JCER Working Paper
AEPR series
No. 2020-1-6

This is the pre-peer- reviewed version of the following article: "Energy and the Environment", *Asian Economic Policy Review*, vol. 16, issue 1, which has been published in final form at https://onlinelibrary.wiley.com/doi/10.1111/aepr.12330 and DOI: 10.1111/aepr.12330.

Transition of the Chinese Economy in the Face of Deep Greenhouse Gas Emissions Cuts in the Future

Jiang Kejun
(Energy Research Institute, NDRC)

He Chenmin
(Peking University)

Jiang Weiyi
(State Grid Jiangsu Electric Power Engineering Consulting Co. Ltd)

Chen Sha
(Beijing University of Technology)

Dai Chunyan
(Chongqing Technology and Business University)

Liu Jia
(Beihang University)

Xiang Pianpian
(Tsinghua University)

This paper was prepared for the Thirty-first Asian Economic Policy Review (AEPR) Conference "Energy and the Environment," March 28, 2020, via ZOOM.

January 2021

Asian Economic Policy Review
Japan Center for Economic Research

To authors

If you want to introduce the same working paper you wrote and presented at the AEPR conference held in Tokyo on Mar. 28, 2020, in your own/your affiliation's website, please be aware the following requirements.

To ensure that all citations and references to your published article are captured by the SSCI (Social Sciences Citation Index), authors are required to amend the cover page of your working paper as soon as practical after publication in AEPR. The amended cover page should include the full article citation, journal name, volume and issue, and DOI, as well as a hyperlink to the published article. The cover page of JCER Working Paper AEPR series has been already amended after publication in AEPR. The face of this working paper is an example of an amended working paper cover page.

Transition of the Chinese Economy in the Face of Deep Greenhouse Gas Emissions Cuts in the Future

Jiang Kejun, He Chenmin, Jiang Weiyi, Chen Sha, Dai Chunyan, Liu Jia, Xiang Pianpian

Abstract: China joined Paris Agreement, and the global 2℃ and 1.5℃ warming targets will be supported by China. In order to reach these targets, China's CO_2 emission need to have deep cut by 2050. This paper presents the studies from IPAC modeling team about the impact on economic development in China due to deep cut of GHGs, in order to realize the Paris climate change targets. With the requirement of deep cut of GHGs in China, China's economic development will also be driven by the deep cut of GHGs, going toward a low carbon or zero carbon emission-based economy by 2050. This means economy need a strong transition in next three decades, which is a relatively short time. All sectors in the economic system need to seek way to reduce GHGs, and this could change the activities, industry process and technologies to make the deep cut of GHGs happen. This is the meaning of economy transition toward to a low carbon economy.

Keywords: CO2 emission reduction, China, Paris Agreement, energy transition, economy transition, scenario

1. Background

In 2015, At the COP25 in Paris, parties decided "to hold the increase in global average temperature below 2°C above preindustrial levels" and make best effort to limit a global average temperature rise of 1.5°C". Many researches in the world on the emission pathways towards to the targets have been published and summaries in recent published IPCC report (IPCC, 2014; IPCC, 2018).

Recently several global emission scenario studies presents energy and emission scenarios focusing on the 2℃ and 1.5℃ targets, which requires global emission must cut 50% by 2050 at least and to be net zero emission by 2050 respectively(IPCC, 2018). It is essential to make further analysis in country level to see whether there is possibility to mitigate CO_2 emission to follow the 2℃ and 1.5℃ target pathway. As a largest emission country, China's future emission pathways are crucial for the global emission reduction pathways. IPAC modelling team published researches for China to make energy transition and emission reduction pathways to support global 2℃ and 1.5℃ targets(Jiang et al, 2013; Jiang et al, 2018), and investment needs were also presented(Jiang et al, 2018). However, there are still many questions remained for feasibilities of these pathways. This paper presents the analysis from IPAC modelling on future economic development pathway which potentially impacted by the deep cut emission pathways.

In IPAC modelling analysis, in order to understand the future transition of energy in China, development ways of economy are one of the most important factors to quantify the future energy demand. IPAC modelling team has been putting efforts on analysing economy development in China by using modelling tools, and involvement in discussion of economists in China, to understand the possible future pattern of economy development. However, this paper will present new findings from IPAC modelling team about the future economic development in the deep cut of GHG emission pathways, which require strong transition of economy in China, also in other countries. This analysis is different with the analysis from economist in China.

2. China's Climate Change Future

In April 2016, China joined the signature of Paris Agreement. This means the global 2℃ and 1.5℃ warming targets were accepted by China. Therefore, China's future GHG emission pathways will be consistent with the global targets. Even though China's commitment to Paris Agreement expressed by NDC is to peak CO_2 emission around 2030, and make effort to peak earlier. The NDC commitment from China is up to 2030. However, based on IPAC model analysis, peaking around 2030 will make China's emission pathway very difficult to be consistent with the global 2℃ warming target, and it is infeasible to make 1.5℃ warming target. All scenarios of GHG emission in China under the global targets required earlier peaking. For 1.5℃ warming target, need to peak CO_2 emission right now, and then make deep cut of CO_2 emission until to be early net zero emission by 2050(Jiang et al, 2018).

3. Emission reduction scenarios

In previous analysis from IPAC, five scenarios were given for IPAC model analysis for China, including baseline, low carbon and enhanced low carbon scenario, 2℃ and 1.5℃ scenario. Recent studies mainly focus on the 2℃ and 1.5℃ scenarios. In this study, we will mainly use the 1.5℃ scenario because there is a strong demand for deep cut in all sectors in order to make China's CO_2 emission to be nearly net zero by 2050, while the CO_2 emission will be reduced by around 65%by 2050 compared with that in 2015 in the 2℃ scenario. From 2012, the 2℃scenario for China was published(Jiang et al, 2013; Jiang et al, 2014), this scenario identify the feasibility for China to reduce CO_2 emission reduction by following global 2℃target, with using burden sharing regime by IPAC team(Jiang et al, 2013). In 2018, emission scenario for China focusing on 1.5℃ target was published[5]. In the scenario analysis from IPAC, there is strong need for deep cut of sectors which is difficult to get deep cut of GHGs, including steel making, cement making, chemical industries. This paper will focus on the ways to use hydrogen as one of key options for deep cut of CO_2 emission. This is a new analysis from IPAC model by looking at the potential to use hydrogen, while the previous analysis for 1.5℃ scenario rely heavily on BECCS in 2050(Jiang et al, 2018; Jiang et al, 2020). However, there are difficulties for capture 1.6billion-ton CO_2 in 2050 by BECCS, due to lack of water supply to plant trees in the area with rich CO_2 storage. Therefore, we are looking at other options in the 1.5℃ scenario including utilization of hydrogen and direct capture of CO_2 from air, with the much cheaper renewable energy power.

The 1.5℃ scenario requires 1900ton to 2300 ton carbon budget for China from 2015 to 2050 based on the study from ADVANCE project and CD-LINK project. Our study for 1.5℃ scenario is following the range. Now we worked out the scenario with 2300-ton carbon budget, but failed to make the lower carbon budget for China.

With the analysis by including hydrogen process in the model, to match with the carbon budget required for 1.5℃ target, the energy transition scenario was given in Figure 1 to Figure 4, and the CO_2 emission is given in Figure 5. Renewable energy power generation is calculated by 860kcal/kWh to convert to primary energy, same method with that used by IEA.

Primary energy demand will reach peak in 2025, which is 3200Mtoe. Primary energy starts to decrease mainly because of much more renewable electricity. Final energy demand would also reach peak by 2025, due to economic structure change and share of electricity significantly increased.

By 2050, the hydrogen demand could reach 52.4million-ton(178Mtoe), account for 9.2% of final energy. There will be 1884TWh electricity demand used for hydrogen electrolytic from water (see table 5). Then total power generation would be 16671TWh by 2050.

CO_2 emission would be 177million-ton, which is 98.6% reduction compared with that in 2015. Accumulated CO_2 emission from 2015 to 2050 is 215billion-ton, which is in the range of carbon budget for China for 1.5℃ target(see figure 4).

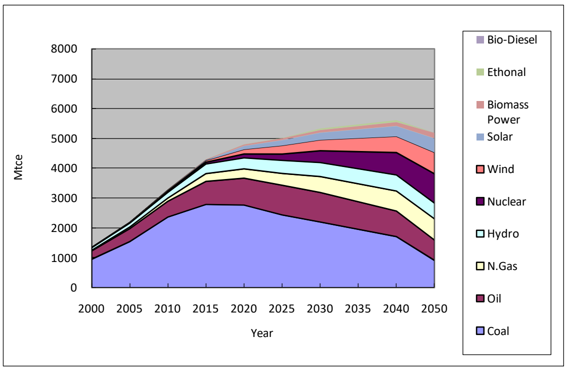

Figure 1 Primary energy demand in China, 2℃ Scenario

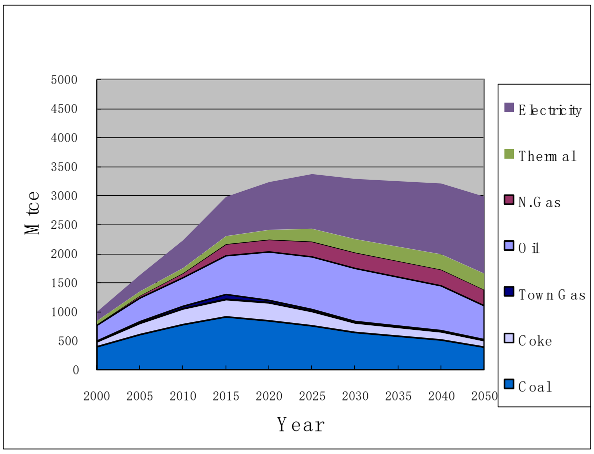

Figure 2 Final energy demand in China, 2℃ Scenario

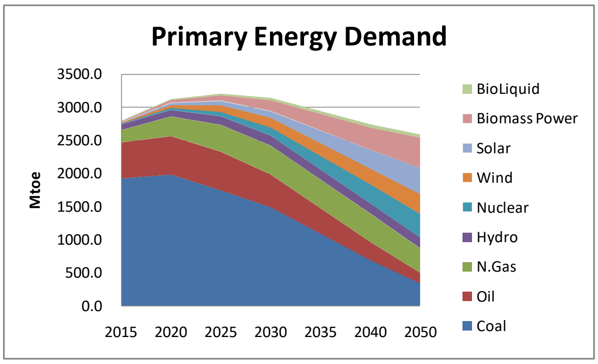

Figure 3 Primary energy demand in China, 1.5 scenario

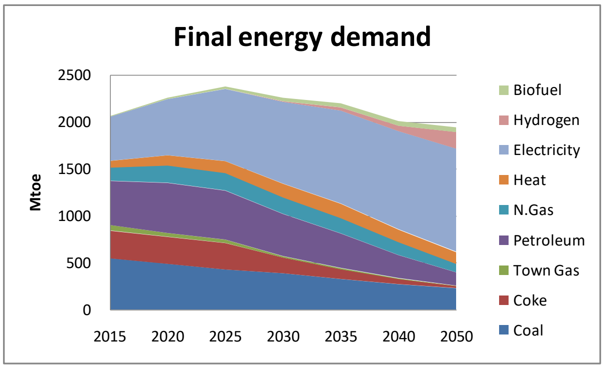

Figure 4 Final energy demand in China, 1.5 scenario

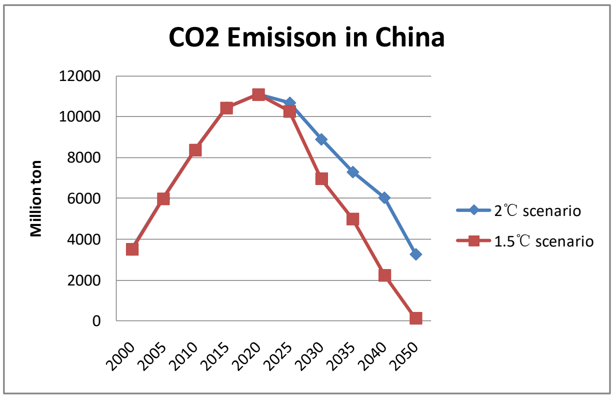

Figure 5 CO_2emission (including industry process emission)

4. Economy development in China and Transition

In last several decades, China's GDP has kept rapid growth. From 1990 to 2015, annual growth rate is 9.81% . After 2015, the growth rate is decreasing, which was called "New Normal". From 2015 to 2019, annual growth rate is 6.55% . One significant changing in the economic structure is share increasing of tertiary sector. It was 41% in 2005, and 53.9 in 2019(NSB, 2019; NSB, 2020).

By following pathways in developed countries, one key factor is the share increasing of tertiary sector, as a normal development patter. In IPAC modeling analysis, increasing share of tertiary sector was given, see Figure 6.

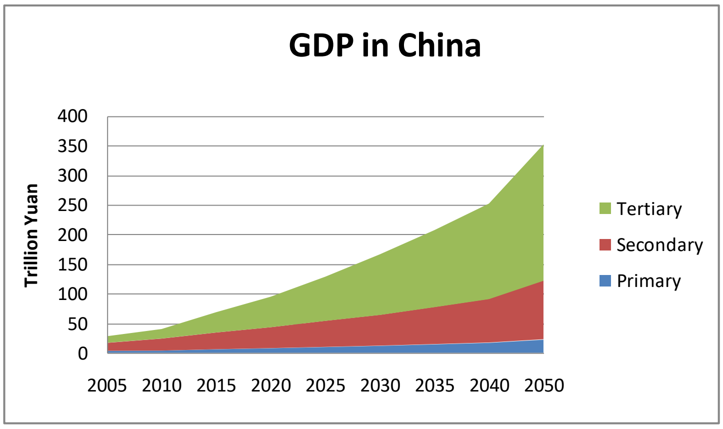

Figure 6 GDP scenario from IPAC

However, the most important factor for economic transition is industry transition. Subsectors in industry sector will have much more significant shifting, from energy intensive industry to other industries. Figure 7 presents the value added in industry sector by using IPAC-SGM model, and Table 1 and Table 2presents the selected energy intensive products scenario which given in different years.

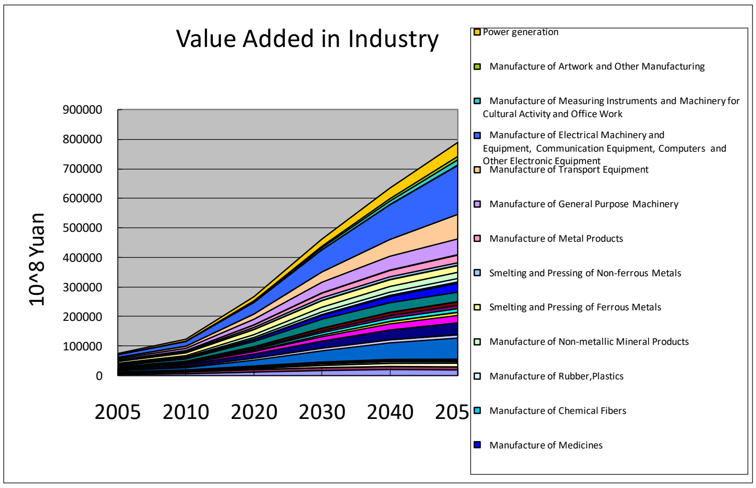

Figure 7 Value added in industry sectors

Table 1 Energy intensive products output scenario from IPAC, set up in 2018

Product	Unit	**2005**	**2010**	**2014**	**2018**	**2020**	**2030**	**2040**	**2050**
Steel	Million ton	3.55	6.27	8.13	9.28	7.1	5.7	4.4	3.6
Cement	Million ton	10.6	18.68	24.9	23.6	22	16	12	9
Glass	Million cases	3.99	5.8	8.31	8.68	7.4	6.9	6.7	5.8
Copper	Million ton	260	479	795		760	700	650	460

Ammonia	Million ton	851	1695	2438		2500	1700	1500	1200
Ethylene	Million ton	510		1005		1000	700	650	550
Soda Ash	Million ton	1467		2525	2620	2500	2450	2350	2200
Caustic	Million ton	1264		3063	3420	3000	2500	2500	2400
Paper	Million ton	6205	9270	11785	11600	11000	11000	10500	10000
Fertilizer	Million ton	5220		6876	5418	6400	5900	5600	5300
Aluminum	Million ton	756		1696	1840	2400	2300	2300	2300
Paper	Million ton	4630		5699		5200	5000	5000	4500
Calcium carbide	Million ton	850				2200	1600	1100	700

Table 2 Energy intensive products output scenario from IPAC, set up in 2008

Product	Unit	**2005**	**2020**	**2030**	**2040**	**2050**
Steel	Million ton	355	650	570	440	360
Cement	Million ton	1060	1750	1600	1200	900
Glass	Million cases	399	650	690	670	580
Copper	Million ton	2.6	7	7	6.5	4.6
Ammonia	Million ton	8.51	17	16	15	12
Ethylene	Million ton	5.1	7.2	7	6.5	5.5
Soda Ash	Million ton	14.67	23	24.5	23.5	22
Caustic	Million ton	12.64	25	25	25	24
Paper	Million ton	62.05	110	115	120	120
Fertilizer	Million ton	52.2	61	61	61	61
Aluminum	Million ton	7.56	34	36	36	33
Paper	Million ton	46.3	50	50	50	45
Calcium carbide	Million ton	8.5	10	8	7	4

Rapid increase of energy intensive products after 2000 was mainly driven by domestic infrastructure development and export. After 2010, China’s infrastructure development gets to be extremely large scale (see Figure 7), and export are also very big, products in China occupiedunbelievable share in the world. Figure 8 presents the newly build building floor space, and Table 3 present the share of products from China in the world.

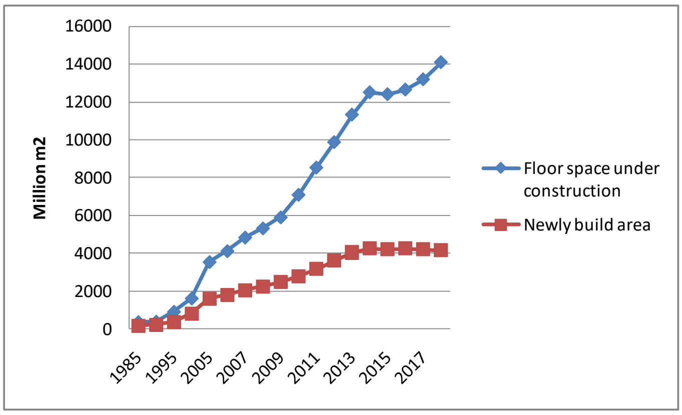

Figure 8Building floor space under construction and newly finished

Table 3 Products output in China and their share in the world

	2009			2018	
	Output	Unit	Share in the world	Output	Share in the world
Raw steel	568	million ton	46.6%	982.3	51.3%
Cement	1630	million ton	51%	22100	55.95%
Glass	580	million ton	50%	868.63	50%
Chemical fiber	27.3	million ton	57%	50.111	68.27%
Aluminum	12.8	million ton	60%	35.8	55.64%
Copper	4.13	million ton	25%	9.03	35%
Cloth	74000	million ton meter		65726	>50%
Coal	3050	million ton	45%	3680	46%
Fertilizer	66	million ton	35%	54.59	
Plastic	44.8	million ton		60.42	17.8%
Automobile	13.8	Million	25%	1798.46 百万台	>90%
Ship	42.43	million carrying ton	34.8%	34.58	36.3%
Computer	182	million	60%	351.92	>90%
Refrigerator	59.3	Million	60%	78.77	>50%
TV	98.99	Million	48%	203.81	>70%
Air Conditioner	80.78	Million	70%	2048	0.75%
Washing Machine	49.45	Million	40%	71.51	>50%
Mobile phone	619	Million	50%	1800	90%
Microwave oven	60.38	Million	70%	62.72	0.75%

Shoes		Million shoes		24200	55.8%

China is in its rapid expending period in infrastructure. Because the importance of energy intensive products in energy scenarios, IPAC modeling team analyzed the future demand scenario of selected energy intensive products based on physical I/O table, together with output from IPAC-SGM model which is a CGE type model. Many energy intensive products have close relationship with infrastructure development and consumer demand in household. Building construction is most important one among them. Data in Table 2 could support 3.5billion m^2 building build every year. Based on the IPAC modeling analysis, if the 3.5billion m^2newly build building floor space could be maintained for next 20 years, and then decrease, floor space per capita could reach more than $75m^2$, while floor space per capita for Europe and Japan is around $55m^2$, and around $90m^2$ in US, Canada and Australia. This is a relatively large number for China. The study from IPAC showed that there would be over capacity of heavy industry in 2010. However due to economic crisis started in 2008 all over the world, China put Rmb4trillion Yuan investment packages to stimulate economy, mainly going to building construction sector and other infrastructure sectors. This drove continuing increase of energy intensive products output in China. By 2019 these energy intensive products reached high level of output. However there increase trend got to be slow down after 2015, and some of them even started to decrease.

The changing trend of energy intensive products sectors play key role in economy transition. Rapid increase of development of real estate is getting to be less important in GDP development. This will bring significant impact on steel, cement, glass, non-ferrous products etc. demand in China. And then the industry in China is shifting to more supermarket demand whicn are based manufactures.

5. Deep cut of GHGs as factor on impacting economy future

5.1 Ways from deep cut of GHGs on impacting economy development

Deep cut of GHGs by 2050 in China, will influence economic development in following ways:

- Overall impact in economic development pattern. Clear reduction targets will ask industries and consumer to response. Policies for reduction could change the production structure. New industry process including hydrogen as feedstock and reduction materials to make steel, chemical products; new technologies including advanced battery for vehicles and power storage, advanced nuclear power generation etc.; new materials which could replace high emission products, such as plastic from renewable materials; new consumption behaviors including carbon labeling, carbon footprint life, which can change manufacture industry significantly; new energy use pattern to be zero emission energy supply, or even negative emission energy supply. Due to GHG emission reduction, the whole economic system has to make the transition to match the requirement for deep cut of GHGs.

- Energy supply industry will have strong transition to zero carbon energy system by 2050, and they have to be high security with totally new supply system. Together with economic transition, there is big potential the energy demand will increase with zero energy supply. And many technologies are needed in the energy supply transition.

- Transition in end use sector. Fully electrification in end use sector, and new industry process with much less GHG emission are key options for deep cut of GHGs. Most of transport will use electricity or hydrogen from electrolytic process including airplane, 100% electricity use in building, replacing fossil fuel by electricity in industry.
- New manufactures process in some sectors. This is very important in industry sector where is difficult to reduce CO_2 emission in some process, where have to use fossil fuel as process input, such as steel making, cement clinker making, chemical products etc. Hydrogen could be an option to be a reduction material, but there is need an innovation in the new process. Good news the hydrogen-based industry process is getting to be at beginning stage, there are several pilot projects undergoing.

5.2 Overall guidance for economy development as deep cut of GHGs

Deep cut of GHG could have big impact on energy use. Energy use is in almost every sector and household. Much lower emission or even zero emission energy supply and use could bring difference course for economy development. Climate change mitigation strategies could play a role in overwhelming dominating strategies in a country or region. EU's GHG mitigation strategy is a good example for this. With a very strong commitment of GHG emission reduction, EU's economic activities followed the reduction targets.

Right now, there is no specified emission reduction target in long-term, say 2050. NDC from China committed to peak CO_2 emission around 2030, and try to peak earlier. Peaking CO_2 emission around seems not a strict target for China, and trying to peak earlier is not regarded as a target in China. Therefore, there is not a strong enough guidance for China's economy to make transition based on CO_2 emission reduction requirement. Peaking around 2030 hardly match with the emission pathways under global targets in Paris Agreement.

In previous analysis from IPAC, five scenarios were given for IPAC modelling analysis for China, including baseline, low carbon and enhanced low carbon scenario, 2℃ and 1.5℃ scenario. Recent studies mainly focus on the 2℃ and 1.5℃ scenarios. In this study, we will mainly use the 1.5°C scenario because there is a strong demand for deep cut in all sectors in order to make China's CO_2 emission to be nearly net zero by 2050, while the CO_2 emission will be reduced by around 65%by 2050 compared with that in 2015 in the 2℃ scenario. From 2012, the 2°C scenario for China was published (Jiang et al, 2013; Jiang et al, 2014), this scenario identify the feasibility for China to reduce CO_2 emission reduction by following global 2°C target, with using burden sharing regime by IPAC team. In 2018, emission scenario for China focusing on 1.5°Ctarget was published (Jiang et al, 2018).

There is large possibility for China to revise its NDC to get strong commitment. And research projects are working on the middle century strategy which will be submitted officially. The possible climate change strategy with a strong target is coming, which will be beneficial for the low carbon economy transition.

5.3 Energy supply transition

Energy supply play most important role in the deep cut future. Recent IPCC reports clearly presents rapid transition in energy system. By 2050, renewable energy and nuclear will dominate energy supply. This is same story for China. Figure 1 and Figure 3 show the primary energy demand in China based on IPAC results. The energy industry will shift largely to renewable energy and nuclear.Figure9 and Figure10 give power generation in the 2°C and 1.5°C scenarios. All these show the energy sector transition is significant, and they present one part of economic transition.

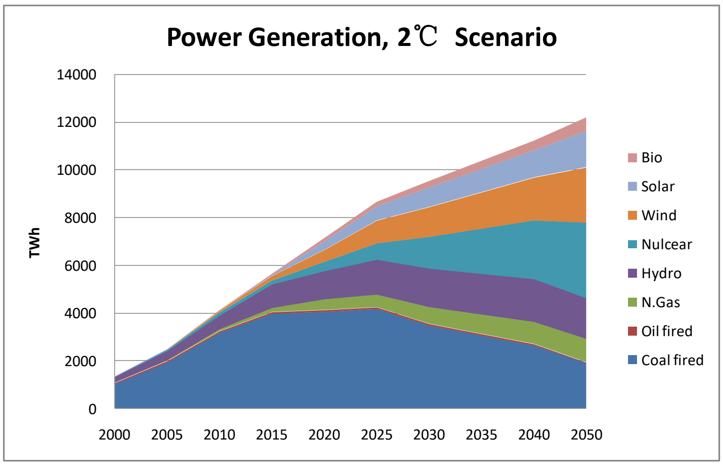

Figure9 Power generation scenario for China, 2 scenario

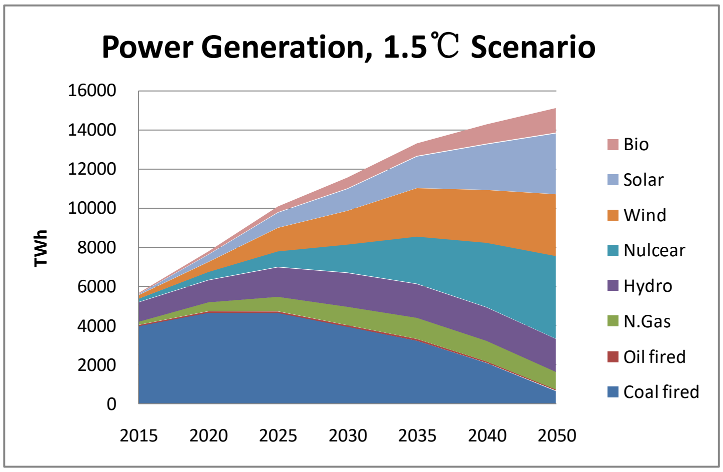

Figure10 Power generation scenarios for China, 1.5 scenario

5.4 Low carbon economy: sectors besides energy supply sectors

Options for end use sector to be deep cut is to use electricity to replace fossil fuel, energy conservation, behavior change. For electrification, it is significant in transport, building, and industry.By 2050, 100% of car, bus, light duty vehicles, part of heavy-duty vehicles, most railways will be electrified. And by 2040, all car fleet will be auto drive which could make electricity use efficiency much higher due to light weight of vehicles when there is no accident, and traffic jam. In this way, public transport by bus would disappear. Part of heavy-duty vehicles, heavy load ship, part of air plane, and some locomotives will use hydrogen by fuel cell. This is totally different with today's transport system.

In industry sector, most manufacture process will be driven by electricity through electric motors. Most of heat demand will also provide by electricity, or recovered heat supply from chemical process.

Hydrogen use in industry will also play key role in the deep cut of GHGs in industry sectors, which will be discussed in detail in next session.

In building sector, low energy demand building will be the mandatory standard for new buildings after 2025, which could bring down the total cost for deep cut of GHGs by 2050, which mainly support by electricity in the sector.

5.5 Transition of manufacture sectors

Hydrogen could play important role in several sectors. In recent EU's carbon neutral scenario by 2050, hydrogen was described as important option for carbon reduction in industry(FCH, 2019). Here we use similar analysis reported in these lectures. However, there are different industry process in related sectors in China with that in EU. For example, coal is major feedstock to manufacture ammonia, methanol in China, while natural gas is used in EU. Such kind of difference could bring different on CO_2 emission and cost analysis.

In the scenario analysis from IPAC, there is strong need for deep cut of sectors which is difficult to get deep cut of GHGs, including steel making, cement making, chemical industries. This is a new analysis from IPAC model by looking at the potential to use hydrogen, while the previous analysis for 1.5°Cscenario rely heavily on BECCS in 2050[5]. However, there are difficulties for capture 1.6billion-ton CO_2 in 2050 by BECCS, due to lack of water supply to plant trees in the area with rich CO_2 storage. Therefore, we are looking at other options in the 1.5 scenario including utilization of hydrogen and direct capture of CO_2 from air, with the much cheaper renewable energy power. Table 4 gives the sectors using hydrogen in IPAC model analysis. Table 5 presents the parameters for these sectors to utilize hydrogen. In these sectors, transition to hydrogen-based process are critical.

Table 4 Hydrogen utilization in different sectors

Sector	Activities
Transport	Heavy-duty truck
	Railway locomotives
	Ship
	Airplane
Industry	Steelmaking
	Ammonia

	Ethylene
	Methanol

Table 5 Parameters for industry sector to use hydrogen

Indicators	Units	2015	2020	2030	2040	2050
Steel making with electric furnace	Million ton	54.6	117.7	169	207	213
Steel making from hydrogen reduction process	Million ton	0	0	5.2	55.9	105
Output of Ammonia	Million ton	57.9	57	56	53	50
Share of ammonia from hydrogen process	%	0	0	5%	48%	100%
Output of ethylene	Million ton	17.1	18.4	24	29	34
Share of ethylene from hydrogen process	%	0	0	6%	35%	50%
Output of Methanol	Million ton	33.9	66	75	78	78
Share of Methanol from hydrogen process	%			2%	16%	55%

5.6 Technology leading

New technology development is one of key part of economic activities in economy system. To be deep cut of GHGs need large scale change of technology system in future, otherwise it is impossible to have the transition toward deep cut, or even net zero emission, negative emission by 2050 or after.

In the energy transition and economic transition, there is strong demand for new technologies in almost all the sectors. This is in general a good opportunity for China’s industry. For traditional industries, most technology IPs were occupied by other countries, there is not much room for Chinese industry to compete. China is a largest country for manufacture, but not in manufacture technology IPs.

With China’s GDP growth, investment on technology R&D increased much faster than GDP growth rate. By 2018, total R&D investment in China is US$409billion, and US is US$496billion, while it is US$336billion and US$457billion in 2013 respectively. With the energy and economy transition, there is large potential for China to play an important role in low carbon related technologies in future.

Potential area for technology leading in China could include CCS, hydrogen, advanced nuclear, new grid system. Especially in advanced nuclear power generation, there is capacity for China to put investment and researcher resource to work on nuclear fusion technology, and to be a second project outside ITER.

5.7 Oversea investment

Traditionally China's export is one of key driving force for economy development. China's oversea investment has played a small role in the export of China before 2010. However, there is a rapid increase of China's oversea investment after 2010(see Figure 11). China's oversea investment could play much big role in China's export (Zheng, 2007; Zhu, 2006; Lin, 2017). In 2017 the regulation from government on oversea investment was announced and the control for oversea investment got strict, and then seeing a decrease of China's oversea investment. However, we think this will be a short-term trend. With China's economic transition, there is no more increase of investment demand for energy intensive sectors, or even started to decrease. There is over supply of investment in China in recent years. Investment going outside China is a necessary way to utilize the additional investment. Based on the GDP assumption in IPAC model (see Figure 6 GDP scenario from IPAC), COI scenario was given, see Figure 12(Jiang et al, 2017). In the COI, nearly one third is in carbon emission related activities, including energy infrastructure, industry, transport etc. It could be nearly US$150billion in 2030, and US$300billion in 2050, which is much big than the amount developing country required from developed countries for GHG mitigation in UNFCCC. If the investment could be low carbon or zero carbon emission investment, it will be much helpful for developing countries to realize deep cut of GHGs, to support the Paris targets (Jiang et al, 2017). In IPAC's study, low carbon principal for COI was proposed.

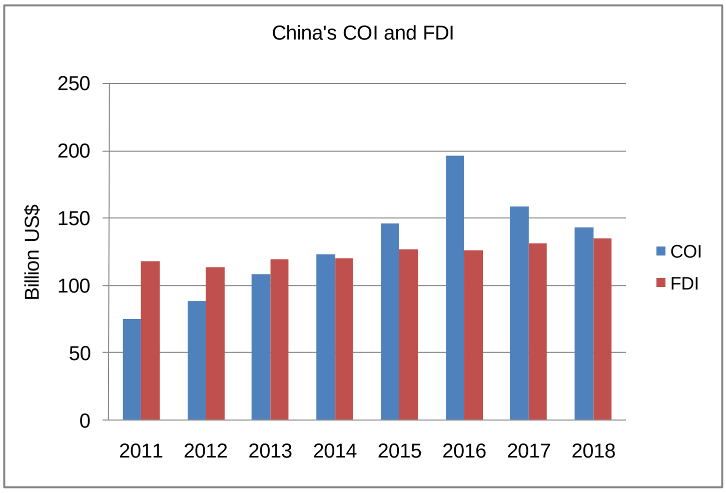

Figure 11 China's oversea investment (COI) and foreign direct investment (FDI)

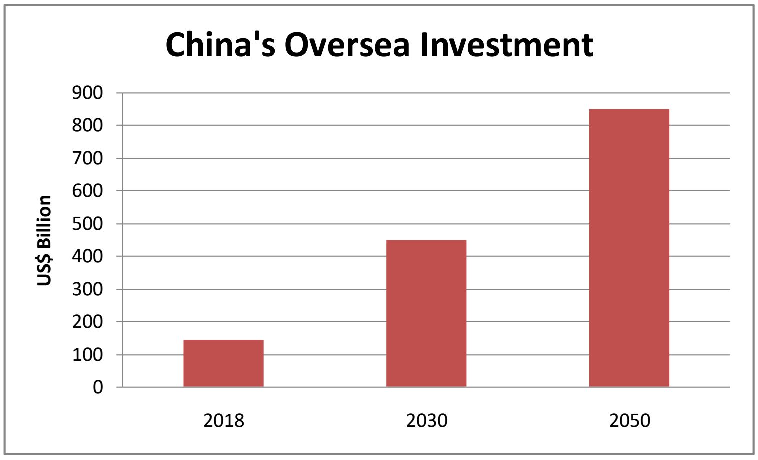

Figure 12 COI scenario from IPAC

If China could make transition on energy and economic, the COI could be benefit from this transition, and may extend COI due to political environment and technology leading. And if the world could make Paris targets happen, it will be less cost for China in long-term when China will be the largest economy country and need to take care of global issues.

5.8 Increasing economy development

In most studies, mitigation of GHGs would have negative impact on economicdevelopment (IPCC, 2001; IPCC, 2014; IPCC, 2018). This mainly presented by improving environment as big burden for cost in mitigation. Even though cost benefit analysis for abatement of climate change could be much larger benefit by including benefit of avoided climate damage. But negative impact on economy from mitigation of GHGs already brought in loud argument on moving further on mitigation by countries, especially in the international collaboration process.

In the traditional economic, prevention of air pollution and other environment could bring negative impact on economy activities (Jaffe, 1995). In the meantime, some studies conclude that there could be consistency between environment improvement and economy development. Well-designed environment regulation could initiate innovation from enterprises, and then make their economic competition stronger, this is called "Port Hypothesis ". However, this was not fully supported by other studies.

China's could make good choice of policies to have positive impact on economic development by deep cut of GHGs. Figure 13 and Figure 14 present the results from IPAC-SGM model, which is a CGE type model. The results show that in deep cut scenarios (2°C scenario), the GDP could be increased. Reasons for this include extended export due to leading in low carbon technologies, China's oversea investment, productivity increase due to technology innovation, much low cost for zero emission technologies which could significantly reduce investment need compared with baseline scenarios. More energy conservation in 2°C scenario could also reduce expenditure of energy from public, this could make higher consumption in other economic activities.

Recent studies focusing on economic impact from air pollution control in China show there could positive effects on economy development (Jiang et al, 2020). Such kind of finding could encourage policy maker to check their policies on environment improvement, and combine well the policies on environment improvement together with economic development policies.

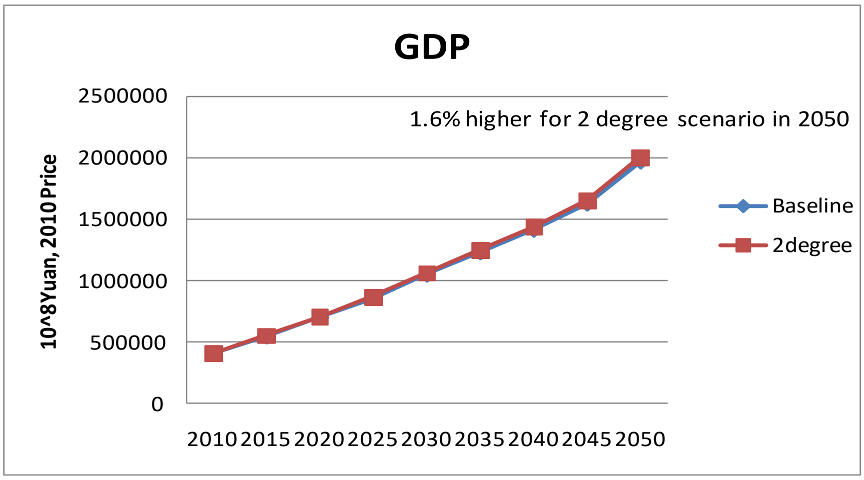

Figure 13 GDP in baseline scenario and 2 scenario, IPAC results

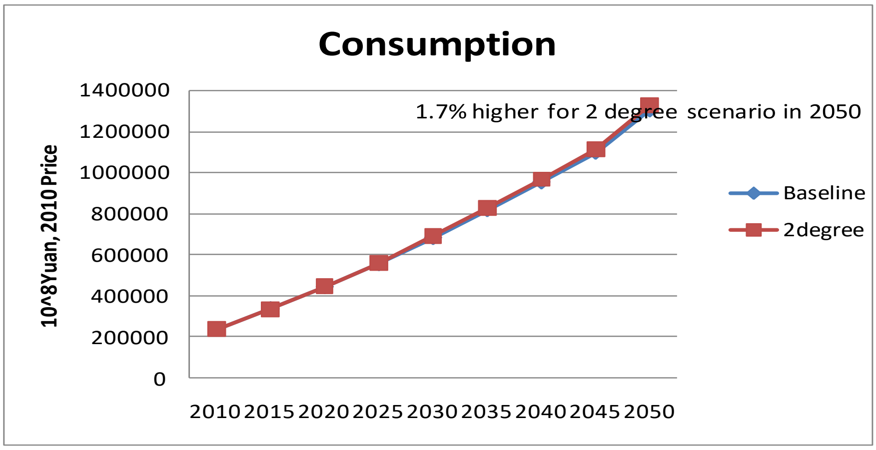

Figure 14 Consumption in baseline scenario and 2 scenario, IPAC results

6. Conclusion

This paper presents the studies from IPAC modeling team about the impact on economic development in China due to deep cut of GHGs, in order to realize the Paris climate change targets. With the requirement of deep cut of GHGs in China, China's economic development will also be driven by the deep cut of GHGs, going toward a low carbon or zero carbon emission-based economy by 2050. This means economy need a strong transition in next three decades, which is a relatively short time.

All sectors in the economic system need to seek way to reduce GHGs, and this could change the activities, industry process and technologies to make the deep cut of GHGs happen. This is the meaning of economy transition toward to a low carbon economy.

There will be totally innovation in some sectors for industry process and technologies, such as hydrogen-based reduction process to make materials, electric vehicle, electric airplane or hydrogen fuel cell air plane, high security grid system to utilize renewable energy etc.

Such kind of economic transition could bring benefit for China's social-economic development. China's economy is already in transition, and need to be further low carbon oriented. This transition will increase China's technology leading in future, and get economic activities extended. IPAC's modeling results also show deep cut of GHGs could increase GDP rather than a loss of GDP. These together could encourage China's policy making process.

Reference

FCH(2019)Hydrogen Roadmap Europe, FCH publication, available at: https://www.fch.europa.eu/sites/default/files/Hydrogen%20Roadmap%20Europe_Report.pdf
IPCC(2007)Forth Assessment Report: Mitigation, Cambridge University Press, UK.
IPCC(2014)Fifth Assessment Report: Mitigation, Cambridge University Press, UK.
IPCC(2018)Special Report on 1.5℃ Warming, IPCC
JaffeAB,PetersonSR,PortneyPR,StavinsRN.Environmental Regulation and the Competitiveness of U.S. Manufacturing:What Does the Evidence Tell Us[J]? Journal of Economic Literature.1995.33(1):132-163.
PorterME,Lindevan der C.Toward a New Conception of the Environment-Competitiveness Relationship.Journal of economic perspectives[J].1995.9(4): 97-118.
AlbrizioS,KozlukT,Zipperer V. Environmental policies and productivity growth: Evidence across industries and firms[J].Journal of Environmental Economics and Management.2017,81:209–226.
Jiang Kejun, Xing Zhuang, Ren Miao, He Chenmin (2013) China's Role in Attaining the Global 2 Target, Climate Policy, Vol.13, No.S01, S55-S69, http://dx.doi.org/10.1080/14693062.2012.746070
Jiang Kejun, Xing Zhuang, Ren Miao, Song Li Zhu, Chen Min He(2014). China's Energy and Technology Development to Support Global 2 Degree Target，Advanced Materials Research (Volumes 524 - 527), 2496，Doi：10.4028/www.scientific.net/AMR.524-527.2496
Jiang, Kejun, Chenmin He, Hanchen Dai, Jia Liu, and Xiangyang Xu. 2018. "Emission Scenario Analysis for China under the Global 1.5℃ Target." Carbon Management. doi: https://doi.org/10.1080/17583004.2018.1477835.
JiangKejun, Xing Zhuang, Chenmin He, Jia Liu, Xiang-Yang Xu, Sha Chen（2016）China's low-carbon investment pathway under the 2 °C scenario，Advances in Climate Change Research，Volume 7, Issue 4, December 2016, Pages 229–234，https://doi.org/10.1016/j.accre.2016.12.004
Jiang Kejun, He Chenmin, Liu Jia, Feng Shengbo, Wang Juan(2017)Low Carbon and Green Strategy For China's overseas investment, ERI report, Beijing.
Jiang Kejun, Dai Chunyan, He Chenmin, Chen Sha, Xiang Pianpian(2020a)Impact of Air Pollution Prevention on Economic Development in China after 2013：Case Analysis for Beijing-Tianjin-Hebei, Journal of CAS, to be pubished.
Jiang Kejun, He Chenmin, Chen Sha, Xiang Pianpian, Jiang Weiyi, Liu Jia(2020b) Role of Hydrogen in China's Deep Cut of GHGs Scenarios Toward to Paris 1.5℃ Target: IPAC Analysis, Process, to be

published
Lin Wen(2007) . An Empir ical Analysis of the Inter active Relation between International Tr ade and International Dir ect Investment—Based on China's data. Journal of Hubei University of Economics,2007,5(6):62-66.doi:10.3969/j.issn.1672-626X.2007.06.013.
NSB(2019)China Statistic Year Book 2019, China Statistic Publishing House, Beijing
NSB(2020) National economic and social development statistics bulletin 2019, National Statistic Bureau, Beijing
Zheng Menglu(2017) Relationship between International Trade and International Direct Investment-Taking China and India As Case. Knowledge Economy, 2017,(5):37-38.doi:10.3969/j.issn.1007-3825.2017.05.019.
Zhu Liang,Yang Minghua(2006). Relationship Between Foreign Direct Investment and International Trade, Northern Economy and Trade[J]. 2006, (8):89-91. doi:10.3969/j.issn.1005-913X.2006.08.038.