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## CDM Potential for Rural Transition in China Case Study: Options in Yinzhou District, Zhejiang Province

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# CDM Potential for Rural Transition in China

## Case Study: Options in Yinzhou District, Zhejiang Province

### ABSTRACT

This paper aims to examine the potential of the Clean Development Mechanism (CDM) to address energy-related issues during the rural transition process in China, using a case study of quickly urbanizing and industrializing Yinzhou district in coastal Zhejiang province. Yinzhou's per capita GDP reached US\$ 3100 in 2002, three times China's average, and is targeted to achieve \$10,000 in 2020.

We assess the current energy status of Yinzhou, and provide projections of energy consumption and CO<sub>2</sub> emissions up to the year 2020. Energy resource shortages and limited possibilities to obtain coal-fired electricity from national grid illustrate the opening gap between energy supply and demand. We find that Yinzhou's CDM potential is concentrated in efficiency improvement on the demand side. In that context, we suggest to systematically explore the CDM potential in the industrial sector. Projects will have to involve many stakeholders and the necessary local capacity has to be built. These CDM projects can be considered as killing three birds with one stone, namely maintaining continuous economic growth, alleviating local environmental pollution as well as mitigating global climate change.

**Key words:** Clean Development Mechanism, China, urbanization, energy efficiency

**JEL codes:** Q 540, Q 580

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## 1. Introduction

A large majority of scientific analysis shows that climate change poses a long-term and irreversible threat to the earth's ecosystems and to the way people lead their lives (IPCC, 2001). An overview of recent research gives aggregate damage estimates due to a 2.5°C temperature increase in developed and developing countries of 0.5-2.8% and 2-9% of national GNP respectively (IPCC, 2001). Developing countries are much more vulnerable to climate change due to rich countries' higher potential to mobilize resource for adaptation (van Kooten, 2004).

The UN Framework Convention on Climate Change (UNFCCC), the international community's response to the threat posed by climate change, was signed by 154 countries in 1992 at Rio Earth Summit. It stipulates the principle of "common but differentiated responsibilities" for developed and developing countries. The Kyoto Protocol to the UNFCCC was agreed upon at COP3 in December 1997 and has been ratified through March 2004 by 121 Parties. It includes three so-called flexible mechanisms, designed to make it easier and cheaper for industrialized countries to meet their greenhouse gas (GHG) reduction targets. Among them, the Clean Development Mechanism (CDM) has attracts the highest attention from the international community. CDM allows governments or private entities in developed countries to implement emission reduction projects in developing countries and receive Certified Emission Reductions (CERs), that can be credited towards their emission targets. The countries where CDM projects take place can check whatever the proposed projects contribute to their sustainable development goals and reject proposals that do not.

China has already identified its national development priorities: optimizing and upgrading the industrial structure, promoting urbanization, and realizing balanced development between urban and rural areas. Simultaneously, China also has a deeper consciousness of the need to pursue a balanced-growth goal, namely sustainable development. Indeed, China was the first country to publish a national Agenda 21, in March 1994. Since then, sustainable development has gradually been incorporated into the national development planning, and many related programs and policies have been set up to support and promote its implementation.

For example, in 1994 National Ecological Demonstration Zone Construction Planning was established by State Environment Protection Agency of China (SEPA). On February, 2003, Indicators for Eco-county, Eco-city and Eco-province Construction were published by SEPA. Up to the end of 2003 484 ecological demonstration zones were approved by SEPA. Indeed, on November, 2002, the 16th Party Congress set the objective for building a well-off society

in an all-round way, in which it is also clarified to steadily enhance the capability of sustainable development by improving the quality of the environment, increasing the resource efficiency and enhancing harmony between man and nature. Within the context of China's sustainable development goals, climate change mitigation efforts, as a component of sustainable development, will play an integral role. However, in actual practice economic development often takes precedence to protection of the environment, as is also the case in many industrialized countries.

China has recognized the global challenge of climate change by ratifying the UNFCCC in January 1993 and the Kyoto Protocol in August 2002. The Chinese government has invested a significant amount of institutional effort in the formation of the National Climate Change Coordination Committee. China is fully engaged in comprehensive assessment of CDM issues and has set up a national CDM Project Office, which was notified to the UNFCCC in May 2004. In order to ensure effective management of the CDM project activities and an orderly implementation of CDM projects, the "Tentative Rule on Operations and Management of CDM Projects" has been published on May 31, 2004, which took effect on June 30, 2004. Now China can participate in CDM efforts and facilitate the world's transition to a lower carbon development pathway. Once sufficient CDM capacity has been built, China's CDM participation can contribute to achieving national sustainable development.

China, as the largest developing country in the world, undeniably has huge CDM potential, which could represent a substantial component of the global carbon market. Michaelowa et al. (2003) estimate that a coordinated Chinese CDM strategy could provide more than 2 billion CERs to the industrialized countries by 2012. This would cover 20-40% of the demand of Organization for Economic Cooperation and Development (OECD) countries. World Bank (2004) also sees that China could cover half of total CDM supply during the first commitment period.

Indeed, China's reported GHG emissions actually have been reduced by 17% from the mid 1990s to 2000 (Sinton and Fridley, 2001). This reduction is remarkable, especially when considering the national GDP growth of 36% achieved over the same period. China's forecast significant role in the CDM is mainly due to its overwhelming reliance on coal for energy, and its lack of up-to-date technologies on energy efficiency and renewable energy. Few countries in the world depend on coal as heavily as China. Coal accounts for 75% of primary energy consumption in China, making China the second largest carbon emitter in the world after the United States, and resulting in severe urban air pollution responsible for many premature deaths each year.

Moreover, China has a quite good environment for CDM investments. Fankhauser and Lavric (2003) argue that foreign direct investment (FDI) might serve as a useful, albeit incomplete, indicator of potential CDM flows. It is not difficult to prove China's enormous attraction to FDI. Indeed, 25% of FDI to developing countries already has gone to China (RFI, 2003). Since 1991, China has been the largest non-OECD recipient of FDI inflows; in 2002, China garnered 10% of the world total (52.7 billion US\$), up from 3% in 1991 (UNCTAD, 2003a). China's success in attracting inward FDI can largely be attributed to its large domestic market size, cost advantages and openness to the rest of the world (Dees, 1999). As CDM investment is likely to build on the same factors, China should have a leading position in the CDM market. This, however, presumes that Chinese CDM institutions operate smoothly. So far, CDM potential in China has always been assessed from a top-down perspective (World Bank et al., 2004).

This paper takes a bottom-up approach to examine the influence of the rural transition process on the CDM potential. The case study of an explosively developing area in coastal Zhejiang province illustrates the chances and challenges related to CDM.

This paper is structured as follows. Section 2 briefly discusses the necessary methodology-related issues. Section 3 outlines the social and economic background and the current status of energy consumption and CO<sub>2</sub> emission in Yinzhou. Section 4 describes the baseline scenario based on local government medium and long-term social and economic planning. Section 5 examines what the CDM possibilities look like during the rural transition process and analyzes examples regarding solar-water-heaters, airconditioners and compact fluorescent lamps. The paper ends with the main conclusions and policy recommendations.

## **2. Methodology Issues**

### **2.1 Major targets**

We examine CDM potentials by comparing energy consumption of different sectors and related greenhouse gas emissions in different scenarios for the development of Yinzhou. On this basis, we identify opportunities for integrating local priorities with international financial and technological cooperation concerning energy-related projects. Finally we give policy recommendations for facilitating the implementation of qualified CDM projects.



## **2.2 Analytical Framework**

This paper combines the “top-down” and the “bottom-up” approach to allow both an aggregated scenario analysis and concrete CDM recommendations. The top-down method displays a general picture of what the CDM potential looks like. To examine and quantify various CDM options, the bottom-up approach must be employed. There are 3 steps for the purpose of CDM potential analysis in this paper (See figure 1).

### **Step 1. Baseline Scenario**

This type of scenario is sometimes called “business-as-usual”. Defining a reasonable baseline scenario is a critical element in a mitigation assessment since the incremental costs and benefits of mitigation options will depend on the definition of the baseline scenario. Based on local government economic development planning and population growth, we get a baseline scenario for future energy consumption and CO<sub>2</sub> emissions, which incorporates a judgement of the likely evolution of resource-consuming and producing activities and technologies. This aggregated baseline scenario is not necessarily identical with a baseline scenario for a specific CDM project which defines a specific economically attractive alternative to the project.

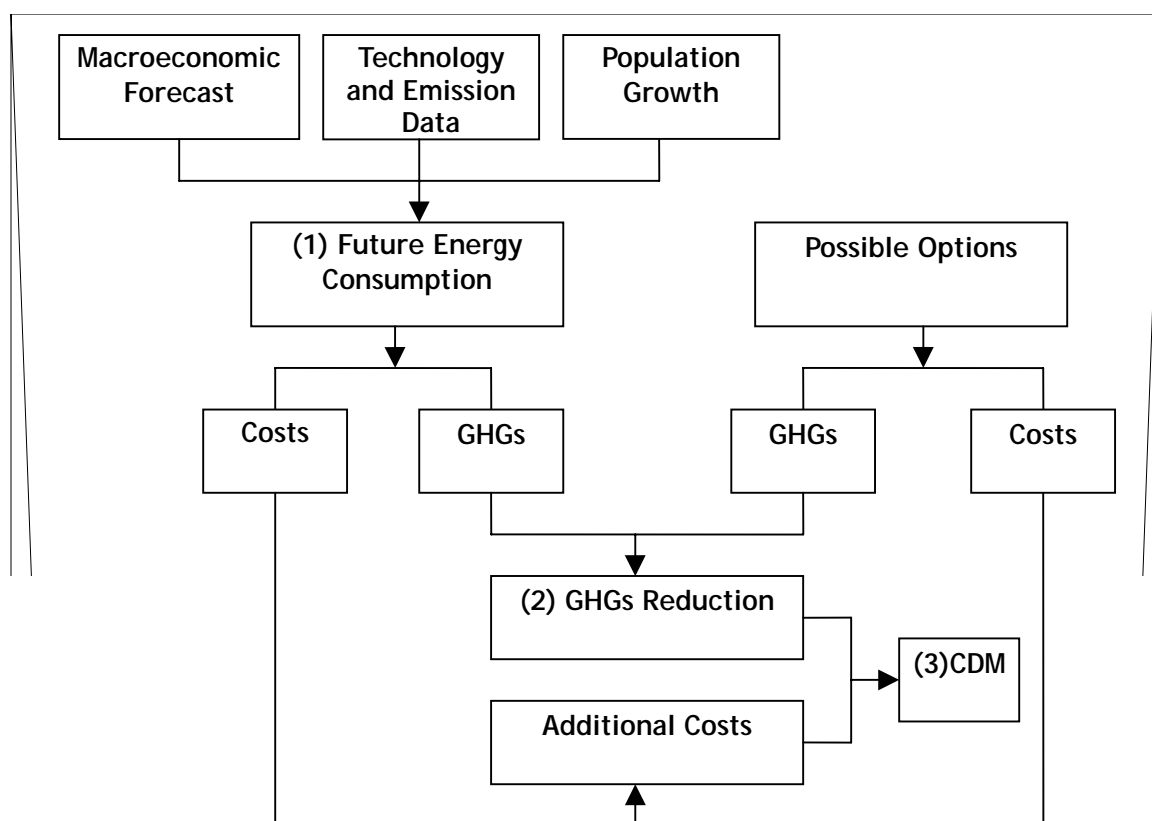
### **Step 2. Mitigation Possibility Scenario**

A mitigation possibility scenario reflects a future in which climate change mitigation is a primary motivation for adoption of technologies and practices that reduce GHGs. It is worth noting that this scenario reflects only the technical potential for reducing GHGs.

### **Step 3. CDM Potential Scenario**

Based on step 2, CDM potential scenario will be developed by incorporating concerns of what can be achievable. It considers many factors (economic, institutional, cultural, legal, etc) that may limit the implementability of the technically available options.

**Figure 1 Analytical Framework**



### 2.3 Analysis Methods

Various methods are employed to make scientific assessments on GHG reduction choices, including cost-benefit analysis (CBA), cost-effectiveness analysis (CEA) and multi-criteria analysis (MCA). The key difference of three analyses is the selection and the measurement of targeted indicators. These targets can be the costs, the benefits, local environmental effects, GHGs and so on, using either economic measurement such as monetary unit or physical measurement like GHGs (t CO<sub>2</sub> emissions) or both of them.

CBA needs to make comparisons between all the costs and benefits of a policy on the basis of an economic unit used by private investors all over the world. Sometimes, however, CBA is quite difficult to fulfill. Indeed, CEA is an extreme of CBA. Namely, given the same benefits which are represented by policy targets, comparisons of various policy costs are enough. However, not all the costs can be denoted by monetary units, e.g. equity and human health. Thus, MCA is necessary and widely used in sustainability assessments of mitigation policy instruments. In this paper, we orient ourselves along the lines of MCA but do not apply it in full detail; this should be done in possible further studies of Yinzhou's CDM options.

## 2.4 Reason for Yinzhou Case Study

Ningbo city is an economic powerhouse on the coast of Zhejiang province south of Yangtze Delta. Located in the southeast of Ningbo City, Yinzhou District with an area of 1380 km<sup>2</sup> is the most important element of Ningbo's economy.. Particularly with the rapid development of Huadong transportation network, Yinzhou can make full use of its geographic advantages to achieve wide domestic and international cooperation in economy and technology . At least two reasons exist for choosing Yinzhou for our CDM case study. First and foremost, data are more easily available compared to similar regions. This makes it possible to assess a baseline for energy use and GHG emissions. Moreover, Yinzhou is a showcase for several typical and significant developments in China which have crucial effects on GHGs.

### ◆ High economic growth rate and strong industrialization trend

Even for Chinese standards, Yinzhou has a rocketing economy which leads to a per capita income of three times the Chinese average. Looking at past experiences of economic development, a country with a per capita GDP between 3000 and 10,000 US\$ will experience aggressive economic growth<sup>1</sup>. Yinzhou per capita GDP has exceeded 3000 US\$, which indicates a rapid growth in the future.

### ◆ Accelerated Urbanization

Rural population transition process is a typical characteristics in China and is particularly fast in the Yinzhou case. The trend of rural-to-urban migration in Yinzhou has been accelerated since the late of 1990s. This has been recognized by the change of the administrative status of Yinzhou county in 2002 to become a district of Ningbo City. Thus Yinzhou's development pathway with respect to Ningbo City shifts from competition to cooperation, avoiding building of similar infrastructure. Coordinated planning will enhance urban and rural economic and social development in Ningbo City.

### ◆ Threat by Energy Shortages

Undeniably, sufficient energy regarding quality as well as quantity is necessary for maintaining the pace of industrialization and urbanization in China. Yinzhou suffers from severe energy shortages.

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<sup>1</sup> Obviously, this does not apply to natural resource-exporting economies like OPEC countries.

### ◆ Emphasis on Sustainable Development

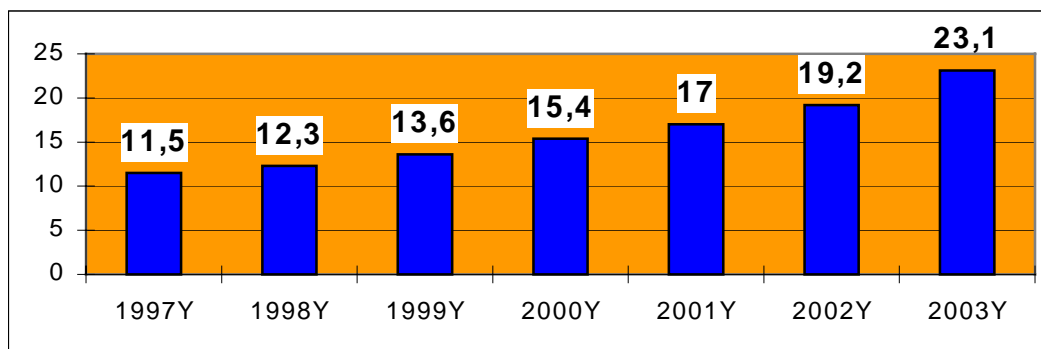
Actively responding to the national sustainable development enhancement, Yinzhou formally set up the goal of Green Yinzhou Construction at 11th District Party Congress in 2003 for the purpose of harmony between man and nature. At the end of 2003, Research Centre for Sustainable Development, Chinese Academy of Social Sciences (RCSD, CASS) was formally entrusted to coordinate the Yinzhou Eco-zone Construction Planning for the government of Yinzhou District.

## 3. Energy Consumption and CO<sub>2</sub> Emission Status quo

### 3.1 Social and Economic Context

With a population of 742,000, Yinzhou has a strong economy of 19 billion RMB in 2002 (2.2 billion US\$)<sup>2</sup>, ranking 11th in China and 2nd in Zhejiang. GDP per capita is more than 26,000 RMB (3100 US\$). Figure 2 shows that since 1997, Yinzhou has had an average GDP growth rate of 14%. According to the latest data, in 2003, Yinzhou GDP jumped to 23.1 billion RMB. Yinzhou's rapid growth is driven overwhelmingly by industry which accounts for almost 68% of GDP, far more than the average level of Ningbo City. Table 1 reveals different trends of three basic components of Yinzhou economy. The share of agriculture declined from 12.2% in 1995 to 7% in 2001, which is not unexpected during the industrialization process, while service shows a relatively smaller proportion of only one quarter. Industry has been the backbone rising from 65.2% in 1995 to 68.1% in 2001. It is foreseeable that industry will continue to play a substantial role as the engine of Yinzhou economy.

**Figure 2 GDP in Yinzhou since 1997 (billion RMB)**



Source: Yinzhou County Statistic Yearbook (1998—2002); Yinzhou District Statistic Yearbook (2003).

<sup>2</sup> According to the People's Bank of China, in 2002, the average exchange rate is around 8.3 RMB per US Dollar. This

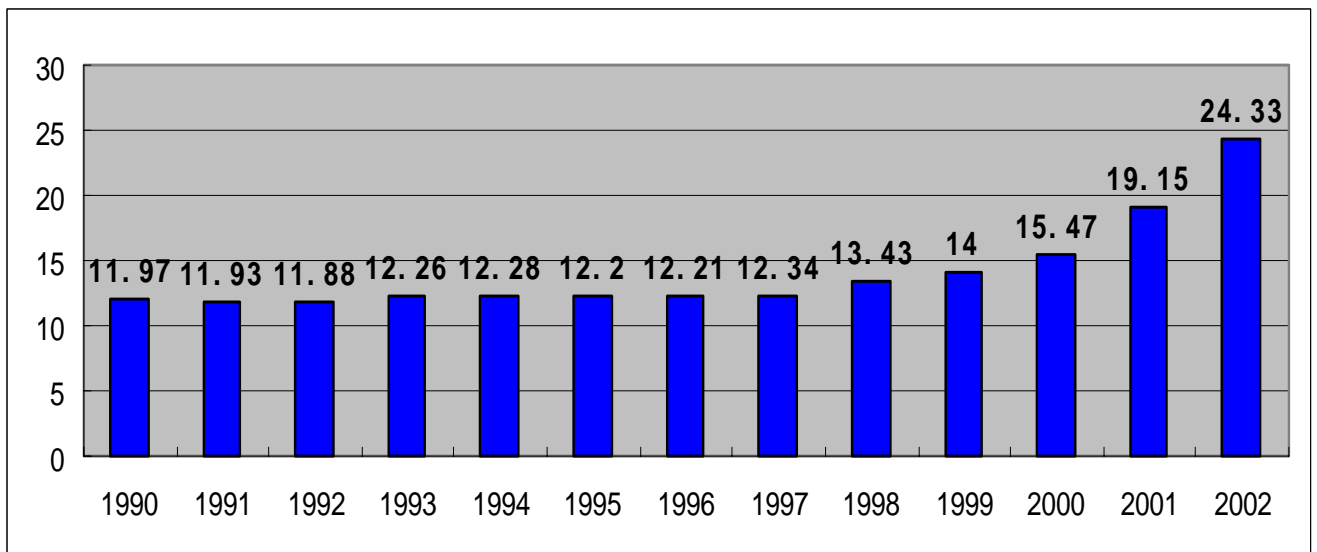
**Table 1 Comparisons of GDP Contributions of Three Sectors (%)**

	Yinzhou District			Ningbo City		
	Agriculture	Industry	Service	Agriculture	Industry	Service
1995	12.2	65.2	22.3	13.4	56.4	30.2
1996	13.3	63.3	23.4	11.7	56.6	31.7
1997	10.8	65.6	23.6	9.5	57.0	33.5
1998	9.6	66.7	23.7	9.1	55.8	35.1
1999	9.2	68.5	22.3	8.9	55.9	35.2
2000	9.9	68.0	22.2	8.2	56.0	35.8
2001	7.3	68.1	24.6	7.6	54.8	37.6

Source: The Institute of Urban and Rural Planning and Designing of Zhejiang University, Yinzhou District Government (2003).

Such an unbalanced economy structure partly results from the liberalization of labour mobility. Characterised by labour-intensive sectors, Yinzhou industry expansion is maintained by increasingly prosperous labour markets. The total population growth in Yinzhou is basically smooth but with a growing urban population share and decreasing rural population share. Figure 3 displays the continuous trend of rural-to-urban migration. From 1990 to 2002, the level of urbanization in Yinzhou increased from around 12% to 24%. Having originally experienced a gradual growth until the end of 1990s, the rate of this trend has actually accelerated in the latest several years. Authorized finally by National Government, Yinzhou became an element of city from a county, one of six districts of Ningbo City in 2002. According to the latest data, urban population jumps up to more than 40% of the total population in 2003. The change of administrative status has been a driver for further urbanization in Yinzhou by eliminating the development obstacles resulting from the system of restricted registration for permanent residents in urban districts in China. Thus, fast industry expansion has been a direct, if unintentional, consequence of the far-reaching urbanization.

**Figure 3 Urbanization Rate in Yinzhou since 1990 (%)**



Source: Yinzhou County Statistics Yearbook (2001, 2002); Yinzhou District Statistic Yearbook (2003); Transportation Bureau of Yinzhou, ChangAn University (2001).

### **3.2 Energy Consumption and CO<sub>2</sub> Emissions**

Before we concentrate on detailed energy consumption, some background facts are necessary to be recognized clearly. Zhejiang province can be properly characterized by “strong economy but weak energy basis”: it has no native oil or gas resource and a minimum amount of coal. The lack of primary energy resources means that Zhejiang province absolutely depends on electricity import characterized mainly by thermal power. Since 1980 thermal power has accounted for an overwhelming share of around 80% at the national level of China (Michaelowa et al., 2003). Regarding Yinzhou, whose electricity supply comes primarily from Huadong power grid, the coal-fired-power-based consumption is even higher with less than 3% hydropower. Because of severe water shortages, in 2003 the hydro power generation plants almost had to stop.

#### **◆ Increasing Electricity Consumption**

Continuous prosperity undoubtedly drives increases in electricity consumption, especially in periods of rapid economic growth, which is the typical feature of Yinzhou. Table 2 displays current electricity consumption pattern in Yinzhou. With the GDP growth from 15.4 billion RMB in 2000 to 19.2 billion RMB in 2002, by around 25%, the total electricity consumption sharply rose at the rate of 45%, from 1437 GWh to 2096 GWh during the same period. The contributions of agriculture, industry and residential sector to such a huge electricity

consumption growth rate reach 36%, 45% and 35% respectively.

It is noteworthy that the electricity consumption by building construction also experiences a surprising increase by more than 3 times, from 8.3 GWh in 2000 to 28.8 GWh in 2002. Yinzhou's building construction industry has boomed because of the dramatic demands for more building by enterprises, government and households. Since the late of 1990s, Yinzhou enterprises have been expanding rapidly in both quantity and scale, which results in more needs for production workshops and office buildings. And owing to overall city planning, a variety of government buildings also have a chance of retrofitting or rebuilding. Certainly, the key factor is the rapid growth of urban residential buildings. With more mobility, immigrants from rural to urban areas have pressing needs for settlements.

**Table 2 Electricity Consumption in Yinzhou (GWh)**

	2000	2001	2002
Total	1436.96	1636.69	2096.06
Agriculture	101.8	176.18	138.32
Industry	1059	1164.88	1546.05
Quarrying	3.50	3.14	2.54
Building Construction	8.29	15.75	28.81
Transport and Telecommunication	3.97	4.79	8.16
Commercial, Food and Material Storage	3.85	4.85	14.03
Others	30.96	36.25	53.38
Residential	225.59	230.85	304.77

Source: Yinzhou District Statistic Yearbook (2003)

**◆ Industry Dominates Energy Consumption**

It is not difficult to prove that industry accounts for the major share of energy demand. In 2002, out of 2096 GWh, the total electricity consumption by industry is 1546 GWh, which accounts for 73% of the total electricity consumption in Yinzhou. The residential sector consumes about 305 GWh, which stands at about 15% of YZ electricity consumption. 7% of total electricity consumption is used by agriculture.

We look at the large-scale enterprises to assess the role of different energy categories as an example. Table 3 details the energy consumption of industrial enterprises with more than 5 million RMB annual turnover by source. The total energy consumption rises drastically at the rate of 34%, from 220 thousand toe in 2001 to 296 thousand toe in 2002. However, energy intensity of those enterprises actually shrank by 5%.

**Total 3 End-use Energy Consumption of Yinzhou Industry Enterprises with the Annual Turnover beyond 5 Million RMB (toe)**

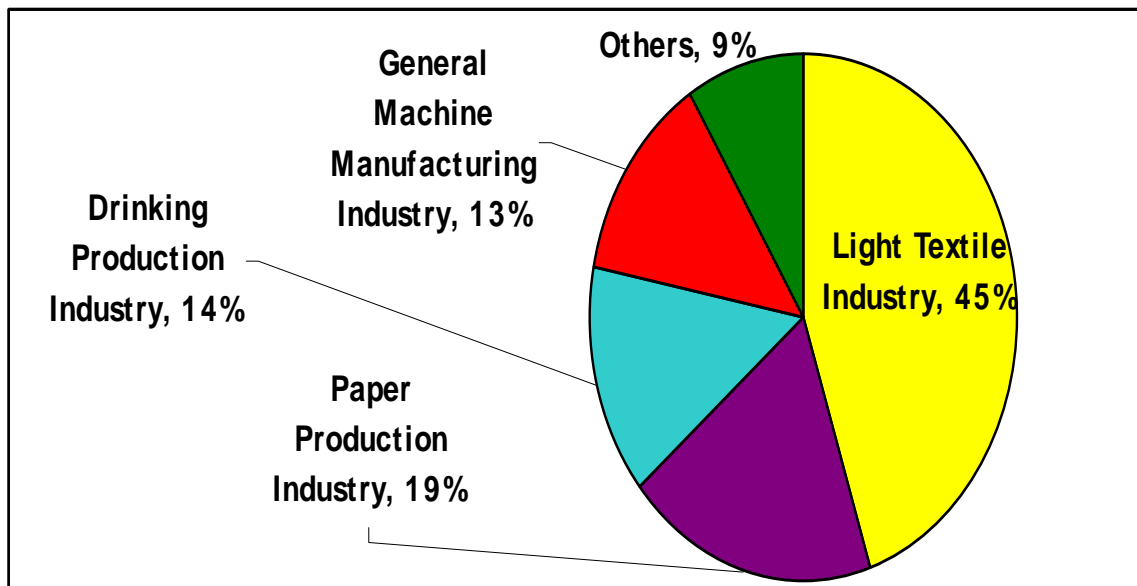
	2001	2002	Growth Rate (%)
Coal	111909	143781	28.5
Coke	9474	15598	64.6
Gasoline	8352	9995	19.7
Kerosene	4757	4318	-9.2
Diesel	14641	17675	20.7
Fuel oil	1944	635	-67.3
LPG	839	1539	83.5
Heat	10513	18200	73.1
Electricity	58211	83782	43.9
<b>Total</b>	<b>220640</b>	<b>295523</b>	<b>34</b>

Source: Yinzhou District Statistic Yearbook (2003)

Although other sectors, for example, the residential sector for purpose of cooking or heating water, also consume some coal, the industry now is the mainstay for coal consumption in Yinzhou. Figure 4 shows the details on the percentage of the major industry subsectors. The light textile industry stands at 45% of the coal consumption in 2002, which is far more than those consumed by other sectors. This is mainly due to Yinzhou's industry characteristics. Light industry, especially its garment production and processing subsector, accounts for a big percentage in Yinzhou economy and is becoming a world market leader.



**Figure 4**Yinzhou Coal Consumption in Industry by Sector in 2002



Source: The Institute of Urban and Rural Planning and Designing in Zhejiang University, Yinzhou District Government (2003).

#### ◆ Energy Transition in Households

Energy is consumed by households for purpose of heating, cooling, cooking, bathing, lighting and electric appliances. The share and the structure of energy in households are much associated with the quality of lives. To some extent it can be argued that what looking at the type of energy is used is one of the best way to examine the standard of living. Electricity, LPG and decreasingly coal are the main types of energy used in Yinzhou households.

With higher income per capita, Yinzhou people can easily enjoy more electric appliances (Table 4). Because Yinzhou has no district heating system, in winter, individual households depend heavily on electricity-consuming appliances such as air conditioners or electric heaters. In summer, naturally, electric fans and air conditioners are the major ways to stand against hot weather. Electric water heaters for bathing and drinking are quite popular. Moreover, in terms of cooking which consumes a half of the residential energy consumption at the national level in 2000 (RCSD, 2003), more than 70% of the population can access LPG for cooking, including bottled gas and piped gas (Zhejiang University, 2003). In Yinzhou, LPG is used for major cooking, while electricity is consumed as supplements via specific cooking appliances such as electric cookers.

**Table 4 Ownership of Selected Electric Appliances per 100 households**

	Yinzhou in 2002	Average at national level in 2000	
	Rural	Urban	Rural
TV	127	116.0	49.0
Refrigerator	81	80.1	12.3
Washing machine	58	90.5	28.6
Air conditioner	10.4	30.8	
Water heater	38	49.1	
Computer	3.5		

Source: Yinzhou Statistic Yearbook (2003); RCSD (2003)..

◆ **Threat by Electricity Shortages**

As mentioned above, Yinzhou electricity supply is controlled primarily by Huadong power grid. With the limited hydro power capacity and the need for approval by central government of large new coal-fired power plants, Yinzhou cannot satisfy its increasing demands for electricity. In 2003, average real electricity load grew to 0.25-0.3 GW, while the full load derived from total demand would be 0.52 GW (The Institute of Urban and Rural Planning and Designing of Zhejiang University, Yinzhou District Government, 2003). The gap will not disappear in the near future without additional energy production capacity.

Indeed, since the late of 2003, most of the enterprises have to confront the unfortunate condition of “**Ting San Kai Si**” which means electricity is provided only four days per week. Recently, the situation has deteriorated further: “**Ting Yi Kai Yi**” is not rare in Yinzhou in the first half of 2004, which means the normal electricity supply can be ensured only every second day. With shortages in electricity, many enterprises suffer adverse consequences such as production decline. To prevent electricity shutdown and to ensure normal production, individual enterprises try to settle it by purchasing small diesel-powered generators, which results in rising diesel demand and finally increase the energy supply problem.

**Table 5 Summary for Energy Consumption and CO<sub>2</sub> Emission in Yinzhou**

		2001	2002
End-use Energy Consumption (Mtoe)	Electricity	0.14	0.18
	Coal	0.13	0.16
	Oil	0.16	0.18
	<b>Total</b>	<b>0.43</b>	<b>0.52</b>
Primary Energy Consumption (Mtoe)	Coal	0.79	1.02
	Oil	0.47	0.54
	<b>Total</b>	<b>1.26</b>	<b>1.56</b>
	Per capita consumption (toe)	1.72	2.10
CO <sub>2</sub> Emission	<b>Total (Mt)</b>	<b>4.10</b>	<b>5.10</b>
	Per capita emission (t)	5.50	6.90

Source: Yinzhou District Statistic Yearbook (2003); The Institute of Urban and Rural Planning and Designing in Zhejiang University, Yinzhou District Government (2003) Chang'an University (2003).

Note: The efficiency of coal-fired power conversion from primary energy to end-use energy is about 34%. The overall average conversion efficiency from primary energy to end-use energy is about 33.4% in 2000 (Source: Tsinghua University). Emission factors are 1toe (coal)=3.6 t CO<sub>2</sub>; 1toe (oil)=2.73t CO<sub>2</sub>; 1toe (gas)=2.07 tCO<sub>2</sub>, source: [www.cas.ac.cn/html/Books/O61BG/a1/2002/5/5.2\\_2.htm](http://www.cas.ac.cn/html/Books/O61BG/a1/2002/5/5.2_2.htm) "Energy Consumption-related Pollution of Environment in China" (in Chinese)

#### **4. Baseline Scenario in the Future**

The 16th Party Congress on November, 2002 set the national objective for building a well-off society in an all-round way, which is the comprehensive economic, political and cultural development of socialism with Chinese characteristics. Regarding economic aspects, on the basis of optimized structure and better economic returns, efforts will be made to achieve full industrialization and quadruple the GDP of the year 2000 by 2020. Actually local governments of various levels actively make responses to the implementation of the national long-term target.

Yinzhou District is the 11th strongest economy in China looking at the district level, and undeniably, it will make further progress due to its rapidly enlarging industry and growing urbanization. Local government has engaged in making prudent and scientific targets and associated supporting policies up to 2020. Table 6 displays several key social and economic development indicators, which are important considerations for forecasting energy demands and CO<sub>2</sub> emissions. The expected economy growth rate will always be kept over 8% from 2005 to 2020, which is far beyond the whole national development rate. In light of its planning, Yinzhou will in advance achieve the national target for \$10,000 per capita in 2050, namely realize 10,000 US\$ per capita already in 2020.

**Table 6 Yinzhou District Social and Economic Development Planning**

Indicators	2002	2005	2010	2020
GDP (billion RMB)	19.2	25	39	66
Average annual growth rate (%)	13	14	12	8
GDP per capita (\$ )	3100	4000	5200	10000
Urbanization rate (%)	24	55	60	70
Total population (thousand)	724	950	1000	1100
Dwelling areas per capita (m <sup>2</sup> per capita)	30	Above 30	Above 30	Above 30

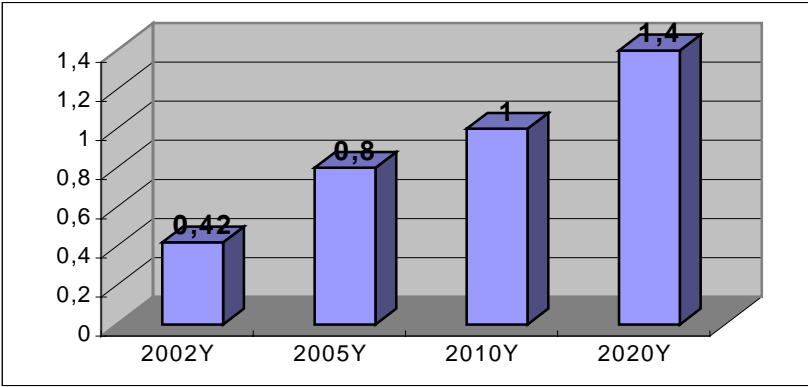
Source: Yinzhou District Land Resource Administrative Bureau, China Land Exploration and Planning Institute, (2003)

The change of administrative status has been a driver for further urbanization in Yinzhou by eliminating the development obstacles resulting from the system of restricted registration for permanent residents in urban districts in China. It is expected that the share of Yinzhou urban population will realize 70% in 2020 from 41% in 2003. Population in urban areas is not the only criterion upon which to judge the rate of urbanization. Urbanization is a process of social development supported by economic growth, which help enlarge the demand market for goods and services. Parallel to urbanization, people still staying in rural areas will also see an increasingly narrowing living quality gap between rural and urban areas. Bigger availability of electricity-oriented products and services indicate more energy demand from wealthier households.

◆ **Household Electricity Demand**

In order to observe the relationship between energy demands and urbanization, we examine the difference about ownership and usage of electric appliances in urban and rural areas. Generally speaking, electric appliances have increased much faster in urban areas than those in rural areas since 1990. The fact that household electric appliances gain high ownership in urban areas but low ownership in rural areas suggests a huge space for further popularization during the rural transition. According to local government plans, residential electricity consumption per capita will be almost doubled in 2005 compared with that in 2002, and thereafter, it will be expected to grow to 1.4 MWh per capita in 2020 (Figure 5).

**Figure 5 Projections of Household Electricity Consumption per capita in Yinzhou District (MWh per capita per year)**



Source: Yinzhou District Yearbook (2003); The Institute of Urban and Rural Planning and Designing in Zhejiang University, Yinzhou District Government (2003).

**◆ Transportation Expansion**

Yinzhou relies principally on road transportation which is well developed. In terms of the density of road network, Yinzhou achieved 68.2 km per km<sup>2</sup>, far higher than the national average of 13.3 km per km<sup>2</sup>. As transportation is one of the major contributors to facilitate economy growth and social welfare by promoting division of social labor, enhancing production efficiency and providing traffic convenience. Thus, a large expansion in transportation will be seen in order to meet the needs of passenger travels and commodity delivers, and accordingly results in more fossil fuel demands especially oil.

**Table 7 Yinzhou Road Transportation Projections**

		2000	2005	2010	2015	2020*
Motor Vehicle for Passenger	(million person)	25.6	41.73	62.57	75.81	90

	(million person km)	890.32	1627.4 7	2440.23	2956.59	3547
Motor Vehicle for	(million ton)	11.67	20.89	24.76	35.78	50
Cargo	(million ton km)	1155.49	1420.5 2	1708.44	2468.82	3455

\*Since the future scenarios made by local government are only up to 2015, the relevant data in 2020 are extrapolated linearly. Source: Changan University, (2003)

### ◆ Industry Energy Consumption

Yinzhou will experience a phase of rapid economic growth until 2010, and then the GDP growth rate will be kept over 8 percent. If the targets in table 6 are to be pursued, Yinzhou industry will continue to provide a huge contribution to GDP. Since a sector with the largest energy consumption is taken as the key factor for GDP growth, it is not difficult to draw a conclusion that more energy supports are needed for further industry growth.

In sum, urbanization certainly will accelerate energy demand growth. Together with the household income growth, differences of living style and living standard will be narrowed between urban and rural areas, which imply high-quality and large volume of end-use energy. Simultaneously, rural people will definitely investments in various agricultural machines for production efficiency purpose. Moreover, continuous economic expansion, especially the impressive growth of industry which accounts for an overwhelming contribution to GDP, cannot be realized without the support of necessary energy. Based on local government development planning and the results of related studies and projections up to 2020, we make a rough estimation of the reference scenarios by examining four economy components, including agriculture, industry, service<sup>3</sup> and residential sectors (Table 8).

**Table 8 Projections for Energy Consumption and CO<sub>2</sub> Emission in Yinzhou in 2020**

	Electricity	Coal	Natural gas	Oil	Total
End-use Energy (Mtoe)	1.49	0.70	0.13	0.38	2.70
Primary Energy (Mtoe)	5.475		0.325	0.95	6.75
Per capita energy (toe)	6.14				
CO <sub>2</sub> Emission (Mt)	22				
Per capita CO <sub>2</sub> (t)	20				

Source of energy data: The Institute of Urban and Rural Planning and Designing of Zhejiang University, Yinzhou District Government (2003)

<sup>3</sup> Here, it has a wide dimension, including transportation, commercial buildings and other sectors except agriculture and industry.

Note: Currently the most efficient coal-fired power plant in Germany has a conversion efficiency of 45%, while Chinese average is only 34%. Considering the situation of China, it can be projected that the average coal-fired power efficiency will achieve approximately 40% in 2020. The average conversion efficiency from primary energy to end-use energy will rise around 40% in 2020 from 33.4% in 2000.

The per capita CO<sub>2</sub> emission level of Yinzhou would thus quadruple from today's level and reach the current US average in 2020. But if Chinese engineers and managers manage to achieve similar improvements in energy efficiency to those reached from 1980 to 2000 in the next 15 years, the per capita level may be limited to a level more akin to current EU value at around 10 t per capita.

## **5. CDM: Opportunities for Addressing the Threat of Energy Shortages**

As described, it is likely that Yinzhou's energy demand, particularly electricity demand, will experience a rapid increase in the future. However, the energy supply seems to be insufficient to meet it. In fact, black-outs are now so common that local newspapers and websites carry notices, rather like weather reports, of planned regular subdistrict black-outs. Moreover, currently three new large-scale industrial parks in Yinzhou are being actively developed and constructed, which have a strong thirst for foreign investment. Plus, local environment pollution is degraded as one of the consequences of heavy coal-fired power dependence. Indeed, acid rain coverage rises to 100% within the whole Zhejiang province. It becomes more and more urgent to address those issues for sustainable development purpose.

As stated above, advanced technological options required by CDM should bring about additional, real and measurable long-term global environmental benefits as well as local development priorities associated with GHGs mitigation. The Tentative Rule on Operations and Management of CDM Projects indicates that the priority areas for CDM projects in China will be increase of energy efficiency, development and use of new energy and renewable energy, and the use of landfill and coal bed methane.

Such CDM priorities will undeniably contribute to economic development by promoting efficiency, environmental benefits including GHGs mitigation and more localized acid rain reduction, and investment and technology transfer by spreading the scope and scale. The CDM opportunities can be likely considered by Yinzhou as killing three birds with one stone, resulting in more industry growth, mitigated global climate change, and less acid rain. Before

focusing on CDM possibilities, we need to examine the potential of energy resource and energy efficiency in Yinzhou.

## **5.1 Yinzhou Energy Supply Potential Profile**

### **◆ Small hydro power generation**

In light of the survey results of water resources, Yinzhou has a capacity of about 28.3 MW, which can supply the electricity of 244.5 GWh per year in theory. Up to now 23 hydro power plants have been developed. Their gross installed capacity achieves 17.6 MW and the annual average electricity generation achieves 41.3 GWh. Compared with the huge electricity demands of 2096.6 GWh in 2002, the share of hydro power is absolutely negligible, less than 3%. Moreover, five hydro power plants have been planned with total installed power generating capacity of 14.9 MW, which can cover an electricity demand of 38.9 GWh. In 2020, new hydro power, combined with existing hydro power generating capacity, can only provide 80.2 GWh. Although the local government has actively engaged in developing new hydro power plants, the hydro power in Yinzhou can only play a extremely tiny role, compared with anticipated local huge expected electricity demands of 17,364 GWh in 2020 .

### **◆ Wind Energy**

Results from the resource survey indicate that Yinzhou basically has no profitable wind energy potential. It is known that one elementary factor for wind energy exploitation is the minimum wind speed of 3 m/s. If the wind speed is lower than 3m/s, the turbine machine will not be driven. On the contrary, the maximum wind speed is up to 20 m/s, otherwise, it will bring damages to the turbine machine. Scientific surveys show that the yearly average of wind speed in Yinzhou is only 2.6 m/s (Elementary Researches for Wind Power Development in Ningbo City, 2004), compared with Ningbo City of 5 to 8 m/s and Zhejiang Province of 5 m/s. Although some parts in Yinzhou District can also reach a wind speed of 6 m/s, it is not possible for wind power investment in Yinzhou because more profitable opportunities can be easily found in neighboring areas.



### ◆ **Biomass**

Generally speaking, after agriculture rice harvesting farmers usually set the straw on fire, which bring about substantial local environmental pollution. If such agricultural residues can be put into full use such as gasification, undoubtedly, it will be a good choice. Certainly, the problem comes out when the cost is considered. However, the higher cost is not the prohibition for people's attempts. Indeed, with 1.8 million RMB of investments, the first straw gasification demonstration project of Ningbo City has been put into use, and achieved 300 m<sup>3</sup> average gas output per day in Yinzhou. However, the increase in urbanisation will reduce farm output and thus the availability of rice straw in the medium term.

### ◆ **Solar energy**

Yinzhou has a relatively valuable solar resource with 2010 hours sun shines per year and the yearly average of solar radiation of 4.61 MJ/m<sup>2</sup>, which can be utilized to provide energy to households. Although the resources and technology are available to the population, there are barriers to the widespread implementation of solar projects. One of these barriers is the initial cost. Although the cost of thermal solar energy employment is competitive over the long term compared with conventional sources of energy, the initial cost is high. Of all forms of renewable energy, this is the most promising for CDM projects in Yinzhou and will be addressed in detail below.

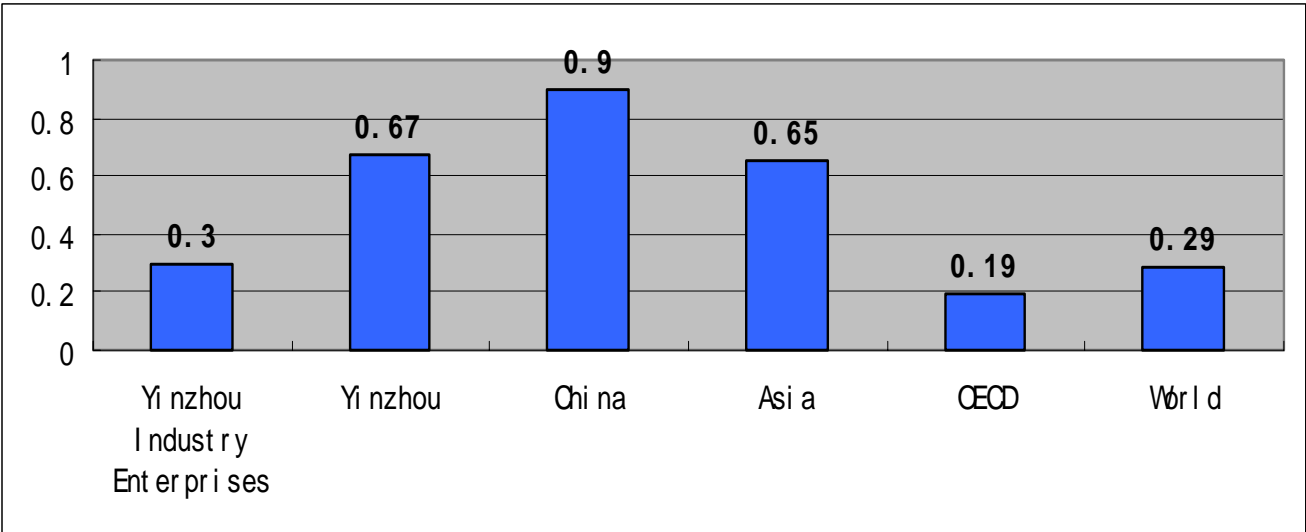
## **5.2 Options in Energy Demand Reduction**

### ◆ **Industry**

Globally, the industrial sector accounts for about 40% of primary energy use (Price et al, 2001). On average about 40% of China's GDP originated from the industrial sector from 1990 to 1998, it accounts for as high as 68% of the country's total end-use energy consumption (Zhang, 2003). Regarding Yinzhou, industry is the dominant energy-consuming sector. As the spectacular contributor of more than 65% to the local GDP, Yinzhou industry is the dominant end-use energy-consuming sector of more than 70%. Compared with other regions of the similar development level in China, the energy intensity in Yinzhou is not high. Indeed, in 2002 Yinzhou average energy intensity declined to 0.67 toe per thousand US\$ of GDP, while in 2001 China average energy intensity reached 0.9 toe per thousand US\$ of GDP (IEA, 2003). Especially, those enterprises with annual turnover beyond 5 million RMB maintain a

much lower level of energy intensity than China average, at only 0.3 toe per thousand US\$ of GDP, about one-third of Chinese average. Figure 6 shows the energy intensity of some selected regions.

**Figure 6 Comparisons for Energy Intensity at various levels (toe per thousand US\$)**



Note: The data of Yinzhou energy intensity is in 2002, while the average data of China, Asia, OECD and world are in 2001. And Yinzhou industry enterprises here only include those big-scale enterprises with annual turnover beyond 5 million RMB.

Source: Yinzhou Statistical Yearbook (2003); IEA (2003).

Nevertheless, it is still possible for emission reductions to be achieved in industry by improving the level of energy efficiency through state-of-art technologies. Such technologies or practices can roughly be divided into two groups: process promotion and equipment improvement. It is noteworthy that opportunities for CO<sub>2</sub> mitigation in industry are somewhat different from those in other sectors, as industry consists of a vast array of activities involving thousands of different processes that are often site-specific in design. The industrial sector requires more of a focus on options in specific equipment or processes. As the data on energy consumption by Yinzhou companies show, there is a substantial potential for fuel substitution as coal could be replaced by less carbon-intensive fuels.

◆ Measures for Existing Processes

Some industries could pool resources to jointly fulfil their electricity and steam needs instead of through diesel generation and boilers through combined heat and power systems, or cogeneration that have efficiencies of up to 90%. Cogeneration is an important option for industries with large process heat requirements such as pulp and paper and food processing. Yinzhou may have a great market potential for cogeneration because of Yinzhou industry characteristics, namely the textiles, food and paper industries are particularly strong candidates for GDP growth. Moreover, it is likely that efficiencies of older boilers could be increased and that more efficient electric motors could be installed.

◆ Measures for New Equipment

Another option is the adoption of more energy-efficient new equipment replacing those outdated but widely used devices across industries, such as electric motors, pumps, fans, compressors, and boilers. It is an especially important option in regions where industry is growing rapidly and the manufactured equipment is outdated.

Energy use accounts for a large share of an industry’s total operating costs, which highlights profitable opportunities for best energy management practices in industry, including the adoption of new, efficient technologies and equipments. Table 11 provides illustrative internal rates of return for some selected projects in paper and textile industry, which are quite relevant to Yinzhou case. It clearly suggests that rates of return are high enough to justify investment in many cases, as long as the projects meet other selection criteria.

**Table 11 Estimated Internal Rates of Return for Selected Energy-Efficiency Investments in China**

Sector	Investment	IRR(%)
Pulp and Paper	Adoption of cogeneration	25
	Black liquor recovery	25
Textiles	Cogeneration in printing and dyeing	38
	Caustic soda recovery	58
	Computerized energy management	>100

Source: Hamburger and Jonathan (1996)

In 2002 there were 815 large-scale industry enterprises with the annual turnover beyond 5 million RMB in Yinzhou. Those enterprises with the largest emissions, or prospects for

major emission growth, are most important to target in a mitigation strategy. The other town and village enterprises (TVEs), which use inefficient, polluting, secondhand equipment can also be responsible for emission reductions.

The challenge in the CDM context is how to find clusters of companies willing to implement the same type of measures as a joint CDM project. This would require a company survey that may be possible in the context of RCSD activities in Yinzhou.

## **5.2 CDM Opportunities in Yinzhou**

### **5.2.1 The Example of Residential Solar Water Heaters**

The size and the growth rate of end use are particularly important criteria in screening options for the residential sector (Sathaye and Meyers, 1995). With the continuous growth of annual average income per capita, a strong demand increase for hot water for bathing, as the symbol for the living standard improvement, is anticipated. Thus, it is expected that electric water heaters will be one of the largest and the fastest growing household electric appliances.

Domestic solar water heaters are currently easily available in China which is the world market leader in this technology.. Through solar water heaters in the residential sector coal-fired electricity can be substituted. However, if aimed at in the CDM context, a large number of existing electricity-based water heaters would have to be replaced with solar energy water heaters to be able to generate a sufficient amount of CERs. Of course, such projects would still be relatively small-scale compared with other CDM projects in the energy sector. The main barrier for household acquisition of solar water heaters is their relatively large initial installed cost.

A standard electric water heater in China with a 40-litre water tank and a power of 3 kW covers the needs of a three-people household. It can be assumed that on average, one bath per day will be taken in 2020 as wealthier people have more requirements for individual healthy conditions. Thus, based on the specific heat of water, namely 4.2kJ per kg · per centigrade, we can anticipate one household will approximately consume 0.6 MWh per year for bathing. For Yinzhou's population of 1.1 million, the total electricity consumed by water heaters in 2020 would reach around 220 GWh, equal to 0.019 Mtoe. It is expected that the conversion efficiency of the coal-fired power will reach 40% in 2020. Thus, in terms of primary energy, 0.048 Mtoe coal would be utilized by electric water heaters, which results in 0.16 Mt<sup>4</sup> CO<sub>2</sub>

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<sup>4</sup> This includes a hydro share of 20% in the national grid.

baseline emissions.

Although the solar water heater has a much longer life expectancy of 15 years than the electric water heater of 5 year, the cost (including purchase and installation) of the former is also much higher than that of the latter, 3000 RMB vs. 1000 RMB<sup>5</sup>. However, the total cost of an electric water heater is much higher than that of a solar water heater. The former includes both electricity fees and water fees, while the latter has only water fees. To make an overall evaluation on the solar water heater project, not only the direct costs and benefits but also the associated ones should be estimated for the whole residential sector as well as the local community. Details of a project encompassing 200,000 solar water heaters are given in Table 9.

**Table 9 Costs and Benefits of the CDM Solar Water Heater Project in Residential Sector**

End-use		Water Heating
Technical Options		200,000 Solar Water Heaters
Benefits	Climate Benefits (CO <sub>2</sub> )	88,900 t p.a., 1.3 Mt over 15 years
	Other Environment Effects	SO <sub>2</sub> ; NO <sub>x</sub> ; and other air pollution and wastes
	Economic and Social Effects	Health Improvement
Costs	Subsidy (Million US\$)*	1.28
	Gross Financial Costs **	400 million RMB (equal to 48 million US\$)
	Administrative, Institutional and Political Considerations	Transaction costs likely to reach 2 \$ per heater to the need for advertisements and a good distribution system, i.e. 0.4 million US\$
The Cost of CERs (US\$/tCO <sub>2</sub> )		1.3

\* Subsidy is calculated as the amount necessary to cover the cost differential between the solar water heater and the electric water heater for the first 5 years including the electricity cost reduction

\*\*Gross financial costs here refer to the total cost of initial purchase and installation. And the price of residential electricity adopted here about 0.65 RMB per kWh.

### 5.2.2 The Example of Residential Air Conditioners

An important feature of the residential sector in rural transition is the growth taking place in the demand for electric appliances. Native urban residents' demands for many electric appliances have relatively become saturated, while immigrants towards cities are just now

beginning to acquire electric appliances. Besides the electric water heaters, another example is just the air conditioner. Judging from Table 4, it is possible that the air conditioner will undergo a dramatic expansion. Thus, the demand for the electricity consumed by air conditioners will increase rapidly.

Greater use of available, cost-effective technologies to increase energy efficiency in air conditioners such as using a more efficient compressor can lead to sharp reductions in emissions of CO<sub>2</sub> resulting from associated coal-fired electricity consumption. We make a comparison between two types of air conditioners in the market: one is common and low-efficiency air conditioner of 3000 RMB, the other is high-efficiency but more expensive at 8000 RMB. At the same performance, the latter use only 50% of the electricity compared to the former<sup>6</sup>. Table 10 gives the details for a project of 100,000 air conditioners, i.e. covering about a fourth of Yinzhou's households.

**Table 10 Costs and Benefits of the Air Conditioner Project in Residential Sector**

End-use	Cooling	
Technical Options	100,000 Air Conditioners	
	Low-efficiency AC	High-efficiency AC
Price of per unit (RMB)	3000	8000
Life Expectancy (years)	10	15
Electricity Consumption per household per year (kWh)	1500	750
Cost for Electricity Consumption per household per year (RMB)	975	487.5
Climate Benefits (MtCO <sub>2</sub> )	54,500 t per year, i.e. 818,000 t over 15 years	
Subsidy (Million US\$)*	3	
Cost of CERs (US\$/tCO <sub>2</sub> )	4	

\* Subsidy of 250 RMB per unit. The amount necessary to cover the cost differential for the first 10 years including the electricity cost reduction would be 125 RMB /unit, i.e. in total 1.5 million \$ and a CER cost of 2 \$/t This subsidy obviously will not be sufficient to change the behaviour (it finances just 2.5% of the initial cost

<sup>5</sup> See <http://www.ehomeday.com>, "Six Indicators for New Water Heaters" ( June 30, 2004), in Chinese

<sup>6</sup> See <http://info.news.hc360.com/HTML/001/002/003/013/53964.htm> "Haixin's frequency conversion air conditioners come up" (June 21, 2004); <http://www.cb-h.com/shshshow.asp?n-id=13140> "Whether "Energy-saving air conditioners" can save energy or not" (June 22, 2004); [http://www.cheaa.com/public/news\\_selinfo.asp?News-id=27298](http://www.cheaa.com/public/news_selinfo.asp?News-id=27298) "Tips for air conditioners (June 29, 2004); <http://tech.163.com/tm/030401/030401-88276.html/> "Xinke sets its own price standards for frequency conversion air conditioners, which results in more discussion" (April 1, 2004). All sources in Chinese.

gap). Whether the 250 RMB are sufficient is also unclear.

## 5.2.2 The Example of Residential Lighting

Lighting accounts for approximately 10% of the total electric power consumption in Yinzhou households. Low efficiency devices, such as incandescent lamps and ordinary fluorescent lamps, still dominate local lighting sector, leading to high electricity consumption. Judging from developed countries' experience where these projects have been implemented in the past, Compact Fluorescent Lighting (CFL) also has a sense for energy conservation. CFL projects are energy efficient lighting projects in the building sector, which intends to replace existing low-efficiency lamps with CFL lamps. Saving electricity on lighting will both mitigate electric power supply shortages and create tremendous potential for protecting the environment. However, given the unstable Chinese electricity grid, only high-quality CFLs will reach a long lifetime.

Greater use of high-quality CFLs can lead to sharp reductions in emissions of CO<sub>2</sub> resulting from associated coal-fired electricity consumption. We make a comparison between a high-quality 12 W CFL that costs 40 RMB and a standard incandescent 60 W lamp at 3 RMB. Table 11 gives the details for a project of 200,000 CFLs, i.e. distributing one CFL to about half of Yinzhou's households.

**Table 10 Costs and Benefits of the Lighting Project in Residential Sector**

End-use	Lighting	
Technical Options	200,000 CFLs	
	60 W bulb	12 W CFL
Price of per unit (RMB)	40	3
Life Expectancy (years)	1	10
Electricity Consumption per household per year (kWh)*	90	17
Cost for Electricity Consumption per household per year (RMB)	58	11
Climate Benefits	10,600 t per year, i.e. 106,000 t over 10 years	
Subsidy (Million US\$)**	0.22+ 0.1 transaction costs	
Cost of CERs (US\$/tCO <sub>2</sub> )	3	

\*Lamp burns 4 hours per day

\*\* Subsidy is calculated as the amount necessary to cover half of the cost differential.

This project has a relatively small size and crucially depends on the transaction costs, e.g. costs for monitoring whether the lamps are actually used.

### **5.2.3 Other Potentials in Residential and Commercial Sectors**

Usually, residential and commercial sectors are considered together as the building sector due to energy use in both sectors primarily resulting from activities that take place inside buildings. Large cost-effective savings potentials could be found in each end use, such as heating, cooling, lighting, cooking and electric appliances. There are a variety of technologies and practices that may be applied to reduce energy use or switch to energy sources with lower GHG emissions. CDM possibilities for the residential and commercial sectors in Yinzhou can be found as follows:

#### **◆ Efficiency Improvements on Existing and New Building Shells to reduce Cooling and Heating Load**

The Yangtze River serves as China's official dividing line between north and south. The latter cities generally do not have central heating systems but have cold and humid winters. From some data evidences, for climate change, extreme temperature days in the south are getting longer and longer. Thus, air conditioners and electric heaters are not uncommon for individuals to cope with cold weather. Findings of a survey on the consumption of household appliances in Chinese cities in 2001 reflect a southward shift of the electric heater market, with consumer demand showing a faster growth in areas along the Yangtze River. It is likely that with growing affluence, comfort requirements concerning indoor temperature levels will rise, as they did in industrialised countries.

Indeed, China has been putting efforts on energy-conservation in buildings. As a result of a variety of building standards and application regulations issued, residential buildings of 0.15 billion m<sup>2</sup> have been built, which can reduce 17 million t CO<sub>2</sub> emissions (CNICRCCU, 2002). A variety of measures are available for making both existing and new building shells more energy-efficient (Sathaye and Meyers, 1995).

- ◇ using adequate levels of insulation for ceilings, walls, and floors;



- ✧ insulating glazing for windows;
- ✧ controlling air infiltration;
- ✧ shading devices or solar control glazing to reduce unwanted solar heat gains through windows; and
- ✧ Using high-albedo materials, coatings, and paints to reflect shortwave solar radiation and thereby keep building surfaces cooler.

Regarding Yinzhou, measures can generally be applied more easily and at lower cost in design and construction of new buildings. First, as a district in the process of accelerated urbanization, Yinzhou has rapidly growing new building stocks. Plus, retrofitting existing buildings are typically more difficult and expensive than building a more efficient building in the first place. However, unfortunately, at present, there is little incentive for efficient residential construction in Yinzhou because municipalities are under pressure to provide housing as quickly and as cheaply as possible. Efficient construction represents a relatively high initial cost while the cost of energy waste can be spread out over a long time. Indeed, this is also the fact at the national level (Hamburger and Jonathan, 1996).

## **6. Conclusions and Recommendations**

It is clear that Yinzhou can slow down its phenomenal increase in energy use through well-targeted CDM projects. The challenge is to organize diverse stakeholders and to provide incentives that take into account the international CER price while providing enough impetus to actually acquire a more efficient technology. The local authorities will play a decisive role to frame CDM project activities that fulfil immediate local development priorities. Indeed, focusing on synergies between the long run planning known as sustainable development and shorter run targets like GDP growth rate is always the core concern in China. Despite the co-benefits of CDM, national and local authorities should bear in mind that CDM is not a panacea of all funding needs. Regarded as an additional financial instrument, CDM can only be implemented for specific types of projects, as our case studies have shown. Moreover, although large technical potentials for CDM projects do exist, turning the potential into the reality represents a significant challenge for China. A number of barriers needs to be overcome before the CDM projects can be effectively implemented. We would recommend that the CDM potential of Yinzhou's industrial sector is addressed through a detailed survey, especially with regards to cogeneration, boiler improvement and fuel substitution. This could then be extended to all coastal provinces and further, in the long run, to the rest of the country.

The available information and awareness on CDM in China is usually limited, especially outside the big cities, although at the same time the awareness on sustainable development and knowledge of local needs is often much broader. As a result, potential synergies to address other environmental problems cannot be achieved without making full use of the available international mechanisms. The general lack of awareness, institutional structure and implementation strategy by both the government and business communities has raised great concern about China's ability to compete internationally for CDM projects and exploit fully its CDM potential. In order to be able to join in playing the CDM game, the capability of collecting, analyzing and disseminating CDM information; recognizing the potential CDM opportunities; and implementing CDM projects by empowering the knowledge, understanding and skill of the stakeholders has to be enhanced across the country. China can learn from the experiences in several host countries that have been frontrunners in CDM (Michaelowa 2003). Particularly, the level of awareness on CDM in the end-use sectors (e.g. buildings) is much lower than in the energy sector. According to the priority areas for CDM projects clarified in Tentative Rule on Operations and Management of CDM Projects, China did not express any preference for end-use energy efficiency projects when selecting and approving projects. However, as Yinzhou clearly demonstrates, the rural transition results in huge growth of energy demand that if unchecked, risks to wreck economic and social progress. Obviously, end-use sectors, especially building sector have huge CDM potentials, but they can only be harnessed under sophisticated project designs..

Regarding China case, it is crucial to build the awareness of the linkage between sustainable development and climate change in order to broaden the basis for CDM implementation. Considered as the national strategy, sustainable development is well developed with a comprehensive policy and measure system in China. During the past ten years, a variety of laws and regulations have been promulgated for sustainable development purpose. If the CDM associated work can be properly integrated with China's sustainable development network, it will result in getting twice the result with half the effort. Moreover, China should not ignore its FDI experiences. As the classical funding mechanism to the world and a key financing channel to China, FDI can also provide a lot of valuable experiences and lessons. Certainly, learning by doing is always highly praised by researchers. Much progress will be made when capacity building is combined with real CDM implementation.

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