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The Economy and Environment Program for Southeast Asia (EEPSEA) was established in May 1993 to support training and research in environmental and resource economics across its 9 member countries: Cambodia, China, Indonesia, Laos, Malaysia, Papua New Guinea, the Philippines, Thailand, and Viet Nam. Its goal is to strengthen local capacity for the economic analysis of environmental problems so that researchers can provide sound advice to policymakers.

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China's Energy Intensity – Past Performance And Future Implications

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A key environmental challenge facing all developing countries is the need to reduce the intensity with which energy is used by industry. In the 1980's and 1990's, China saw a dramatic decline in the energy intensity of its economy. However, between 2000 and 2005, the country's energy intensity flattened out and even rose slightly. Since 2005, it has started to drop again. Now, a new EEPSEA report has looked at why these changes have taken →

A summary of EEPSEA Research Report No.2010-RR12: Changes In China's Energy Intensity: Origins and Implications for Long-Term Carbon Emissions and Climate Policies' by Jing Cao and Mun S. Ho; Shunde 128, School of Economics and Management, Tsinghua University, Beijing, 100084, P.R. China.
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place and assessed their significance for future energy policy.

The study is the work of Jing Cao and Mun S. Ho from the School of Economics and Management, Tsinghua University, Beijing, and Harvard University. It finds that technological improvements drove the sustained decline in China's overall energy intensity before 2000. By the years 2000/2002, technological progress had peaked and no other factors were driving improvements – hence the flattening out of energy intensity. After 2005, new strict energy intensity policies reversed the energy intensity trend, but this change has mainly been restricted to the coal sector. In light of these findings, the study projects how energy intensity might change in the future and finds that a carbon tax would be the most cost-effective way of cutting the environmental and social costs of industry and reducing a wide range of pollutants.

The Energy Intensity Challenge

In many developing or transitional economies, energy consumption typically grows faster than GDP during periods of industrialization and urbanization. This is due to rising capital-labour ratios, the increasing use of commercial energy and the construction of modern infrastructure. However China, the biggest transitional and developing economy in the world, exhibited a strikingly different pattern of consumption up until the year 2000: the country had an average annual growth rate of 9.7% from 1978 to 2000, but commercial energy consumption per unit of GDP declined by about two thirds during this period. However, as already mentioned, after 2000/02, the rate of declining energy intensity slowed down or rose even slightly.

China's energy intensity has a global significance. This is because much of China's energy comes from fossil fuels, the combustion of which produces carbon emissions that are linked to global warming. Given the size of the country's economy and the rapid growth of its GDP, it is now estimated that Chinese carbon emissions have surpassed the U.S. and the country is now the biggest carbon emitter in the world. After 2002, as the country's energy intensity flattened out and then rose, its carbon emissions increased dramatically, much faster than other developed and non-Annex I countries. As this shows, any changes in China's energy intensity will have a profound implication for global warming and international climate policy. Understanding trends in China's energy intensity is important for any discussions about the future path of international policies to control emissions.

Responding to the Challenge

The Chinese government has set the country various targets to reduce national energy intensity and so help reduce carbon emissions. For example, the Chinese government's 11th Five-Year Plan has set the country a target to reverse its energy intensity by 20% during 2006–2010. The question is how can the country best achieve its energy intensity reduction goals? In particular, what kind of policies should the government follow: command-and-control policies, as it has in the past, or economic incentive-based policies (such as energy or carbon taxes)?

To help shed some light on these questions, this study investigates the reasons for past changes in China's aggregate energy intensity. It then uses its findings to project future energy intensity changes and carbon emissions. It also analyzes the effectiveness of both command-and-control policies and incentive-based policies at reducing energy use and emissions.

Assessing the Factors that Affect Energy Intensity

Decomposition analysis was used to isolate and assess the factors that affect changes in energy use and, in particular, to see what role technical changes (such as improvements in technology) and structural changes (such as changes in the quantity and composition of imports and exports) play. Decomposition analysis has been extensively applied in energy research, in particular in interpreting the factors affecting aggregate energy intensity, or energy-related carbon emissions. However, there is little consensus on methodology and results vary depending on the methods used. Due to this uncertainty, this study uses three different types of decomposition analysis. This allowed the researchers to choose the best method for the other parts of their analysis and to shed some light on the methodological issues involved.

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Previous analysis of changes in China's energy intensity has either used input-output tables from two benchmark years or has used annual data for gross output and energy input only. This study uses an annual series of input-output tables. This data covers a comprehensive range of industry sectors, including agriculture, coal mining, chemicals and textiles. It includes details of the sectors' outputs, capital, labor and energy use. This data set covers the period 1980–2005 and comprises a preliminary version of estimates made by a group led by the National Accounts Department in the National Bureau of Statistics (NBS) and Ren Ruoen of the School of Economics and Management, Beihang University. This is the first study to use this unique data set for energy analysis of this type.

Experiments with the zCGE model AEEI scenarios Scenarios Growth Rate of AEEI

Scenarios	Growth Rate of AEEI
I	No AEEI improvements
II	1% per year
III	Average annual rate of overall energy intensity change $(\Phi^{*}+\Psi^{*}) = 0.0476$, 1981 – 2007
IV	Average annual rate of overall energy intensity change $(\Phi^{*}+\Psi^{*}) = 0.0229$, 2000 – 2007
V	Average annual rate of overall energy intensity change $(\Phi^{*}+\Psi^{*}) = 0.0177$, 2000 – 2005

Pollution Impact Pathways and Analysis

1	Economic activity and fossil fuel use to pollutant emissions
2	Emissions to concentrations
3	Concentrations to human exposure
4	Exposure to health impacts
5	Valuation of health impacts
6	Marginal damage by industry and fuel type
7	Benefit-cost analysis of command-and-control and energy taxes based on marginal damag

Assessing the Factors that Affect Energy Intensity

The study finds that during the 1980s and 1990s, technological changes played a very important role in explaining the sustained decline in overall energy intensities, while structural shifts played very limited roles. The reasons for this are relatively easy to understand: Before economic reform in the 1970's, productivity and technological progress in many industries in China was lower than that of developed countries. After economic reform, it was easier to make productivity gains and this allowed industry to make sustained efficiency improvements. However, after improvements had been sustained over a 20-year period it became more difficult to achieve further gains through technological change alone. As the government was not driving improvements through policy in the early years of the new millennium, improvements in the country's energy intensity stalled.

Another factor behind the flattening out in energy intensity from 2002 to 2005 was that, as a result of the government's 10th Five-Year Plan, China faced huge demand from infrastructure development. With big profits in iron, steel, cement and the chemical industries, small-scale inefficient firms were built up quickly to meet the surge in demand. As a result, the level of energy efficiency actually declined substantially. This contributed to the country's failure to reach the environmental targets set in its 10th Five-Year Plan.

After 2005, China set out some stringent energy efficiency policies for energy-intensive sectors – mainly in the coal mining and electricity sectors. For example inefficient coal mines and power plants were shut down, and energy saving and environmental targets were highlighted as important performance indicators for local government. As a result, substantial energy intensity improvements were achieved after 2005, particularly in the main sectors targeted by policy reform.

Projecting Future Energy Intensity

To project the future energy intensity performance of the Chinese economy, the study looked at a key performance indicator: the Autonomous Energy Efficiency Improvement (AEEI) parameter. This is used to project improvements in energy per unit of output that do not depend on factors such as levels of output or prices. It is commonly assumed that the AEEI is a "one-size-fits-all" parameter and that all sectors show a 1% improvement in energy efficiency each year.

The study's assessment of the performance of the Chinese economy suggests that, for a transitional economy such as China, a parameter set at 1% is not accurate. It also shows that such an AEEI level does not generate trajectories of energy use and carbon emissions that are consistent with the historical trend.

Instead, the study finds that, considering the technological progress that took place, the overall AEEI for 1981–2007 stands at 4.76%, 2000–2005 at 1.77% If the 11th Five-Year Plan period after 2005 is taken into account, then the overall AEEI for 2000–2007 is about 2.29%. This study compares some existing studies on Chinese carbon emission trends, and suggeststhat an AEEI of 1.7% seems to be consistent with these studies, and also used to project changes in the functioning of the country's industrial economy in the following policy analysis.

Which Policy is Best?

To have a better forecast of future energy use and carbon emissions in China, the study incorporates its AEEI results into a computable general equilibrium (CGE) model of the Chinese economy. This model assesses the benefits and costs of environmental policies by assessing how they impact on a wide range of key indicators, including factors such as economics, energy use, pollution and people's health. In contrast, many previous studies in this area have dealt only with the direct costs of pollution control, such as the cost of scrubbers.

The CGE model is used to analyze the economy-wide impacts of two alternative policies – a command-and-control policy and an economic incentive-based policy. The command-and-control policy is an existing policy used widely in China's 11th Five-Year Plan. It involves a technological mandate that requires the installation of fluidized gas desulfurization (FGD) equipment in the electricity sector and a mandate to shut down small-scale coal-fired power plants. The incentive-based policy is a carbon tax of 100 YUAN per tC imposed on fossil fuel use. Based on a recent Ministry of Finance Carbon Tax study, it is likely that such a tax on fossil fuel will be implemented in the 12th Five-Year Plan or the 13th Five-Year Plan.

Incentives Provide the Most Benefits

It is clear that the technology mandates contained in the command and control policy would produce negative large-scale costs. That said, the policy could have some positive effects. For example, shutting down inefficient small-scale power plants and replacing them with large-scale efficient power plants, could have positive economic and environmental effects and help correct short-sighted investment distortions and market failures. However, under the command-and-control policy no revenues would be produced that could be utilized to reduce other distortions, for example research and development investment in low-carbon technologies.

When the command-and-control policy and the carbon tax are compared, it is clear that the carbon tax would be a cost-effective way of reducing a wide range of pollutants, while the command-and-control technology mandates would only lead to big cuts in one type of pollutant. In addition, the carbon tax would be more efficient at reducing carbon emissions and would have great potential to bring other co-benefits to public health. Thus, in general, the carbon tax is superior to the command-and-control policy, if both economic and environmental net benefits are taken into account. For this reason, the study concludes that it be a good way to address both local environmental protection and global climate change challenges.

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