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The Dynamics of China's Bio-Fuel Industry and its Policy Options

Master Thesis

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2012/4/27

The Abstract

The economic development of China following the changes in 1978-79 has transformed the country from a poor nation to being the second largest economy in the world. The change came about as China focused on manufacturing industry as a driver of economic growth. This has led to an increasing demand for energy and thus to a greater reliance on fossil fuels. Concerns for greenhouse gas (GHG) emissions and global warming have also created a huge pressure from the world for China to reduce emissions that accompany extensive use of fossil fuels.

The sustainability of the growth and the economic stability of the country faces a severe threat as available reserves of crude oil and coal in China and in the world are limited, making it highly unlikely that the country can continue to depend on these resources for its future energy needs. Because China imports more than half of its oil requirement, it needs to find viable alternatives to decrease its trust on continuing import.

Biofuels appear as one such alternative and China has invested in setting up manufacturing facilities for producing bio-ethanol from cereals and cassava. However, the existing production has helped substitute only about 8% of oil requirement and 0.45% of its overall energy needs. On the other hand, diversion of grain, sugarcane, soybeans etc for biofuel production creates shortage in the supply of food leading into high prices and need to import food, sugar, and oil that will affect its trade balance negatively.

This report investigates the different aspects of the crises of energy and food security that China faces, which will only become more severe in the very near future. The aim of

the analysis is to make some recommendations that can help reduce the negative effects of these issues.

Analysis shows that China needs to diversify its risks and take major initiatives to increase production of bio-fuels for this will simultaneously reduce its dependence on oil and reduce GHG emissions. In order to do so, China needs to shift focus from a manufacturing intensive economy toward horizontal and vertical growth of the agriculture sector. While this happens, it will have to use its vast positive balance of payments to import food.

1.0 Introduction

The negative effects of fossil fuel use include "global climate change, world energy conflicts, and energy source shortages" and these "have increasingly threatened world stability" affecting all levels of society (Kothari et al, 2010: 2). These researchers show that the negatives against the use of fossil fuel include the depleting fossil fuel reserves and increasing demand, which will create a major demand-supply gap for energy in the near future. In addition, concerns for global climate change due to increased CO_2 content in the atmosphere, leading to the greenhouse effect and increase in the levels of solid and liquid wastes from increasing world populations add to the pressures against fossil fuel use (Kothari et al, 2010). In addition to CO_2, atmospheric pollution caused by the use of fossil fuels to generate electric power and in transport has severe implications for human health. Important pollutants are CO, NOX, volatile organics, SO_2, and perhaps the most important – Suspended Particulate matter (SPM).

China has demonstrated a sustained growth in its economy measured as GDP and GDP per capita following Deng Xiao-Ping's policy changes in 1978-79. This growth has seen China emerge as the world's second largest economy. From a nation considered a poor country with a per capita GDP of $45.77 in 1980, China has reached a situation where its current per capita GDP is $6,567 in 2009. The progress has outmatched any in history. In terms of gross GDP, the country ranks second only to the USA (World Bank, 2009). Figures 1 and 2 extracted from the tradingeconomics.com website depict the almost fairytale-like growth of China's economy.

Figure -1: China's GDP Annual Growth Rate

(Source: www.tradingeconomics.com)

Figure -2: China's GDP per capita in 2010 US$

(Source: www.tradingeconomics.com)

Many researchers and institutions have attempted to analyze and discuss the growth of different sectors of the Chinese economy, in absolute and comparative terms. The consensus is that a major driver of the change is the change in focus from traditional to technologically driven economy and exports. Some also criticize the regional and sectoral imbalances in growth (e.g. Rehbar and Grega, 2008).

For countries with large populations such as China, development of industry that seeks to meet indigenous market demand is perhaps as important, if not more important, than exports for sustained economic development (Cyper and Dietz, 1997). China's shift to basic and advanced technology industry sought to exploit the availability of cheap labor, specialized skills, availability of inputs, and logistical advantages and use massive economies of scale to capture world markets. An important aspect of this shift in focus is that the new industrial base requires energy in different forms as a prime input. Figure -3 shows the phenomenal growth of energy use, which has kept pace with the economic growth.

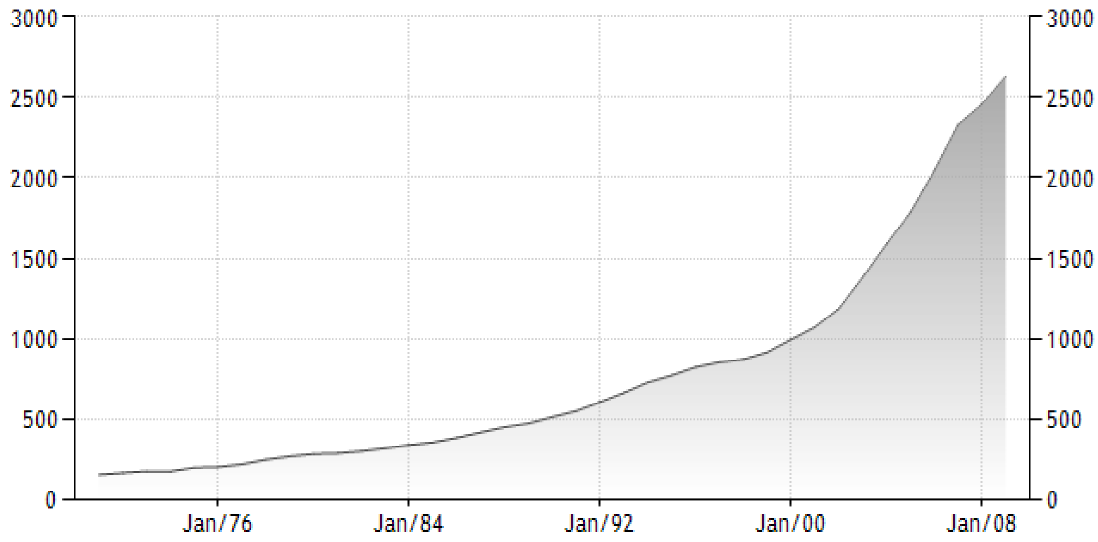


Figure -3: China's Electric Power Consumption KWH/per capita

(Source: www.tradingeconomics.com)

Qiu et al (2012) quote other studies to say that China produced 189million tons of crude oil and imported another 199million in 2011. Projections show that by 2030 China will import about 75% of its need of crude. This has increased concerns of future energy security, particularly in the volatile political situation that exists in some of the major oil producing regions. In addition, China faces considerable pressure from the world community on controlling greenhouse gas (GHG) emissions. These issues have forced the China to invest heavily in alternate and renewable energy including bio-fuels. These forms of energy formed 8% of total oil-based energy consumption in 2008 and the government has set targets of increasing this to 10% by 2010 and 15% by 2020 (Qiu et al (2012).

On the negative side of this ambitious plan is that the 10million tons of bio-ethanol that China proposes to produce by 2020 will require 32million tons of corn, provided that all the production comes from corn as feedstock. This represents 20% and 6.6% of China's production of corn and all cereals respectively in 2009 (Qiu et al, 2012). The impact this massive diversion of food grain on food security would be grave and all that it will achieve is a substitution of 14% of the gasoline consumption in 2009. Responding to this threat perception China has decided to use non-cereal grain and bring marginal land under cultivation of such crops to feed the bio-ethanol plants (Qiu et al, 2012).

The biggest challenge facing all programs for bio-fuel production lies in obtaining raw materials (Koizumi and Ogha, 2007). Presently available technologies look at farm products to generate bio-fuels raising the food v/s fuel debate. The underlying reality is that large areas of the world still face food security problems. Therefore, diversion of any of the farm product or farmland from food to fuel use will result in an increase in food costs with attendant social problems. Scientists today talk of second-generation bio-fuels, which will use biomass conversion of farm and forest wastes. However, Paul and Ernsting (2008) point out that commercially viable technology for production of all bio-fuels including second-generation bio-fuels are not available at present and that such technology may not be available in time to prevent the disaster that faces the world when fossil fuel begins to run out.

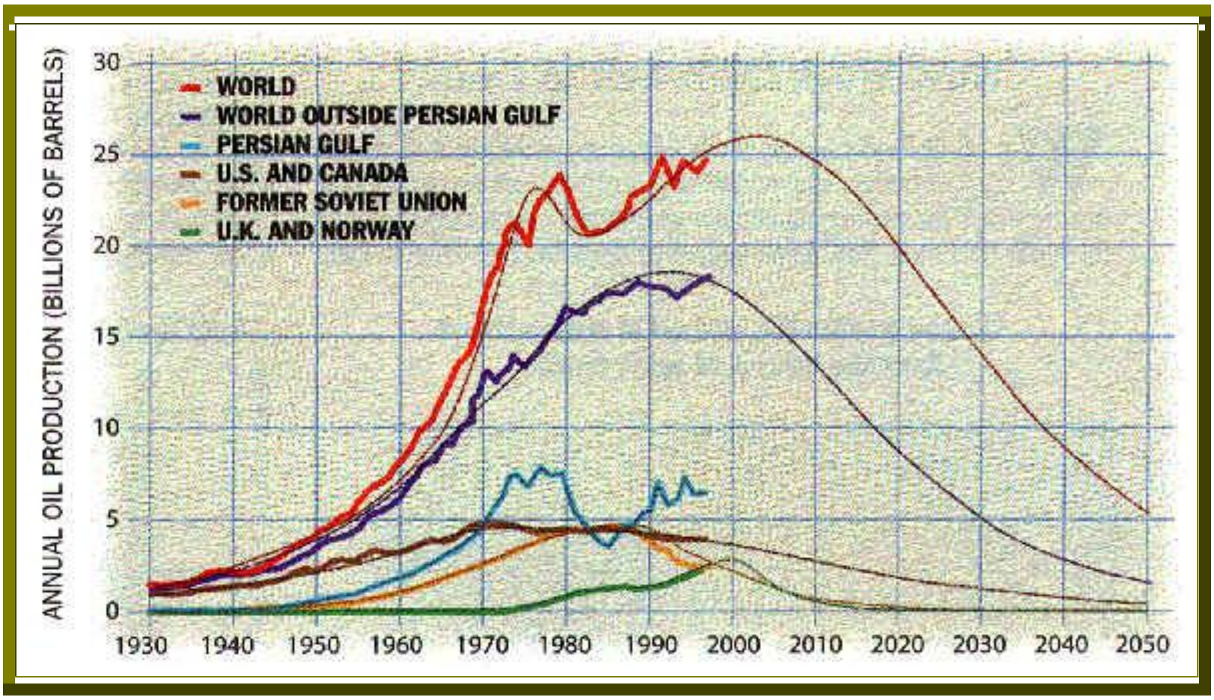
The aim of this paper is to use existing research, opinions, and policy documents to provide a detailed view of the energy security problems, present situation in bio-fuel technology and production initiatives, and challenges that face China in ensuring sustained economic development at present levels.

2.0 Energy Security

2.1 Peak Oil

A concept introduced by MK Hubbert in 1956 (in Tao and Li, 2007) became a worldwide concern when Campbell and Laherrere (1998) reopened the idea that the time is fast approaching when the demand for crude will exceed our capacity to extract it. Looking at the production pattern from a single well, we see that after the initial tapping, oil production increases to peak at a certain point after which, production falls as the resource depletes. It is not possible to extract the last drop of oil from a well. After a certain level of production, it is no longer economical to continue operations. To meet demand, geologists continue to explore for new reservoirs to tap. So far, they have kept ahead of the demand. Campbell and Laherrere (1998) contend that worldwide production will behave the same ways as a single well – the oil production will peak and begin to die down even as demand continues to grow.

Campbell and Laherrere (1998), say that even if we assume that the estimate of total reserves of 1,020billion barrels of oil is correct, which they dispute, the estimate that these reserves will last 43 years is not correct. This is because the estimate of 43 years assumes that world demand for oil will remain steady at 23.3billion barrels as it was in 1998. They argued that demand would continue to grow and peak before reducing availability would bring it down. They used the examples of the oil crises in 1973 and in 1979 and forecast that the next crisis will not be that short and will lead to global recession. Their prediction proved correct in 2008 when oil prices rose to nearly $140, the recession that followed in late 2008 is fresh in everyone's memory. Researchers have ascribed many reasons for the recession, but the resurgence of oil prices to their current level of around $110 per barrel has definitely prevented the western economies' recovery. While relatively insulated growing economies like China, India, and Brazil did not suffer much in the economic crisis of 2008 and its aftermath, continuing increase in oil prices have fuelled high inflation rates in these countries.



When will oil peak? Some believe it has already occurred and some say it will happen soon. Tranter and Sharpe (2007) quote several research studies to conclude that although individual researchers differ, none of them put the 'peak oil' event beyond 2020. Tranter and Sharpe (2007) debunk the theory that in the post-industrialization period the reduced dependency on manufacturing activity ought to bring oil consumption down. The fact, according to them, is that manufacturing activity has increased and the impact of this is increased consumption of oil because of a) the relocation of manufacturing activity to less energy efficient countries, and b) the additional transportation involved.

Countries like China will have to withstand the worst of the oil crisis that is bound to follow peak oil because of its dependence on oil imports.

2.2 Hubbert's Peak – The looming coal crisis

"Coal is the most abundant and economical of fossil fuels; on the basis of proved reserves at end-2008, coal has reserves to production ratio of about 128 years, compared with 54 for natural gas and 41 for oil" (WEC, 2010).

The majority (approximately 70%) of the energy China depends on comes from coal that it mines from sources within the country. The World Energy Council survey of energy resources (WEC, 2010), says that it estimates the world's coal reserves at 860billion tons, with some qualifications with regard to accuracy of this estimate. Russia and China share about 60% of the total. In 2008, China produced 2,716 million tons of coal (2,782 including lignite) of which it used 81% to produce electric power. Simultaneously, China also imported 46 million tons of steam and coking coal in 2008 to supplement its own production and meet energy demand (WEC, 2010). The report estimates that the global demand for energy will grow at 1.5% annually to 2030, with China and India accounting for over 50% of this growth. Different agencies peg China's coal reserves at different levels, but official estimates put it at approximately 330 billion tons – sufficient to last more than 100 years at current production levels and assuming the country does not discover any new resources.

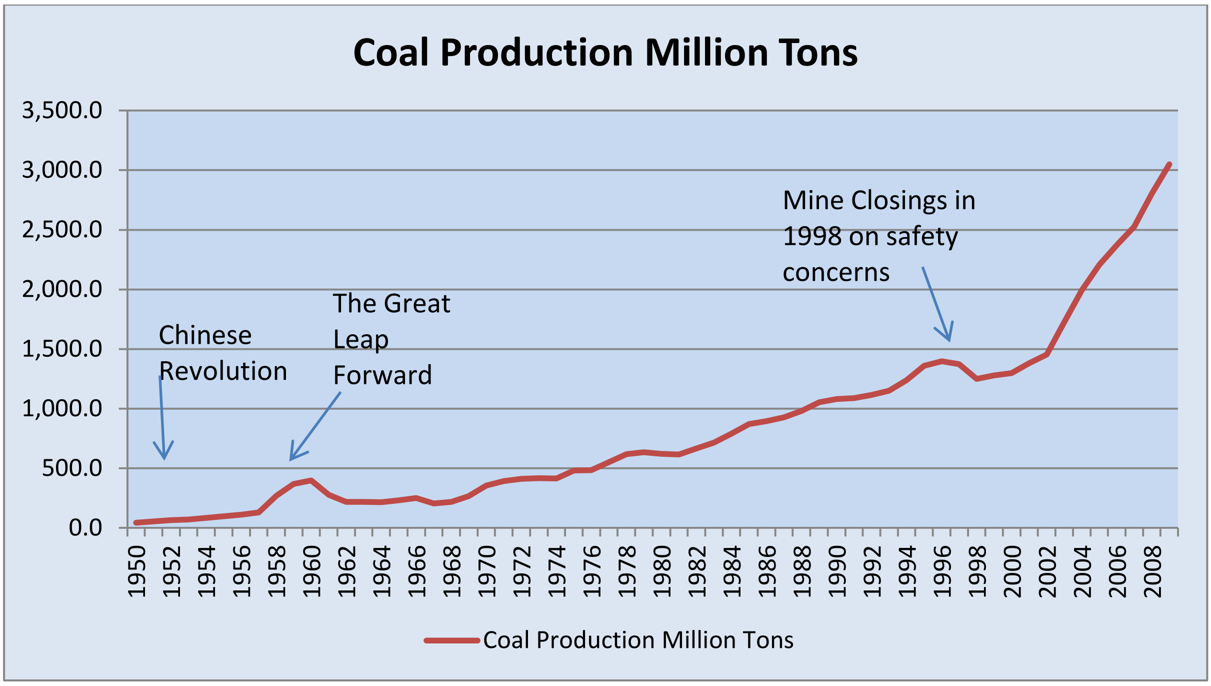


Figure -4: China's Coal Production

(Source: WEC Reports and own calculations)

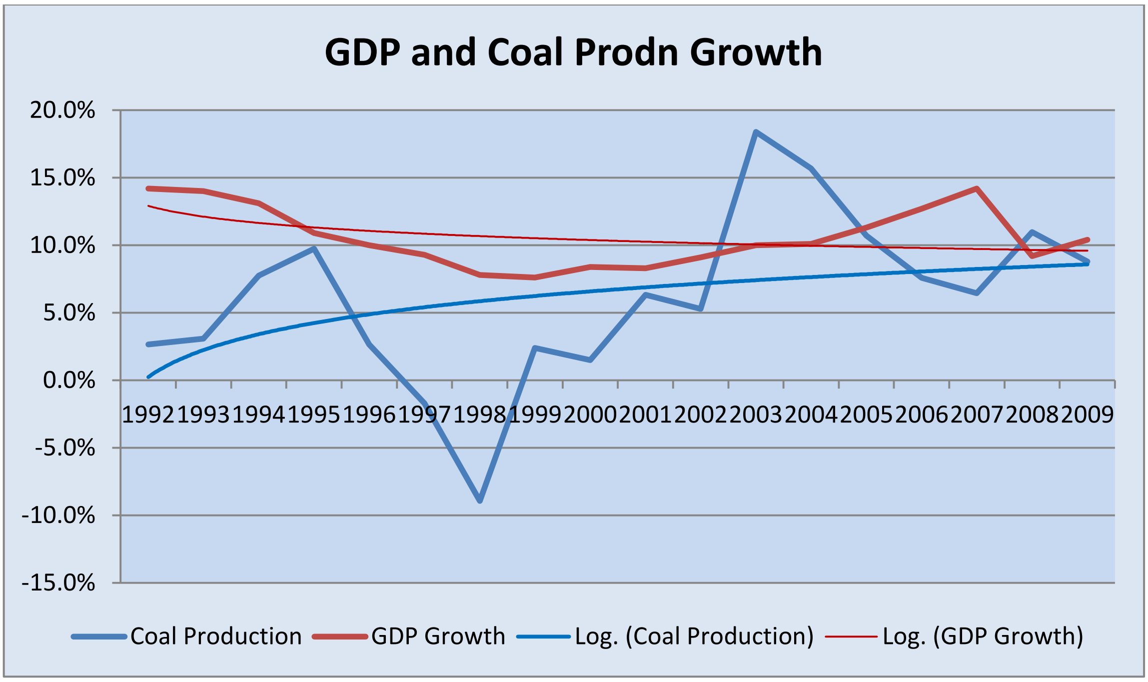


Figure -5: China's GDP and Coal Production Growth Rates

(Source: WEC Reports, World Bank[1] data and own calculations)

Figures 4 and 5 shows the trend of GDP growth and coal production growth. A clearer picture emerges from a comparison of the two in the first decade of the current century. The average GDP growth rate between 2000 and 2005 was 9.5% while coal production grew at 9.7%. The growth of coal production slowed down to 8.5% in the subsequent four years while average GDP growth increased to 11.6%. This indicates a reducing dependence on coal as a prime driver of the Chinese economy. However, it is important to understand whether the country can sustain this continuous growth in coal production.

Tao and Li (2007) extend the Hubbert Peak theory to coal production to say that as in the case of oil wells, production from coalfields also follows a bell-shaped curve, which shows a gradual increase in production followed by a short peak after which

[1] World Bank data accessed on March 26, 2012 from http://search.worldbank.org/all?qterm=China%20GDP%20growth%20data

production declines gradually. Once production has crossed the peak no matter how much effort or technology, it is impossible to increase production. As long as geologists find new coalfields, the new fields overlap the peaking and decline of existing fields to form a sustained production volume curve. The central argument of the Hubbert peak is that overall production from all fields in a region, and indeed the world, follows the same pattern. Tao and Li (2007) use the STELLA model to simulate Chinese raw coal production patterns. Their results project China's production to peak between 3.3 to 4.5 billion tons in 2025-27. They add that before the peak comes, coal production growth-rate will slow down to 3-4% annually and after the peak, growth will enter negative territory. The simulation shows that in year 2050 demand for Coal in China will be about 2500 million tons while production will slow down to 2338 million tons thereby opening a major demand-supply gap of over 7%.

This research (Tao and Li, 2007), as most other research that attempts to predict the behavior of the Chinese economy, appears to fail in the face of reality. Coal production in 2009 exceed 3,050 million tons and with a growth of 8.8% over 2008 following a growth of 11% in the previous year. Does this imply that China is approaching the peak much earlier than the prediction of 2025-27? The answer to this question requires further research perhaps using the same model as the one deployed by Tao and Li (2007). For the purpose of this paper, it is sufficient to say that in the coming time China will not be able to place as much reliance as it does on coal as a source of energy to sustain its economic growth. As Tao and Li (2007: 3153) put it, "In the coming decades, China should find a new energy development policy related to supply diversification."

A part of this policy is to diversify its energy dependence to other sources.

3.0 Economic, Environment, and Political Factors

"The complexity of Chinese attempts to manage human effects on the environment makes China special. Still more special are Chinese beliefs and attitudes towards the environment over the millennia. Generalizations are bound to be misleading." (Tickell, 2004)

The economic and environmental impact of bio-fuel production on local populations has produced much debate. In the following paragraphs, this report examines the different aspects of this debate.

Even if one were to discard the fears of peak oil and peak coal, the need for environmental sustainability itself justifies the exploitation of Bio-fuel resources. Beer et al (2006) hold that bio-fuels compare favorably with fossil fuels because the energy they provide comes from renewable resources and because their use creates lower greenhouse gas emissions and other atmospheric pollutants. One of the largest concerns, especially in the use of fossil fuels to generate electricity and in transportation is CO_2 and particulate emissions. Recent advances in Carbon Capture and Storage (CCS) technologies have alleviated CO_2 emissions to the atmosphere, yet the IEA estimates that CO_2 emissions in 2006 were around 28gigatons. In addition to the residual gas emissions, methane from coalmines makes for about 8% of the total methane emissions (WEC, 2010). Concerns for CO_2 emissions are particularly stronger for China as indicated by the strong upward trend in the emissions per capita for China (Figure 2). This compares poorly with high income countries where the situation appears to be improving.

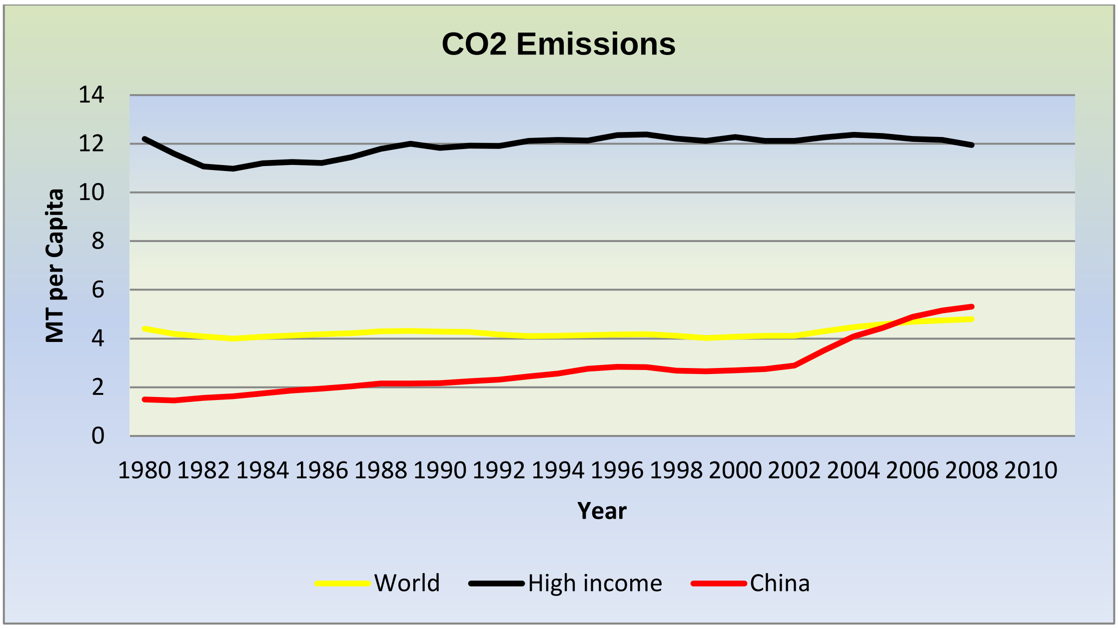


Figure -6: CO_2 Emissions in Tons per Capita

(Source: World Bank data from: http://data.worldbank.org/indicator/EN.ATM.CO2E.PC/countries/1W-CN?display=default)

Some studies have questioned the sustainability of bio-fuels and questioned their viability. An example is the study by Fargione et al (2008) (see also Searchinger et al, 2008), which analyzes the carbon balance changes that occur because of the diversion of farmlands, rainforests, grasslands et al to the production of crops for bio-fuels. Their study reports that land-use change would create a carbon debt that would take anything between 17 to 423 years to repay. The worst case is that of the conversion of tropical rainforests in South-East Asia to palm plantations for palm oil where it would take about 423 years for palm diesel to become CO_2 negative. The study concludes that most bio-fuels produced from virgin resources are not sustainable.

Advocates for setting up more bio-ethanol plants in the US have made unsustainable claims about the number of jobs created in some of the states that have invested in setting up plants for ethanol production. For example, Novack (2002) reported that the ethanol industry added about 200,000 jobs in the US economy.

However, if we look at the US Census Bureau data for 2002 (USCB, 2010) we see that the total employment in the ethyl alcohol industry was 2,200 jobs. How can such a difference exist unless those claiming the high numbers include those employed on the farm or in the downstream service units? If that be so, then the obvious mistake such people make is that they do not consider that people were working on the farm or were pumping gasoline even before the ethanol production units came into being. If the plants had not come up these people would still be growing corn or some other produce and those operating the pumps would be pumping oil instead of gasohol. The only difference that occurred was that instead of exporting the corn produced the shipments of produced were now going to the ethanol plants. Specific research on the impact of ethanol production on employment shows that a 10MGPA ethanol production plant in Nebraska would create 48 direct jobs in the plant itself and would link to an additional 163 jobs only in the rural economy of the area around the plant (Petersan, 2002). The researcher clearly mention that his calculations did not include jobs created for the construction of the plants.

The World-Watch Institute (2007) notes that transport is a significant factor in the equitable distribution of food, goods, and services and personal mobility, but current infrastructure faces a risk because of an overwhelming reliance on fossil fuels. On one hand is the estimated 95% dependence on fossil fuel for mobility and on the other is the concentration of oil reserves in a few countries with many weighed down by economic and political problems. This puts sustained reliance on such sources at risk of disruption. Recent political turmoil in the Middle East, particularly in Libya, Iran, Syria, and even Bahrain, and ethnic violence in Nigeria lend credence to the concerns expressed by World-Watch. China places a large dependence on import of oil from these countries and this uncertainty makes the need for diversification of fuel sources critical to its sustained development, even if costs appear difficult to justify purely on economic grounds.

4.0 Development of Biofuel Industry and Research

Bio-fuels take two forms. The first is ethanol, used directly in vehicles designed to run on alcohol or blended with gasoline to produce 'gasohol', which can be used in all vehicles designed to run on gasoline. Both uses require ethyl alcohol completely free of any water content. Addition of ethanol to gasoline improves the octane number and reduces CO/ CO_2 emissions. Primary sources of materials for production of ethanol include corn, sugarcane, wheat, or sugar beet. The second form of bio-fuels is biodiesel, a product derived from vegetable oils or animal fats. Use of waste cooking oil has found currency recently. Use of biodiesel directly in vehicles requires engine modification, but if used as an additive to gasoline or diesel engine modifications may or may not be required depending upon the concentration of biodiesel in the mix (Demirbas, 2009).

The basic requirement for production of bio-fuels, seen as ethanol, is raw material that has good amounts of sugar or materials possible to convert to sugar such as cellulose or starch. Sugarcane and beet fall in the first category while the latter can include a vast array of materials including corn, wheat, barley, straw, forestry processing residues etc (Tian et al, 2007).

Corn forms the feedstock for 90% of the ethanol produced in America and about 70% in China (Qiu et al 2012). However, the difference in cost of production in China exceeds that in America by a factor of 1.5-2.0. Yue et al (2007) put this difference as resulting from the use of more advanced technologies in the US, both in managing corn plantation and in ethanol extraction.

China today is the third largest producer of bio-ethanol after America and Brazil. Beginning with a capacity of just 30,000 tons per annum, its capacity rose sharply to touch 1.9 million tons in 2008. During this period, it experimented with an array of feedstock for the production units including corn, wheat, Jatropa, cassava, and sweet potatoes. Four of the new ethanol plants sought to convert stale corn and wheat that had become unfit for human consumption. These plants, located in Heilongjiang, Jilin, Anhui, and Henan provinces, soon ran out of the stale grain in 2005 and the government had no alternative but to convert to fresh grain. These plants consumed 4.25 million tons of corn, which represents 2.6% of the total corn production in 2008. Another plant using cassava as feedstock produced 150,000 tons of using 375,000 tons of cassava in 2008 (Qiu et al, 2012).

Biodiesel is a bio-fuel specifically aimed at replacing in part the diesel used for transport and has gained popularity because of the improvement in the quality of exhaust gases, sustainability considerations, and bio-degradability (Atadashi et al, 2010). Attempts to use number of vegetable oils including soybean oil and rapeseed oil have yielded mixed results. A strong factor against their exploitation at a significant level is the high cost of the raw material, which contributes 30-60% of biodiesel cost (Pandey, 2008) and of course the ‘food versus fuel’ debate that attend all bio-fuel initiatives . The strong argument in favor of biodiesel is its biodegradability and that it can substitute diesel without modification of the engine (Atadash et al, 2010). More recently, Jatropa oil has caught the world’s attention as the ‘green gold growing in a shrub'. Luoma (2009) warns provides a good overview of the state of progress and warns against over enthusiasm, because, according to him "the jury is still out."

A relatively recent development is the emergence of the opportunity for production of biofuel from microalgae. This area has found a lot of interest in China and the government provided the funding for a number of research projects. The first attempts by the Wu Group at the Tsinghua University failed because the results showed high emission of CO_2 and high cost (Peng et al, 2001). The Guardian (2008) reports that the latest development in the UK is the sanction of a public funded project of approx $40million for a microalgae based bio-fuel plant to begin commercial production by 2020. This clearly shows that this technology would not help the world and specifically China ride over the looming energy crisis for the simple reason that this technology is still under development and even if the scientists succeed, commercial exploitation would take a long time to fructify.

Looking specifically at oil, Figure-6 shows the increasing gap between oil consumption and domestic production in the last few years.

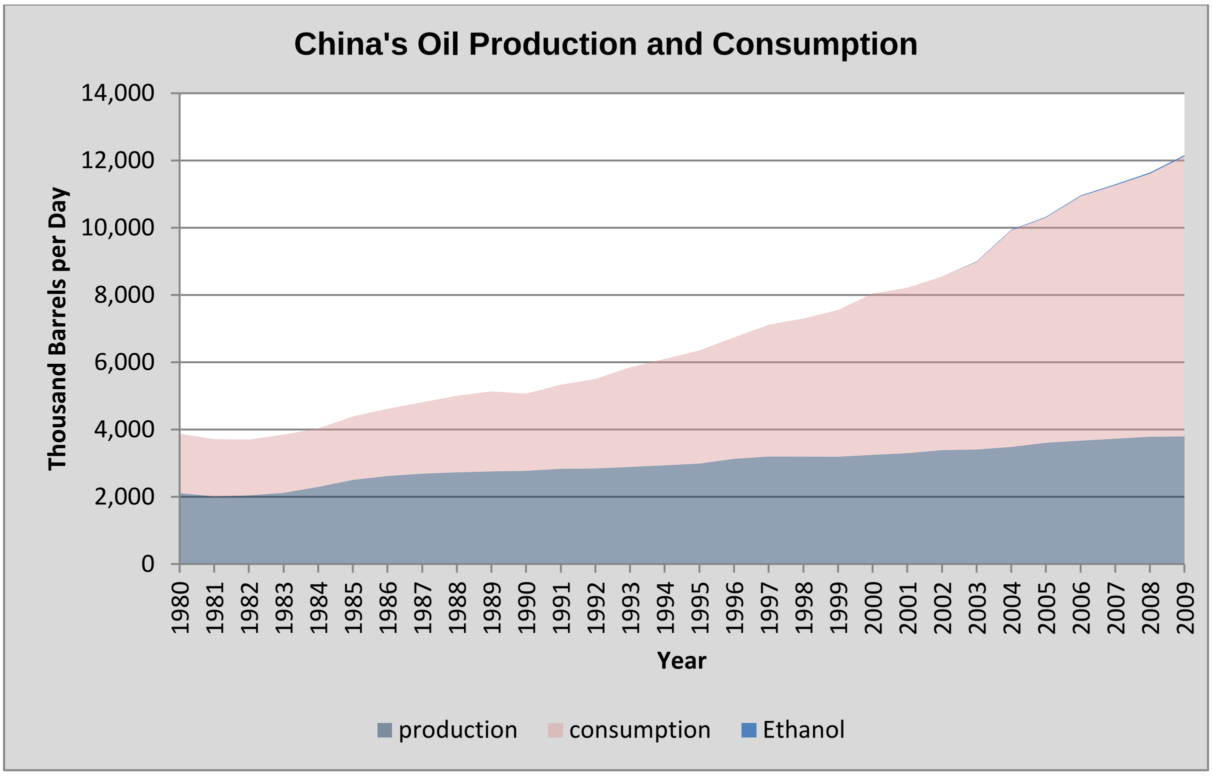


Figure – 7: Crude Oil Production and Consumption in China 1980-2009

(Source: Data from http://www.indexmundi.com/energy.aspx?country=cn)

Figure-7 shows the ethanol production in China since the start of the four major ethanol factories in 2003. To put this production in perspective, the percent contribution to the total oil consumption shows that despite a major increase in absolute terms, the total production represents less than half a percent of the total consumption of fuel in China. In addition, we can see that the increase in production in 2009 over 2008 had only a marginal effect on the percent contribution due to the substantial increase in the overall crude oil use.

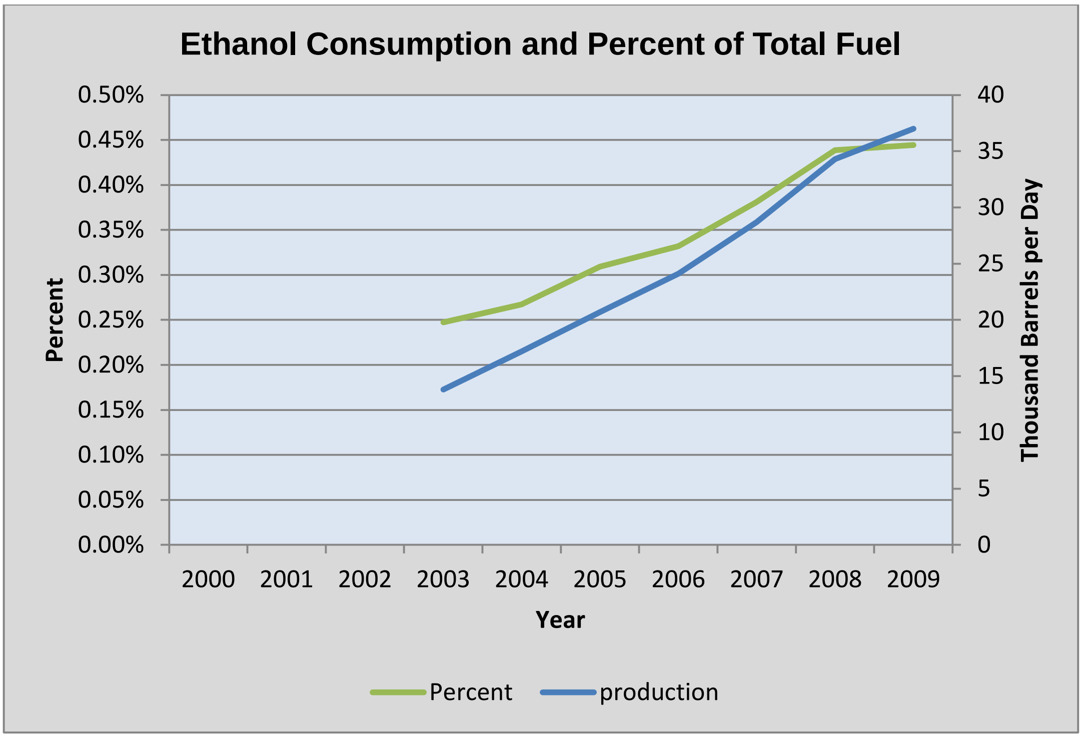


Figure – 8: Ethanol Production and Percent of Total Crude Oil Consumption in China 1980-2009

(Source: Data from http://www.indexmundi.com/energy.aspx?country=cnandproduct=ethanolandgraph=production+consumption)

5.0 Economics of Production

An important impediment to extensive production and use of bio-fuels are capital cost in setting up the plant. Infrastructure for collecting the raw materials, blending, and distribution of the finished product add to project costs. The production of the raw materials, usually dispersed over large agricultural areas, requires major investments in infrastructure for collecting and storing the seasonal products to ensure continuous operations of economically viable plants. In addition, consistency and safety requirements necessitate the transport of gasoline or diesel to the plant or a central hub where blending takes place. The second impediment is the cost of raw materials, which constitute 75-80% of total operating cost.

Traditionally, sugarcane is the major raw material for production of sugar. The low concentration of sugar in molasses requires extensive use of energy for distillation of the alcohol produced. Brazil's success in producing alcohol from sugarcane is because it converts a large percent of the juice of the cane directly to alcohol without producing sugar. Higher concentration of alcohol makes it cheaper to distill. For countries like China who import sugar to meet domestic requirements (Javier, 2011), eschewing sugar recovery in favor of producing bio-alcohol might become counterproductive. Liang et al (2011) examined the economics of a plant producing only sugar, only ethanol, and a mix of the two to demonstrate that combined production represents the best alternative for using sugarcane. In addition, ethanol produced from sugarcane demonstrates the highest energy balance between renewable products and energy input as fossil fuels. This is primarily because sugar production from sugarcane derives most of the energy requirement from burning the bagasse byproduct compared to beet where external power input has to come from electricity and fossil fuel.

Feedstock	Energy Ratio
Sugarcane	9.3
Lignocelluloses residues	8.3~8.4
Cassava	1.6~1.7
Beet	1.2~1.8
Wheat	0.9~1.1
Corn	0.6~2.0

Table -1: Comparison of different feedstock for biofuel production

Source: Liang et al (2011: pp.77)

Two features of the above table stand out sharply. The first is that the ethanol production from lignocelluloses residues also represents a part of the ethanol derivation from sugarcane and second that a plant reporting average performance using wheat or corn is likely to consume more energy than it produces. Liang et al (2011) explore the cropping pattern for sugarcane in China, and the problems and developments that have attended this field to conclude that in order to produce enough sugar to meet current demand of 12million tons per year the maximum potential to produce ethanol from this source is 2million tons. Application of improved technology, planting improved varieties of sugarcane, and increasing the land under sugarcane cultivation by about 2 million acres (the maximum possible limit) can increase ethanol production to about 4million tons. There appear two problems with the assumptions in the study of Liang et al (2011). Firstly, China's sugar requirement is 14million tons and not 12 million tons (Javier, 2011) and secondly, they assume that it is possible to convert 2 million acres of farmland to sugarcane production without any social or economic cost. They themselves say that sugarcane crop grows only in good farmland and state, "the further expansion of sugarcane areas forecasted for China ... mustn't reduce the availability of arable land for the cultivation of food and feed crops" (Liang et al, 2011: 78). How this miracle will happen, they do not say.

Root crops, with cassava and beet being the most important, represent another important agricultural product for conversion to ethanol. In China, the area under cultivation for root crops and production has remained stable at 9.93 million hectares and 34.06 million tons respectively (Li et al, 2008).

6.0 Agriculture and Economic Indicators

The World Bank provides data on a number of economic and social indicators for most countries of the world. Some those have particular importance from the viewpoint of this report. The first is the percent of land under agricultural use. Figure-8 shows that China has traditionally used a higher percentage of its land for agriculture. Following a strong increase in the 1980s, this has reached a plateau perhaps indicating that finding additional land for growing crops for bio-fuel use may not be possible. Therefore, the two possibilities are a) divert some of the existing land for bio-fuel feedstock, and/or b) locate and use marginal land not presently used for growing food.

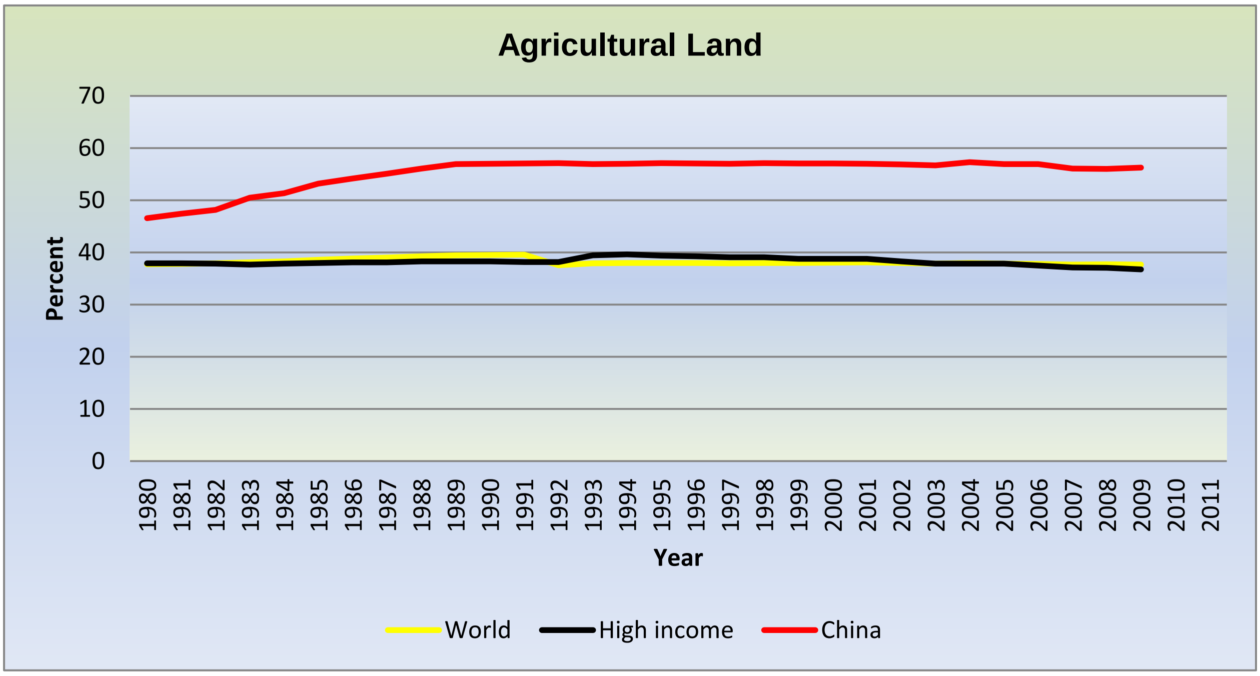


Figure -9: Agricultural Area as Percent of Total Area
Source: World Bank data from:
http://data.worldbank.org/indicator/AG.LND.AGRI.ZS/countries/1W-CN?display=default

Figures-9 and 10 below shows the intense pressure on urban areas as farm workers continue to migrate to the cities. From nearly 70% of the population living in rural areas in the early 1980s the number declined to below 40% in 2008. This can only reduce further as indicated by world averages and particularly by the extent of urbanization in the high-income countries.

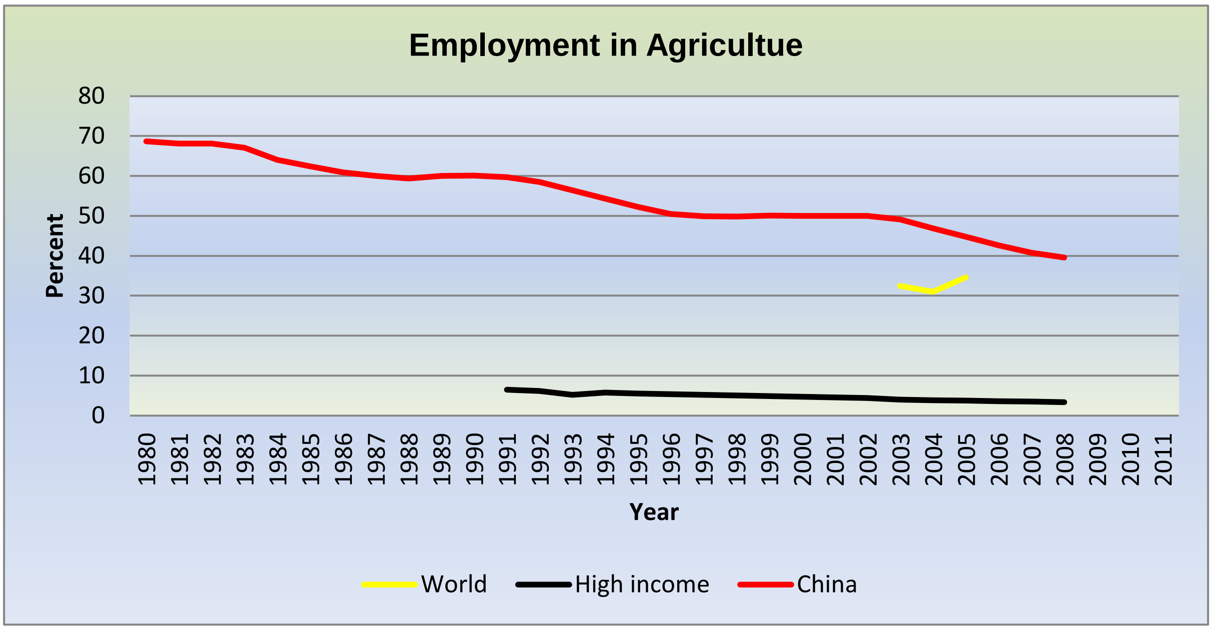


Figure – 10: Percent of Population Employed in Agriculture

Source: World Bank data from:
http://data.worldbank.org/indicator/SL.AGR.EMPL.ZS/countries/1W-CN?display=default

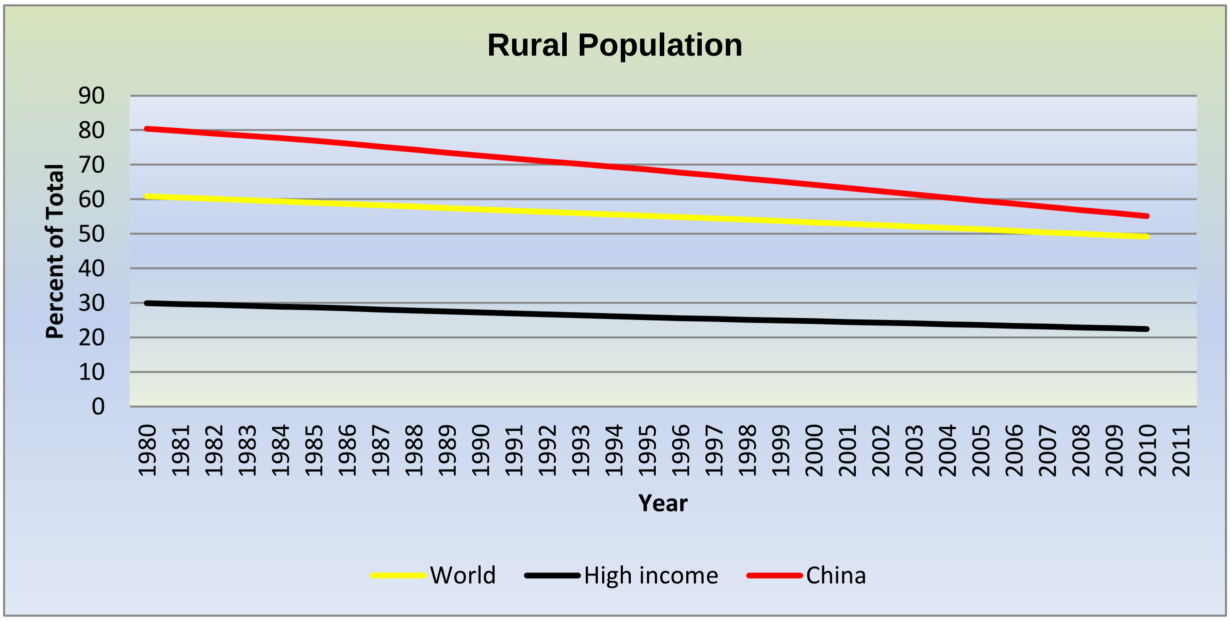


Figure -11: Rural Population as Percent of Total Population

Source: World Bank data from:
http://data.worldbank.org/indicator/SP.RUR.TOTL.ZS/countries/1W-CN?display=default

Despite the above migration to urban areas, China's food production has grown substantially as indicated by worker productivity increase (Figure-11). However, world averages and China do not compare at all with the average productivity of the farm worker in the high-income countries. This indicates that the agriculture technology deployed in the high-income countries is vastly better than in China and indeed in the rest of the world. It is essential moderate this observation as we see that the yield of cereals per hectare in China more or less matches that of the high income countries. Therefore, it becomes evident that in addition to technology, the farms in the high-income countries also put more emphasis on growing higher value crops.

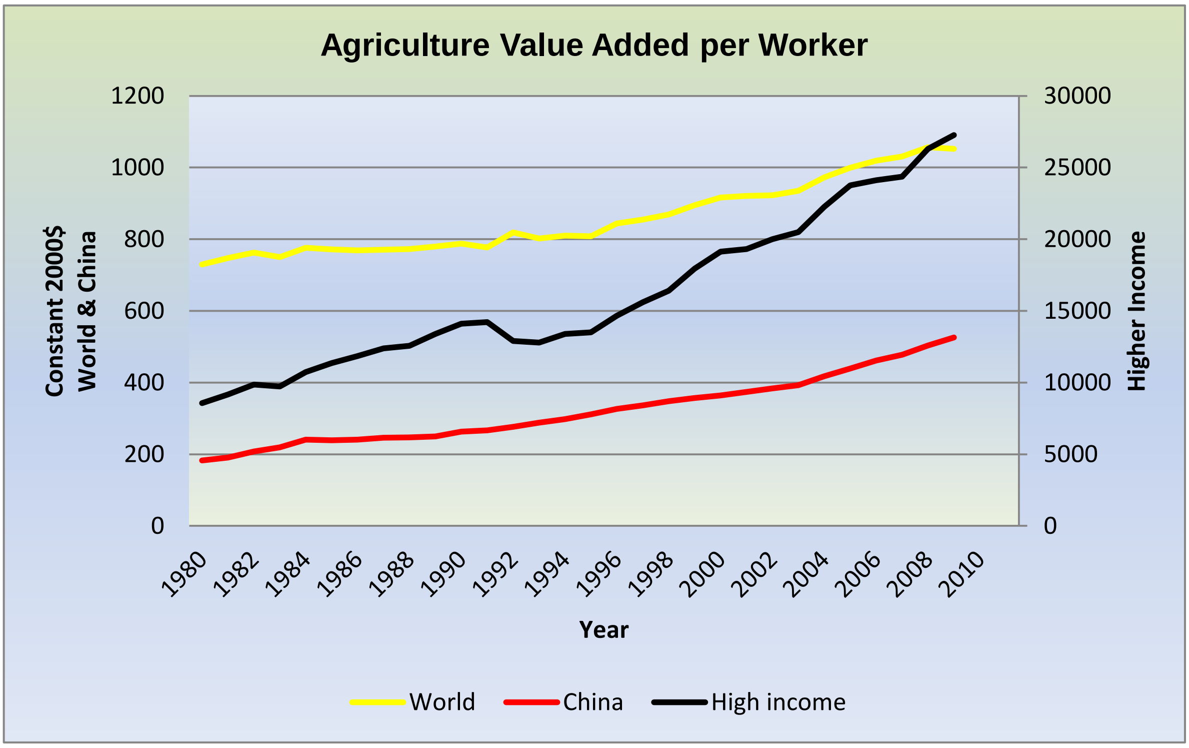


Figure -10: Agriculture Value Added per Worker

Source: World Bank data from:
http://data.worldbank.org/indicator/EA.PRD.AGRI.KD/countries/1W-CN?display=default

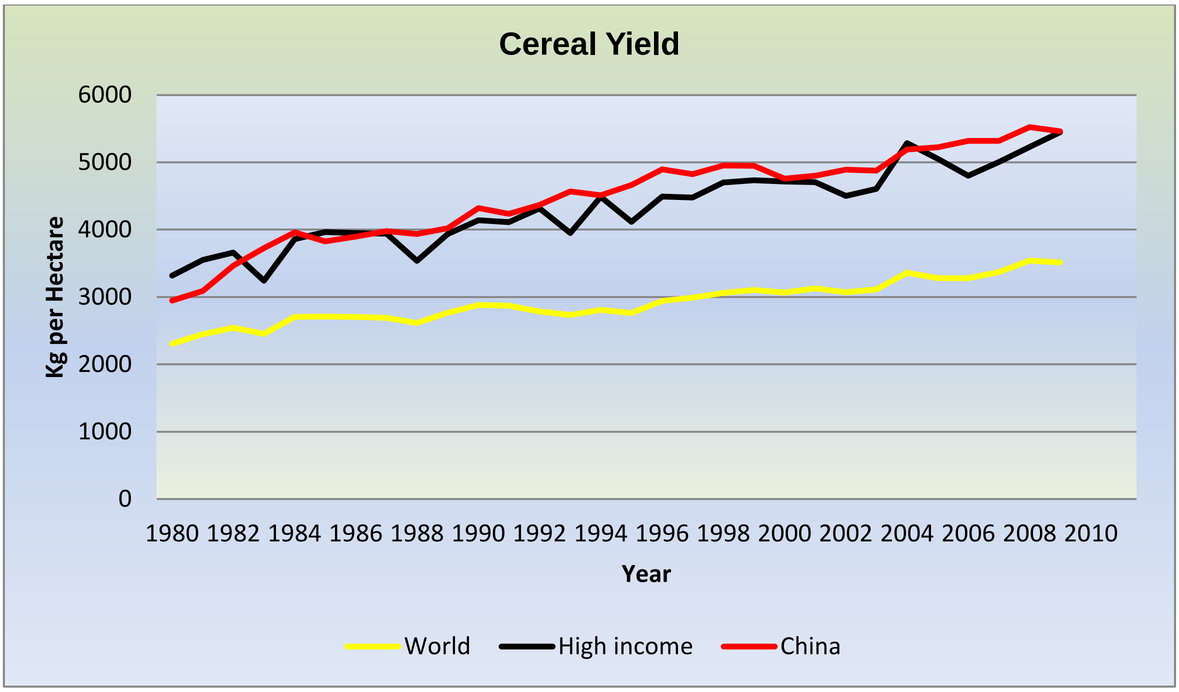


Figure -11: Cereal Yield per Hectare

Source: World Bank data from:
http://data.worldbank.org/indicator/AG.YLD.CREL.KG/countries/1W-CN?display=default

The conclusions we can draw from the above analysis is that there appears little scope for China to increase agricultural land and improve yield per hectare. In case cereals are diverted from food use to produce bio-ethanol the argument that it will increase food prices requires examination. The FAO food price Indices (Figure-12) show that food prices have fluctuated widely in the previous two decades. However, if we compare these fluctuations with the production of bio-ethanol, no correlations appear. It is obvious that the change in food prices is subject to many other stronger influences, which include harvest results, weather changes, balance of payments etc.

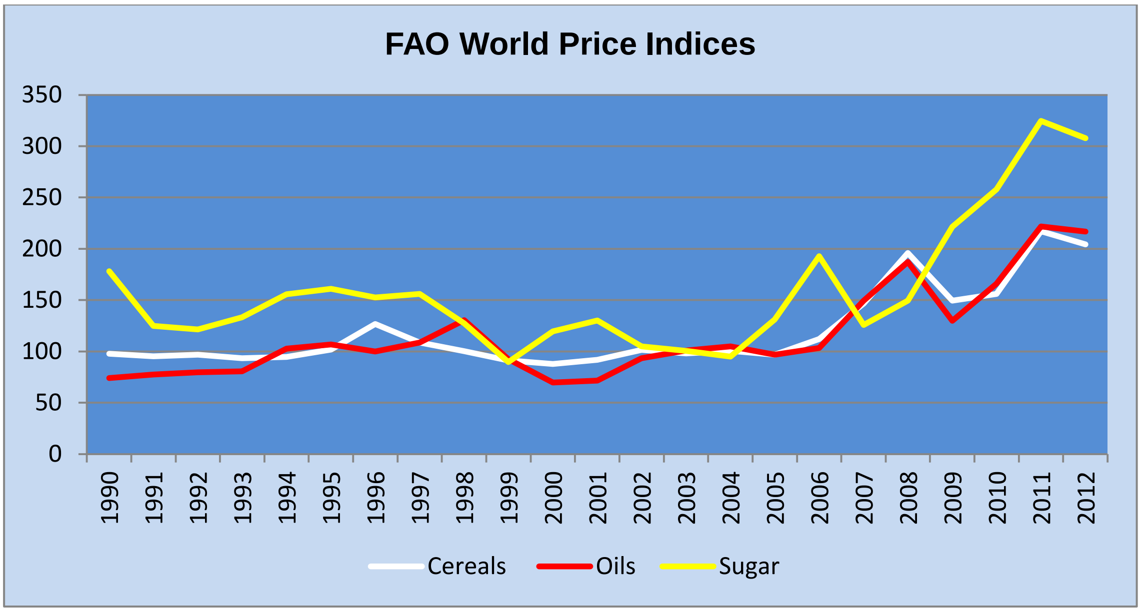


Figure -12: World Food Price Indices

Source: FAO data from:

7.0 Major Policy Initiatives

Qiu et al (2012) trace the policy initiatives in China's Biofuel development. They say that before 2000, there was no specific government policy on the issues but simultaneously the government had been spending substantial amounts on research and development aimed at developing bio-fuel technologies. In 2001, the tenth five-year plan made a special provision for development of denatured ethanol for use as an additive to gasoline meant for automobiles. The main thrust of this policy was to use grain declared unfit for human consumption for conversion to ethanol. Under this plan, testing of the technologies developed began on a pilot scale in 2002. Simultaneously, the government laid down national standards for E-10 (90:10 gasoline/Ethanol) and designated five cities for trail with the product making it mandatory to use E-10. This program extended to 27 cities in five provinces in January 2006. An important guidance from the Ministry of Finance in 2004 provided the details of how the government would subsidize manufacturers of bio-ethanol for the difference between manufacturing cost and market price for 2004-2008. The government promulgated the Renewable Energy Law in 2005, which lay down the rules for development and use of renewable sources of energy including bio-fuels and got the wheels rolling.

Subsequent announcements, regulations, and clarifications issued by the government followed the broad pattern set in the above initiatives. These included clarifications on subsidy structures and additional subsidy on capital investment in bio-fuel plants and conversion of marginal lands for tree and bio-fuel feedstock. Qiu et al (2012) say that compared to bio-ethanol, policy initiatives on biodiesel did not receive as much attention.

The first mention of biodiesel came only in the MOF policy document of 2006, which provided for subsidy on bio-fuels including biodiesel on price and capital costs. The 'Middle and Long Term Development Plan of China's Renewable Energy' announced in 2007 provided for increasing biodiesel production to 2million tons by 2020.

The model: What the Future Holds for China's Energy Needs

In this section, the research develops a mathematical framework for predicting the energy scenario in China in 2015 and 2020. A comparison with the existing situation (in 2010) assists a discussion on what problems and possible solutions the country will face, with an emphasis on the need to divert more resources for the development of alternate sources of energy, particularly biofuels.

Calculation Basis

A large majority of the data analyzed in this report, particularly for the period beginning 2000 shows a linear trend. Evidence of this is available from the examples provided below.

Example-1

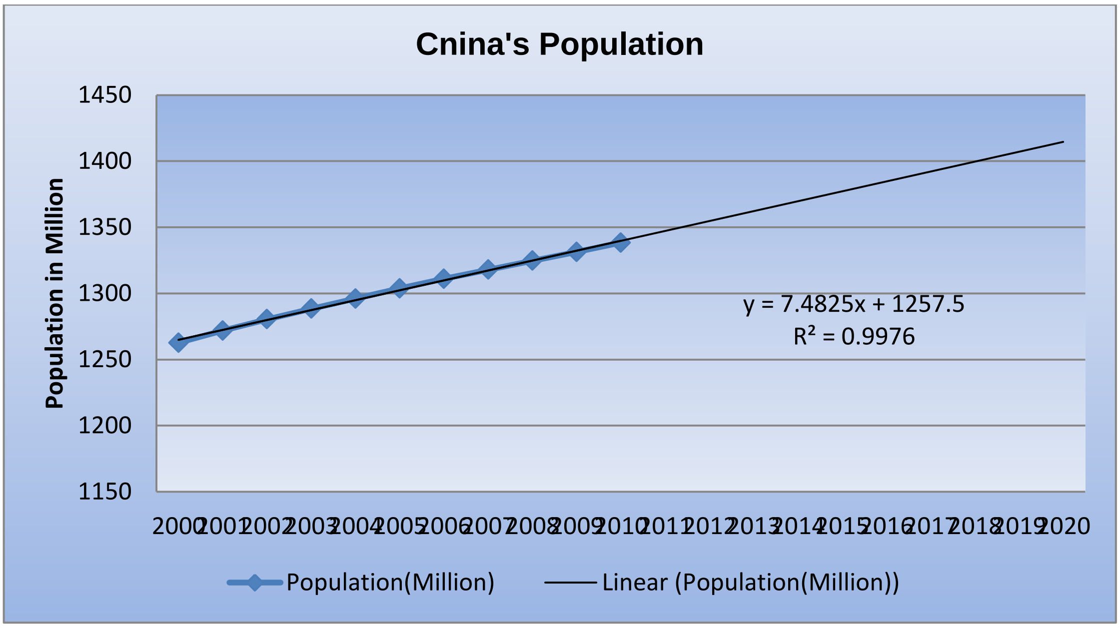


Figure-13: Population Growth of China and Forecast

The R^2 value of 0.997 shows a very tight fit between the data and the straight line given by

$$y = 7.482\,x + 1257$$

Where Y is the population and X the year. Using this equation we can predict that China's population will be 1377.22 million in 2005 and 1414.03 million in 2020. This is also in line with the current trend in population growth, which has shown a declining trend and can be expected to continue. Population growth levels in 2015 and 2020 will be 0.33 and 0.22 percent respectively.

Example-2

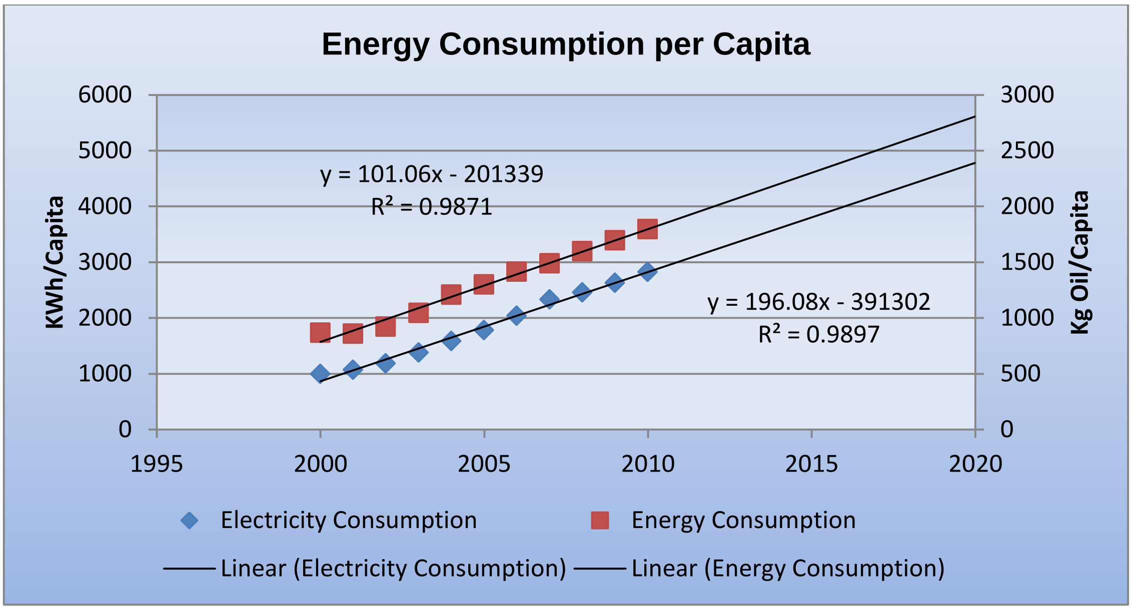


Figure-14: Energy Consumption in China and Forecast

Both, the energy consumption per capita in KWh and in terms of Kg Oil equivalent per capita also show an excellent ability of the equations

$$y = 101.0\ x - 20133, \text{ and}$$

$$y = 196.0\ x + 39130$$

To explain the changes in the two parameters because of the sum of squares R^2 is close to 1 at 0.987 and 0.989 respectively.

This gives us the energy consumption per capita in China in the years 2015 and 2020 as 3804.39 and 4750.99 million KWh respectively.

Similar calculations for all other data show some startling data. For example, the facts are that the production and consumption of coal in the country has followed a linear growth and the linear trending line shows a close fit with R^2 values at 0.980 and 0.981 respectively making a linear prediction of future acceptable. However, we also know that for the first time in 2009, China became a net importer of coal because consumption at 3308 million tons outstripped production as 3210 million tons by close to a million tons – not an alarming figure because it represents a small 3% of the total consumption but considering that it is the first time China imported coal for electricity generation is critical for this study.

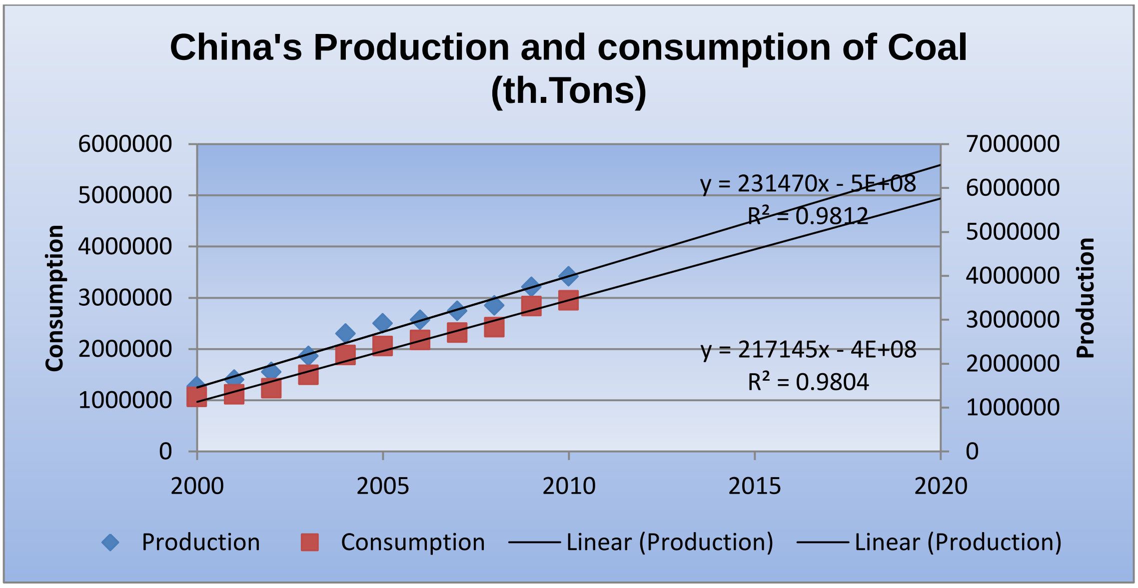


Figure-15: Energy Consumption in China and Forecast

With consumption increasing to 4602 and 5759 million tons in 2015 and 2020 respectively, it appears untenable that production would be able to reach the levels predicted by the mathematical model i.e. 4506 and 5592 million tons in the same periods, especially given the tapering off of production since 2003. If we use the trend since 2003 then production in 2015 and 2020 will be 4368 and 5360 million tons making for a shortfall of about 2 million tons in 2020.

Oil Prices also show a close fit ($R^2 = 0.892$) with a linear trend indicated by the straight line y = 6.939x – 13860. While it appears foolish to attempt to predict oil prices, current trends place the price at $ 127 and 164 per barrel in 2015 and 2020 (Figure-16). However, oil production and consumption projections (Figure-17) show the increasing gap between the two opening up a huge gap between demand and supply.

This shows that the shortfalls in oil availability will nearly double present levels. This is bound to have a reaction in the oil market making the mathematical projection highly doubtful. Prices of oil will be much higher.

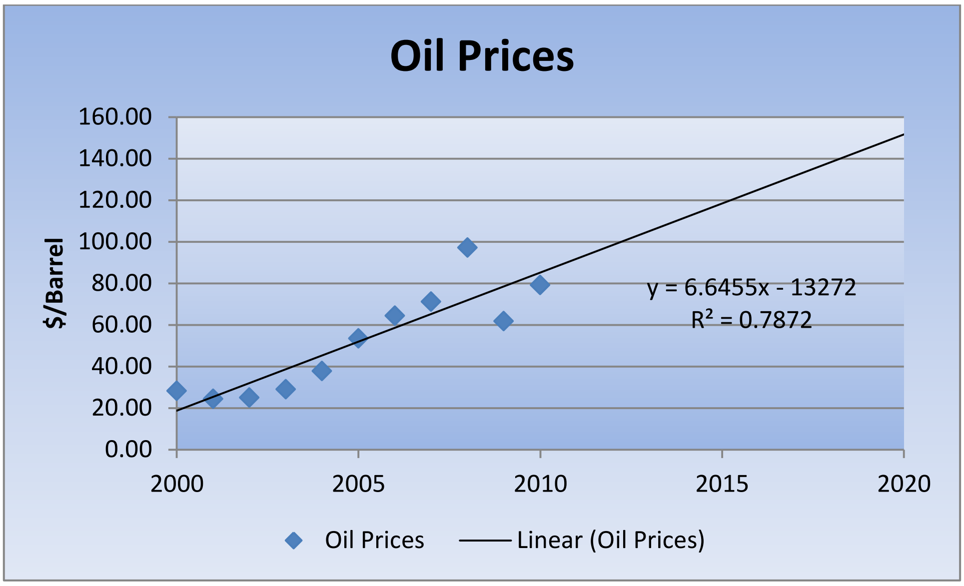


Figure-16: Historical Oil Prices and Forecast

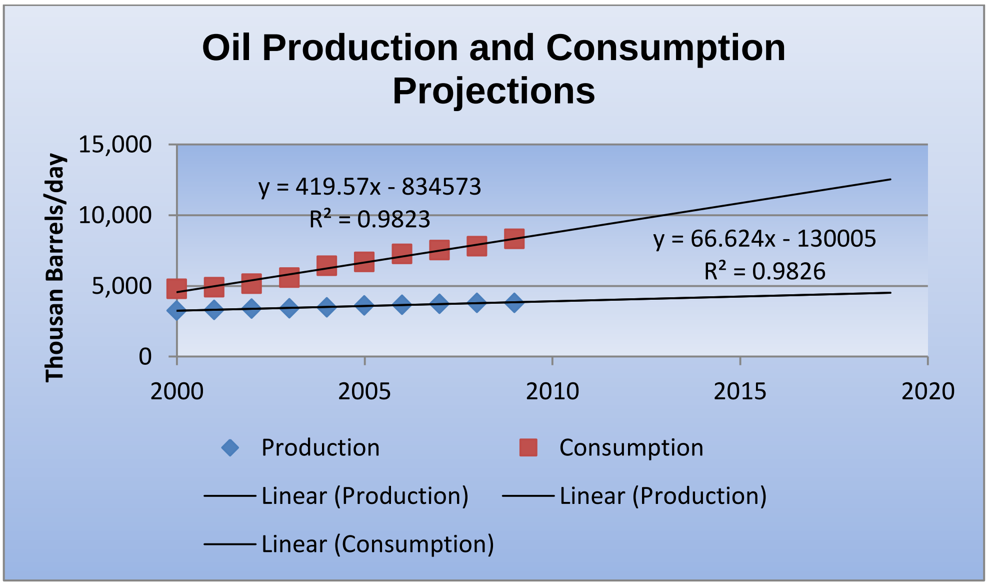


Figure-17: Oil Demand-Supply Gap for China

The data below (thousand barrels per day) shows the extent of the demand-supply gap:

	2010	2015	2020
Production	3,909.62	4,242.74	4,575.86
Consumption	8,760.00	10,857.85	12,955.69
Shortfall	4,850.39	6,615.11	8,379.83

Finally, projections predict per capita CO_2 emissions will increase to 8.12 and 9.95 tons if the same energy generation pattern continues into 2015 and 2020 respectively. These numbers are completely indefensible if China has to adhere to its commitments to the world community.

China's Growth Drivers

Correlation analysis to find if any correlations exist between China's GDP, Oil prices, crude oil production and consumption, and ethanol production show very strong correlation between these factors. Table 2 shows the results of correlation analysis using the data from 2000 to 2010.

	Oil Price	*GDP*	*Oil Prodn*	*Oil Cons*	*Ethanol*
Oil Price	1				
GDP	0.857096963	1			
Oil Prodn	0.915812692	0.940737033	1		
Oil Cons	0.892332444	0.946339316	0.9895919	1	
Ethanol	0.818723335	0.991036801	0.9771417	0.9813165	1

Table-2: Correlation Analysis

The surprises in this analysis are the relatively weaker correlation between GDP and Oil price and oil price and ethanol production. This shows that the GDP growth depends only marginally on the oil prices.

The Changed Energy Scenario

Using the data projections explained above, with the limitations explained above, still helps explain that the sustainability of China's growth stands severely threatened because of the looming energy crisis. Table -3 summarizes the findings of the projected scenario.

Energy Scenario	2010	2015	2020
Population in million	1,338.30	1,377.22	1,414.03
Population growth (annual %)	0.52	0.33	0.22
GDP (current US$)	5,926.61	7,586.48	10,269.54
GDP growth (annual %)	10.40	12.67	12.28
Energy use (kg of oil equivalent per capita)	1,795.97	2,301.28	2,797.07
CO2 emissions (metric tons per capita)	6.23	8.12	9.95
Power consumption (kWh per capita)	2,823.98	3,804.39	4,750.99
Crude Oil Price	79.03	127.58	164.81
Coal Production	3,420.97	4,506.64	5,592.40
Coal Consumption	3,444.69	4,602.03	5,759.39
Oil Production	3,909.62	4,242.74	4,575.86
Oil Consumption	8,760.00	10,857.85	12,955.69

Table-3: Critical Factors in the Energy Scenario in China

The changing structure of the economy becomes evident from the contribution of different sectors to China's GDP (Table-4).

Sector	2010	2015	2020
Agriculture	10.10	7.11	4.93
Industry	46.75	48.38	48.61
Services	43.14	44.52	46.46

Table -4: GDP Contribution by Different Sectors

Table-5 provides evidence that the Chinese economy will derive most of its growth from the industrial sector where the consumption of energy is the maximum. The services sector will probably show the strongest growth and this is encouraging because, this sector is not so heavily energy dependent.

Discussions and Conclusions

Using corn to produce ethanol for fuel diverts food grain from food use. This diversion affects supply in the market and adversely affects the price. Evidence of this comes from the 23% rise in corn price in China in a single year in 2006 (Liu, 2008). This corresponds with the time when China's new plants switched from use of stale grain to fresh grain. The impact of the rise in grain prices also affects livestock rearing and food processing industries. In 2006, the total corn production was 145.48 million tons. As against this, estimates by Zhang and Hu (2000) project the demand for corn as food itself to grow to 204 million tons by 2020 while the production would only increase to 180 million tons. The options before China to cover the deficit of 24 million tons include the import of corn from other countries and/or to increase domestic production by increasing land under corn cultivation, using biotechnology, and deployment of the best farm management practices (Luo and Li, 2006).

All the research reviewed for this paper makes a basic assumption of a divide between power requirement for domestic and industrial use as electricity and fuel needs. A well-known fact is that a major effort is on worldwide to use electric power for transportation needs, particularly automobile, spurred by the same concerns that attend the efforts to develop alternate fuels. While research on individual areas is welcome, some research has to approach this problem as an integrated whole.

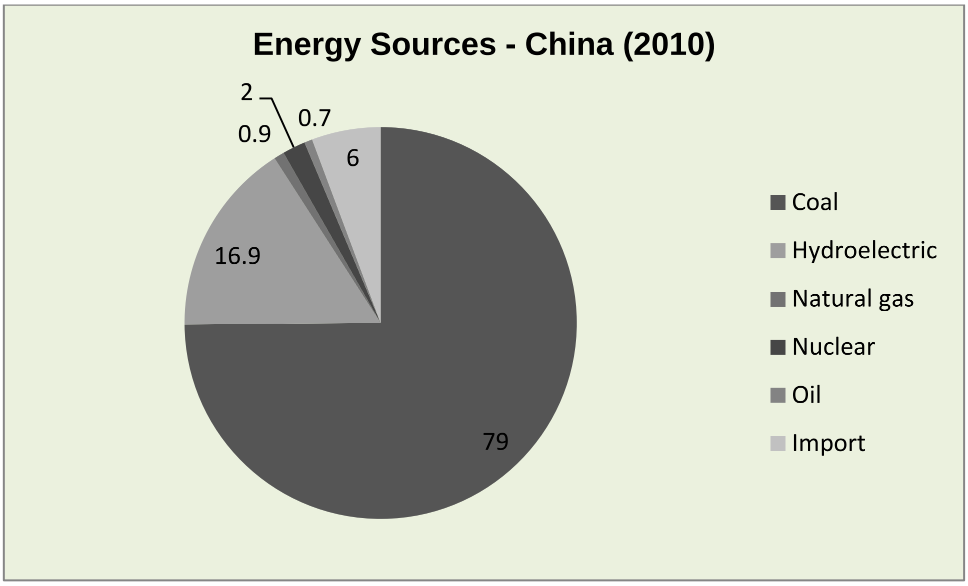


Figure- 18: Energy Sources Used by China in 2010[2]

(Source: Data from tradingeconomics.com and own calculations)

A major difference between fuel and other energy forms is that China produces most of its electric energy requirement using indigenous resources whether coal, hydroelectric, nuclear, or other renewable resources like wind and solar power. It does import some coal but of different grades meant for use as a raw material in the steel industry, rather than for electricity generation. On the other hand, data presented shows that the country depends on importing more than half its consumption of crude oil. The increasing upward trend in international crude prices (Figure 14) show that this ought to be a major concern for China.

[22] Note: the data for all sources is the total generation except for imports, which is data for consumption.

Figure – 19: Historical Crude Oil Prices 2003-2012

(Source: http://quotes.post1.org/historical-crude-oil-price-chart/)

As noted earlier, efforts to develop bio-fuels thus far have yielded a substitution of less than 0.5% of fuel. How much fuel can China save by converting its automobiles to hybrid technology and what is the possible impact insofar as environmental degradation is concerned? However, the policy declarations thus far appear aware of this possibility.

For example, on January 1, 2010 the government ushered in an automotive purchase stimulus package that provided tax cuts and subsidies ranging from $732 to $2,00on purchase of gasoline driven cars (Tutu, 2010). The result is that China has emerged as the world's largest producer and consumer market for cars, surpassing even America. However, they immediately extended subsidies to those customers who opt to buy electric or hybrid plug-in vehicles in a later move in July 2010. These subsidies aim to pay between $7,800 and $8,800 for the first 50,000 vehicles in five designated cities. This means a roughly 30% discount on a car costing around $25,000.

In a related move, China announced that it would build several new hydroelectric power plants to increase non-fossil fuel energy share to 20% by 2020 and 33% by 2050 (Juan, 2011). Therefore, this shows that the Chinese government is aware of the problems it faces in ensuring energy security for the country.

The Ministry of Land and Resources of the PRC reports the land use in 2007 as under

Land Use	Total Area (Million Hectares	Percent increase (decline) over 2006
Cultivation	121.7352	-0.03
Garden	11.8131	-0.04
Forests	236.1174	-0.002
Pastures	261.8646	-0.03
Other Agricultural use	25.4911	
Residential/ Industrial/ Mining	26.6472	+1.11
Transport/communications	2.4443	+2.05
Water Conservancy	36.286	+0.37

Table 5: Land use Pattern and Change

Source: Data from: http://www.mlr.gov.cn/mlrenglish/communique/2007/

The above table clearly shows the pressure on agricultural, garden, and forestland because of China's development efforts, which led to an increased in the land used for residential areas, factories, and infrastructure development requirements. The per capita arable land in China is 0.093 hectares, which is roughly 37% of the world average. This makes it important to understand that any further encroachment on arable land or diversion to non-food use will create pressure on the country to grow enough food to feed its population.

Small landholding means that the farmers produce and consume a major portion of the produce and only the excess enters the market.

Use of vegetable oils for production of biodiesel appears similarly challenged by the huge gap between demand and supply. Partly because of a reduction in yield, and partly because of an increase in consumption, import of food grade oil reached a record high of 9.165million tons in 2007 with a further import of oilseed equivalent to 5.925 million tons of oil. This total of 15.09 million tons compared to a production of about 10 million tons (less an export of 0.356million tons) translated to a per capita consumption of 19.48Kg, which is almost the world average but far behind that of developed countries. Therefore, there is considerable margin for growth of food oil in the country.

The findings of this report indicate that production of bio-fuels provides no commercial advantage to China, given the cost of production and the impact on food security. However, other reasons make it almost mandatory for the country to pursue an active policy towards promoting the production and use of bio-fuels. Briefly, these are:

1. The need to reduce CO_2 emissions
2. The need to diversify the risk that comes from an increasing dependence on petroleum crude oil

3. To meet the pressures on urban environment because of an increasing trend of migration away from rural areas

Even if this means import of food to substitute the cereals, sugar, and oil used for production of bio-fuels, China appears to have no alternative. Given these imperatives, this study makes the following recommendations for policy decisions in China.

a. Put in place initiatives for the horizontal increase in production of food and inputs required for bio-fuel manufacture by bringing marginal and fallow land under cultivation.
b. Procure or develop improved cultivars, new generation fertilisers, and technology for a vertical expansion of agricultural output. Focus on raising value addition at the farm and related input and output handling supply chains.
c. Drive initiatives and provide incentives to change consumption behaviour leading to lower energy use in all spheres.
d. Develop other renewable resources, particularly hydroelectric, nuclear, and wind and solar power etc at a faster pace.
e. Push for increasing production of bio-fuels even if it means having to import larger amounts of food to maintain prices at a stable and reasonable level.

This report has looked at different alternatives and possibilities before China and the essential conclusion is that China has to find ways to decrease dependence on import of oil in the immediate future and look to exploit all opportunities to reduce energy consumption across all sources in future.

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