Key issues for China to Support Global 2 Degree Target

1. Background

In December, 2009, The Copenhagen Accord declared that deep cuts in global emissions are required "so as to hold the increase in global temperature below 2 degrees Celsius". At the climate conference in Cancun one year later, parties decided "to hold the increase in global average temperature below 2 °C above preindustrial levels" and left open the option for "strengthening the long-term global goal on the basis of best available scientific knowledge including in relation to a global average temperature rise of 1.5 0C". The Copenhagen Accord called for an assessment that would consider strengthening the long-term goal including "temperature rises of 1.5 degrees". And the IPCC AR5 called research communities to work on assessment by modeling on the emission pathway and feasibilities for the global target.

Recently several global emission scenario studies presents emission scenarios focusing on the 2 degree target, which requires global emission must peak at latest before 2020. However the commitments in Copenhagen Accord is not matching with the global 2 degree target scenarios(UNEP,2010, 2011). Therefore further efforts from countries is needed. It is essential to make further analysis in country level to see whether there is possibility to mitigate CO_2 emission to follow the 2 degree target pathway. This paper presents the modeling results based on IPAC modeling team in

Energy Research Institute(ERI) on China's emission scenario analysis in the background of global 2 degree scenario.

Emission from energy in China over passed United States around 2006 and it accounts for around 24% of global emission in 2010. And due to rapid economy development, it is expected CO2 emission would increase significantly in coming decades(Jiang, et, al, 2009). This bring China very big challenge to peak CO2 emission before 2025 and start deep cut after 2030. Much more effort to be done in China and in the world.

2. Emission scenarios

2.1 methodology framework

In this study, we use the linked Integrated Policy Assessment Model of China (IPAC) to give quantitative analysis, covering both global scenario analysis and China's national emission scenario analysis. IPAC is an integrated model developed by ERI, to analyze global, national and regional energy and environment policies. ERI has been doing long-term research in developing and utilizing energy model since 1992(jiang et al, 2009).

In order to analyze global emission scenario and China's emission scenario, , here we use three models including a global model and two national model, that are IPAC-Emission global model , IPAC-CGE model and IPAC-AIM/technology model. The links among three models are shown in Figure 1. These modules in IPAC are currently soft-linked, which means the output of one module is used as the input of another module. In IPAC-emission model, the modules have realized the hard link.

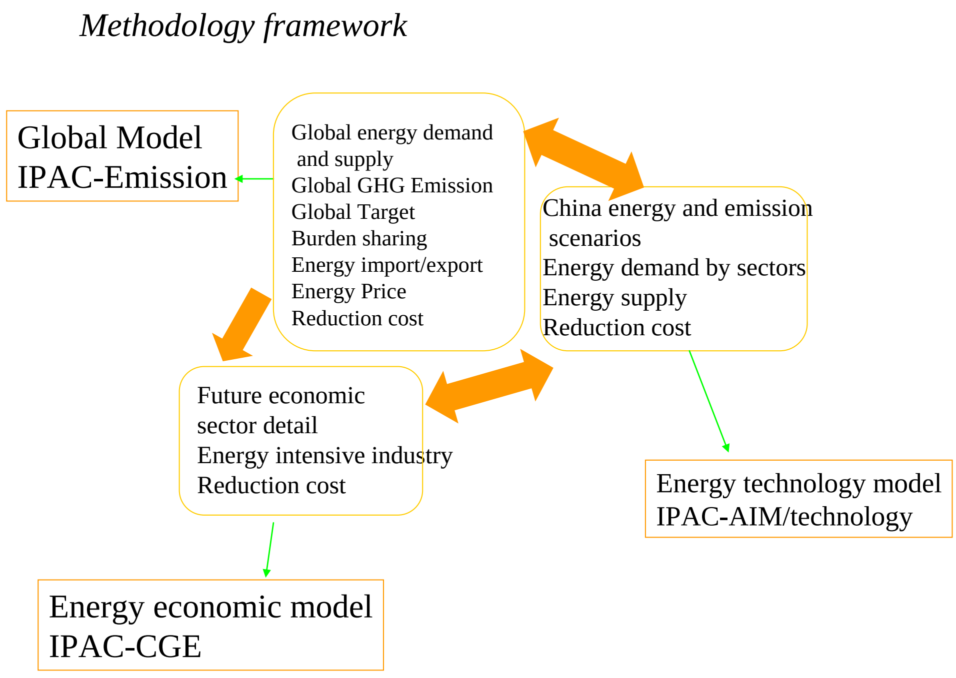

Figure 1 Links among modules in the research

IPAC-Emission model is a global model inside IPAC family, which cover 9 regions right now and it is extending to 22 regions. Because IPAC-emission model focus on energy and land use activities, in order to simulate other gases emissions, the model was revised to cover the analysis for HFC, PHC, SF6, CH4 and N2O. Study result for EMF-21 was used here(Jiang, et al., 2006). Data for abatement curve for HFC, PFC and SF6 emission from industry process and other sources were used in IPAC model.

IPAC-Emission global model is an extended version of the AIM-Linkage model used in IPCC Special Report on Emission Scenarios (SRES)(Jiang et al, 2000). This model links the social and economy development, energy activities and land use activities, and forms a full range of emission analysis. IPAC includes mainly four parts: (1) society, economy and energy activities module, which mainly analyzes the demand and supply in the condition of social and economic development, and determines the energy prices; (2) energy technology module, which analyzes the short and mid-term energy utilization technologies under different conditions, and determines the energy demand under different technology compositions. The energy demand in energy technology module will modify the short and mid-term energy demand in society, economy and energy activities module, which makes the energy analysis in macro-economic model better reflect the short and mid-term energy activities; (3) land use module, which analyzes the emissions from land use process. This mainly includes emissions from agricultural food supplies, stock raising, forest management and biomass energy production; (4) industrial process emission module, which mainly analyzes the emissions from all kinds of industrial productions. The society, economy and energy activities module is built based on ERB model developed by Pacific Northwest National Laboratory (PNNL) in US(Edmonds, et al, 1983). Energy technology module is the IPAC-AIM/technology module developed collaboratively by Climate Change Strategies Assessment Research Team in ERI and National Institute of Environmental Studies in Japan. Land use module is modified and extended based on the AGLU model developed by PNNL(Edmonds, 1996).

IPAC-AIM/technology is the main component of the IPAC model(Jiang et al, 1998). IPAC-AIM/technology model analyzes based on a cost-minimization principle, i.e. technologies with the least costs would be selected to provide the energy service.

The current version of IPAC-AIM/technology model includes 42 sectors and their products, and nearly 600 technologies, including existing and potential technologies.

IPAC-SGM is a general equilibrium model (CGE model) for China. It is mainly responsible for analyzing the economic impacts of different energy and environmental policies, and can analyze the mid- and long-term energy and environment scenarios. IPAC-SGM divides the whole economic system into household, government, agriculture, energy and other production sectors. Now there is 42 sector inside IPAC-SGM model.

Scenario setting for China comes from relative studies such as GDP, population, sector outputs etc. But IPAC modeling team also do own studies on these parameter by using IPAC-SGM(a CGE type of model), and own population model. Economy activities is getting to be one of key research topic in IPAC modeling studies due to the potential big Change in economy development. Sector development trend is a crucial factor for energy and emission scenario in the modeling studies. Energy intensive sectors, such as ferrous metal manufacture, non-ferrous metal manufacture, building material manufacture and chemical industry accounts for 50% of total final energy use in China. Future changes in these sectors are very important for scenario analysis. By using IPAC modeling framework, we made scenario for these economic activities. Figure 2 and 3 presents the structure change in industry in China, by using IPAC-SGM model. In the meantime, physical unit output in energy intensive sectors is given by modeling study using CGE model, and input-output analysis. Table 1 gives a scenario for energy intensive products output in China.

Compared with global model data, the national analysis on economy development could well reflect national experts' view points, which normally has quite big difference with the global projection on China's GDP growth. And the sector study for output analysis could present much more sight inside economy structure change, to think about the contribution for lower energy demand and emission from economic structure change, when in many case global model is difficult to deal with. This is very important for scenario analysis in China because China is in the period for rapid economy development and changing ways for economic development, where normally is big trouble for economic dynamic modeling.

The quick change in the pattern of economy development, means much high social energy conservation rate, which could be different with historical trend in China. This also bring big uncertainty for China's future energy demand and CO2 emission scenario. Many global models use AEEI as key factor for energy demand factor, and therefore need to pay more attention on that.

2.2 Global emission scenarios and regional allocation

The global emission scenario from IPAC mainly comes from IPAC-emission model, with recent studies focusing on global mitigation scenarios. Here a 2 degree emission scenario was developed based on the 450ppm emission scenario in IPAC model, based on the. Figure give the emission scenario from IPAC-Emission model. A simplified climate model, MAGGIC model was used here to set up the CO2 concentration with 450ppm by 2100.

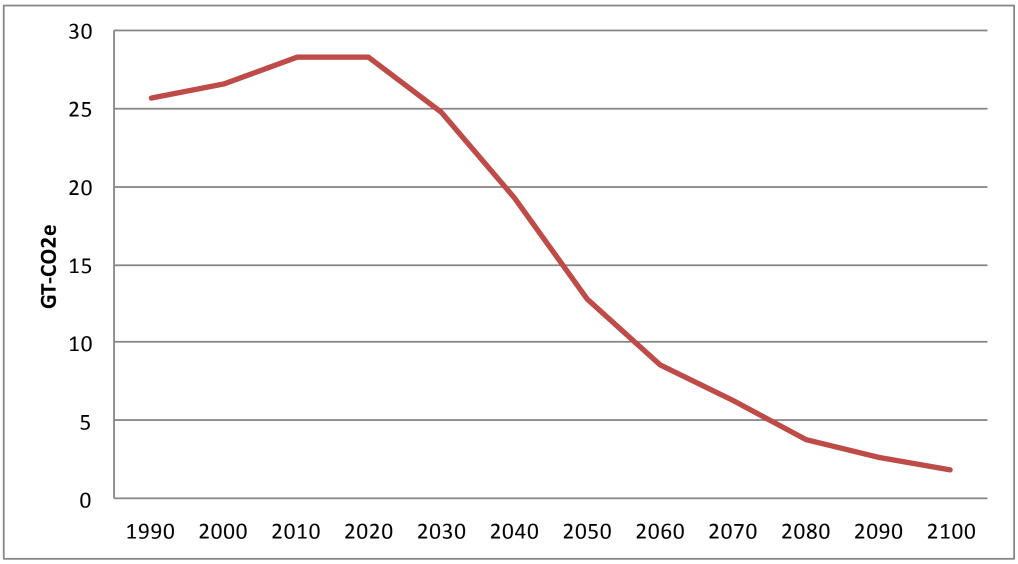

Figure 1 Global CO_2 emission with 450ppm by 2100

With the global emission scenario, regional emission allocation was given by simply using CO_2 emission per capita convergence criteria. It is assumed CO_2 emission per capita will be similar by 2070.

In order to analyze the emission from China, here we use a relative simple model for burden sharing, that is per capita emission convergence.

When burden sharing using emission per capita is analyzed, there are some assumption should be given:

- Year to reach emission per capita convergence: here we use 2070.
- Annex 1 countries will start reduction based on Kyoto commitment, and then go to deep reduction. Non-Annex 1 countries will start to departure from baseline

emission from 2010.

- Co2 emission per capita in some developing countries may exceed developed countries.

Population in IPAC model come from IIASA's analysis(IIASA, 2004). Figure 2 gives the CO2 emission by major regions and countries.

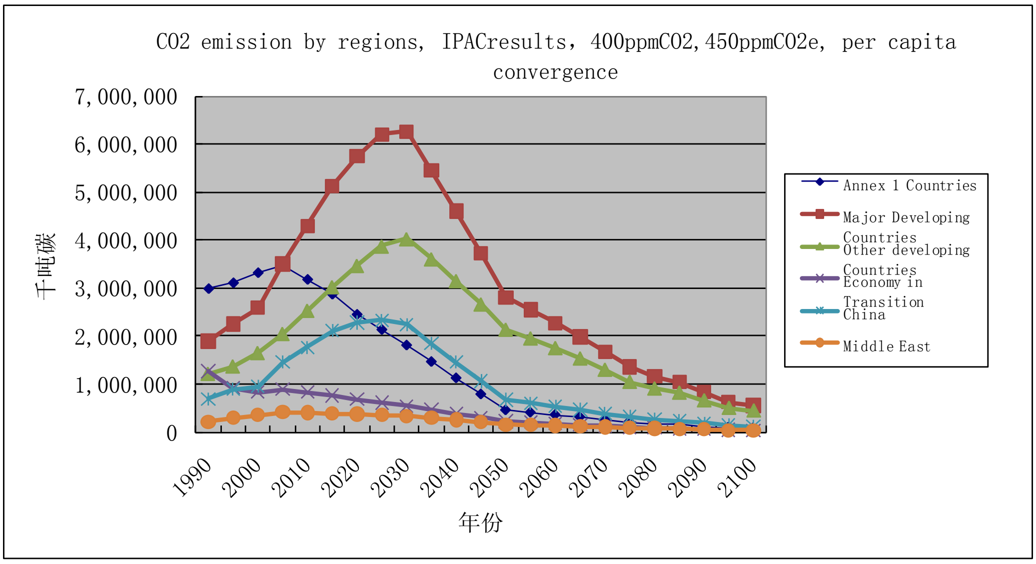

Figure 2　Emission in regions based on per capita emission convergence burden sharing

In order to leave space for developing countries' emission, developed countries have to make early deep reduction as soon as possible. In the analysis, we also assumed other developing countries will do their effort on CO2 mitigation based on countries development and international collaboration.

Technology possibility was also considered based on the global emission scenario study from IPAC model. This presents a picture for emission reduction in 2020 toward to 2 degree target.

2.3 China's emission scenarios

IPAC team developed and published emission scenarios for China, with three scenarios inside(Jiang et al, 2009; Jiang et al, 2009). The three scenario is Baseline, low carbon and enhanced low carbon scenario. The enhanced low carbon scenario says China could peak Co2 emission by 2030 and then start to decrease after that.

From figure 2, we can see China's emission will peak around 2025, with total CO2 emission 8.56billion ton. This is more tough than the enhanced low carbon scenario from IPAC. With different assumption on GDP, the carbon intensity from 2005 to 2020 will be in the range from 49% to 59%, which is much higher than the government target announced.

The government target announced with 40% to 45% carbon intensity reduction between 2005 to 2020, is domestic effort. In one hand it is possible for China to do better, if existing policies on energy efficiency and renewable energy, nuclear could continue for next two five year plans, and put more effort on low carbon development, pursued low carbon transport and life style, it is possible to do better; and on the other hand, it is also possible to go further with international collaboration by technology collaboration, international carbon financing, carbon market etc. Basically the possibility for China to do better is high.

In order to analyze the feasibility for China, one more scenario, the 2 degree scenario for China was given by using IPAC-AIM/Technology model. By using this model, can see much more detail into economic activities, energy activities, technology progress and lifestyle change. The 2 degree scenario was developed based on the Enhanced low carbon scenario.

Figure 3 presents the results for the new scenario family.

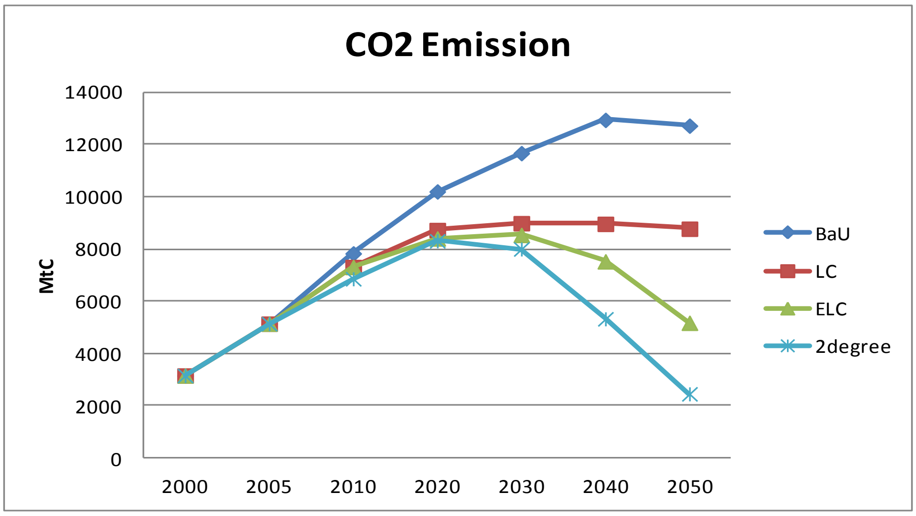

Figure 3 CO2 emission scenario in China

3. Key factors to go to the low emission pathway

In the enhanced low carbon scenario, in order to reach peak by 2030 and then start to decrease CO2 emission, key issues include:

- Economy structure change. There are a lot of discussion during the scenario building process by inviting experts on economics and reviewing relative studies. The GDP growth used here is a most common results from economic research teams, especially before 2030. Economic structure change by three industrial sectors also present a middle line from reviewed lectures. But there is not much research in detail in quantitative way for structure change in second industry. Here by reviewing lectures, we used our own mode, IPAC-SGM model to simulate the structure change in secondary industry, seeing figure 4.

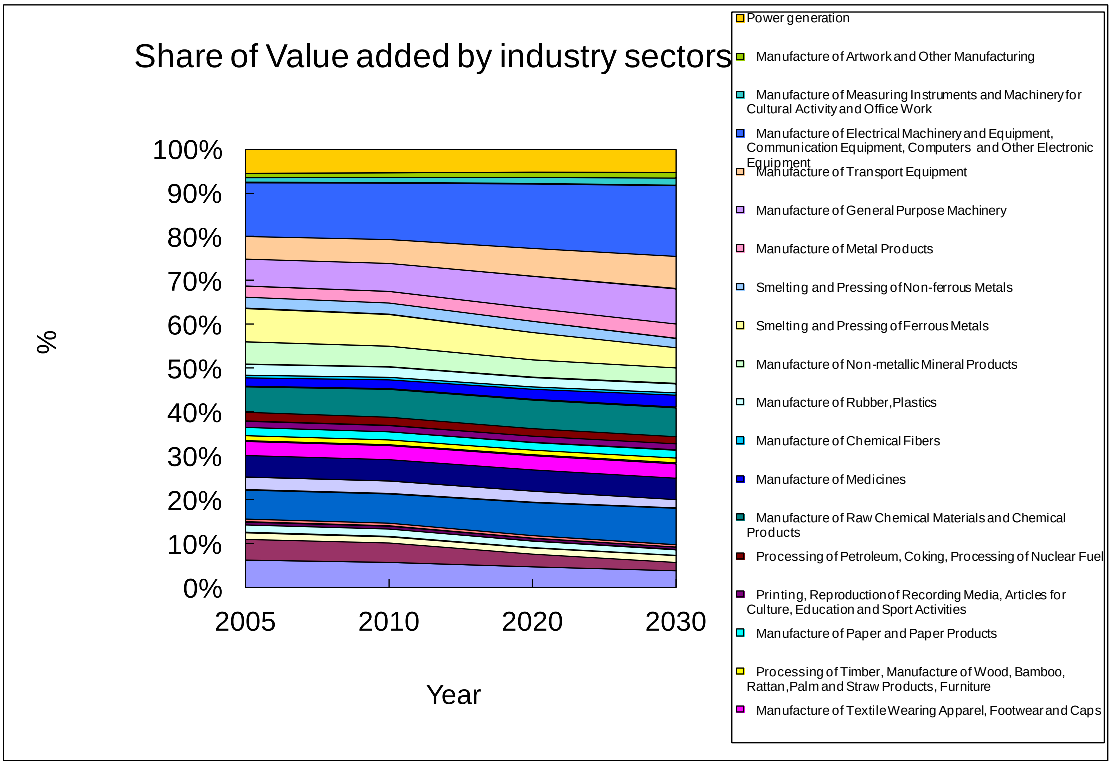

Figure 4 Structure change in second industry

The share of GDP from energy intensive industry(middle part in the figure 4) will reduce due to demand change. China's GDP will surpass US in between 2020 and 2030, such a huge amount of GDP could not rely on existing economic pattern which mainly driven by heavy industry development and raw material production. Based on bottom study on demand of energy intensive products, it is found many energy intensive products will peak in between 2020 and 2025, assuming that in future export of energy intensive products based exports will not increase much, when it is already major part of global output(see table 1).

Table 1 Production of main energy-intensive products, LC and ELC scenarios

	Unit	2005	2020	2030	2040	2050
Iron and	10^8 tons	3.55	6.7	5.7	4.4	3.6

steel						
Cement	10^8 tons	10.6	17	16	12	9
Glass	10^8 weight cases	3.99	6.5	6.9	6.7	5.8
Copper	10^4 tons	260	700	700	650	460
Aluminium	10^4 tons	851	1600	1600	1500	1200
Lead and zinc	10^4 tons	510	720	700	650	550
Sodium carbonate	10^4 tons	1467	2300	2450	2350	2200
Caustic Soda	10^4 tons	1264	2400	2500	2500	2400
Paper and paperboard	10^4 tons	6205	11000	11500	12000	12000
Chemical fertilizer	10^4 tons	5220	6100	6100	6100	6100
Ethylene	10^4 tons	756	3400	3600	3600	3300
Ammonia	10^4 tons	4630	5000	5000	5000	4500
Calcium carbide	10^4 tons	850	1000	800	700	400

Energy intensive products is consuming nearly 50% of energy in China, so if there is not significant increase in energy intensive products production, with a much lower growth than GDP, the energy use in these energy intensive products will also limited. This will be a big contribution on energy intensity per GDP decrease, and then contribution on CO2 intensity.

- Energy efficiency improvement. During 11th Five Year plan(2005 to 2010), energy efficiency has been improved significantly. By reviewing what happened in energy efficiency in 11th Five Year Plan, Comparing with energy conservation effort in last several decades, and effort in other countries, China now is making an unprecedented action on energy conservation, Which could be seen from following:

- Made energy conservation policy as one of national top policies.
- Made energy intensity target as one of key indicator for local government official.
- Frequency of policy making is extradinary high. There are nearly one policy per week in 2007 on energy conservation from centrol government, which not include local government energy conservation policies.
- Closure of small size power generation and other industry is a very brave action which may cause social unstable with unemployment and loss of profit for stock holders.

From the technical view point, energy efficiency made big achievement. Unit energy use per ton of steel products decreased 7.1% in 2006 for key steel making plants, and it is 1.3% in 2007. There was 63 blast furnace with capacity above 2000m3, with iron capacity 137million ton, 35% higher than that in 2005. There was 98 convertors with unit capacity above 100ton, total capacity is 134million ton, 8% higher than that in 2005. Coke Dry Quenching(CDQ) accounted for 45% of total output of coke in 2007, while it was less the 30% in 2005. By end of 2007, blast furnace TRT equipments increased to 49 sets.

Due to government effort on energy conservation, several key energy high efficiency technologies made significant progress during last several years. High energy efficiency technologies in major energy intensive sectors diffused quickly due to much lower cost than before and make stong market competitiveness. Some high energy efficiency technologies are even cheaper than old technologies such as dry rotary kiln in cement industry, super critical and ultra-super critical power generation technologies.

With the progress of energy efficiency improvement in China, there is more opportunities for China to make further step on energy efficiency improvement, as following.

- The importance of energy efficiency was well realized by government and public. As discussed above, energy efficiency or conservation policies is one of top issues in government including national government and local government.
- Energy efficiency improvement is recognized to be one way to increase economy competitiveness. Experience from other countries shows higher energy efficiency comes together high national economic competitiveness. The pathway of United States is not acceptable for China, China can only learn from other developed countries such as Japan and EU.

Technology progress for high energy efficiency initiated new manufacture market for Chinese technologies. Lower cost for advanced technologies in China already made rapid diffusion in China, which bring profit to industries. In the meantime, international market also has very big potential for the new technologies. It is not only good for the manufacture industry, also has very good effort on energy efficiency improvement and GHG mitigation in developing countries.

It is expect energy efficiency will continue to improve from 2010 to 2020 in a similar effort in 11th Five Year Plan.

- Renewable energy development.

China is a new energy and renewable energy, the fastest-growing country. We are in the protection of the ecological basis, and orderly development of hydropower, actively develop nuclear power, encourage and support rural, remote areas and other suitable areas to develop biomass energy, solar, geothermal, wind and other new renewable energy sources. From 2005 to 2008, renewable energy increased by 51%, average annual increase of 14.7%. The use of renewable energy in 2008 amounted to 250 million tons of standard coal. There are 30.5 million to spend in rural areas of methane, equivalent to less emission of carbon dioxide more than 4900 million tons. Installed capacity of hydropower, nuclear power construction scale collector area of solar water heaters and photovoltaic power generation capacity ranking first in the world.

For last several years, there is a surprising increase for renewable energy in China including wind and solar. From 2005 to 2009, the growth rate is higher than 50% annually. Based on the planning in China, by 2020 renewable energy will take 15% of total primary energy, which include renewable energy not included in national statistics of energy.

Nuclear energy, it is estimated to have nuclear installed capacity more than 80GW by

2020 based on new nuclear planning, which is much bigger than the original planning with 40GW by 2020. This is in the low carbon emission scenario.

- Carbon capture and storage(CCS).

China has to use CCS in the case of large amount of coal use for next several decades. Even with the enhanced low carbon scenario, there will be around 1.8 billion ton coal used by 2050. CCS is essential for China to go to deep cut after 2030. Even though CCS is not yet get into commercial market, and still high cost. However based on the study IPAC team involved for CCS implementation in China, in the Enhanced low carbon scenario(ELC) adopted CCS as one of key mitigation options.

For CO2 emission, removed CO2 emission is given in figure 5. Key assumption is given in table 2 and 3. Lower removed rate for different power generation technologies is assumed because of technology development is not yet mature at beginning of adoption of CCS.

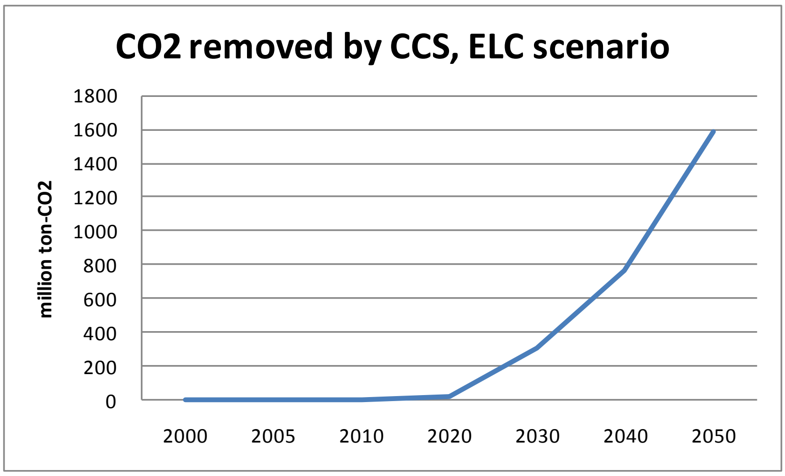

Figure 5 CO2 removed by CCS in power generation sector

Table 2 removal rate for CO_2 by CCS in ELC scenario, %

	Super Critical	US-Critical	IGCC	IGCC-Fuel Cell	NGCC
2020	80.0	80.0	85.0	85.0	85.0
2030	85.0	85.0	90.0	90.0	90.0
2040	85.0	85.0	90.0	90.0	90.0
2050	85.0	85.0	90.0	90.0	90.0

Table 3 power generation capacity with CCS in ELC scenario

	Super Critical	US-Critical	IGCC	IGCC-Fuel Cell	NGCC
2020	0	0	1316	0	203
2030	217	379	6310	701	3411
2040	1319	2184	12890	2275	9679
2050	2822	8465	22045	5144	21514

In the 2 degree scenario, compared with enhanced low carbon scenario, further implementation of renewable energy and replacing coal by natural gas were considered. For economic structure change, energy efficiency, it keeps same in the 2 degree scenario. With these, it is possible to China to peak CO_2 emission before 2025, and start deep cut on CO_2 emission.

In the 2 degree scenario, renewable energy is much more extended from enhanced low carbon scenario. In the enhanced low carbon scenario, power generation from renewable energy(including large hydro) will be around 34%, ad nuclear will account for 35%. Installed capacity for wind, solar, hydro will be around 450GW, 360GW and 510GW by 2050. In the 2 degree scenario, power generation from renewable energy could reach 48% of total power generation, leave only 17% for coal fired power generation. Installed capacity for wind solar and hydro is 930GW, 1040GW, 520GW respectively by 2050.

And another key factors is increasing of natural gas use in China. In the enhanced low carbon scenario, natural gas use will be 350BCM by 2030, and 450BCM by 2050. In the 2 degree scenario, natural gas would be around 480BCM by 2030, and 590BCM by 2050. Together with renewable energy, leave coal use in China by 2050 to be lower than 1billion ton. And here CCS could be used by all coal fired power plants, and half of natural gas power plants.

Then CO2 emission in China could reach peak before 2025, and cut CO2 emission by 2050 to be more than 70% reduction compared with that in 2020.

The renewable energy scenario in the 2 degree scenario is feasible because recent progress on renewable energy development in China. The cost leaning curve for wind and solar is much stronger than model used. Figure 6 present the cost learning curve used in the model compared with data by 2010. Such kind of progress made the cost from wind power and solar power decrease a lot within 2 years. And now in the cost area, power generation cost for some wind farm already can compete with coal fired power plants.

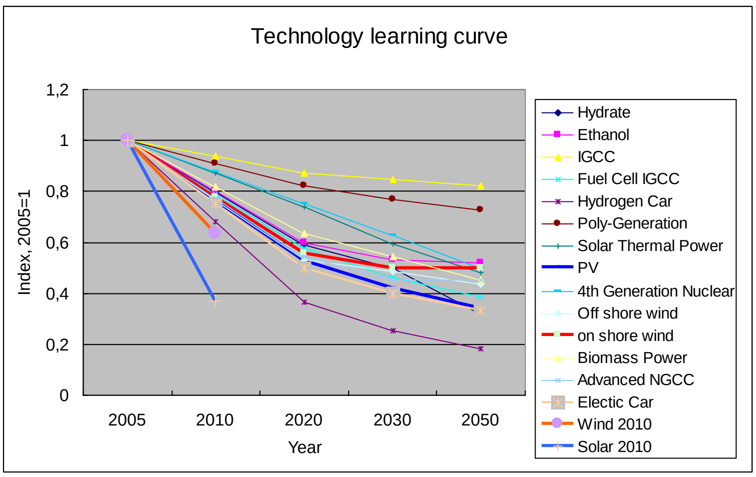

Figure 6 technology learning curve used in IPAC/AIM-technology model and data for 2010.

The progress for end use technologies also move faster than model assumption. Electric appliance such as LED TV, higher efficiency air conditioner, high efficiency car etc., already have higher penetration rate by 2011 then model assumed. If policy is right, lower energy demand in the 2 degree scenario much feasible by 2020 and after.

In the meantime, rapid GDP growth rate provide strong support for low carbon development in China. In 11th Five Year Plan period(2006-2011), annual GDP growth rate is 11.2%. But it is 16.7% annual growth rate if calculated based on current value. It is expected by 2015, GDP in China could reach 75trillion Yuan(in current value), newly added accumulated GDP is 450 Trillion Yuan, and cumulated GDP is 860 Trillion Yuan. The investment need in all modeling study is much small compared with GDP, normally it is smaller than 2 to 4%. If think about the investment in China, new and renewable energy is one of key sector to be promoted in China inside government policies and planning, there could be much more investment on renewable energy in future, even though China already is the biggest country in the world for renewable energy investment in 2010, which accounts for 24% of the world(UNDP, 2011).

If review the progress on renewable energy planning in China, the target for renewable energy was revised to be much higher in recent years. Renewable Energy Planning 2006 set up the target is wind 30GW, Solar 2GW by 2020. By 2009 National

Energy Administration(NBA) announced the installed Wind power generation will be 80WG by 2020. By 2010 NBA said installed Wind power generation will be 150 GW, solar 20GW by 2020. By end of 2011, the discussion to increase the target to be wind 200GW to 300GW, and solar 50WG to 80 GW.

Based on the conclusion from Chinese Academy for Engineering, grid in China could adopt these renewable energy power generation in short term.