China's Low Carbon Finance and Investment Pathway

Annex A: China's Investment Pathways to 2030

Jiang Ke Jun, Energy Research Institute (ERI)

1. Introduction

Climate change poses a major challenge to the security and development of all mankind. Many countries are now incorporating climate challenges in their national development strategies, including China. The target to keep man-made global warming to less than 2°C (the 2-degree target) by 2100 has been confirmed in international climate negotiations in recent years. For China, it is essential to limit CO2 emissions and to support global climate change objectives. Modelling research suggests that China could peak its emissions before 2025, which makes the global 2-degree target feasible.

Using low-carbon technologies to reduce carbon emissions is one of the most critical policy options. However, to make this happen, there is a strong need to invest in the deployment and penetration of low-carbon technologies. In order to understand the China's investment needs, this study will analyse technology investment demands under different scenarios using quantitative modelling tools.

2. ERI's IPAC Model

2.1 IPAC Model and its Applications

Since 1992, the Integrated Policy Assessment Model for China (IPAC) modelling team of the Energy Research Institute (ERI) has been building models for policy analysis. After more than twenty years of research and development, IPAC has now become a comprehensive policy evaluation model, with a variety of analytical approaches1. Models and methods currently used by the IPAC team include a computable general equilibrium model, a dynamic economic model, a partial equilibrium model, a minimum cost optimization model based on detailed linear programming techniques and industry simulation models. In recent years, the IPAC model has been widely used. As the ERI is a research institute in the National Development and Reform Commission (NDRC), IPAC has been widely applied to evaluate energy and climate change policy in China. It has also been used in planning relevant research into China's "10th five-year", "11th five-year" and "12th five-year" plans, and has supported energy planning and polices in some Chinese provinces and municipalities. This research will provide quantitative analysis, based on the long-term modelling data and scenario research provided by the IPAC model, on the investment needs of major, especially low-carbon, technologies in the future.

Future low-carbon technology investment needs depend entirely on carbon emissions scenarios. Different emission levels will require different technology combinations, and thus investment scales are different. The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) focused mainly on the 2-degree target; the IPAC model has also analysed emissions scenarios in China in the context of a global 2-degree scenario, also

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[1] http://www.ipac-model.org

known as China's 2-degree scenario. This paper will discuss low carbon technology investment needs under the 2-degree scenario in China.

To calculate future investment demands, we use the IPAC-AIM/technology model to carry out a quantitative analysis. The IPAC-AIM/technology model covers more than 600 kinds of technologies, and outlines fixed investment needs of various technologies, energy consumption parameters and emissions parameters for each technology. It can be used to calculate the investment needs of different technical combinations.

Table 1 List of low-carbon technologies

Sectors	*Industries (Uses)*	*Service technology (Equipment)*
Industry	*Steel*	*Advanced oven, advanced sintering machine, advanced blast furnace, efficient steelmaking, continuous casting device and hot direct rolling device, dry coke quenching device, wet coke quenching device, blast furnace top-gas recovery turbine device (TRT), coke oven gas recovery device, converter gas recovery device, blast furnace gas recovery device, power cogeneration device.*
	Non-ferrous metals	*Bayer alumina, aluminum side slot, blister copper flash smelting furnace, reverberatory furnace, hydrometallurgy, vertical tank zinc.*
	Building Materials	*Cement industry: precalciner dry process kiln, waste heat power generation unit, CCS* *Brick Industry: tunnel kiln.* *Lime Industry: mechanized shaft kiln.* *Glass industry: the float process.*
	Chemical Industry	*Ammonia production unit: reformer, gasifier, gas furnace, reactor, desulfurization conversion device.* *Caustic soda production equipment: caustic production process.* *Carbide production: waste heat recovery unit.*

		Soda Ash Production Equipment *Fertilizer production plant: organic production equipment. Waste heat utilization device.*
	Petrochemical	*Waste heat utilization device.*

	Papermaking	*Cooking equipment, waste heat utilization device, black liquor recovery device, cogeneration power plant.*
	Irrigation and drainage	*Diesel engines, electric motors.*
Construction		*Cogeneration heating, central heating boilers, advanced air conditioning, LED lighting, energy efficient appliances, stove.*
Transportation	*Freight* *Passenger transport*	*Rail transport (passenger and cargo): advanced diesel locomotives, advanced electric locomotives.* *Road transport (passenger and cargo): Advanced public diesel vehicles, public gasoline vehicles, hybrid cars, electric cars* *Water transport (passenger and cargo): energy ocean-going vessels, coastal vessels, inland vessels.* *Air transport (passenger and cargo): Energy saving aircraft.* *Subway* *Fuel ethanol, biodiesel technology*
General technology	*Motor* *Lighting* *Heating* *Kiln*	*Energy-saving motors* *Energy-efficient lighting* *Advanced boiler, cogeneration* *Advanced furnace*
Power sector	*Coal technology*	*Ultra-supercritical units, IGCC，CCS*
	Gas technology	*NGCC, CCS*
	Renewable energy technologies	*Onshore wind power, offshore wind power, small wind power* *Large-scale photovoltaic, household photovoltaic technology* *Large hydropower, small hydropower* *Geothermal power*

		Ocean energy generation technology *Waste generation* *Biomass gasification, biomass power generation technology*
	Nuclear power	*II-plus, III generations, IV generation*
Grid	*Grid*	*High-grade grid, smart grid*
Mining and transport		*Coal mining, oil exploration, gas exploration, pipeline*
Oil processing		*Oil processing equipment, warm-up recovery*
Others		*Coal gas, coal oil, CCS*

The IPAC-AIM/technology model is a major component of the IPAC model, which aims to give a detailed description of energy services and the current and future development of energy equipment/installation, as well as simulating energy consumption processes. The IPAC-AIM/technology model is the minimum cost optimization model based on linear programming.

The IPAC-AIM/technology model employs the minimum cost method i.e. the result of the selection of a set of minimum cost technology to perform energy services. This model adopts a linear programming method so that the model can analyse some of the complex processes of energy use, with analysis from the viewpoint of a process rather than a single technology. In the modelling analysis, when setting various parameters, different criteria and methods can be taken into account to expand the scope of the analysis coverage. For example, the technology operation cost consists of the combined cost of various inputs, including energy, raw material and labour, so that the analysis of technology cost is closer to the real-life scenario.

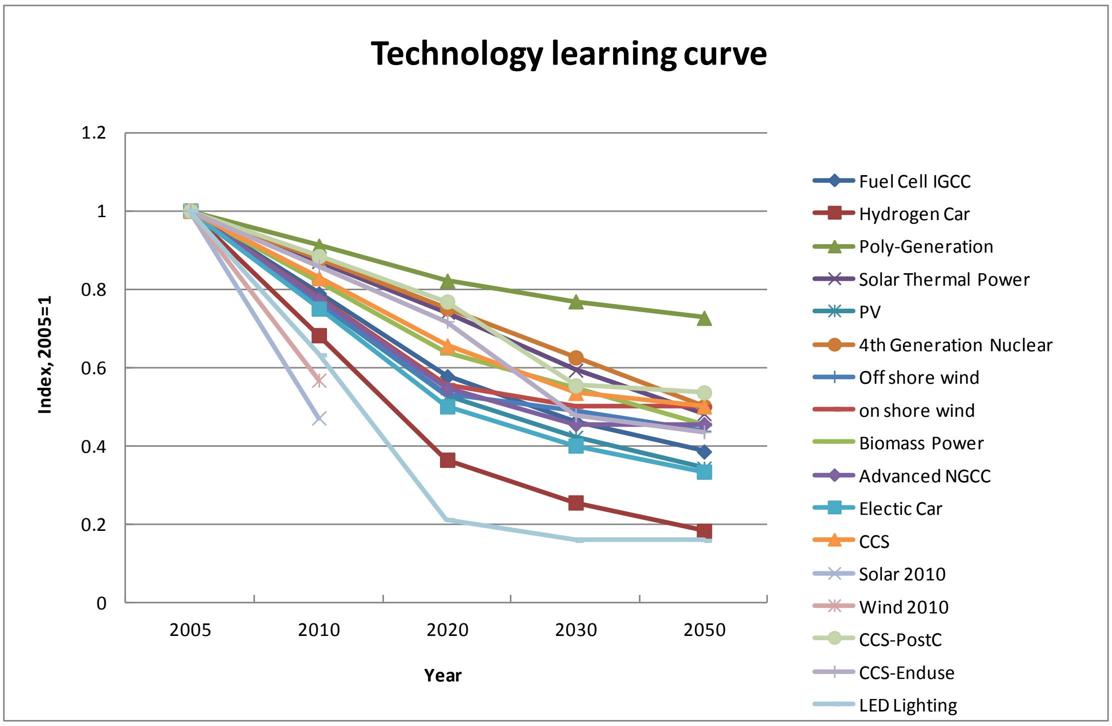
Criteria for the technical selection of the IPAC-AIM/technology model are relatively straightforward, which makes its conclusions easily understandable and more acceptable to users, providing better support to decision-making processes.

In the IPAC-AIM/technology model, technology parameters include the amount of per unit output, energy consumption of different types of technology, other non-energy inputs, technology fixed investment, and technology pollutant emissions factors. Data of annual technology fixed investment is provided, including both the technology learning curve and the description of future technology costs.

The IPAC-AIM/technology model covers more than 600 kinds of technologies in 43 sectors, of which more than 150 kinds of important technologies in low-carbon and energy-saving fields are selected to be the key subjects of this analysis, as shown in Table 1.

Figure 1 shows the learning curve i.e. future investment cost of key technologies. .

Figure 1 Technologies learning curve

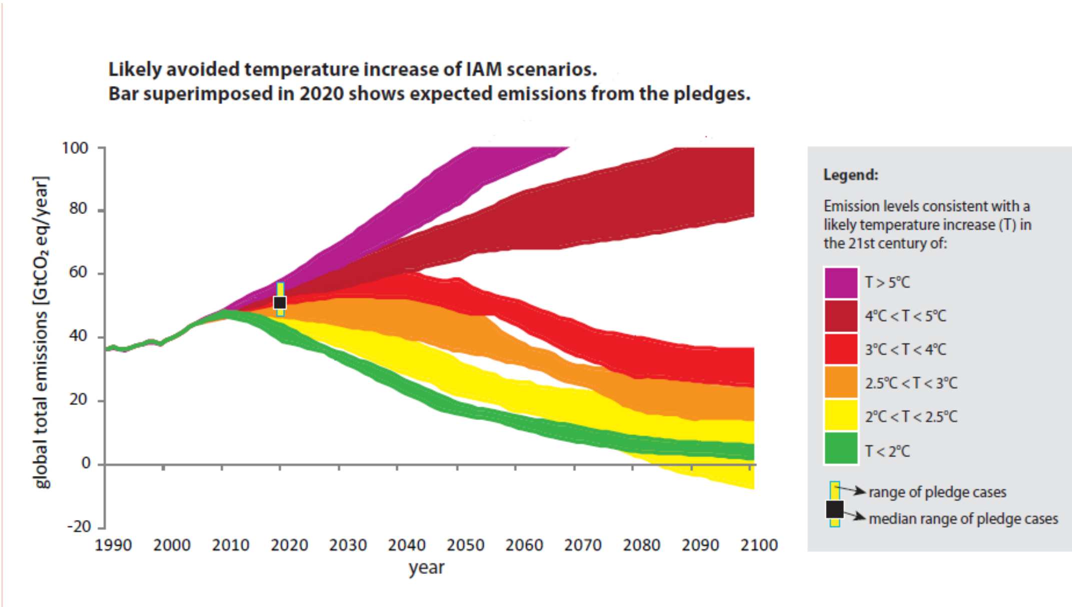


2.2 Key Factors for Future Energy Use and Greenhouse Gas Emissions in China

The 2-degree target proposed by G8 summit in Italy in 2009 was written into the Copenhagen Accord, but a further objective to reduce global greenhouse gas emissions by half from 1990 to 2050 was not included in the Accord. Although the 2℃ target is closely related to the goal of halving global emissions by 2050 – which also requires developed and developing countries to share responsibility - due to the fact that it is accompanied by political appeal for Annex I (of the United Nations Framework Convention of Climate Change) countries to achieve a 80% reduction by 2050, both the 50% and 80% targets by 2050 were not included in the Accord.

Figure 2 shows the analysis of emissions pathways for different warming goals that different international modelling groups have produced. (UNEP, 2012). Among them, the green emissions range, where the likelihood of achieving the target of 2℃ temperature rise is more than 66%, is considered the last possible way to achieve the emission target. In the process of preparing the IPCC Fifth Assessment Report, most 2-degree compatible scenarios suggested the need for a global emission peak from 2020 to 2025. The sooner global emissions peak, the greater the pressure will be on China. Here, we have chosen the scenario in which global emissions will peak relatively late to analyze an emissions scenario for China. Hence, the analysis of China's emission scenario is already the most favourable to China in the context of meeting the global 2-degree target.

Figure 2 Various Emission Pathways



Source: Emission Gap Report 2011, UNEP

3. The structure of China's economy and energy consumption patterns

China's economic and population growth is following a similar pattern to that set out by its national development plan. This development pattern is accepted by most people as it is drawn out of many relevant studies after years of research. However, some relatively optimistic economic forecasts in recent years are also considered here.

According to medium and long-term development goals, the national economic development strategy will be implemented in three steps and the economy will match the level of developed countries by 2050. Following the strategy, China will undergo industrial restructuring due to changes in the domestic and foreign market landscape. Coupled with China's entry to the WTO, China is in need of progressive internationalization. In the next decade, China will continue to be an international manufacturing center, and its exports will still be a key driver of economic growth. Taking into account the rapid economic development in China, however, the main factor supporting GDP growth after 2030 will be dominated by domestic demand; the competitiveness of international conventional manufacturing will decline due to rapidly rising labour costs. By taking a series of effective measures, China's economic structure has been continuously improved, its industrial structure has been gradually upgraded, and the international competitiveness of its advanced industries has been increasingly strengthened, making the Chinese economy develop at a more normal pace even as it experiences constant readjustment. It is estimated that the Chinese economy will maintain an average annual growth of 6.4% from 2000 to 2050. Economic growth for each period is shown in Table 2.

Over the past few decades, China has managed to sustain rapid economic development. Its tertiary industry has expanded slightly although it is not consequential. This is because China is still at the early stage of industrialization where its economic development is mainly driven by industry. The adjustment of its economic structure is one of the targets that has not been achieved during the 11th FYP period (2006-2010).

Optimizing its economic structure and achieving high-quality economic growth are the goals that the government has prioritised for many years.

During the 11th FYP period, an annual economic growth rate of 7.5% was proposed, which was lower than its previous targets of more than 8%. This showed the government was starting to aim for a better quality of economic growth. Nevertheless, the actual economic annual growth was more than 11% during the period, an impressive overshoot of its original target. An annual GDP growth rate of 7% has been proposed under the 12th FYP, although China is again likely to accomplish a much higher growth rate.

The Chinese economy has developed rapidly over the years, and its total GDP has reached more than 40 trillion RMB. The annual investment in fixed assets rose to more than 27 trillion RMB in 2010 from nearly 11 trillion RMB in 2006. Large-scale investments contributed significantly to the country's infrastructure construction, which particularly enabled the industrial development of energy-intensive business sectors. By achieving impressive economic growth and large-scale infrastructure improvement, Chinese people's living standards have increased significantly. However, this unprecedented growth has been accompanied by many environmental and social problems, largely affecting social welfare and causing social instability, which still need to be resolved urgently. Nonetheless, many economic development studies predict that rapid economic development in China will continue for some time. In this case, it will be crucial to adjust China's economic development model. There is little potential left in the original development model, and we believe that during the 12th FYP period (2011-2015), China will enter a crucial stage of economic restructuring. Our analysis shows that the existing economic pattern supported by the rapid development of high-energy-consuming industries is unsustainable, and will soon reach a tipping point. Regarding the question as to how to carry out economic restructuring, national policies need to be realistic and contain a strong, explicit intention to promote structural adjustment.

China can be either proactive or reactive in terms of restructuring its economy. Proactive restructuring would involve pursuing a smooth adjustment, avoiding economic fluctuations and other problems; whereas reactive structuring would depend on market regulations, which could cause massive overcapacity, price volatility and potentially other socio-economic problems.

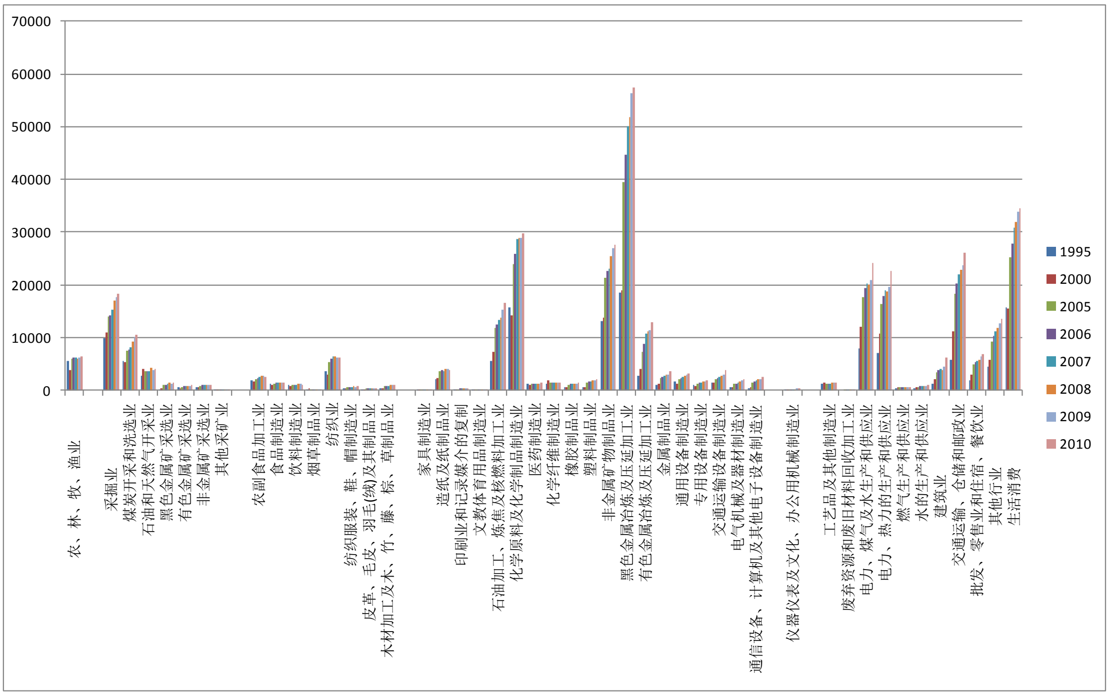
Table 2 GDP scenario, 100 million RMB, in 2005 price

	2005	*2010*	*2020*	*2030*	*2040*	*2050*
GDP	*183132*	*290505*	*649852*	*1291047*	*2099744*	*2991810*
Value added through primary industry	*22718*	*29206*	*44179*	*55819*	*65786*	*73824*
Value added through secondary industry	*87446*	*142889*	*316258*	*587736*	*853207*	*1087893*
Value added through tertiary industry	*72968*	*118409*	*289415*	*647491*	*1180751*	*1830094*

As the table above shows, the industrial sector will still be a key driver of GDP in 2030, as well as a key energy consumer. Therefore, a detailed analysis of industry in medium- and long-term scenarios will be required. We will therefore focus on energy-intensive industries and industrial sector scenarios covering the next 30 to 50 years. There has been a lack of detailed analysis of the industrial sector in studies looking at energy scenarios. In the past, the general approach was to predict the growth of energy intensive industries (i.e. production of energy intensive products) through discussions with industry experts. The lack of in-depth research at government departments resulted in large deviations, causing inaccuracies in energy demand forecasts. To better understand the future development of the industrial sector and more accurately analyze future trends in energy-intensive and other industries, several analytical methods will be used here. These can present the research data better, providing not only the model input parameters for this study but also methods used for other research, and form a basis for discussing the data.

From 2000 to 2010, 70% of energy and power growth in China was led by six highly energy-intensive industries, as shown in Figure 3. Therefore, once the development trend reliant on energy-intensive industries changes significantly compared to that of the 11th FYP period, the pattern of energy demand growth will also change correspondingly.

Figure 3 Electricity consumption in different sectors of China



Source: China's Statistic Yearbook 2012, China Statistic Publishing House

The key drivers of the development of energy-intensive industries in China have been domestic manufacturing production, domestic infrastructure and exports. The development of domestic manufacturing production includes two aspects, namely domestic final demands and exports.

We believe that based on the current pace of development, the growth rate of the most energy-intensive products in China during the 12th FYP period will become sluggish, reach a tipping point and start to decline. Therefore, any increase to the rate of energy during the period will be relatively low. The pre-2020 rapid economic growth is likely to lead a CO2 emission peak before 2025.

Figures in 2012 indicated that market demand for energy-intensive products was clearly inadequate. Rates of planned railway and real estate construction began to decline, and the scale of coal-fired power plants construction also significantly decreased. Even if outputs of high-energy products do not decrease, their growth will be very slow. Additionally, fewer infrastructure projects have been built in the past two or three years, and it has been difficult to roll out new economic stimulus measures of the same scale as the four trillion RMB in 2009.

In the near future, China needs to increase investment in green and sustainable urban development to compensate for the previous excessive focus on economic growth at the expense of sustainable development. A large number of recent policies issued by the National Development and Reform Commission (NDRC), including the construction and restoration of subways, waste treatment facilities, drainage systems, green spaces, urban forest parks, and water systems, reflected the government's intention for green urban development. As a result, although there will be demand for the cement and steel industries, the increase will not be significant. Meanwhile, the construction of transportation infrastructure, particularly subway system, will greatly help control energy consumption in the transportation sector.

In 2010, the output of crude steel reached 630 million tonnes and the output of cement reached 1.83 billion tonnes in China, exceeding the data level in the low carbon scenario and enhanced low-carbon scenario. Therefore, we will also analyse the future uncertainty of the production volume of energy-intensive goods. The IPAC model team analysed the relationship between cement and steel and iron production capacity on the one hand, and infrastructure construction on the other in 2009. The research shows that outputs of cement, steel and iron in 2009 supported Chinese infrastructure construction under rapid economic development (including housing construction, highway, road, railway, high speed railway and airports, etc.). Therefore, the output of energy intensive products in China may reach a peak in the 12th FYP period. Due to the inertia effect of economic growth and uncontrolled investment, the space for production capacity increase is limited, although it may go up for a certain period of time.

In order to accelerate economic restructuring and environment protection in China, applying taxation mechanism to promote environment protection and low carbon development has been put on the agenda. As stated in the 2014 Government Work Report and the 2013 Report on the Implementation of the Central and Local Budgets, as well as the draft report on Central and Local Budgets for 2014, the government "will enhance effort in formulating regulations on environmental protection tax and "will accelerate implementation of environmental protection tax regulations" in 2014.

The Environment Protection Tax Law (Draft for Examination), which was led by MOF (Minister of Finance) and worked on by the Ministry of Environmental Protection (MEP) and the State Administration of Taxation (SAT), was submitted to the State Council in March 2013. By July 2013, reviews and feedback from local governments, experts, academics and relevant industrial associations and enterprises including electricity, iron and steel, nonferrous metal were collected. At present, relevant suggestions have been taken on board to formulate a new draft. The draft law defines environmental tax as an "independent environmental tax", meaning it is a separate and independent tax item levied on emissions on pollutants.

According to this plan, the environmental tax (evolved from environmental fee) will include 4 tax categories, such as waste gas, waste-water, solid waste and carbon. Among them, the tax on waste gas mainly targets sulfur dioxide while the carbon tax will focus on CO2.

The tax rate for sulfur dioxide and solid waste is 2 RMB/kg, while the tax rate for waste-water is 1 RMB/tonne and the tax rate for carbon dioxide is 10-100 RMB/tonne. Among them, the carbon tax rate will adopt a progressive adjustment method from 10 RMB/tonne to 100 RMB/tonne.

At present, the carbon tax and tax rates for sulfur dioxide and chemical oxygen demand (COD) in the Environment Tax Law (draft for examination) are controversial. For the carbon tax, some actors believe that a carbon tax should be delayed as carbon reduction technologies are immature and the state has not yet identified CO2 as a pollutant. Some enterprises and industrial associations believe that a carbon tax will increase costs and be a burden for businesses. Local government agencies are also concerned about the potential that revenues may decrease after launching a tax-based rather than a fee-based regime.

4. China's carbon emissions scenarios

Low-carbon development is not always costly. In the scenario analysis, there are two factors at play. First, because the energy demand resulting from energy savings in a low-carbon scenario is significantly less than that in the baseline scenario. Accordingly, in terms of the scale of the energy sector, the investment required in low-carbon scenario is less than that in the baseline scenario. Second, technology costs in the low-carbon scenario are higher than that in the baseline scenario, which results in increasing investment in energy. Considering these two factors together, investment in energy in the low-carbon scenario is slightly less than that in the baseline scenario.

Energy consumption is another indicator to measure national investment. National energy consumption refers to the amount of end-use energy times energy prices. On one hand, due to energy-saving, end-use energy demand declines in the low-carbon scenario, resulting a decrease in spending. On the other hand, due to energy tax and carbon tax, energy price rise leads to increased cost. Overall, energy costs in the low-carbon scenario are lower than in the baseline scenario. If energy tax and carbon tax are not taken into account, energy price in the low-carbon scenario is lower than in the baseline scenario.

4.1 Scenarios

In order to comprehensively reflect China's future greenhouse gas emissions, we have designed 4 emission scenarios based on several critical factors closely related to emissions in the future, according to the previous IPAC study of scenarios for 2050.

First is the business as usual scenario (BaU), in which no extra climate change countermeasures are adopted and all development models are possible. The key driving factor here is economic development. Based on the conclusion of previous scenario analysis, this could realistically reflect the economic development path of China in the next 50 years. The population development model follows the national population plan, whereby China's population is predicted to reach a peak of 1.47 billion between 2040 and 2050. Since 2010 is the baseline year, the policies issued before 2010 are included in the scenario.

The second scenario is the low-carbon scenario (LC). Taking into account national energy security, domestic environment and low-carbon pathway, it is a low-carbon scenario that can be achieved with support from government policy. This scenario projects energy and emissions scenarios based on China's own efforts in the context of its domestic economic and environment development needs, and transformation of its economy, consumption patterns, improvement in energy efficiency as well as reduction in GHG emissions through technological innovation.

The third scenario is the enhanced low-carbon scenario (ELC). It mainly considers further contributions that China could do under a common vision that all the nations will work together to combat climate change. Under joint global efforts, technological progress would be accelerated, reducing costs of major technologies faster. Policies in developed countries would be gradually expanded to developing countries. At the same time, China may become the world's largest economy and develop the capacity to invest more in the low-carbon economy and further accelerate economic growth. Meanwhile, China has already become a leader in technology development in some areas, such as clean coal technology and Carbon Capture and Storage (CCS). The later has been applied in large scale in China.

The fourth scenario is the 2-degree scenario, and analyses whether or not Chinese emissions can stay within 2 degrees of warming from the pre-industrialization period (approximately 1850) to 2100. The method used here first estimates China's emission space under the 2-degree target. It then uses the IPAC-AIM technology model to analyse China's scenario within this space and the various possibilities. The main measures include further enhanced energy savings, enhanced renewable energy sources and nuclear power development as well as the further use of CCS.

The main parameters of the 4 scenarios can be seen in Table 3 (see next page)

Table 3 Main Parameters and Characteristics of Different Scenarios in 2015

	BaU	LC	ELC	2℃
GDP	Achieved the national 3-step objective. Average annual growth is 9% from 2005 to 2020, 6% from 2020 to 2030, 4.5% from 2035 to 2050	Same as BaU	Same as BaU	Same as BaU
Population	Peak at 1.47 billion in 2040, 1.46 billion in 2050	Same as BaU	Same as BaU	Same as BaU
GDP per capita	270,000 RMB (38,000USD) in 2050	Similar to BaU	Similar to BaU	Similar to BaU
Industrial structure	The industrial structure will be optimised to some degree. In 2030, the 3rd industry will become the dominant part in the economic structure. Within the secondary industry, high material consumption will continue due to economic growth and heavy industry is still important.	The industrial structure will be further optimised to be similar to the current layout of developed countries. Emerging industries and the tertiary industry develop quickly and the information industry will occupy an important position.	The industrial structure will be further optimised to be similar to the current layout of developed countries. Emerging industries and the tertiary industry develop fast and the information industry will occupy an important position.	The industrial structure will be further optimised to be similar to the current layout of developed countries. Emerging industries and the tertiary industry develop fast and the information industry will occupy an important position. Output from energy-intensive industry will peak before 2020.
Urbanization rate	70% in 2030，80% in 2050	Similar to BaU	Similar to BaU	Similar to BaU

Import and export patterns	*From 2030, primary commodities will begin to lose international competitiveness. Energy-intensive products mainly manufactured to meet domestic demand.*	*From 2020, primary commodities will begin to lose international competitiveness. Energy-intensive products mainly manufactured to meet domestic demand. Exports of high added-value industry and service industry will increase in a notable way.*	*From 2020, primary commodities will begin to lose international competition. Energy-intensive products mainly manufactured to meet domestic demand. Exports of high added-value industry and service industry will increase in a notable way.*	*From 2020, primary commodities will begin to lose international competition. Energy-intensive products mainly manufactured to meet domestic demand. Exports of high added value industry and service industry will increase in a notable way.*
Primary energy demand	*About 6.5 billion tonnes of coal equivalent (tce) in 2050*	*About 5.3 billion tce in 2050*	*About 5.3 tce in 2050*	*About 5.1 billion tce in 2050*
CO_2 emissions	*12 billion tonnes of CO_2 in 2050*	*8 billion tonnes of CO_2 in 2050*	*5.5 billion tonnes of CO_2 in 2050*	*3.4 billion tonnes of CO_2 in 2050*
Environmental protection in China	*Treated relatively well. Tendency is still first pollution then treatment, which shows the environmental Kuznetz curve (EKC) effect.*	*Treated relatively well. Tendency is still first pollution then treatment, which shows the EKC effect.*	*Treated in 2020. Tendency is still first pollution then treatment, which shows the EKC effect.*	*Treated in 2020. Tendency is still first pollution then treatment, which shows the EKC effect.*
Progress of energy utilization technology	*Advanced technologies will be widely deployed in 2040. China will become a world leader in technology and technology efficiency is about 40% higher than at present.*	*Advanced technologies will be widely deployed in 2030. China will become a world leader in industrial technology and other energy unitisation technologies. Meanwhile, China will also become a world leader in energy saving*	*Advanced technologies will be widely applied in 2030. China will become a world leader in industrial technology and other energy unitisation technologies. Meanwhile, China will also become a world leader in energy saving technology manufacturing and*	*Advanced technologies will be widely deployed in 2025. China will become a world leader in industrial technology and other energy unitisation technologies. Meanwhile, China will also become a world leader in*

		technology manufacturing and technology efficiency is about 40% higher than at present.	*technology efficiency is about 40% higher than at present.*	*energy saving technology manufacturing and technology efficiency is about 40% higher than at present.*
Unconventional energy resources utilization	*Unconventional natural gas and oil will be exploited after 2040.*	*Unconventional natural gas will be exploited after 2040.*	*No need to exploit unconventional natural gas and oil.*	*Unconventional natural gas will be exploited at large scale to replace coal before 2020.*
Power technology such as solar energy and wind energy	*The cost of solar energy will be 0.39RMB/kWh by 2050, and onshore wind farms are widely established*	*The cost of solar energy will be 0.27 RMB/kWh by 2050, and onshore wind farms are widely established. Large-scale construction of wind farms in coastal waters.*	*The cost of solar energy will be 0.27 RMB/kWh by 2050, and onshore wind farms are widely established. Large scale construction of wind farms in coastal waters.*	*The cost of solar energy will be 0.27 RMB/kWh by 2050, and onshore wind farms are widely established. Large- scale construction of wind farms in coastal waters.*
Nuclear power technology	*Over 200 GW in 2050, production cost will drop from 0.33 RMB/kWh in 2005 to 0.24RMB/KWh in 2050.*	*Over 330 GW in 2050, production cost will drop from 0.33 RMB/kWh in 2005 to 0.22RMB/KWh in 2050. 4th generation nuclear stations will be constructed at large scale after 2030.*	*Over 380 GW in 2050, production cost will drop from 0.33 RMB/kWh in 2005 to 0.20RMB/KWh in 2050. 4th generation nuclear station will be constructed at large scale after 2030.*	*Over 450 GW in 2050, production cost will drop from 0.33 RMB/kWh in 2005 to 0.20RMB/KWh in 2050. 4th generation nuclear station will be constructed at large scale after 2020.*
Coal power technology	*Mainly supercritical and ultra-*	*Mainly supercritical and ultra-supercritical until 2030, and IGCC*	*Mainly IGCC from 2020.*	*Mainly IGCC before 2020*

	supercritical	*after 2030*		
CCS	*Not considered.*	*Demonstration projects start in 2020. Low cost CCS will be carried out. By 2050, CCS will begin to be compatible with all the newly established Integrated Gasification Combined Cycle (IGCC) power stations.*	*Combining IGCC power stations, all use CCS. Meanwhile, industries such as iron and steel, cement, electrolytic aluminum, synthesis ammonia and ethylene will use CCS, which will be almost universally used after 2030*	*Combining IGCC power stations, all use CCS. Meanwhile, industries such as iron and steel, cement, electrolytic aluminum, synthesis ammonia, ethylene will use CCS, which will be almost universally used after 2030*

Table 3 Main parameters and Characteristics of Different Scenarios in 2015(Continued)

	BaU	*LC*	*ELC*	*2℃*
Hydroelectricity	*Installed capacity of 340 GW and over 1100 billion kWh energy generated in 2050*	*Installed capacity of 430 GW and over 1300 billion kWh energy generated in 2050*	*Installed capacity of 450 GW and over 1400 billion kWh energy generated in 2050*	*Installed capacity of 500 GW and over 1600 billion kWh energy generated in 2050*
Modern biomass energy utilization technology	*Utilisation of biomass energy close to 70 million tce in 2050. Costs will be lower than 430RMB/tce*	*Utilisation of biomass energy close to 90 million tce in 2050. Costs will be lower than 370RMB/tce.*	*Utilisation of biomass energy close to 90 million tce in 2050. Costs will be lower than 370RMB/tce.*	*Utilisation of biomass energy close to 90 million tce in 2050. Costs will be lower than 370RMB/tce.*

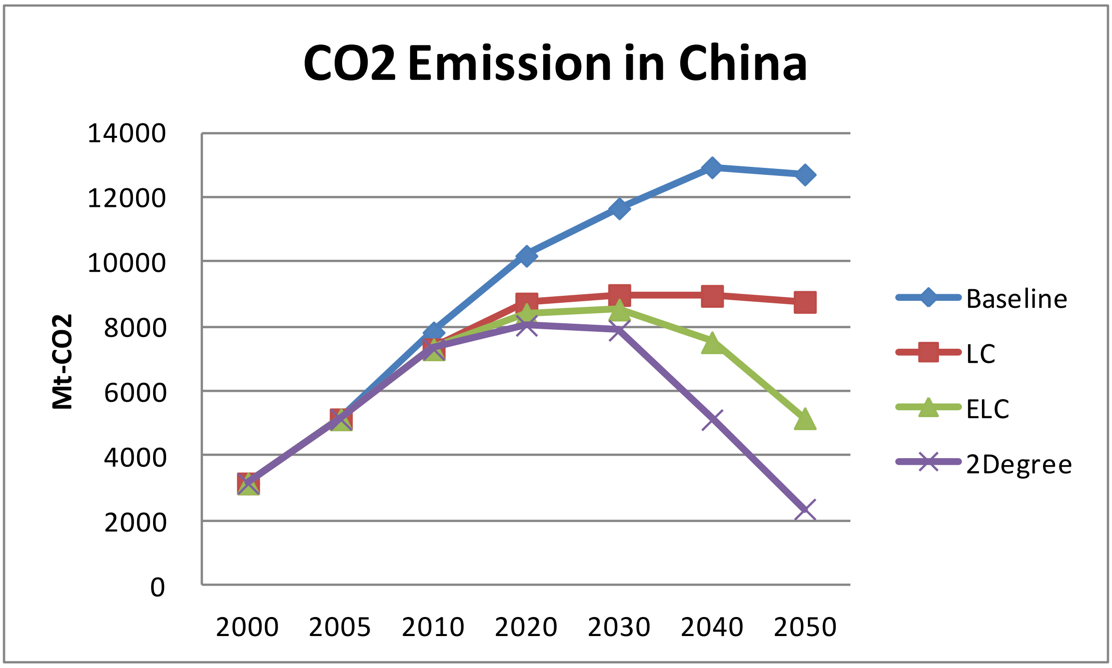
Residents' lifestyle	*Full use of clean energy. Energy-saving appliances mainstreamed. Rural residents will use more commercial energy.*	*Wide use of low carbon and environmental-friendly residential buildings.*	*Wide use of low carbon and environmental-friendly residential buildings.*	*Wide use of low carbon and environmental-friendly residential buildings.*
Transportation development	*Rapid development of convenient public transportation and good quality rail system in large cities*	*Fast, sound public transportation network, environmental-friendly transportation and good quality rail system.*	*Mainly public transportation in cities with over 1 million inhabitants, and non-motor vehicles in small cities and rural areas.*	*Mainly public transportation in cities with over 1 million inhabitants, and non-motor vehicles in small cities and rural areas.*
Transportation technology	*30% increase of fuel economy*	*60% increase of fuel economy*	*60% increase of fuel economy*	*70% increase of fuel economy*
Food composition tendency	*Rapid increase of meat product consumption*	*Slow increase of meat product consumption*	*Limited meat production consumption*	*Limited meat production consumption*
Forest land development	*Increasing growth of forested area*	*Rapid growth of forested area*	*Rapid growth of forested area*	*Rapid growth of forested area*
Carbon tax	*Energy tax from 2020 with relatively low tax rate*	*Carbon tax from 2020 with relatively low tax rate, which increases later.*	*Carbon tax from 2020 with relatively low tax rate, which increases later.*	*Carbon pricing from 2017 (via carbon tax or carbon trading) with relatively low tax rate, which will increase later.*
Carbon trading	*Through methods similar to Clean Development Mechanism (CDM)*	*Participation in international carbon trading around 2020, sectoral or regional*	*Participation in international carbon trading around 2020, sectoral or regions*	*Begin domestic carbon trading in 2017 and participation in international carbon trading in 2020, sectoral or regional*

Emissions reduction objective	*None*	*Commitment in 2030*	*Commitment in 2030*	*Target for controlling total emissions from 2020*

In this research, we mainly use the 2-degree scenario to carry out investment demand analysis. However, a comparison between different scenarios is also used to discuss investment and cost.

The four energy and CO_2 emission scenarios are produced using the IPAC model as shown in Figure 4.

Figure 4 CO2 Emissions from Energy Activities in China

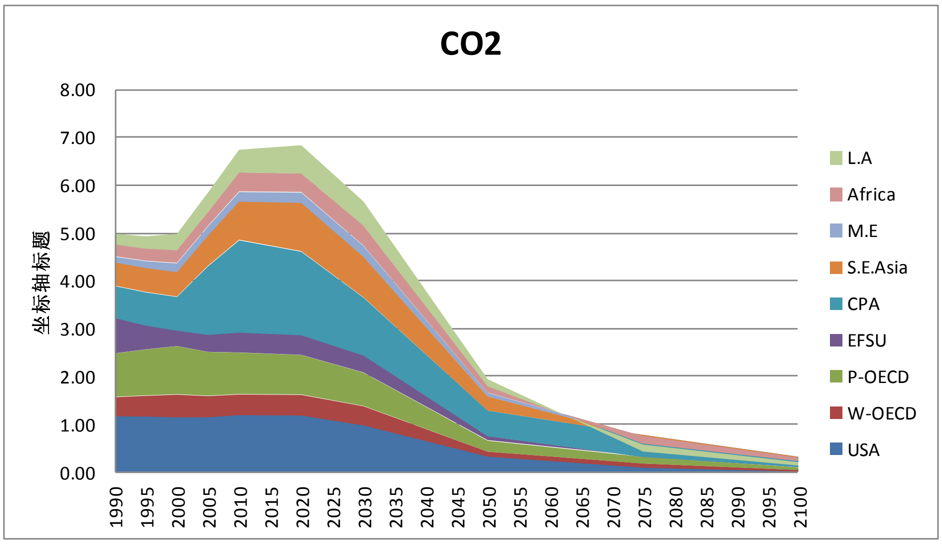


Our recent research mainly focuses on the analysis of the 2-degree scenario. Compared with the baseline scenario, low carbon investment in the 2-degree scenario has obviously increased, hence the focus on the 2-degree scenario. We will introduce the main analytical methods and conclusions of the 2-degree scenario.

When developing targets for future climate change mitigation, the objective is usually to control future temperature increase. The IPCC report effectively discusses a target temperature increase for 2100. At present, widely discussed emissions reductions have been developed based on the temperature increase target in the IPCC report.

Figures 5 shows us results from the latest research in global scenario research. To achieve the target of below 2-degree global temperature increase by 2100, CO_2 emissions from energy use must drop by 60% by 2050, which is consistent with a 50% decrease in GHG emissions. As reducing GHG in non-energy activities is rather difficult, the main contributing factor to achieve this decrease will come from the GHG released through energy use. In addition, 1400 billion tonnes of CO_2 can be released (from all emissions sources) from now to 2100 in order to achieve 2-degree temperature target. Based on our previous research, from 2005 to 2050, the cumulative emissions of CO_2 in the baseline scenario is 480 billion tonnes, while the LC scenario shows 378.2 billion tonnes of CO_2. Emissions in the ELC scenario, which will peak in 2030, is 338 billion tons of CO2. Under the 2-degree scenario, China must limit cumulative emissions volume to within in 300 billion tons, which is 38% of the global share.

Figure 5 Global Energy Activity CO2 Emissions under 2—Degree Scenario, 1 Billion Tons of Carbon



In order to simulate future emissions spaces for different countries and regions, the "burden-sharing" approach should be used. Principal options for burden sharing include:

> Convergence of per capita CO2 emissions: refers to the convergence of annual per capita CO2 emissions in a target year, which is treated as a form of human right.. 2020, 2070 and 2100 are often set as target years of convergence of per capita CO2 emissions although different research teams may vary. Also, before the year of ultimate convergence of per capita CO2 emissions, emission pathways of different countries and regions are important and need to be considered in parallel with analysis on the convergence of per capita CO2 emissions.

> Cumulative CO2 emissions per capita: based on the convergence of cumulative CO2 emissions per capita in target year (such as 2050, 2075). The starting year is chosen as 1850 or 1900.

> Mixed method: Taking into account payment capacity, per capita emissions and potential for emissions reduction, this burden-sharing method is widely accepted.

4.1 Policies in Different Scenarios

A variety of policies are considered in the low carbon and 2-degree scenarios to project carbon emissions pathways. The following provides a brief introduction.

- **Adjustment of Economic Structure**

One of the main reasons that China keeps increasing its carbon emissions is related to its imbalanced industrial structure. Research shows that China can no longer sustain its economic model based on the rapid development of energy intensive industries, with most energy intensive products expected to peak their emissions by 2020. The period of the 12th FYP is viewed as critical to Chinese economy in terms of structural adjustment, energy conservation and emissions reduction. In order to realise the targets, national policies need to be defined and implemented, China's economic restructuring needs to be strengthened.

In the past decades, the development of the Chinese economy was mainly driven by manufacturing as China was at the preliminary stage of industrialization. In 2011, China's investment in fixed assets rose to 30.19 trillion RMB from round 11 trillion RMB in 2006, with the greatest investment in secondary industries such as mining and manufacturing. The speed of investment growth moved China into a phase of massive infrastructure construction across the country, with 70% of increased energy and electricity consumed by 6 major industrial sectors in the period of the 11th FYP. This resulted in the stunning development of energy intensive sectors in China. Many studies indicate that the high-speed development of the Chinese economy will continue for some time, hence why it is significant to adjust the development model for the Chinese economy.

The rapid development of energy intensive sectors in China was mainly driven by the demands of domestic manufacturing, domestic infrastructure construction and exports. In 2011, China produced 0.683 billion tonnes of crude steel (44.7% of the global supply), 0.881 billion tonnes of rolled steel (47% of the global supply) and 2.09 billion tonnes of concrete (59% of the global supply). China's production of 18.06 million tonnes of electrolytic aluminum was the highest in the world. In terms of China's infrastructure construction, China has the world's largest electricity installed capacity in the world with 1.56 billion kw, and second in the world in terms of the total distances of expressways with 85,000 km. China also has one of the longest railway lines in the world with 93,000 km and has increased its automobile output from 5,704,900 in 2005 to 18,419,000 in 2011. Obviously, the volume of Chinese energy intensive products now accounts for the lion's share of the world market with very limited possibility to further sharply increase the growth rate.

Research indicates that the rapid development of energy intensive products during the period of the 11th FYP accelerated the pace of Chinese infrastructure construction; in other words, what would have taken 30-50 years to finish building could now be accomplished in 15-30 years. In particular, our original analysis predicted that the rate of annual infrastructure constructions would peak from 2020 to 2025, while we now know they will likely be accomplished by the end of 12th FYP. To avoid economic fluctuations as a result of the substantial redundancy of production capacities and the shrinking markets of those industrial products, we took into consideration the changes of economic structure in the original IPAC scenario, set the trend of energy intensive industries and defined the changes to output data of major energy intensive products. In 2011 and 2012, we used the IPAC model to analyse the output of Chinese energy intensive products so that the data could better suit the development needs of Chinese society and the economy.

At present, China needs to initiate the transition of its economic structure by controlling investment in its energy intensive sectors, increasing the export tax rate, and imposing a carbon tax or energy tax to raise costs for energy intensive sectors. Meanwhile, development plans and policy for energy intensive sectors such as steel, non-ferrous and concrete should be further improved, standards of industry entry should be increased to eliminate obsolete production capacity and upgrade the industries. The economically developed regions should be compelled to recognize that the core competence of future economic development lies in the competitiveness of the service industry rather than in manufacturing. China needs strive to develop its tertiary industry, particularly a modern industry of high value-added commercial and information services that require few resources for development, and increase its share of the GDP.

In the near future, China also needs to increase investment in the sustainable development of its green cities to compensate for the unitary pursue of economic growth at the expense of sustainability. The NDRC recently announced a series of new policies that point to this new direction, covering the construction of subway, sewage treatment, drainage systems, garbage disposal, urban landscaping, urban parks, river system construction and recovery, etc. The construction of subway will help enormously with limiting increases of energy use from urban transportation.

➢ Progress of Low-Carbon Technology to Promote Green Development

Technological progress plays a significant role in effecting deep CO2 cuts in the long term. Recently, technological progress and investment potential in low-carbon development have started to play a greater role in Chinese energy conservation and emissions reduction. In the future, Chinese technological advances will not only create the dual effect of reducing GHG emissions and facilitating growth, but will also create new potentials for economic growth and competitive advantage. Hence, the technology strategy must be combined with energy and economic policies to reduce costs effectively, and achieve the objectives of low-carbon development.

In the future course of China's industrial development, many technologies available now will not only make great contributions to energy efficiency but also help reduce GHG emissions. These technologies can and will be entirely mainstreamed before 2020.

Here we list those technologies with the biggest potential to reduce emissions by 2020: advanced large equipment for steel production (coke oven, blast furnace, oxygen converter, etc.); advanced sintering/minus energy converter for steel production; advanced electro-smelting; hot charging/feeding; continuous casting; immediate rolling; dry quenching; coke oven gas; blast furnace gas and converter gas; large-scale direct arc furnace; recycle gas combined cycle power generation; advanced smelting; iron reduction with new reagent; electrolytic iron making, etc. Thanks to technological progress, energy consumption per tonne of steel produced in China has reduced from 1.5 tonnes of standard coal equivalent to about 0.6 tonne of standard coal equivalent, the most advanced level in the world.

In the building materials industry, there are technologies to reduce emission such as the new drying-process rotary kiln; cogeneration; float glass process; medium altitude kiln and tunnel kiln; waste utilization; utilization of kiln renewable energy source; concrete biomass alternate fuel; concrete made of construction waste and wall materials made of crop waste etc.

In the transport industry, there are advanced large diesel trucks; fuel efficient passenger cars; electric cars; HEV; gas-fueled vehicles; advanced electric locomotives; energy efficiency ships; bio-diesel powered ships, aviation, locomotives; and high-speed trains, etc.

In the electric power industry, there are power generation from natural gas combined cycle power generation; advanced nuclear power technology; advanced large-scale hydro-power technology and small run-off generation technology; advanced supercritical state and supercritical technology; IGCC; and CCS. Since the advanced technologies have been adopted to reduce the consumption of coal power, the consumption level of coal power has fallen below 300 gm per kw/h in China - better than in most developed countries.

With regard to residential power conservation, there are highly energy efficient gas and LPG ovens; centralized heating system; advanced power saving appliances; efficient LED lighting; zero emissions buildings; advanced solar water heaters and solar heating techniques, etc.

The most notable progress has been made in renewable energy technologies such as large-scale wind farms and efficient solar power at low cost. In 2011, Chinese wind turbine technology became world-leading by reducing turbine cost to 3200-3500 RMB per kw and power generation cost to 0.4 RMB, and is now entering the stage of large-scale development. The installation cost of photovoltaic power has decreased to 16,000 RMB per kw so that some photovoltaic power generators can be cost competitive. The cost of photovoltaic power is predicted to decrease to 0.6-0.9 RMB per kw, making it generally suitable for large-scale commercial applications.

Therefore, we increase the renewable energy target for 2050 in our 2-degree scenario. In view of the future learning curve of cost reductions for both renewable energy sources and fossil fuel technologies, costs for renewable energy will be entirely competitive with fossil fuel power before 2020, so long as the cost of fossil fuel power keeps rising and external environmental costs are internalized. On these assumptions, installed capacity will reach 860 GW for wind power and 1,040 GW for photovoltaic power by 2050. Additionally, the model projects an increase in the applications of solar heat water and solar heating and takes into account a large number of dispersed renewable energy technologies such as solar air conditioning, photovoltaic power generation and heating, and CCS to capture and store CO_2. Compared to the ELC scenario, in the 2-degree scenario the installed capacity of coal power drops to 710 GW from 760 GW in 2020; and to 570 GW from 630 GW in 2050. By 2050, 410

GW of coal power will utilise CCS, although coal power by then will be dominated by IGCC technology.

➢ Large-Scale Development of Renewable Energy and Nuclear Energy

In recent years, impressive renewable energy development has made China a world leader in terms of annual investment and newly-added installation capacity. The rapid development of the renewable energy equipment manufacturing sector in China has significantly reduced costs for wind and photovoltaic power, laying strong foundations for future development of renewable energy at a large scale. In regions with abundant wind resources as well as in the eastern provinces with limited coal, costs of wind power are already becoming competitive with those for coal power. In view of these recent positive developments, the objectives for Chinese renewable energy in 2020 have been continually revised: for example, the target for installed capacity of wind power was raised from 40 GW to 80 GW and then to 150 GW. Recent discussions have put forward the possibility of wind power installed capacity to reach 200-250 GW, or even 300 GW. Photovoltaic power capacity has been increased from 2 GW to 20 GW, making a target of 50 GW by 2020 credible, and even a goal of 80 GW is likely to be achieved. The current problem of integrating this supply with the grid can be solved with better grid planning and the construction of smart grids. As a large state-owned enterprise, the State Grid needs to support the development of renewable energy, acting as a key player in the development of renewable energy on a hyper-large scale in China.

Various studies indicate that nuclear power remains one of the cleanest and safest energy sources. In spite of the Fukushima nuclear power accident (accident is used here instead of catastrophe because there insufficient data to justify a description of catastrophe), the potential death toll, environmental implications and latent health impacts caused by nuclear are still less than those caused by accidents from regular power generation. China needs to drive the massive development of nuclear power. Additionally, the successful development of Chinese nuclear power (which for now looks assured) would likely affect global energy supply, hence a return to a nuclear-oriented power supply would benefit the development of technologies and industries in China.

➢ Transportation Policy

Public transport has much lower CO2 emission than private cars. In the lower CO2 emission scenario, the promotion of public transport to curb car use is one of the most important policies. Public transport and non-motorised vehicle transport systems must be strengthened in metropolitan cities. Bus Rapid Transit (BRT) systems must be built up so that the urban transport system is mainly made up of non-motorised vehicle and public transportation; high-level facilities such as footpaths, bike paths and parking lot systems must be installed; non-motorised vehicle must be given priority; escalator, walkway and bicycle signal systems must be widely used, and parking priority and footpaths must be provided; existing expressways must be turned into the rapid transit system to support public transport; finally, the development of rail systems and buses must be accelerated and equipped with more convenient transfer systems.

Energy saving vehicles must be quickly mainstreamed. Key emphasis must be placed on energy saving vehicles, promoting clean fuel vehicles (electric cars, motor rail transit), and managing and limiting vehicle emissions. China's developed regions can adopt tougher local vehicle admittance standards than the national fuel efficiency standards so that new motor vehicles produced in the current period of fast growth satisfy the highest standards of fuel efficiency. This can be achieved by establishing local sales permit system for motor vehicles. Meanwhile, the generation of clean energy automobiles must be encouraged and priority parking in public areas must be made available to people driving new energy or energy efficient cars. Taxes on clean energy and energy efficient cars must be cut down.

Green bus and taxi fleets must be established so that the bus transport system and taxis become pioneers in satisfying green and low-carbon development objectives. The number of electric buses and taxies must be quantified in setting the target for new vehicles, and the construction of charging stands and stations must be carried out. In combination with the recent Beijing Rail Transit Plan, electric taxis can be introduced to serve short trip connections between residential areas and subway stations at a preferential fare policy such as a low starting price. This will not only fulfil the objectives of low-carbon development, but also solve the chronic problem of illegal taxis and support further utilization of public transport.

The rail transit system must be developed. While efforts are currently underway to extend the distances covered, more attention must be paid to the details of the construction of the rail transit system, e.g. the inconvenient transfers; infrequent trains; and incomplete facilities (e.g. one-way escalators and underpasses) so that rail can become a comfortable and rapid transport system.

The overall public transport system must be optimized. Bus priority system and bus special lanes must be further expanded, and the BRT system should be set up in all urban expressways including the main urban transport network. By using current expressways, many cities can operate dozens of BRT lines on routes without traffic lights and ensure BRT lines cover urban traffic networks fairly well.

Development of the non-motorised vehicle transport system must be widely encouraged. Bike paths and sidewalks must be restored and widened, street-crossing facilities for pedestrians and cyclists must be improved and traffic lights expanded, and bike paths should be narrowed to protect cyclists from motor vehicles using them. In public and commercial facilities, government buildings and hotels, priority parking facilities must be set up for bicycles.

More service facilities should be developed to reduce outbound trips, e.g. convenient payment points at the supermarkets and other service outlets, telephone conference systems, online shopping etc.

The cost of using passenger cars must be increased in order to decrease the justification for using them. In addition to increasing parking fare, more thought should be given to improving bus transit lanes, bike lanes and street traffic lights, in order to effectively limit the use of motor vehicles. In the future, the increase of motor vehicles travelling speed should not be the government's main objective for transport development.

➢ Buildings

Promoting high standards of energy efficiency and near 'zero emissions' buildings are some of the most important policies for lowering emissions in the building sector. Relevant programmes must be introduced to support higher energy-saving standards in buildings. In the period of the 12th FYP, renovations to improve energy efficiency of existing buildings must be stepped up.

Energy saving appliances must be promoted in local markets, and local admittance standard for appliances higher than the national one must be introduced to boost the popularity of local energy efficient appliances. In the initial stage of the 12th FYP, incandescent light bulbs should be eliminated across the cities to promote the universal application of energy saving lights. As a mature technology, the use of LED lights should be encouraged and mainstreamed.

The application of renewable energy heating technology in solar heaters, and ground source heat pumps (GSHPs) must be mainstreamed, while advanced garbage disposal technology must be used to develop local sewage treatment and build up recycled water system in communities.

Low carbon services standards should be initiated (including low-carbon hotels, restaurants, entertainment facilities, office buildings, hospitals and universities) as well as the 'green government' plans. Standards for the service industry should include quantitative criteria to clearly define the scope of low carbon services. Low-carbon service industry can also be incorporated into the framework of government procurement.

In the period of the 12th FYP, demonstration of zero carbon emission buildings will be launched, with the objective of having it extensively implemented in the period of the 13th FYP.

Distributed power network system should be wide implemented through cooperation with grid companies in order to promote renewable energy application in buildings and distributed power generation.

Campaigns for garbage classification and reduction and waste-water reduction should be launched. A variety of low-carbon treatment technologies should be introduced to cope with urban waste, and mainstreamed through demonstration projects.

Actions must be taken to strengthen public knowledge about low-carbon lifestyles and promote all aspects of low-carbon lifestyles.

Labelling for low-carbon products should be introduced to encourage the development of low-carbon products end-use consumption.

The government should establish a system to provide information about low-carbon services as well as equip users with knowledge about low-carbon manufacturers and products so that users can choose trustworthy suppliers. Good examples should be available to customers to provide the information basis for selection.

4.3 Computation of Investment Needs

Based on the modeling analysis, two kinds of investment are computed: one is the investment needed in the energy sector, including power generation, heat supply, mining, grid construction, oil processing and coal gas. The second is the investment in energy efficiency programmes of sectors such as agriculture, industry, housing, services and transportation. The definition of energy saving investment is the investment in energy saving technology minus the investment in baseline technology, which equals the extra investment incurred. Concerning transportation, it is hard to compare this with baseline technology, such as investment in the subway, railroad locomotives, vessels, and aircrafts. As a result, investments in these technologies are the total investment. Please refer to Table 4 to 11.

Table 4: Energy Industry Investment in the Baseline Scenario, Unit: 100 million RMB

	Investment
2000	*2059*
2005	*7119*
2010	*10453*
2020	*7845.3*
2030	*8199.9*
2040	*8500.5*
2050	*12072.6*

Table 5: Energy Saving Investment in the Baseline Scenario, Unit: 100 million RMB in 2010

	2010	2020	2030	2040	2050
Manufacturing	3426	1928	2207	2278	2479
Transportation	1001	4945	4344	3720	2360
Building	4453	3919	4976	3658	6259
Total	8880	10792	11527	9656	11098

Table 6: Energy Industry Investment in the Low Carbon Scenario, Unit: 100 million RMB

	Investment
2000	2059
2005	7119
2010	10453
2020	6925
2030	7336
2040	8312
2050	10061

Table 7: Energy Saving Investment in the Baseline Scenario, Unit: 100 million RMB in 2010

	2010	2020	2030	2040	2050
Manufacturing	3426	1928	2040	2395	2479
Transportation	1500	5850	8450	7633	7067
Building	4453	5197	6696	5149	7856
Total	9379	12975	17186	15178	17402

Table 8: Energy Industry Investment in the 2 Degree Scenario, Unit: 100 million RMB in 2010

	Investment
2000	2059
2005	7119
2010	10453
2020	11853
2030	9842
2040	14180
2050	13767

Table 9: Energy Saving Investment in the 2 Degree Scenario, Unit: 100 million RMB in 2010

	2010	*2020*	*2030*	*2040*	*2050*
Manufacturing	*3426*	*2152*	*1906*	*2216*	*2278*
Transportation	*2965*	*7315*	*9807*	*8886*	*8214*
Building	*4453*	*6183*	*6696*	*5149*	*4470*
Total	*10844*	*15650*	*18409*	*16251*	*14962*

Table 10: Transportation Investment in the 2 Degree Scenario, Unit: 100 million RMB

	2010	*2020*	*2030*
Subway	*1300*	*15000*	*29000*
Energy saving vehicles	*960*	*1740*	*4249.875*
Energy saving locomotives	*72*	*84*	*84*
Energy saving vessels	*43.4*	*43.4*	*35*

Energy saving aircrafts	1350	1350	1250

Table 11: Energy Industry Investment in the 2 Degree Scenario, Unit: 100 million RMB

	Coal Power	Oil Power	Gas Power	Hydro-Power	Nuclear Power	Wind Power	Solar Power	Biomass Power	Total
2010	3005.9	31.1	85.9	1530.4	258.7	515.8	90.3	45.2	5563.4
2020	934.7	40.3	273.7	2323.2	883.4	1682.8	1987.5	228.0	8353.6
2030	312.3	26.0	160.9	1272.1	863.6	1621.4	2063.1	80.2	6399.6

Please refer to Table 12 for detailed investments and emissions per sector, and to Table 13 for capacity of generation per technology.

Table 12: Investment/Power Saving Investment (Unit: 100 million RMB RMB) and CO2 Emissions (Unit: million Tons of CO2) in the 2 Degree Scenario

	Investment breakdowns per sector			Emissions	
		2020	2050	2020	2050
Electric power	Traditional resources	1248.7	263.8	4034.381	3663.489
	Renewable resources	3898.3	6690.5		
	Nuclear power	883.4	1285.5		
	CCS	159.2	1044.9	114.1	1781.4
	Grid	3968	4426		
Petroleum		987.8	913.4		
Coal		536.6	4.0		

Agriculture		*327.0*	*465.6*	*95.4*	*112.8*
Manufacturing	*Steel*	*855.7*	*336.0*	*1069.6*	*452.9*
	Glass	*83.2*	*89.7*	*31.0*	*17.9*
	Non-ferrous	*50.3*	*24.7*	*219.4*	*107.4*
	Chemical	*260.7*	*217.5*	*497.0*	*311.8*
	Boiler	*216.15*	*280.5*		
	Electric motors	*496*	*1180*		
Transportation	*Energy saving vehicles*	*1740*	*4666.667*		
	Subway	*6987*	*4080*		
	Others	*1477.4*	*1147.2*		
Building	*New buildings*	*2044.533333*	*1848*		
	Old building renovation	*3610.8*	*1693.2*		

Table 13: Generation Capacity per Technology in the 2-degree Scenario, TWh

	Small Coal	*Large Coal Unit*	*Super Critical*	*US-Critical*	*IGCC-20%*	*IGCC-Fuel Cell*	*PFBC*
2010	*319*	*1565*	*894*	*287*	*0*	*0*	*128*
2020	*116*	*1625*	*1122*	*638*	*213*	*0*	*155*
2025	*37*	*1312*	*1162*	*750*	*337*	*0*	*150*
2030	*0*	*831*	*1143*	*793*	*554*	*38*	*104*
2040	*0*	*276*	*645*	*524*	*483*	*60*	*26*
2050	*0*	*0*	*366*	*392*	*457*	*78*	*13*

Table 14: Generation Capacity per Technology in the 2 Degree Scenario, TWh (Continued)

TWh	N.Gas	NGCC	Oil	Solar PV	Solar Thermal	Biomass Direct	Biomass IGCC	Wind on shore	Wind off shore	Nuclear	Hydro
2010	78	5	58	1.2	0.0	20.7	0.0	66.0	0.2	140.7	575.2
2020	349	122	72	130.4	0.0	130.4	0.0	502.1	5.1	760.8	1304.3
2025	404	208	64	225.7	0.0	145.1	0.0	718.4	7.3	1088.4	1451.2
2030	415	353	61	323.2	17.0	165.7	0.0	882.8	76.8	1483.0	1483.0
2040	356	652	50	735.1	72.7	189.5	0.0	1292.5	303.2	2613.0	1695.4
2050	185	1133	44	1006.8	124.4	208.7	0.0	1481.6	605.2	3240.0	1647.5

Table 15: CO2 Emissions of Energy Activity in Different Scenarios (Unit: million Tons of CO2)

	Baseline Scenario	Low Carbon Scenario	2 Degree Scenario
2000	3161	3161	3160.6273
2005	5143	5143	5143.0225
2010	7831	7831	8501.0274
2020	10200	8925	8868.6946
2030	11667	8986	8340.353
2040	12937	8961	5669.5055
2050	12716	8775	2936.6231

5. Conclusion

From the analysis above, we can make the following conclusions:

- Globally the 2-degree target by 2100 has been confirmed in the international negotiation process in recent years. Even though this target was set by the Kyoto Protocol in 2010, given the slow progress on this in the last decades, the question remains whether or not this target is actually China plays a critical role in the global GHG mitigation effort. China's CO2 emissions from energy and cement consumption already account for nearly 29% of global emissions, and this is expected to keep increasing.
- The findings suggest it is possible for China to limit its CO2 emissions and peak its emissions before 2025, which makes the global 2-degree target feasible. In this case, development of China's energy system is key.
- Previous studies on emissions scenario shows that it is possible for China to peak its CO2 emissions by 2030 if strong policies are adopted, although with a relatively high cost. Peaking CO2 emissions before 2025 would be a very big challenge for China. An IPAC modeling study on the feasibility of meeting the 2-degree target shows it is possible for China to peak CO2 emissions before 2025 with several pre-conditions, including optimising economic development, further improvements to energy efficiency, enhanced renewable energy and nuclear development, CCS etc.
- The installation of new technology is a key driver in the LC emission scenario. And recent progress of key technologies as well as enhanced low carbon investment and policy implementation make it more likely for China to embark on a low carbon emission development pathway.
- Energy efficiency should be further promoted. A policy framework was established in the 11th FYP to encourage energy conservation, which provides a good basis for improving energy efficiency in the 12th FYP and after. Much more specific policy and action on energy efficiency could be implemented such as higher energy efficiency standards, market-based mechanisms, higher building energy code, etc. The target is to make China's energy efficiency in major sectors world-leading by 2025 to 2030.
- China is now a world leader in new and renewable energy production. By 2011, installed wind power capacity in China was 62.7GW, with an increase of 18GW in 2011 (two thirds of newly installed capacity globally that year); and the annual growth rate from 2008 to 2011 was higher than 60%. Based on the government's plan, by 2020 renewable energy will make up 15% of total primary energy, which includes renewable energy not currently shown in national energy statistics.
- In the global 2-degree scenario, power generation from renewable energy could reach 48% of total power generation, leaving only 17% for coal fired power generation. Installed capacity for wind, solar and hydro energy is projected as 930GW, 1040GW, and 520GW respectively by 2050.
- The transition towards a low-carbon future requires large-scale investment. China's rapid GDP growth has provided the basis for the investment needed.
- It is difficult to determine the investment needs for China's CO2 emissions target because of the different definition and methodology adopted. However, we managed to present investment needs for technology. Investment needed in the energy industry is

provided based on the specific technologies required in the low carbon scenario to calculate their investment need for fixed asset. For other energy end use sectors, investment needs are given based on the additional costs for more energy efficient technologies, compared to baseline technologies.

- Based on the IPAC modeling analysis, investment needed in the energy sector in the 2-degree scenario could reach 1.2 trillion RMB by 2020, 1 trillion by 2030 and 1.4 trillion RMB by 2050.
- The investment needed for energy saving could be 1.6 trillion RMB by 2020, 1.8 trillion RMB by 2030, and 1.5 trillion RMB by 2050. This is the additional investment compared with old technologies.
- The investment needed in the energy sector including energy saving would be 2.8 trillion RMB by 2020, 2.8 trillion RMB by 2030, and 2.9 trillion RMB by 2050.
- These investment figures account for 2.5% of China's total GDP in 2020, 1.3% in 2030, and 0.6% by 2050, which presents quite a small share of the intended investment in low-carbon development.