TRANSITIONS PATHWAYS AND RISK ANALYSIS FOR CLIMATE CHANGE MITIGATION AND ADAPTATION STRATEGIES

D3.2 Context of 15 case studies:

China: Construction Sector

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1 Country case studies of the human innovation system (HIS): the enabling environment for sustainability

1.1 Research questions for the building case study

Overarching case study question: How can China promote low carbon development in its building sector considering the varied climatic zones and economic needs in different regions?

1. **What are the main driving forces of energy conservation in building sector?**
    (1) What are the potential factors that hinder the use of energy conservation technology in buildings design, construction and operation?
    (2) Which factors would have impacts on the green energy supply in buildings operation?
    (3) Which factors would have impacts on the behaviours change of energy consumption in buildings sector?

2. **What difference of buildings energy supply and energy demand in the different climate zones in China taking Beijing and Shanghai as two case studies?**
    (1) What are the specific pathways (reduction potentials, economic and social priorities to be considered) in Beijing and Shanghai?
        a) Supply side: what technological options (or processes) are available to promote energy conservation in the building sector?
        b) Demand side: what actions are necessary to increase energy conservation at the end-user side?
    (2) What are the different costs, benefits, risks and opportunities of low-carbon transition in Beijing and Shanghai?
        a) What are the potential CO_2 emission savings from demand and/or supply side energy efficiency measures?
        b) What is the impact of energy efficiency measures on labour in the short medium and long term?
        c) What are the costs associated with improving energy efficiency by X%?
    (3) What are the interests and capabilities of key local actors in Beijing and Shanghai's building sector? Are they conflicts or synergies?

3. **What are the policy options and governance modes for impelling low-carbon transition in buildings sector?**
    (1) What policy options can confront with these potential risks and opportunities of low-carbon transition for buildings sector?
    (2) How can the public be involved in the low-carbon transition for buildings sector?
    (3) What are the difficulties or uncertain risks during the policy options fulfilled?

1.2 Introduction to the general context

1.2.1 Policy overview

Through a long-term development strategy, China has become both the world's largest energy producer and consumer. It has a comprehensive energy supply system based on coal, electricity, oil, natural gas and renewable energy, meeting the basic demands for socio-economic development. However, China's energy production and consumption are also facing difficult challenges, such as enormous energy demand pressure, multiple energy supply constraints, severe damage to the ecological environment, lagging energy technology level and energy security issues due to geopolitical changes. In China, major driving forces for energy structure adjustment are: pressure from population growth and new-type urbanisation development; energy supply security and emission reduction pressure.

As can be seen from China's economic development process, in the thirty years since the process of reform and opening up started, China has been undergoing extensive growth that can be summarised by "sacrificing the environment to attain economic growth". Energy consumption rapidly increased in order to fuel economic growth, which resulted in problems such as energy supply shortages and environmental issues such as air pollution. In order to effectively control CO_2 emissions and alter its energy structure, China has been gradually establishing stricter emission standards and energy development strategies. In 2008, the country issued the Energy Conservation Law of the People's Republic of China to promote energy saving in multiple areas, such as social production and day to day activities and also to improve energy efficiency.

In 2009, China established a target to lower CO_2 emissions per unit of GDP by 40%-45% from 2005 levels by 2020. In the same year, in its 12th Five-Year Plan, the country further established binding targets to: a) cut energy consumption per unit of GDP by 16% from 2010 levels by 2015; b) lower CO_2 emissions by 17%; and c) achieve 11.4% of non-fossil energy in primary energy consumption. In March 2012, according to the 12th Five Year Plan (2011-2015) for Coal Industry Development, total coal consumption would be limited to 3.9 billion tonnes in 2015, a decrease by 3.7% compared to 2013 levels. In the 12th Five Year Plan for Energy Development released in January of 2013, primary energy consumption would be limited to 4 billion tce by 2015 compared to primary energy consumption in 2010 (3.2 billion) (Bureau, 2011).

In September of 2013, the Chinese government put in place the most stringent air pollution prevention and control action plan in its history, which stipulated that the density of inhalable particles in cities at or above prefecture level in 2012 should be cut by over 10% by 2017, and required Beijing-Tianjin-Hebei region, Yangtze River Delta region and Pearl River Delta region to strictly control coal consumption. In 2014, the General Office of the State Council officially issued the Energy Development Strategy Action Plan (2014-2020) (hereinafter referred to as the Action Plan), defining the overall goals, strategic guidelines and major tasks for China's energy development to 2020.

The main actions on low-carbon development and energy conservation include:

1. China has adjusted industrial structure through promoting the transformation and upgrade of traditional industries, accelerating the development of strategic emerging industries and vigorously developing the service industry. The "Government Working Report in 2015" has for the first time put forward the "Internet+" action plan and promoted an in-depth integration of information technology with industrialisation.
2. China has put emphasis on energy conservation and efficiency improvement by: a) strengthening the management and appraisal of energy conservation (e.g. the "2014-2015 Action Plan on Energy Conservation, Emission Reduction and Low-Carbon Development" and coordinating work on energy conservation, emission reduction and carbon mitigation in 2014 and 2015); b) accelerating the implementation of key energy-saving projects, and putting forward improvement in energy efficiency standards and labelling schemes; c) promoting energy-saving technologies and products; and d) vigorously developing the circular economy by promoting energy conservation in buildings, the transportation sector and public institutions.
3. The energy structure optimisation has been progressed by imposing strict control over total energy consumption. For example, the "Energy Development Strategy Action Plan (2014-2020)" has put forward China's energy development targets for 2020, substituting coal to reduce the proportion of coal consumption in primary energy and cutting total regional coal consumption in Beijing-Tianjin-Hebei-Shandong, the Yangtze River Delta and Pearl River Delta regions; by strengthening the clean use of fossil fuels and promoting the development of non-fossil energy (e.g. the "Air Pollution Prevention Action Plan"); and by strengthening the transformation and upgrading of thermal power units. (Dong, 2016)
4. China has been controlling GHG emissions from non-energy activities and increasing forest carbon sinks.
5. Low carbon development actions have also been carried out. These include two batches of low carbon development pilots, which have been launched in forty-two cities in 2010 and 2012 respectively, and seven provinces/cities selected as the pilot places for carbon emissions trade rights in 2011. Additionally, pilot sites for low carbon towns, industrial zones, communities and business places have been selected in 2015.
6. The inventory for greenhouse gases emission has been published in 2005 and 2008, and the "National policies and actions on addressing climate change" annual report has been opened to the public since 2008, with 8 reports published thus far. A "National Low Carbon Day" was also officially announced about on June 2013, as well as specialised funds from the "Clean Development Mechanism (CDM)". For example, there are more than 3,600 CDM projects in China successfully registered with the UN, which form more than 65% of the annual emission reductions from all the registered projects.
7. China is also engaging on capability building on mitigating climate change. Divisions and industries are getting proactively involved in promoting work on mitigating climate change.

Besides technology-based improvements on the capability in emergent weather responses, a series of research projects have been conducted in relevant fields, as well as the education and training programs for both governmental officials and the public.

In order to effectively control the emission of CO_2, relevant departments and fields have set up specialised working schemes and action plans on addressing climate change. The goals for emissions are becoming stricter. By 2020, CO_2 emissions per unit of GDP should be reduced by 40%-45% compared to 2005 levels. China has further improved research on significant strategies and top-level strategies, as well as the administrative system and working mechanisms on addressing climate change. The central government has also set up a responsibility system to reach carbon intensity reduction goals, enacted the "National Planning for Climate Change Programme (2014-2020)", and promoted the legitimisation of relevant laws and regulations. Consequently, from 2005 to 2013, China's energy consumption per unit of GDP has reduced by 26.4%, and the carbon emission intensity has dropped by 28%, amounting to more than 1 billion tce energy saved and a reduction of 2.4 billion tons of CO_2 emission. (Bureau, 2016b). Renewable energy capacity now leads the world, with non-fossil fuels making up 9.6% of the primary energy consumption. Although China still needs to address its energy consumption, and to continue strengthening environmental protection and promoting low carbon development, the general developing ideas have already been made at the top decision-making level. These include efficient and equitable economic development, realising sustainable development goals and low carbon development, as well as strictly controlling energy consumption patterns.

For example, during the 11th Five Year Plan (2006-2010) period, the State Council released a series of policy documents and established a target-oriented responsibility system for energy saving. The Energy Saving and Emission Reduction Comprehensive Work Programme released in 2007 by the State Council defined responsibilities and tasks for State Council departments and local governments for working on energy saving and emission reduction, marking the actual execution phase for the responsibility system as a basic mechanism. In the same year, the Energy Conservation Law stipulated that the complete status of energy saving targets would be added into the performance assessment of local governments. Assessment mechanisms such as the "one vote veto" effectively mobilised initiatives of local governments' fulfilment of carbon emission control. However, China's low carbon development is very dependent on governmental administrative means, requiring heavy investment of governmental administrative resources and funds which have led to some perverse incentives in policy-based supply. For example, at the end of 2010, in order to accomplish "energy saving targets", local governments adopted some administrative orders to limit or even forbid normal energy consumption for day-to-day living and business production.

In recent years, China has realised the importance of market mechanisms and has been actively putting in place relevant policies to support market construction for carbon emissions permit trading. The country proposed to "build and improve trading mechanism for major pollutants and carbon emissions" in the Decision of the State Council on Accelerating the Cultivation and Development of Strategic Emerging Industries in October of 2010. In November 2011, China's

Policies and Actions for Addressing Climate Change (2011) clearly mentioned to “gradually establish a trans-provincial carbon emission trading system by regulating voluntary emission reduction trading and permit trading pilots and by improving carbon emission trading pricing mechanism”. Later, the General Office of the NDRC issued the Circular on Undertaking Carbon Emissions Permit Trading Pilots”, which comprised of seven provinces and cities, including Beijing, Tianjin, Shanghai, Chongqing, Hubei, Guangdong and Shenzhen as China’s pilot regions for carbon emission permit trading (He, 2013).

In December of 2012, the Report to the Eighteenth National Congress of the CPC clearly proposed to “actively undertake carbon emission permit trading, pollution rights trading and water rights trading pilots”. In May of 2013, the State Council approved and transmitted the Opinions of the National Development and Reform Commission on the Key Work in Deepening Economic Restructuring in 2013, committing to deeply advance pollution rights and carbon emission permit trading pilots, and to research the establishment of a national pollution rights and carbon emission permit trading market. Both the 12th Five Year Plan and the Work Plan for Greenhouse Gas Emission Control during the 12th Five-Year Plan Period proposed to “establish and perfect greenhouse gas emission statistical accounting system and gradually build a carbon emission permit trading market” (Song, 2015).

Various regions in China proactively established environmental exchanges. For example, in 2008, Shanghai, Beijing and Tianjin took the lead in establishing environmental (emission rights) exchanges. Later, provinces and cities followed suit and established many exchanges at a fast pace. Shenzhen Carbon Exchange, Guangzhou Environmental Resources Exchange, Dalian Environmental Exchange, Hubei Environmental Resources Exchange and others were established consecutively. Currently, China has about 100 environmental exchanges. They have been actively offering CDM emission reduction trading and consulting service and conducting VER trading. As of now, seven carbon emission permit trading pilots (Beijing, Tianjin, Shanghai, Shenzhen, Hubei, Guangzhou, Chongqing) have independently established their own trading and accounting systems, as well as total carbon emissions and the corresponding distribution mechanisms in their regions. Research and good practice regarding such mechanisms will have a positive impact on building a national carbon trading market in the future.

1.2.2 Natural resources and environmental priorities

China has rich energy resources. Its conventional energy reserves make up around 10.7% of the world’s energy reserves. It also owns rich coal and oil resources. However, due to its large population, China’s per capita energy capacity is relatively low. Per capita coal capacity is only 1/2 of the world’s average level and that of oil and gas are respectively 11% and 4.1%. In 2014, the country’s total primary energy output reached 3.6 billion tce, a year-on-year 0.5% increase. In the primary energy output, raw coal production was 3.87 billion tons, a year-on-year 2.5% decrease; crude oil was 210 million tons, a year-on-year 0.7% increase; natural gas was 160 million m^3, a year-on-year 7.7% increase. Power generation reached 5.6 trillion KWh, a year-on-year 4% increase. Regarding electricity generation, thermal power was the predominant source at 75.5%, a 0.3% decrease from 2013; hydropower was 18.8%, a year-on-year 15.7% increase; and nuclear power underwent the fastest growth of 18.8%. In general, coal is still the major energy source for China’s economic development. However, output of coal and oil is shrinking as a proportion of the overall energy mix, dropping to 84.7% in 2013 from 94% in 1978 ,while that of natural gas and renewables rose from 6.8% in 1978 to 15.5% in 2013 (Bureau, 2015b, Bureau, 2014).

In recent year, China’s power industry has been developing rapidly. According to data from the National Bureau of Statistics, for the year 2014, China’s total power supply was 5.5459 trillion KWh, making it the largest electricity generator in the world. Thermal power including all the power generated from coal, oil and gas reached 4.1731 trillion KWh, accounting for 75.2% of the total. It dropped by 1.8% over 2013. Due to the rich coal resources in China, thermal power is mainly generated from coal. Power supplied from nuclear energy was 0.1215 trillion KWh, accounting for 2.19% of the total, and increasing 36.1% over 2013. Hydro power reached 0.8596 trillion KWh, of the total 15.5%. The wind power generated 0.1555 trillion KWh, accounting for 2.8% of the total, and increased 25.6% over 2013 (as seen in Table 1)

In 2014, China's total power consumption reached 5.5233 trillion KWh, increasing 3.8% by 2013. Primary industry consumed 99.4 billion KWh, accounting for 1.8%, attaining a year-on-year fall of 0.2%; secondary industry used 4.0650 trillion KWh, accounting for 73.4%, with a year-on-year growth of 3.7%; and tertiary (service) industry consumed 666 billion KWh with a year-on-year growth of 6.4%, accounting for 12.1%. For the tertiary industry, transport and housing contributed to the largest growth (Li, 2014). Household power consumption by urban and rural residents was 692.8 billion KWh (12.5%), with a year-on-year growth of 2.2%.

Table 1: Electricity supplied in the China in 2014, in TWh and %

Energy commodity	TWh	%
Thermal power	4173.1	75.2%
Nuclear	121.5	2.19%
Hydro	859.6	15.5%
Wind	155.3	2.8%
Solar	105.4	1.9%
Other fuels	133.7	2.41%
Total	**5545.9**	**100%**

Source： National Bureau of Statistics, 2014

Along with China’s rapid economic development, industrialisation and urbanisation, citizens’ energy consumption keeps increasing. For example, the annual consumption of energy (see Figure 1) increased from 1.04 billion tce in 1991 to 1.46 billion in 2000. At the start of the 21st century growth increased rapidly and unexpectedly, rising by 9.3%, with energy consumption reaching 3.84 billion tce in 2014. However, in more recent years the average annual growth rate of primary energy consumption has dropped from more than 8.1% from 2000 to 2008, to less than 3.4% from 2009 to 2014. From the perspective of energy consumption per unit of GDP, China’s GDP grew by

7.4% in 2014 while energy consumption per unit of GDP fell by 4.8% from 2013, which partly reflected the achievements of the relevant energy conservation actions. Furthermore, the energy consumption structure has also evolved in China. In 2014, coal consumption reached 2.47 billion tce, accounting for 64.2%, a decrease of 2.1% over 2013. Oil consumption was 0.71 billion tce, accounting for 18.5% and gas consumption was 0.24 billion tce, accounting for 6.3% (Huang, 2015) (See Figure 1). No-fossil fuel consumption including hydro, nuclear, wind and other renewable energy increased from 9.8% in 2013 to 11% in 2014 (CNREC, 2015). Even though the energy consumption structure has been improved in China, coal and high carbon consumption are still the main development driver.

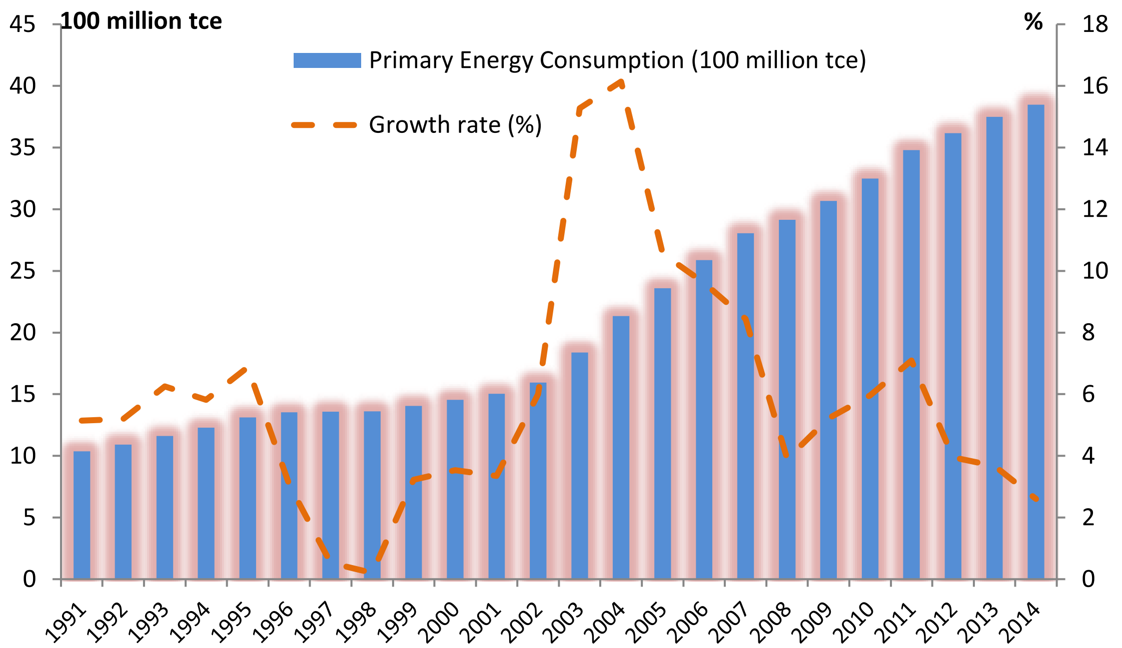

Figure 1 Primary energy consumption in China from 1991 to 2014

Sources: National Statistical Yearbook, 2014; Energy Statistics Yearbook, 2014

China is now the largest coal producer and consumer in the world and currently coal makes up more than 70% of the national total energy consumption (as seen in Figure 2). The massive usage of fossil energy has increased CO_2 emissions from 2.2 billion tonnes in 2001 to 8 billion tonnes in 2015; however, the emissions cap is limited and reducing, which means CO_2 emissions are a major constraint for China's future development. It is therefore important to urgently develop additional policies, and to take actions on setting limitations for coal consumption, fossil fuel usage and to improve air quality (Huang, 2015).

The gap between energy supply and consumption in China is increasing. For example, in 2014, China's energy demand gap was 230 million tce, which needed to be met by imports. In the same year, the country's coal stood at 290 million tce, a year-on-year 10.9% drop and its import dependency was 8.3%; imported crude oil stood at 310 million tons, a 2.6% increase from 57% in

2013 and its import dependency was 59.6%; imported natural gas was 58.4 billion m³, a year-on-year 12.7% increase and its import dependency was 31.9% (Bureau, 2015b).

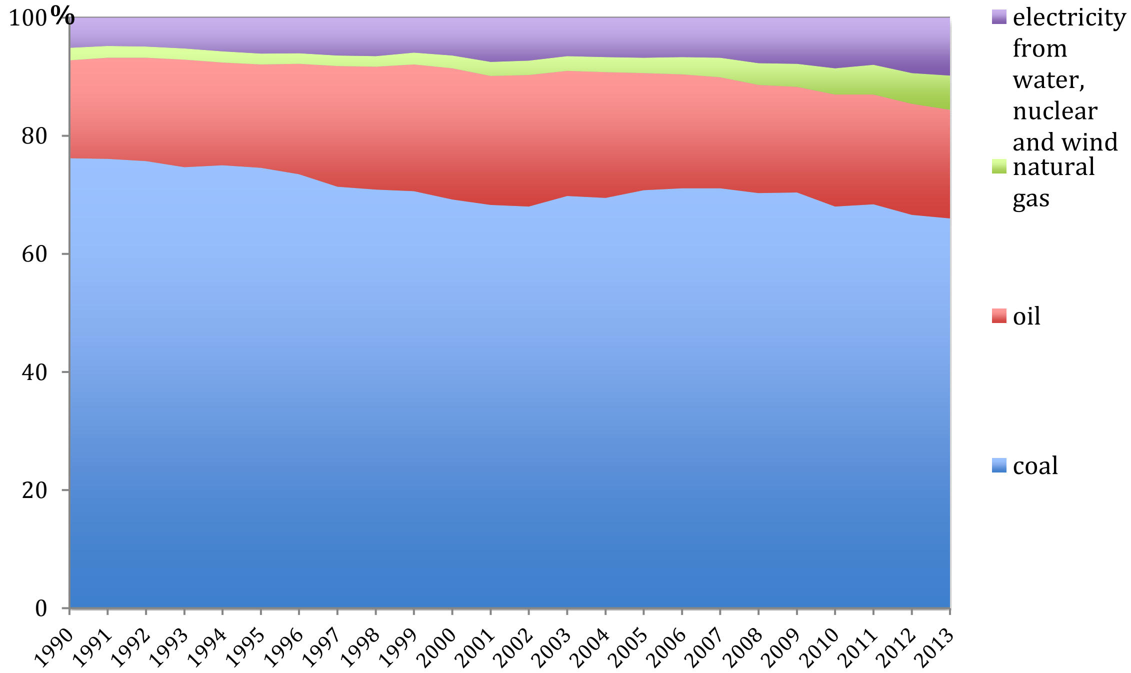

Figure 2 Energy Consumption Structure in China from 1990 to 2013

Sources: National Statistical Yearbook, 2014; Energy Statistics Yearbook, 2014

China's end user energy consumption by sector is dominated by the industrial sector, which makes up around 63% of the total consumption (see table 2). Residential uses comprise approximately 11% of the end-user consumption while transport, electric power, gas and water production together account for 15% of total consumption. Construction has a small portion of the share with only 2% of the total energy consumption.

Table 2: China's energy consumption by sector 2013

Sector	Total energy consumption in SCE*	%
Agriculture, forestry, animal husbandry, fishery and water conservation	8054.8	2%
Industry	262977.82	63%
Electric power, gas and water production and supply	28152.81	7%

Construction	7016.97	2%
Transport, storage and post	34819.02	8%
Wholesale, retail trade, hotel, restaurants	10598.16	3%
Others	19762.59	5%
Residential consumption	45530.84	11%
Total Consumption	**416913.02**	**100%**

*** standard coal equivalent**

Sources: National Statistical Yearbook, 2015

In addition to being the largest energy producer and consumer in the world, China is also the largest greenhouse gas emitter. The share of carbon emissions emitted by sector reflects, to a certain extent, similar patterns as energy consumption by sector. For example, over the 1980-2012 period industry emitted between 65% and 70% of the total emissions while construction comprised of a small share with around 1-3%. The building sector had a share of around 20% of the total carbon emission and demonstrated a decreasing trend over the years. (see Figure 3). However, with energy consumption growing strongly, total carbon emission from building sector keep increasing.

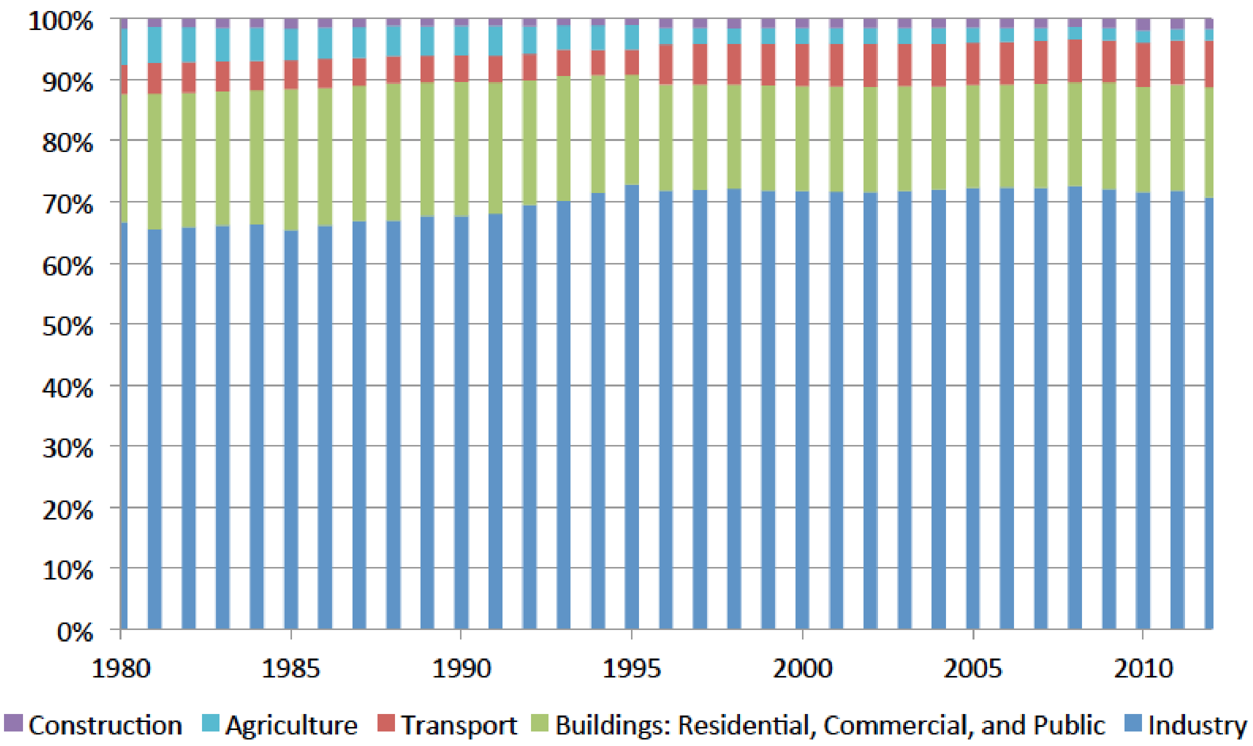

Figure 3 China's energy related carbon emissions by sector (1980-2012)

Source: Lawrence Berkeley National Laboratory, 2014

1.2.3 Natural events

China is a nation that is sensitive and vulnerable to the effects of global climate change. In the 10 years from 2006 to 2015, China, compared to all other countries, suffered the most frequent climate disasters affecting the largest number of people , leading to 12,736 deaths, 84,412 people affected and direct economic loss of RMB 926,042 million ((CRED), 2015).

The exposure of people and economic resources to weather and climate-related disasters has also undergone a remarkable change. Economic sectors impacted include water resources, food, ecology, health, energy, transportation and infrastructure. All links of the energy system, from production and transportation to consumption, are directly or indirectly threatened by the climate extremes to varying degrees. With China's rapid socioeconomic developments energy is in greater demand. The scale of the production and transportation of energy is expanding and energy consumption is growing rapidly. Consequently, the vulnerability of energy production and transportation infrastructure to weather and climate related disasters is also rising. Climate extremes can also influence demand for energy and cause the scope of energy infrastructure affected by disasters to expand. For example, higher temperatures, drought, heavy rains, snow and freezing weather increases the demand for energy that is used for cooling and heating. From 1961 to 2013, the number of high temperatures events and heat waves has been rising. The average annual maximum temperature has increased at a rate of around 0.25°C per decade; the longest stretch of maximum temperature over 35°C since 1961 lasted for eleven days (Dahe, 2015)

1.2.4 Economic priorities

In 2015, China's GDP reached RMB 67.67078 trillion with a per capita GDP of RMB 46,629 and an economic growth rate of 6.9%. In the first half of 2016, the GDP growth rate slowed down and stood at 6.7%. By contrast, the economic growth rate in 2014 was 7.4% and the average growth rate from 1979 to 2014 was 9.7%. During the "13th Five Year Plan" (2016-2020) period, China's potential average growth rate is expected to drop to 6.3%. We can see that China's economy transitioned from a high growth to a medium-high growth at the same time as energy consumption grew at a lower rate. Firstly, the industrial structure transition had a large impact on economic growth and energy demand. Driven by resource and environmental restrictions. and environmental protection policies, China's industrial development slowed while the service industry grew at a faster speed. In 2014, China's tertiary industry contributed to 48.2% of GDP, a 1.3% rise from the previous year and 5.6% higher than secondary industry. Moreover, since 2015, the tertiary GDP growth rate has been surpassing the industrial sector in terms of its contribution to the overall growth rate, demonstrating that China's economy is beginning to gradually move away from an over-dependency on industrial growth. Decoupling economic development and high energy industry helped total energy consumption to fall. In 2013, the country's energy consumption per unit of GDP fell by 3.7% from 2012, and in 2014 the figure decreased by 4.8% from 2013 (Bureau, 2016c).

Secondly, major improvements in energy productivity lowered the energy elasticity coefficient[1] and promoted green economic growth. During the 11th, 12th and 13th Five Year Plan periods, China's energy consumption per unit of GDP was lowered by 19.1%, 18.2% and 15% respectively, and energy consumption per 10,000 Yuan of GDP decreased from 1.08 tons to 0.72 ton. Since 2011, energy efficiency has been improving at an annual average of 3.9% and the annual average energy consumption growth rate was only 3.6% during the same period. The energy efficiency growth rate has surpassed the energy consumption growth rate, while China's energy consumption growth rate had been higher than that of energy efficiency previously. This change indicates that less energy investment is needed to achieve economic growth than in the past, showing, to a certain extent, that China's economic growth has entered into a more efficient-driven growth phase (huang, 2015, Wang, 2015).

Thirdly, China's renewables make up 9.9% of its primary energy, exceeding the world's average level and second only to Germany among major economies. From 2005 to 2015, the proportion of non-fossil energy in primary energy consumption increased from 7.4% to 12%. (， CNREC, 2015). In terms of power source structure, wind power became China's third biggest power source and PV power generation showed a faster development momentum. Compared to the past, the country's energy consumption per unit of GDP is becomingly increasingly low-carbon. Therefore, China's economic growth is stepping away from the past and towards green growth.

Finally, emerging energy industries not only provide a boost for cleaner economic development, but also constitute a new highlight in economic growth. In recent years, investment in clean energy such as wind, PV, biomass and nuclear power has been rapidly rising. Energy consumption sectors or technological innovation such as distributed energy, energy Internet, EV and low carbon industrial park have resulted in spill overs. These combined factors have led to a rapid development of a group of technology enterprises, resulting in in social and economic benefits that include improved employment and business profitability. Also, technical transformation such as clean utilisation of coal, low-emission coal-based power and oil quality improvements created new development spaces for traditional energy. Development of distributed energy improved China's energy supply structure and addressed some power shortage problems in remote areas. At the same time, developing the new energy industry has become an important way for poorer regions to increase their revenue and to reduce poverty.

1.2.5 Societal priorities perspective on climate change

In 2015, China's population reached 1.373 billion, and China became the second largest economic entity in the world with its overall GDP at 67,670 billion yuan. However, when the population structure is explored further, China's demographic bulge is diminishing. The population falling within the labour age between 16 to 60 (60 not included) stood at 915.83 million, 3.71 million less

[1] Energy elasticity coefficient is an index reflecting the relationships between the growth of energy consumption and the economic growth. That is to say, the energy elasticity coefficient is how many the energy consumption would grow by when the economic growth increases by 1%.

than that in 2014 and accounting for 67.0% of the total population. (Bureau, 2016a). From 2012, China's workforce population absolute value has dropped for four consecutive years. Besides, the population ≥60 is at 212.42 million, accounting for 15.5% of the whole population while the population ≥65 is at 137.55 million, accounting for 10.1% of the whole population. (Xue, 2014). Currently, China has the largest population of older people and the fastest aging process in the world. It is estimated that the inflection point of the country's demographic bonus will appear before 2020, followed by labour shortage and increased labour cost. This will not only impact competitiveness of traditional labour-intensive manufacturing industry, it will also impact strategic emerging industries such as new energy industries.

At the end of 2014, China's urbanisation level reached 56.1%. The country's urbanisation level has been rapidly rising since the mid-1990s. During the 9th (1996-2000),10th (2001-2005) and 11th Five Year Plan periods, the urbanisation level rose at annual averages of 1.44%, 1.35% and 1.39%. But during the 12th Five Year Plan period, the urbanisation growth rate lowered to 1.21%. The figure is expected to be lower in the 13th Five Year Plan period. Influenced by slowed economic development, China's urbanisation development pace has moderated in recent years ((CSUS), 2016). During 2005 to 2010, the migration rate of rural population to urban areas stood at an annual 4%, with this figure falling to 1.3% in 2014 and to 0.1% in the first half of 2015, nearing zero. However, in 2003 to 2013, the annual increase in urban population was still over 20 million. In 2014, urban population reached 750 million with urban households rising from 155 million to 264 million ((THUBERC), 2016). As city populations continues to grow and living standards rise, locked-in energy infrastructure, transport and day-to-day activities will continuously increase, making them major emission reduction areas in the future.

1.2.6 Politics of energy development priorities

As stated earlier in section 1.2, the Energy Development Strategy Action Plan (2014-2020) (Action Plan) define the overarching goals, strategic guidelines and major tasks for China's energy development by 2020. Here we highlight the energy goals in more detail:

- To control total primary energy consumption within about 4.8 billion tce by 2020;
- To control total coal consumption within about 4.2 billion tons and proportion of coal consumption within 62%;
- To maintain energy self-sufficient ability at about 85%, enhance oil reserve and production ratio to 14%-15%, and finish constructing the energy reserve contingency system;
- To achieve 15% non-fossil energy and over 10% natural gas in primary energy consumption;
- To execute livelihood projects including natural gas use for urban residents by 2020;
- To cut total coal consumption in Beijing-Tianjin-Hebei-Shandong region, Yangtze River Delta region and Pearl River Delta region. Coal consumption in Beijing-Tianjin-Hebei-Shandong provinces should be cut by 100 million tons by 2020 compared to 2012, and the

Yangtze River Delta region and Pearl River Delta region should also experience negative growth.

In 2014, President Xi Jinping hosted the 6th meeting of the Leading Group for Financial and Economic Affairs to study China's energy security strategies. President Xi stressed in his speech that energy security was a landscape-changing and strategic issue concerning national socio-economic development. He proposed five requirements on advancing an energy production and consumption revolution:

(i) Total energy consumption should be controlled and energy saving should be considered in the whole process and in all areas of socio-economic development. Approaches such as industrial restructuring, urban energy conservation and alteration of consumption ideas shall be used to quicken the construction of an energy conservation-minded society.

(ii) A diversified supply system shall be established. China should vigorously advance clean and efficient coal use and focus on developing non-coal energy, so as to form an energy supply system that is driven by coal, oil, gas, nuclear energy, new energy and renewables.

(iii) Low carbon technologies and green energy technologies should be further developed and commercially promoted, so as to make energy technologies and relevant industries new growth engines for China's industrial upgrade.

(iv) Commodity attributes of energy should be explored to form a market-based pricing mechanism. Government regulation on energy should be altered.

(v) International cooperation should be enhanced. While focusing on improving domestic energy self-sufficient abilities, China should also effectively use international resources in as many areas of energy production and consumption.

China has set climate change as a political priority in its national agenda and policies (as indicated in section 1.2.1. More recently, in 2014, China formulated the National Plan for Tackling Climate Change (2014-2020), the country's first dedicated national plan on responding to climate change. The plan analysed trends in global climate change and their impact on China, and also defined major goals for the country to actively tackle climate change before 2020. Goals include lowering CO_2 emission per unit of GDP by 40-45% from that in 2005, achieving about 15% non-fossil energy in primary energy consumption and increasing forest stock volume by 40 million hm^2 and 1.3 billion m^3 from 2005 levels. To realise the goals, the plan required a restraint on high carbon industries from rapid growth and to vigorously develop strategic emerging industries. By 2020, the percentage contributed from strategic emerging industries to GDP should reach about 15% and that from service industry should reach over 52%. Besides this, the plan clearly stipulated to control total coal consumption and step up the development of oil, gas, nuclear power, wind power and solar power. The plan proposed that, by 2020, China should build about 150 low carbon industry demonstration parks and establish about 1,000 low carbon commercial pilots. Low carbon products would also be promoted and greenhouse gas emission control for industrial production would be pushed forward.

Chinas has also established joint collaboration with other countries to tackle climate change, as seen in November 2014, when China and the US signed the China-U.S. Joint Statement on Climate Change. The Joint Statement declared China's plans to expect a CO_2 emission around 2030 and plans to enhance proportion of non-fossil energy in primary energy to about 20% by 2030.

The above goals constitute a forcing mechanism for China, inhibiting China's fossil energy consumption and promoting an energy structure adjustment. 2016 marks the first year for the 13th Five Year Plan for Energy. The plan proposed three goals:

(i) Energy consumption: In 2016, total energy consumption should stand at around 4.34 billion tce, the proportion of non-fossil energy consumption should be enhanced to about 13%; the proportion of gas consumption should be increased to about 6.3% and that of coal consumption will be lowered to less than 63%.

(ii) Energy supply: In 2016, total energy production should be at around 3.6 billion tce, coal output should be about 3.65 billion tons, crude oil output around 200 million tons and gas output around 144 billion m^3.

(iii) Energy efficiency: In 2016, energy consumption per unit of GDP should decrease by over 3.4% on a yearly basis; coal consumption per KWh of power in coal-fired power plants should be at 314 gce and 1 gram less on a yearly basis.

1.2.7 Conflicts and synergies of priorities

At the 2015 climate conference in Paris, China put forward the following action targets: lower CO_2 emission per unit of GDP by 60%-65% by 2030 compared to 2005; enhance the proportion of non-fossil energy to about 20% by 2030; reach peak CO_2 emission from fossil energy consumption by 2030 and; increase forest stock volume by 4.5 billion m^3 by 2030 compared to 2005. However, as coal constitutes a major part of China's primary energy and with urbanisation and industrialisation rapidly developing, it is very difficult to lower carbon emission per unit of GDP.

China has rich resources of coal. Even though the energy supply and consumption structure have been improved in china, economic and social development in china will still rely on coal consumption in the long term which results in increasing carbon emissions. Especially, as the urban population and density continues to grow, energy consumption in building, transport and daily living section will keep on increasing. China is now under more pressure to slow down energy consumption and carbon emissions, not only from the international requirement and promises for carbon emissions reduction, but also from domestic environmental deterioration such as air pollution issues. However, it has been observed that the growth speed of energy consumption in China has shown a sliding trend since 1999, reaching its lowest point at 2.3% in 2014. Energy consumption per unit of GDP has dropped 18.2% during the period 2011 to 2015. These achievement result from policies such as the Energy Development Strategy Action Plan (2014-2020), Coal industry Development Planning (2011-2015) and Energy Planning (2011-2015) in China. Furthermore, the policies for building carbon emission trading system also play an important role as well as policy instruments for incentive the energy consumption efficiency. Slowing economic growth also makes a positive contribution.

1.3 The Human Innovation System Narrative

1.3.1 Overview of the development of urbanisation in China

As China's urbanisation rapidly progresses, a large population has entered cities. Rapid urbanisation has boosted continuous development and scaled-up the construction industry. During 2001 to 2014, the country's building area saw growth every year, with annual completed floor space exceeding 1.5 billion m^2. In 2014, newly completed floor space stood at 2.89 billion m^2, compared to the total building area in China of 56.1 billion m^2, (See Table 3). Among the new buildings, residential housing accounted for about 75% and public buildings 25%. Among the new public buildings, office buildings accounted for the largest proportion of about 34%, educational buildings 19% and other buildings about 47% (Bureau, 2016c).

As completed floor space grew every year, China's stock volume of building area also rose at a high speed. In 2014, China's building area was around 56.1 billion m^2, among which urban residential building area reached 21.3 billion m^2, rural residential building area 24.1 billion m^2 and public building area 10.7 billion m^2. The area of northern cities and towns with centralised heating was 12.6 billion m^2. At the same time, floor space under construction in 2015 was around 12 billion m^2. Based on historical trend, building floor area is projected to reach about 70 billion m^2 before 2020 ((THUBERC), 2016).

In 2014, building energy consumption and biomass energy consumption totalled 921 million tce, of which biomass energy consumption stood at 102 million tce and final energy consumption of buildings was 819 million tce, amounting to about 20% of the total domestic energy consumption. In the same year, energy consumption of new buildings accounted for about 16% of the total domestic primary energy consumption ((THUBERC), 2016). Energy consumption of the whole building sector took up 36% of the country's total primary energy consumption. Table 3 below provides an indication of building energy consumption in China in 2014.

Table 3: Building Energy Consumption in China (2014)

Function type	Area or householders	Power (100 million KWh)	Total energy consumption (100 million tec)	Energy consumption intensity
Urban residential buildings	21.3 billion m^2 or 263 million residents	4048	1.92	9 kgce/ m^2 or 729 kgce/ person
Public buildings	10.7 billion m^2	5889	2.35	21.9kgce/ m^2

Rural residential buildings	24.1 billion m^2 or 160 million residents	1927	2.08	8.6 kgce/ m^2 or 1303 kgce/ person
Heating in the north	*12.6 billion m^2*	*97 (heating only)*	*1.84 (heating only)*	*14.6kgce/ m^2*
Total	**56.1 billion m^2 or 1.37 billion residents**	**11993**	**8.19**	**54.1 kgce/ m^2 or 598 kgce/ person**

Sources: China Statistical Yearbook on Construction，2014；2015 Annual Report on China Building Energy Efficiency，2015

As shown in Table 3, urban and rural residential buildings were the largest energy consumers. The heating area in northern cities and towns consisted about 25% of the total building area; and the public building area only accounted for 20% of the total (Bureau, 2015a). However, heating energy consumption (excluding other energy consumption in these buildings) in the north was 184 million tce, accounting for 21% of the total building energy consumption. Energy consumption of urban residential buildings was 192 million tce, accounting for 22%; public buildings stood at 235 million tce, accounting for 27%; rural residential buildings was 208 million tce, accounting for 25% of the total building energy consumption. As we can see, energy consumption in public buildings has taken up the biggest portion in China's building energy consumption ((THUBERC), 2015).

In 2014, China issued a series of (work) plans that were closely related to building construction work. The National New-type Urbanisation Plan (2014-2020), released in 2014, summarised the contradictions and problems that occurred during the rapid urbanisation development, whilst also offering a lifestyle guiding direction that promotes "green production and consumption to be part of the mainstream urban economic life". The plan proposed to "greatly increase the proportion of energy-saving and water-saving products, recycled products and green buildings" and to "significantly improve urban underground pipe network coverage" so as to achieve building energy conservation. In terms of infrastructure, the plan aims to "improve infrastructure and public service facilities to become more accessible, and enhance ecological capacity and air quality gradually". This has further highlighted the importance of green living and consumption. Therefore, both energy-saving products and corresponding green buildings are centred on their residents.

1.3.2 TIS life cycle value chain: a cradle to grave analysis of the building sector in China

a) **Raw materials:** The productions of raw materials for construction, such as steel, wood, and cement, consume a significant amount of energy and make up 93% of energy consumption in the construction industry. In 2014, China's construction industry consumed 743 million tons of steel, amounting to about 50% of the total steel consumption. Of the

743 million tons of steel consumed, over 50% went to the real estate industry. In addition to this, wood consumption reached 302 million m^3, cement 2.4 billion tons, glass 618 million weight cases (around 991 million m^2) and aluminium 51.61 million tons (Bureau, 2015b). An example of energy consumed in the production of building materials used in the Beijing area is shown in Table 4 (Xu, 2014).

Table 4: Energy consumption for building materials production in Beijing: an inventory of materials for 100m^2 of buildings (tce)

Year	Steel	Cement	Brick	Wood	Stone	Sand	Glass	Thermal Insulation materials
1990	2.9	15	46.2	0.8	40.4	47.7	0.37	0.39
1995	2.64	14.81	36.43	1.55	55.78	47.35	0.49	0.39
2000	2.5	14.8	38.8	0.6	33.4	41.3	0.48	0.39
2005	3	11.25	31.2	0.6	32.25	34.5	0.25	0.39
2010	2.6	10.84	33.1	0.6	32.25	34.5	1.6	0.39
2014	2.5	9.91	31.2	0.6	32.25	32.1	1.8	0.39

Sources: Analysis of Buildings Construction Energy Consumption, 2014

b) **Energy system for heating and cooling in the building sector:** the current heating system can be divided into major types of energy technologies such as combined heat and power generation CHP, coal-fired boilers, gas-fired boilers and heat pump centralised heat. The energy sources used include coal, gas and electricity. Heating from solar and geothermal have also piloted in green buildings, which are not yet popular but may be a large potential market in the future.

Furthermore, there are heating supplied areas in the north of China such as Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Shandong, Henan, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang and partial Sichuan. In these areas heating is provided by both centralised (district heating) and decentralised systems, with energy mainly supplied by coal and gas because of the rich natural resources endowments in the area.

The non-heating supplied areas focus on the south of China. In these areas heating is mostly supplied from decentralised systems. Heat sources include air source heat pumps and direct electric heating. Electricity is the major form of heating energy consumption, but coal, natural gas and liquefied petroleum gas also play a part.

Cooling systems in urban areas mainly use electricity, however, cooling and heating sources in Chinese rural areas are different and may use electricity, coal and biomass.

c) **Distribution to end-users**: transmission (grid), pipelines (gas, district heating)
End users: Building operation energy consumption greatly differs according to various climatic zones in China, residents' income levels, living habits, lifestyles and urban & rural building types. All in all, the high intensity of heating energy consumption in the north has been declining, with a slower growth rate since 2015. However, final energy consumption demand for urban domestic hot water, air conditioning and appliances increased, and users' average energy consumption intensity grew by 50% from 2001 to 2014. Furthermore, extreme climate events such as heat waves and severe winters are becoming more frequent in some regions such as Yangtze River Delta, thus energy consumption from cooling and heating has increased rapidly in these years.

d) **End of life (dismantling, recycling, disposal):**[2] In upcoming years rapid urbanisation will increase construction activity, which will also increase construction wastes. In 2014, China's annual construction wastes exceeded 1.5 billion tons. The figure is expected to increase year after year as urbanisation speeds up and urban construction scales up. It is estimated that, by around 2020, such wastes will peak. In recent years, the country's annual construction wastes total about 1.55 billion tons to 2.4 billion tons, accounting for about 40% of urban waste. Looking forward more than ten years in the future, China will produce a lot of construction waste whose transportation, disposal and storage will pollute the environment and occupy significant amounts of land.

Taking Beijing as an example, annual construction wastes stand at 40 million tons. It is calculated that every 10,000 **m^2** of floor space under construction produces an average of 550 tons of construction wastes, and floor space under construction contributes to 48% of urban construction wastes. China's current waste handling methods are mainly landfills and open air piling, which causes environmental issues and occupies valuable land resource. Also, since China has not offered adequate policy support to construction waste recycling, waste management has multiple flaws and local governments are not sufficiently supporting the development of construction waste recycling enterprises. Disposal technologies lag behind those in industrialised countries, for example less than 5% of construction wastes are recycled[3] compared to the 95% average in developed countries.

e) **Facilitating services & infrastructure**
These include:

- Industry institutions power: supply (power company), water supply (running-water company) and energy conservation and emission reduction enterprise
- Policy institutions: planning and policies (Ministry of Housing and Urban-Rural Development of the PRC-MOHURD, National Development and Reform Commission-NDRC)
- Political institutions: project approval and initiation (NDRC)
- Financial institutions: banking

[2] Data source: China construction waste industrial recycling strategic coalition, 2014 China construction waste resource industrialization development report, 2015.1

- Education institutions: university, collages etc.
- Media institutions
- Legal institutions
- Other informal 'institutions' (e.g. indigenous practices, culture, etc.)
- Infrastructure that supports the TIS system: including other systems (e.g. water treatment/extraction, road, land (Land and Resources Bureau), pollution discharge (municipal administration), garbage disposal (Ministry of Environmental Protection)

In summary, energy consumption of building in the TIS life cycle allows for the continued growth of the building sector. The main factors triggering the energy consumption growth derive from the increasing population and an increasing building area. However, the rate of growth for energy consumption is lower than that of building area, and energy consumption per unit of area decreased from 2001 to 2014. The major reasons for this is that the heating and cooling systems used are becoming more efficient. For example, there are some new technologies applied in buildings, including green roof, improvements in insulation, and greater use of efficient heat pumps and solar energy for heating /cooling. Furthermore, energy efficiency demonstration projects played active roles to improve efficiency of energy consumption in building section. We will explore these areas in greater detail as we carry out the research over the next year (in part II of the case study for D3.3).

1.3.3 Enabling environment: policy mixes in the socio-economic system

The policy mix presented below includes the eight key national level policies that directly or indirectly impact the building sector in China. We have not included city level policies, such as specific building code or urban development strategies, as these would require further stakeholder engagement and a more detailed understanding of the building sector at the city level. We will identify city-level policies in part II of the case study after further stakeholder engagement and research.

The Energy Development Strategic Action Plan and China's National Plan on Climate Change are mid-term energy and climate change plans, whilst the Law of the People's Republic of China on Conserving Energy focuses on energy efficiency and the Renewable Energy Law provides overarching guidelines on developing renewable energy sources in China. The Circular Economy Promotion Law covers a wider part of the economy, but has specific (in)direct impact on the building sector in terms of waste, resource and water use. Policies specifically aimed at the building sector include the Construction Law and the Green Building Plan, whilst the National Plan on New Urbanisation coordinates urban and rural development. The New Urbanisation Plans promotes the optimisation of land use (e.g. top level city planning) and ecological principals in urban development.

Table 5 China policy instruments that directly or indirectly impact the building sector

Policy themes	China National Policy Instruments			
Energy	Energy Development Strategic Action Plan (2014~2020)	China's National Plan on Climate Change (2014-2020).	Law of the People's Republic of China on Conserving Energy	Renewable Energy Law
Climate				
Waste/ resource use			Circular Economy Promotion Law	
Water				
Building	Construction Law	Green Building Plan		
Land	National Plan on New Urbanization (2014-2020)			

1.3.4 Enabling environment: government institutions

The central government in China is responsible for national policy making, including energy development planning, carbon emission targets and regulatory framework. For example, the state council defined the duties and tasks for all administrative ministries and established a target-oriented responsibility system for carbon emission reduction. Under this system, the national development & reform commission is in charge of setting carbon emission reduction targets for all provinces. The provinces are responsible for disseminating the energy-saving targets to their city-lever governments and section bureaus. The province and local governments agree the energy-saving targets with the central government, however, after the target is established, it becomes binding and is added into the performance assessment of local governments. So the main driving factors for low-carbon action in provinces derive from the central government's requirement. The figure below illustrates the central and province governments involved in this top down system in China.

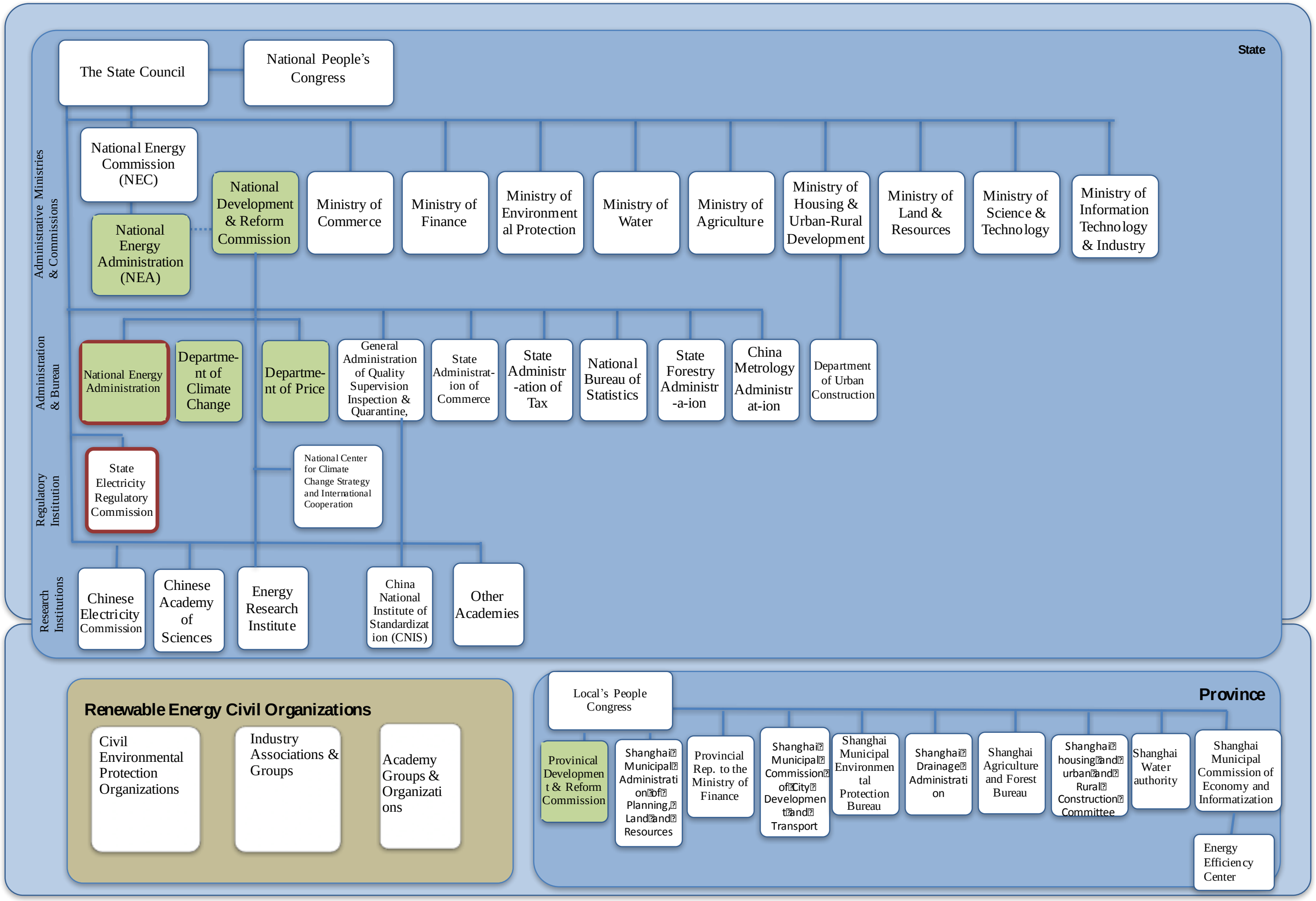

Figure 4 Energy and renewable energy institutions in China

Source: Author's own work

1.4 The Innovation System map

The system map (see Figure 5) is an initial draft for the building sector in China, and identifies some of the key elements that impact the sector's development. The map is based on secondary research, and will be revised over time to reflect the city-level aspects of the building sector as we gain more insights from our research and stakeholder consultations.

On the left hand side of the map, the 'technological innovation system (TIS) life cycle' (i.e. the building sector) primarily focuses on four aspects of the building sector value chain including: 1) raw materials needed for construction; 2) building development, which is consolidated into one box but will likely to be expanded later in the case study; 3) three types of building sectors including commercial, government and the residential sector; and 4) the individual end users.

Below the TIS lifecycle box is the 'Facilitating services and infrastructure' which includes support infrastructure for the building sector value chain and cuts across the electricity infrastructure (e.g. grid infrastructure to provide electricity to buildings), water infrastructure (e.g. water pipelines connecting to buildings), and transport infrastructure (e.g. roads needed for transporting materials). The links between the facilitating services and infrastructure are not yet clear and will be explored later on in the case study. The elements within the facilitating services and infrastructure box are likely to be changed and revised through stakeholder engagement, as stakeholder may identify other services and infrastructure that we have not included. We may also discover that water infrastructure, for example, is not an important element in the discussion of the building sector.

On the top right hand side of the system map, the 'Policy Mix' box highlights the wide range of policies influencing the development of the sector, whilst the 'Government institutions' represent the key institutions with power at the national and city level that have a strong impact on the building sector and policy making process (as indicated by the dotted black arrows flowing from the government institution to the TIS life cycle and policy mix).

The flow of arrows indicates that there are some important interactions that need further analysis. However, at this point we have not defined the nature of these interactions, for example, whether interactions are barriers or enablers to a low carbon development pathway. We will include other key interactions as we engage with more stakeholders thorough our research.

There are also several other key stakeholders not yet included in the system map, including civil society and possibly other institutions. We will explore these missing components in the next version of the system map as we engage further with stakeholders.

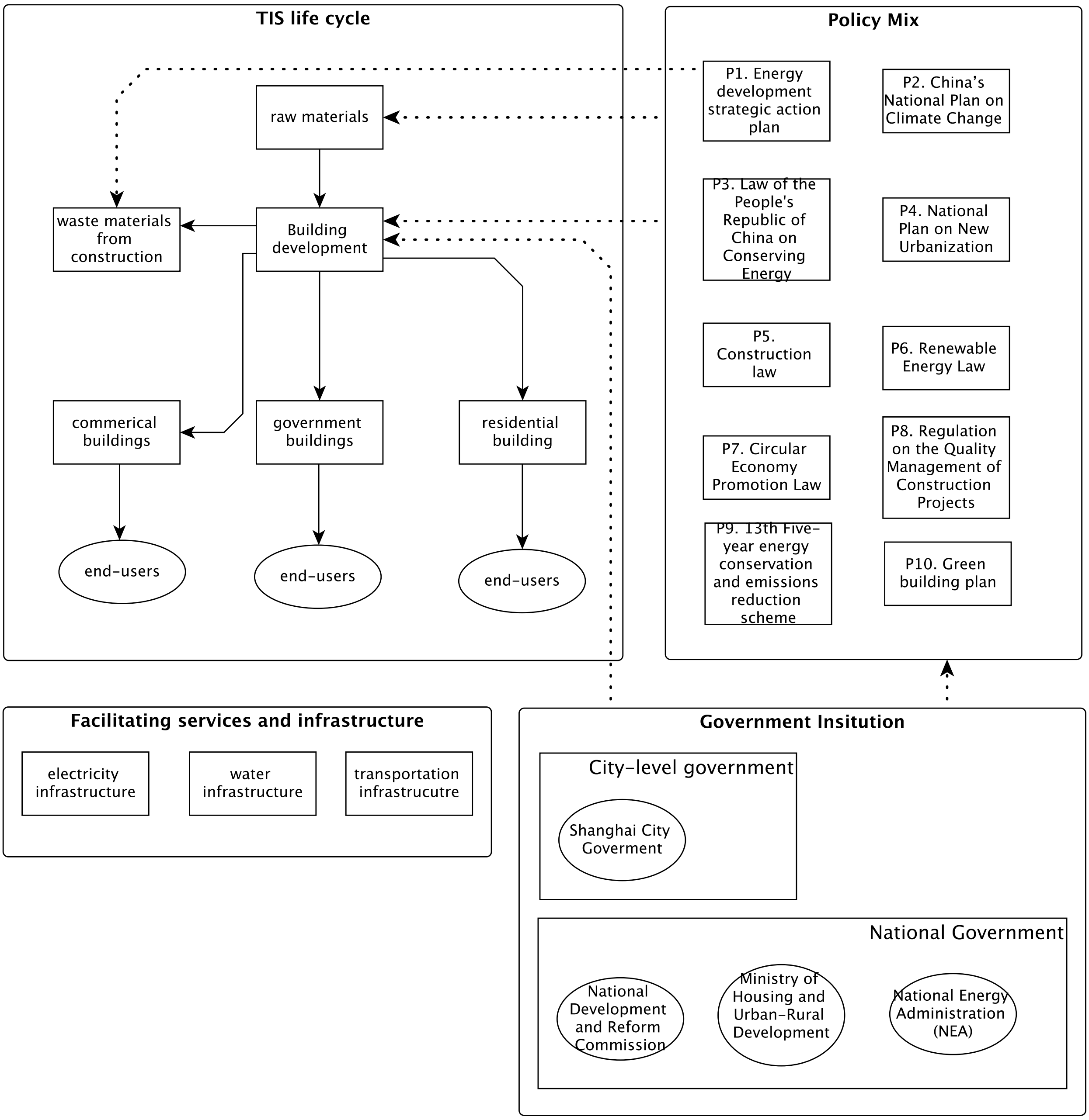

Figure 5 System map of the TIS life cycle for the building sector in China

Source: Author's own work

1.5 Stakeholder engagement

Table 6: Stakeholder Engagement

			Economic sector**	Type of engagement***	Month and year contacted
1.	Government(n)	Dean	Environment	email	September, 2016
2.	Government(n)	research	Metrology	interview	May,2016
3.	Research	professor	energy	interview	August, 2016
4.	Government(s)	dean	agriculture	Focus group	September, 2016
5.	Research	Associate professor	industry	Focus group	September, 2016
6.	Governments(n)	Head of department	Housing management	Focus group	September, 2016
7. NGOs	International	Head in Shanghai	Environment	interview	October, 2016

* Government (national / subnational), research / consultancy, business, other (specify)
** Energy, Industry, transport, environment, agriculture / forest, financial / trader, other (specify)
*** Interview, focus group, workshop, survey etc.

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Appendix A: Detail Research Questions

Detailed Research

1. What are the economic, social and environmental priorities of the Netherlands towards supporting a low-carbon transition, including short- and long-term plans?
    a. Energy security, transition from fossil fuels to renewables using natural gas, phase out of coal plants, protection against sea level rise and river floods, decentralised electricity systems
    b. How can the Netherlands improve its use of renewable energy resources to support sustainable growth and comply with renewable energy goals of the EU?
2. What changes are required in the Netherlands to increase the share of solar PV in electricity production?
    a. Which transition pathways need to be considered next to current preferences? For example: a pathway with increased role for decentralised power systems based on solar PV (rather than centralised grids with a stronger role for wind power), smart grids, mini-grids, etc., and which foresees in (new) buildings being better equipped for solar PV (in terms of position towards the sun).
    b. What is the current role of solar PV in the national plans?
    c. What are the interests and capabilities of actors involved in the solar PV market?
3. What are the policy options for stimulating the Dutch solar energy market and what are their risks, uncertainties and opportunities?
    a. What are the potential policy options to stimulate the solar market to become self-supportive? For example: subsidies; modified spatial planning; information campaigns for consumers who are in general unaware of current technological improvement, costs and benefits of solar PVs; include solar energy in the long term national plans (potential is larger than anticipated); provide more financial support for the deployment of solar panels (currently there is not enough budget to cover all applications).
    b. Uncertainties and possible risks:
        i. Insufficient awareness of solar PV potential among end-users, spatial planners and construction companies.
        ii. Insufficient willingness of stakeholders to modify current energy production and consumption patterns, e.g. due to higher costs, and perceptions of less stable energy supply.
        iii. Less stable grids due to increased use of solar PV, possibly requiring additional investments in grids, mini-grids, power-to-gas, etc.
        iv. How would the abolition of net-metering/tax reduction affect people willingness to invest in solar PVs?
        v. It is uncertain whether fixed and proposed measures (Energy Agreement, 2013) will actually realise. Extra measures might be needed to reach the national target.
        vi. Other factors that are uncertain are technology development, costs, investment availability and availability of capital and proper policies.

vii. How rapidly will solar PV develop in the future?

c. Opportunities
   i. Lower energy bill as power can be produced at home and no centralised power grid may be needed.
   ii. Improvement of energy-save, environmentally-friendly built environment, thereby lowering energy costs.
   iii. Analyse the balance between the treasury`s income and spending, focusing on the revenues from energy tax, corporate tax and income tax related to solar energy based electricity. The revenue losses due to reduced amount of energy tax paid by electricity consumers might be balanced out by increased corporate and income taxes as decentralised electricity production increases. This will be discussed in more detail in chapter 2.

4. How can we prepare to deal with these risks and options, what policy tools and actions could we take to stimulate the solar PV market?
   a. How to improve the awareness of consumers about current technological improvements, cost and benefits of solar PVs?
   b. How to improve the awareness of architects and construction companies of constructions for optimal use of solar PV under Dutch climatic circumstances?
   c. How to improve the awareness of spatial planners in urban areas of options for optimally using solar PV potentials?
   d. What are the impacts and implications (reliability, affordability) of small and large scale deployment of solar PVs on the national electricity grid (with particular focus on balancing, and need for investing on smart/mini grids)? Land use? How would this affect the wholesale market? Consumer bills? Administrative burden?
   e. What is the optimal share of solar energy in the energy mix and what are the costs of small scale and large scale solar power generation? Sensitivity analysis?
   f. At which share of solar energy comes the electricity grid under pressure in terms of balancing?
   g. What kind of flexibility options could be implemented to deal with fluctuations? How fast these flexibility options could be developed and how fast the market can adopt these flexibility options?
   h. Does the energy system remain affordable with the increased share of solar energy, implemented flexibilities etc.
   i. How and to what extent could the government stimulate market developments?

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