China Chapter

pathways to deep decarbonization

2014 report

IDDRI
SciencesPo.
SUSTAINABLE DEVELOPMENT SOLUTIONS NETWORK
A GLOBAL INITIATIVE FOR THE UNITED NATIONS

Published by Sustainable Development Solutions Network (SDSN)
and Institute for Sustainable Development and International Relations (IDDRI),
september 2014

The full report is available at deepdecarbonization.org.

Copyright © SDSN & IDDRI 2014

IDDRI

The Institute for Sustainable Development and International Relations (IDDRI) is a non-profit policy research institute based in Paris. Its objective is to determine and share the keys for analyzing and understanding strategic issues linked to sustainable development from a global perspective. IDDRI helps stakeholders in deliberating on global governance of the major issues of common interest: action to attenuate climate change, to protect biodiversity, to enhance food security and to manage urbanization, and also takes part in efforts to reframe development pathways.

SDSN

Sustainable Development Solutions Network (SDSN) mobilizes scientific and technical expertise from academia, civil society, and the private sector in support of sustainable development problem solving at local, national, and global scales. SDSN aims to accelerate joint learning and help to overcome the compartmentalization of technical and policy work by promoting integrated approaches to the interconnected economic, social, and environmental challenges confronting the world.

Disclaimer

The 2014 DDPP report was written by a group of independent experts acting in their personal capacities and who have not been nominated by their respective governments. Any views expressed in this report do not necessarily reflect the views of any government or organization, agency or programme of the United Nations.

Publishers : Jeffrey Sachs, Laurence Tubiana
Managing editors : Emmanuel Guérin, Carl Mas, Henri Waisman
Editing & copy editing : Claire Bulger, Elana Sulakshana, Kathy Zhang
Editorial support : Pierre Barthélemy, Léna Spinazzé
Layout and figures : Ivan Pharabod

Preface

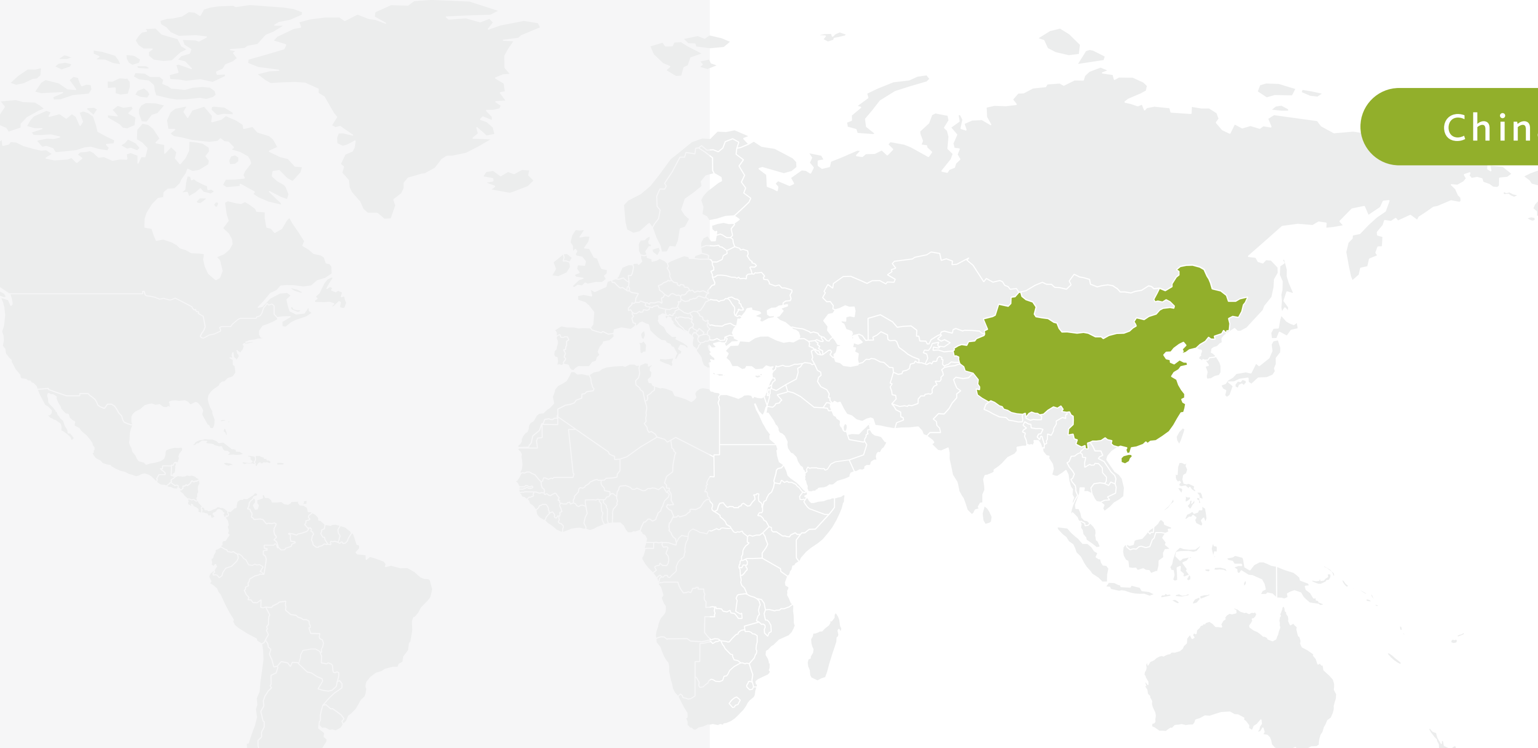
The Deep Decarbonization Pathways Project (DDPP) is a collaborative initiative, convened under the auspices of the Sustainable Development Solutions Network (SDSN) and the Institute for Sustainable Development and International Relations (IDDRI), to understand and show how individual countries can transition to a low-carbon economy and how the world can meet the internationally agreed target of limiting the increase in global mean surface temperature to less than 2 degrees Celsius (°C). Achieving the 2°C limit will require that global net emissions of greenhouse gases (GHG) approach zero by the second half of the century. This will require a profound transformation of energy systems by mid-century through steep declines in carbon intensity in all sectors of the economy, a transition we call "deep decarbonization."

Currently, the DDPP comprises 15 Country Research Partners composed of leading researchers and research institutions from countries representing 70% of global GHG emissions and different stages of development. Each Country Research Partner has developed pathway analysis for deep decarbonization, taking into account national socio-economic conditions, development aspirations, infrastructure stocks, resource endowments, and other relevant factors. The pathways developed by Country Research Partners formed the basis of the DDPP 2014 report: Pathways to Deep Decarbonization, which was developed for the UN Secretary-General Ban Ki-moon in support of the Climate Leaders' Summit at the United Nations on September 23, 2014. The report can be viewed at deepdecarbonization.org along with all of the country-specific chapters.

This chapter provides a detailed look at a single Country Research Partner's pathway analysis. The focus of this analysis has been to identify technically feasible pathways that are consistent with the objective of limiting the rise in global temperatures below 2°C. In a second—later—stage the Country Research Partner will refine the analysis of the technical potential, and also take a broader perspective by quantifying costs and benefits, estimating national and international finance requirements, mapping out domestic and global policy frameworks, and considering in more detail how the twin objectives of development and deep decarbonization can be met. This comprehensive analysis will form the basis of a report that will be completed in the first half of 2015 and submitted to the French Government, host of the 21st Conference of the Parties (COP-21) of the United Nations Framework Convention on Climate Change (UNFCCC).

We hope that the analysis outlined in this report chapter, and the ongoing analytical work conducted by the Country Research Team, will support national discussions on how to achieve deep decarbonization. Above all, we hope that the findings will be helpful to the Parties of the UNFCCC as they craft a strong agreement on climate change mitigation at the COP-21 in Paris in December 2015.

Contents



China

Teng Fei,
Institute of Energy, Environment and Economy, Tsinghua University

Liu Qiang,
National Center for Climate Change Strategy and International Cooperation

Gu Alun,
Institute of Energy, Environment and Economy, Tsinghua University

Yang Xi,
Institute of Energy, Environment and Economy, Tsinghua University

Chen Yi,
National Center for Climate Change Strategy and International Cooperation

Tian Chuan,
National Center for Climate Change Strategy and International Cooperation

Zheng Xiaoqi,
National Center for Climate Change Strategy and International Cooperation

1 Country profile

1.1 The national context for deep decarbonization and sustainable development

Despite fast growth over the last decade (with an average GDP growth rate of 10% over 2000-2012), China is still a developing country with a low level of economic development. In 2010, its GDP was 5,930 billion US$, and per capita GDP was just 4,433 US$. China's has a very significant secondary sector of the economy, which contributed 48.3% to GDP in 2013, but this sector's contribution has declined by 12.5 percentage points since 2000, while the tertiary sector of the economy increased by 12 percentage points. Due to economic and social development, China's level of urbanization has risen from

26.4% in 1990 to 53.7% in 2013. With a 1% increase in urbanization rate, 13 million Chinese inhabitants move to cities every year to pursue a higher standard of living. China is also the most populous country in the world; by the end of 2013, China's population was 1.36 billion, about 20% of the world total.

Although China has made remarkable progress, it is under heavy pressure to improve environmental protection due its resource-intensive development. Xi Jinping, China's President, has described the country's recent model of economic development as "unsustainable," not least because pollution is harming lives and livelihoods, particularly in cities. China recognizes the problems created by pollution, both from greenhouse gases (GHGs) that cause climate change and from other gases and particles. China is also facing growing constraints due to the limited availability of natural resources other than coal. China's leadership has signaled its intention to accelerate the transformation of China's growth model, to make China an innovative country, and to promote more efficient, equal and, sustainable economic development.

1.2 GHG emissions: current levels, drivers, and past trends

According to "Second National Communication on Climate Change" in 2005, China's total GHG emissions were approximately 7.5 Gt CO_2eq of which carbon dioxide accounted for 80%, methane for 13%, nitrous oxide for 5%, and fluorinated gases for 2%. The total net GHG removals through land use change and forestry was about 421 Mt CO_2 eq.

Of total GHG emissions, energy activities represent 77% in 2010 (7.2 GtCO_2) with direct emissions from electricity, industry, transportation, and buildings at 2,929 MtCO_2, 2,999 MtCO_2, 634 MtCO_2, and 633 MtCO_2 respectively (Figure 1a). The major emitting energy activities are the coal-intensive power generation and industrial sectors (Figure 1b). Notably, as the main sector driving economic growth, the industry sector accounts for 68% of total final energy consumption and almost 71% of total energy-related CO_2 emissions in 2010. This is essentially from a few energy-intensive industries, which consume about 50% of energy use in the industry sector (iron and steel, cement, synthesis ammonia, and ethylene production).

The growth of China's economy has been the major driver of increasing emissions in the past three decades. The structure of this growth has had opposite dynamics over the last decades with direct consequences on emissions. During the first ten years of China's openness policies (1980-1990), structural change favored lower-emission activities and helped to decouple emissions from aggregate growth. This was followed by a rapid process of industrialization, which saw a double digit growth rate in the heavy industries. This industrialization accelerated growth in emissions faster than GDP, though this was tempered in the 11th Five-Year Plan. This shows the crucial impact of economic structure on China's future emission rates.

Coal has dominated China's energy mix over the past decades, supporting economic growth with a high carbon intensity fuel. The only factor that has significantly contributed to slow the rate of growth in emissions has been energy efficiency, as seen in the reduction of China's energy intensity per unit of GDP (Figure 2a). Electricity generation has been the major driver of the increase in carbon emissions, since the growing needs for electricity have been satisfied by the fast development of coal-based power units.

Although China is now the country with the highest emission levels, current and historical per capita emissions are still lower than IPCC

Annex I country levels, whether on an annual (5.4tCO_2e/cap) or cumulative (95 tCO_2e/cap over 1850-2009) basis. Given these recent trends, continuously increasing emissions can be expected in the future with business as usual economic growth.

Figure 1. Decomposition of GHG and Energy CO_2 Emissions

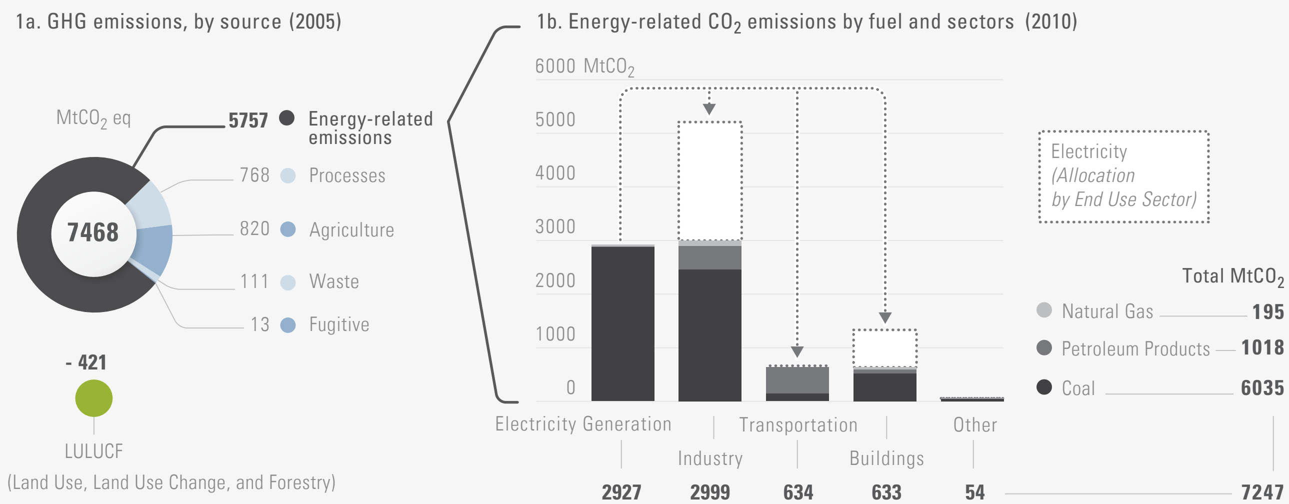
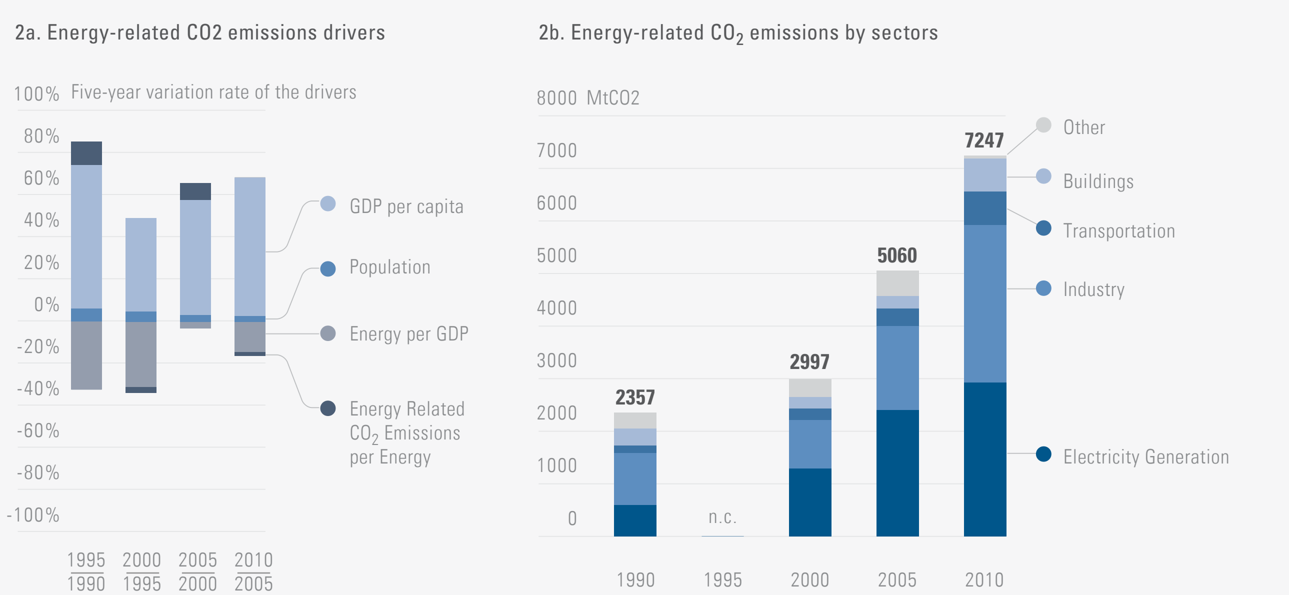


Figure 2. Decomposition of historical energy-related CO_2 Emissions, 1990 to 2010



Source: Second National Communication on Climate Change (2005)

2 National deep decarbonization pathways

2.1 Illustrative deep decarbonization pathway

2.1.1 High-level characterization

The illustrative deep decarbonization pathway combines an acceleration of the evolution of economic structure, reductions in energy intensity and the promotion of non-fossil fuel energy to control emissions in a context of continued economic growth. GDP per capita is assumed to increase by more than 6 times from 2010 to 2050 to satisfy development needs, but energy trends are significantly decoupled from this growth with an increase of primary and final energy of 78% (from 93.7 EJ in 2010 to 166.9 EJ in 2050) and 71% (from 66.9 EJ in 2010 to 114.4 EJ in 2050) respectively (Figure 3). This increase is mainly triggered by the industrial sector (+28%), buildings sector (+141%), and transportation sector (+204%), along with changes in economic structure, an increase in urbanization rate, and the completion of the industrialization process. In particular, the share of coal in primary energy consumption falls to 20% in 2050, while the use of natural gas and non-fossil fuels increase, contributing 17% and 43% respectively.

Figure 3. Energy Pathways, by source

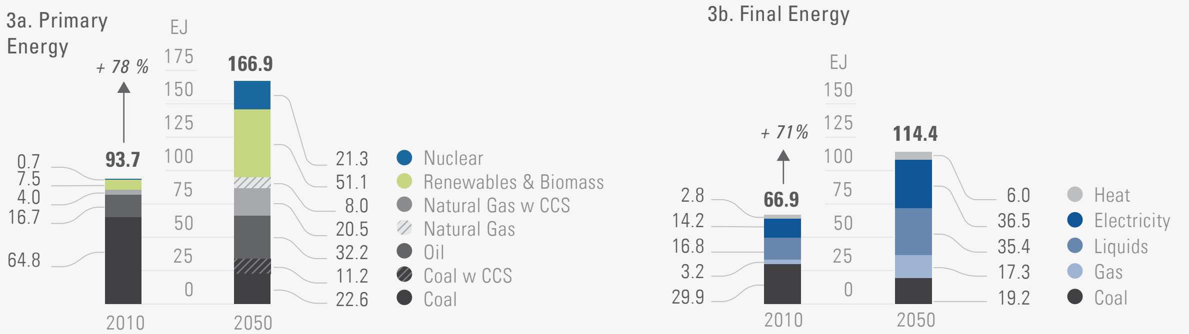
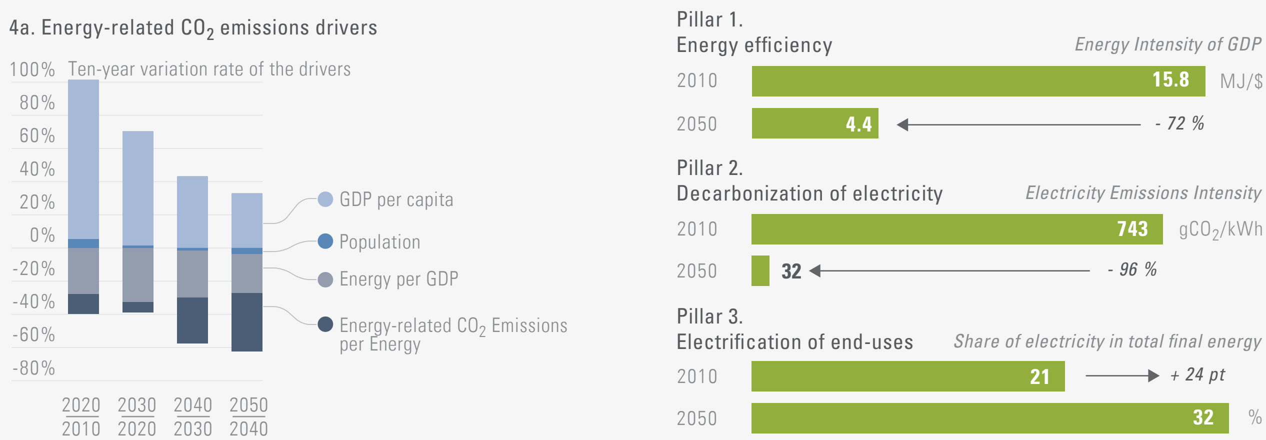


Figure 4. Energy-related CO_2 Emissions Drivers, 2010 to 2050



In the illustrative deep decarbonization pathway, energy-related CO_2 emissions decrease by 34%, from 7.25 $GtCO_2$ in 2010 to 4.77 $GtCO_2$ in 2050, essentially due to a decrease of both the primary energy per unit of GDP by 73% and of energy-related CO_2 emissions per unit of energy by 61% (Figure 4a). The former is largely explained by structural change with a large decrease of the share of energy-intensive sectors of the economy and improvement of economy-wide energy efficiency. The latter mainly comes from decarbonizing the power sector and the electrification of end-uses (from 21% in 2010 to 32% 2050) while increasing living standards and modernizing energy use patterns (Figure 4b). The application of CCS technologies in power generation and the industrial sector is also a crucial feature of this illustrative pathway, contributing 1.3 $GtCO_2$ and 0.8 $GtCO_2$ respectively.

At the sectoral level, the industry sector emissions remain the largest, but buildings and transportation increase in share, from 17% in 2010 to 49% of 2050 emissions (Figure 5).

Table 1. The development indicators and energy service demand drivers in China

	2010	2020	2030	2040	2050
Population [Millions]	1360	1433	1453	1435	1385
GDP per capita [$/capita, 2010 price]	4455	8708	14666	20945	27789

Figure 5. Energy-related CO_2 Emissions Pathway, by Sector, 2010 to 2050

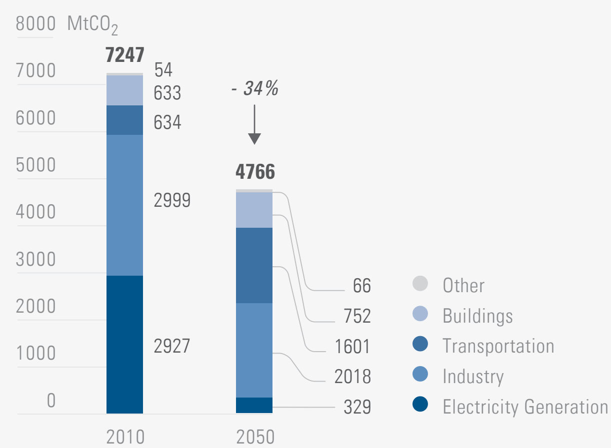
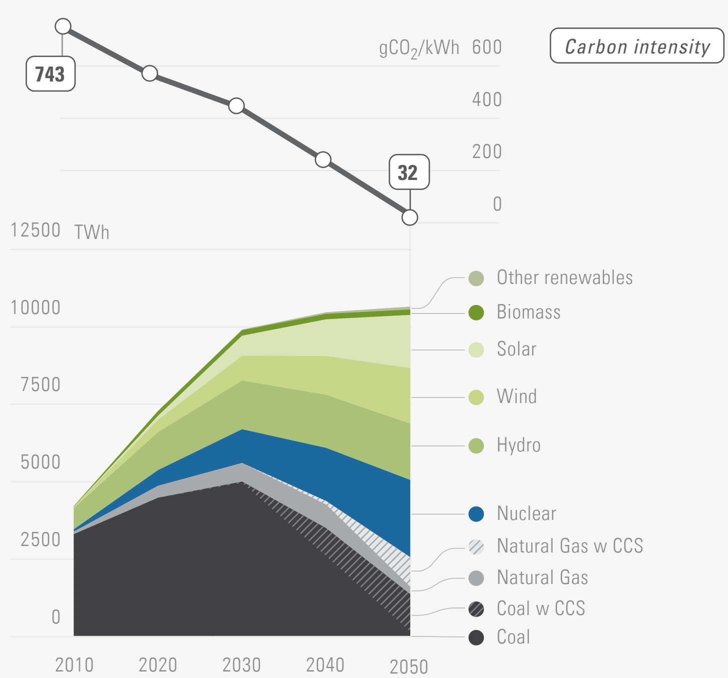


Figure 6. Energy Supply Pathway for Electricity Generation, by Source



2.1.2 Sectoral characterization

Power sector

Electrification is an important indicator of economic and social development, and electricity consumption in the illustrative deep decarbonization scenario is projected to reach 10,143 TWh in 2050, or 7,300 kWh per capita (around 2.5 times the 2010 level).

Since thermal power, especially from coal, is an important source of local pollutants and GHGs, the decarbonization of power sector is of significance for the achievement of low-carbon development. The carbon emission intensity of power generation in 2050 will decrease from 743 gCO_2/kwh in 2010 to 32 gCO_2/kwh in 2050 (Figure 6a). This is permitted by the large-scale use of nuclear (which reaches 25% of electricity production in 2050), intermittent renewables (installed capacity of wind and solar respectively equal 900 GW and 1,000 GW in 2050, contributing 18% and 17%

of electricity generation respectively), and hydro (which accounts for an additional 18%). Fossil-fuel power generation units still represent 24% of electricity generation in 2050 (notably because natural gas power generation technologies act as an important back-up technology for intermittent generation technologies). Fossil-based emissions are reduced by a large percentage due to the deployment of efficient technology options (notably, all new coal power plants after 2020 will be supercritical, ultra- supercritical, or IGCC power generation technologies) and CCS facilities on 90% of coal power plants and 80% of natural gas power plants. This diffusion supposes that CCS technology will become commercialized after 2030.

Industry

Energy efficiency could be improved by a large degree through technological innovation in industrial sectors[1]. This would permit a reduction of energy consumption per value added of the industry sector by 74% from 2010 to 2050, limiting the rise of final energy consumption to 28% (from 46 EJ in 2010 to 58 EJ in 2050). By promoting the transformation of coal-fired boilers to gas-fired boilers and enhancing the use of electricity, the illustrative pathway reduces the share of coal from 56% in 2010 to 30% in 2050, while increasing that of gas and electricity in final energy use. Since it's hard to change feed composition in some industries, it is not expected that further significant changes in energy structure are possible.

In addition, structural changes in industry could be achieved through developing strategic industries, controlling overcapacity of main industry outputs, and eliminating backward production capacity. Notably, many high-energy-intensive industry sectors will experience a slower growth, and the output of some high-energy-intensive industry products (notably, cement and crude steel) are anticipated peak by 2020. These different options lead a 57% decrease of CO_2 emissions in the industry sector, particularly due to the contribution of CCS technology. If CCS is deployed appropriately on a commercialized scale after 2030 in key industry sectors, it is expected to sequester 28% of total CO_2 emissions in the industry sector in 2050 (Figure 7a).

Buildings

Total floor area will continue to grow (from 45.2 billion m^2 in 2010 to 80.3 billion m^2 in 2050), and the urban and rural residential building floor areas per capita will increase (reaching around 36 m^2 and 47 m^2 respectively) in parallel with the process of urbanization. This pushes total energy consumption up by 140% (from 11 EJ to 27 EJ) in line with a 33% increase of energy consumption per capita. Energy efficiency measures play an important role in limiting this rise of energy demand, where performance improves by 25%, 22% and 10% from 2010 to 2050 for commercial, urban residential and rural residential units respectively and appliance energy efficiency increases (e.g. 66% and 75% for regular and central air conditioners). The proportion of coal in energy use decreases gradually (from 39% in 2010 to 5% in 2050), as electricity and gas rise (reaching 50.5% and 33.2% in 2050 respectively). This triggers a decrease of the average carbon emission intensity from 119.8 gCO_2/MJ in 2010 to 32.7 gCO_2/MJ in 2050. That ensures a 34% lower emissions level in 2050 compared to 2010 (Figure 7b).

Transport

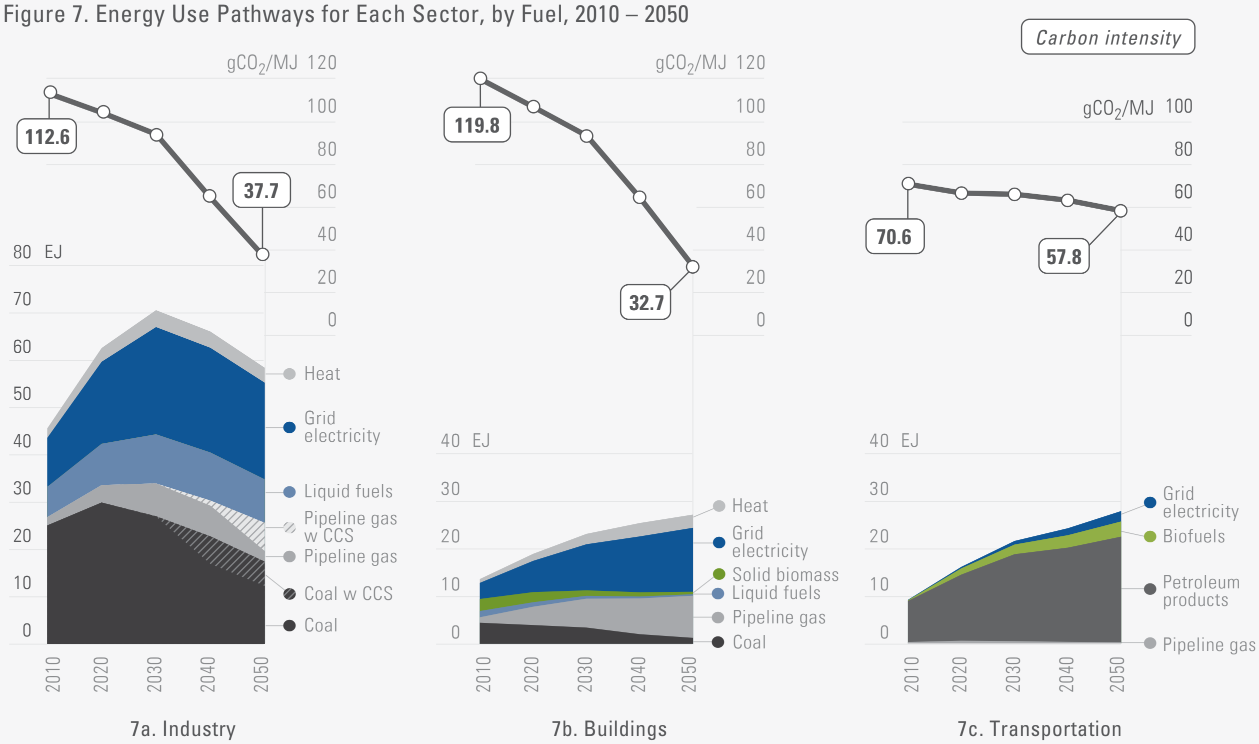
Pushed by rising mobility demand along with wealth increase (a ten-fold increase of kilometers per capita to reach 20,000 km/cap in 2050), energy consumption in transport will almost triple, from 9.3 EJ in 2010 to 28.1 EJ in 2050, representing a rising share of total energy consumption, from 14% in 2010 to 24% in 2050. A partial decoupling will allow the carbon emissions to rise by only 149% (from 652 $MtCO_2$ in

1 E.g., replacing converter with electric furnace or using waste heat of low temperature flue gas in sintering and pelletizing in iron and steel industry and replacing vertical shaft kilns with new dry production process and enforcing low-temperature cogeneration in cement industry.

2010 to 1,621 $MtCO_2$ in 2050) due to transport mode shifts, an increase of vehicle fuel economy, and the promotion of electricity and biofuel use (Figure 7c). The primary mode shift encompasses a transition from on-road to off-road modes of transport, where rail and water transport grow over time. In freight transportation, road transportation is limited to 32% in 2050, water transportation maintains the highest share (about 42% in 2050) and railway grows to 24%. Within the passenger transportation, road transportation will be kept at 35% in 2050 and railway transportation will remain the main transportation mode (45% of total passenger mobility in 2050) notably due to the development of high-speed railway and rail-based transit systems in cities (attaining 50,000 km by 2050, 36 times higher than in 2010).

For the On-road transportation, improvement of transportation management is an important option to control the rapid growth of demand. An increase in fuel economy is also crucial, with a 70% improvement of light duty vehicles' energy intensity and the deployment of high efficiency diesel vehicles in freight transportation. And, even more importantly, the share of gasoline and diesel vehicles sold significantly decreases by 2050 because of the adoption of alternative fuel vehicles. In intra-city transportation low-carbon vehicles gradually play a more dominant role with the adoption of pure electric vehicles, plug-in hybrid electric vehicle (PHEV), biofuels and fuel-cell vehicles (FCV). A reduction in gasoline and diesel use also occurs because of railway electrification, which will play a dominant role in the railway energy mix by 2050.

Figure 7. Energy Use Pathways for Each Sector, by Fuel, 2010 – 2050



Note: Carbon intensity shown in Figure 7 for each sector includes both direct end-use emissions and indirect emissions related to electricity production.
Figure 7b only includes energy use for commercial buildings. Non-commercial low-carbon energy options (e.g. biomass and biogas used in rural buildings and residential solar water heating) that reduce use of fossil fuels and electricity in the buildings sector are included in the scenario analysis but not shown in the Figure 7b.

2.2 Assumptions

Emphasizing technology development and innovation is vital for the achievement of the Illustrative Deep Decarbonization Pathway. Sufficient input on technology R&D and incentives for technology deployment are necessary. In order to achieve the decarbonization pathway, significant technological and economic effort needs to be made in different sectors, and low-carbon technologies must be distributed across the country. The most important low-carbon options, especially energy saving technologies in end use sectors, in the illustrative pathway are discussed below:

- Transport: high-efficiency diesel vehicle or gasoline cars, electricity vehicles, plug-in hybrid vehicles, and fuel cell vehicles in passenger transport; a 30% improvement of fuel economy for conventional high duty vehicles; fully electrified rail-based transit for both long-distance and short-distance by 2050.
- Buildings: increasing energy efficiency for both existing and new buildings through innovative technologies (like advanced, low-carbon buildings, which will increase their share in urban regions from 2% in 2012 to 50% in 2020 and help to reduce the heating and cooling demand); to substitute for coal boilers, the application of advanced heating facilities, such as ground source heat pumps and decentralized solar heating systems as well as natural gas boilers and CHP for centralized heating; development of high-energy-efficiency cooling systems, lighting system and appliances; the large-scale use of renewable energy, such as solar water heaters in residential buildings.
- Industry: high-efficiency waste heat recycling technologies, high efficiency boilers and motors across all sectors; energy saving technologies in high-energy-intensive industries permitting a fall from 2010 to 2050 of the energy consumption per unit of product output of crude steel, cement, ammonia and ethylene by 48%, 32%, 26%, and 26%, respectively.
- Electricity generation: an increased reliance on non-fossil fuel power generation technologies is the major contributor to the reduction in the carbon intensity of electricity generation. Hydro power production of 500 GW approaches its potential by 2050; wind power reaches 1,000 GW in 2050 (70% off-shore); solar energy power generation experiences a fast development, where solar PV and solar thermal reach approximately 1,000GW and 150GW respectively in 2050; biomass-fired power generation and other renewables will be limited due to resource constraints and high relative cost; nuclear power generation technologies will be developed (due to learning from foreign advanced technologies and domestic research and demonstration) and exceed 300GW by 2050.
- CCS technologies will be another important technology and will be deployed in both the power and industry sectors at scale in 2050. It is expected that CCS is developed and demonstrated from 2020 and deployed at a commercialized scale from 2030. Both CO_2 utilization and geologic storage have great potential compared to the amount of CO_2 captured in the illustrative pathway (0.1 to 1 billion ton per year for the former, more than 1 billion ton annually for the latter).

2.3 Alternative pathways and pathway robustness

In order to achieve the illustrative decarbonization pathway, there are key measures that must deviate significantly from current trends. This includes a low-carbon transition in electricity generation even as electricity demand increases faster than gains in end-use energy efficiency. The former dimension depends on the development and deployment of non-fossil fuel power generation; the improvement in energy efficiency concerns key industrial sectors, vehicles, urban buildings, and residential appliances. There are still uncertainties with some key measures and technologies that might affect the achievement of this pathway, such as the integration of intermittent renewable power into the power system, application of CCS facilities, supply of natural gases, and penetration of electric vehicles.

In case the magnitude of the measures discussed above is less than assumed, some alternative approaches could be envisioned, leading to different emissions scenarios. For example, the proportion of non-fossil fuel electricity is 41% in 2050 in the illustrative deep decarbonization pathway, of which nuclear power represents a share of 31%. However, if the nuclear development is hindered in the future, coal power (with CCS) or renewable power might grow in its place. Increase reliance on wind and solar energy in the power sector is possible, though it largely depends on the possibility of developing new energy storage solutions or enough natural gas power units to manage the resource intermittency.

2.4 Additional measures and deeper pathways

Dematerialization

A large portion of China's emissions are linked to the process of urbanization since large quantities of construction materials will be required to build and maintain urban infrastructure, especially cement and steel. Measures to decrease the demolition of buildings and transportation infrastructures will contribute to further deeper decarbonization by combining a reduction of material consumption intensity and reuse of waste construction materials.

Technology innovation

The early deployment of key mitigation technologies can help China follow a deeper decarbonization pathway that will also contribute to the growth of China's economy in other ways. Notably, the large scale of the Chinese market, production economies of scale, and learning-by-doing can help accelerate cost reductions and diffusion of low-carbon energy options, in line with China's development strategy to grow "strategic emerging industries."

Structural change

China's growth has been characterized by a high saving and investment rate in the past three decades. In the future, China will maintain its growth rate around 7%, reduce its saving and investment rate, and increase the share of consumption in its GDP. To maintain the growth rate at a relatively high level while reducing the investment rate, China needs to increase the productivity of its investment. Deep decarbonization strategies can contribute to this gain in productivity through: 1) shifting the structure of the economy towards less capital intensive sectors (e.g. from industrial sectors to service sectors); 2) improving the efficiency of capital investment to produce output, especially through energy saving; and 3) increase the productivity of other factors, especially labor and energy.

2.5 Challenges, opportunities, and enabling conditions

China's future development is the source of much uncertainty when examining potential emission reduction pathways.

First, the level of economic growth is largely uncertain. The average Chinese growth rate has been a little more than 10% in the past twenty years. The 18th CPC National Congress has projected that the GDP growth rate will be around 7.2% in the next decade. This reduction of 3 to 4 percentage points is more than the typical growth rate of developed countries. China's economy will continue to develop at a relatively high speed, varying from 5% to 10%. This expected variation will have a significant impact on the actual level of energy demand.

The second aspect is future adjustments to industrial structure and changes in the mode of development. China's energy consumption per unit of GDP is twice the average level of the world, which means there is a significant opportunity for reductions in energy intensity. However, the decline cannot depend on incremental technology change, because China's power plants are newly-built with efficient super-critical and ultra-supercritical units, and for energy-intensive industries the efficiency gap compared to developed countries is low (10%-20%).Therefore, the focal point in China is to adjust the industrial structure and change the mode of development towards less heavy and chemical industry as well as less production of energy-consuming products like steel and cement. Nevertheless, the issues of how to adjust and how to identify the degree and intensity of the adjustment have great uncertainties. The third aspect is urbanization, triggered by the demand of social development. The demand for steel and cement is very large in the process of urbanization. According to estimates, there may be an increase of 1 percentage point in the urbanization rate each year.

Finally, exports are an important factor in the economy, production of which significantly contributes to total emissions. Currently, 25% of energy is used for the production of export products in China, and given that adjustments of the structure of exports is not an easy task, manufacturing exports (and associated emissions) are expected to remain important in the long run. This area of potential emission reductions would benefit from further investigation.

2.6 Near-term priorities

The reduction of CO_2 emissions is not only a response to climate change, but it also addresses the urgent demand of developing the national economy. If the coordination works well, the strategy of climate change mitigation and sustainable development will lead to a win-win situation.

Change the concept of development

The guiding ideology and the concept of development must be changed among all cadres. The central government should understand the trade-off between GDP growth highly dependent on resource industry and the cost paid for resources losses. The central and western regions need to be redesigned and readjusted so as to draw more attention to climate change. At the same time, the evaluation mechanism of officials must be revised. The promotion of a position should not only rely on the growth rate of GDP but should also look at a comprehensive analysis of gain and loss.

Deepen the energy reform

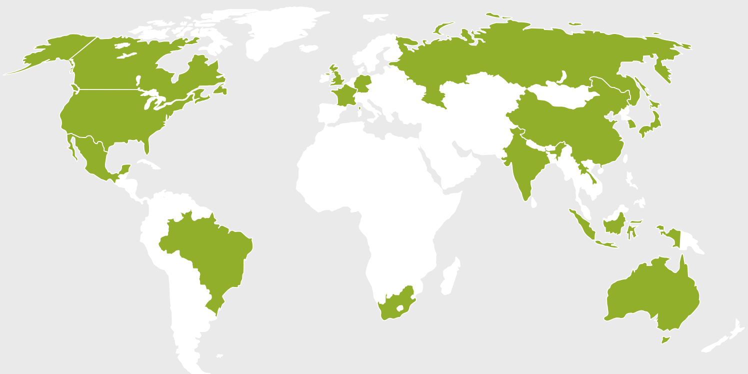
The reform of the energy sector needs to be promoted, including the reform of the price system and fiscal taxation system. Although China's energy price remains high in developing countries, the price structure and pricing system is very reasonable, especially that of coal and electricity. The current price of coal and electricity does not include the environmental cost, and so the exploitation of resources does great damage to the environment. The reform of resource taxes and the proposal of a carbon tax must be considered in energy policy, along with the price system and fiscal and financial field.

Pricing Carbon

China has established 7 pilot emissions trading schemes (ETSs) at provincial and city levels with a view to establish a national ETS around 2020. The future development of China's ETS should build upon the experience gained in regional pilots and resemble the approach taken in the EU ETS and the Australian and Californian schemes. A careful design is key for the success of China's ETS, especially in the electricity sector, as is practical and reliable company-level measurements, reporting, and verification of emissions. An early stage of harmonization with design of other international ETSs will facilitate the linkage with these ETSs in the future.

Reduce coal consumption

Methods for reducing the use of coal have many synergistic effects. The main way to improve the domestic environment is to reduce coal mining. Substantial coal mining not only consumes a large amount of water, but it also leads to slag penetration and deposition, resulting in the serious pollution of groundwater resources. In addition, coal mining causes the collapse of areas that have been mined. The area of subsidence in China has reached 10,000 km^2. Furthermore, conventional pollutants, such as sulfur dioxide, nitrogen oxides, and dust (including the thick fog and haze weather in Beijing and Tianjin) are partly caused by burning coal. Therefore, the reduction of coal consumption is essential for China to improve domestic environmental quality.



COUNTRY RESEARCH PARTNERS. Australia. Climate Works Australia; Crawford School of Public Policy, Australian National University (ANU); Commonwealth Scientific and Industrial Research Organization (CSIRO); Centre of Policy Studies, Victoria University. Brazil. COPPE, Federal University, Rio de Janeiro. Canada. Carbon Management Canada; Navius Research; Simon Fraser University; Sharp. China. Institute of Energy, Environment, Economy, Tsinghua University; National Center for Climate Change Strategy and International Cooperation (NCSC). France. Université Grenoble Alpes, CNRS, EDDEN, PACTE; Centre International de Recherche sur l'Environnement et le Développement (CIRED), CNRS. Germany. Dialogik. India. The Energy and Resource Institute (TERI). Indonesia. Center for Research on Energy Policy-Bandung Institute of Technology, CRE-ITB; Centre for Climate Risk and Opportunity Management-Bogor Agriculture University (CCROM-IPB). Japan. National Institute for Environmental Studies (NIES); Mizuho Information and Research Institute (MIRI). Mexico. Instituto Nacional de Ecología y Cambio Climático (INECC). Russia. Russian Presidential Academy of National Economy and Public Administration (RANEPA); High School of Economics, Moscow. South Africa. The Energy Research Centre (ERC) University of Cape Town (UCT). South Korea. School of Public Policy and Management, Korea Development Institute (KDI); Korea Energy Economics Institute (KEEI); Korea Institute of Energy Research (KIER); Korea Environment Institute (KEI). United Kingdom. University College London (UCL) Energy Institute. United States of America. Energy + Environmental Economics (E3).

DDPP PARTNERS ORGANIZATIONS. German Development Institute (GDI); International Energy Agency (IEA); International Institute for Applied Systems Analysis (IIASA); World Business Council on Sustainable Development (WBCSD).