Chapter 2
Transition to a Low-Carbon Future in China Towards 2 °C Global Target

Jiang Kejun, Chenmin He, and Jia Liu

Abstract The purpose of low-carbon development in China is for both national sustainable development and global climate change action. For the global climate change target 'to hold the increase in global average temperature below 2 °C above preindustrial levels', China needs to peak in CO2 emissions by 2025 *at the latest* and then secure deep cuts in CO2 emissions. Previous studies on emission scenarios show that it is possible for China to peak in CO2 emissions by 2030 if strong policies are adopted, albeit at relatively high cost. In other words, peaking in CO2 emissions before 2025 represents a huge challenge for China. A modelling study conducted by IPAC on the 2-degree target stated that it is also still possible for China to peak in CO2 emissions before 2025 as long as several preconditions are satisfied, including optimised economic development, further energy efficiency improvements, enhanced renewable energy and nuclear development and CCS.

Energy-intensive industries consume more than 50 % of energy in China and account for more than 70 % of newly increased power output. Scenario analysis shows that many energy-intensive product outputs will reach a peak before 2020, with a much slower growth rate compared with that in the 11th Five-Year Plan, and therefore will significantly change the pathway for energy demand and CO2 emissions.

Energy efficiency should be further promoted. In the 11th Five-Year Plan, energy efficiency was improved significantly, and by reviewing what happened in this Plan compared to energy conservation efforts over the last several decades, as well as effort in other countries, it can be seen that China is now making unprecedented efforts in energy conservation. The target is to make China's energy efficiency in major sectors one of the best by 2030.

China is a now a leading country in new energy and renewable energy. Based on planning taking place in China, by 2020, renewable energy will provide 15 % of the total primary energy, which includes renewable energy excluded from the national energy statistics.

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Another key factor is the increase in natural gas use in China. In the enhanced low-carbon scenario, natural gas use will be 350 BCM by 2030 and 450 BCM by 2050; and in the 2-degree scenario, it will be around 480 BCM by 2030 and 590 BCM by 2050. Together with renewable energy, this leaves coal use in China by 2050 at below 1 billion tonnes.

For CO2 emissions, carbon capture and storage could further contribute to CO2 emission reduction. China has to use CCS if large amounts of coal are used for the next several decades, but even with the enhanced low-carbon scenario, coal use will be around 1.8 billion tonnes by 2050.

Technological progress is a key assumption for a low-carbon future for China. The cost learning curve for wind and solar and many other technologies is much stronger than the model used. Such progress greatly reduces costs in wind power and solar power within 2 years.

Keywords Emission scenario • CO2 mitigation • Modelling • Energy transition • Emission target • China

Key Message to Policymakers

- In order to achieve '2-degree' global target, China's CO2 emissions have to be at peak before 2025.
- China can peak CO2 before 2025 and reduce emission 70 % by 2050 compared with that in 2020.
- Setting a cap for CO2 emissions in China is an effective way to limit CO2 emission increases.

2.1 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 1 year later, parties decided 'to hold the increase in global average temperature below 2 °C above preindustrial levels' and made a decision 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 °C'. The Copenhagen Accord called for an assessment that would consider strengthening the long-term goal. Further, the IPCC AR5 called on research communities to work on assessments by modelling on the emission pathway and feasibilities for the global target.

Recently, several global emission scenario studies present emission scenarios focusing on the 2-degree target, which requires global emissions to peak by 2020 at the latest (IPCC 2014). However, the commitment in the Copenhagen Accord does not agree with the global 2-degree target scenarios, which implies that further efforts are needed by each country. It is thus essential to perform more analysis at the country level to assess the potential for CO2 emission mitigation to follow the global 2-degree target pathway. This paper presents the key factors China needs to consider in order for it to follow the global target, based on modelling results from the IPAC modelling team in Energy Research Institute (ERI).

GHG emissions from energy use in China surpassed those of the United States in around 2006 and accounted for around 29 % of global emission in 2013 (Olivier et al. 2013). And due to rapid economic development, CO2 emissions are expected to increase significantly in the coming decades (IEA 2011; Kejun et al. 2009). This presents China with a huge challenge to peak in CO2 emission before 2025 and start deep cuts after 2030. Much more effort is thus required, not only in China, but by the reset of the world.

2.2 Emission Scenarios

2.2.1 Methodology Framework

In this study we used the linked Integrated Policy Assessment Model of China (IPAC) for the quantitative analysis, which covers both global emission scenario analysis and China's national emission scenario analysis. IPAC is an integrated model developed by ERI and analyses effects of global, national and regional energy and environment policies. ERI itself has conducted long-term research in developing and utilising energy models since 1992 (Kejun et al. 2009).

In order to analyse global emission scenarios and China's emission scenario, three models are used, one being global and the other two national: the IPAC-Emission global model, the IPAC-CGE model and the IPAC-AIM/technology model. The three models are linked as shown in Fig. 2.1. The modules in IPAC are currently soft linked, which means the output from one module is used as the input for another.

The IPAC-Emission model is a global model within the IPAC family and presently covers nine regions, to be extended to 22. Because this model focuses 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.

The IPAC-Emission global model is an extended version of the AIM-Linkage model used in IPCC Special Report on Emission Scenarios (SRES) (Kejun et al. 2000), which links social and economic development, energy activities and land use activities and offers a full range of emission analyses. The IPAC-Emission global model comprises four main parts: (1) society, economy and energy activities module, which mainly analyses demand and supply under conditions of social and economic development and determines energy prices; (2) energy technology module, which analyses the short- and mid-term energy utilisation technologies under different conditions and determines the energy demand under different technology

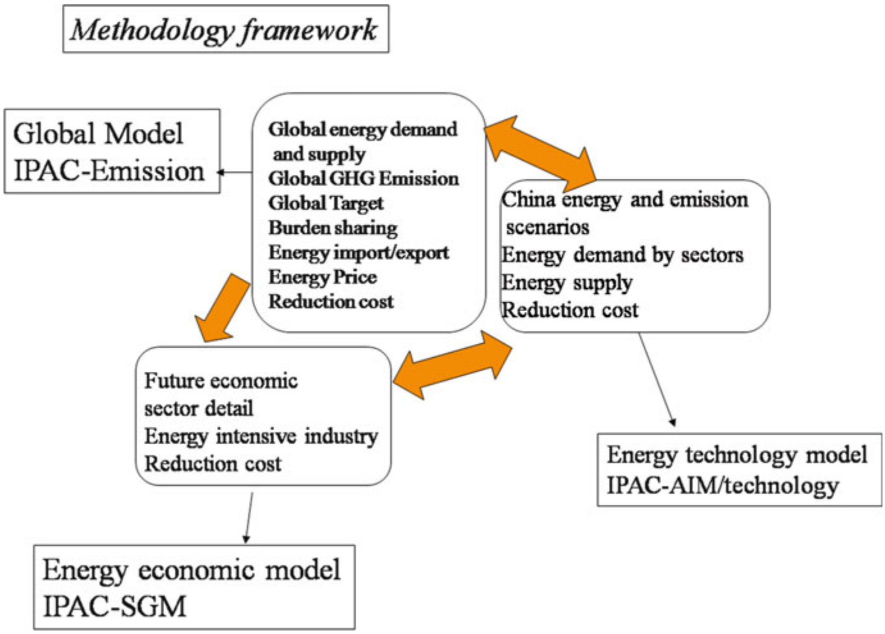

Fig. 2.1 Links among models in the research

compositions. The energy demand in this module modifies the short- and mid-term energy demand in module (1) so that the energy analysis in the macroeconomic model can better reflect short- and mid-term energy activities; (3) land use module, which analyses emissions from land use processes; and (4) industrial process emission module, which mainly analyses emissions from industrial production.

IPAC-AIM/technology is the main component of the IPAC model (Kejun et al. 1998), and it performs analyses based on the cost-minimization principle, i.e. technologies with the least costs will be selected to provide the energy service. The current version of IPAC-AIM/technology model includes 42 sectors and their products and more than 600 technologies, including existing and potential technologies.

IPAC-SGM is a computable general equilibrium model (CGE model) for China. It is mainly responsible for analysing the economic impacts of different energy and environmental policies and can analyse mid- and long-term energy and environment scenarios. IPAC-SGM divides the overall economic system into household, government, agriculture, energy and other production sectors, 42 in total.

The key focus of this study is how China can support the global 2-degree target based on its emission pathway, as well as related issues. In order to analyse the feasibility of the 2-degree target for China's emission pathway and related options, we start from the global modelling analysis performed on the target to learn how China's current emissions are affected by the 2-degree emission scenario. Then the options for the 2-degree target for China are analysed via the national model, based on the previous emission scenario analysis for China.

In the IPAC scenario setting for China, input is also needed from other relevant studies, such as GDP, population and sector outputs (Shantong 2011; Xueyi and Xiangxu 2007). The IPAC modelling team also performed studies on these parameters by using IPAC-SGM and the population model. Economic activity is becoming one of the key research topics within IPAC modelling studies due to the large uncertainty surrounding economic development and its heavy impact on energy demand. Sector development trends are crucial for energy and emission scenarios in the modelling studies, as around 50 % of total final energy use in China is accounted for by energy-intensive sectors such as ferrous and non-ferrous metal manufacture, building material manufacture and the chemical industry (China Energy Statistical Yearbook 2013 2013). In the meantime, demand for energy-intensive products was simulated by input-output analysis with a focus on downstream sector development analysis. Table 2.1 gives a scenario for energy-intensive product output in China used in the emission scenarios.

The national analysis on economic development could much more reflect national experts' viewpoints, which normally has quite big difference with the global projection on China's GDP growth. This could be seen in comparison between global modelling excises and China's national model analysis, such as IEA's World Energy Outlook (WEO) and IPAC model (IEA 2011; Kejun et al. 2009). 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.

2.2.2 Global Emission Scenarios and Regional Allocation

The global emission scenario from IPAC mainly comes from the IPAC-Emission global model, with recent studies focusing on global mitigation scenarios. Here, a 2-degree scenario was developed based on the IPAC 450 ppm emission scenario model, as shown in Fig. 2.2. A simplified climate model, MAGICC, was used to set up the CO2 concentration at 450 ppm by year 2100 (Wigley and Raper 2001).

Regional allocation of emissions from the global emission scenario was given by using the 'burden-sharing' method. There are several ways to share the burden of emission reduction, and the subject itself has attracted much political discussion as regards whether to base it on emission per capita convergence, accumulated emission per capita convergence or something else. Sidestepping the politics, the method we used is the widely used model based on the per capita emission convergence method. With the global emission scenario from the global model, regional emission allocation was performed using CO2 emission per capita convergence criteria.

Table 2.1 Production of selected energy-intensive products

	Unit	2005	2020	2030	2040	2050
Iron and steel	10^8 tonnes	3.55	6.7	5.7	4.4	3.6
Cement	10^8 tonnes	10.6	17	16	12	9
Glass	10^8 weight cases	3.99	6.5	6.9	6.7	5.8
Copper	10^4 tonnes	260	700	700	650	460
Aluminum	10^4 tonnes	851	1600	1600	1500	1200
Lead and zinc	10^4 tonnes	510	720	700	650	550
Sodium carbonate	10^4 tonnes	1467	2300	2450	2350	2200
Caustic soda	10^4 tonnes	1264	2400	2500	2500	2400
Paper and paperboard	10^4 tonnes	6205	11,000	11,500	12,000	12,000
Chemical fertilizer	10^4 tonnes	5220	6100	6100	6100	6100
Ethylene	10^4 tonnes	756	3400	3600	3600	3300
Ammonia	10^4 tonnes	4630	5000	5000	5000	4500
Calcium carbide	10^4 tonnes	850	1000	800	700	400

Source: Author's research result

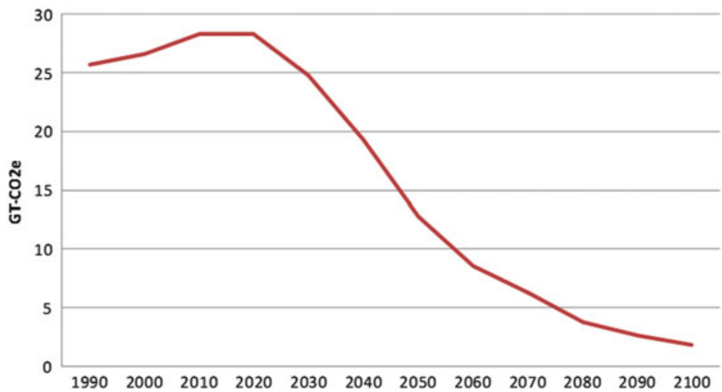

Fig. 2.2 Global CO2 emissions at 450 ppm by 2100 (Source: Author's research result)

When burden sharing using emission per capita is analysed, certain assumptions are made:

– Year to reach emission per capita convergence: here, we use 2070.
– Annex 1 countries will start reduction based on the Kyoto commitment and then proceed to deep reductions. Non-Annex 1 countries will start to depart from baseline emissions from 2010.
– CO_2 emission per capita in some developing countries may exceed developed countries.
– Population in IPAC model comes from IIASA analysis. Figure 2.3 gives the CO_2 emissions by major regions and countries.

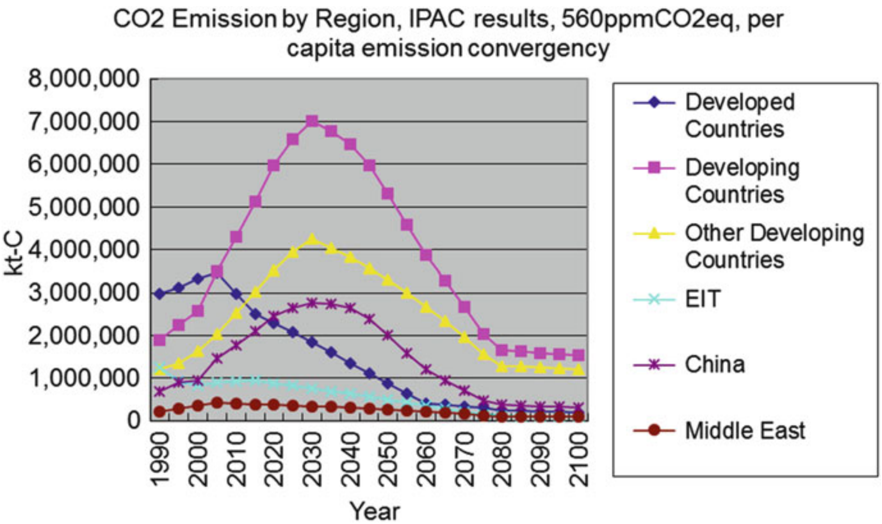

Fig. 2.3 Emissions in regions based on per capita emission convergence burden sharing (Source: Author's research result)

In order to allow more leeway for the emissions of developing countries in the future, developed countries need to make deep reductions as soon as possible. In the analysis, we also assumed other developing countries will do their part in CO2 mitigation, based on country developments and international collaboration.

The technological feasibility was also considered, which was based on the global emission scenario study from IPAC model. Figure 2.3 presents a picture for emission reduction in 2020 towards the 2-degree target.

2.2.3 China's Emission Scenarios

The IPAC team developed and published emission scenarios for China (Kejun et al. 2008, 2009), which comprise the three scenarios: baseline, low carbon and enhanced low carbon. The enhanced low-carbon (ELC) scenario involves China peaking in CO2 emissions by 2030 and then starting to decrease after that.

From Fig. 2.3, we can see China's CO2 emissions peaking at around 2025 at 8.56 billion tonnes, in order to reach the global 2-degree target. This is tougher than the enhanced low-carbon scenario from IPAC. With the assumption on GDP, the carbon intensity from 2005 to 2020 will be in the range of 49–59 % for these scenarios, which is much higher than the government target announced.

The government target announced based on a 40–45 % carbon intensity reduction between 2005 and 2020 is realised via domestic efforts. On the one hand, it is possible for China to do better if existing policies on energy efficiency, renewable energy and nuclear energy continue over the next two Five-Year Plans but with more emphasis placed on low-carbon development and low-carbon transport and

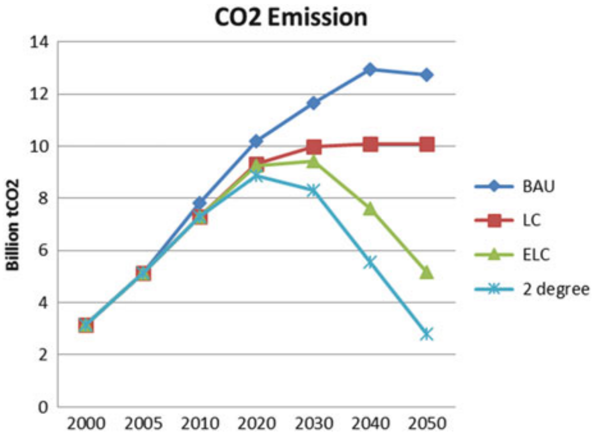

Fig. 2.4 CO2 emission scenario in China (Source: Author's research result)

lifestyle; on the other hand, it is also possible to go further with international collaboration via technology collaboration, international carbon financing, carbon market and so on. Basically, the possibility for China to do better is high.

In order to analyse the feasibility for China, one more scenario—the 2-degree scenario for China—was given using the same model. Under this modelling analysis, we can see economic activities, energy activities, technology progress and lifestyle change in much more detail. The 2-degree scenario was developed based on the enhanced low-carbon scenario by pursuing further action in order to assess the feasibility.

Figure 2.4 presents the results for the new scenario family.

2.3 Key Factors in the Low-Emission Pathway

In the modelling analysis, key areas for CO2 emissions include economic development optimisation, energy efficiency improvements, renewable energy and nuclear development, carbon capture and storage and change of lifestyle and consumption. Efforts in the IPAC *modelling* study were based on the possibility of key assumptions by taking a broad look at driving forces, technology, the environment, social development and so on. In the enhanced low-carbon scenario, in order to reach the peak by 2030 and then start to decrease in CO2 emissions, several key challenges have to be overcome:

Change in economic structure. There was much discussion during the scenario building with the invited economics experts, as well as reviews of related studies. The GDP growth used here is the most commonly used result obtained from economic research teams, especially concerning pre-2030. Economic structural change in the three industrial sectors also presents a middle line, based on the literature reviewed. However, there is little research quantitatively detailing structural change within secondary industry. Here, based on the available research, we

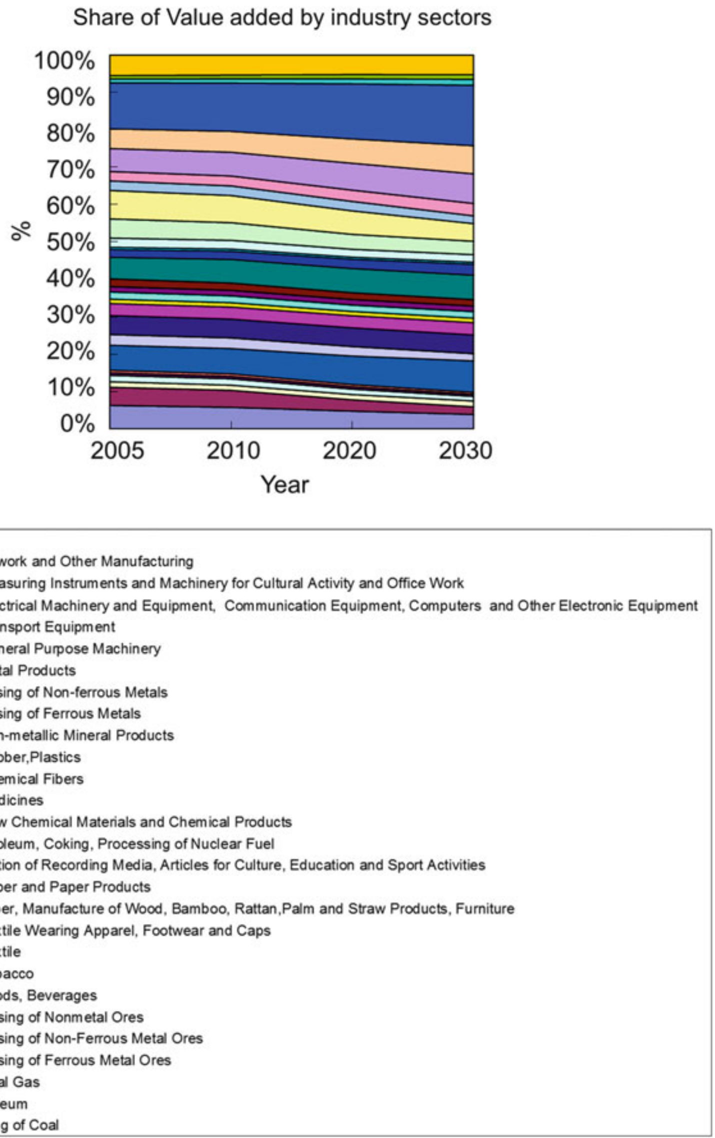

Fig. 2.5 Structural change in second industry (Source: Author's research result)

applied our own IPAC-SGM model to simulate structural change in secondary industry, as shown in Fig. 2.5.

The share of GDP from energy-intensive industry (middle part in Fig. 2.5) would reduce due to demand change. China's GDP will surpass that of the United States between 2020 and 2030, as such huge amount of GDP cannot rely on the existing economic trend involving heavy industry-driving development and raw material production. Based on a bottom-up study on the demand of energy-intensive products, it was found that many energy-intensive products will peak during 2020–2025, assuming that in the future the export of energy-intensive products will increase little, when it is already a major part of global output (see Table 2.1). This was learnt by looking at infrastructure development, including building construction, roads, railways, airports, etc., and final consumption needs, which consumed more than 95 % of cement and more than 55 % of steel (Kejun 2011). This analysis shows that the output of most of the energy-intensive products will peak before 2020.

Energy-intensive products consume nearly 50 % of energy in China, and provided that there is no significant increase in energy-intensive product production and that the growth rate thereof is much lower than GDP, the energy use increase associated with these energy-intensive products would also be limited. This would contribute greatly to decreased energy intensity per GDP and also contribute to reduced CO2 intensity.

As regards improving energy efficiency, during the 11th Five-Year Plan (2006–2010), energy efficiency was improved significantly (State Council 2011; Mark et al. 2010; Kejun 2009). In consideration of what occurred in energy efficiency during the 11th Five-Year Plan, and compared with energy conservation efforts over the last several decades and efforts made by other countries, China could be seen as having taken unprecedented action on energy conservation. Specifically, it:

- Made energy conservation policy one of the top national and top policy priorities.
- Made the energy intensity target a key indicator for local government officials.
- Involved a high number of new policies—nearly one a week from 2007 to 2008—on energy conservation from central government, in addition to local government energy policies.
- Initiated the Top 1000 Energy-Consuming Enterprise Programme, which focused on improving energy efficiency of China's largest 1000 companies which in total account for one third of China's total energy use.
- Closed small-sized power generation facilities and other industries, which was a bold measure that could have led to social unrest, unemployment and loss of profit for stockholders.

From the technical viewpoint, the above energy efficiency measures represent big achievements. China has released a total of 115 state key energy-efficient technology promotion catalogues in three batches and specially promoted seven energy-efficient technologies in the iron and steel, building material and chemical industries. Unit energy use per tonne of steel products, copper and cement decreased by 12.1 %, 35.9 % and 28.6 by 2010, respectively. By 2010, almost all advanced technologies on energy saving in industry were adopted in China. In the steel-making industry, the penetration of coke dry quenching (CDQ) increased from 30 % to more than 80 %. Use of top gas recovery turbines (TRT) increased from 49 to 597 sets. The share of furnaces with capacities above 1000 m^3 increased from

21 to 52 %. The share of new advanced rotary kilns in cement manufacturing increased from 39 to 81 %. The use of coke dry quenching in coke making increased from less than 30 % to more than 80 %. Heat recovery in cement manufacturing increased from nearly 0 to 55 %. Unit energy use for power generation supply decreased from 370 gce/kWh to 333 gce/kWh.

Owing to the widespread use of advanced high energy efficiency technologies, costs have been greatly reduced over the last several years—to the point at which some high energy efficiency technologies are even cheaper than old technologies, such as dry rotary kilns in the cement industry and super critical and ultra-super critical power generation technologies.

Such progress in energy efficiency improvements in China brings with it more opportunities for further steps in energy efficiency improvements, as follows:

– A deeper public and governmental understanding of the importance of energy efficiency. As discussed above, energy efficiency and conservation policies are one of the key issues in government—both national and local.
– Improvements in energy efficiency have been acknowledged as a means to increase economic competitiveness. Experience from other countries shows that higher energy efficiency is related to increased national economic competitiveness.
– Progress in technology towards high energy efficiency has led to new manufacturing markets for Chinese technologies. Lower cost, advanced technologies have already rapidly penetrated within China, which has profited industry. In the meantime, the international market also has a very large potential for new technologies, which will benefit not only the manufacturing industry but also energy efficiency improvements and GHG mitigation in developing countries.

It is anticipated for energy efficiency to continue improving from 2010 to 2020 in a similar manner in the 11th Five-Year Plan, based on the IPAC modelling results.

– Renewable energy development

China is the fastest-growing country for new energy and renewable energy. In order to improve the quality of the environment and promote new industry, China has extended great efforts to promote renewable energy, particularly over the past several years, and especially in wind and solar—from 2005 to 2010 the average annual growth rate exceeded 50 % annually (CEC 2011). Based on China's plans for renewable energy, by 2020 renewable energy will represent 15 % of total primary energy, which includes renewable energy not included in national statistics on energy, such as solar hot water heaters and rural household biogas digesters. Another related target is a share of non-fossil fuel energy of 15 % of the total primary energy by 2020, which includes both commercial renewable energy and nuclear energy.

– Nuclear energy development

It is expected that a nuclear energy installed capacity of over 58 GW will be realised by 2020 based on new nuclear planning, which is much larger than that original planned (40 GW).

Since the Fukushima nuclear accident in Japan, there has been much discussion on nuclear development in China; however, China has little choice in light of future power generation. Over the last several years, coal-fired power generation has increased rapidly, with an annual newly installed capacity of more than 60 GW. However, as is well known, compared to nuclear, coal-fired power generation causes high environmental and human damage. Based on the expected high demand due to energy use in China, by 2050 there is no future major role for renewable energy. Therefore, nuclear power generation will play an important role in China's future energy system by 2020.

– Carbon capture and storage (CCS)

China will have to use CCS for the next several decades if coal use continues on its present course. Even with the enhanced low-carbon scenario, coal use will be at around 1.8 billion tonnes by 2050. CCS is essential for China to enable deep cuts in CO2 emissions after 2030. Based on the study IPAC team involved for CCS implementation in China, the learning effect will have to be big to foresee the cost reduction in future. The total cost to apply CCS for 100 coal-fired power plants is not very high and will raise the price of grid electricity by 3 cent/kWh. In the enhanced low-carbon (ELC) scenario, CCS was adopted as one of the key mitigation options.

For CO2 emissions, removed CO2 emissions are given in Fig. 2.6. The key assumptions are given in Tables 2.2 and 2.3 (Kejun 2011). A lower removal rate for different power generation technologies is assumed because technological development is not yet mature at the beginning of adoption of CCS.

In the 2-degree scenario, compared with the enhanced low-carbon scenario, further implementation of renewable energy and replacing coal with natural gas were considered. For economic structural change, energy efficiency stays the same in the 2-degree scenario. Based on this, it is possible for China to peak in CO2 emissions before 2025 and then start deep cuts in CO2 emissions.

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

Another key factor is the increasing use of natural gas in China. In the enhanced low-carbon scenario, natural gas use will be 350 BCM by 2030 and 450 BCM by 2050. In the 2-degree scenario, natural gas would be around 480 BCM by 2030 and 590 BCM by 2050. If natural gas is combined with renewable energy, coal use in

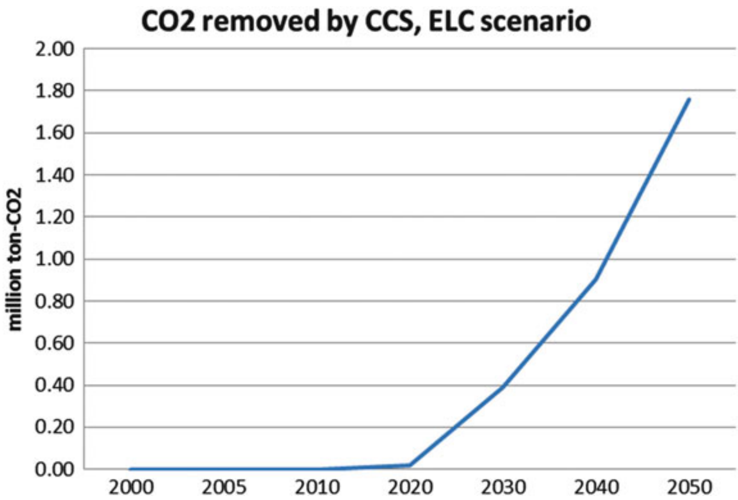

Fig. 2.6 CO2 removed by CCS in power generation sector (Source: Author's research result)

Table 2.2 Removal rate for CO2 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

Source: Author's research result

Table 2.3 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	12,890	2275	9679
2050	2822	8465	22,045	5144	21,514

Source: Author's research result

China by 2050 will be lower than 1 billion tonnes. If so, CCS could be used for all coal-fired power plants and half of natural gas power plants.

Then, CO2 emissions in China could reach a peak before 2025, and the reduction in CO2 emissions by 2050 would be more than 70 % compared with that in 2020.

The renewable energy scenario in the 2-degree scenario is feasible owing to the recent progress in renewable energy development in China; the actual cost learning curve for wind and solar is much stronger than the model used. Technology perspective studies were also one of the key research areas in the IPAC modelling team, which has performed detailed analysis on selected technologies such as

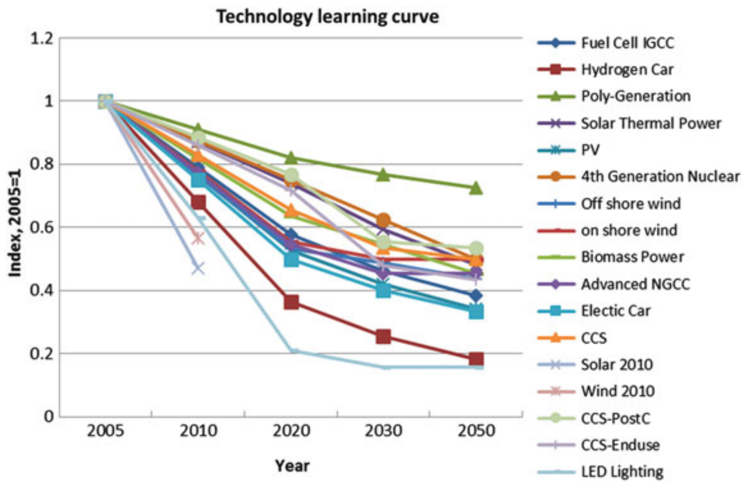

Fig. 2.7 Technology learning curve used in IPAC-AIM/technology model and data for 2010 (Source: Author's research result)

electric cars, nuclear energy, renewable energy and electric appliances (Kejun et al. 2009, 2012; Kejun 2011). Figure 2.7 presents the cost learning curve used in the model compared with actual data by 2010. Such technological progress results in a big drop in the cost of wind power and solar power within 2 years. Presently, in the coastal area, the cost of power generation for some wind farms can already compete with coal-fired power plants.

The progress in end-use technologies also moves faster than assumed by the model. Electric appliances such as LED TVs, higher-efficiency air conditioners and high-efficiency cars already had a higher penetration rate by 2011 than the model assumed. If policy is correct, a lower energy demand in the 2-degree scenario will be much more feasible by 2020 and after.

In the meantime, rapid GDP growth provides strong support for low-carbon development in China. In the 11th Five-Year Plan period (2006–2010), the annual GDP growth rate is 11.2 %, but is 16.7 % if calculated based on current value (China Statistic Yearbook 2013 2013). It is expected that by 2015, GDP in China could reach 75 trillion Yuan (at current value), newly added accumulated GDP will be 450 Trillion Yuan and cumulative GDP will be 860 Trillion Yuan. The investment needed in all modelled studies is very small compared with GDP and is normally 2–4 % or less. Regarding investment in China, new and renewable energy is one of the key sectors to be promoted within government policies and planning; thus there could be much more investment in renewable energy in the future, based on the fact that China was already the biggest investor in renewable energy as of 2010 and accounted for 24 % of the world's total.

Reviewing the progress in renewable energy planning in China, the target for renewable energy has been greatly revised upwards in recent years. Renewable

Energy Planning 2006 set the targets for wind at 30 GW and solar at 2 GW by 2020. By 2009 the National Energy Administration (NEA) announced that installed wind power generation will be 80 WG by 2020, and then in 2010 the NEA stated that installed wind power generation will reach 150 GW and solar at 20 GW by 2020. As of the end of 2011, targets for wind of 200 to 300 GW and solar of 50 to 80 GW were under discussion.

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

2.3.1 Policy Options

In the modelling analysis, several policy options were simulated, one of the key ones being carbon pricing. Introducing carbon pricing, including a carbon tax or emission trading, could be an effective way to control CO2 emissions in China.

Another key policy option is setting more caps for CO2 emissions in China, which has been an effective way to limit CO2 emission increases in recent years.

2.4 Factors Causing Uncertainty in the Modelling Analysis

If we look at the scenarios, there are still several uncertainties in the emission path.

The biggest challenge is whether China's economic structure could be optimised and be directed away from a heavy industry-based and energy-intensive economy to a tertiary sector-based and less energy-intensive economy. By 2010, cement and steel output was 1.8 billion and 630 million tonnes, which is already higher than or close to the data in Table 2.2. Recently, the IPAC modelling team reanalysed the demand for cement and steel by using a methodology similar to energy forecasting, which reconfirmed the data in the table is the way for China to go. In recent years China has undergone a period of rapid infrastructure development, which cannot be sustained year-on-year going forwards. We have high confidence that many energy-intensive products will reach a peak in the near future, before 2015.

Another big uncertainty is whether the grid could adopt a large influx of renewable energy. Based on EU's experience to date, power generation from wind and solar could rise above 15 % of total power generation, and technological progress could potentially push the share of renewable energy power generation much higher (WWF 2010). However, based on the 2-degree scenario, by 2020 power generation from wind and solar in China still only accounts for 9 %.

2.5 Conclusions

If the global 2-degree target is to be implemented, China's CO2 emissions have to peak before 2025.

By using a detailed analysis modelling tool, it has been found that China could peak in CO2 emissions before 2025 and start deep cuts after that to a 70 % or greater cut by 2050 compared to 2020.

Meeting the 2-degree goal within the next 40 years will be challenging enough, and a reduction of such magnitude would require the near-simultaneous and successful deployment of all available low-carbon energy technologies and a high level of international cooperation. China will need to substantially exceed the government target announced in Copenhagen, but it is feasible if sufficient domestic action is taken and international collaboration takes place, and progress is made in technology. China's low-carbon development planning and effort should be encouraged in the future; a well-designed international regime aiming at a low-carbon pathway should be designed.

The study focus on a deep-cut emission scenario by region based on efforts and technological feasibility should be presented to show a possible future for reductions towards a 2-degree global target.

Renewable energy development policies are crucial for China to reach the 2-degree target; as with technological progress, much more renewable energy could be utilised in China. Further, China's energy system has to be diverse, and nuclear energy is still an important option due to its relative safety and low environmental impact, despite the recent developmental slowdown caused by the accident in Japan.

Carbon pricing could be introduced in the near future. It is hard to reflect shorter-term change but needs more policy support to make technology development.

Setting a cap for CO2 emissions in China has been an effective way to limit CO2 emission increases over recent years. China is now implementing cap setting on energy demand in its 12th Five-Year Plan, together with a target for non-fossil fuel energy by 2020, which will represent a good practice as regards setting up caps on CO2 emissions post-2015. In the meantime, China is implementing domestic emission trading in pilot cities and provinces that will be capped for emissions in the near future.

Specific policy recommendations are as follows:

- Place a high emphasis on optimising economic development. For a long time, China has announced its desire to adjust the economic development pattern away from heavy industry-based development to a service industry-based economy. However, little effective action has been taken. The newly announced 12th Five-Year Plan sets a GDP growth target of 7 %, which implies economic optimisation will occur. Recent government action favouring a lower economic development growth rate has started to produce results, and this action should be continued in the long term.

– Put in place a clear long-term target for CO2 emissions with specific total amount control (emission caps). China is currently attempting energy total amount control, which will provide a good basis for setting a target for total CO2 emission amount control. In this regard, setting long-term targets for CO2 emissions up to 2030 and 2050 would send a clear message that future CO2 emission reductions are being targeted.
– Introduce a carbon-pricing regime, such as carbon tax or emission trading, in the near future, to send a carbon-pricing signal. This will help push economic optimisation in the direction of a low-carbon economy.
– Make energy efficiency efforts deeper and wider ranging. Despite the huge achievements in energy efficiency in the 11th Five-Year Plan, there is still much more room for further action. Policies such as energy efficiency standards could be accelerated due to rapid progress in technologies.
– Make full support on renewable development, leave market for renewable energy development with support of feed-in tariff. Recently there has been discussion on limiting wind and solar energy, and this will obviously negatively impact on renewable energy development in China. There is plenty of space on the grid to adopt renewable energy in the future.
– Continue to support nuclear energy development and raise the security level of nuclear energy to provide cleaner energy. In China, nuclear power generation is still one of the cleanest and safest forms of energy supply compared to fossil fuel energy, which will continue to dominate China's energy system for decades. The strategy should be clear, involving more efforts to improve the technology.
– Initiate a pilot phase project as soon as possible for CCS in China. A plan should be made to have 7–10 CCS projects by 2020 to test the technology and make a decision on the best type. This will be crucial for expanding the utilisation of CCS projects post-2020.
– Do more for public awareness on low-carbon development; the public needs to be much more involved in low-carbon development as this could lead to reorientation of the manufacturing industry.

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