CHINA'S EMISSIONS glimpsing the peak

China recently announced its intention to peak its carbon-dioxide emissions. How soon could the emissions peak and at what absolute value? **Libo Wu** explores.

In November this year Chinese President Xi Jinping announced that his nation would seek to achieve a peak in its greenhouse-gas emissions by 2030 (see page 4 of this issue). The significance of this announcement cannot be overemphasised: China is the world's leading emitter of carbon dioxide and, as this year's Global Carbon Budget[1] underscores, its per capita emissions now exceed the European average (see page 6 of this issue). Moreover, the economic engine that drives its emissions also drives domestic environmental degradation, so a peak would have a bearing on quality of life too. In this context there is growing interest in exploring the timing of peak emissions and energy consumption in China.

Integrated Assessment Models (IAMs) provide one way of knowing when emissions might peak – that is, when they will cease to grow further – and at what absolute value. These models simulate emission trajectories by combining various socio-economic pathways and policy options. However, feedbacks and interactions among social, economic and environmental systems introduce uncertainties that limit the persuasiveness of IAM studies.

Here I discuss an alternative, comparative approach that looks at income growth and per capita emissions through time in China and some other representative countries. This approach complements a recent analysis[2] that explored what it would take for China's emissions to peak by the year 2030. That analysis considered the experience of developed countries as well as factors such as GDP per capita and carbon emissions per unit of energy consumed. My approach can be described as top-down, underpinned by the rationality of pursuing equity: the principle that given a particular income level, one human being should be able to emit as much carbon dioxide as another at the same level. This approach throws up several possible emission trajectories regarding per capita emissions for China. When combined with possible trajectories of the country's GDP growth and population growth, we can get some handle on the path that its total emissions might take.

Economies and emissions

We know that emissions of some substances – sulphur dioxide and particulates, for example – tend to follow what's called the Environmental Kuznets Curve: emissions increase with economic growth, peak at a certain per capita income level and then decrease. The peak is driven mainly by end-of-the-pipe treatment, industrial transformations and the increasing demand for environmentally friendly goods. We could estimate when greenhouse-gas emissions in China would peak assuming they too follow this curve. As discussed below, that does not seem to be the case.

End-of-the-pipe treatment such as carbon capture and storage is at present too costly to be applied on a large scale. Renewable energy is making inroads but is not yet

© iStockhphoto.com/Tian Zhan

competitive in terms of price. Meanwhile, emissions from increased consumption and the expansion of transportation infrastructure are only partly offset by industrial transformation. Finally, because global warming is a complex issue and poses more indirect health risks as compared with common pollutants (such as sulphur dioxide), the public demand for "green" goods can be influenced by several factors including scepticism. Indeed, during the past five decades today's developed economies have improved their living standards greatly while achieving little reduction in per capita greenhouse-gas emissions (Figure 1).

Generally, there is a positive relationship between energy consumption and greenhouse-gas emissions. Developed countries consume more energy and emit more greenhouse gases than developing ones. But Figure 1 shows that there are distinct differences within these groups too: this suggests countries have taken or are taking different pathways to achieve income growth. The United States, for example, uses energy equivalent to almost 140 kilograms of oil per unit of GDP[3], whereas Germany uses just over 90. Diverse factors such as the economic and energy structure, efficiency, and transportation infrastructure affect per capita emissions. The energy-consumption behaviour depends on energy pricing and taxation systems. The difference between Germany and United States can be attributed chiefly to differences in energy efficiency and the higher penetration of nuclear and renewable energy in Germany.

Chinese per capita energy use – equivalent to over 200 kilograms of oil per unit of GDP – and per capita emissions are much higher than those of Brazil, for example. The high growth rate of the Chinese economy, its reliance on the export of primary products and the domination of coal lead to mass consumption of energy and thus high emissions.

Germany has decoupled, to an extent, energy consumption from emissions. Such decoupling can be attributed mainly to the fact that renewable energy such as wind and solar forms a significant part of Germany's energy mix. The Chinese government is taking a series of measures to similarly decouple its economic growth from energy use and greenhouse-gas emissions.

In 2006, China drew up mandatory targets of energy intensity, carbon intensity, the share of non-fossil sources in total energy supply, and pollution by sulphur oxides and nitrogen oxides. China has committed to the following by 2020: a) lower emissions per unit of GDP by 40 to 50% of the 2005 level; b) meet 15% of its primary energy consumption from non-fossil fuels; c) and increase forest coverage by 40 million hectares and forest stock by 1.3 billion cubic metres from the 2005 level. Then there is the recent US-China agreement. These measures may lead to some GDP loss in the short term but stimulate green innovation in the long term.

Glimpsing the peak

Scenarios for peak emissions can be constructed by combining the pathways of peak per capita emissions, economic growth and population growth in China. I first use the relationship between per capita income and per capita emissions of developed economies as a reference to construct three possible pathways for peak per capita emissions in China (Figure 1).

The black pathway allows China's per capita emissions to peak at a level similar to that of Canada. The growth rate of per capita emissions will decline gradually and stabilise (that is, reach convergence) at an income of around 15,000 US dollars per capita. If China follows the brown pathway its emissions will peak at a level similar to that of Germany. They will converge at an income level of 10,000 US dollars per capita. Finally, the green pathway is relatively inflexible in that it requires China to maintain its current level of per capita emissions. If the country follows this pathway its per capita emissions will be lower than the emissions of the developed economies.

I then factor in the effects of economic growth and population. The former is assumed to follow one of three pathways: high growth, medium growth and low growth. As to the latter, China's population is ageing and – based on the United Nations forecast – will begin to shrink from 2030.

Figure 2 shows the results of the analysis in the form of several possible trajectories of total emissions until 2100. Assuming the UN population projection holds, the absolute values and timing of peak emissions depend on both the per capita emission pathways as well as the rate of economic growth. If China were to follow the black emission pathway the total emissions would soon exceed 15 billion tonnes irrespective of growth rate, which seems incompatible with the target of restricting the increase in global temperature to two degrees Celcius above its pre-industrial value. In contrast, the green emission pathway coupled with moderate to low growth would lead to total emissions of about 11 billion tonnes, which would peak between 2040 and 2045. Although this timing is not very different from that estimated for the black emission pathways, the significant reduction in total emissions would help to limit the increase in global temperature over its pre-industrial level.

The principle emphasises equity rather than efficiency.

Realistically speaking, however, China will most likely follow the brown emission pathway. For low to moderate growth rates, the peak would appear around 2040 and the absolute level would be between 13 and 14 billion tonnes of carbon dioxide. If the growth rate were high, the peak would appear even later and total emissions would be almost 15 billion tonnes.

Getting there

In its Fifth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) has put forward "burden sharing" as a new principle for allocating responsibility for mitigating greenhouse-gas emissions. The principle emphasises equity rather than efficiency. The three per capita emission pathways considered here are consistent with this principle: they take the contemporary levels of per capita emissions in developed countries as benchmarks.

The analysis presented here suggests that both the rate of economic growth and the emissions pathways govern the absolute value and timing

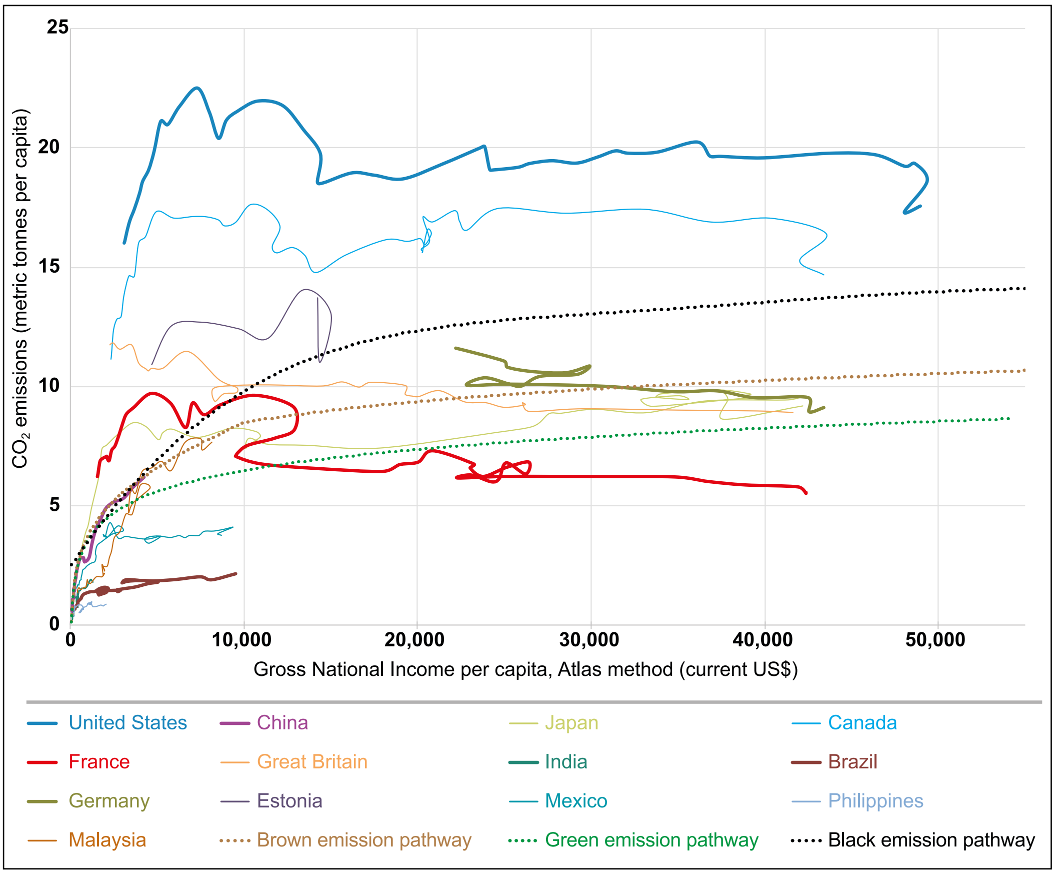

Figure 1. Pathways for China's per capita emissions (dotted lines) along with historical trajectories for selected countries (continuous lines). In general, emissions increase with income up to a point before stabilising. Loops in the country-specific trajectories indicate severe economic downturns or recessions. See text for more details.
Data: World Development Indicators 2014 (http://data.worldbank.org/sites/default/files/wdi-2014-book.pdf) and author.

of the emissions peak. Growth patterns depend on how energy is produced and consumed, the evolution of infrastructure, land-use change and ultimately how resources are allocated. China has many similarities with Germany: for example, both countries are richly endowed with natural resources, display an export-oriented growth pattern and have similar roles in regional economic development. If China could follow Germany's emission pathway its emissions would peak at a level and time that would help to limit the rise in global average temperature over its pre-industrial value.

From the supply side, the transformation of the energy structure is the most urgent challenge. Compared to Germany, China's energy supply is still highly dependent on coal. China will need to pursue feasible alternatives to coal so as to generate cleaner energy. The German experience with renewable energy and the distributed co-generation of heat and power systems highlights the importance of green fiscal policies. More stringent taxes on fossil fuels and more flexible feed-in-tariff policies can help China to accelerate the timing of the emissions peak.

In today's globalised world, though, what the world chooses to do might be just as important as what China does. We know that a significant fraction of China's emissions can be attributed to goods that are made in this country but consumed elsewhere (in Europe and the US, for example)[1]. Many of those countries have per capita emissions that are much higher than the world average. So a change in consumption patterns in such countries will only stimulate the transition to a low-carbon economy in China.

What the world chooses to do might be just as important.

The shift in manufacturing to China can be traced, in part, to the "Polluters Pay Principle (PPP)" enshrined at the 1992 Rio Summit. There was no parallel change in consumption patterns, however, leading to many irreversible environmental externalities in China and the rest of the world. It would be important to insure that China's transformation will not be at the expense of emissions transfers to less developed regions. So although the current focus on China is justified, we should not ignore developing economies such as the Mint countries (Mexico, Indonesia, Nigeria and Turkey), which are also experiencing rapid industrialisation. It is incumbent on the international community to help them get onto a more sustainable path. ▮

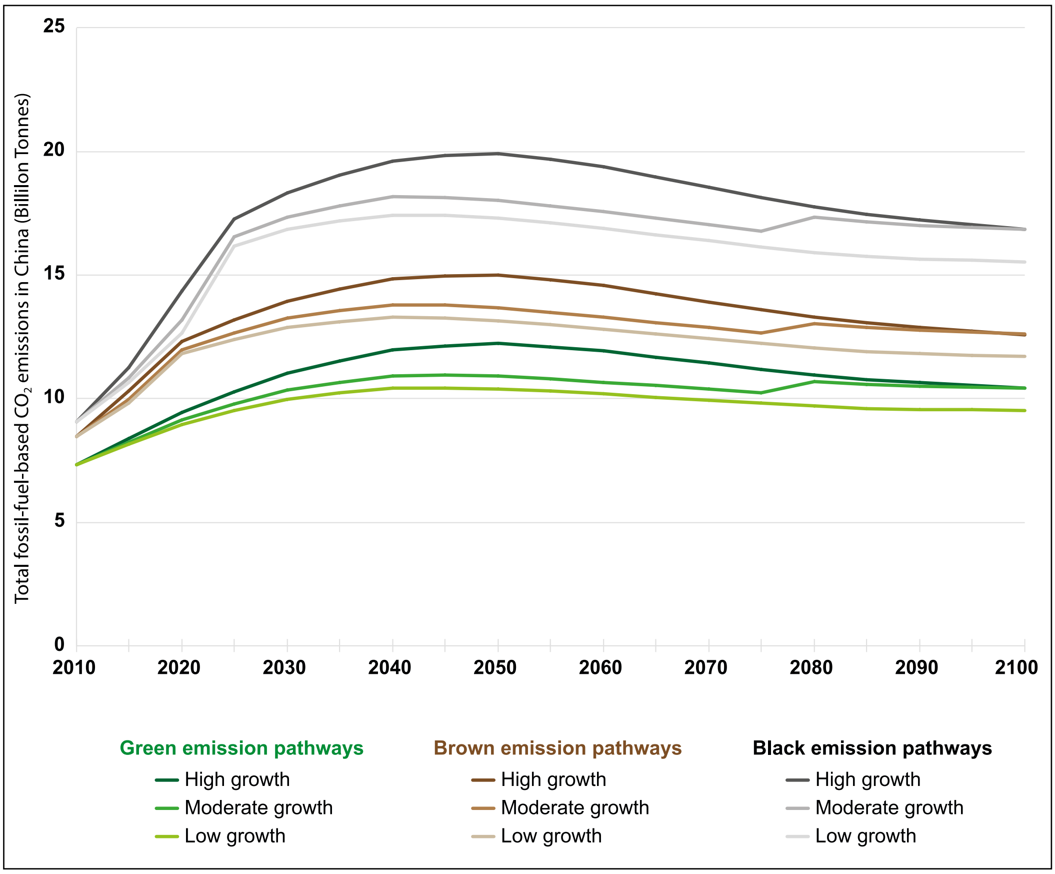

Figure 2. Trajectories for total carbon-dioxide emissions in China for different economic, demographic and environmental scenarios. See text for details.

LIBO WU is Executive Director of the Center for Energy Economics and Strategy Studies, Fudan University, Shanghai, China. She is also a member of the Scientific Steering Committee of the Global Carbon Project.
E-mail: wulibo@fudan.edu.cn

REFERENCES AND NOTES

1. The Global Carbon Budget is published by IGBP's Global Carbon Project. For more information see: http://www.globalcarbonproject.org/carbonbudget/

2. He (2014) *Chinese Journal of Population Resources and Environment* 12(3): 189-198, doi: 10.1080/10042857.2014.932266

3. The unit of gross domestic product considered here is 1000 constant international dollars using purchasing power parity rates for 2011. An international dollar has the same purchasing power over GDP as a US dollar has in the United States.