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SCOPING PAPER:
A STUDY OF CHINA'S ENERGY COMMITMENTS

PREPARED BY
THE ASIA PACIFIC FOUNDATION OF CANADA

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GLOSSARY

CBM: Coalbed methane

CCS: Carbon capture and storage

CNNC: China National Nuclear Corporation

EV: Electric vehicle

FIT: Feed-in tariff

GHG: Greenhouse gases

IEA: International Energy Agency

INDC: Intended Nationally Determined Contributions

LNG: Liquefied natural gas

MLR: Ministry of Land and Resources (China)

MOF: Ministry of Finance (China)

MOHURD: Ministry of Housing and Urban-Rural Development (China)

NDRC: National Development and Reform Commission (China)

NEA: National Energy Administration (China)

RMB: Renminbi

SCE: Standard coal equivalent

SOE: State-owned enterprise

TCE: Ton of coal equivalent

TOE: Ton of oil equivalent

VAT: Value-added tax

INTRODUCTION

CHINA'S ENERGY POLICY VISION, TARGETS, AND KEY FINDINGS

1. CHINA'S ENERGY POLICY VISION

China's energy strategy has traditionally been linked to its economic development agenda. Securing energy to meet domestic requirements remains a high priority today. While China is currently experiencing a reduction in energy demand growth, even moderate growth translates into substantial absolute demand increases. Predictions vary, but the International Energy Agency suggests that China's energy demand will increase roughly 30% between 2013 and 2035.[1] However, China's energy production does not meet current energy needs. A major objective of Chinese energy policy is to increase energy security by decreasing reliance on fossil fuel imports.

Concerns about pollution, climate change, and environmental damage are increasingly shaping Chinese policy-making. The growing importance of green development can be seen in China's 13th Five-Year Plan, which lays out a blueprint for the country's development over the next five years. The plan aims to double 2010's GDP and per-capita income by 2020 through "innovative, co-ordinated, green, open, and inclusive" development.[2] The plan includes a prominent section outlining the concept of "green development," including green lifestyles, high energy efficiency, low carbon emissions, and the introduction of market mechanisms.

The Central Leading Group on Financial and Economic Affairs has taken up the green development agenda. This Group is the most important decision-making body on China's major economic strategies and is led by President Xi Jinping. The Group sets strategic goals for China's economic development that are subsequently implemented by ministries and departments.

In June 2014, the Group proposed to push forward a revolution in the energy sector, through a strategy of 'four revolutions and one co-operation.' Accordingly, the Group is addressing the four energy 'revolutions' in (1) consumption, (2) supply, (3) technology, and (4) systems, as well as international co-operation in energy. The green development concept and the 'four revolutions and one co-operation' have since served as guiding principles for China's emerging energy strategy.

In addition to furthering green growth, Chinese policy aims to increase the role of the market in allocating resources, including in the energy sector. While market reform has been a long-standing policy goal, the emphasis was heightened at the third plenum of the 18th Central Committee of the Communist Party in 2013. As part of wider changes to the structure of the economy, government has been increasing the role of market mechanisms in pricing energy and increasing areas of the energy sector open to private investment. These changes are largely intended to balance energy supply and demand and to increase the efficiency of the energy system.

Finally, Chinese energy policy stresses 'going global' as a leader in the provision of energy technology and services. China's export ambitions cross all energy types, including coal, oil and gas extraction, renewable energy, and nuclear technologies.

2. CHINA'S ENERGY POLICY TARGETS

These overarching macro objectives are reflected in China's current energy targets and commitments as outlined in several key documents, including:

- *The Thirteenth Five-Year Plan on National Economic and Social Development*, published on March 17, 2016;
- *The Energy Development Strategy Action Plan (2014-2020),* published on June 7, 2014;
- *The National Plan on Climate Change (2014-2020)*, published in September 2014; and
- *Intended Nationally Determined Contribution: Enhanced Actions on Climate Change (INDC),* published on June 30, 2015.

These documents set out the following key national targets and commitments on energy, most to be reached by 2020:

- Control national energy consumption at around 5 billion tons of standard coal equivalent (SCE) (3.38 billion TOE), and coal consumption at around 4.2 billion tons SCE (2.94 billion TOE);
- Ensure domestic production of energy of 4.2 billion tons of SCE (2.94 billion TOE), around 85% of total supply;
- Ensure that non-fossil energy reaches 15% of total consumption by 2020 (and 20% by 2030), that natural gas exceeds 10%, and that coal consumption is less than 62%;
- Deepen institutional reform in the energy sector and let the market play a decisive role in resource allocation;
- Achieve the peaking of CO2 emissions around 2030 with efforts to peak prior to 2030; and
- Lower CO2 emissions per unit of GDP by 40% to 45% of the 2005 level by 2020, and by 60% to 65% of the 2005 level by 2030.

3. KEY FINDINGS

- China faces a major energy challenge as it aims to secure sufficient energy to maintain and grow its economy while also enhancing environmental performance. Measures to attain these two goals are often, but not always, complementary.
- China entered a period of slower energy demand growth post-2009 due to a combination of factors, including slower economic growth rates; a shift in the economy away from high energy intensity industries, such as coal and steel production; and ongoing energy intensity improvements. While energy demand growth rates have intensified in the transportation and residential sectors, China's energy demand growth is not projected to return to pre-2009 levels.

- Slowing energy demand growth is resulting in a reduction in emissions growth rates and air pollution. However, China will still need to implement strong policies aimed at emissions reduction if the country is to meet its emissions targets.
- Industry has been the primary driver of energy and electricity demand in China. Success in reducing emissions will require the continuation of policies aimed at reducing the role of energy-intensive industries in the economy.
- China's energy policy-making structure consists of a wide variety of ministries, departments, and state-owned enterprises (SOEs) with entrenched interests. This structure creates complexity in implementing energy policies aimed at improving environmental performance and increasing private sector involvement.
- China will need to continue reducing coal consumption if it is to reduce GHG emissions. China's absolute coal consumption declined for the first time in 2014, a trend that continued in 2015. However, since approximately two-thirds of China's primary energy consumption comes from coal, ongoing coal use reduction poses a challenge for energy security and will require substantial increases in non-coal energy production.
- Implementation of carbon capture and storage is mentioned in climate change-oriented policy as a means of reducing the environmental impact of coal use in power generation and industry.
- Growth in fossil fuel production lags behind demand growth, making China highly import dependent. International collaboration in oil and gas extraction technology is a priority.
- China needs a safer and more developed transmission network and improved demand side management to better manage energy storage and transmission for peak uses. This applies to all energy types including coal, oil, gas, and electricity. China has been implementing large-scale build-out in renewable power generation but faces challenges integrating renewable energy into the grid.
- International collaboration is an important part of China's energy development strategy. Key areas where China requires international collaboration to meet domestic needs include commodity imports, as well as technologies for carbon capture and storage, shale gas extraction, smart-grid, nuclear energy, and water conservation in the energy extraction process.
- China aims to become a global leader in the export of technology in all energy categories, including coal, oil and gas extraction, renewable energy, and nuclear energy.

4. STRUCTURE OF PAPER

This paper is divided into five parts. Section I discusses current trends in China's energy sector; Section II outlines China's energy policy structure; Section III describes energy-related greenhouse gas (GHG) emissions targets and actions on climate change in China; Section IV describes energy production and consumption targets, policies, and measures by primary energy sources; and Section V discusses China's needs for international co-operation. Finally, the conclusion provides an overview of China's energy policy approach and highlights its implications for Canada.

SECTION I

TRENDS IN CHINA'S ENERGY CONSUMPTION AND PRODUCTION

Over the last 30 years, China's energy demand has increased rapidly due to economic growth, resulting in rising CO2 emissions and dependency on imported fossil fuels. Since 2009, this growth has slowed—a trend that is anticipated to continue in the long term. This section provides an overview of China's trends in energy consumption and production as context for further discussion of China's energy and emissions targets.

1. TRENDS IN ENERGY CONSUMPTION: SLOWING ENERGY DEMAND GROWTH

Chinese energy consumption has increased dramatically since the 1980s, with particularly strong demand growth occurring between 2000 and 2009 (Figure 1.1). Since 2009, however, growth in China's energy demand has slowed. In 2014, primary energy demand grew only 2% relative to 2013, the lowest percentage increase since 1998.[3]

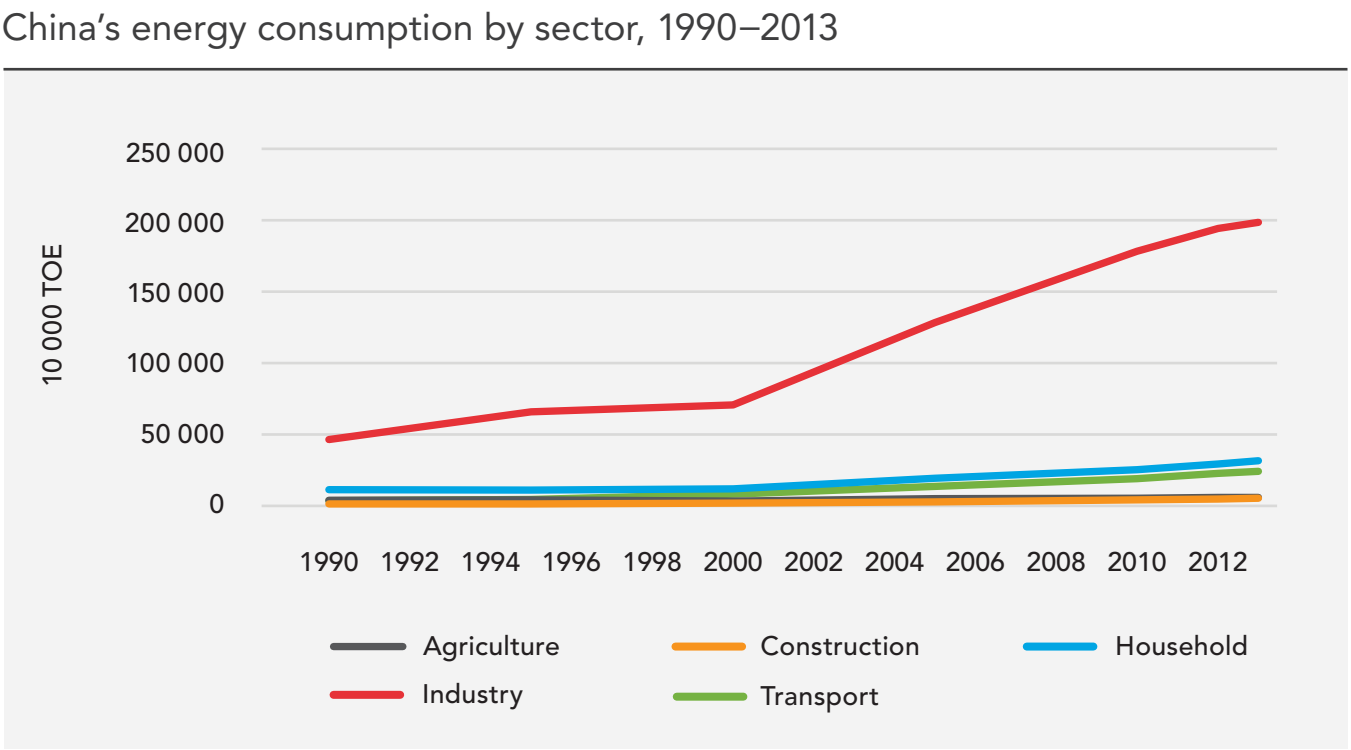

Figure 1.1: China's energy consumption by sector, 1990–2013[4]

Coal has consistently been China's largest energy source, comprising approximately 66% of primary energy consumption in 2014 (Figure 1.2).[5] While renewables have experienced the highest percentage increase over the past 25 years, coal has seen the greatest increase in absolute terms.

Electricity consumption reflects the trajectory of China's primary energy consumption growth trends. Demand for electricity in China is still increasing but at a declining rate, reflecting slower economic growth and industrial demand. The bulk of the demand increase over the last two decades has been met by thermal generation, which makes up about two-thirds of installed electricity-generation capacity (Figure 1.3).

China's primary energy consumption by fuel type, 2014

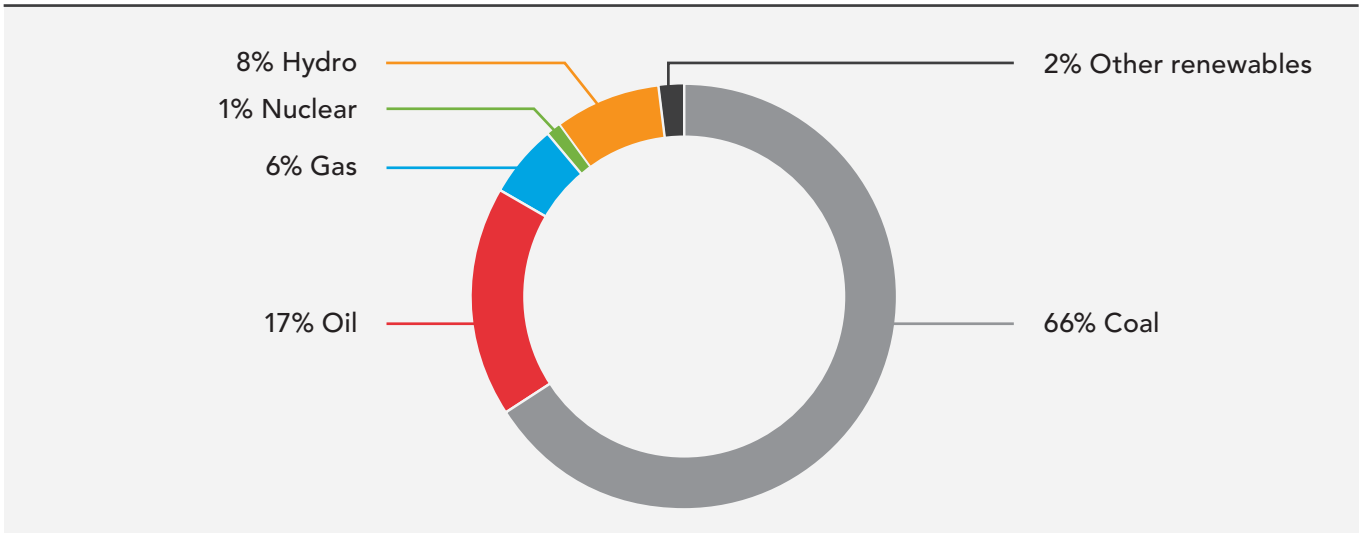

Figure 1.2: China's primary energy consumption by fuel type, 2014[6]

China's electricity consumption by energy source, 1990–2013

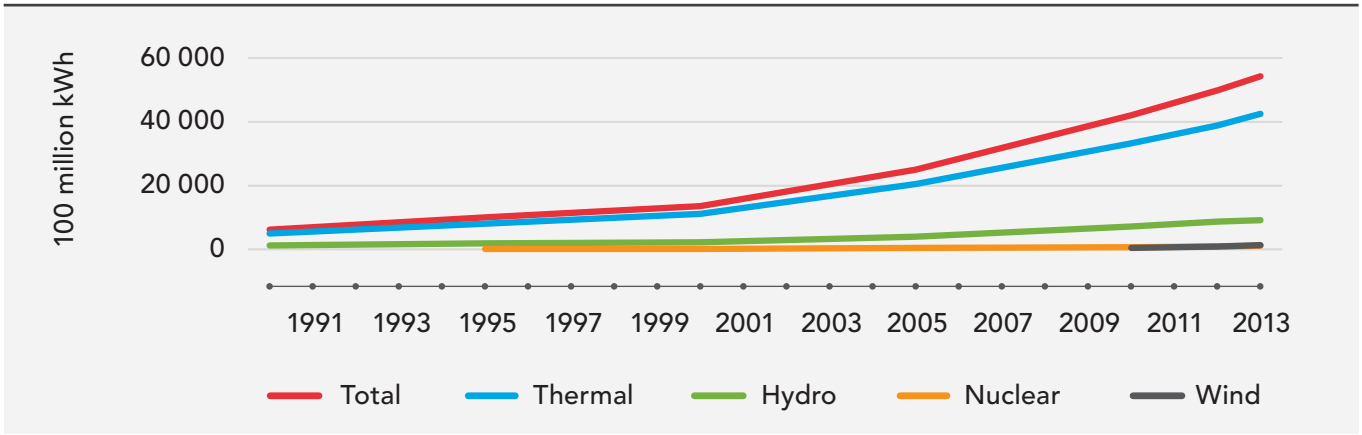

Figure 1.3: China's electricity consumption by energy source, 1990-2013[7]

Projections from a variety of institutions suggest that slower energy demand growth is China's "new normal"; however, the level of reduction varies by commentator. Under its central scenario, the International Energy Agency (IEA) predicts 1% annual growth in primary energy demand through 2040, down from the 2% annual growth (through 2035) that the agency predicted in 2010.[8] BP's *Energy Outlook to 2035* likewise predicts a slowing in energy demand growth rates to less than 2% per annum, compared with more than 8% in recent years.

Nevertheless, China's slower energy demand growth rates still translate into substantial absolute energy demand increases. The IEA notes that China's energy demand will increase 30% between 2013 and 2035, while projections by ExxonMobil predict that China and India together will account for half of total energy demand growth through 2040.[9]

FACTORS DRIVING DEMAND TRENDS

There are a number of core drivers that have fuelled China's rapid growth in energy demand through the early 2000s and the slowdown (but still significant overall energy growth) post-2009:

1. Changes in GDP growth: For most of the 1990s and early 2000s, China was experiencing double-digit economic growth, resulting in skyrocketing energy demand. China's energy demand is anticipated to keep growing, but at a slower rate, due to lower GDP growth rates. The World Bank estimates that China's GDP will grow approximately 5% to 6% per annum between 2016 and 2020.[10]
2. Changes in industrial demand: Industry has consistently been the largest end user of energy in China (70% in 2014).[11] The spike in energy consumption in the early 2000s can largely be attributed to growth in production of energy-intensive products, such as cement and steel, for both the domestic and international markets (Figure 1.4). China's economic composition is gradually shifting away

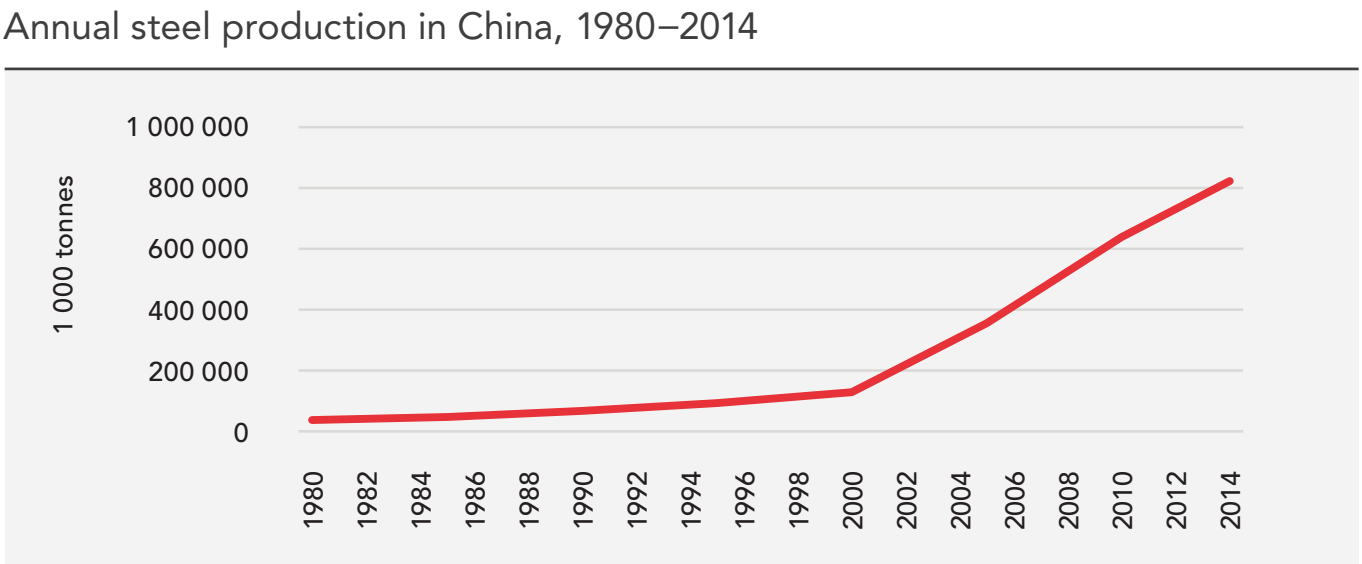

Figure 1.4 Annual steel production in China, 1980-2014[12]

from these high-energy-intensity industries toward the services sector, contributing to a reduction in energy consumption growth rates.

3. Improvements in energy intensity: Even as energy demand in China increased rapidly, the country experienced substantial progress in reducing energy intensity, defined as energy use per unit of GDP (Figure 1.5). This reduction is linked to technological improvements as well as the growing role of both light manufacturing and the service sector in the economy. The rise in energy intensity per unit of GDP in the mid-2000s was caused by growing production in high-energy-intensity industries, such as steel and cement production (Figure 1.5).

China's primary energy consumption per US dollar of GDP, 1980–2011

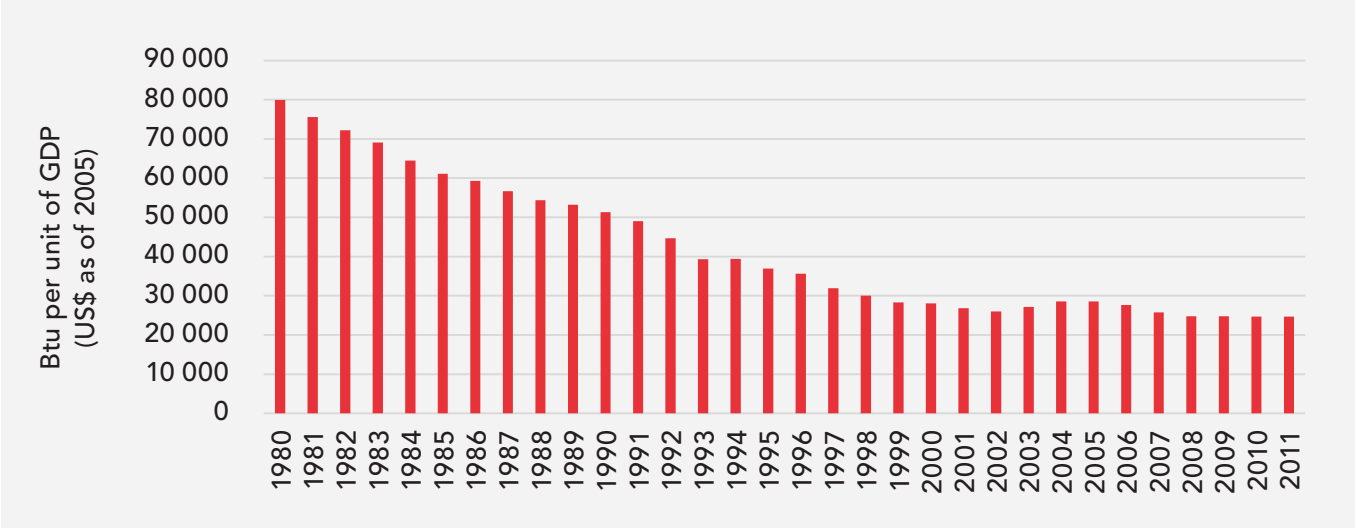

Figure 1.5: China's primary energy consumption per US dollar of GDP, 1980-2011[13]

4. Rising energy consumption by the middle class: Chinese consumers have purchased more consumer goods as per-capita income has increased. Personal automobile ownership has also increased rapidly, more than doubling between 2010 and 2014.[14]

   The rate of energy consumption growth in the transportation and residential sectors outpaced the rate in industry between 2010 and 2013.[15] Nevertheless, China's overall energy demand growth is not predicted to return to pre-2009 levels.

5. Urbanization: Urbanization has been associated with rising income and increased energy demand. Between 1990 and 2015, the number of people living in cities increased 30%, and is anticipated to grow another 35% by 2050 according to United Nations data.[16]

2. TRENDS IN CHINA'S ENERGY SUPPLY AND DEMAND BALANCE: IMPORT DEPENDENCE

China's total domestic energy production does not meet current energy demand (Figure 1.6). This shortfall is most acute in the case of oil (Figure 1.7). According to statistics from BP, China's oil production has increased more than 30% over the last two decades but has not kept pace with demand increases. As a result China has become the world's largest oil-importing country, with imports now supplying more than 60% of domestic oil needs.

With respect to natural gas, China increased domestic production almost five-fold between 2000 and 2014. Nevertheless, output has not been enough to meet demand, which increased seven-fold in the same period. China's dependence on imports has now reached over 30% of its natural gas consumption. China is the largest coal importer in the world; however, most of its coal usage is supplied through domestic production.[17]

Projections suggest that China's energy production will continue to lag behind energy demand. According to the IEA's *World Energy Outlook*, the demand for natural gas in China is expected to more than double before 2025, while production is anticipated to double only by 2030. China's demand for oil is expected to grow nearly 20% between 2014 and 2020, while production is expected to increase only 10%.[18] The difference between supply and demand will be made up by imports, increasing China's oil and gas import dependency. Also, while oil and natural gas demand is increasing, demand for coal is expected to decrease over the next decade and beyond—a trend expected in other major economies as well.

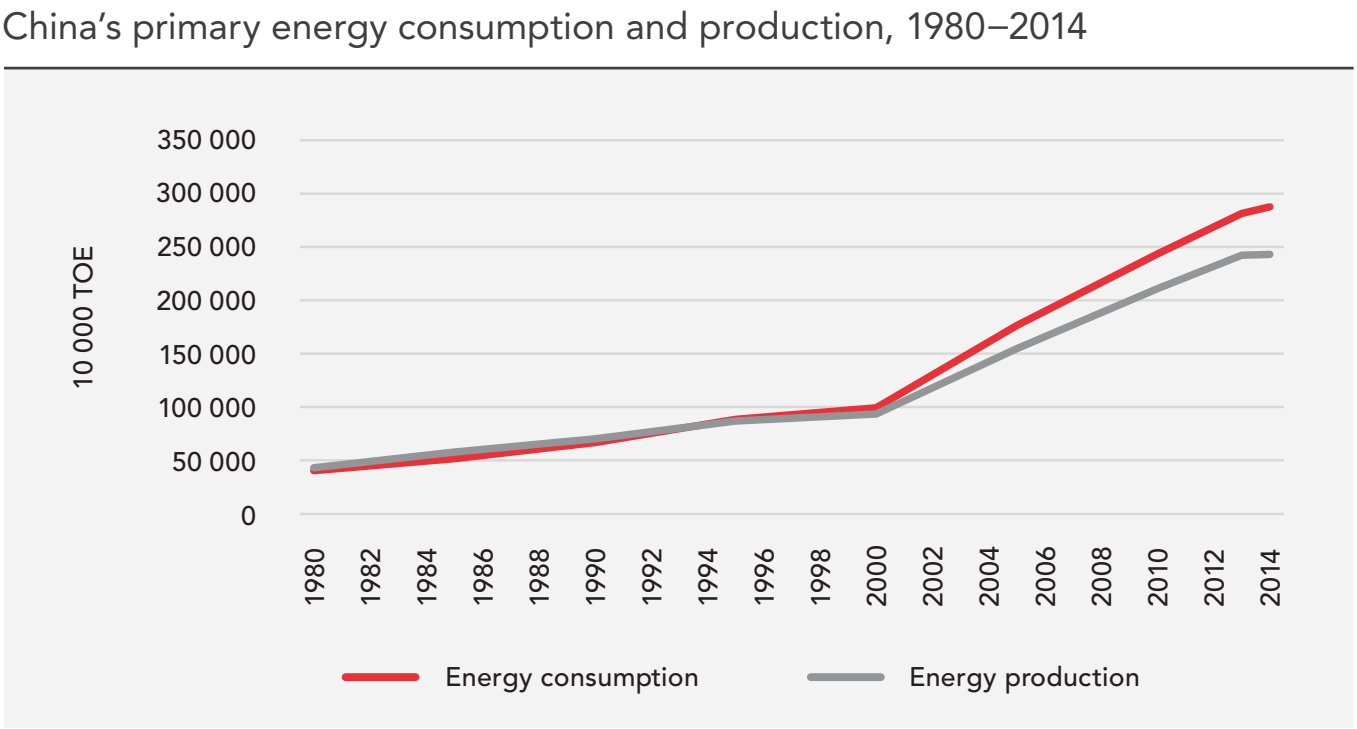

Figure 1.6: China's primary energy consumption and production, 1980-2014[19]

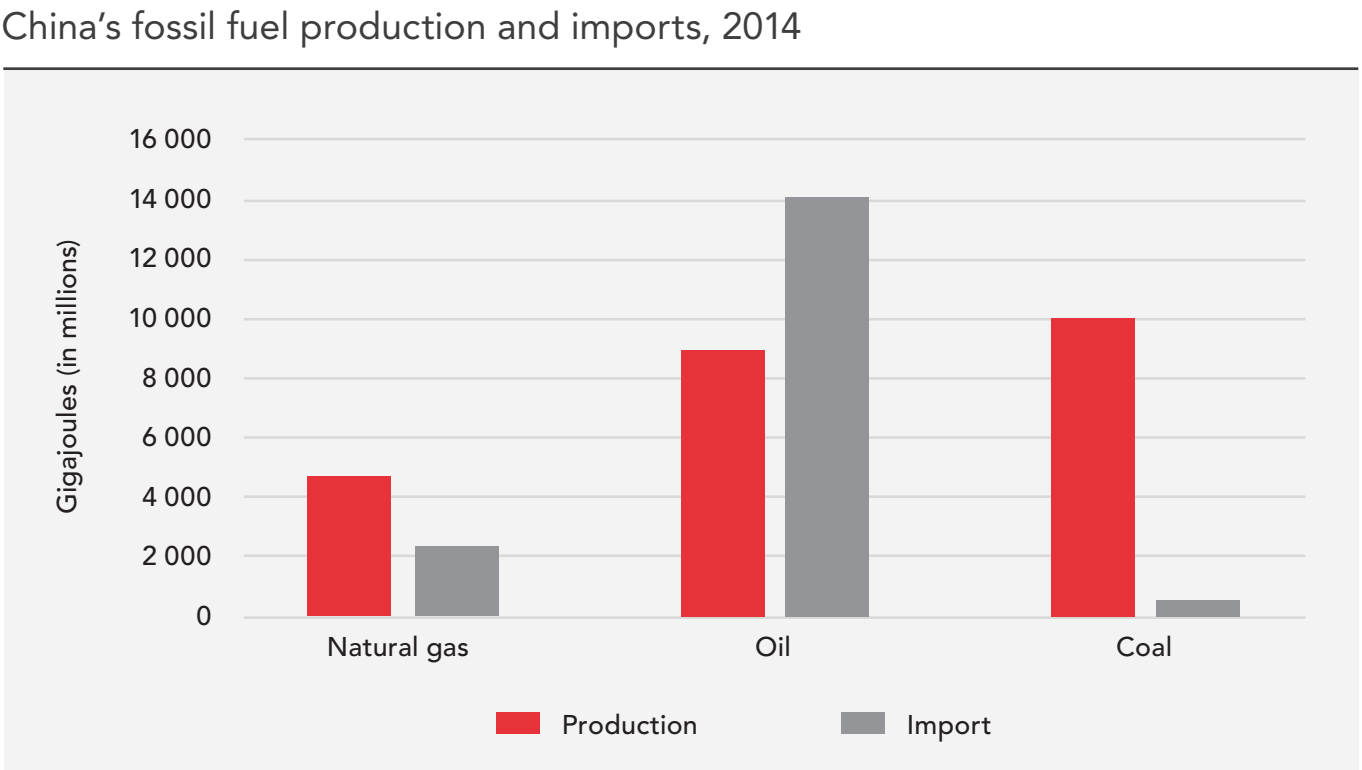

Figure 1.7: China's fossil fuel production and imports, 2014[20]

3. ENERGY INVESTMENT PATTERNS: HIGH INVESTMENT IN OIL AND RENEWABLES

To meet its growing energy needs, China has invested heavily to develop domestic and overseas energy sources. According to the IEA, between 2000 and 2013, China has seen average annual investments of around US$38B in oil, US$9B in gas, US$26B in coal, US$36B in renewable energy, and US$2B in nuclear (Figure 1.8). China surpassed the United States in renewable energy investments in 2014, investing nearly US$83B—a 39% rise over 2013.[21]

Average investment by energy source in China, 2000–2013

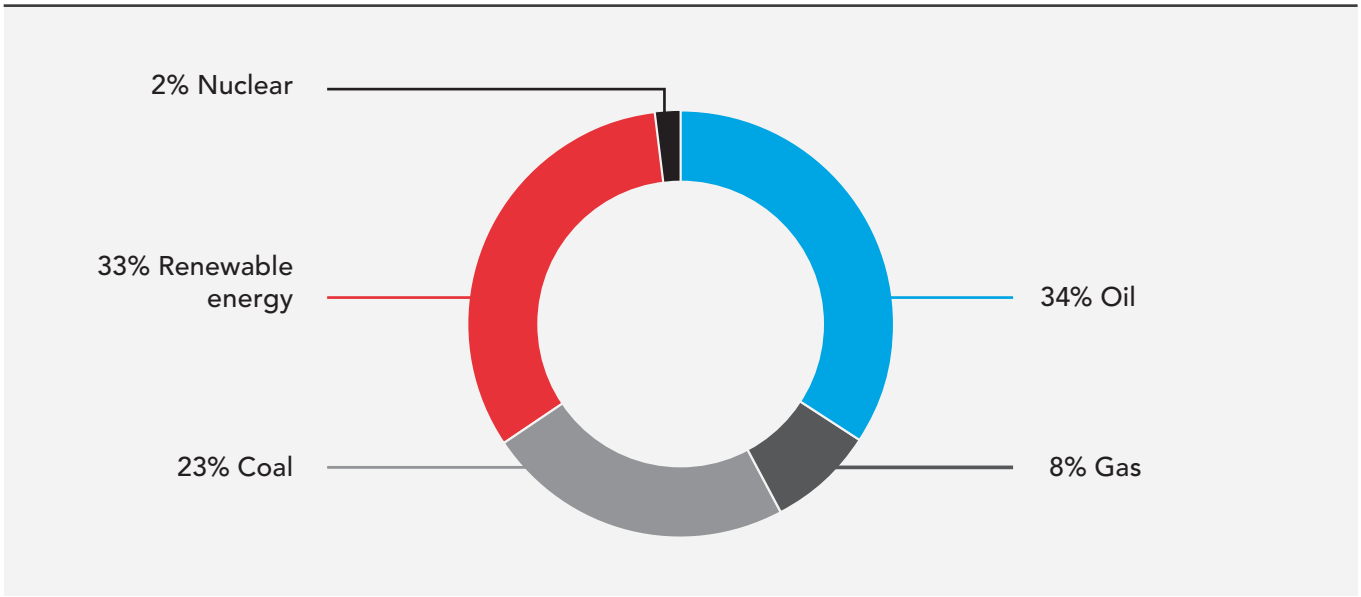

Figure 1.8: Average investment by energy source in China, 2000-2013[22]

Chinese companies have made substantial investments in oil, especially in foreign markets. Chinese national oil companies first ventured overseas to invest in oil and gas production more than 20 years ago. Today, they are key international actors with activities distributed across more than 40 countries and a total production of 2.5 million barrels of oil equivalent per day.[23] Chinese companies have made significant investments in extraction activities in Canada as well as Venezuela and African countries.

Table 1.1: Chinese investments in upstream oil and gas activity

Year	Total amount
2011	US$20B
2012	US$15B
2013	US$38B

SECTION II

CHINA'S ENERGY POLICY STRUCTURE

In 2015, the IEA pointed out that "government policies play a powerful role in determining the evolution of the energy sector," especially in China.[24] This section reviews the many government departments and other stakeholders involved in policy-making.

1. THE POLICY-MAKING AND IMPLEMENTATION STRUCTURE

Policy-making and implementation in China's energy sector is illustrated in Figure 2.1. Descriptions and explanations of the role of each stakeholder in the process follow.

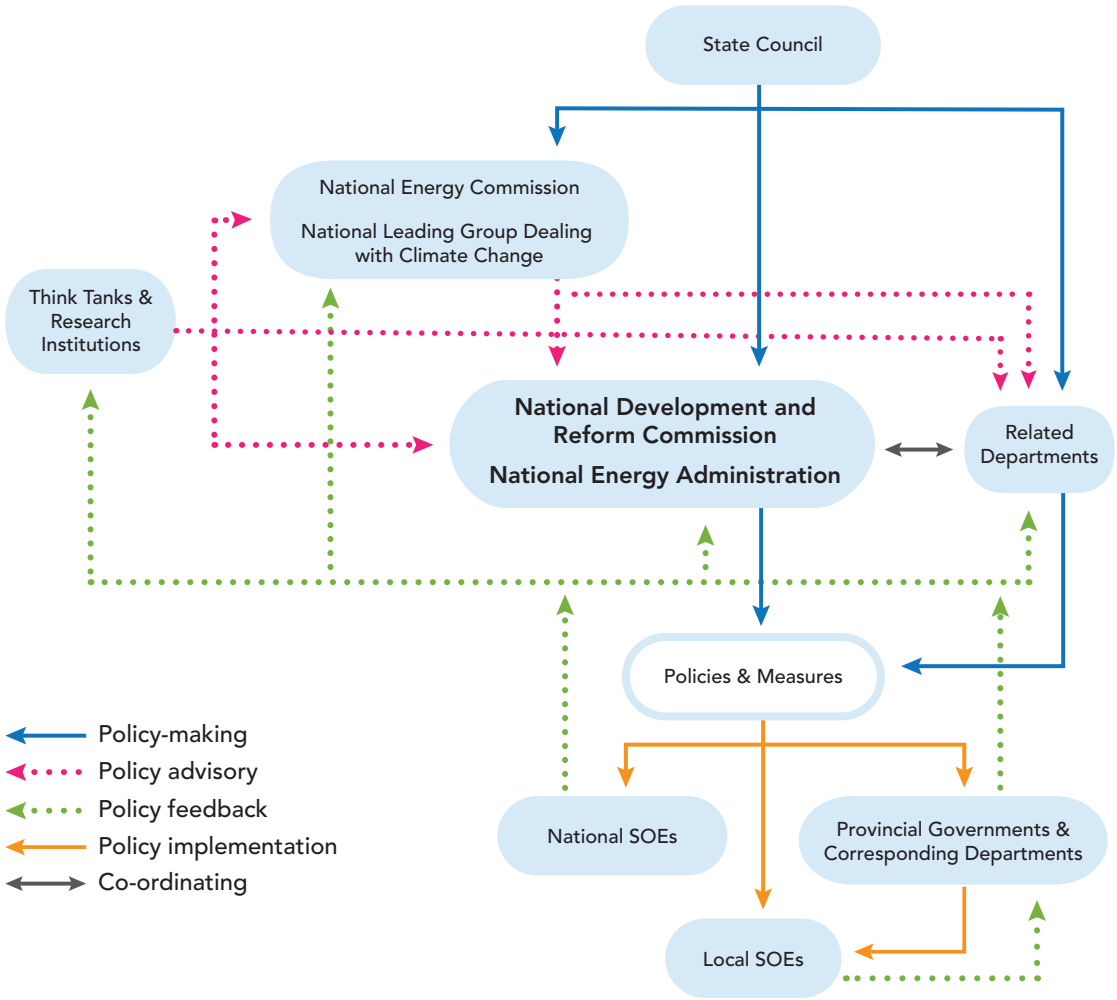

Figure 2.1: The policy-making and implementation structure of China's energy sector

THE STATE COUNCIL

The State Council is the overall governing body in China, ensuring that strategies and policies developed through its ministries and departments are in line with the principles and guidelines set by the National People's Congress. The current premier of the State Council is Li Keqiang. According to China's Energy Law, which was drafted in 2007 and is still being revised, "departments in charge of energy under the State Council oversee the national work on energy, and other related departments are responsible for energy administration in accordance with their respective functions."[25]

THE NATIONAL LEADING GROUP DEALING WITH CLIMATE CHANGE, ENERGY CONSERVATION, AND EMISSION REDUCTION, AND THE NATIONAL ENERGY COMMISSION

The National Leading Group Dealing with Climate Change, Energy Conservation, and Emission Reduction (NLG) and the National Energy Commission (NEC) are also under the leadership of the State Council, and resemble advisory and consulting agencies. Premier Li Keqiang is the leader of NLG as well as the chairman of the NEC. Members of both institutions consist of ministers from major departments. NLG focuses more on climate change while the NEC is more concerned with energy security and development.

NLG was formed in 2007 to "strengthen the leadership in coping with climate change, energy saving, and emission reduction."[26] NLG works on major strategies, principles, and solutions dealing with climate change. NLG also plans unified action on climate change, discusses plans for international co-operation, and co-ordinates the implementation of energy-conservation and emission-reduction policies issued by the State Council. The National Development and Reform Commission (NDRC) manages the daily operations of NLG.

The NEC was established in 2010 to "strengthen strategic policy-making and co-ordination" of the energy sector.[27] Its main responsibilities are to study and draft the national energy development strategies, examine and discuss major issues on energy security and development, and co-ordinate major projects on domestic energy exploration and international co-operation. The National Energy Administration (NEA) manages the daily operations of the NEC.

THE NATIONAL DEVELOPMENT AND REFORM COMMISSION, AND THE NATIONAL ENERGY ADMINISTRATION

In China, NDRC and NEA are two key departments directly in charge of energy work. Instead of being an independent ministry under the State Council, NEA is a "national vice-ministerial ministry under the administration of NDRC."[28]

Besides the administration of NEA, the main functions of NDRC are to ensure the overall planning of national energy strategies, policies, and reserves in line with the goals and principles set by the top leaders and authorities. NDRC is responsible for pricing major products and commodities, and approving large investment projects.[29]

NEA works closely with NDRC on energy, and focuses more on policies and measures relating to specific energy types. It is responsible for:[30]

- Developing laws and regulations for energy development, supervision, and administration;
- Co-ordinating and developing industrial policies and standards for coal, oil, gas, power, new energy, and renewables, as well as refining, coal fuel, and fuel ethanol;
- Co-ordinating and enhancing research and development of major equipment and projects;
- Overseeing energy conservation, utilization, and total consumption;
- Collecting energy data as well as forecasting consumption and production;
- Supervising the power market and power production, as well as managing the administration of nuclear power;
- Promoting international co-operation in the energy sector, and co-ordinating negotiations with foreign governments and international organizations, overseas exploration, the utilization of energy, and overseas investment projects; and
- Participating in policy development on resources, taxes, environmental protection, and climate change related to energy.

RELATED DEPARTMENTS

Many departments develop specific policies related to the energy sector. For example, policies on tax incentives that encourage renewable energy consumption fall under the review of the Ministry of Finance (MOF). Sometimes, the development of a policy falls under the jurisdiction of more than one department, requiring co-ordination among multiple stakeholders.

In practice, there is some flexibility as to which department leads the development of a policy. For example, a policy on energy technology could be initiated or led by either NEA or the Ministry of Science and Technology. Usually, the department initiating the policy will get the budget and a leading role in the development and implementation of that policy. In this case, the personality and style of leadership of the related department will play a role in deciding whether the department initiates the policy.

The following table introduces the main departments and their functions related to energy policies and measures.

Table 2.1: Departments and their energy-related functions and responsibilities[31]

Department	Functions and responsibilities related to energy
China Atomic Energy Authority	Conduct research and develop policies and regulations, programs, and industry standards related to nuclear energy
Ministry of Agriculture	Draw up agricultural industry policies for energy microbes and biomass; put forward policy suggestions regarding subsidies, investment policy, taxation, and credit for these sectors

Ministry of Commerce	Formulate strategies, guidelines, and policies for developing domestic and foreign trade and international economic co-operation; draft laws and regulations governing domestic and foreign trade, foreign investment in China, foreign assistance, overseas investment, and foreign economic co-operation
Ministry of Environmental Protection	Establish a basic system for environmental protection; supervise pollution prevention and control; co-ordinate and manage major environmental issues; implement national emission-reduction target; promote environment industry development; manage nuclear and radiation safety
Ministry of Finance	Lead energy-related finance and tax policies
Ministry of Housing and Urban-Rural Development	Manage planning and construction of energy-conserving buildings, urban gas development, renewable energy generation in buildings, and urban electric vehicle charging facilities
Ministry of Industry and Information Technology	Promote major energy technology equipment development and independent innovation; promote energy conservation, resources utilization, and clean production in industry and communication; co-ordinate major pilot projects and the promotion of new products, technologies, equipment, and materials
Ministry of Land and Resources	Protect and utilize land, mineral, and ocean resources; manage mineral resource development; manage the geological exploration industry and mineral resource reserves
Ministry of Science and Technology	Draw up energy-related science and technology development plans and policies, draft related laws, regulations, and department rules, and guide their implementation
Ministry of Transport	Manage energy conservation and emission reduction for road and water transportation; promote the new-energy vehicle industry; build a green transportation system; enhance new technology promotion and application for energy conservation and emission reduction; operate pilot projects in water transport energy efficiency, clean-energy utilization, and green ports
Ministry of Water Resources	Formulate water resources development strategies, plans, and policies; provide draft legislation and publicize water administrative rules and regulations; provide direction to the development of water-energy resources and hydropower in rural areas
State Forestry Administration	Supervise and administer forestry biomass; undertake work dealing with climate change related to the forestry sector

State Oceanic Administration (national bureau under Ministry of Land and Resources)	Manage oceanic renewable energy development
State-Owned Assets Supervision and Administration Commission	Supervise the state-owned assets of national energy enterprises (excluding financial enterprises); guide and push forward reform and restructuring of state-owned enterprises

Note: Departments are listed in alphabetical order.

PROVINCIAL GOVERNMENTS AND CORRESPONDING DEPARTMENTS

Provincial and local governments have little authority in terms of developing energy policies. National authorities co-ordinate this sector, and most of the enterprises in this sector are national SOEs. Provinces and local governments are mainly responsible for the implementation of policies.

The local and provincial departments are responsible for the promotion of the policies and measures, and need to make sure all the measures are implemented by the relevant communities and industries. If any problems arise during the implementation, the local and provincial departments are expected to provide solutions or to communicate with the higher-level decision-makers.

STATE-OWNED ENTERPRISES

State-owned enterprises in the energy sector implement government policies and measures in their daily operations. There are 24 national SOEs in the energy sector, covering coal, oil, natural gas, nuclear energy, hydroelectric energy, the power sector, energy saving, and environmental protection.

Table 2.2: China's National SOEs in the Energy Sector[32]

Industry	**State-owned enterprises**
Coal	Shenhua Group Corporation Limited China National Coal Group Corporation China Coal Technology & Engineering Group China National Administration of Coal Geology
Oil and gas	China National Petroleum Corporation China Petrochemical Corporation (Sinopec Group) China National Offshore Oil Corporation

Nuclear	China National Nuclear Corporation China Nuclear Engineering Group Corporation China General Nuclear Power Corporation
Nuclear, hydropower, thermal power, new energy	State Power Investment Corporation
Hydropower	China Three Gorges Corporation
Power generation	China Huaneng Group China Datang Corporation China Huadian Corporation China Guodian Corporation
Electric power supply	State Grid Corporation of China China Southern Power Grid
Electric power engineering	China Xd Group Corporation Harbin Electric Corporation Dongfang Electric Corporation Power Construction Corporation of China China Energy Engineering Group Co., Limited
Energy conservation and environmental protection	China Energy Conservation Investment Corporation

The national SOEs in the energy sector tend to be very large and also have significant influence on the policy-making process. They have their own think tanks, and their executives are often on the expert committees of national departments.

THINK TANKS AND RESEARCH INSTITUTIONS

Think tanks and research institutions are third-party players influencing the policy-making process. There are five types of think tanks and research institutions in the energy sector in China:[33]

- Think tanks affiliated with government departments, such as the Energy Research Institute under NDRC, the Development Research Center under the State Council, the Strategic Research Center of Oil and Gas Resources under the Ministry of Land and Resources, and the Policy Research Center for Environment and Economy under the Ministry of Environmental Protection;
- Sectoral associations and societies, including the China Energy Research Society and the Center for Energy and Environmental Policy Research at the Chinese Academy of Sciences;
- Think tanks affiliated with research organizations and universities, such as the Laboratory of Low Carbon Energy at Tsinghua University, the Academy of Chinese Energy Strategy at China University of Petroleum, and the China Center for Energy Economics Research at Xiamen University;

- Think tanks affiliated with large SOEs, such as the Economics and Technology Research Institute under China National Petroleum Corporation and the State Grid Electric Power Research Institute; and
- Independent and private think tanks, which have been growing in recent years and are likely to have more influence in the future.

Think tanks and research institutions that focus on energy are playing an increasingly important role in the decision-making process through two main channels. One is through having their staff sit on the advisory or expert committee of the National Energy Commission, expressing their views and opinions on strategic development plans for different types of energy. The other is by providing recommendations when ministries or departments consult experts on policies before they are formally published.

2. PROPOSED REFORMS TO THE DECISION-MAKING SYSTEM

The third plenum of the 18th Central Committee of the Communist Party in 2013 noted that the market should play a more decisive role in the economy, and energy policy is broadly following this trend. Experts anticipate that government will increasingly play a macro strategic and regulatory role in the sector, while production, investment, and pricing will be decided by the market.[34] Government plans emphasize that legal systems and regulations will be improved to provide a sound institutional environment for the energy sector.

A number of policies under consideration aim to open up the energy sector to private and foreign enterprises and investment, thereby breaking the monopoly that SOEs enjoy in the energy sector. This is not an easy job, given the entrenched interests of different stakeholders, especially those of SOEs.

There has been a long-standing debate among experts regarding whether the National Energy Administration should separate from the National Development and Reform Commission in order to create an independent, energy-specific agency. Currently, NEA can be challenged by heads of national energy SOEs of similar rank, and, as a result, NEA is often considered to have limited authority and autonomy to implement its energy policies and achieve the intended targets.[35,36] For now, NEA is at the vice-ministerial level, and there are many SOEs that are also at this vice-ministerial level. This is particularly the case in the energy sector, with examples such as China National Petroleum Corporation and the State Grid Corporation. This results in SOE leaders having a lot of authority in China's policies, and gives these national SOEs the capacity to challenge NEA policy implementation.

SECTION III

REDUCTION OF GREENHOUSE GAS EMISSIONS AND AIR POLLUTION

Energy policy in China has largely focused on securing sufficient energy to drive economic growth. Over the last decade, however, concerns about GHG emissions and air pollution have increasingly driven China's energy and industrial policy. This can be seen in particular by the addition of the concept of green development as an overarching principle guiding China's 13th Five-Year Plan.

The largest producers of GHG emissions in China are thermal power generation and manufacturing. Policies for shifting power production to less carbon intensive energy sources will be discussed in Section IV. This section will highlight policies for improving emission reduction and energy efficiency in industry, buildings/construction, and transportation.

1. GHG EMISSION AND AIR POLLUTION TRENDS

After decades of rapid economic growth, China is now the largest absolute emitter of greenhouse gases in the world, accounting for 25% of global annual emissions. However, China maintains an emissions level well below many other countries on a per-capita basis (Figure 3.1). Due to structural shifts in the economy and other factors, emissions growth rates are slowing.

Total and per capita carbon emissions by country, 2014

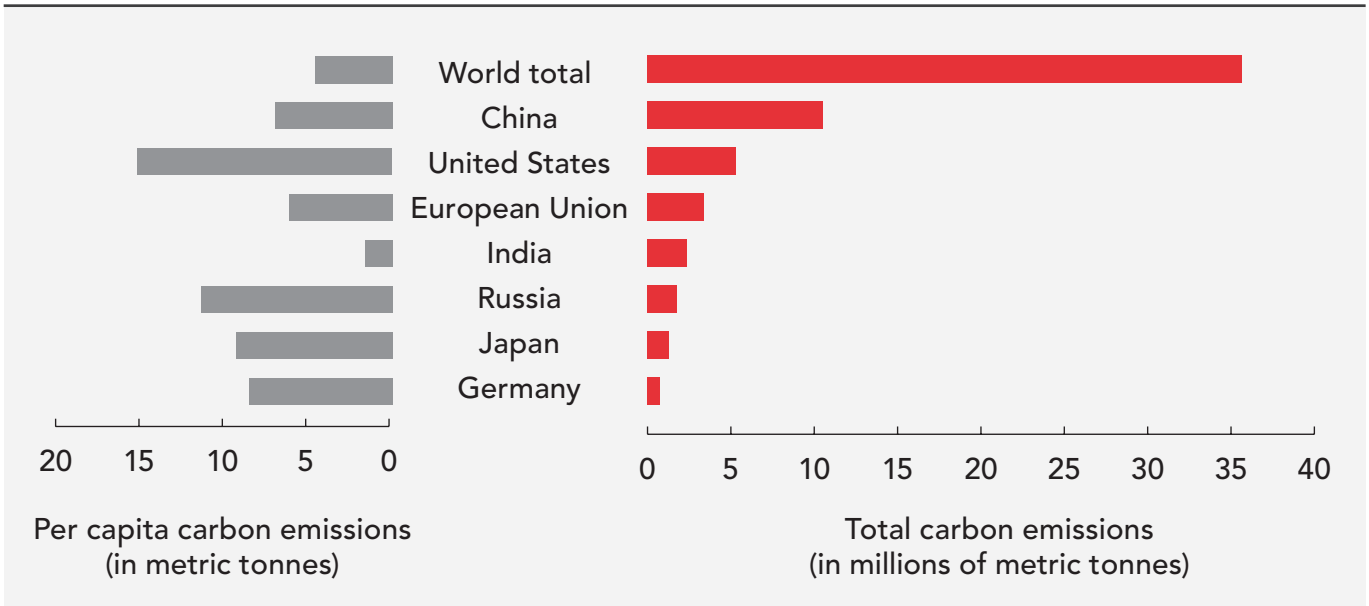

Figure 3.1: Total and per-capita carbon emissions by country, 2014[37]

The largest source of carbon emissions in China in 2014 was thermal power generation, followed by manufacturing (Figure 3.2). In manufacturing, the major CO2-emitting industries are the iron, steel, chemical, and cement production.

While absolute emissions have increased rapidly, China has made substantial improvements in emissions intensity (defined as volume of emissions per unit of GDP). Emissions intensity is influenced primarily by shifts in energy efficiency, economic structure, and fuel mix. As seen in Figure 3.3, emissions intensity dropped in the 1990s due to upgrading and consolidation of outdated industrial capacity. However, improvements plateaued between 2000 and 2006 due to the rapid expansion of energy-intensive industry, such as steel production.

Air pollution has also increased with the growth of the Chinese economy. Only 1% of China's 560 million city dwellers breathe air considered safe by European Union standards.[38]As of January 1, 2015, all Chinese cities at prefecture level or above are required to track five types of pollutants: particulate matter (PM2.5 and PM10),[39] ozone, NOx (nitrogen oxides), SO2 (sulphur oxide), and CO (carbon monoxide).[40] In the first six months of 2015, the average PM2.5 concentration in 358 cities surveyed was more than five times the World Health Organization's prescribed limit. While a red alert for air pollution was issued in Beijing in December 2015, concentrations of PM2.5 declined 90% in 189 cities in 2015, according to a follow up study conducted by Greenpeace.[41]

CO2 emissions in China by sector, 1995–2012

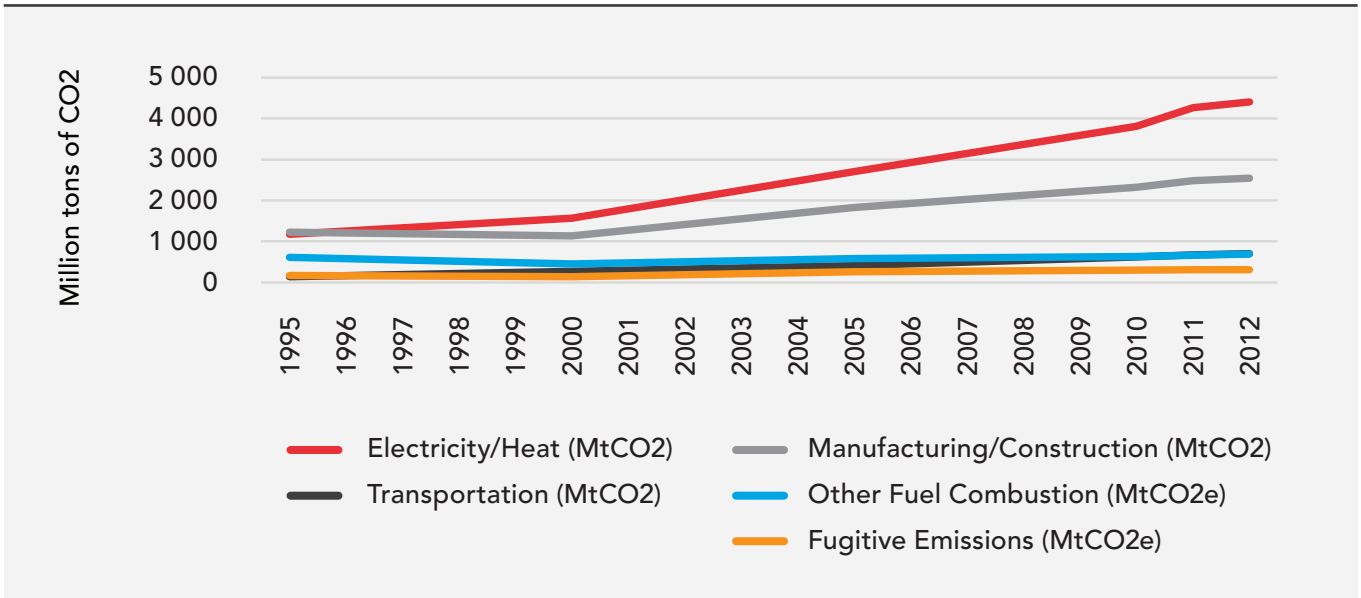

Figure 3.2: CO2 emissions in China by sector, 1995-2012[42]

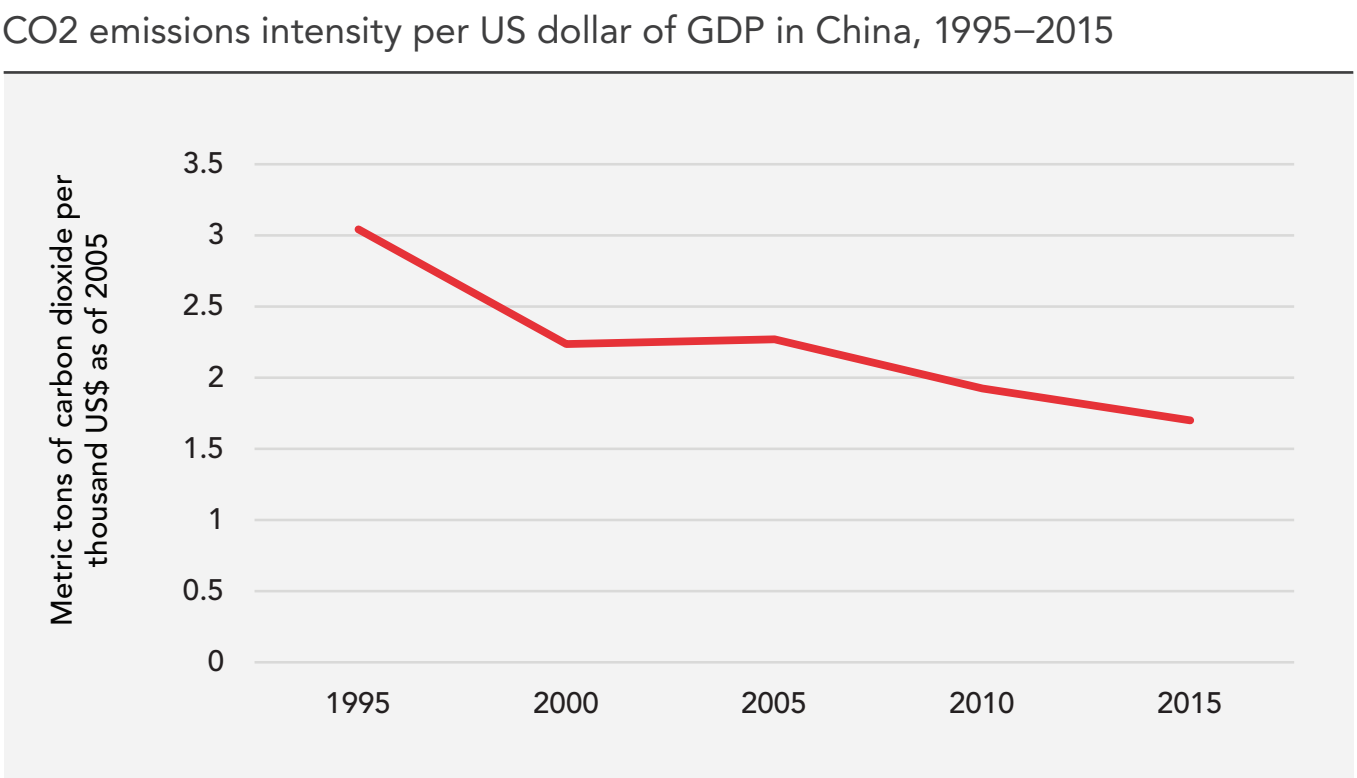

Figure 3.3: CO2 emissions intensity per US dollar of GDP in China, 1995-2015[43]

2. TARGETS AND COMMITMENTS

Due to both domestic demand and international pressure, China has announced the following emissions and air pollution reduction targets:

- To achieve the peaking of carbon dioxide emissions around 2030, with efforts to peak prior to 2030;
- To lower carbon dioxide emissions per unit of GDP by 60% to 65% of 2005 levels by 2030;
- To reduce PM10 concentrations by at least 10% by 2017 compared to the 2012 level in cities nationally; and
- In three key regions (Beijing-Tianjin-Hebei, Yangtze River Delta, and the Pearl River Delta), to reduce PM2.5 concentrations by 25%, 20%, and 15%, respectively, within the same period.

These targets and commitments can be found in the *Energy Development Strategy Action Plan* (2014–2020), released by the State Council, the *Action Plan on Air Pollution Prevention and Control*, issued by the Ministry of Environmental Protection, and the *National Plan on Climate Change* (2014–2020), issued by the National Development and Reform Commission.

A number of academic and industry reports have addressed whether China's emissions reduction targets are ambitious and represent a break from business as usual. As noted in Section I, there are a number of trends in China's economy that are clearly moving the country toward achieving its energy and emissions targets. Nevertheless, substantial policy intervention is required to achieve these targets.

A model by the Massachusetts Institute of Technology (MIT) and Tsinghua University suggests that China's emission targets cannot be achieved only through energy-efficiency gains or a slowing of GDP growth. If no new government policies are implemented post-2014, China will miss its 2020 emissions-intensity reduction target as well as the 2030 emissions peaking target.[44] In the model's "no policy" scenario, in which no new policy is enacted after 2010, emissions will continue to rise until 2050, predominantly because of coal use. The most effective scenario to lower emissions by 2030 is the "accelerated efforts" scenario, which involves more robust policies, including an aggressive carbon tax and other policies to reduce coal and increase renewables in the energy mix.

A model developed by the Boston Consulting Group also suggests that China will need to adopt more aggressive policies to meet its targets. In the "base case" scenario, in which the Chinese government continues to make progress toward its current goals, coal is still used to generate 50% to 60% of electricity by 2030.[45]

Furthermore, the Climate Action Tracker suggests that under the "current policies" scenario, which includes policies proposed or implemented up to 2016, Chinese CO2 emissions will peak between 2025 and 2027 due to important restrictions on coal consumption and aggressive carbon pricing.[46] This is similar to the MIT-Tsinghua model, which predicts emissions peaking between 2025 and 2030.

3. POLICIES AND MEASURES

In order to reduce CO2 emissions and air pollutants from industrial processes, the Chinese government has been introducing policies to decrease the energy intensity of the economy. Policies encourage emission controls in high-energy-intensive industries, construction, and transportation; they also encourage energy efficiency in household appliances, and innovations in the pricing and adoption of emissions trading systems.

SHIFT TO A LESS ENERGY-INTENSIVE ECONOMY: SUPPORT FOR EMERGING INDUSTRIES AND THE SERVICE SECTOR

Chinese government policy aims to increase the share that low-energy-intensity sectors contribute to the GDP. The *The National Plan on Climate Change (2014–2020)* states that the service sector should contribute more than 52% of GDP by 2020, while additional State Council-issued policies have identified seven strategic emerging industries that should comprise 15% of GDP by 2020. These emerging industries were defined in *Decision of the State Council on accelerating the cultivation and development of strategic emerging industries* as:

- Environmental protection;
- Information technology;
- Biotech;
- High-end equipment manufacturing;
- New energy;

- New materials; and
- New-energy automotive.

Mechanisms for enhancing these emerging industries are outlined in the 12th Five-Year Plan's *National Strategic Emerging Industry Development Plan* (2012) and emphasize enhancing innovation capability through improving intellectual property protection, increasing international co-operation, and attracting overseas talent. To finance emerging industries, NDRC approved the establishment of a RMB40B national venture-capital fund for emerging industries focused on early-stage innovative enterprises, and released guidelines for issuing special bonds to strategic emerging industries.[47] Provincial and city governments also provide financial incentives for emerging industries.

China's recently released manufacturing policy, *Made in China 2025*, will also shift China's industry toward lower-energy-intensive sectors.[48] The policy aims to move China's manufacturing industry up the value chain and identifies 10 major industries of focus, including energy conservation. The plan aims to reduce energy consumption per unit of industrial value added by 18% relative to 2015 by 2020, and by 34% by 2025.[49]

CONTROLLING EMISSIONS FROM HIGH-ENERGY-INTENSITY INDUSTRIES

The *National Industry Energy Efficiency Guidance (2014 Edition)* issued by the Ministry of Industry and Information Technology identifies six high-energy-consumption industries (steel, nonferrous metals, petroleum, chemicals, building materials, and electricity) and provides detailed minimum energy-efficiency standards for each. The *National Plan on Climate Change (2014–2020)* aims for carbon emissions from the steel and cement industries to remain at 2015 levels in 2020, and specifies areas for priority technological development in these sectors.

Since the financial crisis, Chinese government policy has aimed to reduce overproduction capacity in high-energy-intensity industries. For example, the State Council's *Guideline on Reducing Over Production* and the *Action Plan for Energy Conservation, Emissions Reduction and Low Carbon Development 2014-2015* prevent authorities from approving new projects in these industries.[50] At the local level, Beijing's *2013-2017 Clean Air Action Plan* aims for the city's cement production capacity to decrease to 4 million tons by 2017, down from 10 million tons at the beginning of the 12th Five-Year Plan.

Governments at all levels provide financial incentives for industries to improve energy efficiency through technical retrofit projects. For example, MOF and NDRC released the *Regulation for Energy Conservation Technology Transformation Financial Reward Fund*. The fund provides companies in eastern China with RMB240 per TCE (ton of coal equivalent) saved, and companies in the central and western regions with RMB300 per TCE saved through technological upgrades.[51] The regulation identifies projects that are supported by the program in each of the main five areas: coal-fired industrial boilers (furnaces), waste heat and waste pressure utilization, oil conservation and substitution, motor system energy conservation, and energy system optimization.[52] Cities also provide incentives. For example, in 2015, the City of Beijing issued incentives that can be received in addition to monies from the financial reward program.[53]

EMISSION REDUCTION IN BUILDINGS AND CONSTRUCTION

It has been estimated that, by 2025, approximately 1 billion people will live in Chinese cities, and 221 cities will each have more than 1 million inhabitants.[54] In 2013, NDRC and the Ministry of Housing and Urban-Rural Development (MOHURD) released the *Green Building Action Plan,* which aims to develop stringent building codes for new building projects and to encourage retrofitting of existing buildings.

The plan highlights improving efficiency of heating and cooling systems, integrating renewable energy generation capacity into new construction, and developing new energy-saving building materials. Attention is also given to enforcement of energy efficiency codes and energy-compliance laws.[55]

With respect to newly constructed buildings, government policies have created building codes that set minimum standards for energy efficiency in new construction. There are energy codes for residential buildings based on four climate zones, as well as codes for commercial and rural buildings. The Ministry of Housing and Urban-Rural Development regularly provides updates to these standards.

The Ministry of Housing and Urban-Rural Development also administers a National Green Building Evaluation Label (three-star) certification, similar to the popular LEED (Leadership in Energy and Environmental Design) system in North America. The system provides credits to developers based on seven areas of environmental performance, including energy savings. MOF issued implementation guidelines for green development that provide subsidies to developers who achieve certification. Provincial and city governments also provide subsidies.[56]

With respect to existing construction, the *2013 Building Action Plan* has established targets for retrofitting existing buildings to the most recent building codes. By 2015, the plan aims for 400 million square metres of residential buildings using central heating systems in the north of the country to be retrofitted to current standards, 50 million square metres of residential buildings in the hot summer and cold winter regions, and 120 million square metres of public buildings. By 2020, all urban residential buildings using central heating systems in the north of the country will be retrofitted.[57]

The northern regions of the country using central heating systems include Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Shandong, Henan, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang.[58] The hot summer and cold winter regions include Shanghai, Chongqing, Jiangsu, Zhejiang, Anhui, Jiangxi, Hubei, Hunan, Sichuan, Henan, Guizhou, and Fujian.[59]

The plan identifies different aspects for retrofitting based on these regions. For northern regions of the country using central heating systems, improvements focus on energy saving by adding insulation to exterior walls, roofs, doors, and windows; heat metering; and improving insulation of the pipeline network. For public buildings, improvements focus on the renovation of air conditioning, heating, ventilation, lighting, and hot water systems. For hot summer/cold winter and hot summer/warm winter regions, improvements focus on doors and windows, external shading, and natural ventilation.[60]

In order to push forward with the retrofitting of existing buildings, MOF issued different policies to provide financial incentives or subsidies based on a certain formula. For northern regions, the financial

incentive is RMB55 per square metre for extreme-cold areas and RMB45 per square metre for cold areas.[61] For hot summer and cold winter regions, the subsidy is RMB15 per square metre for eastern areas, RMB20 per square metre for central areas, and RMB25 per square metre for western areas.[62] For public buildings, subsidies of RMB20 per square metre are provided for qualified cities.[63]

EMISSION REDUCTION IN TRANSPORTATION

The transportation sector—a major oil consumer and GHG emitter worldwide—is one of the most rapidly growing sectors in terms of energy use and GHG emissions in China. Rapid growth of road vehicle use—private automobiles in particular—has resulted in the continued growth of China's oil demand and imports, which has been widely accepted as a major factor affecting future oil availability and prices, and a major contributor to China's GHG emissions increase.

The Chinese government is making great efforts to curb petroleum demand and GHG emissions in the road transport sector by both introducing alternative fuels and regulating vehicle fuel economy. China has implemented directives for improving fuel standards and fuel efficiency, which will be discussed in Section V. China has been promoting E10 (a 10% bioethanol and 90% gasoline blend by volume) as an alternative transport fuel since 2002, and is currently the third-largest producer of ethanol fuel after Brazil and the United States.[64]

China is also strongly promoting green transport, but progress has been slow. Since 1999, the Clean Vehicle Program has been initiated in 12 large cities in China, promoting liquefied petroleum gas and compressed natural gas vehicles in an effort to reduce GHG emissions. Government policy now focuses on electric vehicles (EVs). The 12th Five-Year Plan targeted ownership of 5 million battery-electric vehicles and plug-in hybrid-electric vehicles by 2020. Government has faced challenges meeting this deadline, and sales of EVs have remained low.[65] Thus, new incentives, such as exempting EVs from rush hour rules, are being implemented. Sales rose to around 137,000 EVs in the first 10 months of 2015, a 50% jump over the number sold in the same period of 2014.[66] However, a substantial jump in sales will be required to meet the 2020 target.

In 2009, the Ten Cities, Thousand Vehicles program was launched to stimulate EV development through large-scale pilots in 10 cities focused on deployment of EVs for government fleet applications. The program has since been expanded to 25 cities and includes consumer incentives in five cities. Subsidies have been provided to spur demand, with electric and plug-in passenger cars receiving between RMB25,000 and RMB55,000 per vehicle from the central government. The subsidies are supposed to be reduced by 20% between 2017 and 2018, and by 40% between 2019 and 2020.[67]

ENERGY EFFICIENCY IN HOUSEHOLD APPLIANCES

The 1997 *National Energy Conservation Law* of China provided the regulatory basis for energy-efficiency standards for energy-consuming products and equipment. In August 2004, the State Planning Commission and the State Bureau of Quality Supervision in China issued the *Administration Regulation on Energy Efficiency Labelling*. The China Energy Label categorizes appliances into tiers of efficiency. As of

2013, the China Energy Label is displayed on 29 types of products, covering all major household appliances. A series of government programs has provided financial incentives to customers to purchase labelled products. In 2012, the State Council decided to provide RMB26.5B to consumers to purchase Tier 1 and 2 labelled products in six home appliance categories.[68] In 2016, NDRC issued guidance for promoting green consumption, with a target for household appliances labelled Tier 2 and above to have a market share of over 50% by 2020.[69]

PRICING AND EMISSIONS TRADING SYSTEM (ETS)

In recent years, government policy has increased the use of market mechanisms in addition to administrative measures for combating climate change. During a visit to Washington in September 2015, President Xi Jinping announced that China would implement a nationwide emissions trading system under cap-and-trade by 2017.[70] An emissions trading system sets a price on carbon by establishing a market for tradable permits. The government sets a cap on carbon emissions by industry and then distributes tradable emissions allowances to emitters. Entities that emit below their quota can sell their allowance to those that emit beyond their quota. These companies can sell those units to other companies that emit beyond their quota.

The national system to be deployed in 2017 will be based on findings from the pilot projects. In November 2011, China approved pilot tests for carbon trading in seven provinces and cities: Beijing, Chongqing, Guangdong, Hubei, Shanghai, Shenzhen, and Tianjin. By the end of 2013, Shenzhen, Shanghai, Beijing, Guangdong, and Tianjin had all launched carbon emission trading markets. In the second quarter of 2014, Hubei province and Chongqing followed in their step.[71]

The pilots started trading between 2013 and 2014. As of April 2015, a cumulative trading volume of 21.98 million tons of carbon emissions had been traded through the seven pilot projects.[72] The cap-and-trade systems determine coverage differently—for example, by annual energy usage or annual CO2 emissions. Pilots generally cover major energy-intensive industries including power generation, iron and steel, chemicals, building materials, paper making, and nonferrous metals.

These pilots have helped in determining important aspects of the national policy, such as allocation of emissions allowances, cap size, aspects of verification, monitoring, and reporting. The most important learning from these pilots is in the experience of adapting a market-based instrument to a socialist market economy.

SECTION IV

COMMITMENTS AND POLICY MEASURES BY ENERGY TYPE

China's energy policies aim to ensure sufficient energy supplies to fuel the economy while also reducing import dependency and the emissions intensity of the energy mix. This section discusses key national targets and implementation mechanisms for production and consumption of the major primary energy sources in China, including coal, oil, natural gas, nuclear power, and renewables.

A. COAL

Coal has fuelled China's economic development for decades and will continue to play a significant role in the energy mix in coming years. However, due to environmental concerns and overproduction, China's strategy for coal development and use will follow the principles of efficiency, cleanliness, and security. While also ensuring security of the coal supply, energy policies aim to control production and consumption of coal and encourage the application of technology to make coal use cleaner.

1. COAL CONSUMPTION AND PRODUCTION TRENDS

Coal consumption and production in China has increased fourfold over the past 20 years. However, in 2014, coal use dropped in absolute terms for the first time, declining 2.9%. This downward trend continued in 2015 at 3.7% due to slower economic growth, economic restructuring, shifting of the energy mix toward cleaner sources, and environmental policy.[73] In 2015, China's coal production was 3.75 billion tons, a 3.3% decrease from the previous year.[74] Coal consumption in 2014 was 2.81 billion SCE, accounting for 66% of total energy consumption.[75]

The main uses of coal in China are industry and power generation, with approximately 50% of coal consumed utilized for electricity generation.[76] Coal currently accounts for about 65% of China's electricity-generation capacity, but coal-fired plants have historically contributed a significantly higher proportion of the actual power generated. In 2012, for example, 76% of China's electricity was generated from coal.[77]

The extreme dominance of coal in the energy mix is likely to continue its decline. In 2015, coal plant utilization rates fell below 50%, and overall power consumption growth is now lower than power generation growth from non-coal generation sources, suggesting that coal is losing share in the power mix.[78]

Coal balance in China, 1990–2013

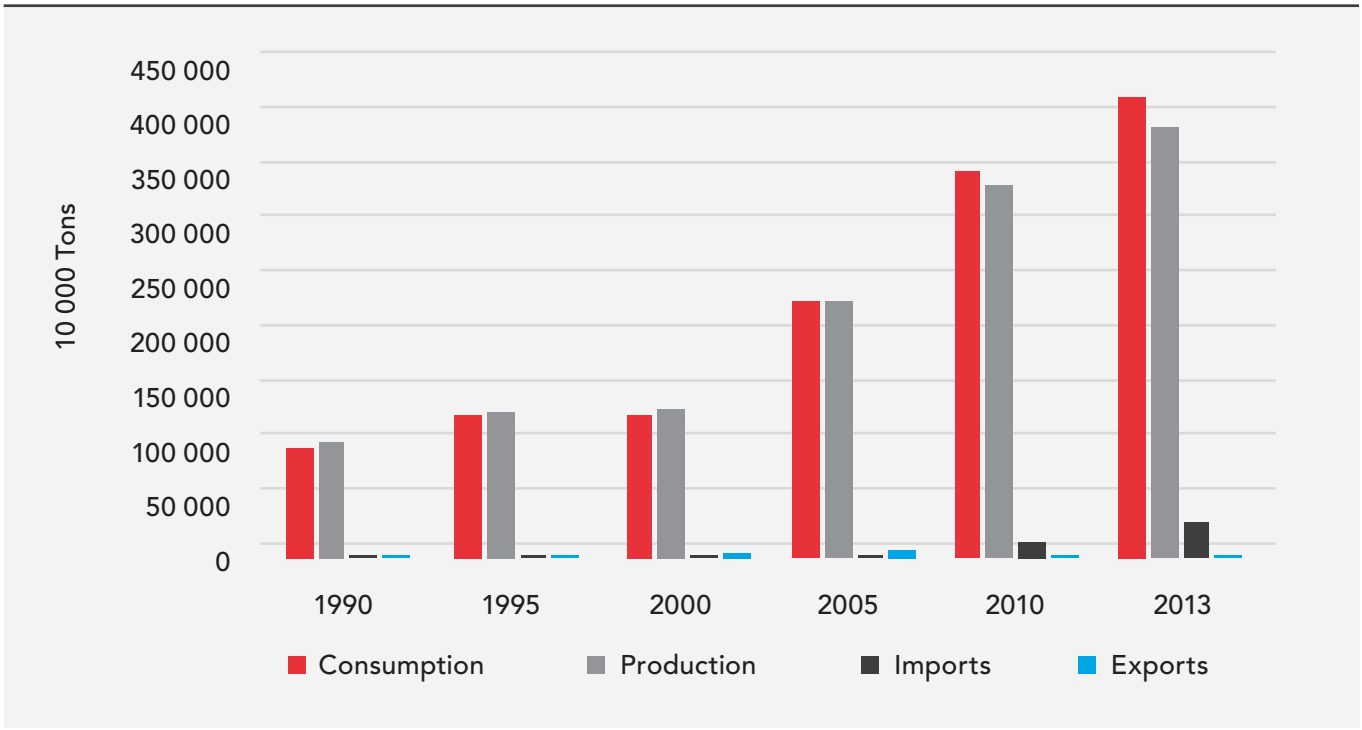

Figure 4.1: Coal balance in China, 1990-2013[79]

China's coal consumption by sector, 1990–2013

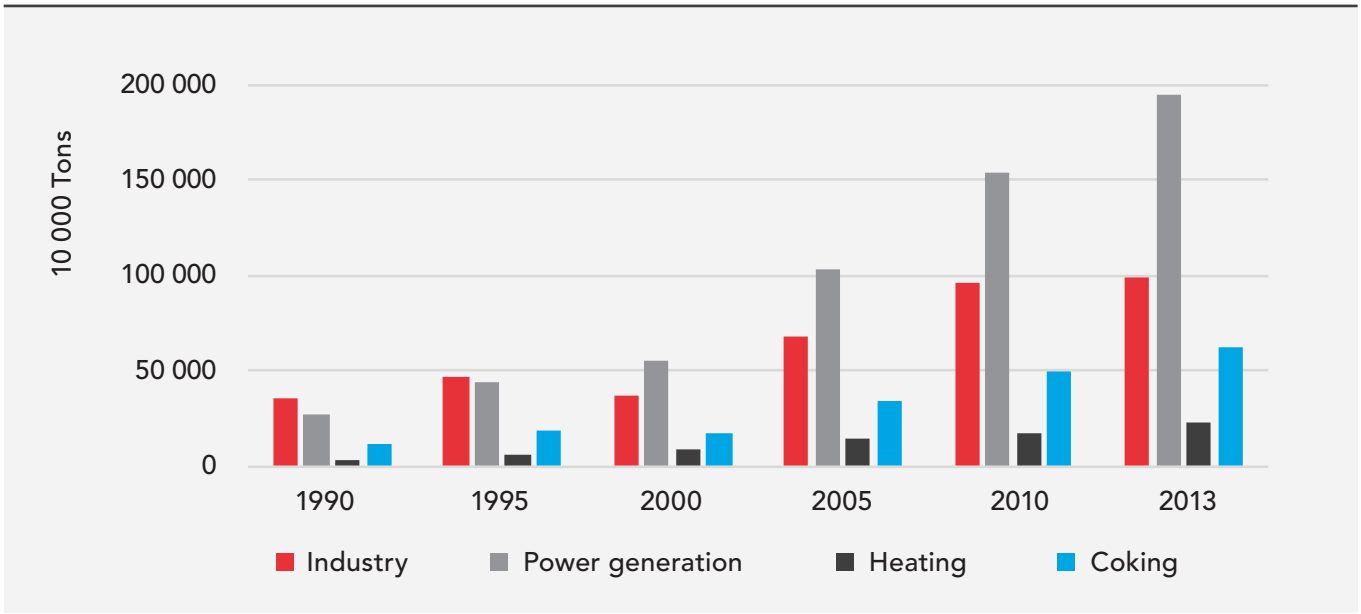

Figure 4.2: China's coal consumption by sector, 1990-2013[80]

2. TARGETS AND COMMITMENTS

Targets and commitments for coal development can be found in two key documents: the *Energy Development Strategy Action Plan (2014–2020)* and the *Action Plan for Coal Power Upgrading and Transformation for Energy Saving and Emission Reduction (2014–2020).*

The following are China's main targets and commitments for the coal sector:

- Control coal consumption at approximately 4.2 billion tons and at less than 62% of total energy consumption by 2020;
- Increase coal consumption for power generation to over 60% of total consumption of coal by 2020, and reduce coal consumption by industry;
- Reduce coal production by shutting down excess production capacity and avoiding the addition of new capacity; and
- Promote the clean and efficient production and utilization of coal.

3. POLICIES AND MEASURES

In recent years, over 40 policies and measures have been issued in the following areas.

CONTROL COAL CONSUMPTION

Government policies aim to reduce coal consumption in major coal-consuming regions and industries. The *Energy Development Strategy Action Plan* (the Plan) identifies the major coal-consuming regions as Beijing, Tianjin, Hebei Province, Shandong Province, Shanghai, Jiangsu Province, Zhejiang Province, and Pearl River Delta in Guangdong Province. It aims for total coal consumption in the Beijing-Tianjin-Hebei-Shandong areas to be 100 million tons lower in 2020 than in 2012, and for coal consumption in Yangtze River Delta and Pearl River Delta to have negative growth.[81] NDRC and other ministries asked that coal be gradually replaced by cleaner energies such as renewables and natural gas in all identified regions.[82]

With respect to industry, the Plan requires, by 2017, major coal-consumption sectors in developed regions and medium/large cities to convert all coal-burning boilers and industrial furnaces to natural gas.[83] The major coal-consumption sectors include coking, industrial furnaces, coal chemical industry, and industrial boilers.[84] NEA policies also aim to reduce coal-fired generation capacity in the power sector. For example, NEA requested that provinces eliminate 4.234 million kilowatts (kW) of coal-fired power capacity in 2015, with the provinces of Hebei, Henan, Qinghai, and Jiangsu at the top of the list.[85]

REDUCE COAL PRODUCTION

China has been closing small and geographically scattered coal mines with annual production capacities below 300,000 tons. According to NEA, China closed 1,254 coal mines in 2015, removing 77.79 million tons per year of production capacity.[86] A 2016 policy issued by the State Council stated that, within three to five years, another 500 million tons of coal production capacity will be removed through mine

closures, and still another 500 million tons of capacity will be reduced through mine consolidation.[87] Furthermore, within three years, every coal manufacturer must have a minimum annual production of 3 million tons; by 2018, no new coal mines or technological upgrades for increasing production will be approved. Similarly, any new mines can only replace previously existing capacity.

In addition, in order to adjust coal production through market mechanisms, MOF has implemented reform on the coal resource tax, linking cost of production to price, and moving from taxation on quantity to taxation on sales price.[88] The tax rate is between 2% and 10%, and is to be determined by the provincial government based on the risk tolerance of local enterprises and the local coal resources.

EFFICIENT AND CLEAN COAL PRODUCTION AND UTILIZATION

Clean production and clean use of coal helps to save energy and reduce emissions, but requires industrial upgrading and technological progress. The government has issued policies regarding coal washing and processing, efficient and clean power generation, coal converting, and pollution control. It also subsidizes coal-fired power that meets high-efficiency standards.

The State Council encourages and supports coal mining enterprises to mechanize and automate coal washing and processing, and to use upgraded equipment.[89] NDRC issued guidelines to regulate the clean production of coal-fired power, including standards on production techniques, equipment, energy consumption and emissions, and production management.[90] On January 18, 2016, NEA released a draft list of recommended technologies and equipment for clean coal development and use.[91]

As directed by NEA, newly built coal power plants should adopt ultra-supercritical units with capacity of over 600,000 kW.[92] The new plants must have an average coal consumption of less than 300 grams SCE/kW. NEA also requires that, by 2020, existing power generators will lower coal consumption to less than 310 grams SCE/kW; coal used for power generation will account for over 60% of total coal consumption; and operational efficiency of coal-fired furnaces will be increased. NEA plans to implement several pilot projects for clean and efficient coal utilization.

NEA requested that low-carbon-emission and energy-saving measures be applied in coal power plants. Some power plants in Zhejiang, Shanghai, Jiangsu, Guangdong and Shandong provinces are required to achieve, through technical reforms, emissions levels equal to those of gas power plants, or in some cases close to zero emissions.[93]

In order to encourage clean production of coal power, NRDC, the Ministry of Environmental Protection, and NEA issued a policy on price to support electricity generated by coal power plants meeting low-emission standards.[94] By 2020, NDRC plans to permit third parties to offer services for the treatment of exhaust gas, waste water, and solid waste from coal-fired power plants. These treatment projects enjoy preferential policies on value-added taxes (VATs) and business income taxes.[95]

The Ministry of Environmental Protection issued standards to regulate the development of the modern coal chemical industry. New coal chemical projects in Beijing-Tianjin-Hebei region, Yangtze River Delta, Pearl River Delta, and water shortage areas are strictly controlled.[96]

For coal used in industrial sectors, the Ministry of Environmental Protection requires that the operational efficiency of coal-fired furnaces will be improved, and that pilot projects of clean and efficient coal utilization will be built.[97] Small coal boilers and furnaces will be eliminated, and all furnaces should be upgraded to reduce emissions.[98] By 2020, coal consumption of the industrial sector will be reduced by over 160 million tons.[99]

REFORM OF THE POWER INDUSTRY

NDRC and NEA issued six documents on reform of the power industry.[100] This new round of reform is intended to let the power generation enterprises and end users decide electricity prices through market mechanisms.

China currently has a power generation capacity of 1.36 billion kW, of which thermal power capacity accounts for 916 million kW, or approximately two-thirds of total capacity. However, coal generation accounts for 76.4% of total thermal power production. A closer look at this thermal power shows that gas power accounts for only 5.3%, and the remainder is mostly coal power. Therefore, reform of the power industry will have a far-reaching impact on coal power generation. In areas where power is already oversupplied, demand for coal power will decrease. Coal power will be further replaced by new-energy power, since the new reforms prioritize hydropower and clean energies such as wind, solar, and biomass to be transmitted through the power network. Thus, the share of coal-fired generation in the power mix is expected to decline.[101]

B. OIL

Although oil's share of the energy mix in China has been declining, China still relies heavily on oil. China is now the world's largest oil importer, depending on the Middle East for the majority of its imports. China is trying to expand its oil reserve and domestic production, as well as diversify its import sources to ensure more security and supply.

1. CHINA'S OIL CONSUMPTION AND PRODUCTION TRENDS

China was a net oil exporter until the early 1990s, but is now dependent on imports for over 60% of oil consumption (Figure 4.3). China's oil consumption patterns have changed substantially since 2010. The major end user of oil shifted from industry to transportation, and, as a result, demand for fuel oil has decreased while demand for gasoline has risen (Figure 4.4). The rise in oil demand for transportation is expected to continue, as China's growing middle class purchases personal vehicles. The diesel forecast, however, is flat to falling due to sluggish industrial oil demand.

In addition, China's annual growth in oil consumption slowed after a high in 2010, reflecting the effects of the global financial crisis and domestic economic downturn as well as China's policies to reduce excessive investment and export capacity over-building in the economy (Figure 4.3).

Petroleum balance in China, 1990–2013

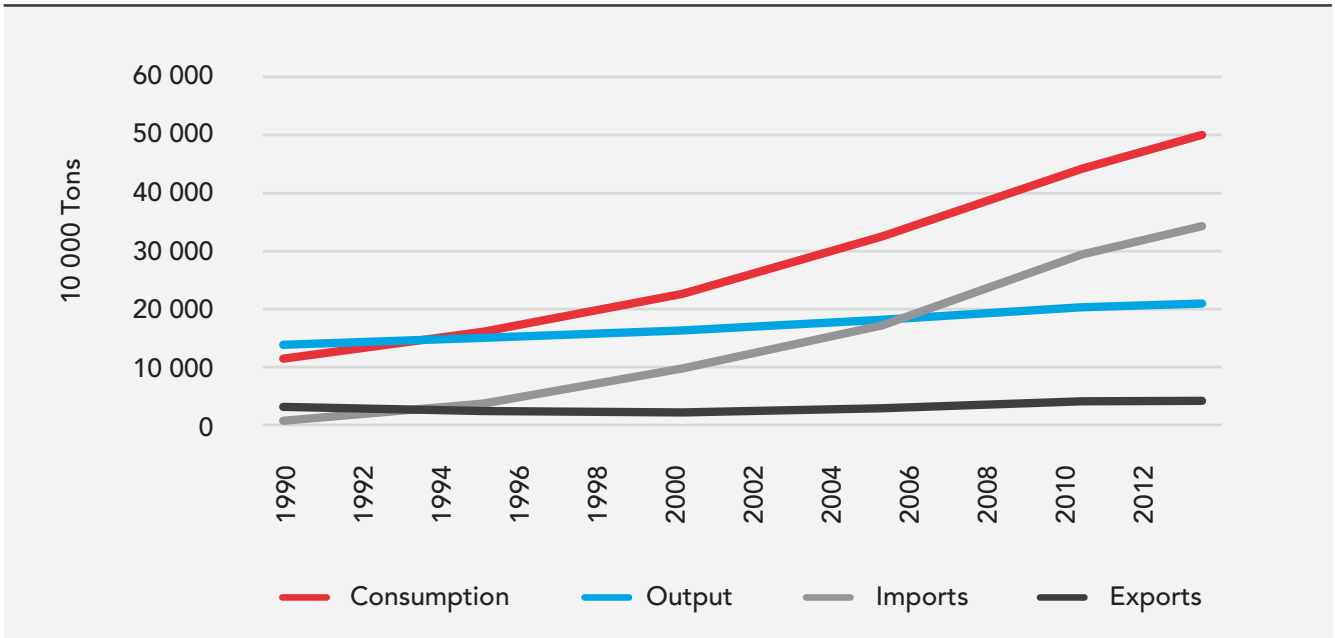

Figure 4.3: Petroleum balance in China, 1990-2013[102]

China's petroleum consumption by sector, 1990–2013

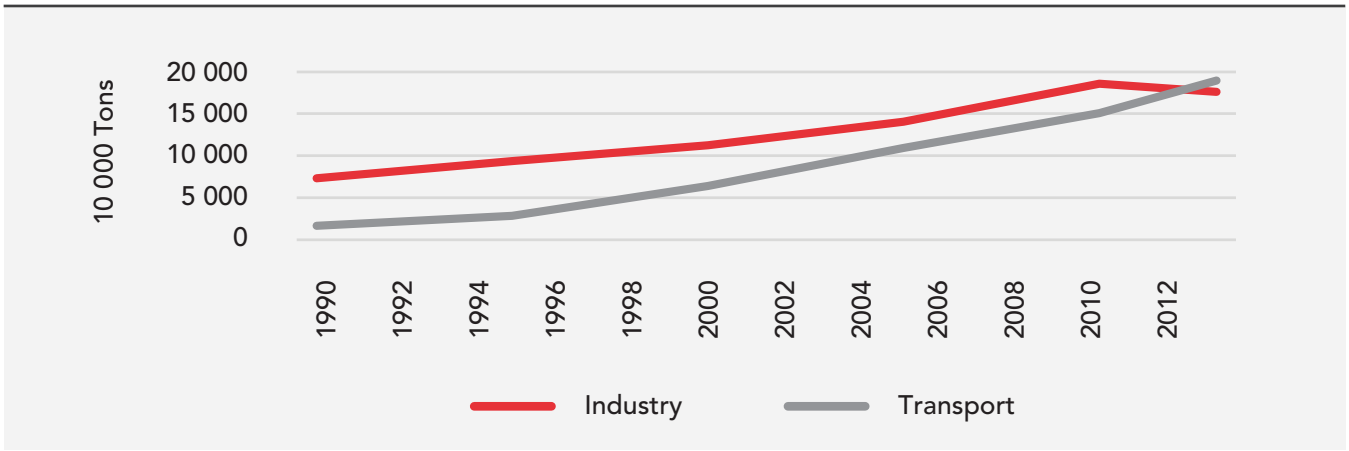

Figure 4.4: China's petroleum consumption by sector, 1990-2013[102]

China aims to reduce its 60% dependence on foreign oil. To achieve this goal, China is developing alternative fossil fuels such as natural gas and shale gas. It is also seeking to achieve long-term growth in oil production, which requires enhancing recovery at mature crude oil fields; greater investment to access more technically challenging plays, such as shale oil, tight oil, and deep-water fields; and increased use of non-petroleum liquids, such as gas-to-liquids, coal-to-liquids, and biofuels.

The major suppliers of petroleum to China are located in the Middle East, with more than 50% of total imports supplied by Saudi Arabia, Oman, Iraq, Iran, Kuwait, and the United Arab Emirates (Figure 4.5).

China's 2014 crude oil imports by source country

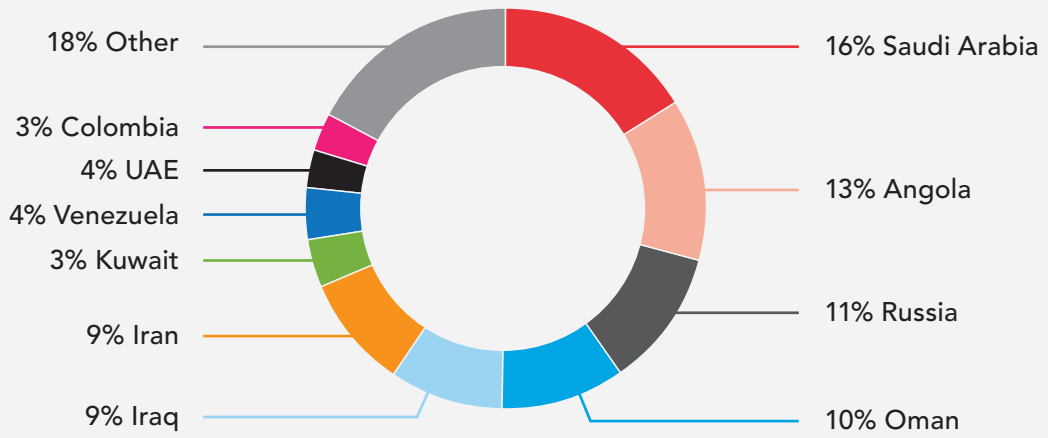

Figure 4.5: China's 2014 crude oil imports by source country[103]

2. TARGETS AND COMMITMENTS

Oil targets and commitments are outlined in the *Energy Development Strategy Action Plan (2014–2020)*. The main commitments are to increase domestic exploration and production of oil and to improve the efficiency of oil consumption.

- Increase domestic exploration and production of oil:
  - Build nine major oil fields with production capacity of 10 million tons each;
  - Apply new technology in traditional oil fields to increase productivity;
  - Explore more reserves in western regions to increase oil production;
  - Accelerate maritime oil exploration;
  - Strengthen exploration of low-grade resources; and
  - Develop technologies in large-scale oil fields and deep-sea oil.

- Expand oil reserves by building more oil reserve bases, encouraging private capital participation in building reserves, establishing corporate obligations for reserves, and encouraging the development of commercial reserves. Targets include increasing the oil-reserve-to-production ratio to 14:15, and completing the energy reserve emergency system;
- Strengthen international co-operation, and speed up the building of import channels as part of the emergency management of oil and gas strategy;
- Improve efficiency and environment protection standards for oil use;
- Develop oil alternatives through coal-based alternative, biomass substitution, and transportation alternative. Oil alternative capacity is intended to reach over 40 million tons by 2020;
- Execute the green transportation action plan, improving the economic and environmental standards of vehicle fuel.

3. POLICIES AND MEASURES

To achieve the above goals, China has been expanding funding for geological exploration, with a special focus on unconventional and deep-sea oil and gas resources development and international co-operation. The government has introduced price reforms, a futures market, and tax policies. In addition, China has been increasing the intensity of energy-conservation and emission-reduction policies in the oil sector.

DOMESTIC PRODUCTION: INVESTMENT AND INDUSTRIAL POLICIES

In order to steadily increase domestic oil production, China has been strengthening oil and gas exploration and development. The Ministry of Land and Resources consistently promotes the exploration for oil and gas resources and the enhanced effectiveness of mineral resources exploration. For example, the State Council issued an action plan for 2011 to 2014 in which it aims to achieve major breakthroughs in basins containing oil and gas, and to discover 10 to 20 new oil and gas target reserve areas by 2020.[104]

In 2013, NDRC included "conventional oil and gas exploration and drilling" in its catalogue of industries that will receive encouragement.[105] In 2015, NDRC and the Ministry of Commerce permitted foreign investment in some oil-processing industries, and allowed wholly foreign-owned investment in new technology development and application in oil harvesting, exploration, and development.

TAX POLICIES

On December 1, 2014, MOF adjusted to zero the exploration rates that companies pay for crude oil, natural gas, and mineral resources, and increased the resource tax rate from 5% to 6%. At the same time, MOF reduced or exempted the resource tax for certain types of oil and gas.[106]

China started collecting a special levy on oil in 2006. Accordingly, when the domestic oil price went above a certain level, the government collected a levy from the sale of domestically produced oil. On January 1, 2015, the threshold price for collecting the oil special levy was raised to US$65 per barrel, further lessening the burden on oil companies.[107]

BUILDING A CRUDE OIL FUTURES MARKET

China has taken steps to develop an oil futures market. As a first step, it set up the Shanghai International Energy Exchange in 2014.[108] Since then, MOF and State Administration of Taxation, General Administration of Customs, Administration of Foreign Exchange, and People's Bank of China respectively issued regulations on taxation, bonded delivery, foreign currency exchange, and capital settlement for oil futures trading. Relevant regulations on future market business are being drafted.

The futures market is a further step toward the marketization of the Chinese oil sector and part of the energy reform. As the largest trader of oil, China hopes to establish its own pricing benchmark for the oil it buys. Open to both domestic and foreign investors, the futures market will help promote the use of the yuan (the currency used to trade on the Shanghai exchange). China hopes to better manage and stabilize costs of gasoline and other petrochemicals.

OIL PRICING REFORM

The main objective of pricing reform is to establish a market price mechanism. On January 13, 2016, NDRC issued a notice to set the minimum price limit on refined oil.[109] When the global oil price is lower than US$40 per barrel per barrel, the domestic refined oil price will no longer be lowered. The notice also stated plans to set up an oil price risk-control reserve fund and simplify the refined oil price adjustment procedure. The government will fully liberalize refined oil prices as part of broader oil and gas system reforms.

REFORM OF THE OIL AND GAS INDUSTRY

With the fast growth of China's oil and gas industry, private capital has begun to enter oil and gas development and sales. As a result, the upstream and downstream market is gradually seeing more diversified players. However, pipeline infrastructure construction and operation are still concentrated in a few large, central enterprises. The national pipeline network is under the control of China National Petroleum Corporation (CNPC) and China Petroleum & Chemical Corporation (Sinopec).

Since the 12th Five-Year Plan, opening up of oil and gas pipelines has been a key focus of market reform. In 2014, NEA issued a policy that when the oil and gas pipeline network has excess capacity, operators should open it to third parties and provide services such as transmission, storage, gasification, liquefaction, and compression.[110] The policies aim to create more transmission opportunities and more reasonable transmission prices for upstream and downstream enterprises, as well as reduce transportation costs and encourage investment.

In the same year, the State Council issued a policy to encourage private capital to invest in the construction and operation of oil and gas pipelines and storage, as well as coal transportation and storage. The policy encourages private and local SOEs to participate as minority shareholders in the construction of main oil and gas pipelines, LNG terminals, underground gas storage, and city gas distribution and city gas storage. Private and local SOEs can be majority shareholders in the construction of oil and gas sublines and crude oil and refined oil storage.[111]

In November 2015, PetroChina announced that it would sell 50% of its shares in its subsidiary Trans-Asia Gas Pipeline Company. This action was considered the official launch of PetroChina's restructuring of its oil and gas pipeline assets.[112]

EXPANDING OIL RESERVE

The government wants to have a larger oil reserve to ensure domestic supply. In 2014, China's total oil reserve capacity was 16.4 million cubic metres and the country had actual reserves of 12.43 million tons of crude oil.[113] In mid-2015, China built eight national oil reserve bases. Now China has a total oil reserve capacity of 28.6 million cubic metres with actual reserves of 26.1 million tons of crude oil. China aims to have a total reserve capacity equivalent to 100 days of net oil import by 2020 to reduce the risk of oil supply interruption.

In 2015, NDRC regulated that crude-oil-processing enterprises must put aside an oil reserve stockpile. All enterprises that use crude oil as a raw material for processing petroleum products must keep at least 15 days inventory of crude oil.[114]

ENERGY-CONSERVATION AND EMISSION-REDUCTION POLICIES

In order to reach its energy-conservation and emission-reduction targets, China is focusing on reducing vehicle emissions and implementing waste disposal standards for the refining and onshore oil and gas exploration industry. In May 2015, NDRC issued the latest *Proposal on Speeding up Refined Oil Quality Upgrading*, expanding the implementation of vehicle gasoline and diesel with national V standard, advancing the timeline for supplying vehicle gasoline and diesel with national V standard, as well as upgrading regular diesel.[115] A separate directive requires passenger vehicle manufacturers to reduce average fuel consumption of vehicles to 6.9 litres per 100 kilometres by 2015 and 5.0L/100 km by 2020.[116]

The Ministry of Finance, the Ministry of Industry and Information Technology, and the Ministry of Transport reduced the refined oil price subsidy to city buses in 2015 in order to promote new-energy vehicles, energy conservation, and the restructuring of the public transportation industry.[117] Refined oil consumption tax in China has also been increased three times since 2014, rising from RMB1/L to RMB1.52/L.[118]

The Ministry of Environmental Protection developed waste disposal standards for the refining and onshore oil and gas exploration industries, starting on July 1, 2015.[119] Other directives indicate intentions to strictly implement energy and environment assessment on projects and to ensure that energy-efficiency and pollution-emission standards of high-energy-consumption and high-emission projects meet the advanced domestic level.[120]

C. NATURAL GAS

Natural gas currently accounts for about 6% of the total energy mix in China, but national policies aim for 10% by 2020.[121] As the price of natural gas is relatively high compared to coal and oil, natural gas

demand growth has slowed substantially. The government is implementing a number of policies to spur both domestic production and consumption of natural gas in order to meet its target of 10% by 2020.

1. CHINA'S NATURAL GAS CONSUMPTION AND PRODUCTION TRENDS

China's consumption of natural gas has increased rapidly since the early 2000s, increasing almost seven fold between 2000 and 2014. Consumption outstripped production in 2007, leading China to become a net importer of natural gas. Natural gas imports by pipeline and LNG met one-third of natural gas demand in 2014 (Figure 4.6).

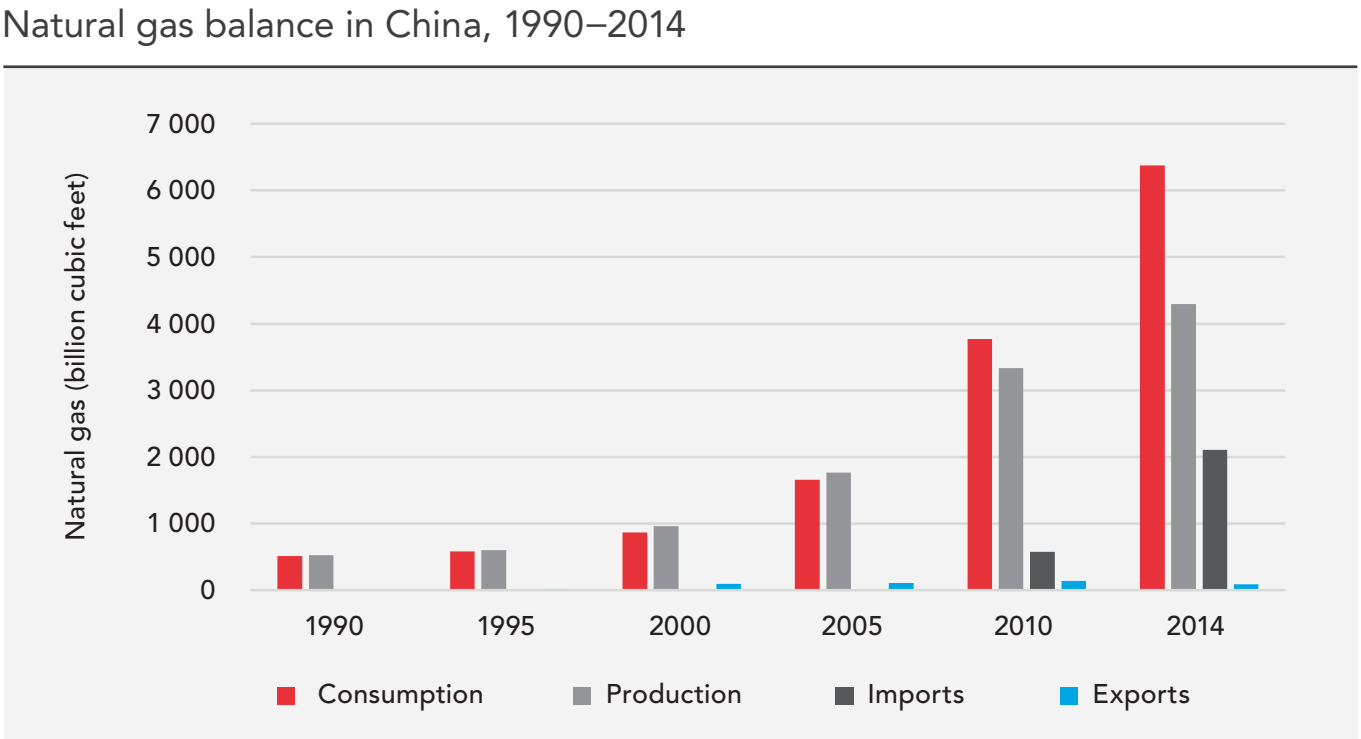

Figure 4.6: Natural gas balance in China, 1990-2014[122]

China had been experiencing extremely high growth in natural gas consumption, but in 2014 the country's consumption growth decelerated from double digits, to 8.6% in 2014 and 3.3% in 2015.[123] This slowdown is attributed to slower economic growth in China as well as pricing reforms that resulted in high domestic gas prices relative to substitutes. The price differential challenge was exacerbated by the drop in oil prices in 2015.

While industry is currently the largest end user of natural gas (31% in 2013),[124] the power and transportation sectors' shares of gas consumption have been rising over the past decade.

China's LNG imports by source country, 2014

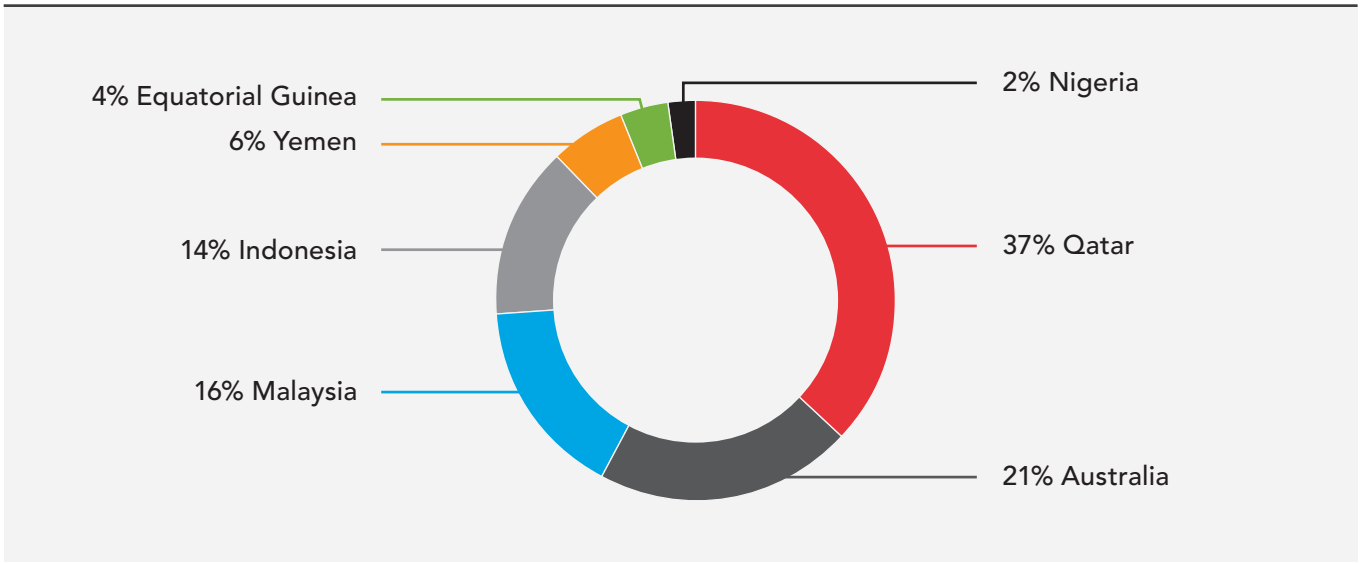

Figure 4.7: China's LNG imports by source country, 2014[125]

2. TARGETS AND COMMITMENTS

China's natural gas policy aims to increase conventional and unconventional gas reserves and production; increase the share of natural gas in the energy mix; expand import volume to move forward energy portfolio restructuring; and improve energy conservation and emission reduction. The main targets and commitments on natural gas as stated in the *Energy Development Strategy Action Plan (2014–2020)* are to achieve the following targets by 2020:

- Total new proven geological reserves of conventional natural gas to reach 5.5 trillion cubic metres;
- Annual production of conventional gas to reach 185 billion cubic metres;
- Annual production of more than 30 billion cubic metres of shale gas;
- Annual production of coalbed methane to increase to 30 billion cubic metres;
- Natural gas to comprise more than 10% of primary energy consumption; and
- Expanded imports of both pipeline and liquefied natural gas.

3. POLICIES AND MEASURES

China's policies aim to open up the upstream and downstream sectors of natural gas to expand reserve and production. There are also government subsidies and incentives to increase gas use in certain industries. The reform on oil and gas pipelines discussed in the preceding oil section also has a significant impact on the development of natural gas.

EXPLORATION AND PRODUCTION POLICIES

China is increasing investment in exploration, and is opening the upstream sector to private entities and, in some cases, foreign investors. In 2011 and 2012, the Ministry of Land and Resources (MLR) launched two domestic public tenders to select companies for transferring shale gas exploration rights.[126] For the second tender, private companies and joint ventures with more than 50% Chinese ownership were allowed to participate for the first time, and two areas were successfully won by private companies. In 2015, MLR launched a domestic public tender for the Xinjiang oil and gas exploration area, which was the first tender of a conventional oil and gas exploration area to be open to China-dominated joint ventures.[127] These actions indicated that the upstream sector will be more open in the future.

SHALE GAS AND COALBED METHANE PRODUCTION INCENTIVES

To encourage shale gas development and production, China implemented a financial subsidy in 2012. In 2015, MOF and NEA continued the subsidy policy, subsidizing shale gas development between 2016 and 2020. The subsidy standard for 2016 to 2018 is RMB0.3 per cubic metre, which will be reduced to RMB0.2 per cubic metre for 2019 to 2020. The subsidy policy will be adjusted based on factors of industrial development, technological improvement, and changes to the cost of producing shale gas.[128] The new subsidy decreased from the 2012 standard of RMB0.4 per cubic metre for a variety of reasons: gas price increases, market reform, domestic shale gas drilling technology improvement, and cost reduction.

China also subsidizes coalbed methane (CBM) extraction. Starting from 2007, the central government has subsidized CBM extraction enterprises at a rate of RMB0.2 per cubic metre.[129] In addition, local governments provide subsidies of RMB0.1 per cubic metre.[130] In 2013, the State Council requested an increase to the subsidy, asking MOF to work out details with NDRC and NEA.[131] So far, no new subsidy has been issued, which, to some extent, impacted CBM development. In 2015, China's CBM extraction totalled 18 billion cubic metres, which did not meet the 12th Five-Year Plan target of 20 billion cubic metres.[132]

PRODUCTION STIMULATION: TAX POLICIES

On December 1, 2014, MOF implemented a tax reform to encourage the exploration of natural gas. This increased the resource tax from 5% to 6%, and reduced the tax for natural gas from sources requiring more inputs, such as gas extraction in deep water.[133]

DOMESTIC GAS PRICING REFORM

The State Council's strategy for energy price reform is "to control the middle and open two sides."[134] This means that government will gradually open pricing in the upstream and downstream sectors to market mechanisms, while controlling the pricing of transmission. Accordingly, the State Council hopes that natural gas price reforms will gradually introduce market mechanisms, and that this will ultimately lead to the full opening of non-residential gas pricing.

Since 2011, NDRC has adjusted and tested reform on gas pricing several times. Under the current mechanisms, natural gas prices vary by province and sector. In the case of non-residential sectors, the price of gas is linked to alternative fossil fuels (liquefied petroleum gas and fuel oil). According to the latest policy, NDRC determines a benchmark city gate gas price, based on which both buyers and sellers can negotiate a price up to 20% above the city gate price. The "price-up" policy will not be implemented until November 20, 2016.[135]

In both February and November of 2015, in consideration of the sharp fall of global oil prices, NDRC significantly lowered the gas price for non-residential users in order to stimulate demand for natural gas by making natural gas more competitive with oil.[136] On July 1, 2015, the Shanghai Petroleum and Natural Gas Exchange started trial operations, signalling a big step toward the marketization of gas pricing.

INCENTIVES FOR INCREASED GAS USE IN POWER, TRANSPORTATION, AND INDUSTRIAL SECTORS

To encourage natural gas consumption and increase the natural gas consumption ratio, NDRC issued a policy on October 14, 2012, to regulate the downstream sector of natural gas.[137] It applies to domestic natural gas, shale gas, CBM, coal-to-gas, imported pipeline gas, and LNG. The policy categorizes natural gas downstream sectors into four grades: encouraged, permitted, restricted, and prohibited. The encouraged sectors include city gas for urban residents, public service facilities, and natural gas vehicles; gas for interruptible industrial fuel; and projects of distributed natural gas, CBM power, and gas-fired combined heat and power. Permitted sectors include natural gas alternatives to oil and liquefied petroleum gas. Natural gas chemical projects and gas power for coal mines are categorized as restricted or prohibited. For encouraged sectors, local governments may provide support in planning, land use, and financing.

Ministries have developed more specific and detailed regulations to encourage gas usage. For instance, NDRC issued guidance to promote distributed natural gas projects, and published the demo project list and implementation details.[138] The Ministry of Transportation issued a policy to promote LNG use in shipping, and wants LNG consumption to account for over 10% of total energy consumption by 2020 for shipping on inland waterways.[139] The Ministry of Finance and the Ministry of Housing and Urban-Rural Development promoted public-private partnerships in transmission and distribution of gas for consumer use.[140]

In January 2015, NDRC issued a notice on the feed-in tariff (FIT) for gas-fired power generation. The FIT mechanism is differentiated according to gas power's contribution to the power system and production span. Benchmark pricing is adopted for power generated by natural gas combined heat and power. Power producers are encouraged to sign contracts directly with end users with independently negotiated power amounts and prices. Mechanisms for aligning gas and power prices have also been established.[141]

INTERNATIONAL PIPELINES AND LNG IMPORTS

To expand LNG imports, MOF raised the imported gas price in 2014 to reduce losses for gas importers. On October 1, 2014, the LNG sales price was adjusted to RMB38.82 per gigajoule, and the pipeline gas price to RMB1.37 per cubic metre.[142] In 2013, imported LNG was RMB31.45 per gigajoule and pipeline gas was RMB1.11 per cubic metre. Meanwhile, China will gradually open pricing of imported pipeline gas and LNG. In 2014, NDRC requested further open up sourcing price of imported LNG.[143]

D. NUCLEAR ENERGY

As China aims to control high levels of air pollution and meet its commitments on climate change, it is increasingly turning to nuclear energy as an alternative to coal-fired power generation. Nuclear power will supply the largest share of China's non-carbon-emitting generating capacity additions through 2030.

1. CHINA'S NUCLEAR ENERGY PRODUCTION AND CONSUMPTION TRENDS

In 2011, NEA declared that nuclear energy would be the foundation of China's power generation system in the next 10 to 20 years, adding as much as 300 gigawatts of electric energy in nuclear capacity over that period. China suspended new reactor approvals and launched a nationwide inspection of all its nuclear projects in 2011 in the wake of the Fukushima disaster. However, new reactors are now being approved.

China currently has 30 reactors in operation, with a total capacity of 28.3 gigawatts. Another 24 units are under construction. The operational reactors generated 169 billion kilowatt-hours of power in 2015, an increase of 29.4% from 2014.[144]

Nuclear power generation in China, 1995–2015

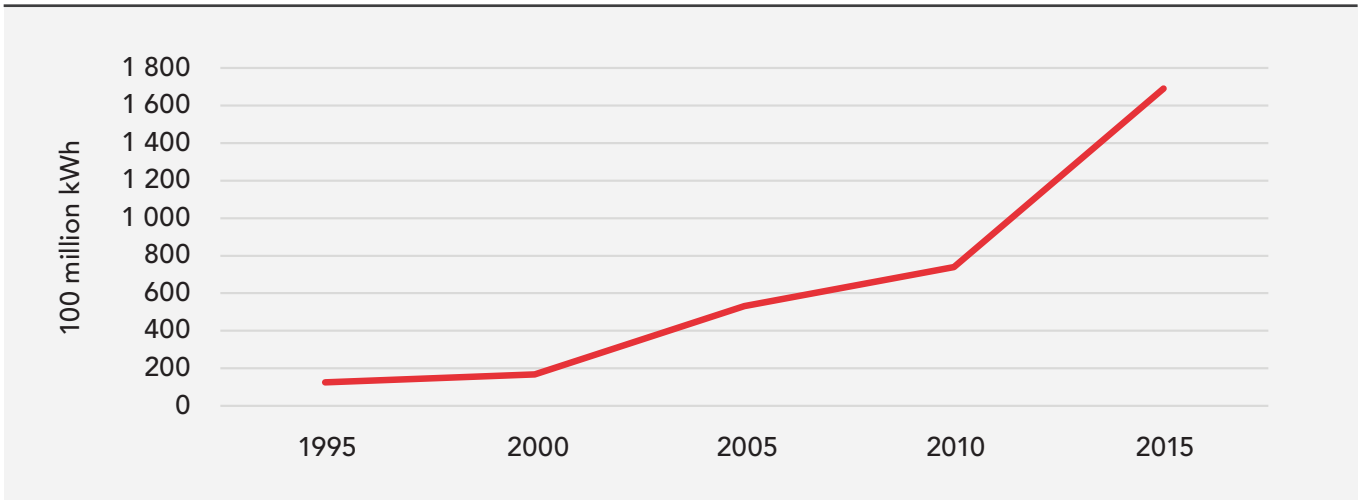

Figure 4.8: Nuclear power generation in China, 1995-2015[145]

2. TARGETS AND COMMITMENTS

Current targets and commitments relating to nuclear energy development can be found in the *Energy Development Strategy Action Plan (2014–2020)* and the *12th Five-Year Plan for Nuclear Safety and Radioactive Pollution Prevention and Vision for 2020*. Major targets and commitments are as follows:

- Meet the highest international safety standards and ensure safety; start new nuclear power projects in China's eastern coastal area; and study and evaluate building nuclear power projects inland. Nuclear power capacity will reach 58 million kW, with 30 million kW under construction by 2020;
- Develop advanced nuclear power technology, and strengthen major national R&D projects on advanced large-scale, pressurized water reactor technology and high-temperature, gas-cooled reactor technology;
- Increase public knowledge of nuclear science and nuclear safety; and
- Actively promote "going global" with (exporting) nuclear technology.

The *13th Five-Year Plan for the Nuclear Sector* has been drafted under the leadership of NEA and is now being circulated for comments.

3. POLICIES AND MEASURES

To achieve the above targets and commitments, China introduced policies and measures regarding the construction of nuclear power plants and the restructuring of the nuclear power industry, as well as pricing and taxation incentive policies. Power system reform will also have an important impact on nuclear power consumption and production. China has also developed relevant policies regarding nuclear emergency preparedness, and the development and export of nuclear technology.

REORGANIZATION OF THE DOMESTIC NUCLEAR ENERGY INDUSTRY

In May 2015, China Power Investment Corporation and the State Nuclear Power Technology Company merged into the State Power Investment Corporation (SPIC).[146] This reduces the number of major national SOEs in the nuclear energy sector to three: China Nuclear Industry Corporation (CNNC), China General Nuclear Power Group (CGN) and SPIC.

By the end of 2015, CNNC owned 14 nuclear reactors with installed capacity of 11.512 million kW, and had 11 reactors under construction with capacity of 12.098 million kW.[147] CNNC's floating nuclear power plant ACP100S was included in the 13th Five-Year Plan of energy innovation.[148] CGN has 16 nuclear reactors with installed capacity of 17.09 million kW, and 12 reactors under construction with capacity of 14.65 million kW.[149] SPIC is the only energy enterprise with power transmission, thermal power, nuclear power, and new-energy assets; 40% of SPIC's assets are in clean-energy facilities.[150]

INLAND NUCLEAR POWER CONSTRUCTION

China is studying the feasibility of inland nuclear power construction, and the Chinese Academy of Engineering evaluated the site of the inland nuclear power plants in preparation. The Taohuajiang nuclear power plant in Hunan Province, the Xianning Dafan nuclear power plant in Hubei Province, and the Pengze nuclear power plant in Jiangxi Province will likely become the first inland nuclear power plants. These three projects have been permitted by NDRC to start preparatory work, including site pavement, meteorology, and geological surveys.[151]

PRICING MECHANISMS

In order to promote the development of nuclear power and guide rational nuclear power investment, China implemented a benchmark price policy on new nuclear power units. Based on the average cost of nuclear power and electricity market supply and demand, the national benchmark price for nuclear power is RMB0.43 per kilowatt hour. If the benchmark price is higher than that of coal-fired electricity in a particular locality, then the local price for coal-fired electricity should be adopted. If the benchmark price is lower, however, then the local price of nuclear power can be increased from the benchmark price and the increase will be subsidized by the government.[152] The national nuclear power benchmark price will be assessed and adjusted based on nuclear power technology progress, changes in the costs of generating nuclear power, and changes in the power market.[153]

TAX INCENTIVE REGULATIONS

MOF and the State Administration of Taxation issued a policy in 2008 granting VAT rebates over 15 years to nuclear power generation enterprises that produce and sell power products: a 75% rebate on VAT for the first five years of operation, 70% for the next five years, and 55% for the remaining five years. VAT rebates used to pay back bank loans are exempted from enterprise income tax.[154]

Tariffs are waived on equipment and technology imports that cannot be produced domestically. According to a policy issued by the MOF, NDRC, the Ministry of Industry and Information Technology, and other ministries, starting from January 1, 2010, key parts and raw materials imported by domestic enterprises for producing third-generation nuclear power reactors will be exempted from customs duties and import-associated VAT. Five years later, the policy was updated to apply to a more restricted list of imported technical equipment for the third-generation and improved second-generation nuclear power units. This equipment has customs duties and import-associated VAT waived, starting from January 1, 2016.[155]

NUCLEAR SAFETY

With the development of nuclear energy, China has attached great importance to nuclear safety and nuclear emergency management. On January 7, 2016, China published a white paper on "China's nuclear emergency management," introducing specific requirements and measures on the formation of laws and regulations, capacity building, nuclear accident response, exercises and drills, public communication, technological innovation, and international co-operation and exchanges.[156]

POLICIES FOR ENCOURAGING NUCLEAR ENERGY TECHNOLOGY DEVELOPMENT

Since 2006, advanced large-scale, pressurized water reactors and high-temperature, gas-cooled reactors in nuclear power plants have been listed as special major national projects. In recent years, NEA has formulated specific rules for project management, intellectual property management, and funding management to ensure the smooth implementation and research of the special major projects.[157]

REFORMS TO THE POWER INDUSTRY

Reforms to the power industry require "nuclear power generation to adjust to peaking needs."[158] This will have an important influence on nuclear power. Nuclear power units are large and difficult to adjust, and without large and stable demand, cannot compete economically with coal power or hydropower.[159]

E. RENEWABLE ENERGY

Renewable energy development is a key aspect of China's plan to increase energy security through domestic production and to reduce GHG emissions from power generation. China has also identified renewable energy and energy-conservation technologies as priority sectors for furthering China's economic development. As a result, policies focus on increasing renewables in the power and fuel mix, but also on increasing R&D and the domestic manufacture of sustainable energy technologies.

1. CHINA'S RENEWABLE ENERGY CONSUMPTION AND PRODUCTION TRENDS

The Chinese Renewable Energy Law defines renewable energy as "non-fossil energies, such as wind energy, solar energy, hydro-energy, bioenergy, geothermal energy, and ocean energy but not including the utilization of straws or stalks, firewood, or dung in the form of direct burning through an inefficient cooking range."[160] The following discussion will address the use of renewables in power generation and as an alternative transport fuel.

RENEWABLES IN POWER GENERATION

Renewable energy comprised a robust 30% of installed capacity for power generation in 2014, due predominantly to the large role of hydropower, which alone comprises 22% of installed capacity. Solar, wind, and biomass energy provide the remaining 8%.[161]

Of all energy types, wind and solar experienced the fastest percentage growth in power generation over the past five years. Solar installation began in 2009 and grew to 40,000 megawatts by 2015, while wind capacity increased more than fivefold to 145,104 megawatts in the same period, nearly one-quarter of installed capacity worldwide. Hydropower grew at a much slower pace, although from a much larger base, at about 55%, similar to the growth rate of coal-based power-generation capacity.

One of the major drivers of the increase in renewable energy installation and production is large-scale investment in renewable energy technology and services. China surpassed the United States in renewable energy investments in 2014, investing nearly US$83B, a 39% rise over 2013 (Figure 4.9).

The impressive rate of growth in renewable energy has also been driven by the reduced costs of producing wind and solar energy. According to a study by the International Renewable Energy Agency, hydropower is the least expensive energy source for power generation with a weighted-average levelized cost of electricity (LCOE) of around US$0.04/kWh, followed by biomass at between US$0.05 and US$0.06/kWh. Wind has project costs in the range of US$0.05 to USD$0.10/kWh, while the LCOE of utility-scale photovoltaic (PV) energy has declined rapidly from an average of around US$0.24/kWh in 2010 to just US$0.11/kWh in 2014.[162] However, the low cost of coal and other fossil fuels in China continues to create strong competition for renewable energy.

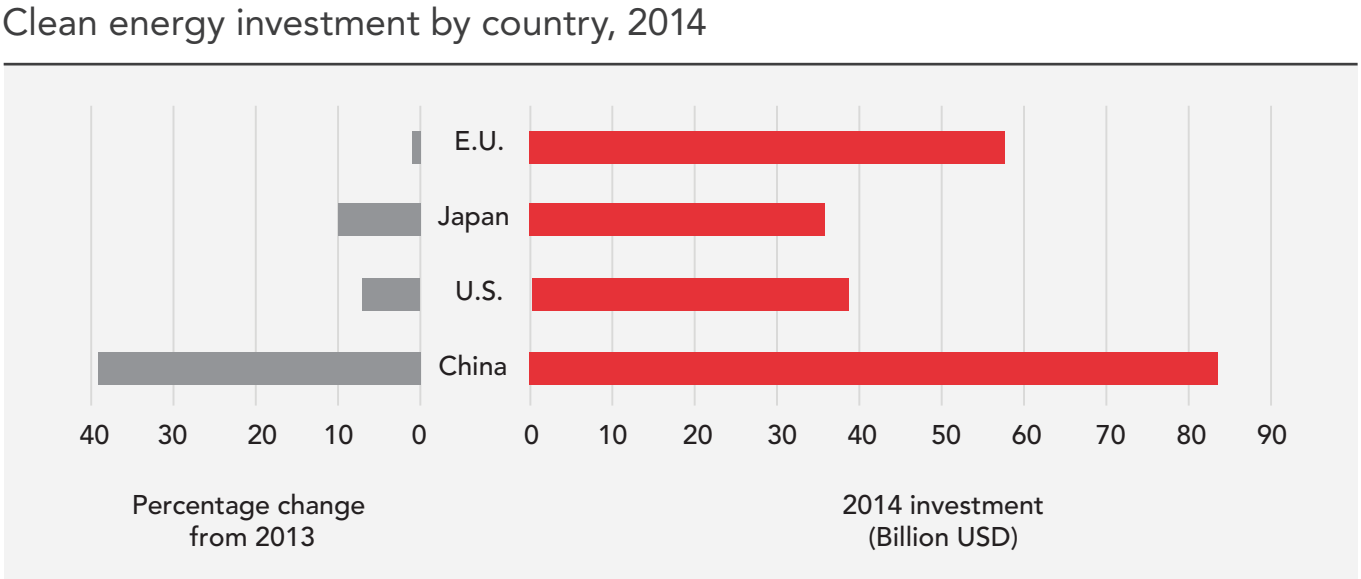

Figure 4.9: Clean energy investment by country, 2014[163]

BIOFUELS IN TRANSPORTATION

China is a world leader in the production of biofuels as a replacement for petroleum products as transportation fuel. The two key types of biofuels encouraged by government policy are non-grain-based ethanol and biodiesel. China is estimated to produce about 2.43 million tons of ethanol annually, making it the third-largest producer of ethanol after the United States and Brazil.[164]

Biodiesel production is estimated to have reached approximately 1 million metric tons in 2015. In 2014, NEA released a policy for biodiesel that sets out principles and standards for development of the industry. It notes that the Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta regions should be priority for biodiesel distribution projects.[165] The document also highlights regulations for ensuring the environmental sustainability of the industry, including setting standards for the amount of coal and fresh water that can be consumed in production. Currently, biofuel production makes up less than 1% of China's annual liquid fuel production.

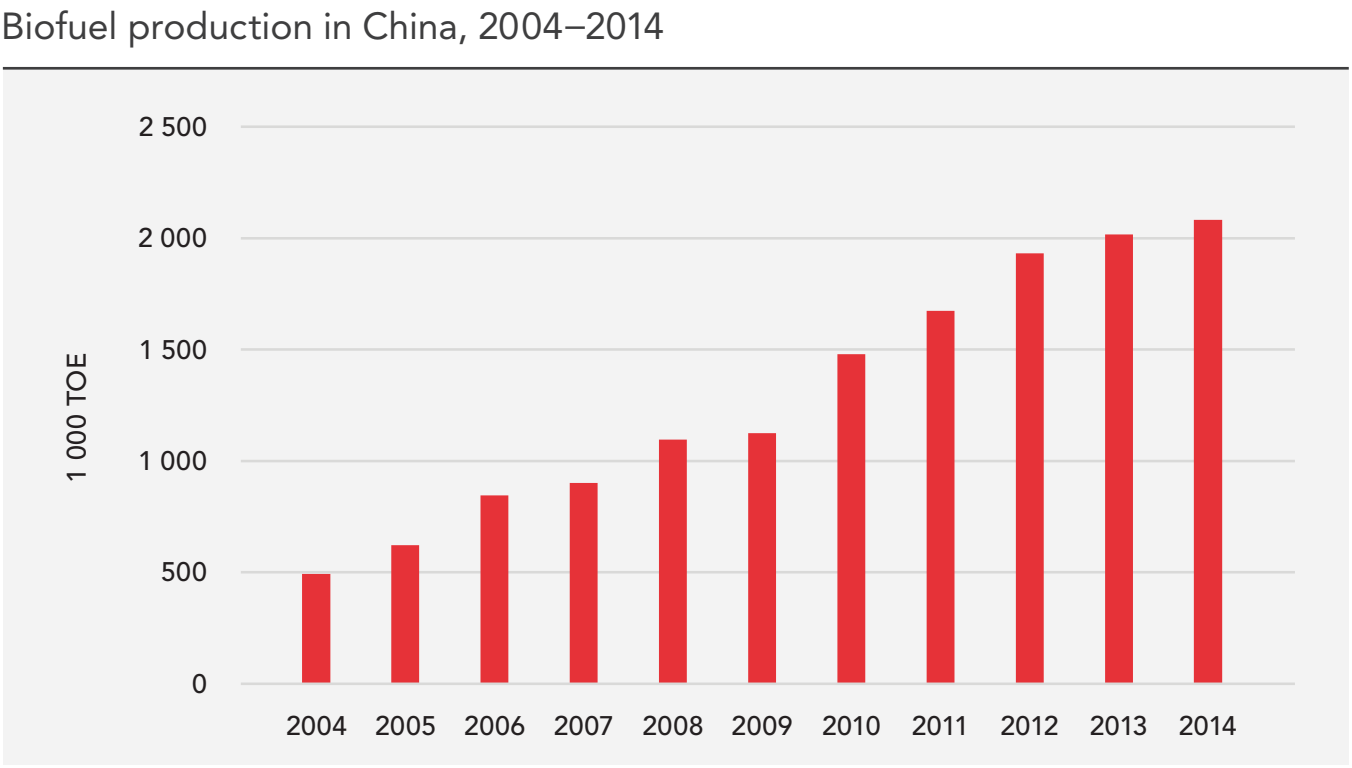

Figure 4.10: Biofuel production in China, 2004-2014[166]

2. TARGETS AND COMMITMENTS

Targets directly relevant to renewable energy through to 2030 can be found in the *Energy Development Strategy Action Plan (2014–2020)* and the *National Climate Change Action Plan (2014–2020)*. These targets include the following:

- Increase the share of non-fossil fuels in primary energy consumption to 15% by 2020, and to around 20% by 2030;
- Increase installed capacity of wind power to 200 gigawatts and installed capacity of solar power to around 100 gigawatts by 2020;
- Reach 350 gigawatts of installed capacity of hydropower by 2020;
- Achieve geothermal energy capacity equivalent to 50 million tons of standard coal (35 mtoe) by 2020.

3. POLICIES AND MEASURES

The primary piece of legislation on renewable energy production and technology development is the Renewable Energy Law, which came into effect in 2006 and was amended in 2009. NDRC developed the *Medium and Long-Term Development Plan for Renewable Energy* in order to implement this law, and

introduced policies and mechanisms to support the renewable energy industry. Both the law and the plan focused on support for the development and domestic manufacture of new renewable technologies, and grid synchronization of power generated from renewable energies. NDRC and other government agencies have implemented a number of measures to stimulate both production and demand of renewable energy.

FEED-IN TARIFFS (FITS), POWER PURCHASE AGREEMENTS, AND SUBSIDIES

A feed-in tariff provides producers with a guaranteed price for each unit of power generated, while a power purchase agreement requires grid operators to purchase energy generated by producers. A FIT scheme for wind was introduced in 2009, under the Renewable Energy Law. The Renewable Energy Law requires power grid operators to purchase energy generated by registered renewable energy producers at a purchase price set by NDRC, which varies by type of energy source and by region.[167]

The Renewable Energy Law stipulated that renewable energy be subsidized through a surcharge on electricity, with industry paying a significantly higher surcharge than residential users and other sectors. Funds from the surcharge are provided to grid operators who are required to purchase renewable energy from generators.

Solar: Utility-Scale and Distributed

China offers FITs for utility-scale power plants as well as distributed generation installations. The utility tariffs were first introduced at the national level by NDRC in 2011. In 2013, the tariff for on-grid solar energy was adjusted to allow for different payments based on local irradiation conditions. In December 2015, NDRC and NEA announced reductions in FITs for solar power in 2016 and listed benchmarking prices for different regions.[168] Solar photovoltaic (PV) installations approved in 2015 and connected to the grid before June 30, 2016, will be eligible to benefit from the 2015 FIT rates.

The reduction of on-grid solar FITs reflects government policy to encourage greater distributed solar power generation. In 2013, NDRC introduced a FIT specifically for distributed power generation (solar rooftop installations).[169]

Wind: Onshore and Offshore

At the end of 2014, NDRC reduced the FIT for onshore wind power. China's FIT policy divides the country into four zones, with a sliding scale of tariffs based on wind conditions, creating Energy Zones 1, 2, 3, and 4.[170] The government reduced the tariff by RMB0.02/kWh (US$0.003) for three zones, with prices now sitting at RMB0.49, RMB0.52, RMB0.56, and RMB0.61/kWh (US$0.08 to US$0.10). The new tariffs applied to projects approved after January 1, 2015, and to those projects approved before January 1, 2015, but installed after January 1, 2016.[171]

China has the third-greatest installed capacity for offshore wind power, and has excellent wind conditions for expansion. In June 2014, NDRC introduced a FIT for offshore wind power of RMB0.85/kWh (US$0.14) for near-shore offshore projects, and RMB0.75/kWh (US$0.12) for intertidal projects.[172] These

tariffs apply to projects that come online before 2017. Local governments have also implemented FITs and subsidies to spur development.[173]

Hydropower
In January 2014, NDRC asked provinces to set benchmark prices for electricity generated from hydropower projects.[174] Previously, tariffs were set at the national level and paid on a per-project basis.

Biofuels
National government subsidies support the production of non-grain-based biofuels at between RMB750 and RMB 800 per ton[175]. Six provinces and 27 cities in five other provinces have blended-fuel mandates that require transportation fuel to comprise 10% ethanol. Prices for ethanol are fixed by the government. MOF issued a notice in 2014 to lower the grain-based bioethanol subsidy between 2013 and 2015, and to cancel the subsidy in 2016.[176]

TAX INCENTIVES FOR GENERATORS AND DOMESTIC MANUFACTURERS

Tax incentives are provided at each stage of renewable energy production cycle from R&D and the manufacture of clean technology to power generation and sales. In 2005, NDRC issued a *Guidance Catalogue on Renewable Energy Industrial Development* listing 88 types of renewable energy projects eligible for preferential tax treatment or designated funding. NDRC released an *Industry Structural Adjustment Guidance Catalogue* in 2011 and modified it in 2013, which listed some renewable energy projects in the "encouraged" category, such as offshore wind-power project and PV power generation.[177]

Developers of wind energy equipment received an exemption from the VAT. A reduced corporate income tax rate of 15% is granted to qualified advanced and new technology enterprises. VAT refunds are offered on the sale of a number of different types of renewable energy. In 2013, MOF and the State Administration of Taxation issued a policy reducing VAT by 50% for self-processed PV power from October 1, 2013, to December 31, 2015.[178] In 2014, MOF and the State Administration of Taxation issued a VAT policy for self-processed hydropower by hydropower plants with an installed capacity of over 1 million kW: from January 1, 2013, to December 31, 2015, VAT above 8% was rebated, and from January 1, 2016, to December 31, 2017, VAT above 12% is rebated.[179] Starting from July 1, 2015, a 50% VAT reduction is offered for self-processed wind power.[180]

NEA, MOF, MLR, and MOHURD released a guidance to promote geothermal development and use, giving projects using geothermal energy preferential tax treatment.[181]

GOVERNMENT PROCUREMENT POLICY

The Green Procurement Program was introduced in 2005 to foster China's sustainability industries and improve energy efficiency in the public sector. The program requires government organizations to procure green products as identified by the *Environment Products List*, which was created in 2006 by the State Environment Protection Administration (succeeded by the Ministry of Environmental Protection) and the Ministry of Finance. The list is drawn from products that meet China Environmental Labelling

standards, which were initiated in 1993 as a response to the 1992 Rio Conference on Environment and Development.

In 2006, the *Provisional Measures for the Accreditation of National Indigenous Innovation* were enacted wherein Chinese intellectual property would qualify for "priority" in government procurement. The following year, the State Council introduced the *Regulation on Compulsory Government Procurement for Energy Conservation Products*, requiring government organizations to purchase energy- and water-saving products as identified on the *Energy Conservation Products List.* The list contains eight categories and over 100 energy-efficient products.[182]

In 2009, the Promotion of Circular Economy Law was implemented, directing governments to establish a responsibility system, using policy design, fiscal power, investment opportunities, and government procurement power to promote a circular economy. Circular economy aims to increase water efficiency recycling of materials in the manufacturing process.

In 2011, the *Implementing Regulations for the Tendering and Bidding Law* was enacted, giving greater powers to MOF regarding procurement in the area of construction, increasing its oversight of budgetary control and overall policy.

At the national level, NDRC and Ministry of Environmental Protection are leading and governing government procurement policy practice, with the Ministry of Commerce and the Ministry of Finance providing support in market co-ordination and financing.

R&D FUNDING

In 2015, MOF released a policy for allocating renewable energy development funds to support the promotion and industrialization of key technologies of renewable energies, and the exploration and use of renewable energy.[183]

The central government subsidizes research and development on key renewable energy technologies through NDRC and the Ministry of Science and Technology. R&D incentives are mostly in the form of enterprise incentive taxes. China identified eight industries with "high and new technology enterprise" (HNTE) status, which are given priority for R&D incentives. New energy and energy conservation are included in this category. Although companies qualify for the tax incentives irrespective of where they are headquartered, they must give their Chinese subsidiaries a global exclusive license for the intellectual property for at least five years. These companies can qualify for a tax deduction equal to 150% of the qualifying R&D expenses, which can be carried forward for up to five years. There is also a reduced enterprise tax rate of 15% available to HNTE companies until the end of 2018. HNTE status must be renewed every three years.[184]

POWER SECTOR REFORM AND GRID INTEGRATION

While China has increased the installed capacity of renewable energy substantially, actual utilization has not been as successful—mainly due to challenges connecting capacity to the grid, especially in remote provinces.

Numerous directives have been proposed to regulate and improve the power grid in order to better integrate renewables. In March 2015, the State Council stated that it would deepen power sector reform, identifying equitable grid access for renewables as an important step for the development of distributed power.[185] It identified grid upgrades along with the integration of advanced energy storage technologies, information technology, and micro-grid and smart-grid technology as requirements to improve the system's assimilative capacity and energy efficiency.

Demand-side management is also being implemented to help reduce or shift peak electricity load to resolve recurring blackouts and reduce necessary power grid investment. Under NDRC and MOF directives, demand-side management pilots have been introduced in four cities to strengthen the demand-side management platform, and to guide and encourage electricity users to use online monitoring.[186]

The pilot programs are being funded by providing incentives of RMB400 per kW reduced in eastern provinces and RMB550 per kW reduced in central and western provinces. Pilot projects that lead to temporary reductions in peak load via demand response will earn a reward of RMB100 per kW reduced.

RENEWABLE PORTFOLIO STANDARD

The central government has specified targets for different renewables in the energy mix since the Renewable Energy Law was passed in 2006. It is anticipated that individual quotas for provinces will also be implemented, ensuring that a certain percentage of their electricity consumption will come from non-hydropower renewable energy sources.[187] This policy would help to stimulate demand for renewables by better aligning national-level policy with local realities. This policy was anticipated in 2014, but has yet to be announced.

SECTION V

CHINA'S NEEDS FOR INTERNATIONAL CO-OPERATION

1. CHINA'S INTERNATIONAL CO-OPERATION THEMES

China's energy policies highlight the importance of international co-operation to the achievement of its energy goals. There are two key themes in China's international co-operation approach across all energy types: the "One Belt, One Road" strategy and "going global."

THE ONE BELT ONE ROAD STRATEGY

International energy co-operation in the energy sector is to interact with the One Belt, One Road strategy. The "belt" refers to the New Silk Road (or Silk Road Economic Belt) initiative that aims to more closely link overland Europe to Central Asia and China through to Southeast Asia and South Asia.[188] The "road," on the other hand, refers to the 21st-Century Maritime Silk Road initiative, which envisions greater port development and other collaboration on a route beginning in Quanzhou, heading to the Malacca Strait, to ASEAN (Association of Southeast Asian Nations) countries, and then to Kolkata, and across the Indian Ocean to the Horn of Africa before it finally reaches Europe.

The One Belt, One Road strategy emphasizes co-operation on infrastructure. Key areas for co-operation include enhancing interconnection of energy infrastructure, maintaining oil and gas pipeline security, promoting cross-board power supply and transmission, and actively carrying out regional grid upgrades and transformation. It also encourages co-operation in deep processing technology, equipment, and engineering service in the energy and resource sector.[189]

China has invested heavily in oil and gas extraction and pipelines in Central Asian countries mentioned in the One Belt, One Road strategy. For example, Beijing inked 31 deals worth US$15.5B with Uzbekistan in 2013 to build an oil pipeline that will terminate in China, as well as a cross-border railway to China that goes through Kyrgyzstan. Collaboration with Central Asian countries in the One Belt, One Road region, and with Pakistan through the China-Pakistan Economic Corridor, is particularly important to China's oil, gas, and uranium security.

While not mentioned in the *Energy Development Strategic Action Plan*, China has raised the idea of other maritime-focused collaboration concepts beyond the 21st-Century Maritime Silk Road initiative. During then-prime minister Stephen Harper's official visit to the People's Republic of China in November 2014, Ottawa and Beijing agreed to identify new approaches for furthering Canada-China energy trade. One possible mechanism that was referred to in official communications was "an environmentally safe maritime energy corridor."

GOING GLOBAL

Chinese policy aims for the country to become a major exporter of technology and services in almost every energy category. NEA has asserted that it will encourage coal enterprises to provide technical services to foreign projects in order to bid for the construction, technological upgrading, and operation of foreign coal mines.[190]

A particular focus for China is nuclear power. In recent years, China has been actively promoting nuclear power "going global" to push forward international co-operation and jointly build nuclear power projects.

In 2013, China's National Energy Administration and the Romanian energy agency signed a memorandum of understanding to promote co-operation in the peaceful use of nuclear energy, nuclear power project construction, and nuclear technology exchange.[191] Candu Energy is currently collaborating with China General Nuclear Power Group to build units 3 and 4 at the nuclear power facility in Cernavodă, Romania. In 2015, China and Argentina signed an agreement to jointly build heavy water reactor and pressurized water reactor nuclear power plants. China also signed and issued the *2015 Joint Statement on Nuclear Energy Cooperation for Civil Use* with the U.K. to jointly develop Britain's Hinkley Point nuclear power plant with a French power company.[192] According to officials from the NEA Division of Nuclear Power, the Chinese-British-French project, with its multilateral co-operation, is likely to serve as a model for future collaboration.[193]

2. CHINA'S NEEDS FOR INTERNATIONAL CO-OPERATION

China is actively seeking international co-operation in the energy sector to meet its challenges and its overall targets and commitments. Potential areas include energy commodities, infrastructure investment, advanced technologies in shale gas, carbon capture and storage, smart grids, and water conservation.

COMMODITY IMPORTS

China's energy production is not sufficient to meet energy demand. In order to ensure energy security, the government encourages investment in the domestic exploration and supply of oil and natural gas. However, China still needs substantial imports of oil, gas and uranium. The country also encourages importing high-quality coal. Chinese oil and gas companies have been investing in extraction projects around the world to meet domestic demand.

FOREIGN INVESTMENT IN ENERGY-RELATED INFRASTRUCTURE AND SECTORS

China is gradually opening up its energy sector to private investment, and encourages foreign investment in a number of energy-related fields. For example, Chinese government regulations allow Chinese-foreign joint ventures with Chinese-majority ownership to bid for shale gas tenders in order to spur increased production of oil and gas. Some of the fields open to foreign investment include the following:[194]

- Prospecting and exploitation of petroleum and natural gas (unconventional oil resources such as oil shale, oil sands, shale gas, and coalbed gas), and utilization of coalbed gas (limited to equity joint ventures or contractual joint ventures);
- Construction and management of oil (gas) pipelines, oil (gas) depots, and petroleum wharfs;
- Construction and management of nuclear power plants (the Chinese partner must hold the majority of shares);
- Construction and management of new-energy power plants (including solar energy, wind energy, magnetic energy, geothermal energy, tidal energy, and biological mass energy);
- Construction and management of power grids (the Chinese partner must hold the majority of shares);
- Development and application of new technologies that can increase the recovery factor of crude oil (in the form of engineering service);
- Manufacturing of key parts and components for new-energy vehicles; and
- Manufacturing of special equipment for solar cell production.

CARBON CAPTURE AND STORAGE TECHNOLOGY

Carbon capture and storage (CCS) for carbon-intensive industries, such as power and steel production, is generating a lot of interest from the global community. China has had some success in developing CCS, and the technology has been cited in national policies on climate change as an area for technological development. During the 12th Five Year Plan, the Chinese government invested between RMB600M and RMB700M in CCS R&D. An industry matching fund provided approximately RMB2B.

At a March 2015 forum organized by the Ministry of Science and Technology in Beijing, the following priorities were highlighted in regards to developing CCS:[195]

- Learn from the experiences of other countries in developing CCS technology;
- Investigate how to promote "creation-driven" CCS[196] development and how to apply CCS in an economically viable manner; and
- Strengthen the commercial focus of international collaboration.

Attendees at the forum noted that China wants CCS technologies to be ready for deployment by 2030, and is in the process of creating policy support and flexible financial tools to encourage development and implementation. Further investment in CCS technology development is likely to occur under the 13th Five-Year Plan.

SHALE GAS TECHNOLOGY

In an effort to develop alternate fossil fuels, China has started to explore shale gas reserves. Aggressive targets have been set for increasing shale gas production.

Shale gas extraction has many environmental consequences and is associated with high GHG emissions and water contamination issues. Thus, there are many avenues for international collaboration with China to develop technologies for increasing water efficiency, monitoring water contamination, improving water recycling, and lowering CO2 emissions associated with drilling.

To meet these objectives, Chinese companies and government agencies are partnering with international counterparts to build capacity in shale gas. For example, China and the United States have created the Shale Gas Initiative, an agreement to increase bilateral collaboration on environmental regulation, safety and technology for shale gas extraction.[197] Furthermore, The University of Calgary opened a training facility in Beijing to offer education and training and develop collaborative research on unconventional hydrocarbon resources and technologies, including shale and tight gas and oil. The site was developed in cooperation with a Chinese oil and gas company.

SMART-GRID TECHNOLOGY

In recent years, blackouts have been regular occurrences in China's developed east coast cities, especially during peak hours for electricity use in the summer. Key weaknesses of China's existing power grid are inefficient distribution and transmission of power, along with a lack of effective demand-side management. The loss of electricity through transmission and distribution alone is estimated to be around 8% of total generation. Also, although China has significant installed capacity for renewable energy, not all of it is connected to the grid. Demand-side management is highlighted in power grid reform as a means of increasing efficiencies and managing future loads.[198] Thus, China is looking to collaborate internationally on grid technology.

NUCLEAR ENERGY TECHNOLOGY

China has been active in developing nuclear technology for domestic use and building nuclear power projects overseas. China has maintained long-term collaboration with foreign companies in the area of nuclear technology development. For example, China has maintained long-term co-operation with U.S. companies Westinghouse Electric Company and Electro-Motive Diesel on AP1000 project construction and technology transfer.[199] Four AP1000 reactors, a Westinghouse-designed nuclear reactor, are under construction in China. The AP1000 forms the basis for the larger CAP1400 reactor that was built by State Nuclear Power Technology Corporation (SNPTC) in consultation with Westinghouse as one of 16 strategic projects under China's National Science and Technology Development Plan.[200]

Since China does not produce sufficient uranium to meet its domestic needs, it is pursuing technology that can reduce its reliance on imported uranium as well as reduce nuclear waste. While the majority of China's reactors are light water, China National Nuclear Corporation (CNNC) purchased two Candu reactors that were built at its Qinshan site in the early 2000s. Research conducted by Atomic Energy of Canada Limited/Candu Energy and CNNC resulted in further development of the fuel cycle so that these reactors can use natural uranium equivalent that can be formed using spent fuel from light water reactors. In 2014, Candu Energy and CNNC signed agreements to build Advanced Fuel Candu Reactors in China and seek opportunities for the technology globally.[201]

For the development of the third-generation nuclear power technology, CNNC and China General Nuclear Power Group are responsible for the joint technical development and export of "Hualong One," China's first domestically designed reactor, while the State Power Investment Corporation is leading the development of CAP1400 and CAP1700,[202] and the export of CAP1400.[203]

WATER CONSERVATION AND RECLAMATION

Energy generation from fossil fuels requires large amounts of water, especially during the extraction and refining processes. Thus, water monitoring, conservation, and remediation are becoming increasingly important to the fossil fuel sector globally.

In China, rapidly expanding thermal power generation has put a strain on limited water resources, accounting for almost 12% of national water withdrawals annually.[204] As a result, China has passed policies and laws, such as the *Three Red Lines policy and the Water-for-Coal Plan*, that set quotas by province for water usage for coal power plants, and regulate total water use, efficiency, and water quality in energy production.

Extracting shale gas is a water-intensive process. Large quantities of water are injected into the wells to recover the shale gas. The contaminated water can contain brine, metals, and even radioactive materials that can pollute aquifers and other water bodies used for drinking water. China has ambitious shale extraction targets and is exploring technology for water conservation and reclamation.

CONCLUSION

China faces a complex energy challenge. The country's policies aim to ensure the security of its energy supply, while also decreasing carbon emissions and air pollution. This challenge is made more daunting by the fact that emissions-intensive coal comprises more than two-thirds of China's primary energy consumption.

In order to achieve China's energy-related objectives, the Central Leading Group on Financial and Economic Affairs highlighted some key principles for policy making including "green growth" and the "four revolutions"—namely, revolutions in supply, demand, technology, and the energy administration and management system. These principles are reflected in the government policies and targets reviewed in this report.

Green Growth: Green growth is an increasingly important aim of Chinese policy making. The concept was included in the 13th Five Year Plan and, in advance of the COP21 climate conference in Paris, China committed to peaking its carbon emissions by 2030—the first time that China had agreed to an absolute emission reduction in an international forum.

China's green growth policy is also highly motivated by the desire to reduce air pollution. The government has issued a number of polices aimed at increasing air quality in highly populated centres such as the Beijing-Tianjin-Hebei, Yangtze River Delta, and Pearl River Delta regions. Policy aimed at achieving green growth includes the implementation of a nationwide carbon pricing system, world-leading levels of investment in clean-energy technology, and aggressive policies to encourage the use of renewable energy and natural gas for power generation.

Supply and Demand Balance: One of China's greatest challenges is to balance energy supply and demand in a way that both reduces environmental impacts and increases energy self-sufficiency. On the demand side, China has set targets to limit energy consumption and has developed many policies targeted at the largest user of energy (including electricity): industry. These policies focus in particular on increasing energy efficiency and reducing the role of high-energy-intensity industries in the economy. Government policy also aims to shift the composition of demand in power generation from highly emissions-intensive coal to lower-emission sources.

On the supply side, China continues to aim for high energy self-sufficiency and has implemented policies to spur production in all energy categories except coal. Nevertheless, imports of oil, natural gas, and uranium are essential to meet demand. Chinese policy continues to improve energy security by diversifying the countries from which it imports fossil fuels.

Technology: To meet energy production and environmental targets, China is investing heavily in all energy technology types, with growing emphasis on clean-energy and energy-efficiency technology. International collaboration in technology is a priority, and the country continues to increase the number of areas in which foreign capital is permitted. Some key areas for potential collaboration include technologies for shale gas extraction, carbon capture and storage, smart grid and demand management, nuclear energy production, and water conservation and reclamation.

While international co-operation is a priority, China is seeking to become a world leader in the export of energy technology and services. As a result, policy aims at self-sufficiency in the supply chain for many energy types, including nuclear. R&D policies encouraging international cooperation often require Chinese companies to be the holder of resulting intellectual property.

Administration and Management System: An ongoing objective of Chinese energy policy is to increase the role of the market in allocating energy assets. This includes energy pricing, the diversification of actors in the sector, and the introduction of carbon pricing mechanisms. Chinese energy policy also aims to develop new regulations to govern a more market-driven energy system.

Implications for Canada: There are a number of lessons or implications for Canada.

- *Stay focused on China:* China's energy demand growth is slowing, but will still need to meet growing absolute energy demand. As a result, China will remain a large market opportunity for Canada's energy industry well into the future.
- *Environmental policy does not eliminate China as a potential market for Canadian commodities:* Canada has large resources in natural gas, oil, uranium, and coal. China's environmental policies will likely increase demand for natural gas and uranium imports in the long term. Furthermore, China is likely to remain interested in Canadian oil for energy security reasons.
- *Factors limiting commodity trade do not emanate from China:* Canada's opportunity to export oil and natural gas to China is limited by a lack of export infrastructure in Canada and the decline in the prices of oil and LNG, which makes LNG export projects less economically viable.
- *There are increasing opportunities for two-way energy investment:* Investment is not subject to the infrastructure constraints of commodities and is a growth area in China-Canada collaboration. China has been a significant investor in Canada's energy infrastructure for the last decade, while Chinese policy continues to increase the number of opportunities for foreign investment in the energy sector.
- *Canada has strengths in a number of China's priority areas for energy technology collaboration:* Such strengths include:
    - Carbon capture and storage, especially in the power sector and oil and gas extraction industries;
    - Shale gas technology, especially technologies that make oil and gas extraction more energy and water efficient;
    - Pipeline construction and management;

  - Smart-grid and other technologies for improving demand-side management; and
  - Nuclear technology, especially pressurized heavy water technology that helps to reduce nuclear waste and the need for uranium imports.
- *Canadian SMEs often lack the resources to access the Chinese market:* Canada's energy technology export industry is dominated by small and medium-sized enterprises. These companies often do not have the resources to explore international markets or finance in-country demonstrations of technology. Many companies also do not have the capacity to scale their product appropriately in large markets.

Overall, there is plenty of opportunity for Canada-China collaboration in the energy sector. Both countries will need to deepen government and industry level connections to realize these opportunities.

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