	1.1

a) Annual average growth rate.
1) In prices of 1998.
Source: ZRGGT diff. years; LBL 2004.

Table 2: Development of selected household data in China (1981-2001)

	1981	1985	1990	2000	2001	2001 vs. 1990 (percent)
			Selected household data			
Household size (persons/household)	4.24	3.89	3.50	3.13	3.10	-11
Average income (RMB/year)[1]	2,473	3,365	3,415	6,096	6,949	103
Disposable income per capita (RMB)[1]	531	776	1,450	4,824	5,342	268
used for Water, electricity, fuels (RMB)[1]	15.55	21.24	41.32	288.47	333.02	706
Urban per capita net living space (m^2)	4.10	5.20	6.70	10.30	15.50	131
Living space per household (m^2)	17.38	20.23	23.45	32.24	48.05	105
Coal consumption per household (kg/year)	1,018	1,053	721	403	399	-45
			Electrical appliances per 100 households			
Ventilator	43.0	74.0	135.5	167.9	170.7	26
TV (black and white)	57.0	67.0	52.4	n.a	n.a	-
TV (colour)	0.6	17.0	59.0	116.6	120.5	104
Washing mashines[2]	6.0	48.0	78.4	90.5	92.2	18
Refrigerators	0.2	7.0	42.3	80.1	81.9	94
Freezers	n.a	n.a	n.a	6.5	6.6	-
Air-conditioners	n.a	0.1	0.3	30.8	35.8	11,833
Electrical cooking devices[3]	n.a	19.0	46.2	101.9	107.9	134

1) In prices of 1998.
2) Including manually and semi-automatically operated devices.
3) Electrical rice cookers, etc.
Source: ZRGGT 2004.

Table 3: Development of motorisation in China (1970-2001, in thousand units)

Year	Trucks	Buses	Passenger cars	Motorcycles	Tractors	Other vehicles	Total
1970	320	31	44	n.a	n.a	n.a	396
1980	1,299	113	238	245	n.a	306	2,200
1985	2,232	n.a	n.a	946	1,784	1,562	6,523
1990	3,685	333	1,289	4,213	4,626	4,623	18,769
1995	5,854	440	3,739	13,719	n.a	14,946	38,699
1997	6,012	487	5,319	20,222	7,328	22,148	61,517
1998	6,279	521	6,027	25,204	7,720	27,707	73,459
1999	6,770	570	6,832	31,619	7,645	34,570	88,006
2000	7,163	605	7,933	37,718	8,209	41,681	103,308
2001	7,652	n.a	9,940	43,308	8,260	47,241	116,400
Growth rate 1990-2001 (in percent)	108	82	671	928	79	922	520

Source: LBL 2004.

Table 4: Primary energy consumption in China (2002-2030, in m t sce)

	Reference scenario			
	2002	**2010**	**2020**	**2030**
Coal	1,019	1,291	1,599	1,934
Oil	353	536	719	909
Gas	51	84	153	226
Nuclear	10	30	67	104
Hydro	36	47	71	90
Biomass and Waste	309	324	337	337
Other renewables	0	7	14	29
TOTAL	1,774	2,317	2,960	3,627
	Alternative scenario			
	2002	**2010**	**2020**	**2030**
Coal	1,019	-	1,374	1,493
Oil	353	-	663	799
Gas	51	-	183	296
Nuclear	10	-	76	120
Hydro	36	-	71	90
Biomass and Waste	309	-	294	313
Other renewables	0	-	20	40
TOTAL	1,774	-	2,681	3,150

Source: IEA 2004.

Table 5: Requirements for macro-economic energy-intensity in China

	2000	2020			
PES (m t sce)	1,115	4,462	3,569	3,123	2,677
GDP[1] (bn RMB)	9,031	3,6125	36,125	36,125	36,125
PES/GDP[1] (in percent of year 2000 value)	100	100	80	70	60
PES/GDP[1] (t sce/1,000 RMB)	0.124	0.124	0.099	0.086	0.080

1) In prices of 1998.
Source: Own calculations based on data from ZRGGT diff. years.

Table 6: Development of product specific energy intensities in China

Product	Unit	1980	1985	1990	1995	2000	2001	Reduction 2001 vs 1980 (in percent)	Average target in 2020[1]
Power generation	G sce/kWh	498	436	431	456	429	423	-15.1	279
Steel	GJ/t raw steel	59.8	51.2	47.2	44.4	38.4	37.8	-36.8	25.0
Non-ferrous metals									
Aluminum	GJ/t	336.5	303.4	337.9	322.7	300.2	295.7	-12.1	195.1
Copper	t SKE/t	2	1.7	1.7	1.2	1.3	1.3	-35.0	0.8
Textiles									
Cotton spinning (electricity)	MWh/t	1.8	2	2.1	2.3	2.2	2.1	16.7	1.4
Building materials									
Cement	GJ/t	6.1	6.1	5.9	5.7	4.8	4.7	-23.0	3.1
Tiles	GJ/m	375.8	279.9	249.1	203.7	206.4	203.3	-45.9	134.2
Flat glass	GJ/case	1	1	0.9	0.9	0.7	0.7	-30.0	0.5
Chemicals									
Ammonia	GJ/t	41.9	40.1	39.4	37.6	35.6	35.1	-16.2	23.1
Sulphuric acids (electricity)	kWh/t	89.7	88	105	101	n.a	n.a	12.6	65.7
Light industry									
Paper and paper-board	GJ/t	n.a.	n.a.	25.5	46.6	43.3	42.7	67.5	28.1

1) 35 percent reduction of specific energy intensity.
Source: LBL 2004; own calculations.

Table 7: API value and corresponding pollutant concentrations

Pollution index	Pollutant concentrations (mg/m^3)				
API	SO_2	NO_2	PM_{10}	CO	O_3
50	0.050	0.080	0.050	5	0.120
100	0.150	0.120	0.150	10	0.200
200	0.800	0.280	0.350	60	0.400
300	1.600	0.565	0.420	90	0.800
400	2.100	0.750	0.500	120	1.000
500	2.620	0.940	0.600	150	1.200

SO_2, NO_2 and PM_{10} daily average, CO and O_3 hourly average.
Source: SEPA 2005.

Table 8: Definition of the Air Pollution Index (API)

API	Description	Grade	Effects to health	Measures suggested
0-50	Excellent	I	Daily activities not be affected	No
51-100	Good	II		
101-150	Slightly polluted	IIIA	The symptom of the susceptible is aggravated slightly, while the healthy people will appear stimulate symptom.	The cardiac and respiratory system patients should reduce strength training and outdoor activities.
151-200	Light polluted	IIIB		
201-250	Moderate polluted	IVA	The symptoms of the cardiac and lung disease patients aggravate remarkably, and the exercise endurance drop lower. The healthy crowds popularly appear some symptoms.	The aged, cardiac and lung disease patients should stay indoors and reduce physical activities.
251-300	Moderate-heavy polluted	IVB		
>300	Heavy polluted	V	The exercise endurance of the healthy people drops down, some appears strong symptoms remarkably. Some diseases appear earlier.	The aged and patients should stay indoors and avoid strength training; the ordinary should avoid outdoor activities.

Source: SEPA 2005.

Table 9: Emission of major air pollutants in China (1998-2002, in m t and percent)

Year	SO_2-emissions			Soot emissions			Industrial dusts emission
	Total	Industrial	Domestic	Total	Industrial	Domestic	
1998	20.9	15.9	5.0	14.6	11.8	2.8	13.2
1999	18.6	14.6	4.0	11.6	9.5	2.1	11.8
2000	20.0	16.1	3.8	11.7	9.5	2.1	10.9
2001	19.5	15.7	3.8	10.7	8.5	2.2	9.9
2002	19.3	15.6	3.6	10.1	8.0	2.1	9.4
Change (percent)	-1.1	-0.3	-4.4	-5.3	-5.6	-4.3	-5.0

Source: SEPA 2004.

Table 10: Development of selected greenhouse gases in China (1990-2002, in m t)

	1990	1995	2000	2002
TOTAL[1]	3,115	3,687	3,536	4,273
CO_2	2,391	3,100	2,771	3,503
Coal	1,989	2,597	2,019	2,665
Gas	33	39	57	71
Oil	369	464	696	766
CH_4	612	370	369	370
N_2O	112	217	396	400

1) Excl. HFCs, PFCs, SF_6 and Carbon sinks as well as different sources of CH_4 and N_2O.
Source: LBL 2004; TERI 2004; JAMST 2004.

Table 11: Forecast of CO_2-emissions in China (2002-2030, in m t and percent)

	2002	2010	2020	2030
	Emissions (reference scenario)			
Total	**3,307**	**4,386**	**5,708**	**7,144**
Power generation and heat plants	**1,576**	**2,316**	**3,210**	**4,195**
Transformation losses and own use	**140**	**170**	**204**	**232**
Final consumption	**1,591**	**1,900**	**2,294**	**2,717**
Industry	885	984	1,080	1,149
Transport	244	383	592	852
Other sectors	405	466	552	647
Non-energy use	57	66	70	70
	Shares (in percent)			
Total	**100.0**	**100.0**	**100.0**	**100.0**
Power generation and heat plants	**47.7**	**52.8**	**56.2**	**58.7**
Transformation losses and own use	**4.2**	**3.9**	**3.6**	**3.2**
Final consumption	**48.1**	**43.3**	**40.2**	**38.0**
Industry	26.8	22.4	18.9	16.1
Transport	7.4	8.7	10.4	11.9
Other sectors	12.2	10.6	9.7	9.1
Non-energy use	1.7	1.5	1.2	1.0

Source: IEA 2004: 485.

Table 12: Specific environmental goals in the 10th Five Year Plan for Energy Conservation and Resources Comprehensive Utilization (Goals for 2005)

Sector	Field of reduction	Reduction goal
Iron and steel	comprehensive energy consumption per ton of steel for medium and large-sized iron and steel enterprises	less than 0.8 t sce
Power generation	Coal consumption of power supply for thermal power generation plants	380g sce/kWh
Non-ferrous metals	Energy consumption for 10 kinds of non-ferrous metals	4.5 t sce/ ton of product
Chemical industry	Comprehensive energy consumption for large-sized synthetic ammonia	37 Giga-joule
Building Material and glass	Average energy consumption for key products such as cement and glasses	20 percent reduction
Transportation	Oil consumption per 100 km for various types of vehicles	10-15 percent reduction averagely
Building industry	Energy conservation ratio for newly built heating residential buildings	shall reach 50 percent
Building industry	Energy conservation ratio for newly built public works	shall try to reach 50 percent

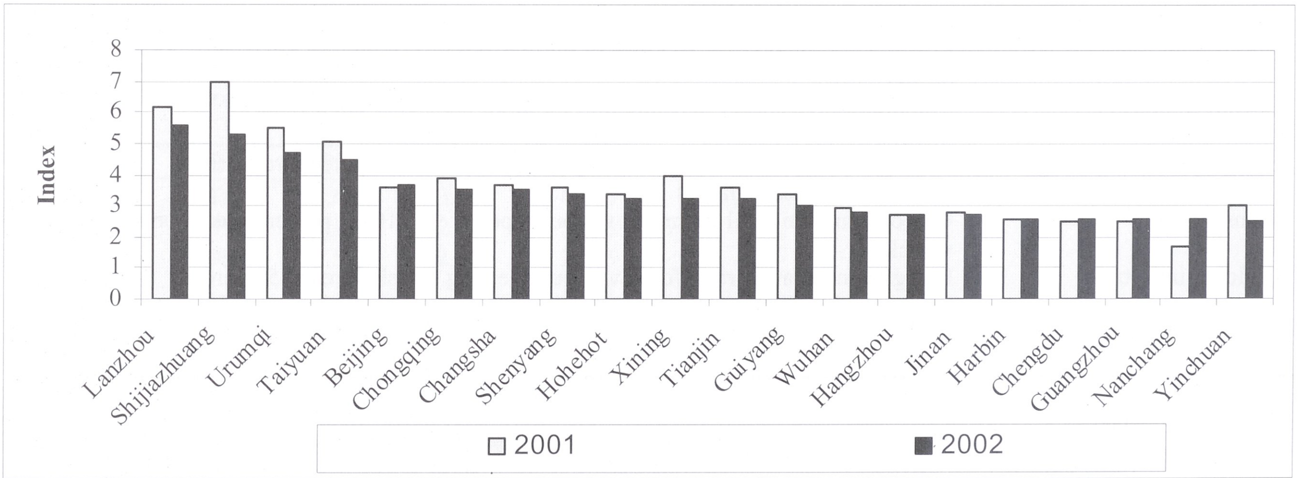
Source: SETC 2000.

Table 13: Structure of primary energy consumption in China (2002-2030, in percent)

	2002	2010	2020	2030
Reference scenario				
Coal	57.4	55.7	54.0	53.3
Oil	19.9	23.1	24.3	25.0
Gas	2.9	3.6	5.2	6.2
Nuclear	0.6	1.3	2.3	2.9
Hydro	2.0	2.0	2.4	2.5
Biomass and Waste	17.4	14.0	11.4	9.3
Other renewables	0.0	0.3	0.5	0.8
TOTAL	100.0	100.0	100.0	100.0
Alternative scenario				
Coal	57.4	-	51.3	47.4
Oil	19.9	-	24.7	25.4
Gas	2.9	-	6.8	9.4
Nuclear	0.6	-	2.8	3.8
Hydro	2.0	-	2.7	2.9
Biomass and Waste	17.4	-	11.0	9.9
Other renewables	0.0	-	0.7	1.3
TOTAL	100.0	-	100.0	100.0

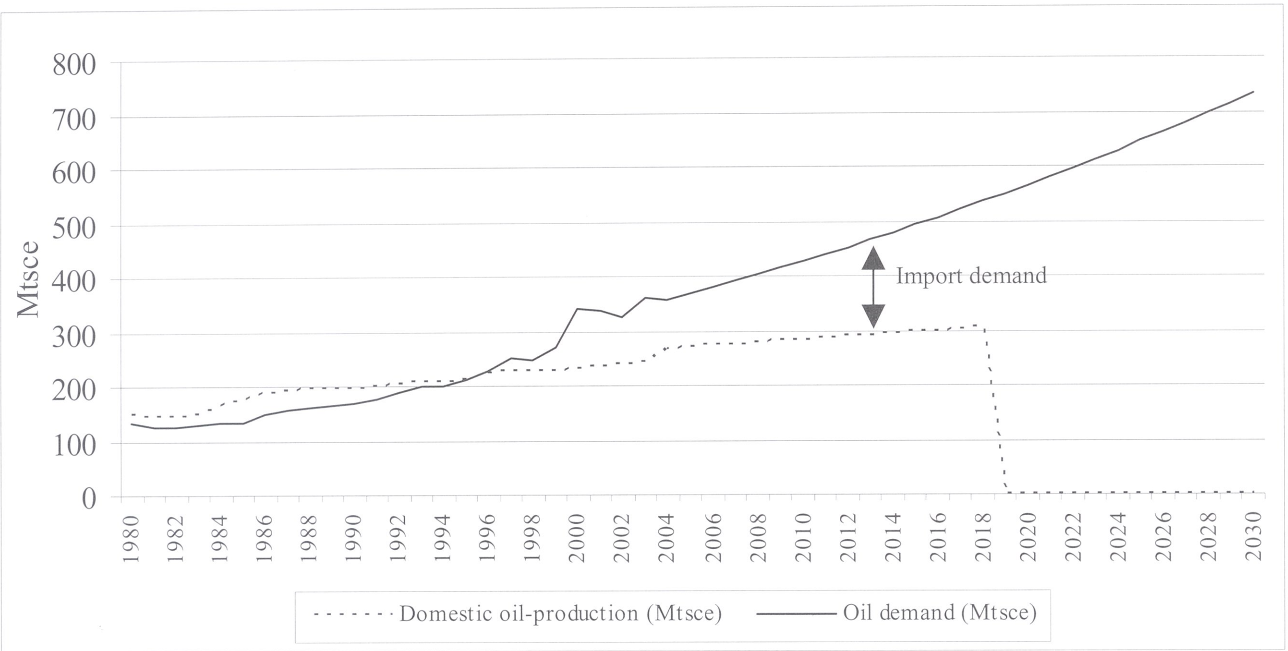
Source: IEA 2004: 482.

Figure 1: Integrated Pollution Index in the key environmental protection cities in China (2002)



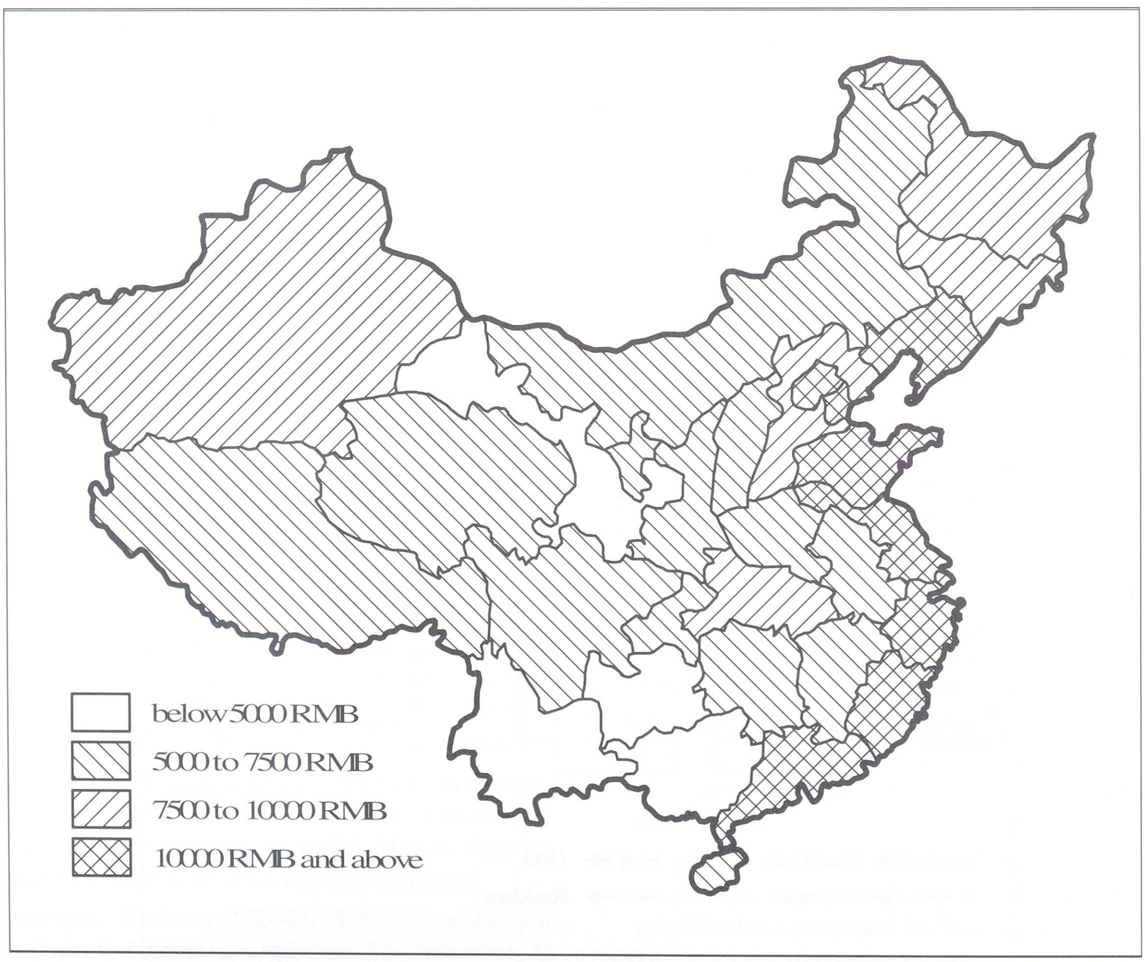
Source: SEPA 2004.

Figure 2: Development of crude oil import demand in China (2002-2030, in m t sce)



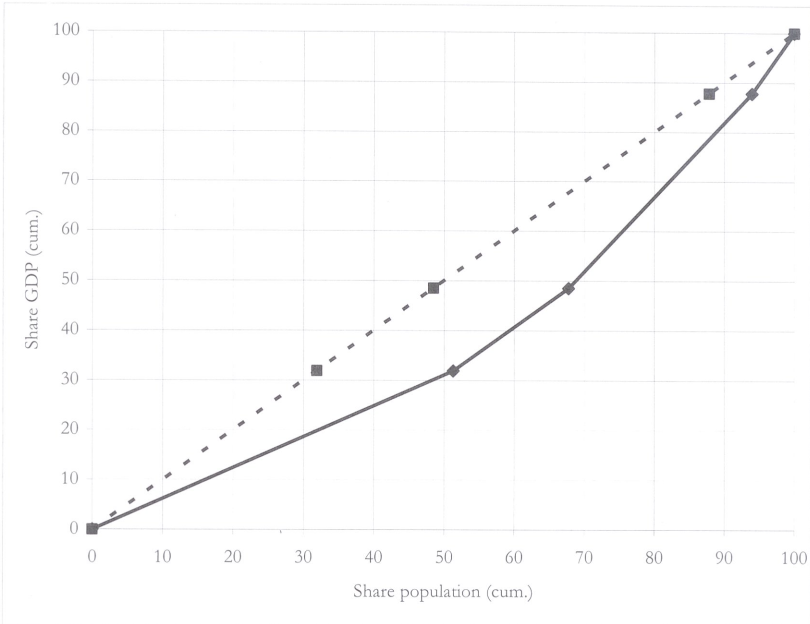
Source: LBL 2004; own calculations.

Figure 3: Real GDP per capita in China (2001)



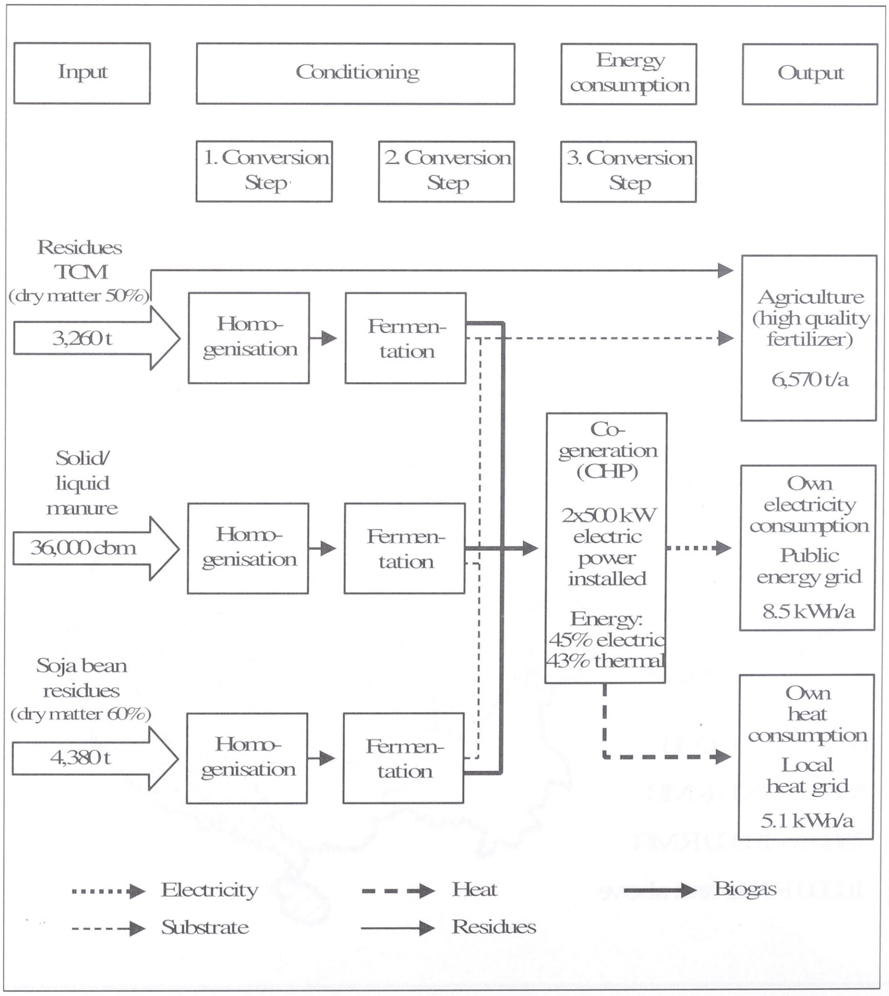
Source: ZRGGT 2004.

Figure 4: Concentration of real per capita income in China (2001, in RMB)



Source: Own calculations based on ZRGGT 2004.

Figure 5: Flow chart biogas plant at San Lian Milk Products Company



Source: IMFM 2005: 87.

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