# Low Carbon Development Roadmap for Jilin City

Chatham House, Chinese Academy of Social Sciences,
Energy Research Institute, Jilin University, E3G

March 2010

# Low Carbon Development Roadmap for Jilin City

Chatham House, Chinese Academy of Social Sciences,
Energy Research Institute, Jilin University, E3G

March 2010

CHATHAM HOUSE

Chatham House (the Royal Institute of International Affairs) is an independent body which promotes the rigorous study of international questions and does not express opinion of its own. The opinions expressed in this publication are the responsibility of the authors.



Chatham House
10 St James's Square
London, SW1Y 4LE
T: +44 (0) 20 7957 5700
F: +44 (0) 20 7957 5710
www.chathamhouse.org.uk

Charity Registration No. 208223

ISBN 978 1 86203 230 9

A catalogue record for this title is available from the British Library.

Cover image: factory on the Songhua River, Jilin. Reproduced with kind permission from original photo, © Christian Als, 2006.

Designed and typeset by Soapbox Communications Limited
www.soapboxcommunications.co.uk

# Contents

**List of Figures**



**List of Tables**

**List of Boxes**



**Appendices**

# Acknowledgments

‘Establishing a methodology and piloting low carbon development zones in China’ is a project jointly undertaken by Chinese and UK research institutions. The project is part of the China-EU Partnership on Climate Change Rolling Work Plan. The project is supported by the National Development and Reform Commission (NDRC) of China and by European governments.

The Steering Committee for the project comprises representatives from Chatham House (Royal Institute of International Affairs), the Chinese Academy of Social Sciences (CASS), the Energy Research Institute (ERI), Jilin University (JLU) and E3G.

The Advisory Committee is led by China’s National Development and Reform Commission (NDRC), the Delegation of the European Union to China, the UK Foreign and Commonwealth Office (FCO), the Municipality of Jilin City and the Development and Reform Commission of Jilin Province. The Vice Mayor of Jilin Municipality, Zhu Tianshu, Deputy Director of the Development and Reform Commission of Jilin Municipality, Mme Shen Huashi, and numerous officials from Jilin Municipality have played an active role in meetings and reviewing the research output.

The supporting research has also benefited greatly from comments, discussion and input from the following: Heike Baumüller, Karen Bell, Will Blyth, Jessica Cave, Chen Dongmei, David Concar, Lars Erik, Matt Findlay, Ruth French, Magnus Gislev, James Godber, Wang Guoqian, Karl Harlding, Isabel Hilton, Bryn James, Laurent Javaudin, Hou Jinglin, Jiang Zhaoli, Jonathan Joo-Thompson, Roseline Legrand, Li Liyan, Li Yan, Sherry Ma, Nick Mabey, Jennifer Morgan, Shelley Nania, Jesse Scott, Shane Tomlinson, Wang Tao, John Warburton, Liz Wilson and Wu Changhua.

The production of the roadmap at Chatham House was supported by Gemma Green, Lucy Ellinas, Tim Eaton and Benjamin Zala.

This report was edited by Kim Mitchell and Margaret May. The translation for the Chinese version was completed by China Dialogue, led by Tan Copsey.

The project team gratefully acknowledge the financial support of the FCO Strategic Programme Fund.

# Authors

*Low Carbon Development Roadmap for Jilin City* is written by the project team, drawing on the reports produced by each of the partners. The following authors have contributed to one or more of these reports:


- Chatham House: Felix Preston, Antony Froggatt, Bernice Lee
- CASS: Pan Jiahua, Zhuang Guiyang, Zheng Yan, Zhu Shouxian, Xie Qianyi
- ERI: Jiang Kejun, Hu Xiulian, Zhuang Xing, Deng Yixiang, Liu Qiang
- JLU: Dong Deming, Wang Xianen, Fang Chunsheng, Duan Haiyan, Ma Zhuo, Liu Hongqin, Zhang Jian, Man Haibo
- E3G: Shinwei Ng, Nannan Lundin

# Acronyms

| | |
|---|---|
| BAU | Business as usual (scenario) |
| CASS | Chinese Academy of Social Sciences |
| CCS | Carbon capture and storage |
| CDM | Clean Development Mechanism |
| CHP | Combined heat and power |
| CTF | Clean Technology Fund |
| ERI | Energy Research Institute, China |
| GHG | Greenhouse gases |
| GTI | Greater Tumen Initiative |
| GW | Gigawatts |
| IGCC | Integrated gasification combined cycle |
| IPAC | Integrated Policy Model for China (an energy-emissions model) |
| IPR | Intellectual property rights |
| LCE | Low carbon economy |
| LCZ | Low carbon zone |
| MW | Megawatts |
| NDRC | China National Development and Reform Commission |
| REDD | Reducing Emissions from Deforestation and Forest Degradation |
| SCE | Standard coal equivalent (a unit of energy) |
| UNFCCC | United Nations Framework Conference on Climate Change |

# Executive summary

## Introduction

The transition to a low carbon economy poses an enormous challenge for developed and developing countries alike. Targeted international or bilateral cooperation is required to deliver successful piloting of low carbon development models at a transformational scale.

In 2007, a consortium of Chinese and European research institutes (comprising the Chinese Academy of Social Sciences, Energy Research Institute, Chatham House, E3G and Institut du développement durable et des relations internationales) recommended strengthening cooperation between China and the European Union (EU) on the basis of a detailed analysis on their energy and climate security interdependencies. The report of the consortium, *Changing Climates*, proposed establishing a range of 'low carbon zones' across China. These zones could serve as major demonstration grounds for policies promoting the economic transformation necessary for a low carbon future, and a focus for successful cooperation.

China is a vast country with a very diverse economy. Natural resources endowment, economic growth, development and export opportunities vary considerably across different regions. It will therefore need a range of low carbon development models to reflect its diversity. Large-scale regional piloting is in line with China's approach to development policy–making. In the early 1980s China embarked on an extraordinary journey towards greater economic openness, in which Special Economic Zones – geographical regions with more liberal economic laws than the rest of the country – played a vital role.

In 2008 the Jilin City Municipal Area in northeast China – an area the size of Belgium and with a population of 4.5 million – was selected as the first official research area for developing a methodology and piloting low carbon zones. The project, supported by China's National and Development Reform Commission and the EU, has undertaken the most detailed regional assessment in China to date. It has also developed and tested a set of methodologies and tools which could now be applied across different regions in China, and in other developing countries. The project partners are the Chinese Academy of Social Sciences, Energy Research Institute, Jilin University, Chatham House and E3G.

Jilin City's challenges are representative of other regions in China and in many developing countries. The four pillar industries in Jilin City are petrochemicals, vehicle manufacturing, metallurgy (especially steel) and electricity. Other industries making a significant contribution include construction, agriculture and electronics. Secondary industry continues to dominate the economic landscape, growing more rapidly than primary and tertiary industry. Jilin City therefore faces serious challenges in meeting its low carbon objectives. One particular challenge is the large potential reserves of oil shale, which releases more emissions than conventional petroleum.

But local industrial capability and political intent, combined with excellent natural resources, provide major opportunities for low carbon growth, employment and exports. The municipal area has a wide range of natural resources, giving it a platform for developing renewable energies. With its excellent water resources, hydropower is expected to be further developed. Wind speeds and average sunshine levels are suitable for the deployment of turbines and solar panels. Since Jilin City is located in a major agricultural area with very high forest coverage, the challenge will be to develop biomass energy without competing with food crops.

This report, *Low Carbon Development Roadmap for Jilin City* is the result of two years of analysis of energy pathways, policy indicators, technology trends and investment requirements. It provides the building blocks for Jilin City to take a decisive step towards achieving low carbon development and become a national leader in China. The report argues that low carbon development is highly consistent with the city's existing objectives, including reducing energy intensity by shifting its manufacturing base to higher-added-value, advanced technology products; achieving excellent resource efficiency (the circular economy); realizing balanced urban-rural growth; and, critically, fulfilling China's scientific development concept.

## Jilin City's low carbon energy future

In Jilin City, high energy-consuming sectors are also some of the fastest-growing industries. In 2007, industrial enterprises accounted for 84% of total energy consumption. The petroleum refining and chemical industry accounts for over half of industrial energy demand, while electricity and heat together is responsible for a fifth of the total.

The energy and emissions scenarios developed for the project demonstrate the technical feasibility and investment affordability of a shift to a low carbon economy in Jilin City. Emissions under the business-as-usual scenario (BAU) continue to grow at a rapid rate until 2030. This would imply considerable stress on the energy supply and a growing exposure to fossil fuel prices. In contrast, under the low carbon scenario greenhouse gas emissions in Jilin City could peak in around 2020 and decline to 60% of the BAU scenario by 2030.

Under each scenario, Jilin City's energy consumption will continue to increase until 2030. This will ensure its development and create the space for efficient heavy industry to grow in the medium term while economic restructuring takes place.

Energy-saving and efficiency contribute about half of the emissions reductions in the low carbon scenario in 2020. Adjustments to the economic structure contribute just over a third to emissions reductions in the low carbon scenario compared to the BAU scenario in 2030. Technology and policy innovation is the core of a low carbon economy. The penetration of best-available technology is a major variable in the model. Investment and technical support are needed across virtually all sectors.

## Benchmarking low carbon development

In China and elsewhere today, there is no formal or official methodology for connecting low carbon development to policy making. For example, officials need to be able to set a range of concrete benchmarks that can be fed in to economic planning, and against which the performance of local officials can be evaluated. For developing countries, still undergoing industrialisation, the relative success of one region against others needs to be considered, as well as absolute progress on emissions reduction.

As far as China is concerned, addressing this gap is critical for feeding the concept into the 12th Five-Year Plan process. This project proposes a new methodology based on four key areas. Benchmarks in each area can be adjusted to reflect different local development conditions.  Here they have been applied to Jilin City they but could be set for any region in China:

- *Low carbon productivity* includes indicators for both carbon and energy per unit of economic output, measurements consistent with China's existing energy-intensity and carbon-intensity targets.
- *Low carbon consumption* covers per capita and per household energy consumption. Consumption indicators can be used to review the impacts of policy on individual behaviour.
- *Low carbon resources* cover the share of low carbon energy, emissions per unit of energy production and the percentage of land covered by forest.
- *Low carbon policy indicators* review the existence of policies and plans for low carbon development, success in implementation of regulations, and public awareness levels.

Any low carbon zone or city would naturally aim to be among the fastest-improving regions of China. For policy-makers, the key question is, what steps can Jilin City take to move from a high carbon to a low carbon economy as soon as possible?

Under the proposed benchmarks set out in this roadmap, Jilin City is not a low carbon economy. Per capita emissions are 2.5 times higher than the Chinese national average. The roadmap proposes an improvement of Jilin City's carbon intensity by 58% in 2020 compared to 2005. This means that in 2020, greenhouse gas emissions would be 19% lower than in the BAU scenario and that by 2015 (the final year of the 12th Five-Year Plan) Jilin City would be fully in line with the low carbon scenario. However, it might be difficult for Jilin City to stay on the pathway set out by the low carbon scenario between 2016 and 2020. International cooperation should focus on bridging the gap.

As part of the 12th Five-Year Plan process, a detailed review by Jilin City can ensure that current policies and investment plans are appropriate for meeting the proposed benchmarks. Successful implementation of the concept would depend on creating integrated systems with an incentive structure for officials that encourages innovation and action on low carbon development. As well as enhanced coordination, the report proposes a new specialist institution and a new government fund for strategic low carbon investments.

## Priorities for investment in the 12th Five-Year Plan

Demonstrating a strong commitment to the low carbon economy would stimulate investment in Jilin City, encourage international cooperation, attract potential business partners keen to be part of a leading region in China and enhance conditions for local innovation and technology development. For local firms, a low carbon Jilin City would be a demonstration ground for piloting and improving products which would later be exported to regional and global markets.

**Technology upgrade**. Currently less than 10% of the production equipment used in Jilin City is said to be of 'international or domestic advanced level'. As a consequence, there is a definitive plan to accelerate the scrapping of redundant and outdated equipment. International cooperation and investment could play an important role.

**Renewable and low carbon energy**. Jilin City is set to comprehensively develop renewable energy, combining its wealth of resources with its strength in manufacturing. Its position at the heart of the northeast grid gives it a major advantage in connecting renewable generation to the network. Jilin City will need to invest RMB 56 billion in power generation by 2020 to meet demand – and more if Jilin City chooses a higher share of low carbon energy. Three low carbon energy projects have been identified which if implemented together would reduce Jilin City's CO2 emissions in 2020 by over 20% compared to BAU.

**Building efficiency**. Meeting the 65% buildings efficiency target in Jilin City would require an additional investment of RMB 2.6 billion per annum. The lower energy prices charged to consumers in Jilin City mean that it would take about 30 years for the investment costs to be recovered, but energy pricing reform could dramatically alter this situation. Jilin City urgently needs energy-saving technology for wall materials and exterior wall thermal insulation. This could be one focus of the proposed technology cooperation platform for Jilin City.

**Transport**. Jilin City's transport strategy should be a combination of avoiding lock-in through urban design and public transport systems; encouraging the manufacture and sale of lower carbon vehicles; and shifting the vehicle-manufacturing base to creating a platform for exports.

**Agriculture and Forestry**. Opportunities for low carbon development also abound in rural areas. Jilin City could focus on increasing the use of renewable energy sources in rural areas, such as methane, straw gasification and solar energy. Further greenhouse gas emissions savings could be achieved through changes in agricultural and livestock production methods. In addition, projects to reduce deforestation and forest degradation could be used to mitigate climate change and help to attract international funds.

## Prospects for domestic, regional and international cooperation

An ambitious low carbon Jilin City would be in an excellent position to attract financial and technical cooperation. This could come from a range of public sources but also from private investment. Cooperation may mean support from the national government, working with other countries in the region or internationally. Existing relationships could be developed to focus on low carbon products, standards and markets. Jilin City could, for example, become a regional hub for investment and trade in low carbon goods and services.

A variety of multilateral and bilateral funds is available for low carbon projects and sector initiatives. Jilin City's interest in benchmarking progress and introducing the low carbon development concept into government institutions suggests that action on data collection, emissions inventories and related institutions may be a priority for cooperation. Steps towards establishing a carbon exchange, an idea proposed by Jilin City, might also be attractive to support from an EU perspective. Low carbon growth plans for petrochemicals and other heavy industries in Jilin City could be of great interest to better understand the challenges and solutions for sustainable industrialization.

International partners should consider a range of opportunities for technology cooperation, such as support for low carbon technology platforms; technologies for the advanced efficiency of buildings; and collaboration on technology research and standard-setting. Major piloting and demonstration projects and programmes (for example, on CCS) are also possible routes for cooperation.

Intellectual property rights (IPR) issues remain a key concern for foreign investors in China. Jilin Province is taking steps to advance IPR protection. For example, it is home to one of China's ten 'IPR maintenance and assistance centres'. This could provide a focus for international cooperation to assist Jilin City in strengthening its IPR activities on low carbon technology.

## Policy recommendations

- **Incorporating the low carbon economy concept into 12th Five-Year Plan** and government departmental planning is an important first step. The roadmap sets out a series of benchmarks in key policy areas which will help guide the implementation. To support this, Jilin City will need to create integrated systems for benchmarking, data collection and policy development. As China's experience with setting building standards shows, institutions and implementation are as important in achieving low carbon goals as is establishing strong standards.
- **Energy-intensity targets could be established at the sectoral level**, taking into account existing standards and production levels, the current best-available technology and anticipated innovation in the sector. Key industries can become a major driver of low carbon growth in Jilin City. Plans should be developed for each sector, focusing on low carbon goods and services and considering the links with other sectors.
- **A low carbon manufacturing and technology exchange should be established in Jilin City**. This would be a centre for innovation, attract investment in low carbon technology from the private sector and develop opportunities for export for local manufacturing industries. Renewable energy, advanced energy efficiency and low carbon vehicle technologies are priority areas for investment and enhanced innovation capacity.
- Jilin City should commit to **deploy renewable energy** faster than the national average and **accelerate energy efficiency improvements** in coal power plant and the transmission grid. Jilin City should also investigate the development and piloting of carbon capture and storage in the light of current experience of its use for enhanced oil recovery and the potentially advantageous geology for CO2 storage.
- **Energy prices** must, eventually, reflect full environmental and societal costs. Without such reform, the economic incentives of energy efficiency are significantly reduced. Price reform and the removal of subsidies have significant societal impacts, but these can be addressed through other social and fiscal policies. Jilin City could establish a new carbon exchange, with a wider scope than the existing exchanges in China. This would make it a low carbon financial centre for the northeast and eventually the rest of the country.
- Jilin City could become **a demonstration area for sustainable low carbon urbanization and transport**. Rapid urban growth and greater demand for transport mean the construction of new infrastructure that will be used for at least a generation. It is important to ensure that this is low

carbon and highly efficient, avoiding locking Jilin City into high levels of emissions. This means looking at urban systems as well as at the energy efficiency of individual buildings and vehicles. As a manufacturing base for vehicles, Jilin City could produce natural gas, biofuels and electric vehicles and develop the region as a testing ground.

- Further research is required to map out the investment requirements, opportunities and challenges for achieving **low carbon growth in rural areas** – including storing carbon in forests and soils; the production of sustainable biofuels; and linkages between urban and rural areas. As a first step, this will require detailed mapping of the existing conditions.

# 1 Introduction

## 1.1 Background

*Low Carbon Development Roadmap for Jilin City* provides the building blocks for Jilin City Municipal Area, northeast China to take a decisive step towards achieving low carbon development.

In 2008 Jilin City became the first official research area in China for developing a methodology for and piloting low carbon development. It was selected because of a strong local commitment to exploring the concept and because its challenges in terms of sustainable industrialization reflect those in many parts of China. The 'City' is in fact a region about the size of Belgium, with a strong industrial heritage and a rich range of natural and mineral resources. Its 4.5 million people are split roughly equally between urban and rural areas.

Low carbon development is highly consistent with Jilin City's existing objectives, including: reducing energy intensity, shifting its manufacturing base to higher added value, advanced technology products; achieving excellent resource efficiency (the circular economy); realizing balanced urban-rural growth; and, critically, fulfilling China's scientific development concept. Local officials recognized the need to reduce economic dependence on low-value heavy industry in the 11th Five-Year Plan (2006–10). Indeed, Jilin City is already taking impressive steps on renewable energy, energy efficiency and public transport.

Low carbon manufacturing and local action on climate change and energy are two sides of the same coin. China's major competitors on low carbon sectors have all found that aggressive local support for technology deployment goes hand in hand with efforts to create global industrial leaders. It gives companies the opportunity to develop and improve their products through practical experience – for example, energy-efficient Japanese electronics, German solar panels and Californian wind power.

Implementing a low carbon development strategy in Jilin City would therefore help to achieve four major objectives together: enhanced resource and energy efficiency; technological advancement; an internationally attractive investment environment for manufacturing low carbon, high-value products; and an innovative space to develop low carbon industry, positioning Jilin City for exports into burgeoning international markets.

The roadmap builds on the insights from a year of extensive analysis by academics and government officials from Jilin City Municipal Area, Jilin Province, Beijing and internationally. It makes the case for moving from a detailed research phase to full implementation of the low carbon zone concept in Jilin City. It is timed to coincide with an important window of opportunity – the development of the 12th Five-Year Plan in 2010 for both Jilin Province and Jilin City.

## 1.2 Low carbon development in China

As the world wakes up to the imperative of a sustainable energy future – one which places energy and climate security at the top of the policy agenda – the ripple effects of this awakening can be felt across the global economy. Governments and businesses are beginning to adjust decisions on trade, financing and production planning. The tightening global supply of oil and natural gas is fuelling the development of new technologies. High prices and supply volatility are motivating a more efficient use of energy. Central to making this vision work is enlightened thinking about the potential economic and political benefits, rather than the costs, of the transition to a low carbon future.[1]

1 Bernice Lee, Antony Froggatt et al. (2007), 'Changing Climates: Interdependencies on Energy and Climate Security for China and Europe <http://www.chathamhouse.org.uk/research/eedp/papers/view/-/id/580/> ', Chatham House Report

The alarming projected impacts of climate change also point to the range of risks, vulnerabilities and choices confronting policy-makers and citizens. The Stern Review estimated that the avoidable costs of inaction would be between 5% and 20% of GDP per annum. Business as usual (BAU) scenarios project extreme temperature rises of 4–7°C by the end of the century. A responsible risk management strategy for policy-makers would be to keep to the low probability range of a 2°C rise, as climate sensitivities appear higher than previously estimated. Put another way, global $CO_2$ emissions will need to peak in the next two decades and to reduce by over 50% by 2050. For developed countries, such as the member states of the European Union, this implies moving to an essentially zero carbon economy by around mid-century, with major developing countries such as China following well before the end of the century.

Harnessing the dynamics of globalization to help the move towards a global low carbon economy (LCE), thus preserving energy and climate security, will require strategic decisions at the highest level. To meet their long-term national security interests, governments and citizens will need to ensure that policies made in environment, planning, trade, investment and technology ministries all reinforce the drive towards a sustainable energy future. The goal is to put in place a new economic, technological and social system of production and consumption for conserving energy and reducing greenhouse gas emissions (compared with the traditional economic system) while maintaining momentum towards economic and social development. This approach will need to be based on appropriate indicators for low carbon development, benchmarking progress and implementing the concept within institutions.

China's immediate decisions about its infrastructure needs and patterns of consumption will have a decisive impact on global efforts to stabilize greenhouse gas emissions and on the feasible rate of reduction to sustainable levels. China emitted about 19% of global $CO_2$ emissions in 2005 and is expected to contribute about 27% by 2030. Preliminary figures for 2008 show that China emitted 7.5 gigatonnes (Gt) of $CO_2$, compared to the United States' emission of 5.65 Gt. However, China's per capita carbon emissions level is 50% less than the EU average and three times less than the US average.

China's strategic aspiration towards an innovation-based economy with science-based development is in line with the vision for a low carbon transition.[2] A focus on developing and deploying advanced climate technologies is also consistent with China's aspiration to move up the global value chain. At the same time, a proactive and early move towards low carbon development will help it to avoid lock-in to a high carbon economy that would be costly to reorientate in the future. Ensuring that China gains a sizeable share of the low carbon economy is therefore critical to managing its domestic emission growth, and would provide incentives for China to play a larger role in global action to mitigate climate change.

There is great anticipation that China will accelerate domestic action to shift towards a low carbon economy. Recent years, not least during the 11th Five-Year Plan, saw the implementation of a highly ambitious programme to improve energy efficiency, accompanied by a rapid acceleration in renewable energy deployment. In the first half of 2009, more wind power was installed in China than in any other country. In September 2009 President Hu Jintao stated at the United Nations that China would endeavour to cut $CO_2$ emissions per unit of GDP by a notable margin by 2020 from the 2005 level.[3] In December 2009 China announced its first carbon-intensity target: an improvement of 40–45% in emissions per unit GDP by 2020 compared to 2005 levels. This represents another major step on to a low carbon economy pathway.

As part of China's broader strategy, a project to examine and develop the concept of low carbon zones (LCZs) was established with the support of the National Development and Reform Commission (NDRC), as well as governments from the European Union. Such zones could serve as major demonstration grounds for policies promoting the economic transformation necessary for a low carbon future. They could help to attract and focus domestic and foreign investment in research and high-value manufacturing, in line with the Chinese leadership's desire to shift from simple processing and assembly. Indeed, the zones could be to China's next industrial revolution what Shenzhen was to the current one – and a powerful demonstration of the viability of the low carbon economy.

2 CCICED Low Carbon Economy Task Force (2009), 'China's Pathway Towards a Low Carbon Economy', CCICED Policy Research Report, China Council for Cooperation on Environment and Development, Beijing

3 Statement by President Hu Jintao at the Opening Plenary Session of the United Nations Summit on Climate Change, New York, 22 September 2009.

LCZs can also be used to pilot different low carbon strategies that may then be transferred to regions with particular characteristics. This strategy responds to challenges posed by the variations in economic conditions and resource endowments across China's provinces, which mean that there is no single development model that will apply across the country. However, on the basis of characteristics such as GDP, energy consumption and natural resource availability, it is possible to identify regions with similar characteristics that would benefit from shared lessons.

In 2008 Jilin City Municipal Area was selected by the NDRC as China's first low carbon zone pilot research area. Jilin City has a long tradition of heavy industry, and the low carbon transition is a challenge that will bring in all parts of its economy and society. Achieving a low carbon economy there, and demonstrating real benefits to local development, would send a powerful message to industrial areas around the world that also seek high-value, sustainable growth. This roadmap makes the case for moving from a detailed research phase to full implementation of the concept in Jilin City.

Commitment to low carbon development is likely to expand national, regional and international cooperation with Jilin City. It could provide an opportunity for developed countries to demonstrate their support for piloting transformative change – moving the approach away from multiple but uncoordinated projects which generate lessons but cannot individually deliver the scale of change required. This is even more significant because of Jilin City's industrial characteristics. It can become a testing ground for low carbon industrial growth pathways. Jilin City could seek additional international support with technology and finance, which would be advantageous to the development of the local economy.

## 1.3 Understanding low carbon development

China is a vast country with a very diverse economy. Natural resources endowment, economic growth, development and export opportunities vary considerably across different regions. The country will of course need a range of low carbon development models to reflect its diversity.

One illustration of this is shown in Table 1.1, a classification prepared by the Energy Research Institute (ERI) of the NDRC. This places Jilin Province in the category of high energy intensity with medium-high GDP.

Table 1.1: Regional variations in development characteristic

| Grouping | Province / City | GDP per capita | Energy use | Energy Intensity | Target for energy saving | Trend for LCE | Level of support needed |
|---|---|---|---|---|---|---|---|
| **Group 1** High GDP, low energy intensity | Guangdong | High | High | Low | Low | High | High |
| | Shanghai | High | High | Low | Medium | High | High |
| | Jiangsu | High | High | Low | Medium | Medium | Medium |
| **Group 2** Medium GDP, medium energy intensity | Chongqing | Medium | Medium | Medium | Medium | Medium | High |
| | Tianjin | High | Medium | Medium | Medium | Medium | High |
| **Group 3** High energy intensity | Jilin Province | Medium-High | High | High | High | Medium | High |
| | Shanxi | Medium | Medium | High | High | Medium | High |
| | Ningxia | Low | Low | High | High | Medium | High |
| | Shandong | High | High | High | Medium | High | High |
| **Group 4** Low GDP, low energy intensity | Guangxi | Low | Low | Medium | Low | High | High |

Source: Jiang Kejun and Deng Yixiang (2009), 'The metrics for low carbon development zones (LCZs) in China', Energy Research Institute of NDRC, Beijing.

Regional variation means that some areas face more difficult starting conditions on their low carbon road. But the important question is how to set out ambitious, achievable low carbon pathways that can be incorporated into local economic and social development planning while fully reflecting the local development situation.

But although low carbon development and low carbon economy are now widely used concepts around the world, detailed studies on how to define, benchmark and evaluate them are yet to be conducted. This is an important gap because countries, regions and cities pursuing low carbon development need to understand how to measure success and to compare their progress with other areas.

Addressing this challenge, the Chinese Academy of Social Sciences (CASS) has developed a new methodology for this project that recognizes and adjusts for local development conditions while comprehensively assessing key elements of the low carbon economy: carbon productivity; consumption; resource availability; and the level of integration with economic and social development planning.

This roadmap builds on the first case study application of this methodology, in Jilin City. And like other dimensions of the roadmap, the methodology is designed in the expectation that other regions across China will study its implications.

## 1.4 A guide to the roadmap

The roadmap sets out how a low carbon economy can achieve local development ambitions, including the evolution of the industrial and economic structure in Jilin City, and create an important platform for growth in new areas. It will promote the innovation and deployment of low carbon energy technology, helping to meet ambitious energy intensity targets and to address growing energy security challenges. The experiences gained from developing and implementing the roadmap will have great value in other parts of China as well as other countries, and they offer Jilin City a unique opportunity to showcase the progress it has made.

**Chapter 2** describes Jilin City's current development situation in terms of social and economic characteristics, energy consumption, natural and mineral resources and a comparison with other Chinese regions – essentially this is Jilin City's starting position on the low carbon road.

**Chapter 3** presents three scenarios for Jilin City up to 2030. They describe the impact on energy consumption, energy-related greenhouse gas emissions and industrial output. Key technologies are identified.

**Chapter 4** focuses on policy, planning and institutions. Key areas for policy and technology are identified. This is followed by a new methodology for assessing low carbon development – including a set of indicators which can be used to benchmark progress over different timescales, starting with the 12th Five-Year Plan (2011–15). Lastly, the chapter considers how low carbon development can be driven forward by government institutions.

**Chapter 5** identifies specific investment opportunities for the 12th Five-Year Plan in key industries, based on extensive bottom-up analysis. The focus is on the major energy consumers identified in Chapter 2: petrochemicals, electricity, transport and buildings. The chapter is about practical steps that Jilin City can take in the short term to shift towards a low carbon path.

**Chapter 6** identifies opportunities for cooperation on low carbon development in Jilin City at the regional, national and international levels. This includes both an analysis of how to connect cooperation opportunities with specific technologies and measures Jilin City can take to encourage cooperation.

**Chapter 7** presents a set of recommendations.

### Box 1.1: Contributions by project partners

This roadmap draws on four major pieces of research, contributed by each of the project partners.

A 'needs assessment' for Jilin City has been completed by researchers at **Jilin University**. It identifies the technical, investment and institutional needs of the area for moving on to an LCE pathway.[a]

Detailed energy scenarios have been prepared by the **Energy Research Institute** of NDRC.[b] ERI and Jilin University have connected the energy technology 'needs' with the major drivers identified in the scenarios analysis, enabling the prioritization of key technology investments over specific timescales.[c]

A unique methodology and set of LCE indicators prepared by the **Chinese Academy of Social Sciences** potentially provides the basis for connecting LCE to Jilin City's 12th Five-Year Plan. The approach has been refined and tested through peer review and local discussions. This is a comprehensive set of indicators, flexible enough to apply to regions across China with widely varying development conditions.[d]

Research from **Chatham House**, with support from **E3G**, discusses how global trends in low carbon technology present opportunities for some of Jilin City's key industries: energy, buildings and construction, vehicles and transport, petrochemicals and iron and steel.[e] Chatham House has also explored the specific role of heavy industry sectors in the low carbon economy.

a Dong Deming et al (2009), 'The construction basis and needs assessment for the low carbon economic zone in Jilin City', Jilin University.
b Jiang Kejun, Zhuang Xing (2009), 'Scenario Analysis on Low Carbon Economy of Jilin City', Energy Research Institute of NDRC, Beijing.
c Jiang Kejun and Zhuang Xing (2009), 'Assessment Roadmaps of Low Carbon Development in Jilin City', Energy Research Institute of NDRC, Beijing.
d Pan Jiahua, Zhuang Guiyang, Zheng Yan, Zhu Shouxian and Xie Qianyi (2009), 'The Concept of Low-Carbon Economy and an Evaluation Methodology for a Low Carbon City: Jilin City Case Study', Chinese Academy of Social Sciences, Beijing.
e Antony Froggatt, Felix Preston and Bernice Lee (2009), 'Low Carbon Technologies in Jilin City', Chatham House Programme Paper.

# 2 Jilin City: an overview

## 2.1 Geography and development level

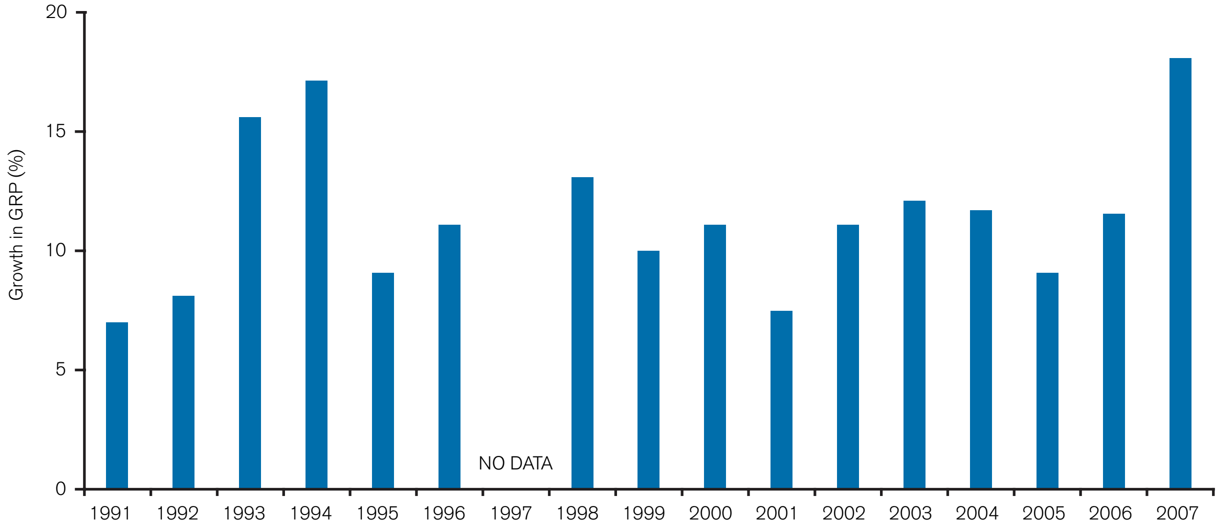
Jilin City Municipal Area is located in northeast China (see Figure 2.1) and is home to 4.3 million people, a similar number to New Zealand, with 42% living in urban areas. At 27,120 $km^2$, it is nearly as large as Belgium. Jilin City is the second-largest area in Jilin Province and is responsible for the generation of one-quarter of its GDP.

Figure 2.1: Location of Jilin City Municipal Area


Source: Wikipedia, 2009

Although the population has increased by just 5% since 1990, the number of households (1.44 million) has risen by 32% over the same period. This change in living arrangements has been accompanied by the City's rapid economic development. GDP grew at an average rate of 10.6% between 1990 and 2007 and by 11.6% from 2000 to 2007 (see Figure 2.2). By 2007, per capita GDP in Jilin City had reached RMB 23,280, 18.7% higher than the national average of RMB 18,930. For comparison, this equates to a nominal GDP per capita similar to that of Jordan.

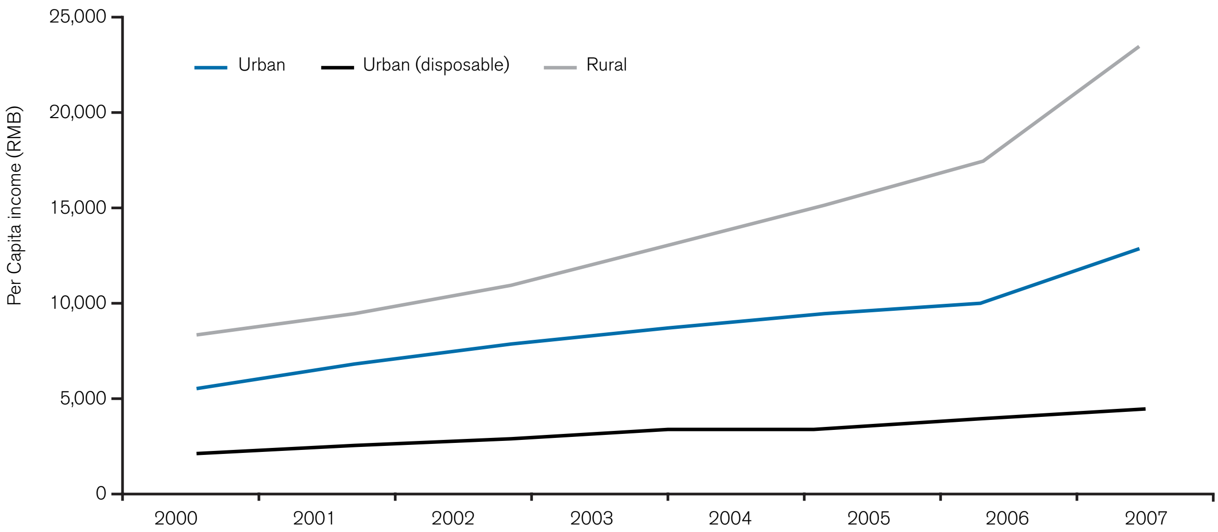
Figure 2.2: Increase in gross regional product in Jilin City, 1991–2007




Source: Energy Research Institute, 2009

Jilin City's rural and urban population have both seen incomes rise during the 2000s, but the gap between them has widened. Disposable income for urban residents is approaching three times the total level of rural income, as shown by Figure 2.3. Achieving balanced urban-rural growth is therefore an important development question. This is a strong argument for exploring the contribution of rural and land-based sectors to the low carbon economy rather than restricting the focus to urban areas.

Figure 2.3: Per capita urban and rural income in Jilin City, 2000–2007




Source: Jilin City Statistical Yearbook 2008

## 2.2 Industrial heritage and economic structure

### 2.2.1 Industrial heritage

Jilin City has a strong industrial heritage dating from over 60 years ago. Seven of the 156 national priority construction projects in China's First Five-Year Development Plan (1953–7), were in the City, including the country's first official 'chemical industry base'. Operated by the Jilin Chemical Industrial Company, this initially produced fertilizers, dyes and calcium carbide.

Resource endowment also influenced the region's industrial path. Rich in forests, water and productive land, Jilin City is today a major food processing centre and home to a range of natural, metal and mineral sectors, as well as to the first commercial hydropower scheme in China, at Fengman Dam.

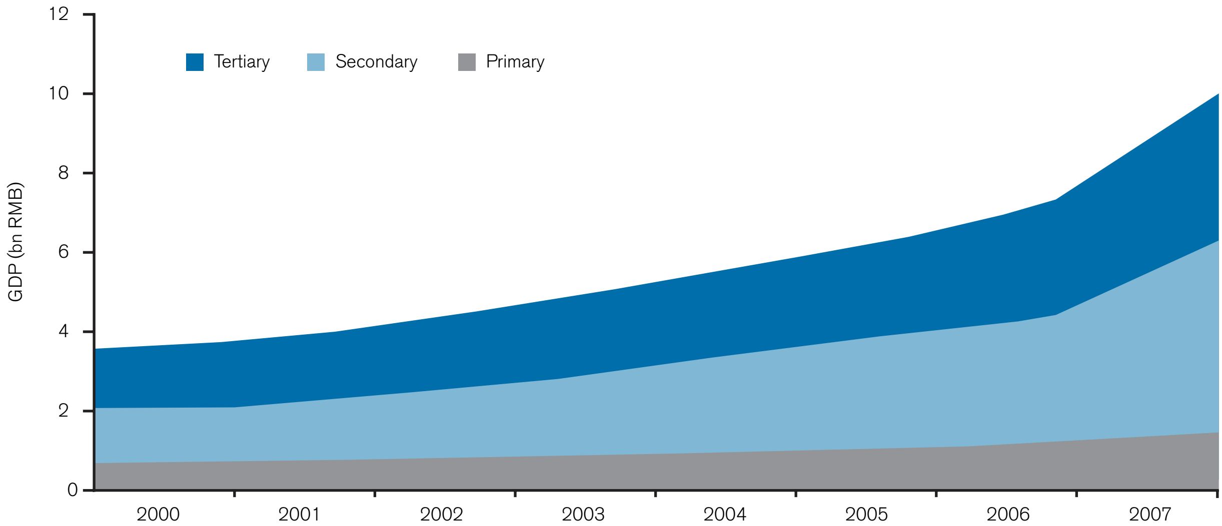
Jilin City's heritage can be seen through its major industries today, including petrochemicals, metallurgy, automobiles, industrial equipment, energy, the processing of farm produce, pharmaceuticals and modern Chinese medicine, and electronics and information technology. Each of these sectors will play an important role in the transition to a low carbon economy.

In the light of the significant economic contribution from heavy industry, especially petrochemicals and metallurgy, Jilin City faces serious challenges in meeting its low carbon objectives. But local industrial capability and political intent, combined with excellent natural resources, provide major opportunities for low carbon growth, employment and exports. Moreover, Jilin City's challenges are representative of those elsewhere in China and in many developing countries. Finding the right solutions here will create important lessons for others, and for Jilin City an opportunity for leadership in China.

### 2.2.2 Economic structure

The four pillar industries in Jilin City are petrochemicals, vehicle manufacturing, metallurgy (especially steel) and electricity. Other industries making a significant contribution include agricultural products processing, textiles and building materials, as well as biological medicine, electronics and advanced materials. Secondary industry continues to dominate the economic landscape, growing more rapidly than primary and tertiary industry (see Figure 2.4).

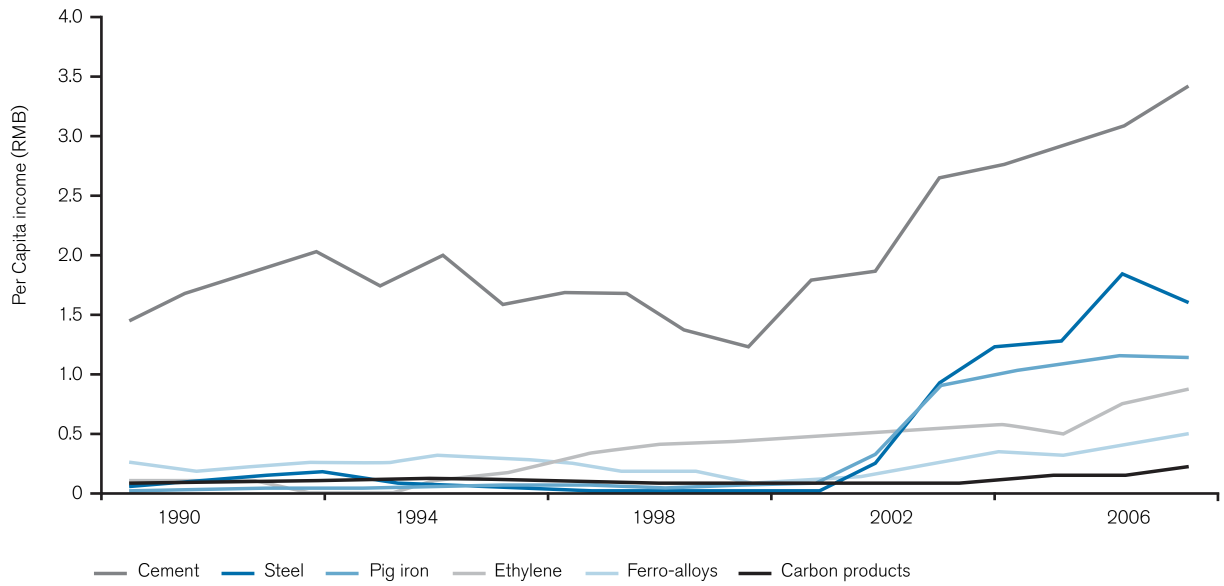
Figure 2.4: Contribution to GDP in Jilin City: primary, secondary and tertiary industry, 2000–2007




Source: Energy Research Institute, 2009

Major industrial products include steel, iron, cement and ethylene (see Figure 2.5). Jilin City aims to move up the value chain within secondary industry, shifting to higher-technology and higher-value products. Car production and related equipment manufacturing is a key industry for the province and a significant one for Jilin City. The output of vehicles has varied in recent years. Some 50,000 were produced there in 2007. Peak production, 93,000 vehicles, was in 2003.

Figure 2.5: Annual output of major industrial products from Jilin City, 1990–2006




Source: Energy Research Institute, 2009

The petrochemical industry has more than a dozen areas of production, including oil refining, ethylene, organic and inorganic material production and a variety of intermediates such as fertilizers and pesticides. Its energy consumption was 48% of the total industrial energy consumption in Jilin City in 2007.

The metallurgical industry is also a pillar industry, with a complete array of systems for ferrous and non-ferrous metal mining and processing. The main products are iron, rolled steel, ferro-alloys and carbon and nickel products.

The automotive sector is founded on FAW Jilin Automobile Co. Ltd, along with nearly 100 auto part manufacturers. FAW Jilin had a production volume of 80,000 vehicles in 2009, and there are plans to increase this five-fold over time.

The power sector will need to accommodate increasing demand, in particular from the industrial sector, where 85% of power goes to 32 large and medium-sized enterprises. Coal power stations generate 77% of the City's electricity, with hydropower providing the remaining 23%.[4]

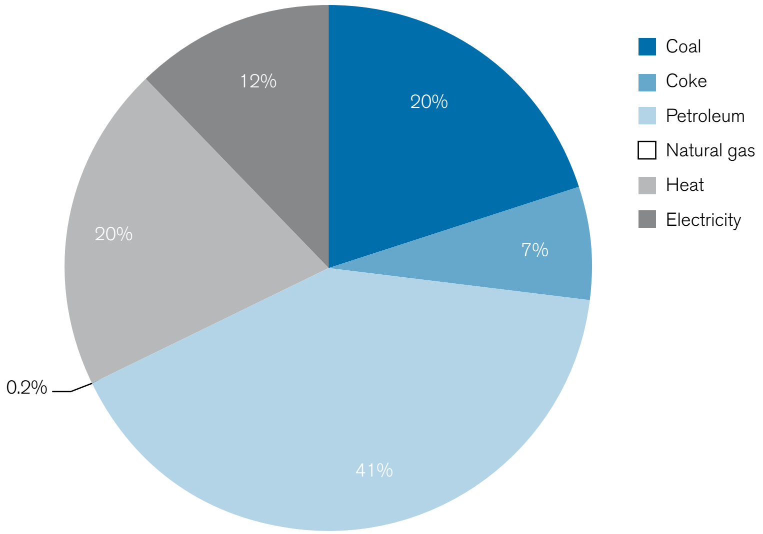
## 2.3 Energy supply and demand characteristics

As noted above, hydropower already contributes almost one-quarter of electricity production in Jilin City. Positioned at the centre of the northeastern grid and with excellent natural resources, the area could become a national leader in low carbon electricity. In addition to plans to develop wind, biomass and solar energy, there is also a proposal to construct nuclear plant with a total installed capacity of 4 gigawatts (GW).

However, electricity is currently a small part (12%) of final energy demand (see Figure 2.6). Coal, petroleum and coke together contribute about two-thirds of final energy demand, and 20% of it is supplied as heat. Natural gas currently contributes just 0.2%, but it is set to grow with the development of local gas fields. Also, a new pipeline is planned.

4 Dong Deming et al, (2009), 'The construction basis and needs assessment for the low carbon economic zone in Jilin City', Jilin University.

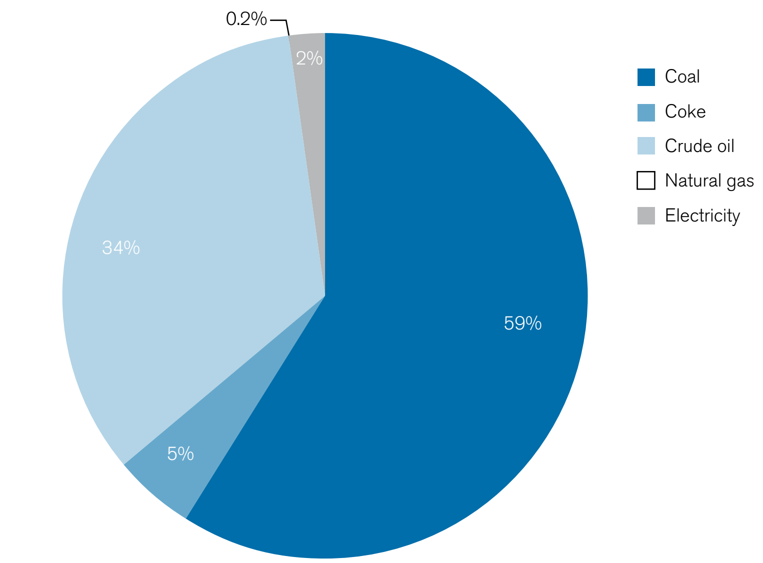
Figure 2.6: Final energy demand by fuel in Jilin City, 2007




Source: Energy Research Institute, 2009

Compared to the average for China, Jilin City is less dependent on coal and more dependent on oil in its consumption of energy. However, as Figure 2.7 shows, coal still makes up almost 60% of primary energy demand (that is, the share of energy before it is converted for its end use). This is partly because it is used to deliver heat and power in the area and because Jilin City exports coal for use in other parts of China and abroad.

Figure 2.7: Primary energy demand, 2007




Source: Energy Research Institute, 2009

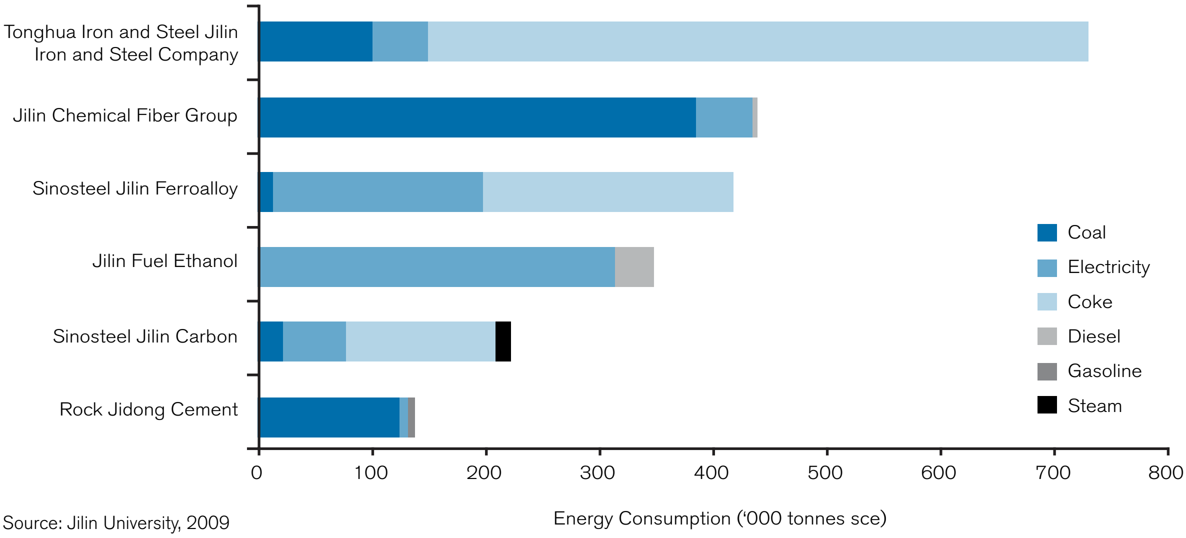
There are 50 enterprises in Jilin City which have an annual energy consumption over 3,000 tonnes of standard coal. Eight of them are among the '1,000 national enterprises of energy-saving and emission-reduction control' (a major Chinese programme established to support the 11th Five-Year Plan). In 2007, industrial enterprises consumed 13.56 million tonnes of standard coal equivalent (sce) of energy, accounting for 84% of the total energy consumption by Jilin City.

An analysis of the energy demand of six key companies in Jilin City is shown in Figure 2.8. Steel companies have a heavy demand for coke and electricity to satisfy energy needs, whereas cement and chemicals firms use much energy from coal.

Petrochemical companies also require large amounts of oil and gas to make products – not shown in the chart. For example, Jilin Petrochemicals has an 'energy balance' of 5.2 million tonnes sce. Of this, 75% represents the energy in raw materials (mainly oil and gas feedstock) and 25% (1.3 million tonnes sce) is the energy consumed in its operations.

The power sector is the largest consumer not shown in the chart. State Power Longhua Thermoelectric consumes 1.3 million tonnes sce – about the same as Jilin Petrochemicals.

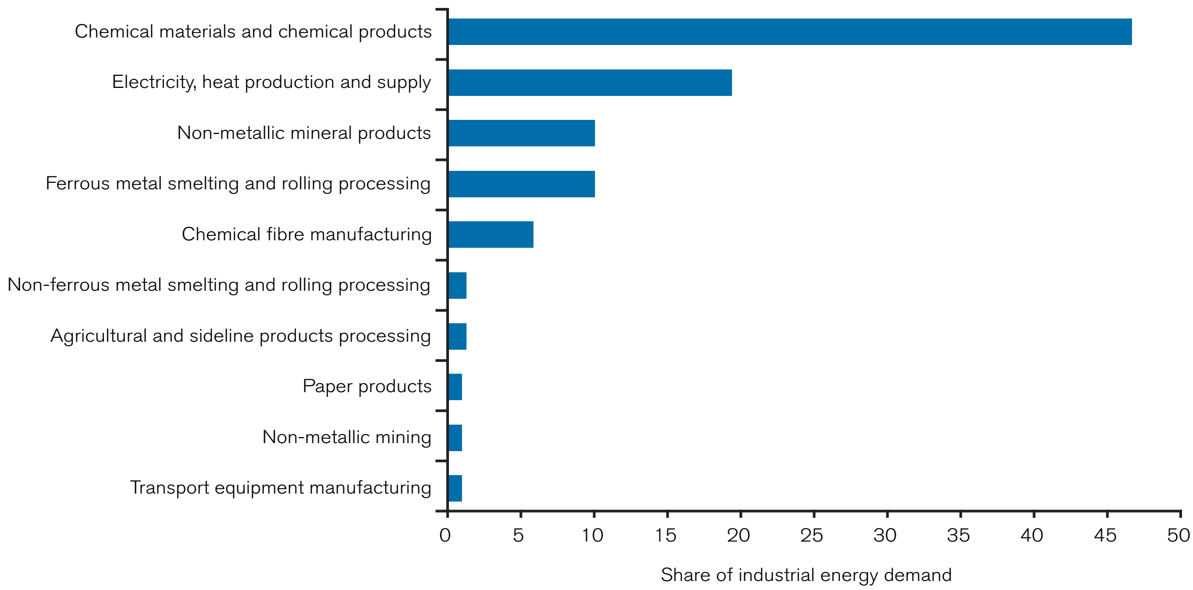
Figure 2.8: Major energy consumers – selected firms




Source: Jilin University, 2009

The petroleum refining and chemical industry is by far the largest energy consumer in Jilin City, with over half of industrial energy demand if the manufacture of chemical fibres is included (see Figure 2.9). Electricity and heat is second largest, with about 20% of the total, followed by the mineral products industry and iron and steel (smelting and rolling), which require about 10% each. This sends a clear message about priorities for energy efficiency.

Figure 2.9: Share of industrial energy demand – key sectors, 2007




Source: Jilin University and Energy Research Institute, 2009

The high energy-consuming sectors in Figure 2.9 are also some of the fastest-growing industries in Jilin City. With the exception of electricity and heat and transportation equipment, all the major energy-consuming industries are growing. Most significant, energy consumption by the chemicals sector has grown by an average of 15% annually over the past few years. The non-metal minerals industry is increasing its energy consumption by over 30% per annum, reflecting annual growth in economic output of 37% (see Table 2.1).

Table 2.1: Growth of major energy-consuming sectors

| | **Energy consumption, 2007** (tonnes sce)* | **Annual growth in energy consumption, 2005-7** (%) | **Annual growth in economic output, 2005-7** (%) |
|---|---|---|---|
| Chemical materials and chemical products | 6,255,004 | 15 | 15 |
| Electricity, heat production and supply | 2,602,735 | -11 | -13 |
| Non-metallic mineral products | 1,348,075 | 31 | 37 |
| Ferrous metal smelting and rolling processing | 1,338,445 | 5 | 4 |
| Chemical fibre manufacturing | 787,658 | 50 | -23 |
| Non-ferrous metal smelting and rolling processing | 162,751 | 33 | 34 |
| Agricultural and related products processing | 150,333 | 214 | 103 |
| Paper products | 125,284 | 371 | 131 |
| Non-metallic mining | 107,615 | 627 | 177 |
| Transportation equipment manufacturing | 103,117 | -17 | -11 |

* standard coal equivalent.
Source: Jilin University, 2009 and Energy Research Institute, 2009

## 2.4 Natural and mineral resources

Jilin City has a wide range of natural and mineral resources, giving it a platform for developing both heavy industry and renewable energies. Some of the key resources can be summarized as follows:

**Excellent water resources:** Jilin City, with a capacity of 3,679 $m^3$ per capita (nearly double the national average), is one of the few cities in China that do not have a water shortage issue. Hydropower is currently 65% of installed generation capacity in Jilin City.

**Rich in biomass resources:** Jilin City is located in a major agricultural area and has very high forest coverage (around 55%). It is part of one of the world's three major corn-belts, producing more than 10 million tonnes per annum. Maize, maize cobs, sweet sorghum and straw can all be used for the development of biomass energy in Jilin City and the surrounding areas. Waste from agriculture and forestry will be readily available as feedstock for biofuels once second-generation technologies are commercialized. Jilin City can take advantage of substantial biomass resources for energy generation. Agricultural residue, notably straw, could be particularly suitable. It is estimated that 3.5 million tonnes of straw could be used for this purpose, and Jilin City plans to build a number of 100 MW direct-fired energy-generation projects during the 11th Five-Year Plan period. Maize and sweet sorghum may also provide suitable energy crops, provided that the use of these crops for biofuel production does not undermine food security and agricultural export interests. Biomass can also help to supply energy for heating and light in rural areas. Over 3,000 biogas digesters, for instance, are already used in rural households. Moreover, Jilin City is planning to use waste to generate electricity. A solid waste incineration power plant that came into operation in 2009 is expected to produce 0.6 terawatt hours (TWh) of electricity per annum.

**Good wind resources:** Wind speeds are suitable for commercial wind power development in parts of Jilin City. As one of seven priority provinces for wind power development, Jilin Province is expected to deploy at least 10 GW of capacity by 2020.

**Rich in oil shale resources:** Jilin Province is an important region for oil shale production for China, with reportedly 50% of the country's reserves. The shale has an average oil rate of up to 10.81%. Therefore the amount of oil that can be commercially extracted from the proven reserves is as much as 450 million tonnes.[5] Huadian, within Jilin City Municipal Area, is the main focus of commercial activity. Discovered (but unproven) reserves in the province are much larger. One estimate puts them as high as 17 billion tonnes.[6] In recent years, domestic and international joint ventures have been signed in order to further document and develop plans for oil shale production (most significantly with Shell). In Jilin City, there are also large potential conventional oil and coal resources. These fossil fuel reserves will pose challenges for its low carbon development.

5 China Daily (2005), 'Top firm develops oil shale reserves'. 28 December, available online at: http://english.people.com.cn/200512/28/eng20051228_231305.html

6 Wang Qing, Bai Jingru, Sun Baizhong and Sun Jian (2005), 'Strategy of Huadian Oil Shale Comprehensive Utilisation', *Oil Shale*, (2005), Vol. 22, No. 3, pp. 305–15

# 3 A low carbon development scenario for Jilin City

This section presents three scenarios for Jilin City's energy consumption and related $CO_2$ emissions up to 2030. It explains the crucial technologies for Jilin City as it leaves a business-as-usual trajectory and joins a low carbon pathway. This is followed by a bottom-up analysis identifying specific low carbon technology investments in key sectors. The work is the result of a detailed assessment undertaken by ERI in collaboration with Jilin University.

The scenarios demonstrate the technical feasibility and investment affordability of a shift to a low carbon economy in Jilin City. However, scenario analysis is not a prediction of the future; it is a valuable tool for exploring the impact of particular sets of policies on energy and emissions. Further, these scenarios are based on a top-down methodology, which cannot fully capture the local situation (see Chapter 5) for specific investment options identified from a bottom-up approach.

The scope of the modelling exercise was restricted to energy and energy-related greenhouse gas (GHG) emissions (predominantly $CO_2$). The major sources of energy consumption and emissions in Jilin City – industry, buildings and transport – are captured in the analysis.

Agriculture and forestry-related emissions and carbon storage are not included in the model. They deserve further analysis: Jilin City has much potential for carbon sequestration in forests; land-based sectors will play a key role in biofuels; and the rapidly growing agricultural product processing industry is a potential candidate for carbon labelling.

## 3.1 Modelling methodology

Jilin City has experienced rapid growth by global standards in energy demand and carbon emissions over the past decades. Since 2003 the annual increase in electricity was in the order of 10%. Overall energy consumption in 2007 was 12 million tonnes of standard coal equivalent, of which over three-quarters was consumed by the industrial sector and only 10% by the residential sector and 3% by transport.

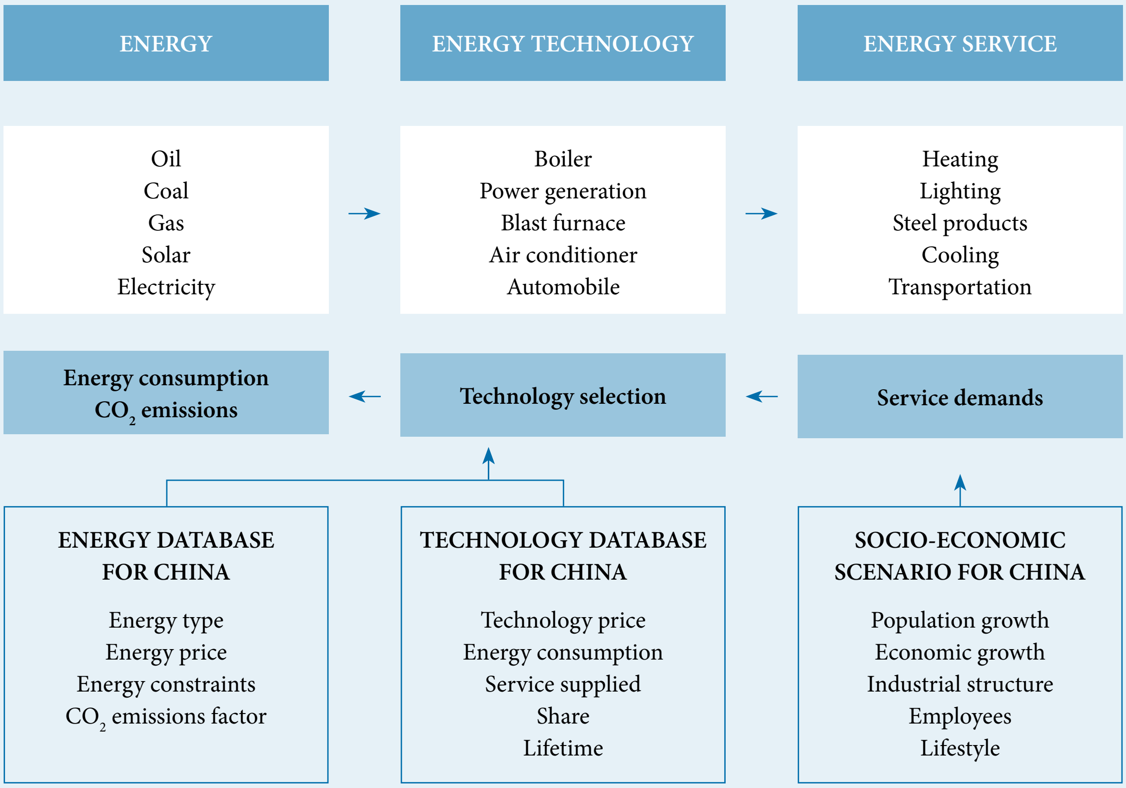
The pattern of industrial energy use is therefore extremely important. Here secondary industry uses around six times more energy than the tertiary sector and 30 times more than primary industry. Although these economic and energy-demand conditions are relatively rare, they are changing fast and create opportunities for rapid reductions in energy consumption and emissions. ERI's energy modelling helps to identify these opportunities and to highlight the advantages which they bring. More specifically, it sheds light on the impact of potential policies on energy use and emissions.

Within the scenario analysis, more than 400 technologies are considered, both existing technologies and those that may be used in the future, on both the demand and supply sides.

### Box 3.1: ERI modelling methodology

The IPAC-AIM technology model was used, as it has been tested in national energy and emission scenario analyses and in several regional scenario analyses including Beijing, Guangdong and Hong Kong.

The model used in Jilin City looks at the timeframe to 2030, with 2005 as the base year. The main parameters of the model are detailed in the figure below.




## 3.2 Defining the scenarios

By adjusting assumptions about the development and deployment of these technologies in the future, three scenarios were developed:

**BAU scenario:** This is based on the current economic development pattern. It includes current policy commitments on energy intensity and other key areas but assumes that no further policies are introduced.

**Policy scenario:** This shows the effect of additional energy-saving measures, renewable energy promotion and pollution reduction (driven by policy, investment and energy expenditure). The main drivers here are:

- Adjustment of economic structure – high energy-consuming industries contribute a gradually shrinking share of industrial added value.
- The deployment of energy-saving technology.
- Excellence in heavy industry: by 2020, the main high energy-consuming industries will catch up with or exceed advanced-country levels and the industry will generally realize effective and cleaner production.

- Buildings: new buildings reach the energy-saving standard. Consumers purchase efficient electricity-using products and make adjustments to their lifestyle. Some install domestic renewable energy.
- Renewable energy will be more rapidly advanced – including wind power, solar thermal utilization, photovoltaic cells, biomass energy power-generation and liquefaction, small-scale hydropower and energy from waste.

**Low carbon scenario:** All the above policy scenario measures are included. Further efforts are made to decarbonize the energy system – for example by the faster penetration of renewables and nuclear power. In particular, the low carbon scenario includes some optimistic assumptions about the rate of introduction of carbon capture and storage (CCS).

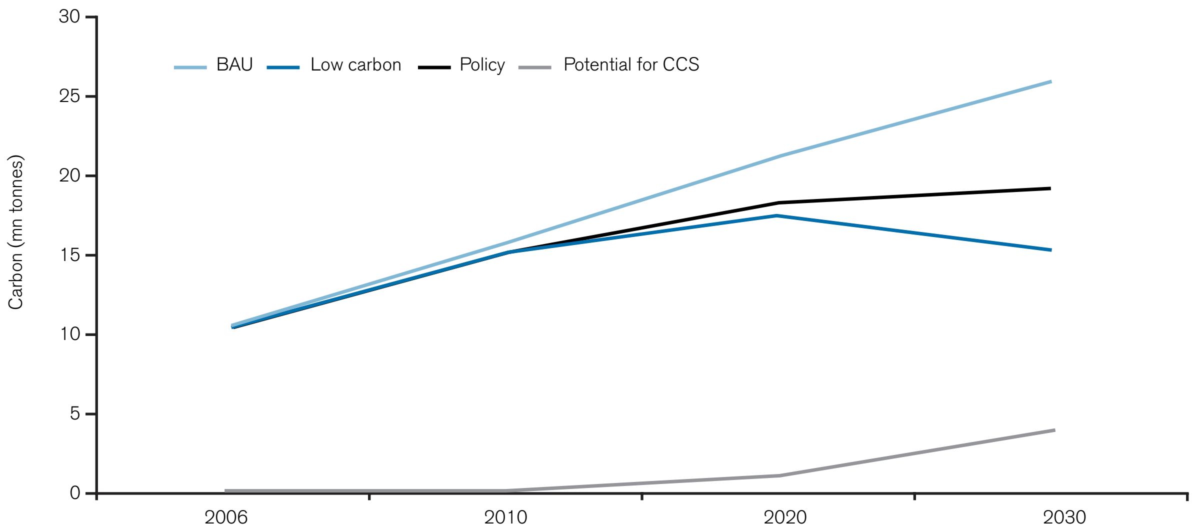
## 3.3 Greenhouse gas emissions, energy consumption and industrial products

### 3.3.1 Impact on energy-related greenhouse gas emissions

The results of the modelling are presented in Figure 3.1. Emissions under the BAU scenario continue to grow at a rapid rate until 2030, showing little sign of tailing off. This would imply considerable stress on the energy supply and a growing exposure to fossil fuel prices.

The energy-saving measures in the policy scenario help to reduce emissions compared to BAU, and emissions start to plateau by 2030. The additional supply-side measures in the low carbon scenario mean that after 2020, a significant additional emissions saving is achieved. This scenario includes an optimistic assumption about CCS; the potential for this is also represented in Figure 3.1.

Figure 3.1: Emissions scenarios for Jilin City (carbon emissions from energy), 2006–2030




Source: Energy Research Institute, 2009

A major finding from the scenario analysis is that low carbon and energy-saving policies can dramatically improve Jilin City's position – to such a degree that emissions for Jilin City could peak in around 2020 and decline to 60% of the business-as-usual scenario by 2030.

### 3.3.2 Impact on energy consumption

Under each scenario, Jilin City's energy consumption will continue to increase until 2030. This will ensure its development and will create the space for efficient heavy industry to grow in the medium term while economic restructuring takes place. This is important to recognize because heavy industry is a major employer in Jilin City.

Under the **BAU scenario**, primary energy demand will increase from 15.62 million tonnes sce in 1997 to 31.26 million tonnes in 2020 and 39.34 million tonnes in 2030. Coal will still be the main energy source, accounting for 59% of all energy in 2030.

Because of various energy-related measures in the **policy scenario**, primary energy demand falls to 28.18 million and 33.51 million tonnes sce in 2020 and 2030 respectively. Coal will account for 55.5% and 53.7% respectively of primary energy. The share of nuclear power will be up to 5% and 8% respectively and that of wind power will be up to 2% and 3% respectively.

Under the **low carbon scenario**, Jilin City sets low carbon economic development strategy as a key goal in social and economic development – perhaps within a low carbon development area or zone. The overall energy saving is the same as in the policy scenario but additional $CO_2$ reduction measures are achieved through further decarbonizing the energy supply. In particular, the model assumes significant penetration of CCS.

### 3.3.3 Impact on industrial output

Importantly, moving to a low carbon scenario does not mean an end to Jilin City's heavy industry sector. Under the low carbon scenario (which is the same as the policy scenario in this area), there is a reduction in industrial output in some sectors, including concrete, tiles and coal. But these changes are not instant or dramatic (see Table 3.1).

In many cases the policy and low carbon scenarios require no change in output. No reductions in production occur before 2010, and in 2020 most products are also unaffected. By 2030, coal and concrete production would be 33% lower in the policy scenario. But concrete production would actually be eight times higher in 2030 than it was in 2005 and coal output would be about 30% higher. Under the policy scenario, fuel ethanol output would be twice as much as under the BAU scenario, owing to a more supportive policy environment for biofuels.

Table 3.1: Physical industrial output – change in policy and low carbon scenarios compared to BAU, 2020 and 2030 (%)

| | 2020 | 2030 |
|---|---|---|
| Iron and steel | 0 | 0 |
| Concrete | -17 | -33 |
| Tiles | 0 | -20 |
| Ethylene | 0 | 0 |
| Vitriol | 0 | 0 |
| Fuel ethanol | 0 | +100 |
| Automobile | 0 | 0 |
| Paper | 0 | 0 |
| Coal | -28 | -33 |

Source: Energy Research Institute, 2009

# 4 Policies and institutions for low carbon development

This chapter addresses the key policies and planning and institutional needs that Jilin City may wish to focus on. It begins with the main policies and technologies highlighted by the scenarios.

It then explains how Jilin City can benchmark low carbon development so that the concept can be properly incorporated into local planning. Indicators are set out and benchmarks are proposed for the 12th Five-Year Plan period (2011–15) and for 2020 and 2030.

Lastly the chapter identifies some of the crucial institutional issues revealed by a detailed needs assessment conducted by Jilin University.

## 4.1 Key policies and technologies

### 4.1.1 Policies

Based on the scenarios in Chapter 3, a number of critical policy areas can be identified. More details on the range of policy options available can be found in Appendices A and C.

Contributions to $CO_2$ emissions reduction are found largely through energy efficiency and decarbonizing the energy system by renewable energy and nuclear power. The penetration of CCS is also important after 2030.

In summary, there are four principal policy areas.

**Adjustments to the economic structure** contribute 37% to emissions reductions in the low carbon scenario compared to the BAU scenario in 2030. This is achieved through the promotion of industries with high added value and low energy consumption and also through limitations on manufacturing sectors that have a high energy demand (directly or via their energy-using products). The government and industries must be more aware of and pay attention to the importance of combining this with short- and medium-term planning.

**Energy-saving and efficiency** contribute 51% to emissions reductions in the low carbon scenario compared to the BAU one in 2020. The policy and low carbon scenarios assume that the energy-saving target in the 11th Five-Year Plan becomes a long-term policy. As Jilin City's energy-saving target is higher than the national average and energy-saving has been widely accepted as a policy, the City can take further measures, such as implementing stricter energy-saving standards and introducing local energy taxes, resource taxes etc.

**Technology and policy innovation** is the core of a low carbon economy, and global research has shown that setting the right innovation frameworks is essential to breaking the link between per capita income growth and per capita $CO_2$ emissions. The penetration of best-available technology is a major variable in the model.

**Investment requirements and technical support** are needed across virtually all sectors, however. Important opportunities can be identified in the construction industry, the transport sector, the power sector and the chemical industry.

### 4.1.2 Technologies

The paramount technologies for energy efficiency and renewable energy have also been identified (see Table 4.1). Further details are provided in Appendix C.

In Jilin City, the energy efficiency of industry is a critical matter, as is the efficiency of transport and buildings. Jilin City has a long way to go to become a leader in China in terms of efficiency. The specific investments outlined in Chapter 5 would be part of addressing this challenge.

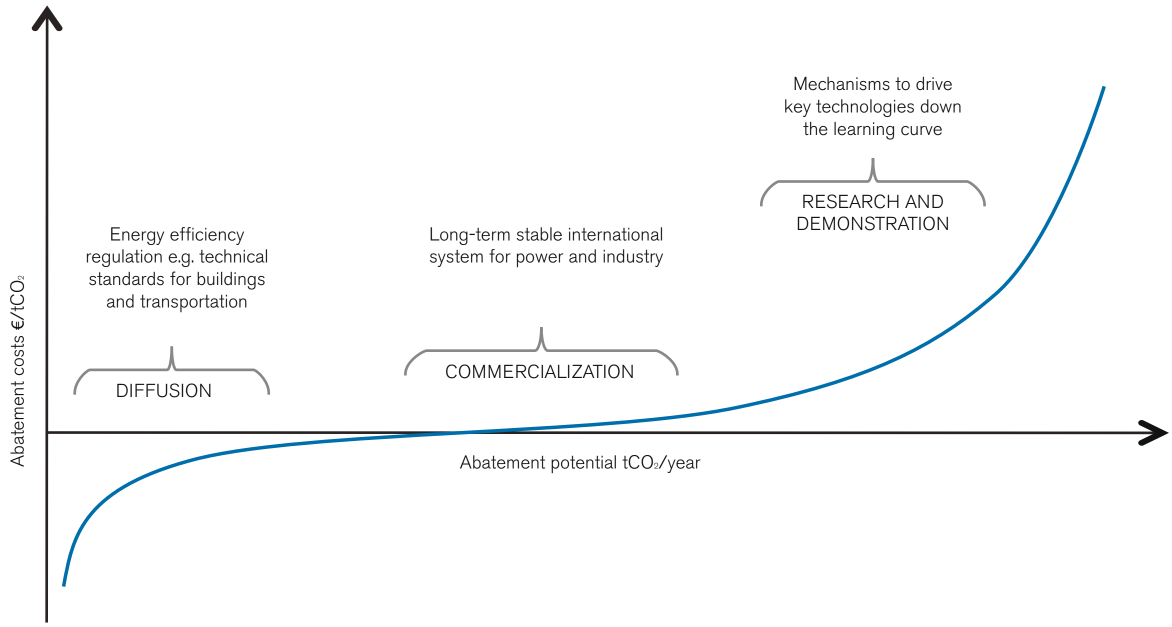
Table 4.1: Technologies contributing to short- to medium-term greenhouse gas emissions reduction

| Sector | Technologies |
|---|---|
| Steel industry | Large-size equipment (coke oven, blast furnace, basic oxygen furnace etc.), equipment for coke dry quenching, continuous casting machine, top pressure recovery turbine. |
| | Continuous rolling machine, equipment of coke oven gas, open hearth gas and blast furnace gas recovery, direct-current electric arc furnace |
| Chemical industry | Large-size equipment for chemical production, waste heat recover system, ion membrane technology; existing technology is improving |
| Paper-making | Co-generation system, facilities of residue heat utilization, black liquor recovery system, continuous distillation system |
| Textile | Co-generation system, shuttleless loom, high-speed printing and dyeing |
| Non-ferrous metal | Reverberator furnace, waste-heat recovery system, Queneau-Schuhmann-Lurgi (QSL) continuous smelting process for lead and zinc production |
| Building materials | Dry-process rotary kiln with pre-calciner, electric power generator with residue heat, Colburn process, Hoffman kiln, tunnel kiln |
| Machinery | High-speed cutting, electric-hydraulic hammer, heat preservation furnace |
| Residential | Cooking by gas, centralized space heating system, energy-saving electric appliances, high-efficiency lighting, solar thermal for hot water, insulation of building and energy-efficient windows |
| Service | Centralized space heating system, centralized cooling heating system, co-generation system, energy-saving electric appliances, high-efficiency lighting |
| Transport | Hybrid vehicle, advanced diesel truck, low energy-use car, electric car, fuel cell vehicle, natural gas car, electric railway locomotive, public transport development |
| Common-use technology | High-efficiency boiler, fluidized bed combustion technology, high-efficiency electric motor, speed-adjustable motor, centrifugal electric fan, energy-saving lighting |
| Power generation | Super-critical unit, natural gas combined cycle, pressurized fluidized bed combustion boiler, wind turbine, integrated gasification combined cycle, smaller-scale hydropower, biomass-based power generation |

Source: Energy Research Institute, 2009

Finding the right policy to promote each of these technologies means understanding their different characteristics. An essential issue is the position of a technology along the innovation chain. This can be separated into three broad categories: diffusion; commercialization; and research and demonstration (see Figure 4.1).

Figure 4.1: Stages of technology development




Source: Chatham House, 2009

**Diffusion:** These technologies are already deployed at scale around the world. What is required is a greater control of their use and stricter regulations and enforcement in order to ensure that best practice is adhered to. This applies to many energy-efficiency technologies and also to some renewables (solar thermal and some biomass technologies, for example) as well as fuel switching to natural gas. In some cases, inefficient factories or power plants may need to be closed down in order for more efficient approaches to make sense.

These technologies will meet much of Jilin City's short-term emissions reduction and energy-saving ambitions. China and Jilin City also have an important role in producing high-quality, low-unit-cost energy-efficient appliances.

**Commercialization:** These technologies are viable but under present conditions they are not able to compete with current technologies – for example because the rate and scale of deployment have been too low to achieve economies of scale to drive down costs; because energy subsidies make them appear uneconomic; or because significant infrastructure development is required before they can be commercially viable. Consequently, mechanisms that can help to overcome the barriers to their introduction need to be developed, deployed and enforced.

For Jilin City, finding the right mix of incentives will be important in ensuring that some of these technologies can achieve significant penetration during the 12th and 13th Five-Year Plans. These technologies will help to shift Jilin City from a policy scenario level to a low carbon pathway, and globally they are expected to be some of the largest potential low carbon markets once prices start to fall.

In view of the local strength in automobile manufacturing, Jilin City has a significant stake in electric vehicles. Building up Jilin City's industrial base in such technologies (through local deployment so as to stimulate learning, by focusing on innovation and through public support for infrastructure) will be an important platform for future low carbon growth.

**Research and demonstration:** Many technologies are at an earlier stage of innovation, under development or under design consideration. International cooperation between government and the private sector is already occurring. However, greater cooperation could be achieved through enhanced coordination in order to avoid overlaps and unnecessary competition.

An important example for Jilin City is second-generation biofuels – an obvious choice in the light of local resources, existing leadership in first-generation (ethanol) biofuel and the strength of the petrochemicals sector. Jilin City, working with local stakeholders such as the China National Petroleum Corporation (and its local subsidiaries) and Jilin University, could position itself as a major demonstration area for these technologies as they emerge.

Another example is CCS, which plays a significant role in the low carbon scenario set out in Chapter 3. Although the individual components of CCS are well understood, it remains at the demonstration stage. This is potentially an important technology for Jilin City, considering its industrial base, petrochemical and energy sectors and local geology.

## 4.2 Benchmarking low carbon development

Jilin City aims to be a leader in China in low carbon development. But to date, there is no formal methodology for benchmarking and reviewing low carbon development. Addressing this is critical for feeding the concept into the 12th Five-Year Plan process. Identifying appropriate criteria for benchmarks has therefore been a major focus of research. A critical issue is how to reflect different development starting conditions such as GDP and also availability of resources and industrial structure.

Taking these issues into account, the Chinese Academy of Social Science (CASS) methodology provides a robust basis for assessing low carbon development. Four categories have been identified which contain 12 indicators in total. These can be adjusted to reflect different development conditions. The full methodology is available in a separate project report.[7]

- **Low carbon productivity** includes indicators for both carbon and energy per unit of economic output, measurements consistent with China's existing energy-intensity target and a potential national carbon-intensity target.
- **Low carbon consumption** covers per capita and per household energy consumption. Consumption indicators can be used to review the impacts of policy on individual behaviour.
- **Low carbon resources** cover the share of low carbon energy, emissions per unit of energy production and the percentage of land covered by forest.
- **Low carbon policy** indicators review the existence of policies and plans for low carbon development, success in implementation of regulations, and public awareness levels.

The proposed benchmarks are presented in Table 4.2 below. These are relative indicators: achieving low carbon status under this methodology means *achieving a level significantly better than the Chinese average* once adjustments have been made to reflect economic and social structure.

Absolute indicators (provided in Appendix B) are also important, to ensure that progress is consistent with the science of climate change. These will be helpful in setting a long-term objective for China as it develops.

7 Pan Jiahua, Zhuang Guiyang, Zheng Yan, Zhu Shouxian and Xie Qianyi (2009), 'The Concept of Low-Carbon Economy and an Evaluation Methodology for a Low Carbon City: Jilin City Case Study', Chinese Academy of Social Sciences, Beijing.

Table 4.2: Indicator system for low carbon economic development (relative)

| | No. | Indicator | Low carbon benchmark |
|---|---|---|---|
| Low carbon productivity | 1 | Carbon productivity | 20% higher than the national average |
| | 2 | Energy consumption per unit output or carbon emission per added value in key industries | In a leading position nationally |
| Low carbon consumption | 3 | Per capita carbon emission | Where per capita GDP is lower than the national average level, per capita carbon emission must be lower than the national average level.<br>Where per capita GDP is higher than the national average level by X%, per capita carbon emission must not be higher than the national average level by 0.5 X%. |
| | 4 | Per capita household carbon emission | Where per capita affordable income is lower than the national average level, per capita household carbon emission must be lower than the national average.<br>Where per capita affordable income is higher than the national average level by X%, per capita household carbon emission must not be higher than the national average level by 0.5 X%. |
| Low carbon resources | 5 | Proportion of zero carbon energy in primary energy | Higher than the national average level |
| | 6 | Forest coverage rate | Refer to existing national standards |
| | 7 | $CO_2$ emission factor per unit energy consumed | Lower than the national average |
| Low carbon policy | 8 | Low carbon economy development plan | The overall plan is developed and agreed; the plan is reflected in plans for relevant government departments |
| | 9 | Development of carbon emission monitoring, statistic and supervision mechanism | The system is effective, sufficient and coordinated |
| | 10 | Public awareness of low carbon economy | Higher than 80% |
| | 11 | Conformity of building energy-efficiency standards | Higher than 80% |
| | 12 | Incentives for non-commercial energies | Well-designed and widely provided |

Source: Chinese Academy of Social Sciences, 2009

Later in this chapter, Table 4.3 presents the current status of China and Jilin City in each of the indicators. The most important points can be summarized as follows:

- **Carbon productivity** stands at almost half the China average (despite a similar industrial structure). A level 20% ahead of the average would be considered 'low carbon' under the CASS methodology.
- **Per capita carbon emissions** were 2.5 times larger than the national average in 2007.
- **Low carbon energy** makes a relatively small contribution to energy supplies, despite excellent conditions. Renewable energy met less than 5% of total energy demand in Jilin City in 2007.
- **Carbon emissions per unit energy** consumed in Jilin City in 2007 was 0.61 tonnes carbon/tonne sce, which is 6.5% lower than the national average. This is due to the fact that coal contributes only about half of all energy consumed, against a national average of about 80%.
- **Forest coverage** is high at 55%.

In a number of these indicators, notably carbon productivity, Jilin City is behind the Chinese average. It is clear from this assessment that Jilin City has yet to reach the target of a low carbon economy.

The good news is that Jilin City is implementing progressive policies to accelerate its transformation. It has adopted an energy-intensity improvement target of 22% between 2005 and 2010, higher than the already ambitious national target. Renewable energies are being strongly encouraged.

Efforts to improve energy intensity are producing good results. By the end of 2008, the energy intensity of the large-scale enterprises in Jilin City declined by 37% compared to 2005.

## 4.3 Short- and medium-term indicators for five-year planning

The five-year planning process requires an assessment of the current position combined with steps towards effective implementation. This is particularly true of low carbon development, which is an economic and social concept with very broad implications.

The indicators and benchmarks presented in the previous section are explicitly designed to be applicable for measuring progress. Once these have been established, steps towards a low carbon economy can be integrated with the 12th Five-Year Plan.

As noted above, Jilin City is not currently a low carbon economy. But this simply reflects its historical position as a heavy industrial and manufacturing base in China. For policy-makers, the real question is, what steps can Jilin City take to move from its high carbon economy to a low carbon economy as soon as possible? A low carbon zone or city would naturally aim to be among the fastest-improving regions of China.

The CASS methodology addresses this by calculating an appropriate level of improvement in each indicator over different time periods – in the 12th Five-Year Plan, by 2020 and by 2030. This is consistent with five-year planning horizons.

Table 4.3 sets out clear proposals for Jilin City for an appropriate rate of progress and level of ambition over different timescales. If the City decides to adopt these or similar indicators, it would send a strong signal that it is pushing forward on the low carbon economy. Over time, meeting the benchmarks would demonstrate commitment to the concept.

Improvements in carbon productivity can give a clear signal of the level of ambition in this set of indicators. Although it is important to note that the figures are highly sensitive to GDP assumptions, several points deserve to be highlighted:

- The indicator for carbon productivity is equivalent to a **58% improvement in carbon intensity in 2020 (compared to 2005) in Jilin City.** In December 2009, China adopted a carbon-intensity target of an improvement of 40–45% by 2020 compared to 2005 levels.
- **Achieving the indicator for carbon productivity in 2020 would result in emissions 19% lower than in the BAU scenario.** Cumulative emissions between 2010 and 2020 could be around 12% lower than BAU.
- **The carbon productivity indicator for 2015 (the final year of the 12th Five-Year Plan) is consistent with the low carbon scenario** set out in Chapter 3. Both result in a 37% improvement in carbon intensity compared to 2005.
- A 58% improvement in carbon intensity by 2020 compared to 2005 is slightly less aggressive than the 64% improvement in carbon intensity set out in the low carbon scenario (the BAU scenario results in a 49% improvement). **International cooperation could be focused on bridging this manageable gap.**

As part of the 12th Five-Year Plan process, a detailed review of policies by Jilin City can ensure that current policies and investment plans are appropriate for meeting the benchmarks. The policy areas set out in the first section of this chapter, and the detailed investment opportunities set out in Chapter 7, provide a starting point for such a review.

Table 4.3: Proposals for low carbon indicators

| Indicators | No. | Sub-indicators | Unit | National average, 2008 | Jilin City, 2008 | Jilin City 12th Five-Year Plan, 2011–2015 | 2020 | 2030 |
|---|---|---|---|---|---|---|---|---|
| Low carbon productivity | (1) | Adjusted carbon productivity | RMB 10,000/ tonnes carbon | 1.56 | 0.83 | 1.07 (2010)<br>1.60 (2015) | 2.40 | 5.38 |
| | (2) | Energy consumption per unit output or carbon emission per added value in key industries | Tonnes standard coal equivalent (tonnes sce) | See Table 4.4 | | | | |
| Low carbon consumption | (3) | Per capita carbon emissions | Tonnes carbon/ person | 1.36 | 2.79 | 3.30 | 3.64 | 3.04 |
| | (4) | Per capita household carbon emissions | Tonnes carbon/ person | 0.05 | 0.10 | 0.112 | 0.137 | 0.131 |
| Low carbon resources | (5) | Per capita zero-carbon energy consumption in primary energy | Tonnes sce/ person | 0.14 | 0.35 | 0.44 | 0.73 | 1.09 |
| | (6) | Forest coverage rate | % | 45.0 | 54.96 | 58.0 | 60.0 | 62.0 |
| | (7) | $CO_2$ emission factor per unit energy consumed | Tonnes carbon/ tonnes sce | 0.65 | 0.61 | 0.88 | 0.74 | 0.53 |
| Low carbon policy | (8) | Low carbon economy development plan | Yes | No | No | Yes, in the 12th Five-Year Plan | Yes, fully integrated with the development plan | Yes |
| | (9) | Develop carbon emission monitoring, statistic and supervision mechanism | Complete | Incomplete | Incomplete | Piloting | Complete | Complete |
| | (10) | Public awareness on low carbon economy | Higher than 80% | Data unavailable | Data unavailable | Higher than 80% | Better than national average | Better than national average |
| | (11) | Conformity of building energy efficiency standards | Higher than 80% | Lower than 50% | 100% | 100% | 100% | 100% |
| | (12) | Incentives for non-commercial energies | Yes, very effective | Yes | Yes | Effective | Very effective | Very effective |

Source: Chinese Academy of Social Sciences, 2009

An important element in following a low carbon pathway is improvements in the energy efficiency of key sectors. Table 4.4 shows the improvements which are anticipated and which can potentially act as benchmarks in future.

Table 4.4: Unit consumption of high energy-consumption products under the policy scenario, 2005–2050

| | | 2005 | 2020 | 2030 | 2050 |
|---|---|---|---|---|---|
| Steel and iron | Kgce/t* | 760 | 650 | 564 | 525 |
| Cement | Kgce/t | 132 | 101 | 86 | 81 |
| Synthetic ammonia | Kgce/t | 1,645 | 1,328 | 1,189 | 1,170 |
| Ethylene | Kgce/t | 1,092 | 796 | 713 | 705 |
| Soda | Kgce/t | 340 | 310 | 290 | 280 |
| Copper | Kgce/t | 1,273 | 1,063 | 931 | 920 |
| Aluminium | kWh/t | 15,000 | 12,870 | 12,170 | 12,000 |
| Paper-making | Kgce/t | 1,047 | 840 | 761 | 740 |
| Thermal power | Gce/kWh** | 350 | 305 | 290 | 271 |

* Kilograms coal equivalent per tonne of product ** Grammes coal equivalent per kilowatt hour
Source: Energy Research Institute, 2009

## 4.4 Low carbon local government

Government institutions will have a leading role to play in Jilin City's low carbon development. Research by Jilin University for the project has identified a number of needs which must be addressed as part of a low carbon strategy.

### 4.4.1 Incorporating the low carbon development concept

A first step is to incorporate the low carbon economy concept into government department planning, in an appropriate way and guided by the scientific development philosophy. An essential part of this process would be to design and agree a low carbon development strategy for Jilin City connected to the 12th Five-Year Plan. The concept would need to be fully incorporated into the development programmes for urban planning and the local economy. Jilin University recommends that officials explore the development strategy as soon as possible, guiding and leading government, enterprises and citizens to act.

In order to meet these objectives and to enable government departments to take the lead, a number of recommendations have been identified:

- Establish a **special fund for low carbon** in district finance so as to support and direct the construction of energy-saving and emission-reducing demonstration projects.
- Set up a **departmental coordination mechanism.** The City government and related departments should set up a specialized agency and employ professionals to strengthen the organizational leadership for addressing climate change and developing an LCE.
- Guarantee **green procurement by government agencies**. For air-conditioners and electronic equipment, the City can introduce compulsory purchase of high energy-efficiency, water-saving products.
- In government offices, upgrade information systems, ensure access to the Internet and introduce e-government measures, all aiding efficient government and helping with the coordination of low carbon development.

### 4.4.2 Systems and incentives

Successful implementation of the concept would depend on creating integrated systems with an incentive structure that encourages innovation and action on low carbon development. In this area, the priorities should be to:

- Set up and perfect an integrated decision-making mechanism for low carbon development with Chinese characteristics.

- Establish an accounting and benchmarking system (perhaps based on the CASS methodology) to promote local government's initiative in developing the low carbon economy.
- Recognize the achievement of energy-saving and emission-reduction targets and progress on low carbon development as important aspects of local government performance evaluation.
- Establish and perfect local government's energy-saving and emission-reduction statistical, monitoring and evaluation system.

#### 4.4.3 Innovation in public policy

China will need a variety of low carbon cities and regions to innovate and lead the way in policy-making. This approach would benefit from the allocation of decision-making powers in the areas of regulation, policy-making and planning for low carbon development so that Jilin City and other regions would have the opportunity to experiment with new approaches.

For this to be most effective, Jilin University suggests that local government establishes a fair, open and multidimensional mechanism to interact with the public, thereby helping to identify the focus and nature of suitable policies. It is clear that low carbon development will require the participation of a wide range of local government departments in Jilin City.

Establishing a low carbon policy review and adjustment process would allow policy to evolve. The government would undertake post hoc analysis of policy implementation and, if necessary, adjust policies so as to ensure that its goals and wider social development are achieved.

Independent evaluation of policy success has also been identified as an important dimension. Policy implementation and monitoring should be led by an independent policy evaluation organization, ensuring the objectivity and impartiality of the evaluation result.

Creating an independent energy-saving agency would improve the accountability of decisions related to energy-saving.

# 5 Priorities for low carbon investment in the 12th Five-Year Plan

As noted in Chapter 4, a top-down scenario analysis is valuable for highlighting important areas of policy, but it cannot fully capture all the complexities of the local situation. This chapter presents specific opportunities for investments that would enhance energy efficiency and decarbonize the energy system in Jilin City. Within key sectors, concrete opportunities for technology investment have been identified. By themselves, they are not sufficient to meet the emissions savings achieved under the low carbon scenario, but they are an excellent starting point for the 12th Five-Year Plan.

Pillar industries in Jilin City will make a major contribution to energy savings and emissions reductions. But this ambitious local action would be part of a broader industrial strategy. Demonstrating a strong commitment to the low carbon economy would stimulate investment in Jilin City, encourage international cooperation, attract potential business partners keen to be part of a leading region in China and enhance conditions for local innovation and technology development.

For local firms, a low carbon Jilin City would be a demonstration ground for piloting and improving products which would later be exported to regional and global markets. Around the world, international experience shows that strong local policy support for deploying and developing technology is an essential condition for building low carbon industry – for example, wind power in Denmark and solar photovoltaic (PV) in Germany.

## 5.1 Petrochemicals

Petrochemicals are the largest energy user in Jilin City; making up over half of total energy demand. They are also a key industry for Jilin City, making it an important focus of energy efficiency and low carbon growth opportunities.

### 5.1.1 Investments and key firms

There are more than 200 major chemical companies in Jilin City, including Jilin Petrochemical and Jilin Chemical Fiber. Jilin Petrochemical Company, the largest, is a wholly owned subsidiary of the China National Petroleum Corporation. It has an annual revenue of $7 billion. Jilin Fuel Ethanol is another of its important subsidiaries located in Jilin City.

Jilin City-based firms produce 1,000 kinds of chemical products, of which more than 60 kinds of key products occupy a share in the domestic market, among them (all per annum) ethylene (0.85 million tonnes), gasoline (1 million tonnes), diesel oil (3 million tonnes), polyethylene (0.57 million tonnes), synthetic rubber (0.24 million tonnes), acrylonitrile butadiene styrene (1,800 tonnes), ammonia (0.30 million tonnes) and acrylic (0.24 million tonnes).

The nature of the chemicals and petrochemicals business is that it provides the inputs and materials for other sectors. The China National Petroleum Corporation explains that its chemical products are 'widely used in automobiles, buildings, electronics, pharmaceuticals, printing, household appliances, daily chemicals, insulating materials, packing, papermaking, textile, pigments, shoes, furniture manufacturing'.[8]

As noted in Chapter 2, there has been a significant increase in economic output, emissions and energy use from the petrochemical sector in Jilin City in recent years. This trend is set to continue, with large investment envisaged, as can be seen in Table 5.1 below.

8 CNPC website: www.cnpc.com.cn/en/productsservices/chemicalproducts/.

Table 5.1: Key projects in planning: Jilin Chemical Industrial Park

| Industry name | Project name and scale | Total investment (bn RMB) | Annual output value (bn RMB) | Annual profit tax (bn RMB) |
|---|---|---|---|---|
| Petrochemicals | 42 projects, including 1,200,000 tonnes of gasoline hydrogenation p.a. and 980,000 tonnes acrylonitrile butadiene styrene extension p.a. | 40 | 70 | 10 |
| Fine chemicals | 17 projects, among them 50,000 tonnes of polyacrylamide p.a. and 5,000 tonnes of automotive coatings p.a. | 5 | 9 | 1.3 |
| New chemical materials | 12 projects, such as 1,000 tonnes of carbon | 12 | 20 | 2.7 |
| Biochemicals | 11projects, including 200,000 tonnes of polylactide p.a. | 8 | 10 | 1.6 |
| New energy materials | Including 5,000 tonnes of polysilicon per annum and 50,000 tonnes of straw fuel ethanol p.a. | 4 | 3 | 0.95 |
| Total | | 69 | 112 | 16.5 |

Source: Jilin University, 2009

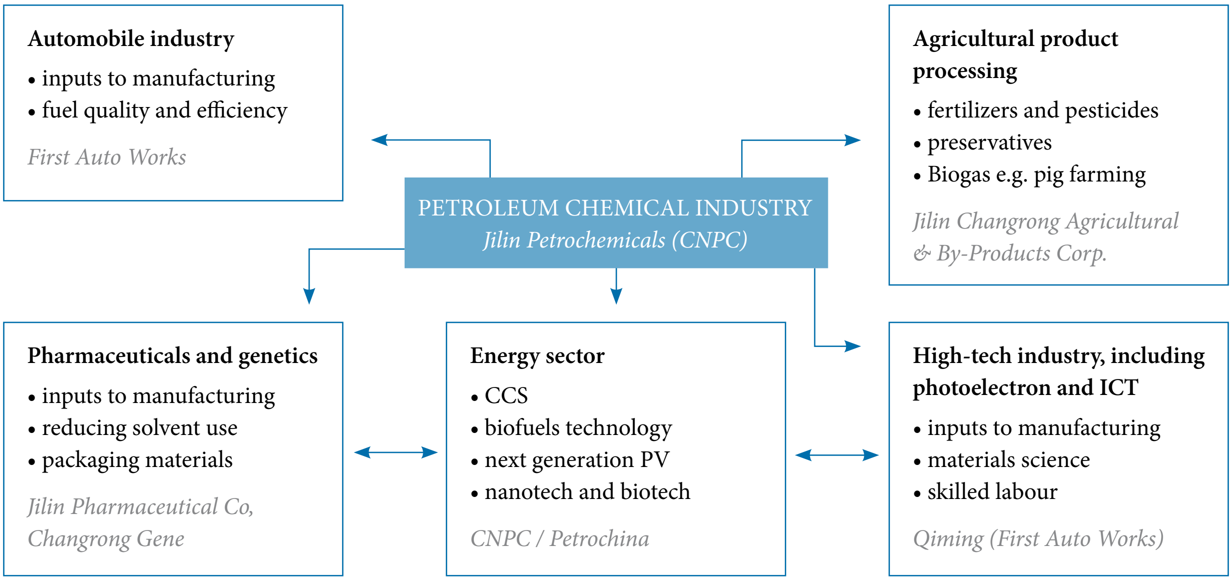
Although the expansion of these sectors will lead to increased energy consumption and emissions, the deployment of modern chemical processing facilities tends to lead to lower emissions per unit of production owing to higher efficiency standards. Furthermore, larger modern facilities often enable the smaller and less efficient facilities to be closed. Currently less than 10% of the production equipment used in Jilin City is said to be of 'international or domestic advanced level'. As a consequence, there is a definitive plan to accelerate the scrapping of redundant and outdated equipment.

As part of its low carbon planning, Jilin City has an important opportunity to strengthen circular economy demonstration projects under the 'new northern industry development strategy' – demonstrating the role of the chemical industry in the transition to a low carbon economy.

### 5.1.2 Links with other key sectors

Moving to a low carbon future in Jilin City does not mean ending the status of heavy industry as a major contributor to the economy. In fact, the petrochemical industry has an essential part in enabling the transition. This is because of its connections with other important industries and the depth of its industrial assets. Producing solar panels, gas-fuelled and electric vehicles, insulation and biofuels will all require a major contribution from the petrochemicals industry.

Figure 5.1: Petrochemicals in Jilin City – linkages with key sectors




*Italics = example company based in Jilin Province*

Source: Chatham House, 2009

Some important links between petrochemicals and other industries in Jilin City are displayed in Figure 5.1, with examples of important companies in each sector. A wide range of opportunities can be identified. For example, a chemicals producer could be encouraged to work with manufacturers of high-efficiency petrol vehicles which require low-sulphur fuels; with farmers and foresters producing biofuels and biochar; and with food processing and pharmaceutical companies seeking to carbon-label their products. A variety of low carbon growth opportunities for petrochemicals is highlighted in Box 5.1.

From this perspective, petrochemicals should be considered central to Jilin City's pursuit of low carbon development. This conclusion is supported by recent research conducted by Chatham House on patents and energy technologies, which shows that heavy industry sectors possess many technological assets that are critical to clean energy deployment.[9]

9 Bernice Lee, Ilian Iliev and Felix Preston (2009), *Who owns our low carbon future?*, Chatham House Report.

### Box 5.1: Low carbon growth opportunities for petrochemicals

The **vehicle** supply chain requires various inputs from petrochemicals. Lightweight cars require less energy. Efficiency improvements in vehicles depend to a significant extent on fuel quality – for example, low-sulphur petrol enables maximum $CO_2$ savings on advanced lean-burn petrol direct injection vehicles, and sulphur-free diesel offers $CO_2$ benefits for vehicles equipped with a diesel particulate filter. Globally, there is a rapid shift towards low carbon vehicle and alternative fuel markets. The chemicals industry will also be central to the race for electric vehicles, and the natural gas industry in Jilin City will supply to customers with gas-fuelled buses and taxis.

Agricultural inputs such as fertilizers and pesticides come from the petrochemicals industry, especially ammonia (the source of nearly all nitrogen fertilizers, usually from a natural gas feedstock). In the other direction, the industry's logistic capacity provides an avenue for bringing biofuels and biomass energy to market at scale, and in future will afford the ability to develop industrial-scale processing of agricultural waste into second-generation biofuels. In the medium term, biomass is likely to become a major feedstock for the chemicals industry. Finally, food retailers are actively developing carbon labelling for products, which will reward those industries that have developed and demonstrated low carbon approaches.

High-value sectors such as **pharmaceuticals** depend on advanced chemical products. High-technology industries in Jilin City, such as the photoelectron industry, already have the involvement of key petrochemicals players, reflecting their research and materials science capabilities.

The petrochemicals industry has many links with energy technology. **Combined heat and power** (CHP) is one of the chief areas for energy-efficiency improvements for the sector,[a] and globally it has been one of the largest users of CHP since the 1980s. **Carbon capture** technology was commercialized in the chemicals sector, and enhanced oil extraction has to date been a key commercial driver for experimenting with carbon storage. The $CO_2$ storage potential of Jilin oilfield has been evaluated as part of the UK–China research project on Near Zero Emissions Coal.[b] The **distribution and supply chains** for fuels may be the most important connection between petrochemicals and the energy sector.

Petrochemical industries affect **life-cycle emissions** from products in a number of ways, including efficiency at the petrochemicals plant; the recyclability of materials used in industrial processes and of end-products such as plastics and rubber; and the characteristics of those products. For example, lighter-weight materials or more effective insulation both help to reduce energy consumption. In some cases these efficiency gains will be larger than the energy embedded in the product.[c]

a IEA, 2007, 'Tracking industrial energy efficiency and $CO_2$ emissions'.
b NZEC website: www.nzec.info/en/jilin-oilfield/
c IEA, 2007, 'Tracking industrial energy efficiency and $CO_2$ emissions'.

## 5.2 Electricity and heat

Major changes in power and heat delivery are set to take place around the world as economies move to be more carbon-efficient.

Electricity and heat account for about 32% of final energy demand in Jilin City, and after petrochemicals they are the second most significant sector in energy terms. Jilin City's total electricity generation capacity is currently 4.6 GW, of which hydropower is 3 GW and coal plant 1.60 GW. In 2007, electricity production in Jilin City was 12.95 TWh, with a 66% contribution from thermal power and 34% from hydropower.

### 5.2.1 Low carbon energy strategy

Jilin City is set to comprehensively develop renewable energy, combining its wealth of resources with its strength in manufacturing. Decarbonizing the energy system will go hand in hand with developing its industrial base in low carbon energy.

According to the latest energy development plan, by the end of the 12th Five-Year Plan renewables and nuclear installed capacity in Jilin City will be 3.99 GW, 45% of the total. In 2020, low carbon installed capacity will be 9.14 GW, 63% of the total electricity installed capacity.

Jilin City has a very large potential in wind, solar heat utilization, advanced biomass energy utilization and solar PV power generation. It is also examining the possibility of constructing a 4,000 MW nuclear power plant.

It already has policies and plans which address each of these technologies, but there are still many opportunities to further promote the development of low carbon energy. Jilin Municipal Government has already considered building nuclear power plants.

Significant efforts will be made on wind power. According to the 11th Five-Year Plan, the aim is to introduce 0.5 GW of wind power, with an additional 0.5 GW in the next five-year period. However, Jilin City has an ambitious aim to utilize all the available wind power resources before 2020. In parallel, it will fully popularize solar water heaters in both urban and rural areas and combine buildings and solar water heaters through local regulations.

Jilin City will also develop biomass power generation and promote biomass liquid fuels, to solve the difficulties with energy supply in rural areas.

### 5.2.2 Major investment projects

Jilin City will need to invest in new generating capacity, in particular owing to expansion plans in the heavy industrial sector. Without this new investment by 2020, it could be short of 170 TWh of capacity. Bridging this gap in the next decade will require an investment of RMB 56.4 billion – and more if Jilin City chooses a higher share of low carbon energy.

During the 11th and 12th Five-Year Plans, Jilin City should seize the opportunities available via the 'great pressure on the small' national policy to strengthen the transformation of key electricity companies. Three major programmes are summarized in Table 5.2, with investment requirements as well as the emissions saved. *These three projects alone would reduce Jilin City's $CO_2$ emissions in 2020 by over 20% compared to BAU.*

Jilin City plans to build small hydropower plants in Huadian Hongshi and Jinzhou, and a larger plant in Xijingou. The total installed capacity is 0.124 Gigawatts and the expected capacity for power generation is 263 GWh per annum. In addition, Jilin City will construct Jiao River and Pi River estuary pumped-storage power stations and Huadian Hongshi pumped-storage power station. Jilin City is also actively promoting wind power and waste incineration.

These investments will not only meet the expected increase in demand but also enable older and less efficient coal-fired generating units to close.

Table 5.2: Key low carbon power investments in Jilin City

| **New generation sector** | **Power generation** (bn kwh per annum) | **Heating area** (mn $m^2$) | **$CO_2$ emissions reductions** (mn tonnes) | **Total investment** (bn RMB) | **$CO_2$ emissions reductions in 2020** (% of BAU) |
|---|---|---|---|---|---|
| Combined heat and power | 15.40 | 28.40 | 5.51 | 7.58 | 7 |
| Hydropower | 4.289 | | 4.23 | 15.24 | 5 |
| Other renewables | 7.25 | | 7.15 | 29.30 | 9 |

Source: Jilin University, 2009

## 5.3 Buildings and construction

Energy is used to produce building materials, as part of the building and infrastructure construction processes and when the building is in operation.

Urbanization and larger average living spaces mean that energy consumption in buildings will be increasingly important for Jilin City. Meeting higher efficiency standards sooner will mean that less expensive retrofitting is required in future. The social benefits are more comfortable accommodation and reduced energy costs. Overall, there is a significant economic and environmental benefit to building low carbon infrastructure now.

Jilin City has been a centre of excellence for the efficiency of buildings in China: a high proportion of buildings meet the energy-saving standards set out in regulations. Low carbon development will continue to improve and to be a model for other northern regions, as suggested by the proposed investments in Table 5.3.

Table 5.3: Potential energy savings from buildings in Jilin City by 2020

| **Building status** | **Area** (mn $m^2$) | **Building standards** (%) | **Energy-saving** (kgce/$m^2$) | **Costs** (RMB/$m^2$) | **Investment in energy-saving** (mn RMB) | **$CO_2$ emissions reductions** ('000 tonnes) |
|---|---|---|---|---|---|---|
| New buildings | 22 | 65 | 2 | 120 | 2640 | 120.7 |
| Existing buildings | 36 | 50 | 3 | 180 | 6817 | 295.1 |
| Total | | | | | 9457 | 415.8 |

Source: Jilin University, 2009

### 5.3.1 New buildings

Jilin City's adoption of the civil building energy-saving by-law, promulgated by the State Council in October 2008, means that regulations for civil buildings are to be formally incorporated in the national system for standardization. Accordingly, Jilin City started to implement a 65% energy-saving design standard, a significant advance on the previous 50% energy-saving target.[10]

At the current rate of construction, new buildings in Jilin City will have a total floor space of about 2 million $m^2$ per annum (see Table 5.3). If all new buildings were to reach the 65% energy-saving standard, the amount of energy consumed for heating would decline by 2 kg sce/$m^2$. Meeting the 65% target would require an additional investment of RMB 2.64 billion per annum.

Under normal market conditions, the 'payback' period for investing in higher-efficiency housing is usually measured in months. However, the lower energy prices charged to consumers in Jilin City mean that it would take about 30 years for the investment costs to be recovered (see Appendix D).

Energy pricing reform could dramatically alter this situation, creating an incentive for consumers to act on energy efficiency.

### 5.3.2 Existing buildings

By 2008, the registered housing area in Jilin City was 55.8 million $m^2$, of which only 12.9 million $m^2$ reached the energy-saving standard of 50%. The remaining 42.9 million $m^2$ reached only a 30% level.

By upgrading insulation in existing buildings, the amount of energy consumed by households for heating can be reduced from 18kg sce/$m^2$ to 15 kg sce/$m^2$. Improving existing buildings to the 50% level will require RMB 6.817 billion. By implementing the energy standard of 3kg sce/$m^2$, Jilin City will save 0.1077 million tonnes sce per annum and reduce $CO_2$ emissions by 29.51 tonnes per annum.

In order to meet the new building energy-saving standard of 65%, Jilin City urgently needs energy-saving technology for wall materials and exterior wall thermal insulation. In addition, new technology for producing low energy-consumption building materials is required. This could be one focus of the proposed technology cooperation platform for Jilin City.

10 'The notice on the strict implementation of the energy-saving design standards for new residential building', promulgated by the Ministry of Housing and Urban-Rural Development of the People's Republic of China.

Requiring higher energy-efficiency standards in new buildings usually has a much faster payback period. Work undertaken by McKinsey in China has suggested that savings in the building sector are large and that '70% of the abatement potentials has a negative cost'. In total, savings across China in the order of 1.1 Gt of $C0_2e$ would be possible by 2030.[11]

## 5.4 Vehicles and transport

Jilin City's transport strategy should be a combination of avoiding lock-in through urban design and public transport; encouraging lower carbon vehicles; and shifting the vehicle-manufacturing base to creating a platform for exports. Vehicle-manufacturing is a key industry for Jilin City. Global trends in lower carbon transport are therefore of significant interest, including more efficient combustion engines, natural gas and electric vehicle options.

Owing to the rapid economic development and urbanization of Jilin City, ownership of motor vehicles is increasing significantly. At the end of 2007, the number of motor vehicles was 480,000. These consumed 216,000 tonnes of gasoline and 269,000 tonnes of diesel, with associated emissions of 1,558,000 tonnes of $CO_2$, about 15% of total energy-related emissions in Jilin City.

Since 2000 the average annual growth rate in the number of private cars has been 24%; the rate for motorcycles and tractors has grown more slowly but still rapidly, at 13% per annum. This is faster than the growth of the economy, and so private transport will take up an increasing share of Jilin City's emissions unless additional policies are introduced.

In order to reduce transport emissions and to promote low carbon development, Jilin City will follow a three-part strategy:

- Develop a comprehensive transport strategy focused on green transport, avoiding lock-in;
- Focus on energy conservation via a modal shift to public transport;
- Manufacture low carbon vehicles, including natural gas and potentially electric vehicles.

Jilin City could also consider introducing vehicle emissions standards above the national average. This is already the case in Beijing, for example, which is only two years behind the implementation of a standard equivalent to that of the EU. Excelling at efficiency will be an important dimension in accessing international markets.

### 5.4.1 Transportation system planning and research

Key research areas for a public transport development strategy include the future network structure; the steps required to construct it; network optimization; and the priority of urban public transport over other more emissions-intensive modes.

In this context, research should focus on a scientific and rational urban road network structure based on wider sustainable urban planning and taking into account the current status of urban road conditions along with future needs.

Jilin City should also establish a plan for a rapid rail transit network to be developed in the medium term.

### 5.4.2 Low carbon public transport

Jilin City is actively promoting the transformation of buses and taxis into compressed natural gas (CNG) vehicles. This is a cost-effective switch which results in lower GHG emissions. Carbon dioxide emissions from CNG vehicles are around 20% lower than for efficient diesel vehicles,[12] and particulate pollution is greatly reduced. A life-cycle assessment using Jilin City-specific data could help identify the environmental benefits in more detail, as emissions along the supply chain need to be considered. Jilin City plans to convert all existing buses and taxis to natural gas. The impact of this move is shown in Table 5.4.

11 McKinsey and Company (2009), 'China's Green Revolution: Prioritising Technologies to Achieve Energy and Environmental Sustainability'.
12 See, for example, Rohan Jayaratne, Soran Ristovski, Nickolas K. Meyer and Lidai Morawska (2009), 'Particle and gaseous emissions from compressed natural gas and ultralow sulphur diesel-fuelled buses at four steady engine loads'. *Science of the Total Environment*, 407(8), pp. 2845–52.

Table 5.4: Potential energy and carbon dioxide savings for CNG buses and taxis in Jilin City by 2012

| Items | Number of vehicles | Cost per vehicle ('000 RMB) | Energy-saving investment (mn RMB) | $CO_2$ emission reductions ('000 tonnes) |
|---|---|---|---|---|
| Bus | 660 | 14 | 9.24 | 9.2 |
| Taxi | 4,452 | 6 | 26.7 | 238.3 |
| Total | | | 36.0 | 247.5 |

Source: Jilin University, 2009

The shift to gas-fired vehicles brings significant savings for users. It is estimated that the payback period for converting a gasoline vehicle is around five months; it is 1.5 years for a new bus and less than 3 years for an existing bus. Details of these calculations can be found in Appendix D.

The China National Petroleum Corporation has signed a joint venture contract with the Jilin Provincial Government to build and manage the Changling–Changchun–Jilin gas pipeline, so the supply of gas to Jilin City is set to expand.

### 5.4.3 Biofuels

Jilin City has a large potential for accelerating the use of bioethanol in transport. In 2004, the Chinese government introduced a regulation requiring gasoline (E10) to be sold with a minimum of 10% ethanol in the provinces of Helongjiang, Jilin, Liaoning, Henan and Anhui. Jilin Province is currently the largest producer of bioethanol in China, and its production is around one-third of China's national total. Table 5.5 shows the major production capacities in China.

Table 5.5: Production of bioethanol in China

| Province | Company name | Raw material | 2005 production capacity (mn t per annum) | 2007 production capacity (mn t per annum) | Supply location | Supply volume (mn t per annum) |
|---|---|---|---|---|---|---|
| Heilong jiang | China Resources Alcohol Co | Maize | 100,000 | 100,000 | Heilongjiang | 100,000 |
| Jilin Province | Jilin Fuel Ethanol Co | Maize | 300,000 | 600,000 | Jilin Province | 100,000 |
| | | | | | Liaoning | 200,000 |
| Henan | Henan Tian Guan Fuel-Ethanol Co | Wheat | 200,000 | 200,000 | Henan | 86,842 |
| | | | | | Hubei<br>Hebei | 113,158 |
| Anhui | Anhui BBCA Biochemical Co | Corn | 320,000 | 320,000 | Anhui | 100,000 |
| | | | | | Shandong<br>Jiangsu | 220,000 |
| Guangxi | China Resources Alcohol Co | Cassava | - | 110,000 | Guangxi | 110,000 |
| Hebei | China Resources Alcohol Co | Sweet potato, maize etc | - | 230,000 | Hebei | 230,000 |
| Hubei | Tian Guan Fuel-Ethanol Co | Grains | - | 100,000 | Hubei | 100,000 |
| Total | | | 920,000 | 1,660,000 | | |

Source: China's Law Concerning Testing of the Extensive Use of Ethanol-Blended Gasoline for Automobiles and Regulations Concerning the Conduct of Testing of the Extensive Use of Ethanol-Blended Gasoline for Automobiles (2006).

China defined its biofuels plan in *The Middle and Long Term Development Plan for Renewable Energies*. In order to mitigate emissions in the transport sector while ensuring food security, the government has forbidden new biofuel projects to use foodstocks and encouraged cassava bioethanol and the development of cellulosic bioethanol technologies. However, life-cycle greenhouse gas emissions (including direct and indirect land-use change) are yet to be addressed, and developing a standardized method for measuring the greenhouse gas intensity of different biofuels is an urgent priority. With its large food manufacturing and forestry industries, Jilin City is an obvious place to examine this benchmarking question.

Jilin City's current supply of biofuels comes from first-generation technologies, which extract ethanol (or biodiesel) for transport use from a wide variety of crops Most of these are foodstocks and this therefore raise food security questions.

Second-generation technologies have the advantages of higher emissions reductions and being more suited for aviation, marine and heavy transport. However, their R&D requires more capital investment and a longer time for large-scale commercialization.

## 5.5 Agriculture, forestry and land use

Opportunities for low carbon development also exist in the agriculture and forestry sectors. Jilin City has, as noted, high forest coverage and is part of a major food-producing and food-processing region.

In 2007, 21% (5,620 km$^2$) of Jilin City's total area was under grain cultivation, including 349,000 hectares of maize, 145,000 hectares of rice, 57,000 hectares of soybean and 10,800 hectares of other grains. By 2007, there were 2,221 enterprises involved in agricultural processing, generating RMB 12.3 billion in output value (an annual increase of 25%) from processing 4.07 million tonnes of agricultural products. With a processing capacity of 8.19 million tonnes, the industry's output has the potential to expand significantly in the near future.

The Implementation Plan for Energy Saving and Emission Reduction in the Agricultural Sector and in Rural Areas in Jilin City focuses on reducing $CO_2$ emissions in the agriculture sector through increased efficiency in agricultural production. About half of the large and medium-sized agricultural appliances are outdated, resulting in very low efficiency and wasting around 20% of diesel. Since early 2008, the Jilin Municipal Agricultural Committee has worked with departments responsible for rural energy management and agricultural machinery to implement energy-saving and emission-reduction measures in rural areas. Planned efficiency-enhancing measures include a machinery purchase subsidy, raising the utilization rate of agricultural machinery and using agricultural machinery inspection and maintenance work as an opportunity to reduce oil consumption in agricultural machinery. Efforts will also focus on increasing the use of renewable energy sources in rural areas, such as methane, straw gasification and solar energy.

Additional greenhouse gas emissions savings could be achieved through changes in agricultural production methods. Improved soil management could provide the greatest potential for emissions reductions (in particular $N_2O$), for example through the reduced use of nitrogen-based fertilizers. Other important sources of greenhouse gas emissions in the sector include livestock and manure management, rice cultivation and the burning of agricultural residues in land clearing.

In addition, projects to reduce deforestation and forest degradation could be used to mitigate climate change and help to attract international funds to Jilin City. These so-called REDD projects (after the UN Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries) are likely to become part of carbon offset options under the successor to the Kyoto Protocol. International donors have earmarked considerable funds for preparing developing countries for such projects.

# 6 Identifying cooperation opportunities

An ambitious low carbon Jilin City would be in an excellent position to attract financial and technical cooperation. This could come from a range of public sources but also from private investment. Cooperation may mean support from the national government, working with other countries in the region (Jilin City has many economic and other ties with Singapore, Russia and South Korea, for example) or internationally.

Cooperation opportunities will depend partly on local development characteristics (as set out in Chapter 5), patterns of trade and foreign investment. Existing relationships (for instance, with Singapore on food processing or the vehicle manufacturer FAW's international partners) could be developed to focus on low carbon products, standards and markets.

At this time, a number of avenues are available for sub-national regions seeking to take transformative action on low carbon development. This also coincides with recent Chinese statements about the importance of pushing forward with regional low carbon development. In many cases, cooperation will be to mutual benefit.

The mutual benefit and interdependency between developed and developing countries on reaching low carbon goals is clear.[13] Experience and lessons learned both domestically and internationally can be shared in order to increase cost-effectiveness and to accelerate the deployment rate of low carbon technologies. Moreover, it is in the interests of international partners pursuing low carbon development to focus cooperation on industrial regions in developing countries such as Jilin City where real and significant ambitious goals for low carbon development are being set out.

## 6.1 Types of cooperation

The preferred type (and source) of cooperation or private investment will vary according to the maturity of a technology, sector or system. The policies and technologies section in Chapter 4 breaks the innovation chain into three broad categories: diffusion; commercialization; and research and demonstration. This is also a helpful distinction when considering cooperation opportunities.

It is important to recognize that this is a simplification. Technologies (such as CCS) can have components which fall at various points along the chain. Technologies are usually part of systems which can also be an important focus of cooperation. Moreover, they usually have a complicated heritage, which means that learning and innovation may cut across sectoral boundaries.[14]

Table 6.1 below provides a guide to matching the different types of cooperation available for technologies, systems and infrastructure issues along the innovation chain. This can be read in conjunction with the list of important technologies provided in Table 4.1.

13 Lee et al. (2007), *Changing Climates.*

14 Lee et al. (2009), *Who Owns Our Low Carbon Future?*

Table 6.1: Cooperation along the innovation chain

| **Diffusion stage** | **Commercialization stage** | **Research and demonstration stage** |
|---|---|---|
| **MATCHING TECHNOLOGIES AND SYSTEMS TO COOPERATION OPPORTUNITIES** | | |
| Regulations and standards:<br>• Technical assistance grants<br>• Support for technology and innovation platforms<br>• Shared policy experience<br>• Outward-looking regulatory approaches, e.g. the Ecodesign Directive<br>• Energy service companies | Market conditions, incentives and infrastructure:<br>• Carbon finance, including a reformed Clean Development Mechanism<br>• Targeted incentives for foreign direct investment<br>• Funds for leveraging private investment, e.g. the World Bank's Clean Technology Fund<br>• Licensing agreements<br>• External participation in standard development (e.g. for energy-using goods, vehicles) | Technology development and piloting:<br>• Joint government research, development and deployment<br>• Private-sector technical cooperation agreements |
| **MECHANISMS FOR JILIN CITY TO DEVELOP COOPERATION OPPORTUNITIES** | | |
| • Clear regulations<br>• Effective enforcement<br>• Commitment to benchmarking energy/emissions<br>• Strategic plans for low carbon development (especially if part of 12th Five-Year Plan) | • Public-sector deployment<br>• Local financial/investment incentives<br>• Targeting of stimulus to low carbon technologies/industries<br>• Reassurance on intellectual property | • Commitment to local piloting of a range of low carbon technologies<br>• Creating conditions to attract national/ international centres for research/ innovation<br>• Clear policy objectives in short and medium term |

Source: Chatham House, 2009

## 6.2 Domestic cooperation

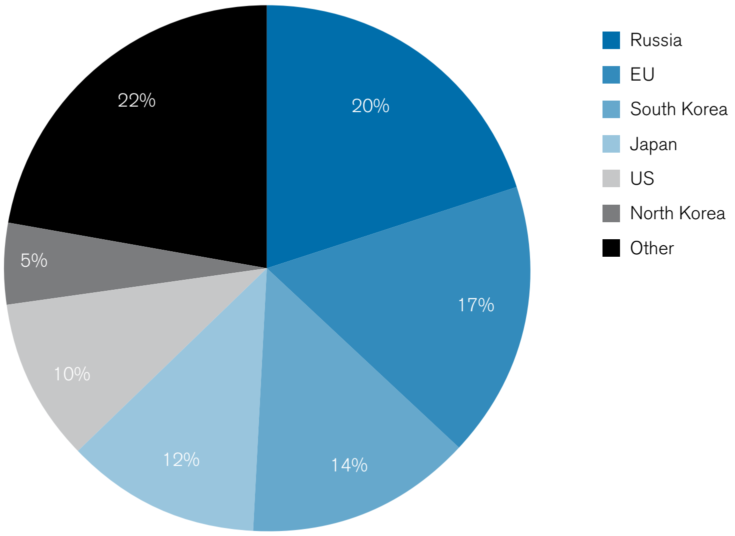
Low carbon development expectations have already been placed upon Jilin Province and Jilin City by the national government, for example through the setting of one of the largest targets for energy intensity improvement (22% in five years, compared to the national 20% target). Expansion of the use of wind energy and biofuels in Jilin Province is also considered a national priority. Such targets bring additional opportunities for national support or cooperation with the private sector elsewhere in China, and these are already being realized in many areas. One example is inward investment from the wind sector: the Jilin Mingyang Chase Wind-Electricity Equipment Manufacture Corporation is a subsidiary of the China Guangdong Ming-Yang Electric Group.

It was recently announced that the Changchun Hi-Tech Development Zone (in neighbouring Changchun, the capital of Jilin Province) would expand to include advanced energy and energy-service industries as well as automobiles, pharmaceuticals, photo-electronics, materials science and high-quality food processing. A strategy is emerging that will combine the strength of manufacturing in Changchun, Jilin City and elsewhere in Jilin Province. This is an exciting area for cooperation, potentially giving a low carbon Jilin City access to additional industrial advantages.

## 6.3 Regional cooperation

Jilin Province's regional connections are shown in the distribution of its exports, with four of the six largest destination countries located in Northeast Asia: Russia, South Korea, Japan and North Korea (see Figure 6.1).

Figure 6.1: Export destinations from Jilin Province




Source: Jilin Province Statistical Yearbook 2008

The extent of regional connections is further demonstrated by the following:

- The Greater Tumen Initiative (GTI), which is set to turn Jilin Province into an economic centre of Northeast Asia. The GTI is a joint mechanism of the five member countries: China, Mongolia, North Korea, South Korea and Russia. It provides a multilateral forum for the member countries to identify and implement regional initiatives that encourage economic growth, improve living standards and contribute to peace and stability in Northeast Asia.
- The Hunchun Border Economic Cooperation Zone in southeast Jilin Province, located at the intersection of the Chinese, North Korean and Russian borders. Initially this is focused on export-processing.
- A new sea route for cargo and passengers to Russia, Japan and South Korea, which was launched in 2007. The route connects Hunchun with Niigata in Japan, running through the Russian port of Zarubino and South Korea's Sokcho.[15]
- Hong Kong, South Korea and Japan are three of the top five investors in Jilin Province, following Germany and the US.
- South Korea has more foreign-funded enterprises in Jilin Province than any other country. Its fourth-largest lender, Hana Bank, has an 18% stake in the Bank of Jilin.
- Trade with Russia grew at an average rate of 90% per annum between 2004 and 2007. In 2009 Jilin University opened a major new Russian centre, an institute jointly established with Tomsk Polytechnic University and Volgograd State University.
- The Jilin City-Singapore food zone, which was established in 2008. Starting with a 5–10 $km^2$ area, this is designed to boost Singapore's food security while increasing investment in Jilin City as well as food exports.

One aim for a low carbon Jilin City could be to accelerate regional investment trade in low carbon goods and services. Regional partners together receive over half the province's exports while the other major trading blocs, the EU and the US, currently receive around 30% combined.

Regional cooperation would be diverse, as in some cases neighbours are much more technologically advanced (Japan, South Korea and in some areas Russia) while North Korea is behind Jilin Province.

15 Sergei Blagov (2006), 'Russia, China, Japan, and South Korea to launch new sea route linking China and Japan', *Eurasia Daily Monitor*, Vol. 3, Issue 166, Jamestown Foundation, Washington, DC

The GTI could review existing areas of cooperation to examine where cooperation on low carbon development could be enhanced, using Jilin City as the nexus.

## 6.4 International cooperation

A variety of multilateral funds is available for low carbon projects and sector initiatives. These include the Clean Technology Fund (CTF), a World Bank-hosted fund (although jointly managed with regional development banks, including the Asian Development Bank) but funded through bilateral contributions from individual countries ($6.1 billion in total). The CTF is intended to support projects in line with the Bali Action Plan, although there has been some discussion of its design and relevance to obligations under the UNFCCC.[16]

Any international deal in Mexico in November 2010 (the next major UN conference on climate change) is expected to be linked to further efforts on joint technology development and financial assistance for mitigation and adaptation. The Copenhagen Accord, signed at the last conference in December 2009, commits developed countries to provide new and additional resources to developing countries approaching US 30 billion for the period 2010 to 2012, balanced between adaptation and mitigation. The accord also includes a new Technology Mechanism, although few details were provided.

The European Commission argues that its share of short-term financing could be focused on developing countries with 'low carbon growth plans'; mitigation, including technology deployment worth €1 billion per annum; and technology research, development and demonstration of a value of €1 billion per annum, including 'assistance to key developing country partners on technology demonstration'. The operationalization of low carbon development in Jilin City could be a prime candidate for early support.

Jilin City's interest in benchmarking progress and introducing the low carbon development concept into government institutions suggests that action on data collection, emissions inventories and related institutions may be a priority for cooperation. Steps towards establishing a carbon exchange, an idea proposed by Jilin City, might also be attractive to support from an EU perspective. Furthermore, low carbon growth plans for petrochemicals and other heavy industries in Jilin City could be of great interest to better understand the challenges and solutions for sustainable industrialization.

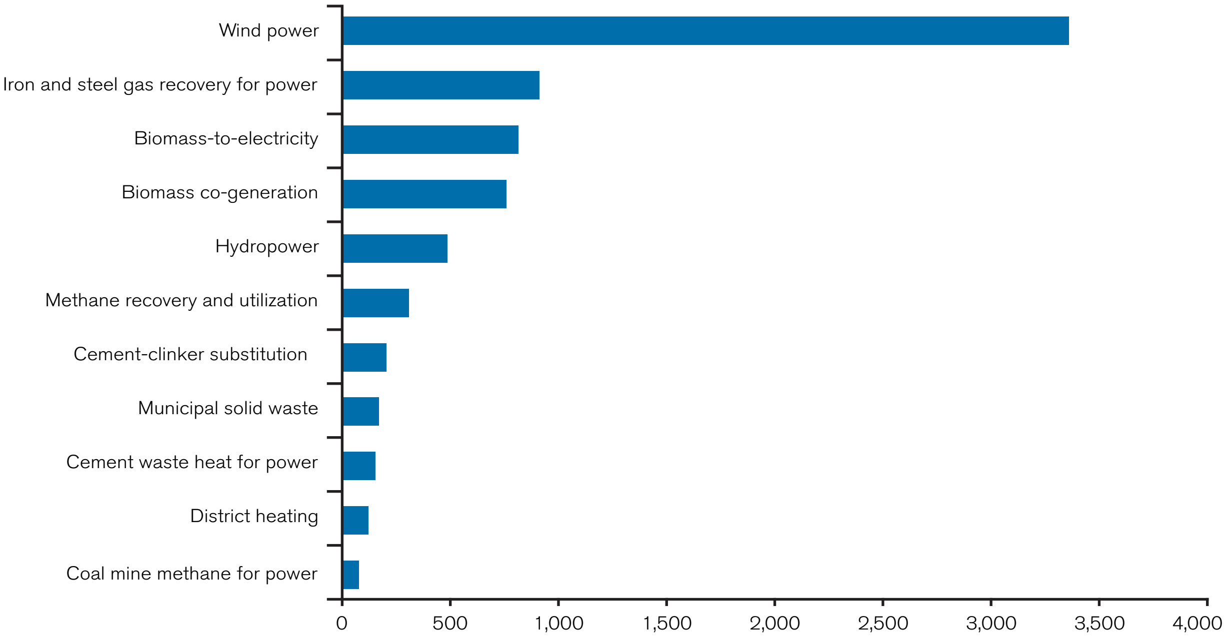
### 6.4.1 Carbon finance

China hosts more Clean Development Mechanism (CDM) projects than any other country – over one-third of the global total[17] – and it has a strong interest in the current discussions of possible changes to the CDM beyond 2012. However, Jilin Province has not been a major focus for the CDM, providing less than 1% of Chinese Certified Emission Reductions.[18] All eight projects that have been issued emissions-saving certificates so far are small to medium-sized wind farms. Developed country partners include Austria, France, Spain and the UK.

However, more than 50 approved projects are in the pipeline for Jilin Province, with total estimated average annual emissions savings of 7.4 million tonnes $CO_2e$ (see Figure 6.2). These are dominated by wind power but also include significant projects in iron and steel (recovery of furnace gas to drive turbines), biomass to electricity, hydropower, methane recovery from landfill, cement (substituting clinker and using waste heat for power) and incineration of municipal waste. The majority of these projects are not in the Jilin City municipality, but they underscore the range of emissions-reduction opportunities available in the region. A more detailed breakdown is provided in Appendix E.

16 Third World Network (2008), 10 April 2008, available online at: http://www.twnside.org.sg/title2/finance/docs/Climate.Funds-Commentary.Revised.doc.
17 UNFCCC, CDM Statistics, accessed 2009, available online at: http://cdm.unfccc.int/statistics1.
18 China CDM website, October 2009, available online at: cdm.ccchina.gov.cn/english/.

Figure 6.2: Estimated annual emissions reductions from approved CDM projects in Jilin Province




Source: Chatham House analysis of data from China CDM website, 2009

The future of the CDM is unclear, as there are a number of proposals for its abolition or reform under international climate change negotiations. This may well include a movement away from individual project financing to a sectoral approach, which would enable larger volumes of funding to be made available for reform across a sector in a particular country or region. Many opportunities may be available to Jilin City in the near future, in key industrial sectors, transport and buildings.

### 6.4.2 Technology cooperation

A major area for cooperation is technology. Jilin City sees technology and innovation as even more important than finance and investment for its low carbon development. Upgrading the existing old industrial enterprises will be one of the largest challenges: the overall level of science and technology in Jilin City is relatively poor.

Across a wide range of energy-saving and energy-efficiency technologies and renewable energy and cleaner coal technologies, Jilin City is a long way from international best-available levels. Moreover, R&D investment is currently too low – Jilin City invests a total of RMB 428.75 million in fixed assets of scientific research, technical services and the geological prospecting industry – accounting for just 0.43% of the region's GDP. Jilin City will need to enhance and accelerate its research base so that its industries can benefit from local innovation and technological progress.

International partners should consider a range of opportunities, such as support for low carbon technology platforms, in Jilin City; technologies for the advanced efficiency of buildings; and collaboration on technology research and standard-setting (for example, for vehicles emissions). Major piloting and demonstration projects and programmes (for example, on CCS) are also possible routes for cooperation.

Partners for technology cooperation are not in short supply. Major research centres include the Electric Power University, the Jilin Institute of Chemical Technology, the Jilin Environmental Science Research Institute, China Petroleum Jilin Chemical Industry Institute of Petrochemical Corporation, the Jilin Carbon Group Technology Centre, the Jilin Ferroalloy Co. Technical Centre and the Centre for Clean Coal Combustion Technology.

### 6.4.3 Intellectual property rights

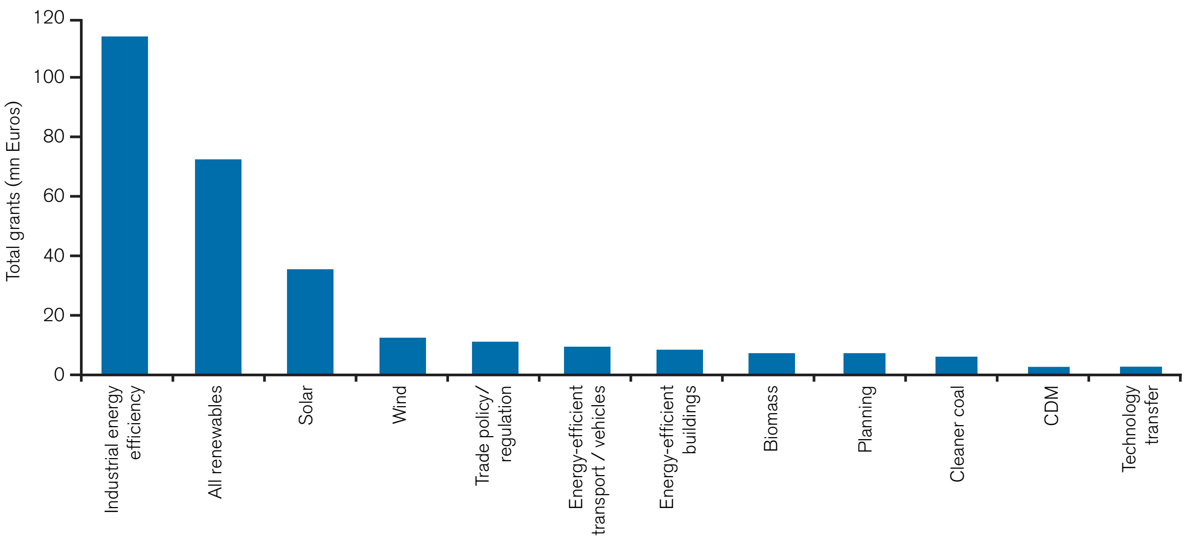
Intellectual property rights (IPR) issues remain a key concern for foreign investors in China. Jilin Province is taking steps to advance IPR protection. For example, it is home to one of China's ten 'IPR maintenance and assistance centres'. Established in October 2008, this is the only such centre in northeast China. It provides IPR-related services for local enterprises, public institutions, organizations and individuals for free, as well as a consultation service for institutions investing in the province. Its main functions are building a cooperative network for IPR maintenance and assistance and conducting related activities. It is staffed by 20 experts from patent and trademark agencies, law offices, universities and scientific institutions.

The IPR Maintenance and Assistance Centre could provide a focus for international cooperation to assist Jilin Province in strengthening its IPR activities. It is situated in Changchun City but serves the whole province. One option would be for it to open an office in Jilin City itself which could focus on low carbon technology.

### 6.4.4 EU bilateral cooperation

At least 10 EU member states plus the European Commission have recent or ongoing projects in China related to sustainable low carbon development. They fall into a range of categories, as shown in Figure 6.3. Over 80% of the grants provided have been aimed at improving energy efficiency in industry and developing renewable energy. There are also significant efforts regarding energy-efficient vehicles and buildings.

Figure 6.3: Relevant 'recent and ongoing' project grants in China from the European Union and EU member states




Source: Chatham House analysis of European Commission data, 2008

The data shown in Figure 6.3 are almost certainly an underestimation, as these projects are officially recorded as cooperation projects – and a significant number of projects are not listed in this way. The vast majority of the projects represented in the data have been undertaken in the past five years.

Regions and cities within developing countries that commit to low carbon development can be expected to attract a greater range and number of cooperation projects with the EU and other countries because the members of the EU and other countries are keen to promote and support commitments to experimenting with low carbon development models. The EU for its part would benefit from focusing and coordinating its cooperation with specific regions, aiming to demonstrate a broad low carbon transition as opposed to dispersed projects across a whole country. Jilin City is clearly one region deserving consideration for such support.

# 7 Policy recommendations

As the world, including China, moves towards a low carbon economy, it will need sub-national governments to demonstrate the quickest and most efficient pathways. As pioneers, those regional governments will potentially have to overcome more barriers than those that follow, but they will also reap the first-mover advantage and potentially gain increased national and international financial and technical support.

Moving towards a sustainable, low carbon economy will require changes across all elements of society, and therefore a clearly developed plan should be implemented, with benchmarks against which progress can be measured and policies adjusted. This roadmap, which sets out the elements of a detailed plan, could act as a template for other regions and cities to develop their own low carbon economic pathways.

In undertaking the proposals in this report, Jilin City would be making a commitment – especially on energy and carbon intensity, renewables and land use – that goes significantly beyond existing and future national targets. This level of ambition should be recognized and rewarded.

The 12th Five-Year Plan offers an important opportunity for Jilin City to integrate its low carbon ambitions with its development strategy. National carbon-intensity targets are expected to be translated to the provincial and municipal levels, requiring additional monitoring and enforcement. To assist in meeting these targets, a number of cross-sectoral and sectoral measures could be considered. Recommendations in key areas are set out in the following sections.

## 7.1 Institutions, regulation and innovation in policy-making

The opportunities, needs and challenges for government institutions in Jilin City are discussed in Chapter 4. Meeting low carbon targets will require enhanced regulations, combined with successful enforcement. As China's experience with setting building standards shows, institutions and implementation are as important in achieving low carbon goals as is establishing strong standards.

Recommendations to consider in this area include:

- Incorporating the low carbon economy concept into 12th Five-Year Plan and government departmental planning.
- Creating integrated systems for benchmarking, data collection and policy development
- Establishing independent agencies to assess the effective implementation of energy-efficiency standards.
- Strengthening the activities of Jilin Province's IPR Maintenance and Assistance Centre with a focus on low carbon technologies.
- Making low carbon development benchmarks an important part of performance assessment.
- Allowing Jilin City the flexibility to innovate low carbon policy and regulations.

Developing the low carbon economy raises new objectives and requirements for relevant enterprises in Jilin City. To speed up its introduction, skills and knowledge development should be supported, for example through training programmes, and access to new technology and financing will require adjustments in the functioning of enterprises and policies of the municipal, provincial and national governments.

There is a clear need for benchmarking and institutional capacity-building, both of which could be supported by international cooperation.

## 7.2 Low carbon growth in key industries

Key industries can become a major driver of low carbon growth in Jilin City, as discussed in Chapter 5. Plans should be developed for each sector, focusing on low carbon goods and services and considering the links with other sectors. The major industries highlighted in the roadmap include petrochemicals, energy, transport and vehicles, and forestry and agriculture. Other local industries, such as pharmaceuticals and information technology, also deserve further research.

Rapid programmes for energy-efficiency improvements are required in heavy industry, where 32 enterprises account for 85% of industrial electricity consumption. Modelling results also highlight the importance of structural reform over time, with a growing share of GDP generated by low carbon industries.

Local deployment of energy-efficient and renewable energy technologies will help to achieve multiple objectives: meeting Jilin City's energy- and emissions-intensity targets; enhancing local innovation and know-how via learning-by-doing; and ultimately creating low carbon industries which are in a strong position to access rapidly growing regional and global markets.

Recommendations to consider in this area include:

- Developing low carbon growth plans with local industry, piloting a 'circular economy-plus' approach that builds on the linkages between sectors.
- Energy-intensity targets at the sectoral level, taking into account existing standards and production levels, the current best-available technology and anticipated innovation in the sector.
- Establishing a low carbon manufacturing and technology exchange in Jilin City. This would be a centre for innovation, attract investment in low carbon technology from the private sector and develop opportunities for export for local manufacturing industries. Renewable energy, advanced energy efficiency and low carbon vehicle technologies are priority areas for investment and enhanced innovation capacity.
- Undertake further research on the important potential contribution from land-based sectors, including agriculture and forestry, which are already major carbon sinks. Forestry could be a major source of carbon finance in future. In general, rural low carbon growth is an important opportunity to help rebalance urban-rural development.

International cooperation in this area could be channelled via the major international companies operating in Jilin City. Public support from developed countries could focus on access to European technology research activities and standard-setting bodies.

## 7.3 Transforming the energy sector

The energy sector will play a major role in Jilin City's low carbon development. The characteristics of existing and future supply and demand scenarios are set out in Chapters 2 and 3. Currently, Jilin City's energy supply is dominated by coal and oil. Over time, a much larger share will be taken by renewable energy, which will also make a major contribution to energy security.

Energy-efficiency measures are at the heart of the short-term measures that will get Jilin City on to a low carbon scenario. Specific requirements can be placed on heavy industry, as described above. However, price reform is essential for broader efficiency improvements.

Recommendations to consider in this area include:

- Commit to renewable energy deployment at a rate significantly higher than the national average. Wind and second-generation biomass have major potential in Jilin City. In rural areas, a significant increase in the utilization of methane, straw gasification and solar energy can be achieved. Jilin

City's position at the heart of the northeast grid gives it a major advantage in connecting renewable generation to the network.

- Accelerate energy efficiency in coal power plant and the transmission grid and switch from coal to natural gas where possible. There should be a continued focus on combined heat and power systems.
- Investigate the developing and piloting of carbon capture and storage in view of current experience of its use for enhanced oil recovery and the potentially advantageous geology for $CO_2$ storage.
- Energy prices must, eventually, reflect full environmental and societal costs. Without such reform, the economic incentives of energy efficiency are significantly reduced. Price reform and the removal of subsidies have significant societal impacts, but these can be addressed through other social and fiscal policies.
- Jilin City could establish a new carbon exchange, with a wider scope than the existing exchanges in China. This would make it a low carbon financial centre for the northeast and eventually the rest of the country.

## 7.4 Urbanization and transport

Rapid urban growth and greater demand for transport mean the construction of new infrastructure that will be used for at least a generation. It is important to ensure that this is low carbon and highly efficient, avoiding locking Jilin City into high levels of emissions. This means looking at urban systems as well as at the energy efficiency of individual buildings and vehicles. Infrastructure must also be able to cope with environmental changes resulting from climate change.

Jilin City has a good record in implementing energy efficiency in buildings compared with other parts of China, and could become a leader in this area as it pushes forward on low carbon development. Together with its near-neighbour Changchun City, it is also a major vehicle manufacturer (see Chapter 5). Combining (the manufacture of) low carbon vehicles, buildings and sustainable urbanization strategies, Jilin City is well placed to begin demonstrating a systemic approach to decarbonization.

Recommendations to consider in this area include:

- Prioritization of public transport (particularly an urban rail system) and encouraging a shift in transport modes.
- Enforcing higher emissions standards for private and public vehicles and encouraging fuel switching to natural gas, biofuels and electric vehicles.
- Becoming a pilot area for an integrated approach to energy efficiency and emissions-saving in buildings, transport and infrastructure.

# Appendix A:
# Summary of policies and measures for low carbon development in Jilin City

| **Sub-sector** | **Short** (before the end of the 12th Five-Year Plan | **Medium** (up to 2030) | **Long** (up to 2050) |
|---|---|---|---|
| GOVERNMENT CAPACITY- BUILDING | | | |
| | Establish new government administration for energy saving and emissions reduction; establish a special fund for low carbon; develop and implement a low carbon economy index. | Detail and implement a low carbon economy development strategy; Develop financial and technology support for the low carbon transformation of enterprises by investment or utilization of the carbon market. | |
| FINANCIAL POLICIES | | | |
| | Enlarge investment for low carbon infra-structure; financial incentives for enterprises developing the low carbon economy (including lowering tax levels and interest rates). Begin reform of energy pricing. | Impose taxes on energy-intensive industries. | |
| PLANNING AND DESIGN | | | |
| | Bring energy-saving and emissions-reduction concepts into the social development programmes of urban planning and the local economy; promote the optimization of urban spatial planning; organize publicity and training programmes to help bring about a low carbon economy. | Develop emissions inventories in pilots. | |
| TRANSPORT | | | |
| Private transport | Raise fuel quality standards so as to reduce emissions (and to enable efficiency improvements, e.g. via lean-burn technology); develop effective enforcement mechanisms for fuel quality and vehicle efficiency; provide clear direction of travel to industry and officials on low carbon mobility. | Establish clear, incrementally increasing vehicle emissions standards and incentives for phasing out inefficient vehicles; make preparations for a significant modal shift away from private transport; seek harmonization of international fuel quality and electric vehicle standards, creating a platform for exports of low carbon vehicles. | |
| | Integrate road building into sustainable urbanization plans; refinery investment to achieve higher fuel standards. | Roll out of charging points for electric vehicles/hydrogen fuelling points; require new fuel stations to carry charging points. | Low carbon transport system integrated with urban design and connected to smart grid; much greater use of mass transit systems requires significant new investment. |

KEY:

Institutions/govt | Infrastructure | Resources | Avoiding lock-in | Technology

| **Sub-sector** | **Short** (before the end of the 12th Five-Year Plan | **Medium** (up to 2030) | **Long** (up to 2050) |
|---|---|---|---|
| TRANSPORT | | | |
| Private transport | Price interventions to encourage fuel efficiency and diversification away from oil, initially through the greater use of liquid petroleum gas in taxi and bus systems. | Lithium/cadmium availability mapping and long-run technology planning; develop hydrogen production facilities; production facilities for second- and third-generation biofuels; resolve food/ fuel conflicts. | Significant concern over widespread availability and affordability of liquid transport fuels. |
| | R&D second- and third-generation biofuels | Lighter materials for car manufacturing; fuel cell R&D. | Battery shapes |
| | Dual use vehicles; avoid lock-in to first- generation biofuels. | | |
| Freight | Priority to move goods by rail or boat; clear investment plans needed | Significant concern over widespread availability and affordability of liquid transport fuels leads to less freight movement by road. | |
| | Identification of bottlenecks | Alternative transport network for freight | |
| | Efficiency standards for trains | | |
| Public transport | Higher priority for government investment; clear investment plans; public procurement of alternative transport fuels and systems. | | |
| | Develop driver training programme for fuel-efficient driving; public procurement of efficient/electric vehicles/H2 vehicles. | | |
| | Identification of key bottlenecks | Roll-out of charging points for electric vehicles/H2 fuelling points. | |
| | | Lithium/cadmium availability mapping and long-run technology planning; develop H2 production facilities; production facilities for second- and third-generation biofuels; resolve food/fuel conflicts. | Significant concern over widespread availability and affordability of liquid transport fuels. |
| | Efficiency standards; intelligent traffic management | | |
| BUILDINGS | | | |
| | Enforcement of existing efficiency standards; planning regulations; regulatory frameworks and targets for CHP. | Introduce higher building-efficiency standards; retrofit government buildings. | Removal of inefficient housing |
| | Planning city infrastructure to provide integrated transport/sustainable urbanization development, including networks for CHP and district heating. | Least-cost planning models, including resource efficiency | |
| | Develop capability for energy services industry. | Establish scope for expansion of co-firing and biomass. | |
| | Materials R&D; develop options for lower embodied-carbon building materials; improve efficiency standards for CHP. | Best available technology on building performance; phase in options for lower embodied-carbon building materials; otions for district cooling. | Zero-emissions housing |
| | Urban design, multi-fuel options for heat and power. | | |

| Sub-sector | **Short** (before the end of the 12th Five-Year Plan | **Medium** (up to 2030) | **Long** (up to 2050) |
|---|---|---|---|
| INDUSTRY | | | |
| | Long-run planning for industrialization strategy to match balancing of export/domestic demand growth; identify strategic roles for high carbon industries in low carbon development. | Phase-out of inefficient facilities; lead development of international energy efficiency best practice standards; appropriate pricing signals, including embodied carbon. | Carbon constraints/pricing |
| | Gearing up supply chains to implement low carbon industrial strategy in key sectors. | | |
| | Efficiency R&D | Innovation leader by 2030 in industrial energy efficiency | |
| GAS/POWER/$CO_2$ NETWORKS | | | |
| | Ensure equal grid access for all sources and equitable treatment of new entrants; technologies for charging from grid extensions/reinforcements. | Planning for changes to gas and electricity supply and demand patterns resulting from sustainable industrialization; assessment of viability of $CO_2$ storage sites; potential for upgrading gas networks for $CO_2$ transport. | |
| | Grid construction to connect renewables; planning for future grid/power expansions from low carbon sources. | Develop pilot $CO_2$ transport/storage infrastructure. | Roll out full CCS infrastructure if proven. |
| | Biogas and biofuel development | | |
| | Efficiency improvements to reduce transmission/distribution losses for electricity and gas; explore high-voltage DC options. | Smart metering for electricity grids. | Dynamic demand and responsive equipment/appliances |
| | Grid restructuring to enable diversity of low carbon energy sources | Biogas grid access | |
| POWER GENERATION | | | |
| Renewables | Price guarantees and targets for renewables; ensure adequate financing mechanisms in place; meeting targets for the increased use of wind, hydro and other renewable energy. | Systems in place to ensure diffusion of concentrated solar/offshore wind; ensure ambitious targets are met for the use of renewable energy, particularly, wind, solar and hydro. | |
| Renewables | Guarantee grid access; scale up manufacturing capabilities. | Micro generation and distributed generation; grid connections. | |
| Renewables | Resource mapping for renewables | | |
| Renewables | Improvements in conversion efficiency for renewables | Next generation of technologies, PV, wind, biomass | |
| | Enforcement of closure plans for inefficient coal; government targets for diversification away from coal. | | Carbon constraints/pricing |

KEY:

Institutions/govt | Infrastructure | Resources | Avoiding lock-in | Technology

| Sub-sector | **Short** (before the end of the 12th Five-Year Plan | **Medium** (up to 2030) | **Long** (up to 2050) |
|---|---|---|---|
| POWER GENERATION | | | |
| Fossil fuels | Access to transportation; ports/railways for coal; pipelines/LNG terminals for gas. | | |
| | | Assess energy requirements for CCS; ensure access to gas markets. | |
| | Power-generation efficiency improvements; develop biogas alternatives. | Carbon capture technology development | CCS deployment |
| | Enforceable emissions targets | | |
| Nuclear | Establishment of independent regulator; streamlined and transparent licensing process. | | |
| | Scaling up manufacturing capabilities | Waste storage facilities | |
| | | Uranium availability | |
| | Waste management | Generation IV design development and material research; reprocessing of waste; non-proliferation measures. | Nuclear fusion |

KEY:

Institutions/govt Infrastructure Resources Avoiding lock-in Technology

Source: Chatham House, 2009

# Appendix B: Additional material on CASS methodology

## Elements of low carbon economy status in Jilin

| National parameters | Jilin City's status |
|---|---|
| RESOURCE ENDOWMENT | |
| Resource endowment covers a wide range of resources, such as minerals, renewable energy potential land resources – especially forestry, available labour, funding and technology resources. All these are crucial inputs to the LCE assessment. Natural and geological conditions shape living conditions and impact on lifestyles, helping to determine the level of energy dependence. The availability of low carbon resources plays an important role in low carbon development. | In 2007 the per capita 'zero carbon' energy consumption in Jilin City was 0.075 tce, only 54% of the national average level of 0.14 tce. This, combined with rich natural resources, indicates a significant potential to develop renewable energy in particular. There are significant hydro, biomass and wind resources.<br><br>The forest coverage rate of Jilin City in 2007 was 54.96%, far higher than the national level of 9.96% that is required for eco-cities. |
| TECHNOLOGY | |
| Technology innovation is crucial to the low carbon economy. Energy-intensive sectors are the focus here – for example, electricity, transport, buildings and construction, smelting, petrochemicals, fossil chemicals and vehicle production. This includes both the application of available technology that could be commercialized, and technologies that could be applied in future. Currently, low carbon technology in the energy sector ranges mainly from energy efficiency, clean coal, oil gas and coal-bed gas to renewable and new energy, carbon capture and storage. | Jilin City is already an important innovator of key technologies, such as biomass (it has one of the largest alcohol fuel plants in Asia) and carbon capture and storage. Actual and proposed policies and measures are likely to augment its innovation role. This applies particularly to the area of automobiles, wind power, building standards and biomass.<br><br>Important opportunities exist to further enhance Jilin's technological leadership through developments in the petrochemical and pharmaceutical fields. |
| CONSUMPTION PATTERNS | |
| All economic activities are aimed at current or future consumption, so eventually all energy consumption is driven by various consumption demands. Research shows that owing to differences in development level, national conditions and lifestyles, residents in different countries have very different energy-consumption and carbon-emission patterns. Consumption emission is not only correlated to climate, per capita income, culture and habits and resource endowment; it is also affected by consumption patterns and consumer behaviour. | The per capita carbon emission of Jilin City in 2007 was 2.79 tonnes carbon per person, 2.5 times as high as the national average level of 1.36 tonnes carbon. However, the per capita GDP for Jilin City in that year was RMB 23,277, only 18.66% higher than the national average. This is a reflection of the higher carbon content of the energy mix and the relatively low energy-efficiency standards of the City. |
| ECONOMY DEVELOPMENT STAGE | |
| A country's stage of development is the context and starting point of its transition to a low carbon economy. Developed countries have already reached a high human development level while developing countries face the challenge of realizing low carbon transition as well as human development.<br><br>The emissions of developing countries will inevitably increase because of their high population growth rate and basic needs to be met. Countries at different development stages face different problems and costs in the process of low carbon transition. Therefore they should choose different policies and pathways. | Jilin City is in the category of medium-high GDP in the China context.<br><br>In 2007 the ratio of primary, secondary and tertiary industry in Jilin City was 13.5: 49.3: 41.9, very close to the national ratio. However, China's average carbon productivity was RMB 15,600/tonnes carbon while Jilin City's carbon productivity was RMB 8,300/tonnes carbon, only 53% of the national level. |

## Indicator system for low carbon economy development (absolute value)

| Indicator | No. | Sub-indicator | Note |
|---|---|---|---|
| Low carbon productivity | (1) | Carbon productivity | Higher than the average level of the Nordic countries is seen as low carbon; between the Nordic countries' average and the OECD average level is medium carbon; lower than the OECD average level is high carbon. |
| Low carbon consumption | (2) | Per capita carbon emission | Below 5t$CO_2$ is seen as low carbon; between 5t$CO_2$ and 10t$CO_2$ is medium carbon; more than 10t$CO_2$ is high carbon. |
| | (3) | Per household carbon emission | Below 5.3t$CO_2$ is seen as low carbon; 5.3t$CO_2$ and 10.3t$CO_2$ is medium carbon; more than 10.3t$CO_2$ is high carbon. |
| Low carbon resources | (4) | Proportion of renewable energy in primary energy | Below 10% is seen as high carbon; between 10% and 20% is medium carbon; more than 20% is low carbon. |
| Human development level | (5) | Human Development Index | Higher than 0.8 is high human development; between 0.5 and 0.8 is medium human development; less than 0.5 is low human development. |

# Appendix C: Additional material from ERI scenarios

## Prioritized sectors and measures for realizing the low carbon development scenario

| Sectors | Prioritized areas and measures |
|---|---|
| Industry | Make industrial development strategies; establish technology R&D plan; enhance R&D investment; carbon tax/energy tax; tax reduction/concessions; government subsidy/support; laws/regulations; build up technology innovation mechanism; new technology demonstration; resource recycle and utilization; energy audit and certification; improve the energy efficiency criteria and labelling; carry out voluntary agreements; carry out international cooperation; build up energy-saving and GHG-reduction consciousness; encourage enterprises to take part in voluntary agreements; give financial support to enterprises which take emissions reduction actions; give income tax preferential policy to energy-saving products etc.<br><br>Low carbon-intensity and high energy-efficiency production techniques; high-efficiency industrial boilers; advanced industrial energy-saving technologies (in iron and steel, building materials, glass, chemicals sectors etc.); energy-efficient electric motors; waste recycle and utilization technology; establish stricter energy-efficiency standards; low carbon product standards; reduce the subsidy or preferential tax for energy-intensive sectors; carbon trade; develop circular economy; develop technology markets; introduce and learn from advanced technologies; adjust product structure; develop high-added-value industries and products with low energy consumption etc. |
| Energy supply (power generation) | Integrated gasification combined cycle (IGCC); natural gas combustion turbine; combined cycle gas turbine; distributed power generation systems; polygeneration technology; biomass utilization technology; hydropower technology; nuclear energy (fission and fusion, including pressurized fluidized bed combustion reactors; combined heat and power (CHP); carbon capture and storage; solar generation, biomass liquefaction; new fuel wood forests; wind power, solar power; non-conventional oil; clean-coal technology; biological technology; nano-technology etc. |
| Transport | Develop non-motorized vehicles; construct convenient urban transport system for bicycles and pedestrians; develop public transport and public transport system; transport system design and planning; hybrid vehicles; reduce tax and fees or give subsidy for new efficient and clean vehicles; establish obligatory or voluntary standards to increase the fuel economy; raise the public consciousness etc.<br><br>Develop advanced diesel, hybrid fuels, hydrogen, fuel cell, advanced diesel vehicles and biomass fuels; increase the operational costs for private cars; TDM; develop non-motorized transport; develop substitute materials and substitute energy (such as using lighter materials); fuel cell vehicles; renewable energy technology; levying fuel tax for vehicles.<br><br>Jilin City can further consider increasing the dash rate of fuel ethanol in gasoline and introduce flexible-fuel vehicles. |
| Buildings | New buildings implement the 65% and 75% energy-saving buildings standards; increase the energy saving standards gradually; use fan pumps in central air-conditioning systems; frequency-control technology; use energy-saving and water-saving electric appliances; use heat pumps and solar water heaters; household solar systems; renewable energy utilization technology; popularize heat supply measurement instruments; build up technology consultation and information network; build up buildings' energy-management systems; implement energy audit; carry out demand-side management; establish energy-efficiency criteria and sign system for all appliances; energy saving criteria for buildings; standards for household appliances; energy-saving lamps etc.<br><br>Super-high-efficiency buildings; sustainable (green) buildings; use advanced heating and cooling technology; encourage using cold and heat storage air-conditioning; popularize combined cooling, heating and power systems (CCHP) technology; supply cheap renewable energy for new buildings; encourage developers to build advanced energy-saving and green buildings; phase-change material storage technology; new building materials etc. |

| Sectors | Prioritized areas and measures |
|---|---|
| Domestic and international low carbon development cooperation | Make full use of all opportunities in international cooperation; extend international cooperation with financial and technical support, including the current CDM projects and possible carbon trade opportunities. Right now there are many bilateral and multilateral cooperation opportunities. |
| CCS technology | Utilize the domestically planned and international demonstration projects, to promote the utilization of CCS technology in the power generation, cement and iron and steel sectors. |

## Key advanced technologies for meeting the low carbon scenario

| Department | Advanced technologies and policies |
|---|---|
| Building industry | The energy saving standards of 65% and 75% are implemented, and the standards will increase year by year. Buildings with characteristics of high energy efficiency, sustainable (green) buildings, applying advanced refrigeration and heating technologies are the main trend. Encourage use of ice storage and heat storage air controllers; CCHP systems; solar water heaters; heat metering technology; and fans and pumps with frequency converters that can adjust the speed and torque of the motor to save energy and water (e.g. in central air conditioning and heating systems, electrical equipment and heat pumps). Establish the energy management system and the technical consultation and information network. Realize the audit of energy and Demand Side Management. Implement energy-efficiency standards in and the identification process for all electrical equipment. Relevant technologies include the solar home system, the regenerative energy application, the thermal energy storage heat exchanger, new building materials, energy-saving lamps and so on. |
| Transportation | Hybrid vehicles, electrical cars, advanced diesel oil automobiles, public traffic system, biological fuel. Increase the purchasing and use cost of personal automobiles. Provide allowance and reduce tax for efficient and environmental automobiles. Traffic-demand management. Develop traffic with non-motor vehicles. Improve economy of fuel by compulsory standards or voluntary agreement. Develop public traffic. Improve public consciousness. Exploit substitute energy (such as hydrocracking), variable valve controls (variable valve timing or VVT), fuel battery automobiles, regenerative energy application technology, substitute modes for non-traffic transportation. |
| Industry | Low carbon intensive and high energy-efficiency production technology, high-efficiency industrial boilers, advanced industry energy-saving technology (in the fields of iron and steel systems, architecture materials, glass, chemical industry and so on), efficient electromotors, re-use and recycling of waste. Establish more rigid standards of energy efficiency and low carbon commodities. Reduce the allowance and tax preference of high-energy-consuming industries. Develop trade in carbon emissions. Define and clarify the energy price/carbon tax/energy tax, tax reduction/preference, government financial support, laws. Establish the policy of industry development and the plan of technology research. Increase investment on research and exploitation. Establish the mechanism of technology innovation, new technology demonstration. Develop circular economy; enlarge the market of technologies; import advanced technologies; adjust industry structure. Take advantage of energy resources; intensify energy-efficiency standards and markings. Develop voluntary agreements and international cooperation. Improve the consciousness of energy saving and greenhouse gas emissions reduction. |
| Energy supply (electricity generation) | IGCC, CCGT, nuclear power, CHP, distributed electric power generation system, biological materials application technology, solar energy for electricity generation, biomass liquefaction, hydropower development, advanced fuel forests, wind energy, solar energy, clean coal and biotechnology. |
| Economic incentive policies | Pay equal attention to tax collection and voluntary agreements and encourage enterprises to take part in voluntary agreement activities. Give financial support to enterprises which put greenhouse gas emissions reduction activities into effect. Implement the preferential tax for energy-saving products. Special support funds for energy-saving should be established by the governments. Start the government purchasing plan. Encourage the exploiting enterprises to build advanced energy-saving and environmental buildings. Encourage consumers to buy energy-saving and environmental buildings. |
| Domestic and overseas low carbon cooperation | Make sufficient use of different chances in international cooperation and expand the international cooperation of financing and technology transference, including the existing CDM projects, and the potential opportunities for carbon trade. There are still many cooperation opportunities at present. |
| CCS technology | Take advantage of the demonstration projects organized by international cooperation and notional programming in order to promote CCS applications in the terminal departments of energy consumption of electricity, cement, steel and so on. |

Source: Energy Research Institute, 2009

## Sectoral carbon intensity: the Jilin and China average
## Carbon emissions per unit of added value: China, Jilin Province and Jilin City

| | Area | | |
|---|---|---|---|
| | **Carbon emission per unit added value** (tonnes carbon/10,000 RMB) | | |
| **Industry** | **China** | **Jilin Province** | **Jilin City** |
| Total | 1.51 | 2.11 | 3.98 |
| 1. Mining industry | 0.81 | 1.6 | 0.47 |
| 2. Manufacturing industry | 0.84 | 1.23 | 3.02 |
| Processing of food from agricultural products | 0.14 | 1.28 | 0.63 |
| Manufacture of beverages | 0.19 | 2.04 | 1.55 |
| Manufacture of raw chemical materials and chemical products | 1.33 | 5.24 | 6.04 |
| Manufacture of chemical fibres | 0.56 | 6.17 | 7.82 |
| Manufacture of non-metallic mineral products | 1.92 | 4.82 | 3.86 |
| Smelting and pressing of non-ferrous metals | 0.32 | 0.52 | 0.42 |
| Manufacture of transport equipment | 0.06 | 0.14 | 1.28 |
| 3. Production and distribution of electricity, natural gas and water | 8.12 | 14.4 | 27.05 |

Source: Energy Research Institute, 2009

# Appendix D: Cost-benefit calculations for proposed investments in Chapter 5

## Costs-benefits of energy saving in buildings

| Investment period | Area (10,000 m²) | Cost (RMB/ m²) | Investment (10,000 RMB) | Coal saving in heating period (t/ m²) | Coal saving (10,000 tce/year) | $CO_2$ emissions reduction (10,000t/ year) | Lifetime earnings (10,000 $): Benefits of coal saving | Lifetime earnings (10,000 $): Benefits of $CO_2$ emissions reduction (10,000 RMB) | Lifetime earnings (10,000 $): Total | Net benefit in lifetime (10,000 RMB) | Static investment recovery period (years) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **New buildings** | | | | | | | | | | | |
| 2009–20 | 2,200 | 120 | 264,000 | 0.002 | 4.4 | 12.07 | 44,950 | 39,666 | 84,616 | 46,076 | 33 |
| **Existing buildings** | | | | | | | | | | | |
| 2009–20 | 3,588 | 180 | 64,5840 | 0.003 | 10.76 | 29.51 | 83,038 | 71,287 | 154,325 | 60,048 | 26 |

Note: The service life of a new building is 50 years and the service life of existing buildings is 40 years. The exchange rate used is USD 6.85.
Source: Jilin University, 2009

## Costs-benefits of bus and taxi modification

| | Number of vehicles | Cost (10,000 RMB) | Energy-saving investment (10,000 RMB) | $CO_2$ emissions reduction (10,000 tonnes) | Benefits of $CO_2$ emissions reduction (10,000 RMB) | Benefit of switching from oil to gas (10,000 RMB) | Total Benefit (10,000 RMB) | Static investment recovery period (months) | Net benefit in lifetime (10,000 RMB) |
|---|---|---|---|---|---|---|---|---|---|
| **Bus** | | | | | | | | | |
| Modification of new buses | 340 | 1.4 | 448 | 0.56 | 45.7 | 270.4 | 316.1 | 17 | 2,713 |
| Modification of existing buses | 320 | 1.4 | 476 | 0.36 | 30.3 | 136.7 | 167.0 | 33 | 1,222 |
| **Taxi** | | | | | | | | | |
| Modification of gasoline vehicles | 1488 | 0.6 | 892.8 | 15.20 | 185.9 | 2,053.0 | 2,238.9 | 5 | 17,018 |
| Modification of LPG vehicles | 2,976 | 0.6 | 1,785.6 | 8.63 | 211.0 | 1,955.2 | 2,166.2 | 10 | 15,544 |

Note: The service life of a bus is 10 years; the service life of a taxi is eight years.
Source: Jilin University, 2009

# Appendix E: Clean Development Mechanism projects in Jilin Province

Estimated annual emissions reductions (tonnes $CO_2e$)

| | Austria | Denmark | France | Germany | Japan | Lux. | Nether-lands | Spain | Sweden | Switzer-land | UK | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Methane recovery and utilization | | | | | 79,694 | | | | | 87,098 | 150,330 | 317,122 |
| Wind | 348,731 | | 89,740 | 198,288 | | | 347,840 | 407,550 | 465,818 | 259,342 | 1,251,553 | 3,368,862 |
| Hydropower | | | | | | 98,245 | 129,559 | | 254,205 | | 11235 | 493,244 |
| District heating | | | | | | | | | | | 130,150 | 130,150 |
| Biomass co-generation | | | | 408,356 | | | | | | | 364,375 | 772,731 |
| Cement waste heat for power | | 36,389 | | | | | | | | | 123,545 | 159,934 |
| Coal mine methane for power | | | | | | | | | | | 57,414 | 57,414 |
| Biomass-to-electricity | | | | | | | | | | | 821,935 | 821,935 |
| Iron and steel gas recovery for power | | | | | 332,781 | | 125,762 | | | | 459,330 | 917,873 |
| Municipal solid waste | | | | | | | | | | | 176,751 | 176,751 |
| Cement-clinker substitution | | | | | | | | | | | 205,911 | 205,911 |
| Grand total | 348,731 | 36,389 | 89,740 | 606,644 | 412,475 | 98,245 | 603,161 | 407,550 | 720,023 | 346,440 | 375,2529 | 7,421,927 |

Source: CDM China website; analysis by Chatham House

CHATHAM HOUSE

Chatham House, 10 St James Square, London SW1Y 4LE
T: +44 (0)20 7957 5700 E: contact@chathamhouse.org.uk
F: +44 (0)20 7957 5710 www.chathamhouse.org.uk

Charity Registration Number: 208223