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Target Allocation Methodology for China's Provinces: Energy Intensity in the 12th Five-Year Plan

Stephanie Ohshita, Lynn Price
Energy Analysis Department
Environmental Energy Technologies Division
Lawrence Berkeley National Laboratory

TIAN Zhiyu
Energy Research Institute

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ABSTRACT

Experience with China's 20% energy intensity improvement target during the 11th Five-Year Plan (FYP) (2006-2010) has shown the challenges of rapidly setting targets and implementing measures to meet them. For the 12th FYP (2011 – 2015), there is an urgent need for a more scientific methodology to allocate targets among the provinces and to track physical and economic indicators of energy and carbon saving progress.

This report provides a sectoral methodology for allocating a national energy intensity target – expressed as percent change in energy per unit gross domestic product (GDP) - among China's provinces in the 12th FYP. Drawing on international experience—especially the European Union (EU) Triptych approach for allocating Kyoto carbon targets among EU member states—the methodology here makes important modifications to the EU approach to address an energy intensity rather than a CO_2 emissions target, and for the wider variation in provincial energy and economic structure in China. The methodology combines top-down national target projections and bottom-up provincial and sectoral projections of energy and GDP to determine target allocation of energy intensity targets. Total primary energy consumption is separated into three end-use sectors—industrial, residential, and other energy. Sectoral indicators are used to differentiate the potential for energy saving among the provinces.

This sectoral methodology is utilized to allocate provincial-level targets for a national target of 20% energy intensity improvement during the 12th FYP; the official target is determined by the National Development and Reform Commission. Energy and GDP projections used in the allocations were compared with other models, and several allocation scenarios were run to test sensitivity. The resulting allocations for the 12th FYP offer insight on past performance and offer somewhat different distributions of provincial targets compared to the 11th FYP. Recommendations for reporting and monitoring progress on the targets, and methodology improvements, are included.

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Stephanie Ohshita, Lynn Price
Lawrence Berkeley National Laboratory

TIAN Zhiyu
Energy Research Institute, National Development and Reform Commission, China

Goals

An overarching goal of China's 11th Five-Year Plan (FYP, 2006-2010) and 12th FYP (2011-2015) is to address energy and environmental concerns in tandem with economic development. Specific goals to reduce the growth rate of energy consumption and carbon emissions include: (1) continuing improvement in physical energy efficiency; and (2) shifting the structure of the economy away from energy-intensive industry and toward a low-energy service sector. In line with these goals, the central government chose to set targets under the metric of **economic energy intensity** (energy/GDP) in the 11th FYP. For the 12th FYP, energy intensity targets are complemented with carbon intensity targets, to explicitly promote carbon emissions reductions.

To achieve a national intensity target, targets must be allocated sub-nationally to provinces, cities, sectors and enterprises. For the 11th FYP, provincial targets were set based on rapid assessment and negotiation, and most were set close to the national target of 20% reduction in intensity over the five-year period. Some provinces exceeded their targets and developed robust management systems for ongoing improvement. Other provinces struggled and took extreme short-term measures to reach their targets. For the 12th FYP, the Chinese government seeks to use a more **scientific methodology** to better estimate the **varying potential** for energy saving across the provinces, to facilitate a change in development mode, as well as to achieve an **equitable distribution** of targets.

Sectoral Methodology for Provincial Target Allocation

This report presents a methodology for provincial-level target allocation based on China's goals and international experience in target setting. In addition to consideration of equity and improved estimates of the potential for energy saving, the methodology is designed to show **effectiveness**—that the combination of provincial targets meets the national goal—and to provide greater **transparency** in target allocation by utilizing **measurable**, readily-available data.

Three Energy Sectors. Because energy intensity varies dramatically among different sectors of the economy, and because absolute energy consumption differs widely among provinces and economic sectors, it is important to divide the targets by end-use sectors. The allocation methodology for China's intensity target disaggregates total provincial energy use into three end-use sectors:
(1) **Industrial Energy** (heavy and light),
(2) **Residential Energy**, and
(3) **Other Energy** (transport, service sector, agriculture, etc.).

These sectors focus on end-use energy consumption under the jurisdiction of the provinces. The three energy sectors, in combination with total provincial GDP, yield provincial economic energy intensities.

The methodology presented here has similarities to the Triptych sectoral approach utilized in the European Union for allocation of the Kyoto Protocol carbon target among EU Member States. The methodology for China makes important modifications to the European approach to address an *energy intensity* target rather than an absolute *CO_2 emissions* target, and for the wider variation in provincial energy and economic structure in China. The EU Triptych approach categorized CO_2 emissions from (1) the power-producing sector, (2) the heavy industrial sector (excluding electricity), and (3) the domestic sectors (including emissions only from direct energy end-use in buildings, service sector, light industry, transport, etc.). In the EU experience, a transparent, scientific methodology helped the Member States reach agreement and track progress. Final targets were based on negotiation as well as the scientific methodology, such that political considerations were layered over a strong analytical foundation.

Sectoral Indicators. The methodology developed for China considers numerous indicators to estimate potential energy savings and targets for each sector. All of the indicators, such as Residential Energy *per capita*, enable comparison across provinces of different sizes. Some indicators are snap-shots in time, such as industrial energy intensity for a particular year. Other indicators represent trends over time, such as annual rates of change in Other Energy during the past Five-Year Plan. In practice, the choice of indictors was constrained by limitations on publicly-available data at the provincial level. Working within these constraints, we utilized the following indicators for each of the provinces:

- **Industrial Energy:** industrial energy intensity (energy per unit value-added output), historical trends in growth rates, GDP per capita.
- **Residential Energy**: per capita residential energy use, weather-related adjustments for heating and cooling, convergence to a common per capita level in 2030.
- **Other Energy:** historical trends in growth rates, GDP per capita.
- **Economy (GDP)**: historical trends in growth rates, GDP per capita.

Along with the sectoral indicators, the sectoral structure of energy and GDP (e.g., the share of Industry in total energy and in total GDP) influences the overall target for each province. Since half of China's provinces have an industrial energy share of 70% or higher, the Industrial sector is especially important for intensity target allocation. Table ES-1 summarizes the energy and economic indicators and structure for each province.

Utilizing the sectoral allocation methodology with recent data and indicators at the national level and for each of the provinces, we estimated provincial energy intensity targets for the 12th FYP. To examine the influence of the different indicators and assumptions on the targets, we prepared several target scenarios; the results of three scenarios are summarized below.

Table ES-1. Energy and Economic Indicators for China's Provinces (2007)

Province	Industrial Energy Intensity (tce/10000 RMB VA)	Industrial Share of Energy	Industrial Share of GDP	Industrial Energy Growth Trend in 11th FYP	GDP (10000 RMB) per capita	Residential Energy (kgce) per capita (weather corrected)
Beijing	1.33	42%	27%	low	58,204	568
Tianjin	1.33	68%	60%	medium	46,122	451
Hebei	**2.96**	**81%**	**53%**	**medium**	**19,877**	**297**
Shanxi	**3.91**	**83%**	**60%**	**high**	**16,945**	**303**
Inner Mongolia	**3.46**	**72%**	**52%**	**high**	**25,393**	**407**
Liaoning	**2.41**	**73%**	**53%**	**high**	**25,729**	**349**
Jilin	2.60	69%	47%	high	19,383	275
Heilongjiang	1.52	67%	52%	medium	18,478	260
Shanghai	1.16	58%	47%	low	66,367	418
Jiangsu	**1.41**	**82%**	**56%**	**medium**	**33,928**	**177**
Zhejiang	**1.35**	**74%**	**54%**	**medium**	**37,411**	**244**
Anhui	**2.51**	**78%**	**45%**	**medium**	**12,045**	**160**
Fujian	**1.41**	**70%**	**49%**	**medium**	**25,908**	**241**
Jiangxi	1.92	73%	52%	high	12,633	145
Shandong	**1.61**	**75%**	**57%**	**medium**	**27,807**	**214**
Henan	**2.08**	**80%**	**55%**	**high**	**16,012**	**185**
Hubei	**2.55**	**70%**	**43%**	**medium**	**16,206**	**174**
Hunan	**2.41**	**69%**	**43%**	**low**	**14,492**	**188**
Guangdong	**1.09**	**67%**	**51%**	**high**	**33,151**	**264**
Guangxi	2.60	74%	41%	high	12,555	119
Hainan	2.79	59%	30%	high	14,555	107
Chongqing	2.30	68%	46%	medium	14,660	188
Sichuan	**2.10**	**69%**	**44%**	**medium**	**12,893**	**176**
Guizhou	5.06	69%	42%	medium	6,915	277
Yunnan	3.28	73%	43%	medium	10,540	160
Tibet	ND	ND	29%	low	12,109	404
Shaanxi	1.92	65%	54%	medium	14,607	206
Gansu	4.12	74%	47%	medium	10,346	214
Qinghai	5.61	78%	53%	high	14,257	429
Ningxia	8.26	85%	51%	high	14,649	268
Xinjiang	3.24	69%	47%	medium	16,999	337

Notes: tan = very high; pink = high; yellow = medium; blue = low. Energy is in terms of primary (total) energy. Economic data expressed in fixed 2005 RMB. **BOLD** = 15 largest energy-consuming provinces.

Target Scenarios and Results

Top-Down National Analysis. Because this is a methodology for allocating a *national* target among the *provinces*, the analysis combines top-down national projections, with bottom-up provincial and sectoral projections of energy and GDP, to determine provincial intensity target allocations that will meet the national target. Top-down national projections of energy and intensity for the 12th FYP were based on three main assumptions: (1) a national energy intensity target of -20% over the five-year period;[1] (2) annual GDP growth of 8.5%;[2] and (3) a small shift in energy structure, from 71% Industrial, 10% Residential, 19% Other to 69% Industrial, 11% Residential, 20% Other.[3] Figure ES1 shows the national results based on these assumptions. The methodology can be utilized for other values of national intensity target, GDP growth, and energy structure; the values here were based on recent studies and stated policy goals.

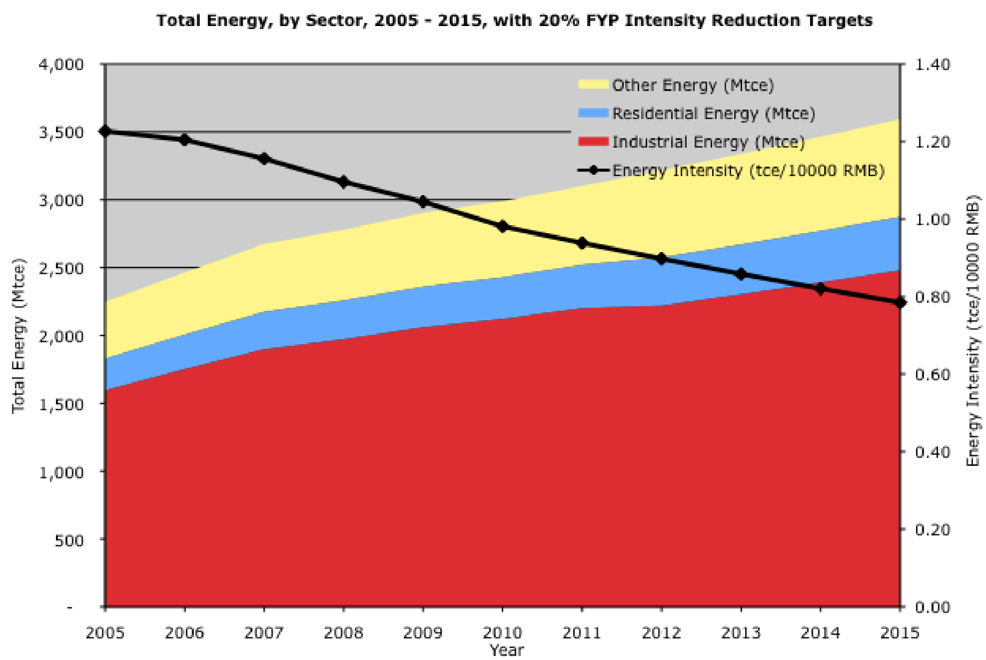

Figure ES-1. Intensity and Energy by Sector, for 20% Intensity Reduction Targets in 11th & 12th FYP

Bottom-Up Provincial Analysis. Table ES-2 presents 12th FYP energy intensity targets resulting from application of the sectoral methodology under three scenarios developed in this analysis, all of which meet a -20% national target. The table also compares the 12th FYP estimated targets with actual targets and provincial progress during the 11th FYP.

[1] A national target value of -20% is the same value set for the 11th FYP. We used the same target to enable comparison of the estimated 12th FYP allocation with the actual allocation for the 11th FYP, and to recognize the ongoing potential for intensity improvement in China. The official national energy intensity target, announced just as this report was being issued, is set at -16%.

[2] A GDP growth rate of 8.5% was chosen based on earlier projections for the 12th FYP period and actual GDP growth during the past 11th FYP. An official GDP target will likely be 7.0% - 7.5% for the 12th FYP.

[3] The projected shift in energy structure was made to address China's goal to reduce the share of the Industrial sector and increase the share of the Service sector in GDP and energy structure.

Table ES-2. 12th FYP Provincial Energy Intensity Targets for a -20% National Target and Comparison with 11th FYP Progress

Province	12th FYP Target Scenarios				11th FYP Targets & Progress	
	Trend Analysis & Targeted Savings (S1)	Equal Growth & Targeted Savings (S2)	GDP-based Growth & Equal Savings (S3)		Actual 11th FYP Target [2]	Reported Progress (2005 - 2009)[3]
Beijing	-20%	-20%	-22%		-20%	-24%
Tianjin	-23%	-21%	-24%		-20%	-22%
Hebei	**-23%**	**-21%**	**-20%**		**-20%**	**-18%**
Shanxi	**-23%**	**-25%**	**-21%**		**-25% [-22%]**	**-20%**
Inner Mongolia	**-21%**	**-24%**	**-23%**		**-25% (-22%]**	**-20%**
Liaoning	**-21%**	**-23%**	**-24%**		**-20%**	**-17%**
Jilin	-19%	-20%	-19%		-30% [-22%]	-19%
Heilongjiang	-19%	-17%	-17%		-20%	-18%
Shanghai	-21%	-19%	-22%		-20%	-18%
Jiangsu	**-21%**	**-20%**	**-23%**		**-20%**	**-19%**
Zhejiang	**-22%**	**-21%**	**-24%**		**-20%**	**-19%**
Anhui	**-17%**	**-17%**	**-13%**		**-20%**	**-17%**
Fujian	**-21%**	**-19%**	**-22%**		**-16%**	**-14%**
Jiangxi	-13%	-15%	-11%		-20%	-17%
Shandong	**-22%**	**-20%**	**-23%**		**-22%**	**-20%**
Henan	**-17%**	**-20%**	**-18%**		**-20%**	**-18%**
Hubei	**-21%**	**-19%**	**-19%**		**-20%**	**-20%**
Hunan	**-23%**	**-18%**	**-18%**		**-20%**	**-20%**
Guangdong	**-17%**	**-19%**	**-22%**		**-16%**	**-15%**
Guangxi	-14%	-17%	-13%		-15%	-14%
Hainan	-10%	-11%	-11%		-12%	-7%
Chongqing	-20%	-19%	-18%		-20%	-18%
Sichuan	**-19%**	**-17%**	**-15%**		**-20%**	**-16%**
Guizhou	-21%	-22%	-16%		-20%	-16%
Yunnan	-24%	-22%	-16%		-17%	-15%
Tibet	ND	ND	ND		-12%	ND
Shaanxi	-21%	-18%	-17%		-20%	-18%
Gansu	-21%	-19%	-13%		-20%	-18%
Qinghai	-20%	-23%	-19%		-17%	-11%
Ningxia	-22%	-25%	-20%		-20%	-18%
Xinjiang	-21%	-19%	-16%		-20%	-9%

Notes: pink = high; yellow = medium; blue = low; bright green = ahead of target; light green = on track; tan = behind target as of 2009. **BOLD** = 15 largest energy-consuming provinces.
[1] 11th FYP Targets for Shanxi, Inner Mongolia, and Jilin were revised to -22% in 2010. [2] The official reported target progress is based on the sum of annual percent changes (2005 – 2009). Progress calculated on cumulative Intensity Change yields different results. Cumulative Energy Intensity Change (2005 - 2009) = (EI,2009 - EI,2005) / EI,2005.

Scenario 1 – Trend Analysis and Targeted Savings.
Scenario 1 emphasizes targets based on each province's **potential for energy saving**, along with consideration of economic development **trends**. Scenario 1 considers equity based on past performance and potential for improvement.

For **Industrial Energy** under Scenario 1, targets are based on industrial energy intensity levels, as well as recent energy consumption growth trends. Tougher savings goals are assigned to provinces with high intensity. Those savings goals are combined with recent energy consumption growth trends to calculate the Industrial Energy targets. Industries in the provinces then have two main ways to achieve their target: enhancing physical energy efficiency and improving the economic output from energy utilization, such as shifting to less energy-intensive enterprises and products and/or higher value added products.

For **Residential Energy**, all scenarios utilized a per capita convergence approach, with appropriate adjustments for different weather conditions, and resulting needs for heating and cooling, across the provinces. A convergence approach has the goal of bringing the entire population up to a common standard of comfort in residential living. Thus, Residential Energy consumption is targeted to increase during the 12th FYP, but at a slower rate than during the 11th FYP. With progress in design standards for buildings and appliances, greater comfort can be achieved with less energy.

The **Other Energy** sector includes energy not covered under Industry or Residential, namely transportation, the service sector, and agriculture. Because this sector is generally less energy-intensive than the industrial sector, and because the government is encouraging development of the service (i.e., tertiary) sector, all provinces are targeted with more growth in Other Energy and less growth in Industrial Energy. Under Scenario 1, provinces with low GDP per capita are allotted additional growth in Other Energy to further encourage the development of a low intensity economy in the 12th FYP.

Recognizing that **GDP** rates have fluctuated frequently in the past across the provinces and are therefore challenging to predict, Scenario 1 assigns the same rate of economic growth (8.5%) to all provinces.[4]

Scenario 2 – Equal Rates and Targeted Savings.
Scenario 2 recognizes the dynamic nature of China's provinces and considers that future developments during the 12th FYP period may not follow historical trends; instead **equal rates** of growth in energy consumption are assigned to all provinces. Scenario 2 still aims to set targets based on each province's potential for energy saving, and consider goals for encouraging the service sector.

For **Industrial Energy** in Scenario 2, all provinces are assigned an equal (national average) rate of change in energy consumption, rather than differentiated rates based on recent trends. Savings goals are then assigned based on industrial energy intensity levels. Tougher savings goals are assigned to provinces with high Industrial intensity.

As in all the scenarios, targets for **Residential Energy** under Scenario 2 utilized a per capita convergence approach, with adjustments for weather conditions across the provinces. For **Other Energy**, Scenario 2 set an equal growth rate for all provinces then allotted additional growth for poorer provinces, based on GDP per capita. All provinces were assigned the same rate of **GDP** growth (8.5%).

[4] In another scenario included in the main body of the report, we differentiated GDP rates based on analysis of recent trends. The resulting targets have very wide variation, showing the strong influence of GDP growth assumptions.

Scenario 3 – GDP-based Growth and Equal Savings.

Scenario 3 gives highest priority to the provinces' **level of economic development** as an indicator for target setting, in terms of GDP per capita, and does not set targets based on the potential for energy saving, nor on recent trends. Scenario 3 considers equity mainly in economic terms. For **Industrial Energy** in Scenario 3, targets are based solely on **GDP per capita**, with poorer provinces allotted more room for growth, and wealthier provinces allotted less growth. **Residential Energy** utilized a per capita convergence approach, as in all the scenarios. For **Other Energy**, Scenario 3 based all targets solely on GDP per capita. All provinces were assigned the same rate of **GDP** growth (8.5%).

Connecting Indicators to Targets: A look at **targets for Guangdong** province illustrates application of the allocation methodology. Guangdong is China's second-largest energy-consuming province, and experienced high growth in industrial energy consumption during the 11th FYP, yet has the lowest industrial energy intensity, 1.09 tce/10000RMB (refer to Table ES-1). One of China's wealthy provinces, Guangdong has a high GDP per capita, yet the residential energy consumption per capita is moderate. In terms of energy and economic structure, Guangdong's Industrial share of energy (67%) and GDP (51%) is a few percentage points below the national average.

Estimated energy intensity targets for Guangdong ranged from -17% in Scenario 1 to -22% in Scenario 3 (see Table ES-2). Why the difference in targets? Since Scenario 1 emphasizes the potential for energy saving and intensity improvement, it recognizes that Guangdong has achieved the lowest industrial energy intensity of all the provinces and has been growing its tertiary economic sector; as a result, Guangdong is allotted a lower target of -17%. Because Scenario 3 focuses only on the level of economic development, in terms of GDP, in allocating targets, the wealthy province of Guangdong is assigned a tougher target of -22%.

Findings

Target Methodology: The sectoral allocation methodology presented here is a **scientific** methodology that makes **transparent** connections between the choice of indicators, and resulting targets, **enabling decision-makers** to clearly set priorities and explain the targets. The methodology accounts for **varying potential** in improving energy intensity by clearly identifying **measureable** indicators; these indicators can also facilitate monitoring progress toward the targets. An **equitable distribution** of targets is achieved by aiming for a common level of residential energy and comfort for all citizens (convergence approach), and by encouraging the development of low-energy economic activity for all provinces, with extra encouragement for poorer provinces. The methodology is **effective** in that it works within the constraints of available data to allocate provincial targets that can achieve the national target.

Energy: Key findings regarding energy, from application of the methodology:

- **Significant slowing in Total Energy** growth is needed to meet 2015 energy intensity targets. To meet a national 12th FYP energy intensity target of -20% by 2015, provincial total energy growth rates should average **3.4%** annually, ranging from 1.5% to 4.5% across the provinces in 2015. This compares to a Total Energy average growth rate of 9.6% in 2007.
- Industrial Energy growth should slow the most, while Residential and Other Energy are allowed to grow, to achieve a well-off society and a less energy-intensive economy.
  - **Industrial Energy** annual growth at an average of **2.5%**, ranging from 1.5% to 4.0% across the provinces in 2015. This compares to an Industrial Energy annual average growth rate of 12.5% in

2007.

- **Residential Energy** annual growth at an average of **3.8%**, ranging from 1.1% to 6.1% in 2015. This compares to a Residential Energy annual average growth rate of 7.4% in 2007.
- **Other Energy** annual growth at an average of **6.4%**, ranging from 6.0% to 7.5% in 2015. This compares to Other Energy annual average growth rate of 9.2% in 2007.

Structure and Size are important. The energy and economic structure of the provinces are important influences on targets. Provinces are assigned different targets due to their structure, as well as indicators like industrial intensity and GDP per capita. The absolute size of energy consumption and economic output are also important influences on target allocation. Indicators and trend analysis were utilized to assign equitable targets to the provinces in terms of *percent change* in energy intensity. A 1% change in the large energy consumption of Shandong accounts for more *absolute* savings than a 1% change the smaller energy consumption of Shanghai, yet provinces were allocated targets based on relative indicators, *not on size*.

Growth rates of GDP also matter. The same GDP rate was assigned to all provinces; however, economic growth rates vary both in the development plan of each province and in reality, which in turn has different influences on the national target. The rapid economic growth accompanied by an expansion of energy-intensive sectors experienced since 2000 lead to a surge in energy consumption. Since one goal of the energy intensity target is to promote structural change, it might be reasonable to assign higher target to faster growth regions, given the immense ability of these local governments to mobilize resources, either in a favorable way or not.

Recommendations

Target Methodology: Attention should be paid to energy intensity of GDP, industrial energy intensity, GDP per capita, trends in growth rates of GDP, etc., when adopting a methodology to allocate the target either to provinces or to cities and counties.

Additional Data: To clearly track progress on energy intensity, provinces and sectors within provinces, should distinctly report energy consumption and corresponding value-added economic output, as well as the aggregated intensity data. Data are also needed on physical and economic energy intensities for industrial sub-sectors (e.g., iron and steel, cement, chemicals), to better characterize energy-saving potential and help provinces develop specific policies to meet their targets.

Additional Metrics: A 'mixed' target like economic energy intensity is challenging, in that energy and GDP interact in so many ways to yield economic energy intensity. It is crucial to specify additional metrics and goals—such as absolute energy savings or other physical limits—to help provinces achieve their intensity targets.

Policy Analysis on Energy and Economic Structure: Further analysis is needed on the mechanisms for energy savings through *economic structure changes* at all levels of the economy, from macro-economic policies and energy pricing, to local taxes and land-use policies, within industrial sub-sectors, to enterprises-level choice of business activities and products. Further examination of the *demand for energy*—especially in *urban areas*—is also needed to better understand the drivers of energy consumption and opportunities for energy saving. Programs are needed to develop thriving urban centers with less energy, fewer materials, and less carbon.

Support for Provincial-level Implementation Plans: A deeper level of analysis is needed at the provincial level, to help the provinces develop *implementation strategies* to achieve the targets, taking into account the variety of economic and industrial structures in the provinces.

The next five years will be a mix of past momentum and strong new efforts toward a low-energy, low-carbon economy. The sectoral methodology developed for China presented in this report offers a scientific and transparent approach for allocating intensity targets among the provinces for the 12th FYP. The scenarios presented here show target outcomes based on measurable indicators, which can also help to track progress toward the targets. The methodology presented here provides a strong basis for negotiating and final target setting.

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1 Introduction

An overarching goal of China's 11th Five-Year Plan (FYP, 2006-2010) and 12th FYP (2011-2015) is to address energy and environmental concerns in tandem with economic development. Specific goals include: (1) continuing improvement in physical energy efficiency; and (2) shifting the structure of the economy away from energy-intensive industry and toward a low-energy service sector. In line with these goals, the central government chose to set targets under the metric of **economic energy intensity** (energy per unit GDP) in the 11th FYP. For the 12th FYP, energy intensity targets will be complemented with carbon intensity targets, to explicitly promote carbon emissions reductions.[5]

To achieve a national intensity target, targets are allocated sub-nationally to provinces, cities, sectors, and enterprises. For the 11th FYP, provincial targets were set based on rapid assessment and negotiation, and most were set close to the national target of 20% reduction in intensity over the five-year period. Some provinces exceeded their targets and developed robust management systems for ongoing improvement. Other provinces struggled and took extreme short-term measures to reach their targets. By 2009, the fourth year of the 11th FYP, five provinces were well ahead of their targets, 18 were on track to meet their targets, and the remaining nine provinces were not meeting their targets. The final year of the 11th FYP proved quite difficult for energy intensity reductions, since much investment from China's economic stimulus was directed to construction and heavy industry, contrary to the 20% intensity reduction target (Levine et al. 2010).[6] In a strong effort to meet the 11th FYP target, provinces expanded measures—such as additional closures of small inefficient enterprises, and added some extreme measures, such as rolling blackouts. Reports in early 2011 indicate that the extra efforts appear to have nudged the country to meet (or nearly meet) the 20% target.[7] These extra efforts also highlight that other strategies must be sought for ongoing energy saving. Thus for the 12th FYP (2011 – 2015), there is an urgent need for a better methodology to allocate targets, as well as to set workable implementation goals and to track important indicators influencing energy and economic structure.

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[5] "China Regions To Have Binding CO_2 Targets: Official." Reuters. 13 Jan. 2011.
[6] Because much of China's economic stimulus money was invested in the energy-intensive construction and heavy industry sectors, the investment led to an *increase* in intensity rather than the targeted *reduction*.
[7] "China meets 5-year target to cut energy intensity: report." Reuters. 6 Jan. 2011

For the 12th FYP, the Chinese government seeks to use a more scientific methodology to better estimate the varying potential for energy saving across the provinces, and to facilitate a change in development mode, as well as to achieve an equitable distribution of targets. This report provides a sectoral methodology for allocating a national energy intensity target among China's provinces in the 12th FYP. International experience informs the methodology—especially the European Union (EU) Triptych approach for allocating Kyoto carbon targets among EU member states (Phylipsen et al. 1998b). The methodology developed here makes important modifications to facilitate China's energy intensity target (rather than a carbon target), and for the wider variation in provincial energy and economic structure in China. The methodology combines top-down national projections of energy, GDP, and energy intensity with bottom-up provincial and sectoral projections to determine target allocations. Total primary energy is separated into three end-use sectors—industrial, residential, and other energy (transportation, commercial, etc.). Readily-available sectoral indicators are used to differentiate the potential for energy saving among the provinces.

National Target Levels. This sectoral methodology is then utilized to allocate provincial-level targets for a proposed national target of 20% energy intensity improvement during the 12th FYP (i.e. between 2010 and 2015). Seven scenarios were run to test sensitivity of the allocations to different indicators, and projections of energy and GDP were compared with other models. The energy intensity target allocation methodology presented here can be applied to different national target levels, For example, in preliminary discussion of the 12th FYP energy intensity target, target levels range from 16% to 20%; this methodology allows quick updating of allocations based on any national target level. From a bottom-up perspective, the target level can be improved as more data is gathered on potential savings in the provinces.

Carbon Intensity. The methodology can also be modified to allocate carbon intensity targets rather than energy intensity targets, in keeping with China's announcement of a 40% to 45% reduction in carbon intensity between 2005 and 2020.[8] With energy-related carbon dioxide comprising the major share of greenhouse gas emissions for China, the energy-focused methodology here provides a strong foundation for analysis of carbon intensity.

Energy and Economic Structure. Along with physical energy efficiency and fuel mix, shifts in economic structure are crucial for meeting intensity targets. The methodology here considers structural change in a very simple way, allowing for adjustment of energy structure (e.g., shares of energy in Industrial, Residential, Other). Future work is needed to strengthen the two-way connections among target setting (national), allocations (local), and implementation mechanisms (e.g., equipment efficiency standards, energy contracts, pricing changes, monetary support for local actions, etc.).

This report provides an overview of target allocation approaches (Section 2); presents key indicators characterizing energy and economic structure in China's 31 provinces (Section 3); explains the energy intensity target allocation methodology developed for China's 12th FYP (Section 4); presents target allocations from application of the methodology under a 20% energy intensity reduction

[8] For information and analysis on China's carbon intensity target, see posts on http://www.chinafaqs.com. For example: Seligsohn. 2009. "China's State Council Unveils 40-45% Carbon Intensity Target." Nov. Also: Seligsohn and Levin. 2010. "China's Carbon Intensity Goal: A Guide for the Perplexed." April.

target (Section 5); and closes with a summary of findings and recommendations for refining the methodology and tracking progress on the targets.

2 Target Allocation Approaches

Key aspects of target allocation include the type of target, setting a value for the target, criteria for allocating the target to lower levels (if the target will be met by different groups), along with target scope (what is covered by the target; who participates) and timeline. Here we define and offer examples of types of energy and carbon targets. Next we discuss methodologies for target setting. Then we examine criteria and methodologies for target allocation, based on experience in China and internationally. This discussion compares and contrasts the methodology developed for allocation of China's 12th FYP energy intensity targets to the provinces.

2.1 Types of Targets

There are three basic types of targets that can be used for setting energy-saving or emissions reduction goals: absolute targets, intensity targets, and economic targets.

An *absolute target* is defined in terms of a total amount of energy that will be used or GHG emissions that will be emitted in the target year. For example, if a steel plant consumed 2.8 million tons of coal equivalent (Mtce) in 2010, an absolute target of 2.2 Mtce could be set for 2015, assuming that such energy-savings potential was identified through an energy audit or assessment of energy-efficiency improvement potential. The Kyoto Protocol is an example of an agreement that although expressed as a relative reduction from an absolute historic emission level, is measured as an absolute target for reduction of greenhouse gas emissions. For example, the target for the European Union (15 Member States) is to reduce greenhouse gas emissions to 8% below the 1990 levels by the period of 2008 to 2012. This translates to an absolute emissions target level of 3900 MtCeq. (EEA, 2009).

The advantages of absolute targets are that they can be relatively simple to set and monitor, are easy to understand, identify an absolute quantity of energy use or GHG emissions that will be released to the atmosphere at a specific point in time, and are transparent in that additional data and calculations are not required to evaluate if the absolute target is met. Disadvantages include the fact that the economic activities at a certain location (or the products produced at a specific enterprise) can change over time, resulting in significantly different structures in the target year as compared to the base year. Hence, targets may be more easy or difficult to achieve than expected, depending on economic and other conditions. Such changes can be significant enough to require adjustments to the base year or to the target, or increased support for achieving the target. Another disadvantage is that accomplishing an absolute target may be difficult if there is significant economic growth. Similarly, decreasing production could lead to a situation where an absolute energy use or GHG emissions reduction target is achieved without undertaking any GHG mitigation options (WBCSD/WRI, 2004).

Intensity targets, defined as energy use per unit of production, can use either an economic (energy use per value added) or physical (energy use per ton of product produced) value for the denominator. For example, the GHG intensity of a cement company can be measured as energy use per value added (economic intensity target) or GHG intensity per ton of cement produced (physical intensity target). Physical energy intensity is calculated as follows:

$$\text{Energy Intensity (physical)} = \frac{E}{P}$$

Where:

E = energy consumption by the plant or sector

P = production by the plant or sector (in physical units)

Physical energy intensity targets are most useful for industries with a relatively simple product mix, e.g. a single energy-intensive product. If there are multiple products produced at a plant or in a sector, an Energy Efficiency Index can be used. The EEI combines the energy intensity of different process steps into one indicator and then determines its distance from best practice.

$$EII = 100 * \frac{\sum_{i=1}^{n} P_i * EI_i}{\sum_{i=1}^{n} P_i * EI_{i,ref}} = 100 * \frac{E_{tot}}{\sum_{i=1}^{n} P_i * EI_{i,ref}}$$

Where:

EII	= energy intensity index
n	= number of products to be aggregated
EI_i	= actual energy intensity for product i
$EI_{i,ref}$	= reference (or best practice) energy intensity for product i
P_i	= production quantity for product i.
E_{tot}	= total actual energy consumption for all products

The advantages of intensity targets are that they measure energy or GHG trends independent of production growth or decline and recalculation of target or base year goals is not needed if there are changes in product mix or production volume. In addition, such targets can allow comparison of enterprise performance with other enterprises that produce similar products or with best practice. The disadvantages are that since the target is independent of production growth, the level of actual energy consumption or GHG emissions in the target year is not set initially and therefore could be higher than the base year, depending upon production trends (WBCSD/WRI, 2004) In addition, it is difficult to track target progress until the target year is reached, making it hard to adjust the target or policy support levels during the target period.

Analyses have shown, however, that intensity targets that use a physical-based denominator more accurately track actual trends in emissions or energy intensity, as they are more closely linked to the emission-producing processes. Economic intensity targets are influenced by economic variability over time due to changes in market prices of the products or relative changes in prices (or value added) of different products (Freeman et al., 1996; Worrell et al., 1997). However, heterogeneity of an enterprise or of activities can make development of physical intensity targets difficult for some situations. As a result, there has been increased attention to the development of suitable physical metrics and indices (Phylipsen et al., 1998a; Farla, 2000; Nanduri et al., 2002).

Economic targets can be designed to take into account the costs of energy-efficiency improvements. For example, an economic target could be that an enterprise is required to implement all measures that have investment costs below a certain threshold value per ton of steel produced. Economic targets can also be expressed in terms of payback time, which is the amount of time it takes to recoup the investment costs through saved energy costs. Such a target could be that all measures with a payback period of 5 years should be implemented. Internal rate of return (IRR) can also be used as an economic target by stating that all measures with a certain IRR should be implemented. The Danish CO2 Tax Rebate Scheme for Energy-Intensive Industries uses an economic target that stipulates that participants must implement all measures with payback periods of less than 4 years in order to be exempt from the carbon tax. Current agreements in The Netherlands require implementation of all measures with payback times less than 5 years in the case of buildings and less than 3 years for facilities and processes (for participants in the Long-Term Agreements).

2.2 Setting Targets

Once the type of overall target is decided—absolute, intensity, or economic - the next step is to set the value of the target for the target year. Targets can be set based on an absolute reduction, a relative reduction, or through benchmarking (i.e. based on energy-efficiency improvement potentials).

The target value can be set by making forecasts of future energy use and carbon emissions under different scenarios, based on factors such as anticipated population change, urbanization, and potential energy and carbon savings or by choosing a desired outcome (e.g. carbon emissions in 2020 will be 40-45% below 2005 levels). Targets need to be measurable and reportable, so that progress toward goals can be tracked. A physical target is preferable because it can be measured and has a direct influence on the health of the city and province. Economic targets are important, too; the goal is to have an economy that is low-carbon and sustains well-being.

An *absolute energy intensity reduction target* specifies the goal in terms of the energy intensity desired at the end of the agreement period, such as “the energy intensity should be reduced by 0.1 tce/t steel over the target period”.

A *relative energy intensity reduction target* specifies the level of achievement in the target year in terms percent improvement over the base year. For example, if a given steel plant has reduced its energy intensity from 1.2 tce/t steel to 0.9 tce/t steel over the previous 5-year period, then the average annual improvement in the energy intensity was 5.6% per year. Depending upon the circumstances at the plant during the previous 5 years, this trend may be viewed as “business-as-usual” and a relative energy intensity reduction target could be set for a higher annual improvement in the energy intensity such as “the energy intensity should be reduced by 6.5% per year”. The Dutch Long-Term Agreements used relative EEI reduction targets. The overall national energy-efficiency improvement target was a 20% reduction in EEI between 1989 and 2000. China’s 11th Five Year Plan outlined a relative energy intensity target of a 20% reduction in energy use/GDP (% change in tce/10,000 RMB) in 2010 compared to this value in 2005.

Using benchmarking to determine an energy intensity-based target involves deciding what reference energy intensity to use for the benchmark. The benchmark could be the world average, the best-plant level (either domestically or in the world), the best-practice level (which combines the process-step best practices from a number of plants operating around the world), or the thermodynamic minimum.

2.3 Allocating Targets

Overall national-level targets are allocated to sub-sets of the economy (e.g. provinces, economic sectors) through a variety of approaches. Target may be distributed relatively evenly among the chosen sub-set, based on equal percent reduction. Target allocation can use assessment of energy efficiency or GHG mitigation potential in each sub-set of the economy to provide guidance, or use more complex allocation methodologies that apply varying criteria for different economic sectors.

China's national-level target to reduce energy use per unit of GDP by 20% during the 11th FYP was allocated to each province through a process in which the target was divided relatively evenly between provinces. The Central government requested that each Province propose its own target. Most Provinces proposed a 20% target in line with the national target, although some proposed higher and others proposed lower targets. After some negotiation, the State Council approved the provincial targets. In China's Top-1000 program which set an overall goal for the 1000 largest energy-consuming enterprises to save 100 Mtce by 2010, targets were set by NDRC for each enterprise in order to support the provincial-level targets and ultimately to meet the national-level 20% target. Initially, NDRC set preliminary targets for each enterprise taking into consideration their general situation such as which industrial sector they belonged to since the potential energy savings vary by sector, as well as the general level of technological sophistication of the enterprise, if known. The targets were not based on detailed assessments of energy-savings potential of each enterprise or each industrial sector. This approach was taken due to time constraints.

A more typical approach for setting energy-efficiency improvement or GHG emission reduction targets involves making a preliminary assessment of the energy efficiency or GHG mitigation potential, which includes an inventory of economically-viable measures that could be implemented. These assessments, which can be made by the company themselves or by an independent third party, are then provided to the government and form the basis for discussions and negotiations related to target-setting between the industries and the government.

In the UK, the process for setting the Climate Change Agreement targets began with information-gathering on the part of the government. The government obtained information regarding energy efficiency potential in energy-intensive industries through the Energy Efficiency Best Practices Program which produced good practice guides and case studies, new practice case studies, and information on future practices (Shock, 2000) as well as through a report on projections of industrial sector carbon dioxide emissions under a business-as-usual scenario as well as two scenarios that included all cost-effective and all technically-possible technologies (ETSU, 1999). Then, for the ten largest energy-consuming sectors, individual companies made estimates of what energy-efficiency improvements they were willing to commit to based on an assessment of their potential and provided this information to their trade associations. The starting point for the major industries was studies establishing what would be expected under business-as-usual and what could be achieved if all cost-effective measures were adopted, which was based on recent history of efficiency measures, rates of technology uptake, expected growth rates, and investment plans. Once this information was gathered, negotiations took place with each sector. The sector offered a target for the whole sector to the government. Negotiation then drew the process forward, with government often requiring the industry sector to improve their offer to a more challenging level, based on information on cost effective processes and general standards of energy management in the sector (Price et al., 2005).

For the Long-Term Agreements (LTAs) in The Netherlands, negotiated agreements between the Dutch Ministries and (industrial) sectors consuming more than 1 petajoule (PJ) per year were established in support of achieving an overall national energy-efficiency improvement target of a 20% between 1989 and 2000. The targets were divided among the various sectors with most industries also adopting a target of 20% reduction, but some establishing different targets based on assessments of their energy-efficiency potential. For example, the petroleum refining industry's overall target was a 10% reduction, while the target for Philips Lighting was a 25% reduction. The process for establishing the industrial sector targets began with a preliminary assessment of the energy efficiency potential of the sector by the industry. A quantified target was then set for the improvement of energy efficiency in the sector, based on the outcome of the study. A Long-Term Plan (LTP) described how the sector planned to realize its target. The LTAs include commitments for individual companies, such as the preparation of an energy conservation plan (ECP) and annual monitoring of developments in energy efficiency, expressed using an energy efficiency index (EEI). Then NOVEM, the Dutch Agency for Energy and Environment[9], established an inventory of economically-viable measures that could be implemented by the companies in each industrial sector and based on this inventory set a target for energy efficiency improvement for each sector (Nuijen and Booij, 2002). The LTA for the period 1989-2000 met its target and more with an improvement of the average energy efficiency of 22.3%.

More complex allocation methodologies use multiple criteria to set targets. The "Triptych approach," used to establish the European Union's Kyoto Protocol negotiation target, divided the overall GHG emissions target between the 15 countries that made up the EU at that time (Phylipsen et al., 1998b; Phylipsen and Höhne, 2004). The approach focused on three key energy-consuming sectors of the economy: industry, electricity, and domestic (buildings and transportation) sectors. The allowance for industry was determined by projecting physical activity at an average of 1.2% per year (2.1% per year in countries with GDP/capita less than 75% of EU average and 1.1% for other member countries), assuming that de-carbonization of fuels in industry increased 0.17% per year, and that energy efficiency improved 1.5% per year for all countries. The allowance for electricity took country-specific conditions, such as opposition to nuclear power, into account and assumed electricity growth would be limited to 1% per year for EU overall (1.9% for countries with GDP/capita is less than 75% of EU average and 0.9% for other countries). The allowance for the remaining more domestically oriented sectors (residential, transport, services) was based on projected population values and an assumption that there would be convergence to similar living conditions among countries by 2030. This meant that per capita emissions for all EU member states were assumed to be equal in 2030 at a level below current levels, in line with general assessments of emission reduction potentials in these sectors (at EU level). The base year (1990) per capita emissions were then extrapolated to 2030 and multiplied with 2010 population levels to determine the 2010 allowance. Domestic sector energy values were climate-corrected to account for different heating and cooling energy needs among countries. The sectoral allowances were then combined to set a total target for each country, such that the overall EU target could be met.

Other allocation methods include distributing a target to sub-regions based on one main indicator, such as GDP per capita, or distributing the target based on equal cost or cost optimization. Other

[9] Subsequently renamed SenterNovem, and recently AgentschapNL (AgencyNL)

multi-criteria decision analysis methods can also be used, such as Analytic Hierarchy Process (AHP), or Cluster Analysis. Decision-makers identify the criteria and assign subjective ranking to them. Because some important criteria are hard to quantify, expert judgment supplements the quantitative analysis. Criteria such as “capability” or “innovation potential” or “leadership” can be assigned quantitative values and used along with reported data on energy consumption and economic structure. The combined effect of the criteria and their rankings are calculated and yield a preferred option. The strength of AHP is that it can make preferences explicit and quantitative, and helps to inform decision-makers. A drawback of AHP is that the results are highly influenced by the subjective rankings; if decision-makers already have a preferred option, they can adjust rankings to yield their result. Another drawback of AHP is that it can be difficult to track progress on policy implementation and determine why results were obtained. It is helpful to distinguish between analytical work and negotiation, to be clear about the reasons behind a decision on target allocation.

3 China’s Provinces: Energy and Economic Indicators for Target Allocation

China’s 31 provinces vary widely in terms of their energy and economic conditions, from coal-abundant Shanxi in north-central China to financial hubs in Shanghai and Guangdong.[10] The following presentation of provincial indicators follows the quasi-geographical order of Chinese statistics, beginning with Beijing in the north, and spiraling out to the northeast, east, south-central, south-west, and north-west of the country.

In the development of a target allocation methodology, we considered several energy and economic indicators as possible criteria for target allocation. Data and Indicators examined for each province include:[11]

- total energy
- total GDP
- population
- energy structure (shares of industrial, residential, and other energy)
- total energy per capita
- residential energy per capita (household energy)
- GDP structure (shares of primary, secondary, and tertiary GDP)
- GDP per capita
- income per capita
- overall energy intensity (total energy per unit GDP)
- industrial energy intensity (industrial energy per industrial value-added economic output)
- cement sector energy, production, and physical energy intensity, for each province (cement being one of the six largest industrial sub-sectors)

[10] China’s 31 provinces include provincial-level municipalities (Beijing, Tianjin, Shanghai, Chongqing) and autonomous regions such as Inner Mongolia and Xinjiang.

[11] We also examined an indicator for Other Energy intensity, namely Other Energy per unit of tertiary sector GDP, but data limitations yielded a mis-matched measure. Since Other Energy includes the service sector, transportation, agriculture; while tertiary GDP includes the service sector but not agriculture, this is not a consistent metric and was not used.

- heating degree days (HDD) and cooling degree hours (CDH), to account for climatic difference among the provinces (to make weather corrections to residential energy per capita)

Indicators sought, but without sufficient data *at the provincial level*, included:
- physical energy intensities, i.e., data on energy per unit of production, for iron and steel
- physical energy intensities for the other largest industrial sub-sectors and their products (chemicals, non-ferrous metals, etc.)

3.1 Energy Indicators

To highlight the variation among provinces for important energy and economic indicators, we begin with presentation of total and sectoral energy for each province in Figure 1, to illustrate absolute amounts of energy as well as energy structure.[12] Shandong, Guangdong, Hebei, Jiangsu, Henan, Liaoning, Zhejiang, Shanxi, and Inner Mongolia stand out as the largest energy-consuming provinces; targets for those provinces are particularly important. Figure 1 also shows the substantial share of industrial energy in provincial energy structure. The national average was 71 percent industrial energy in 2007, and the provinces ranged from 42% in Beijing, to 85% in Ningxia.

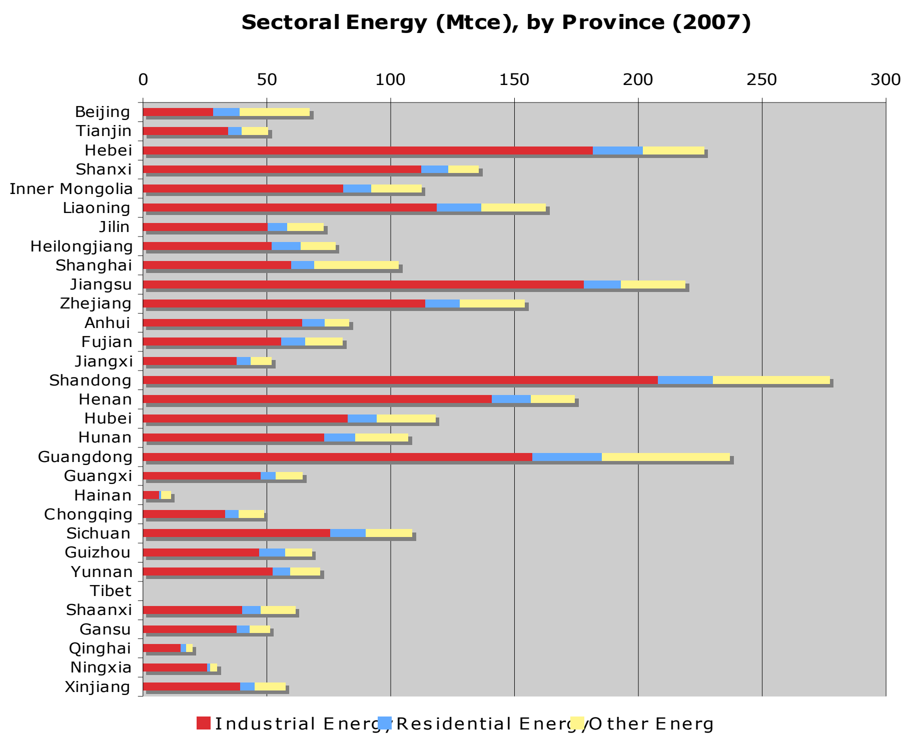

Figure 1. Energy Structure of the Provinces: Total Energy by Sector (Mtce, 2007)

Source: Based on NBS 2009 and various years. Compiled from physical fuel data and electricity in provincial energy balances. Energy in terms of Primary (Total) Energy in million metric tonnes of coal equivalent (Mtce). Electricity conversion factor to primary energy = 0.404 kgce/kWh.

[12] The presentation of provincial indicators follows the quasi-geographical order of Chinese statistics, beginning with Beijing in the north, and spiraling out to the northeast, east, south-central, south-west, and north-west of the country.

To give better comparability of energy consumption among the differently-sized provinces, Figure 2 presents both total and per capita energy consumption. Compared to a national average of 24 tce/capita, per capita energy consumption in Shanghai, Tianjin, and Beijing is higher than average, while the level in provinces such as Henan, Hunan, and Sichuan is below average. However, the share of industrial energy is high, and population-driven energy demand may not directly correlate to industrial production within any one province. Therefore, total per capita energy was not used as an indicator in the target allocation presented in this paper. Rather, residential energy per capita was utilized as a more direct indicator for allocation in the residential energy sector.

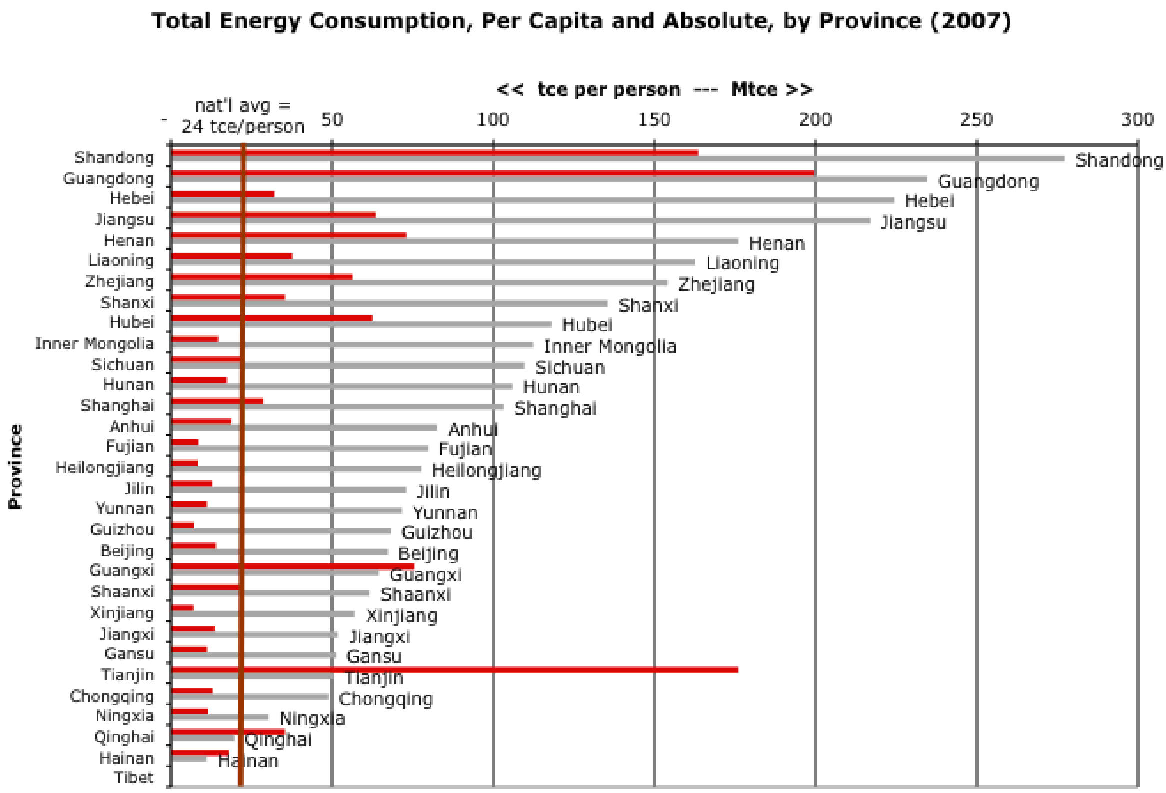

Figure 2. Total and Per Capita Energy Consumption of the Provinces (Mtce, 2007)

Source: Based on NBS 2009 and various years. Compiled from physical fuel data and electricity in provincial energy balances. Energy in terms of Primary (Total) Energy in million metric tonnes of coal equivalent (Mtce). Electricity conversion factor = 0.404 kgce/kWh. Red bars = per capita consumption; brown line = national average per capita consumption; grey bars = total energy consumption.

3.2 Economic Indicators

Figure 3 shows GDP size and structure of the provinces (2007 data, expressed in fixed 2005 RMB). The large energy-consuming provinces such as Guangdong, Shandong, Jiangsu, and Zhejiang also stand out in terms of GDP. Yet the share of GDP from the secondary sector (industry and construction) is smaller than the share of energy from the industrial sector. Across the provinces, the share of secondary (industrial) GDP ranged from 27% in Beijing, to 60% in Shanxi. Tertiary GDP, from the commercial and service sectors, is an economically important, less-energy-intensive sector[13]

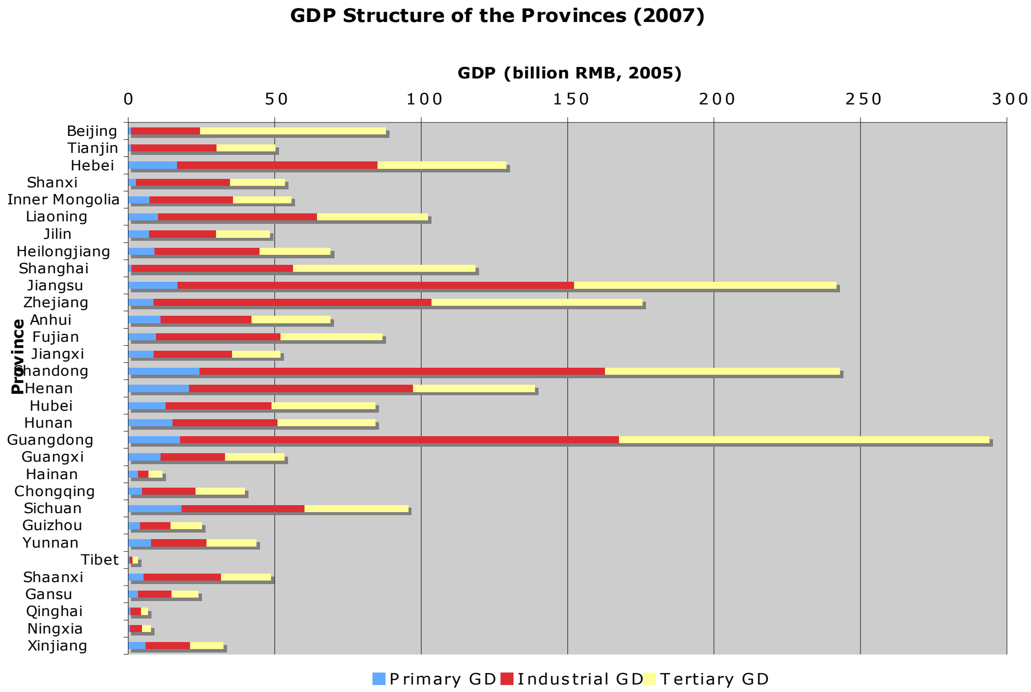

Figure 3. Economic Structure of the Provinces: GDP by Sector (2007)

Source: NBS, 2009. GDP data expressed in fixed 2005 RMB.
See footnote for definition of economic sectors.

Data on GDP per capita are frequently used as an indicator for the overall level of economic development, and for a general indicator of energy demand related to population. Figure 4 illustrates the range of this indicator across Chinese provinces. Here we see dramatic differences between the coastal provinces and financial centers, compared to the Western provinces. It is important to recognize that GDP per capita does not indicate the *distribution* of wealth, and a high GDP per capita is not necessarily reflective of a high *income* per capita. For example, there are relatively poor populations within provinces that have a high GDP per capita due to coal production.

[13] The primary sector of the economy involves changing natural resources into primary products and includes agriculture, agribusiness, fishing, forestry and all mining and quarrying industries. Most products from this sector are considered raw materials for other industries. The Secondary sector includes those economic sectors that create a finished, usable product: manufacturing and construction. The tertiary sector involves the provision of services to businesses as well as final consumers. Services may involve the transport, distribution and sale of goods from producer to a consumer as may happen in wholesaling and retailing, or may involve the provision of a service, such as in pest control or entertainment. Goods may be transformed in the process of providing a service, as happens in the restaurant industry or in equipment repair. However, the focus is on people interacting with people and serving the customer rather than transforming physical goods.

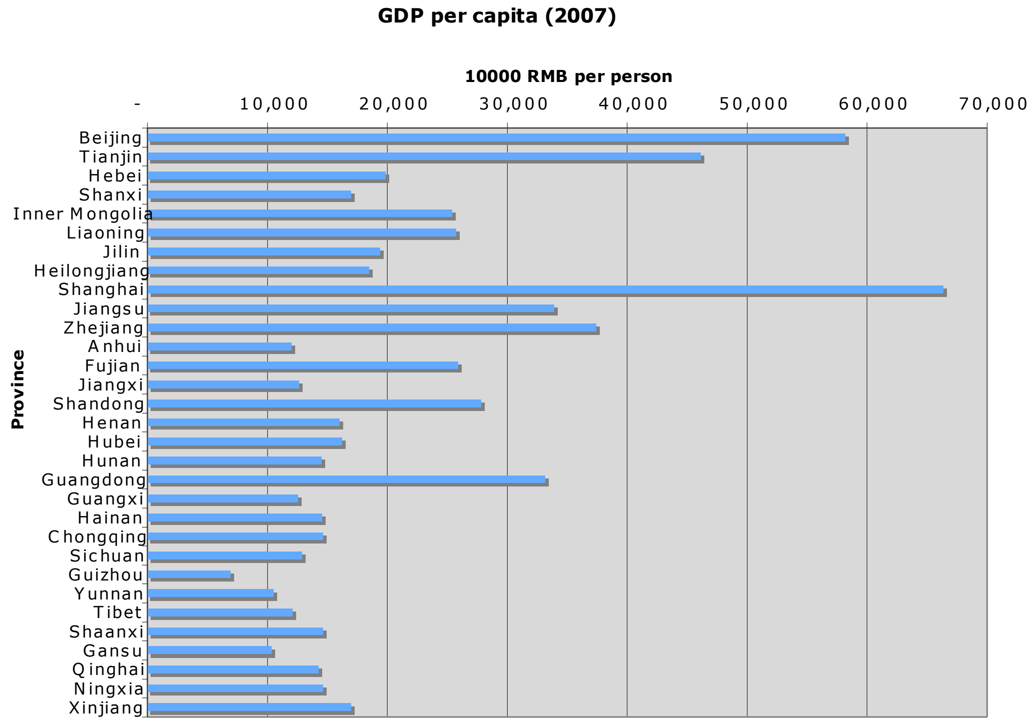

Figure 4. Provincial GDP per Capita (2007)

Source: NBS, 2009. GDP data expressed in fixed 2005 RMB.

3.3 Industrial Indicators

To measure the potential for physical energy efficiency (energy per unit of product), especially in the Industrial sector, we sought provincial data on energy and production levels on five heavy industrial sub-sectors: iron and steel, chemicals, petrochemicals, cement, and non-ferrous metals. Of those, only the cement sub-sector had data on energy and production, by province, as well as value-added economic output (CCA, 2009). We compared and ranked the provinces in terms of the physical and economic indicators of energy intensity for cement. The purpose of this comparison was to see if indicators based on the use of value added economic output could be used as a proxy for indicators based on physical output, since value added data are easier to obtain.

We found that when comparing physical and economic energy intensity of the cement sector, 18 of 31 provinces had the same ranking (high, medium, or low intensity) for both indicators. The rankings differed for the remaining 13 provinces. Those differences are likely due to the scope of reporting (all small- and medium-sized enterprises may not be accounted for), and the extent to which enterprises import or export clinker for their cement production. While it appears that value added indicators for the cement industry are a fair proxy for physical indicators in some provinces, they could be inaccurate for other provinces. Thus, we conclude that physical energy intensity is preferred as an indicator of the potential for energy savings. However, due to lack of data for other industrial sub-sectors, overall industrial economic energy intensity (energy/value added) was used as the main indicator for industrial energy savings potential for this study.

3.4 Mixed Indicators: Industrial Economic Energy Intensity

Since industrial energy and the industrial share of GDP (industrial value added) have a strong influence on the energy intensity of China's economy, and data were available at the provincial level, we utilized industrial economic energy intensity as an indicator for energy saving potential in the industrial sector. This intensity indicator is defined as industrial energy per industrial value-added economic output (industrial tce per 10000 RMB value-added). Figure 5 illustrates the industrial intensity of the provinces. Notable here is that China's largest energy-consuming province, Shandong, has a relatively moderate industrial intensity, along with its large share of industrial energy. In contrast, north and western provinces such as Shanxi and Inner Mongolia—also large energy consumers in absolute terms—have quite high industrial intensities. Thus any improvement in those provinces can have a large influence on national target achievement.

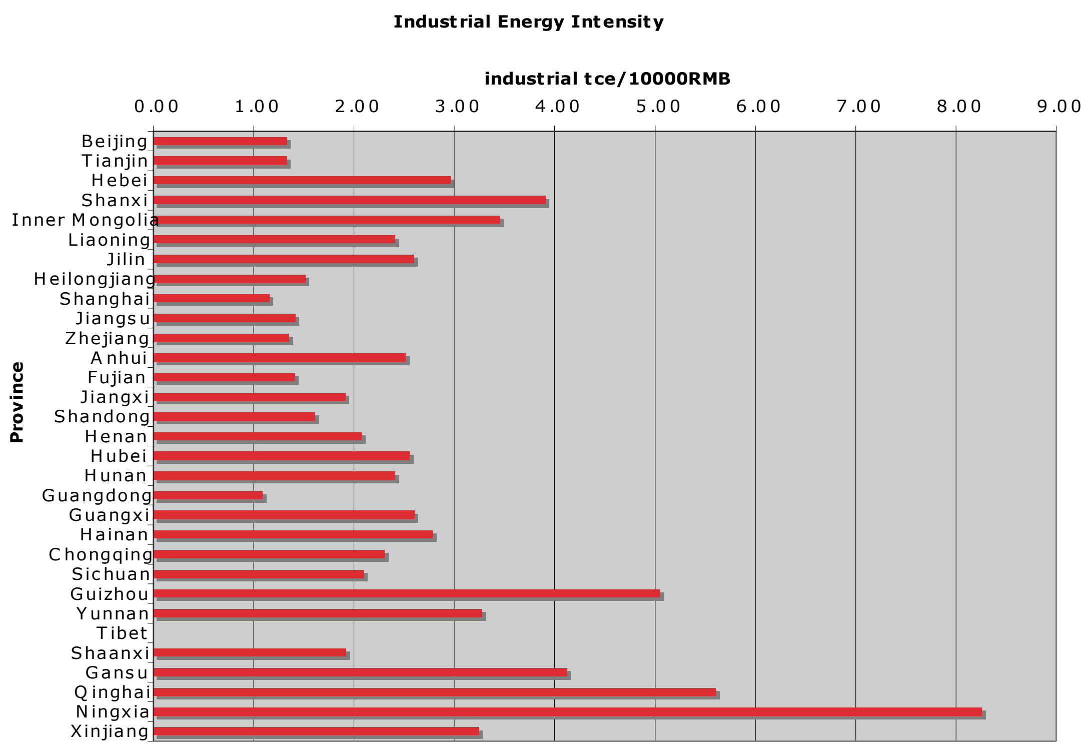

Figure 5. Industrial Energy Intensity of the Provinces (2007)

Source: Based on NBS, 2009. Energy Intensity expressed in terms of total (primary) energy per unit GDP in fixed 2005 RMB [tce/10000 RMB]

3.5 Key Indicators for Target Allocation

Table 1 summarizes the key indicators selected for the 12th FYP intensity target allocation methodology. The combination of industrial share of energy and industrial energy intensity are representative of the potential for reducing intensity, and have a strong influence on the allocation targets.

Table 1. Key Energy and Economic Indicators (2007)

Province	Industrial Share of Energy	Industrial Share of GDP	Industrial Energy Intensity (tce/10000 RMB VA)	Residential Energy (kgce) per capita (weather corrected)	GDP (10000 RMB) per capita
North					
Beijing	42%	27%	1.33	568	58,204
Tianjin	68%	60%	1.33	451	46,122
Hebei	**81%**	**53%**	**2.96**	297	**19,877**
Shanxi	**83%**	**60%**	**3.91**	303	**16,945**
Inner Mongolia	**72%**	**52%**	**3.46**	407	**25,393**
North-East					
Liaoning	**73%**	**53%**	**2.41**	349	**25,729**
Jilin	69%	47%	2.60	275	19,383
Heilongjiang	67%	52%	1.52	260	18,478
East					
Shanghai	58%	47%	1.16	418	66,367
Jiangsu	**82%**	**56%**	**1.41**	177	**33,928**
Zhejiang	**74%**	**54%**	**1.35**	244	**37,411**
Anhui	**78%**	**45%**	**2.51**	160	**12,045**
Fujian	**70%**	**49%**	**1.41**	241	**25,908**
Jiangxi	73%	52%	1.92	145	12,633
Shandong	**75%**	**57%**	**1.61**	214	**27,807**
South-Central					
Henan	**80%**	**55%**	**2.08**	185	**16,012**
Hubei	**70%**	**43%**	**2.55**	174	**16,206**
Hunan	**69%**	**43%**	**2.41**	188	**14,492**
Guangdong	**67%**	**51%**	**1.09**	264	**33,151**
Guangxi	74%	41%	2.60	119	12,555
Hainan	59%	30%	2.79	107	14,555
South-West					
Chongqing	68%	46%	2.30	188	14,660
Sichuan	**69%**	**44%**	**2.10**	176	**12,893**
Guizhou	69%	42%	5.06	277	6,915
Yunnan	73%	43%	3.28	160	10,540
North-West					
Tibet	ND	29%	ND	404	12,109
Shaanxi	65%	54%	1.92	206	14,607
Gansu	74%	47%	4.12	214	10,346
Qinghai	78%	53%	5.61	429	14,257
Ningxia	85%	51%	8.26	268	14,649
Xinjiang	69%	47%	3.24	337	16,999

Notes: tan = very high; pink = high; yellow = medium; blue = low; **BOLD** = 15 largest energy-consuming provinces. Monetary values are in fixed 2005 RMB.

4 Methodology for China's 12th FYP Provincial Target Allocation

This report presents a methodology for provincial-level target allocation based on China's goals and international experience in target setting. As mentioned at the outset, an overarching goal of China's 12th FYP is to address energy and environmental concerns in tandem with economic development. Specific goals include: (1) continuing improvement in physical energy efficiency; and (2) shifting the structure of the economy away from energy-intensive industry and toward a low-energy service sector. In line with these goals, the central government chose to set targets under the metric of economic energy intensity (energy per unit GDP).

4.1 Goals and Criteria for the Methodology

Several criteria were considered in developing the methodology; they are summarized in Table 2. First is the criterion of effectiveness; the combination of provincial targets must meet the national goal. The model developed under this methodology calculates the contribution of each province's allocation to the national target. The methodology has to consider the nature of the 'mixed' national-level target: percent reduction energy per unit of GDP (i.e., economic energy intensity). The combination of energy projections and GDP projections for all of the provinces must cumulatively yield the desired national improvement in energy intensity.

Table 2. Criteria for Target Allocation

Criteria	Explanation
Effective	The combination of provincial targets must achieve China's national goal for energy intensity improvement.
Efficient	Targets should recognize that some provinces have more potential for improvement, and some have already made significant improvements. Different targets for different provinces can be the most efficient way to achieve the national goal.
Realistic	Even while looking forward, targets should take into account existing conditions in the provinces, in terms of energy and economic indicators (e.g., sectoral shares and change in energy and GDP). A rapidly energy-consuming province can't suddenly stop, but will need to slow; a heavily industrial province can't change structure immediately, but must take strong steps.
Transparent & Simple	For transparency and simplicity, it is better to choose only a few indicators, from readily-available data, and clearly link with targets.
Equitable	Intensity targets should recognize social goals for addressing poverty, and especially encourage poorer provinces to develop low-intensity economic activity.

The methodology aims to provide greater transparency in target allocation by utilizing measurable, readily-available data. To better estimate the varying potential for energy saving across the provinces, and realize an efficient allocation of targets, the methodology endeavors to consider numerous energy and economic indicators, yet in practice is constrained by the availability of data. The methodology considers administrative and geographical boundaries (the provinces); any sectoral delineation has to fall within provincial administrative jurisdiction. Importantly, allocations are designed for an equitable distribution, including explanation of how equity is defined and accounting for variations among the provinces.

4.2 Main Steps of the Allocation Methodology

Since this is a methodology for allocating a *national* target among the *provinces*, the analysis combines top-down national projections with bottom-up provincial and sectoral allocations of energy and GDP to determine provincial intensity targets that will meet the national target. In other words, based on a chosen national intensity target level, iterative calculations are done on the provincial and sectoral levels to determine provincial targets. Because the methodology is developed for the 12th FYP, it focuses on the years 2011 to 2015, with 2010 as the base year.

The methodology has five main steps:

1. Project National-Level Values to 2015
2. Disaggregate Energy into End-Use Sectors and Identify Sectoral Indicators
3. Define Allocation Scenarios for Analysis
4. Project Provincial-Level Energy (by End-Use Sector) and GDP Values to 2015 for Each Scenario
5. Calculate Provincial Intensity Target Allocations for Each Scenario

Each of these steps is explained below.

4.2.1. Project National-Level Values to 2015

Based on the national intensity target level for the 12th FYP, the first step in the allocation methodology is to calculate national total energy, disaggregated sectoral energy, GDP, and intensity to the year 2015, assuming 2010 base year values from achievement of the national 11th FYP target. These top-down national projections are necessary for ensuring that when the provincial-level targets are combined, they meet the required national-level energy use, GDP, and economic energy intensity target of the 12th FYP.

With a mixed target of economic energy intensity (percent reduction in energy use per unit GDP), the target allocation methodology relies on projections of GDP. Assumptions about GDP rates of change—and the energy involved in GDP growth—can have a significant influence on projections and targets. The methodology can be used for any GDP growth rate.

4.2.2 Disaggregate Energy into End-Use Sectors and Identify Sectoral Indicators

The second step in the allocation methodology is to define the main end-use energy sectors and identify the main indicators for consumption and potential savings in each energy sector. A sectoral approach is used for target allocation, recognizing that energy intensity varies dramatically among different sectors of China’s economy. To allocate realistic and equitable targets, it is important to consider the different potential for energy saving in each energy sector, as well as the different mix of energy and economic structure among the provinces. The allocation methodology for China’s provincial intensity targets disaggregates total provincial energy use into **three end-use sectors**:

(1) **Industrial Energy** (heavy and light),

(2) **Residential Energy**, and

(3) **Other Energy** (transport, service sector, agriculture, etc.).

These sectors focus on end-use energy consumption under the jurisdiction of the provinces. This grouping of energy sectors was made considering the availability energy and economic data at the provincial level in China. This approach recognizes the different patterns of growth and different policy mechanisms that influence energy consumption. Electric power generation is not broken out as a separate sector; rather, electricity is attributed to each end-use sector (in terms of primary energy). The power generation sector was not considered as a separate category in this analysis because of the focus on end-use energy demand (rather than supply), and because decision-making authority for electric power generation rests mainly with China's five large regional electrical utilities, more than provincial governments to whom targets are being allocated. The sectoral approach also considers other goals and priorities of Chinese economic policy, such as reducing the share of industry in GDP and enhancing the share of the tertiary economic sector.

The choice of sectors for China has similarities to the Triptych sectoral approach utilized in the European Union for allocation of the Kyoto Protocol carbon target among EU Member States. The EU Triptych approach categorized CO_2 emissions from (1) the power-producing sector, (2) the heavy industrial sector (excluding electricity), and (3) the domestic sectors (including emissions only from direct energy end-use in buildings, service sector, light industry, transport, etc.). The methodology for China makes important modifications to the European approach to address an energy intensity target rather than an absolute CO_2 emissions target, and for the wider variation in provincial energy and economic structure in China. The methodology for China also considers differences between Chinese provinces and EU member states in jurisdiction over the electric power sector.

Sectoral Indicators. The target allocation methodology developed for China considered numerous indicators to estimate potential energy savings and targets for each energy sector, in each province. The choice of sectors and indicators considered China's intertwined goals of (1) facilitating a change in development mode (i.e., changing to a low-carbon and low-energy economic structure), and (2) improving physical energy efficiency. With those goals in mind, the methodology utilized physical and economic indicators for each energy sector for target allocation. All of the indicators enable comparison across provinces of different sizes. Thus per capita indicators or intensity indicators are used, such as Residential Energy consumption per capita. Some indicators are snap-shots in time, such as industrial energy intensity for a particular year. Other indicators represent trends over time, such as annual rates of change in Other Energy during the past Five-Year Plan. In practice, the choice of indictors was constrained by limitations on publicly-available data at the provincial level. Working within these constraints, we utilized the following indicators for each sector, in each of the provinces:

- **Industrial Energy**: industrial energy intensity (energy per unit value-added output), historical trends in growth rates, GDP per capita.
- **Residential Energy**: per capita residential energy use, weather-related adjustments for heating and cooling, convergence to a common per capita level in 2050.
- **Other Energy**: historical trends in growth rates, GDP per capita.
- **Economy (GDP)**: historical trends in growth rates, GDP per capita .

A description of each energy sector and GDP is provided below, along with explanation of the indicators used for target allocation.

Industrial Energy Sector

Description of Industrial Energy Sector. As the largest energy-consuming sector, and the most energy-intensive, the Industrial Energy sector is especially important in intensity target allocations for the 12th FYP. Industrial Energy includes heavy industry (e.g., iron and steel, chemicals, cement), light industry, and construction, consistent with definitions in Chinese energy statistics.[14] As shown earlier in Table 1, half of China's provinces have an industrial energy share of 70% or higher; the national average was 71% in 2007. The provinces exhibit a fairly wide range of historical trends in this sector; annual industrial energy growth rates during the past 11th FYP range from 7% to 16%. There is wide recognition by the Chinese government that those rates of industrial energy must slow, to shift to a lower-intensity economy, address energy supply concerns, and reduce damages from air pollution and climate impacts.

Indicators for Allocation of Industrial Energy: To allocate targets based on the potential for energy savings in the industrial sector of each province, ideally one would examine the physical energy efficiencies of industries in each province (e.g., the energy required to produce one tonne of steel) and compare against best practice efficiencies. As noted earlier in this report (Section 3 on indicators), physical indicators are preferable, as they give a better representation of actual potential for improvement, and eliminate problems in comparing value-added data (prices, taxes, etc.) across provinces. We sought provincial-level data for physical energy intensities in six energy-intensive sectors. However, only provincial-level data for physical energy efficiency (energy and production) in the cement sector were publicly available. Thus data limitations necessitated the use of another indicator: industrial economic energy intensity (energy consumed per unit of industrial value-added economic output). In consideration of the strong influence of Industrial Energy on provincial targets, additional target scenarios were run utilizing other indicators, namely GDP per capita and trends in growth rates.

Residential Energy Sector

Description of Residential Energy Sector: The Residential Energy sector includes direct fuel use and electricity attributed to residential buildings and their inhabitants. For this sector, the 12th FYP allocation methodology utilized a per capita convergence approach, aimed at achieving a well-off society in an equitable way. For Residential Energy, a per capita approach is truly meaningful, as energy consumption in this sector is mainly influenced by population size. A convergence approach has the goal of bringing the entire population to a common standard of comfort in residential living (heating, cooling, lighting, use of household appliances). The approach used a convergence year of 2050, recognizing that Chinese provinces are at different stages of development. The convergence value was based on residential energy per capita in the most efficient industrialized economies (e.g., Japan and Germany).

Recognizing that weather (climatic) conditions have a strong influence on residential energy use, per capita consumption is corrected for Heating Degree Days (HDD) and Cooling Degree Hours (CDH).[15] Drawing from contour maps and a data set of more than 430 locations (Zhang 2005; Zhang 2009),

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[14] For explanation and definitions in Chinese energy statistics, see LBNL 2009.

[15] Often termed "climate correction," we use "weather correction" to distinguish from the effects of climate change. The correction involves differentiated shares of residential energy for space heating and cooling, based on each province's ratio of HDD and CDH to national average HDD and CDH. Estimated shares of residential energy for space heating ranged from 25% to 75%, and estimated cooling shares ranged from 20% to 40%.

we estimated provincial average HDD and CDH, estimated shares of residential energy going to heating and cooling for each province, developed a correction index, and performed a weather correction on residential energy use per capita. This weather correction had not previously been available at the provincial level in China, and could be utilized and refined in future analyses of China's residential energy.

Allocation of Residential Energy: Rather than using an indicator such as income level or GDP per capita to allocate targets for Residential Energy, we utilized a convergence approach, as noted above. With a weather-corrected per capita goal for convergence of all the provinces in the year 2050, allocations of Residential Energy for the 12th FYP were determined by linear extrapolation.

Other Energy Sector

Description of Other Energy Sector. The "Other" Energy sector includes energy end-use not in the Industrial or Residential sectors: transportation, commercial and service enterprises, agriculture, etc. The choice of grouping these energy end-uses into the category of "other" was made to keep the methodology relatively simple, and to utilize available data. The Other Energy sector represents nearly 19% of China's total energy and that share has been growing. Other Energy includes the service sector, which typically has a lower energy intensity that the industrial sector. Because the service sector is a less energy-intensive means of economic output, it was targeted for expansion in the 11th FYP.

Indicators for Allocation of Other Energy: Several indicators were considered for projecting and allocating Other Energy among the provinces: GDP per capita, income per capita, indirect measures of the intensity of the Other Energy sector, the share of Other Energy in total provincial energy, and the share of tertiary sector GDP. No direct measures of intensity were available, since the boundaries on tertiary (service sector) GDP do not exactly correspond with boundaries on Other Energy (which includes more than the service sector). Similarly, income per capita does not fully reflect trends in Other Energy; for example, the transportation component of Other Energy could depend more on geographical circumstances than on income levels. In the end, GDP per capita was chosen as a rough but suitable indicator of the potential for savings and growth in Other Energy. Trends in historical growth rates were also utilized.

Economic Development: GDP

With a mixed target of economic energy intensity (percent reduction in energy use per unit GDP), the target allocation methodology includes projections of GDP. Whereas three energy sectors were analyzed, GDP was analyzed only in total, since there is no direct correspondence with each energy sector. For example, the Residential sector is important from an energy perspective, but there is no economic output from the Residential sector.

Assumptions about GDP rates of change—and the energy involved in GDP growth—can have a significant influence on projections and targets. The methodology can be used for any GDP rate. The target allocations presented in this report relied on existing forecasts of GDP growth in China and assumed a national 8.5% annual GDP growth during the 12th FYP period. Projections of energy and GDP included simple consideration of shifting shares among energy sectors, but included only total GDP, not sectoral GDP shares. Our analysis did examine historical trends and variation across the provinces in GDP levels and growth rates, and compared target allocation results from varied and uniform rates of GDP growth across the provinces.

4.2.3. Define Allocation Scenarios for Analysis

Once the overall energy and energy intensity goal is established at the national level (methodology step 1), and energy is disaggregated into end-use sectors and sectoral indicators identified (methodology step 2), the next step is to define target allocation scenarios for analysis. The scenarios are used to project energy use at the provincial level out to 2015 in a manner that reflects not only the potential for improving energy efficiency in each sector but that also strives to ensure an equitable allocation of the burden of meeting the provincial level targets. Ultimately, the scenarios should take into consideration China's intertwined goals of (1) facilitating a change in development mode (i.e., changing to a low-carbon and low-energy economic structure), and (2) improving physical energy efficiency. All of the scenarios and sectoral indicators enable comparison across provinces of different sizes. In practice, the choice of indictors was constrained by limitations on publicly-available data at the provincial level.

Recognizing that different indicators can influence resulting target allocations, we analyzed three main allocation scenarios, each scenario using different indicators. Aiming for a simple and transparent methodology, we utilized a single indicator for each energy sector and GDP, in each scenario. The scenarios are used to compare the sensitivity of the targets to different allocation indicators. Table 3 summarizes the elements of each scenario. (Four additional allocation scenarios were analyzed to examine the influence of GDP rates across the provinces and other indicators; these additional scenarios are included in the Appendix.)

Table 3. Overview of Target Allocation Scenarios

Energy End-Use Sectors	**Scenario 1 Trend Analysis and Targeted Savings**		**Scenario 2 Equal Rates and Targeted Savings**		**Scenario 3 GDP-Based Targets**
	Scenario Drivers and Indicators				
Industrial Energy	Energy growth rates based on provincial trends	Energy saving goals based on provincial energy intensity	Energy growth rates based on national average	Energy saving goals based on provincial energy intensity	Energy growth rates based on provincial GDP/capita
Residential Energy	Convergence of residential energy use per capita				
Other Energy	Energy growth rates based on provincial trends	Additional growth based on GDP per capita	Energy growth rates based on national average	Additional growth based on GDP per capita	Energy growth rates based on provincial GDP/capita
GDP	GDP growth rates based on national average; all values in terms of fixed 2005 RMB				

Note: Three scenarios are summarized here; four additional scenarios were developed to test sensitivity of targets to different sectoral indicators. Additional scenarios are included in the Appendix.

A description of each scenario is presented below.

Scenario 1 Description – Trend Analysis and Targeted Energy Savings

Scenario 1 allocates targets based on each province's potential for energy saving, along with consideration of economic development level. Scenario 1 considers equity based on past performance and potential for improvement. This main scenario for the target allocation takes into account the historical variation in energy consumption trends among the provinces, and applies similar energy consumption trends for the five years of the 12th FYP (2011 – 2015). This main scenario considers that the surge in energy consumption in the early 2000s calmed somewhat in the latter 2000s, due to the global financial crisis and efforts during the 11th FYP. Provincial energy trends are assumed to remain similar (e.g., fast-growing provinces still grow faster than slow-growing provinces), although at slower rates (e.g., all growth rates for the 12th FYP are lower than during the 11th FYP). The same rate of economic (GDP) growth was assigned to all provinces in Scenario 1.

S1 – Industrial Energy. Industrial Energy sector targets are based on recent energy consumption growth trends as well as industrial energy intensity levels. With industrial energy intensity as a key indicator of energy saving potential in Scenario 1, tougher savings goals are assigned to provinces with high industrial energy intensity. Those savings goals are combined with recent energy consumption growth trends to calculate the Industrial Energy targets. Industries in the provinces then have two main ways to achieve their target: (1) enhancing physical energy efficiency, and (2) improving the economic output from energy utilization, such as shifting to less energy-intensive enterprises and products and/or higher value added products.

S1 – Residential Energy. For Residential Energy, all scenarios utilized a per capita convergence approach, with appropriate adjustments for different weather conditions, and resulting needs for heating and cooling, across the provinces. A convergence approach has the goal of bringing the entire population up to a common standard of comfort in residential living.

S1 – Other Energy. The Other Energy sector includes energy not covered under Industry or Residential, namely transportation, the service sector, and agriculture. Because this sector is generally less energy-intensive than the industrial sector, and because the government is encouraging development of the service (i.e., tertiary) sector, all provinces are targeted with more growth in Other Energy and less growth in Industrial Energy. Under Scenario 1, provinces with low GDP per capita are allotted additional growth in Other Energy to further encourage the development of a low intensity economy in the 12th FYP.

S1 – GDP. Recognizing that GDP rates have fluctuated frequently in the past across the provinces and are therefore challenging to predict, Scenarios 1 through 3 assign the same rate of economic growth to all provinces.[16] All economic data are expressed in terms of fixed 2005 RMB.

Scenario 2 Description – Equal Growth Rates and Targeted Energy Savings

Scenario 2 recognizes the dynamic nature of China's provinces and considers that future developments during the 12th FYP period may not follow historical trends; instead, equal rates of

[16] In the four additional allocation scenarios included in the Appendix of this report, we differentiated GDP rates based on analysis of recent trends. The resulting targets had very wide variation, showing the strong influence of GDP growth assumptions.

underlying growth in energy consumption are assigned to all provinces. Scenario 2 still aims to set targets based on each province's potential for energy saving, and consider goals for encouraging the service sector.

For the Industrial Energy sector in Scenario 2, all provinces are assigned an equal (national average) rate of change in energy consumption, rather than differentiated rates based on recent trends. Savings goals are then assigned based on industrial energy intensity levels. Tougher savings goals are assigned to provinces with high Industrial intensity.

As in all the scenarios, targets for Residential Energy under Scenario 2 utilized a per capita convergence approach, with adjustments for weather conditions across the provinces. For Other Energy, Scenario 2 set an equal growth rate for all provinces, then allotted additional growth for poorer provinces, based on GDP per capita. All provinces were assigned the same rate of GDP growth.

Scenario 3 Description –Targets based on GDP per capita

Scenario 3 gives highest priority to the provinces' level of economic development, in terms of GDP per capita, as an indicator for target setting, and does not set targets based on the potential for energy saving, nor on recent trends. Scenario 3 considers equity mainly in economic terms.

For the Industrial Energy sector in Scenario 3, targets are based solely on GDP per capita, with poorer provinces allotted more room for growth, and wealthier provinces allotted less growth. Residential Energy utilized a per capita convergence approach, as in all the scenarios. For Other Energy, Scenario 3 based all targets solely on GDP per capita. All provinces were assigned the same rate of GDP growth.

4.2.4 Project Provincial-Level Energy (by End-Use Sector) and GDP Values to 2015 for Each Scenario

With the first three steps of the methodology completed, the next step is to project provincial-level energy use for the three end-use sectors (Industry, Residential, Other) and provincial-level GDP for the 12th FYP. The allocation methodology for China utilizes trend analysis and sectoral indicators to assign annual rates of change for each energy sector and GDP in the provinces during the 12th FYP. The assigned rates are then used to calculate provincial-level sectoral energy and GDP, which in turn yield energy intensity target allocations.

Because this is a methodology for allocating a national target among the provinces, the analysis combines a top-down national projection, with bottom-up provincial and sectoral allocations of energy and GDP. For each scenario, for each energy sector and GDP, the sum of provincial values must meet the national energy sector and GDP projections for 2015. Thus the provincial-level annual rates of change—sectoral energy growth and savings rates—are iteratively adjusted to balance the provincial allocations with the national projections.

Here we provide explanation of the use of trend analysis and sectoral indicators for bottom-up calculations of sectoral energy and GDP, for each scenario.

Scenario 1 Calculation – Trend Analysis and Targeted Energy Savings

Scenario 1 calculates targets based on each province's potential for energy saving, along with consideration of economic development trends. Scenario 1 considers equity based on past performance and potential for improvement. Provincial energy trends, namely the distribution of slow and fast growing provinces, are assumed to remain similar from the 11th FYP to the 12th FYP.

Industrial Energy Calculations. The allocation of Industrial Energy among the provinces for the 12th FYP for Scenario 1 was calculated from a combination of: (a) annual energy consumption growth rates determined through historical trend analysis, and (b) annual energy saving rates based on industrial energy intensity as an indicator of savings potential:

Net growth rate for Industrial Energy Allocation =
Annual energy growth rate – Annual energy saving rate

Trend Analysis of Industrial Energy Growth Rates. Historical rates of change during the 11th FYP were analyzed and utilized to make projections of underlying annual Industrial energy growth rates for the 12th FYP. Provinces were placed into three groups of Industrial energy consumption rates: high growth, medium growth, and low growth. Grouped rates, rather than individual provincial rates, were utilized to smooth out idiosyncrasies in the data and to simplify target allocations. This is similar to the EU Triptych approach, where member states were placed into two groups, and rates were determined for each group rather than individual states. In Scenario 1, the same trends were assumed for the 12th FYP, i.e., that fast growing provinces would still be growing relatively quickly. In all scenarios, Industrial Energy annual energy consumption growth rates for the 12th FYP are markedly lower than in the recent past (2004 – 2009).

Energy Saving Rates based on Industrial Intensity Indicator. In order to determine annual energy saving rates, Scenario 1 utilizes industrial energy intensity as an indicator of savings potential. Provinces were ranked and put into another grouping, based on Industrial energy consumption per value-added intensity: high intensity, medium intensity, and low intensity. Grouped rates, rather than individual provincial rates, were utilized to smooth out idiosyncrasies in the data and to simplify target allocations. Provinces with higher industrial intensity were assigned tougher savings rates, since they have a greater potential for improvement. Provinces with lower intensity were assigned lower savings rates in recognition of the effort they have already made.

For example, Sichuan province had a medium growth rate in Industrial Energy (roughly 13% annually) and a medium industrial energy intensity (2.10 tce/10000 RMB) during the 11th FYP. For the 12th FYP, under a national intensity target of 20% reduction, medium growth provinces were allotted an annual growth of 7.8% in Industrial energy, and medium intensity provinces were allotted an annual savings rate of -5.5% in Industrial energy. The net annual growth rate for Industrial energy in Sichuan province for the 12th FYP is then: 7.8% - 5.5% = 2.3%

The underlying energy consumption growth rates and energy saving rates were determined iteratively, such that the sum of provincial Industrial energy allocations meet the national target projections for industrial energy.

Residential Energy Calculations. The allocation of Residential Energy among the provinces for the 12th FYP is calculated with a per capita convergence approach. A convergence value of 562 kgce per capita was set at the best (lowest) developed country level, that of Japan in 2005 (IEA 2007; IEA 2008; WRI 2009). A convergence year of 2050 was chosen in recognition of the different levels of economic development among China's provinces. From actual 2005 levels, all provinces converge to weather-corrected values of 562 kgce per capita in 2050.[17] Linear interpolation is used to determine each province's per capita residential energy in 2015 for the 12th FYP target. Population projections for each province are then applied the per capita energy values to obtain residential energy consumption in each province in 2015.

Recognizing that weather (climatic) conditions have a strong influence on residential energy use, per capita consumption is corrected for Heating Degree Days (HDD) and Cooling Degree Hours (CDH).[18] Drawing from contour maps and a data set of more than 430 locations (Zhang 2005; Zhang 2009), we estimated provincial average HDD and CDH, estimated shares of residential energy going to heating and cooling for each province, developed a correction index, and performed a weather correction on residential energy use per capita. This weather correction had not previously been available at the provincial level in China, and could be utilized and refined in future analyses of China's residential energy.

Other Energy Calculations. The allocation of Other Energy among the provinces for the 12th FYP for Scenario 1 has similarities to calculations for Industrial Energy, but with an important distinction. Whereas Industrial Energy calculations utilize an indicator of energy saving potential to allocate energy *saving* rates among the provinces, Other Energy calculations utilize an indicator of economic development to allot *additional growth* to poorer provinces. These calculations reflect Chinese policy goals for shifting economic structure away from energy-intensive industry and toward less-intensive service-oriented economic activity; the Other Energy sector includes energy used by the service sector (tertiary economic sector). Thus Other Energy is calculated from a combination of: (a) annual energy consumption growth rates determined through historical trend analysis, and (b) annual rates of additional growth in Other energy, based on GDP per capita as an indicator of economic development level:

> **Net growth rate for Other Energy Allocation** =
> Annual energy growth rate – Annual rate of additional growth allocation

Trend Analysis of Other Energy Growth Rates. Historical rates of change during the 11th FYP were analyzed and utilized to make projections of underlying annual Other Energy growth rates for the 12th FYP. Provinces are placed into three groups of consumption rates: high growth, medium growth, and low growth in Other Energy. Grouped rates, rather than individual provincial rates, were utilized to smooth out idiosyncrasies in the data and to simplify target allocations. (This is similar to the EU Triptych approach, where member states were placed into two groups, and rates were determined for each group rather than individual states.) In Scenario 1, the same trends were

[17] Refer to the previous section for description of the weather correction method.
[18] Often termed "climate correction," we use "weather correction" to distinguish from the effects of climate change. The correction involves differentiated shares of residential energy for space heating and cooling, based on each province's ratio of HDD and CDH to national average HDD and CDH. Estimated shares of residential energy for space heating ranged from 25% to 75%, and estimated cooling shares ranged from 20% to 40%.

assumed for the 12th FYP, i.e., that fast growing provinces would still be growing relatively quickly. In all scenarios, Other Energy annual energy consumption growth rates for the 12th FYP are somewhat slower than in the recent past (2004 – 2009).

Additional Growth in Other Energy based on Economic Development Indicator (GDP per capita). To give additional encouragement to poorer provinces for their shift to a less energy-intensive economic structure, and to enable a shift toward a greater share of Other Energy use, Scenario 1 utilizes GDP per capita as an indicator of economic development level to allocate additional growth in Other Energy. Provinces were ranked and put into another grouping, based on GDP per capita: high, medium, and low. Grouped rates, rather than individual provincial rates, were utilized to smooth out idiosyncrasies in the data and to simplify target allocations. Provinces with lower GDP per capita were assigned higher additional growth rates for Other Energy, since they have a greater potential for improvement. Provinces with lower intensity were assigned lower savings rates in recognition of the effort they have already made.

For example, Henan province had a medium growth rate in Other Energy (roughly 8% annually) and a medium GDP per capita (roughly 16,000 RMB annually) during the 11th FYP. For the 12th FYP, under a national intensity target of 20% reduction, medium growth provinces were allotted an annual growth of 5.0% in Other energy, and medium GDP per capita provinces were allotted an additional growth rate of +1.0% in Other energy. The net annual growth rate for Other energy in Henan province for the 12th FYP is then: 5.0% + 1.0% = 6.0%

The underlying energy consumption growth rates and additional growth rates were determined iteratively, such that the sum of provincial Other energy allocations meet the national target projections for Other energy.

GDP Calculations. All provinces were assigned the same (national average) rate of GDP growth.

Scenario 2 Calculations – Equal Growth Rates and Targeted Energy Savings

The calculation methodology for Scenario 2 is similar to Scenario 1; the difference is the choice of assumptions about growth trends for the upcoming five years. As noted above, Scenario 2 recognizes the dynamic nature of China's provinces and considers that future developments during the 12th FYP period may not follow historical trends. Without a sound basis for predicting new directions in provincial trends, Scenario 2 instead allocates equal (national average) rates of underlying growth in energy consumption to all provinces. Scenario 2 still aims to set targets based on each province's potential for energy saving, and consider goals for encouraging the service sector.

Industrial Energy Calculations. For the Industrial Energy sector in Scenario 2, all provinces are assigned an *equal* (national average) rate of change in energy consumption. Energy saving goals are then assigned based on industrial energy intensity levels of high intensity, medium intensity and low intensity, similar to Scenario 1. Tougher savings goals are assigned to provinces with high Industrial intensity. For the example of Sichuan province, a medium growth, medium intensity province for Industrial energy, a national average annual growth rate of 8% was assigned, and a medium savings goal of -5.5%, yielding a net annual growth rate of 2.5% for Industrial energy during the 12th FYP.

Residential Energy Calculations. As in all the scenarios, targets for Residential Energy under Scenario 2 utilized a per capita convergence approach, with adjustments for weather conditions across the provinces.

Other Energy Calculations. For Other Energy, Scenario 2 set an *equal* (national average) growth rate for all provinces, then allotted additional growth for poorer provinces, based on GDP per capita. Following the example of Other energy in Henan province, this medium growth province with a medium level of GDP per capita was allotted the national average growth rate of 6.0% for Other energy, and an additional growth rate of 1.0%, for a net annual growth rate of 7.0% in Other energy for the 12th FYP.

GDP Calculations. All provinces were assigned the same (national average) rate of GDP growth.

Scenario 3 Calculations –Targets based on GDP per capita

As noted above, Scenario 3 gives highest priority to the provinces' level of economic development, in terms of GDP per capita, as an indicator for target setting, and does not set targets based on the potential for energy saving, nor on recent trends. Scenario 3 considers equity mainly in economic terms.

The calculation methodology for Scenario 3 is somewhat similar to Scenario 2; the difference is the choice of sectoral indicators and assumptions about growth trends for the upcoming five years. Scenario 3 is based on the assumption by some government officials that wealthier provinces have more economic resources and can therefore make greater improvements. In the absence of national funding for implementation, this may be a pragmatic approach. However, this scenario does not consider the variations in intensity among the provinces nor their physical or structural potential for energy saving.

Industrial Energy Calculations. For the Industrial Energy sector in Scenario 3, targets are based solely on GDP per capita. Provinces are placed into three groups based on their economic development level: high, medium, and low. Poorer provinces are given more room for growth (higher growth rates) for industrial energy. Wealthier provinces are assigned lower growth rates, without regard to their recent level of industrial energy intensity or their recent performance during the 11th FYP. For the example of Sichuan province, in terms of its economic development level, Sichuan has a relatively low GDP per capita, and is allotted a net annual growth rate of 4.0% for Industrial energy. Compared to Scenario 1, where Sichuan was viewed as a medium growth, medium intensity province for Industrial energy, and assigned a net annual rate of 2.3%, Scenario 3 allows more growth in Industrial Energy for the relatively poorer province.

Residential Energy Calculations. As in all the scenarios, targets for Residential Energy under Scenario 3 utilized a per capita convergence approach, with adjustments for weather conditions across the provinces.

Other Energy Calculations. For Other Energy, Scenario 3 bases provincial allocations solely on level of economic development, in terms of GDP per capita. Provinces are placed into three groups based on their economic development level: high, medium, and low. Following the example of Other energy in Henan province, with a medium level of GDP per capita, Henan is allotted a net annual growth rate of 7.5% in Other energy for the 12th FYP (under a 20% national intensity target).

GDP Calculations. All provinces were assigned the same (national average) rate of GDP growth for Scenario 3.

4.2.5 Calculate Provincial Intensity Target Allocations

After provincial bottom-up calculations of energy and GDP are balanced with national top-down projections for each energy sector and GDP (methodology steps 1 through 4), the final step of calculating provincial energy intensities and intensity target allocations is taken.

To calculate provincial economic energy intensity, the three energy sectors sum to total energy, which in combination with total GDP, yield intensity.

Provincial Economic Energy Intensity ($EI_{i,n}$) = $\frac{(\text{Industrial + Residential + Other Energy})_{i,n}}{GDP_{i,n}}$

[tce/10000 RMB, 2005]

i = province, n = year

Provincial intensity targets are then expressed as the percent change in intensity over the five-year period.

Provincial Energy Intensity Target [ΔEI_i %] = $\frac{(EI_{i,\,2015}) - (EI_{i,\,2010})}{(EI_{i,\,2010})}$

for 12th FYP (2011-2015)

i = province, n = year

As a final check that provincial intensity targets will meet the national 12th FYP target, the sum of provincial total energy, and the sum of provincial total GDP, are used to calculate a bottom-up value of national energy intensity (tce per 10000 RMB) for each year of the 12th FYP.

Bottom-up National Energy Intensity ($EI_{N,\,n}$) = $\frac{\Sigma\,(\text{Industrial + Residential + Other Energy})_{i,n}}{\Sigma\,GDP_{i,n}}$

[tce/10000 RMB, 2005]

N = National, i = province, n = year

These "bottom-up" calculations of national intensity are compared with the top-down national intensity projection (from step 1 of the methodology). The bottom-up values of national intensity in the years 2010 and 2015 are then used to calculate the percent change in national intensity over the five-year period, which is then compared to the national intensity target.

Bottom-up National Energy Intensity Target [ΔEI_N %] = $\frac{(EI_{N,\,2015}) - (EI_{N,\,2010})}{(EI_{N,\,2010})}$

for 12th FYP (2011-2015)

N = National, n = year

The next section provides results of the intensity target allocation methodology, including results of top-down national projections, and provincial sectoral energy growth rates and savings rates, GDP rates, and intensity target allocations.

5 Allocation of a National Energy Intensity Target to the Provinces: Results

This section utilizes the methodology presented above to allocate a national Energy Intensity improvement target among China's provinces during the 12th Five-Year Plan period (2011 – 2015). Here we examine target allocation for three scenarios, illustrating application of the trend analysis and indicators discussed earlier in the report, and presenting the resulting targets for the provinces. The target allocations for the 12th FYP are also compared to targets and performance during the 11th FYP. To test the sensitivity of the methodology to different indicators, four additional allocation scenarios are analyzed, for a total of seven; the additional scenarios are included in the Appendix.

5.1 National Target Projections: Results

National-level projections of energy and intensity for the 12th FYP were based on three main assumptions: (1) a national energy intensity improvement target of 20% over the five-year period; (2) annual GDP growth of 8.5%; and (3) a small shift in energy structure, from 71% Industrial, 10% Residential, 19% Other Energy; to 69% Industrial, 11% Residential, 20% Other Energy. Utilizing these assumptions, energy and GDP are projected out to 2015, in total and for three energy sectors: Industrial, Residential, and Other Energy. Figure 6 shows the results of the national-level projections of energy and energy intensity during the 11th and 12th FYP period based on these assumptions.

The allocation methodology can be utilized for other values of national intensity target, GDP growth, and energy structure; the values here were based on studies and policy goals through 2010. We used a national target value of 20% to enable comparison of the estimated 12th FYP allocation with the actual allocation for the 11th FYP, and to recognize the ongoing potential for intensity improvement in China. The official target, still under discussion during the writing of this report, was expected to be lower than 20%. A value of 17.3% was suggested in the news (Seligsohn and Hsu, 2011); while a draft of the 12th FYP hints at a national target of 16%.[19] Just as this report was being issued, Premier Wen Jiabao announged the official national energy intensity target of 16%.[20]

Concerning GDP projections, a GDP growth rate of 8.5% was chosen based on earlier projections for the 12th FYP period and actual GDP growth during the past 11th FYP.[21] After our analysis was completed, news reports suggested that an official GDP target would likely be 7.0% or 7.5% for the 12th FYP (Seligsohn and Hsu 2011). The official announcement, made as this report was being issued, set a GDP goal of 8% growth in 2011, slowing to 7% by the end of the 12th FYP.[22]

[19] 地方游说“十二五”环境指标, China Climate Change Info-Net. 2011.1.14

[20] "Key Target of China's 12th FYP." China Daily. 2011.3.5. http://www.chinadaily.com.cn/xinhua/2011-03-05/content_1938144.html. "China Unveils Economic Plan With Focus on Raising Incomes and Reining in Pollution." New York Times. 2011.3.4. http://www.nytimes.com/2011/03/05/world/asia/05china.html?_r=2&pagewanted=1&hp

[21] With a target in terms of economic energy intensity, projections and assumptions about GDP growth have a strong influence. It is especially challenging to make near-term (five-year) predictions of provincial GDP growth. Thus we analyzed multiple scenarios for provincial GDP, based on equal growth rates, recent trends in GDP, and allocation based on GDP per capita, giving poorer provinces more room for growth.

[22] "Premier sets 7% growth target." China Daily. 2011.2.28. http://www.chinadaily.com.cn/china/2011-02/28/content_12084841.htm

The projected shift in energy structure for the 12th FYP was made to address China's goal to reduce the share of the Industrial sector and increase the share of the Service sector in GDP and energy structure.

Assuming intensity targets of 20% reduction during the 11th FYP and the 12th FYP are met, national energy intensity drops from 1.23 tce/10000 RMB in the year 2005 (the base year for the 11th FYP) to 0.98 in 2010, to 0.79 in 2015. Under the assumption of 8.5% annual GDP growth during the 12th FYP, total energy still rises, from 2,247 Mtce in 2005, to 2,987 Mtce in 2010, and 3,593 in 2015.[23] In 2005, national energy consumption structure was 71.0% Industrial Energy, 10.4% Residential Energy, and 18.6% Other Energy. For the 12th FYP period, we modeled a small shift in the structure of energy use, to 69.0% Industrial Energy, 11.0% Residential Energy, and 20.0% Other Energy. This shift in energy structure is based on China's goals for shifting away from an energy-intensive Industrial sector, and promoting less energy-intensive development of the service sector.

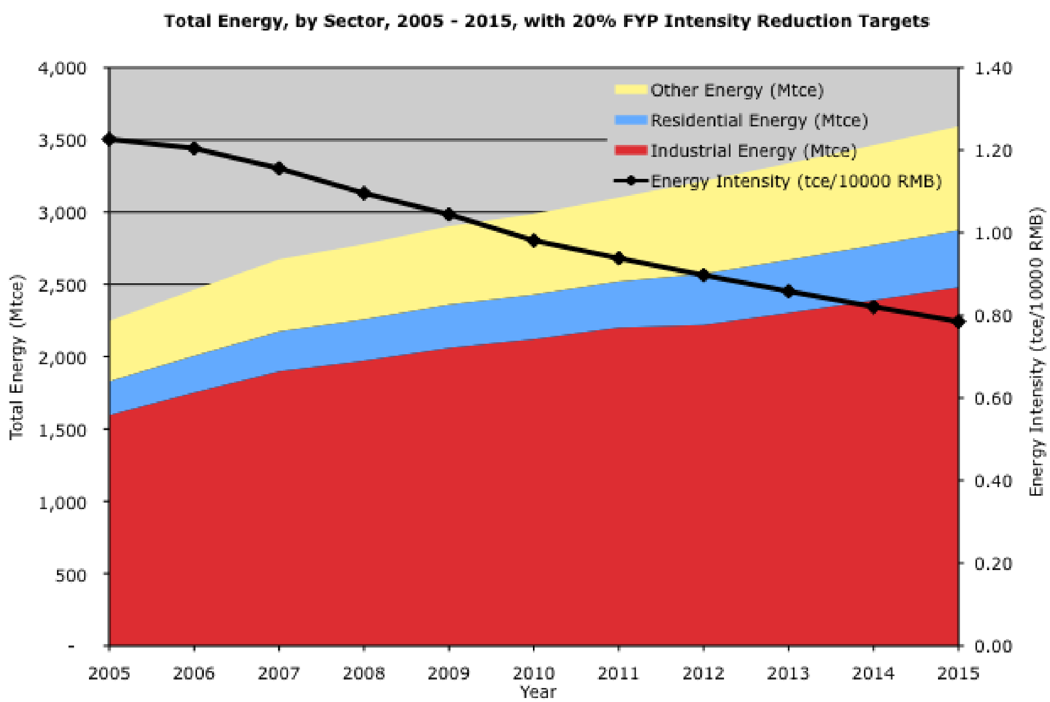

Figure 6. Intensity and Energy by Sector, for 20% Intensity Reduction Targets in 11th & 12th FYP

The amount of energy savings—i.e., avoided energy consumption—to meet the national target was also determined, from the difference between a frozen intensity baseline and the target energy projections. The energy savings needed for the 12th FYP are much larger than in the 11th FYP, despite the same percent change intensity target. This is due to the fact that absolute energy consumption has still been growing. The momentum of large numbers makes it crucial to achieve savings and reductions sooner rather than later. While a portion of 11th FYP savings came from the closure of

[23] The energy data and projections are based on NBS statistics and updates as of January 2010. These numbers do not reflect the widespread revisions of energy and economic statistics made in 2010 in conjunction with China's economic census. Nonetheless, the allocation approach would yield a similar distribution of percent change targets under either set of data.

hundreds of small, inefficient industrial enterprises (Levine et al., 2010), the 12th FYP will have to utilize other strategies for energy saving; in particular, easing the huge demand for industrial products (cement, steel, glass, chemicals), even as production efficiencies improve.

5.2 Provincial Bottom-up Energy Projections: Scenario Results

This section describes the provincial bottom-up energy projections from application of the target allocation methodology under three scenarios, all of which meet a 20% national target. (Additional scenarios are presented in the Appendix.)

Scenario 1 Results - Trend Analysis and Targeted Energy Savings

Scenario 1 allocates targets based on each province's potential for energy saving, along with consideration of economic development trends. Scenario 1 considers equity based on past performance and potential for improvement. This main scenario for the target allocation takes into account the historical variation in energy consumption trends among the provinces, and applies similar energy consumption trends for the five years of the 12th FYP.

Industrial Energy Growth and Saving Rate Allocation – Scenario 1: Tables 4, 5, and 6 summarize the industrial energy consumption growth and energy saving rates assigned under this allocation scenario. All rates are determined through iterative calculations, based on trend analysis and indicators, to meet the national target. Table 4 summarizes the industrial energy growth rates allocated for high, medium, and low growth provinces, based on trend analysis; it also summarizes the energy saving rates allocated for high, medium, and low industrial intensity provinces, based on their recent intensity. Table 5 shows the net industrial energy rates allocated for the 12th FYP. For example, a province that experienced medium growth in its industrial energy during the past five years, with a medium industrial intensity, is assigned a net annual growth rate of 2.3% in Industrial Energy (net rate of 2.3% = 7.8% underlying growth -5.0% savings). Table 6 presents the growth trends, industrial intensity, and resulting net growth rate for industrial energy for the 12th FYP.

Table 4. Industrial Energy – Scenario 1: Growth Rates and Savings Rates

Trend: Industrial Energy Growth in 11th FYP	Assigned Energy growth rate based on trend analysis	Indicator: Industrial energy intensity in 2007	Targeted Energy Saving rate based on industrial intensity
11th FYP	12th FYP	11th FYP	12th FYP
hi growth	9.0%	Hi intensity	-6.5%
med growth	7.8%	med intensity	-5.5%
low growth	6.5%	low intensity	-5.0%

Table 5. Industrial Energy – Scenario 1: Trends and Net Growth Rates

Trend: Industrial Energy Growth in 11th FYP	Indicator: Industrial energy intensity in 2007	Net Annual Growth Rate for Industrial Energy in 12th FYP
11th FYP	11th FYP	12th FYP
hi growth	hi intensity	2.5%
hi growth	med intensity	3.5%
hi growth	low intensity	4.0%
med growth	hi intensity	1.3%
med growth	med intensity	2.3%

med growth	low intensity	2.8%
low growth	hi intensity	0.0%*
low growth	med intensity	1.0%
low growth	low intensity	1.5%

* Note: No provinces were assigned a rate of zero growth for the 12th FYP.

Table 6. Industrial Energy – Scenario 1: Provincial Trends and Target Rates for Industrial Energy

Region	Trend: Industrial Energy Growth in 11th FYP	Indicator: Industrial energy intensity in 2007	Net Annual growth Rate for Industrial Energy in 12th FYP
Beijing	low	low	1.5%
Tianjin	medium	low	2.8%
Hebei	**medium**	**medium**	**2.3%**
Shanxi	**high**	**high**	**2.5%**
Inner Mongolia	**high**	**high**	**2.5%**
Liaoning	**high**	**medium**	**3.5%**
Jilin	high	medium	3.5%
Heilongjiang	medium	low	2.8%
Shanghai	low	low	1.5%
Jiangsu	**medium**	**low**	**2.8%**
Zhejiang	**medium**	**low**	**2.8%**
Anhui	**medium**	**medium**	**2.3%**
Fujian	**medium**	**low**	**2.8%**
Jiangxi	high	medium	3.5%
Shandong	**medium**	**low**	**2.8%**
Henan	**high**	**medium**	**3.5%**
Hubei	**medium**	**medium**	**2.3%**
Hunan	**low**	**medium**	**1.0%**
Guangdong	**high**	**low**	**4.0%**
Guangxi	high	medium	3.5%
Hainan	high	medium	3.5%
Chongqing	medium	medium	2.3%
Sichuan	**medium**	**medium**	**2.3%**
Guizhou	medium	high	1.3%
Yunnan	medium	high	1.3%
Tibet	low	low	1.5%
Shaanxi	medium	medium	2.3%
Gansu	medium	high	1.3%
Qinghai	high	high	2.5%
Ningxia	high	high	2.5%
Xinjiang	medium	high	1.3%

Notes: pink = high growth; tan = high intensity; yellow = medium; blue = low
BOLD = 15 largest energy-consuming provinces.

In comparison with industrial growth rates from the past 11th FYP period, the rates allocated for the 12th FYP are markedly lower. For example, Industrial energy in Guangdong province grew at an annual rate of 12% during the 11th FYP; for the 12th FYP, Guangdong was allocated a 4% annual growth rate in Industrial energy under Scenario 1, in support of a national 20% reduction in economic energy intensity.

Residential Energy - Scenario 1: For the Residential Energy sector, the 12th FYP allocation methodology utilized a per capita convergence approach, aimed at achieving a well-off society in an equitable way. Figure 7 presents the results of the allocation for the Residential Energy. A convergence value was set at the best (lowest) developed country level, that of 562 kgce per capita in Japan in 2005 (IEA 2007; IEA 2008; WRI 2009). A convergence year of 2050 was chosen in recognition of the varying development levels of China's provinces, and to meet the overall 20% intensity reduction goal at the national level. From actual 2005 levels, all provinces converge to a value of 562 kgce per capita in 2050, corrected for weather.[24] Linear interpolation was used to determine each province's per capita residential energy in 2015 for the 12th FYP target. Population projections for each province were then applied to obtain residential energy consumption.

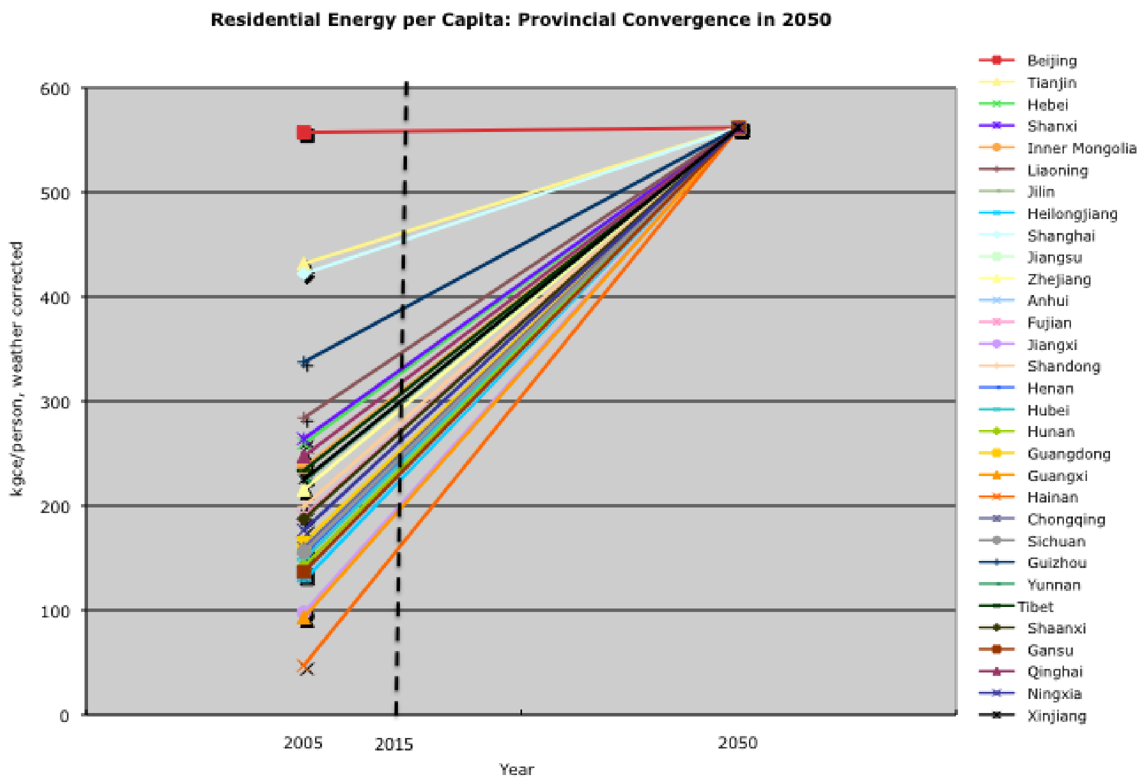

Figure 7. Residential Energy per Capita: Provincial Convergence in 2050

Note: The graphic here shows weather-corrected per capita values for 2005, converging to a uniform convergence value in 2050. In the target analysis, the convergence value was weather-corrected for each province, and future residential energy was projected from actual 2005 values. Values for the 12th FYP target year of 2015 were determined by linear interpolation between 2005 and 2050.

[24] Refer to the previous section for description of the weather correction method.

As can be seen in Figure 7, the convergence is in an *upward* direction. This is in contrast to the situation for most EU member states, where per capita residential energy is targeted to decrease under Kyoto target allocation. Recognizing that China is still lifting millions of its citizens to more comfortable living standards, Residential energy is targeted to increase during the 12th FYP, but at a slower rate than during the 11th FYP. The national average Residential energy growth rate allocated from the convergence approach is 3.8% per year during the 12th FYP; rates for most provinces range from 1.1% to 5.9%.[25] The share of Residential energy in the total energy mix was determined in the national projections. If more room for growth is desired in Residential energy, Industrial energy could be further constrained, or Other energy could be allotted less growth. With progress in standards for buildings, heating, and appliances, greater comfort could be achieved with less energy in the Residential sector.

Scenario 1 – Other Energy Results. Other Energy is calculated from a combination of: (a) annual energy consumption growth rates determined through historical trend analysis, and (b) annual rates of additional growth in Other energy, based on GDP per capita as an indicator of economic development level. Other Energy calculations utilize an indicator of economic development to allot *additional growth* to poorer provinces. These calculations reflect Chinese policy goals for shifting economic structure away from energy-intensive industry and toward less-intensive service-oriented economic activity; the Other Energy sector includes energy used by the service sector (tertiary economic sector).

Tables 7, 8, and 9 summarize the Other energy consumption growth rates and additional growth assigned under this allocation scenario. All the rates are determined through iterative calculations, such that the sum of provincial energy values meets the national target. Table 7 summarizes the Other energy growth rates allocated for high, medium, and low growth provinces, based on trend analysis; it also summarizes the additional growth allocated for high, medium, and low levels of economic development, based on GDP per capita as an indicator of economic development.

Table 7. Other Energy – Scenario 1: Growth Rates

Trend: Other Energy Growth in 11th FYP	Assigned Other Energy growth rate based on trend analysis	Indicator: GDP/capita (2007)	Add'l Other Energy Growth Rate based on GDP/capita
11th FYP	**12th FYP**	**11th FYP**	**12th FYP**
hi growth	7.0%	hi GDP/capita	+0.5%
med growth	5.0%	med GDP/capita	+1.0%
low growth	4.0%	low GDP/capita	+2.0%

Table 8. Other Energy – Scenario 1: Trends and Net Growth Rates

Trend: Other Energy Growth	Indicator: GDP/capita (2007)	Net Annual Growth Rate for Other Energy in 12th FYP
11th FYP	**11th FYP**	**12th FYP**
hi growth	hi GDP/capita	7.5%
hi growth	med GDP/capita	8.0%
hi growth	low GDP/capita	9.0%

[25] The nearly flat growth in Residential energy allocated to Beijing is due to the high per capita consumption in the capital city, and possibly due to population statistics, which didn't account for non-resident population.

med growth	hi GDP/capita	5.5%
med growth	med GDP/capita	6.0%
med growth	low GDP/capita	7.0%
low growth	hi GDP/capita	4.5%
low growth	med GDP/capita	5.0%
low growth	low GDP/capita	6.0%

Table 9. Other Energy - Scenario 1: Provincial Trends and Target Rates

Region	Trend: Other Energy Growth in 11th FYP	Indicator: GDP/capita in 2007	Net Annual growth Rate for Other Energy in 12th FYP
Beijing	high	high	7.5%
Tianjin	low	high	4.5%
Hebei	**low**	**medium**	**5.0%**
Shanxi	**low**	**medium**	**5.0%**
Inner Mongolia	**high**	**high**	**7.5%**
Liaoning	**medium**	**high**	**5.5%**
Jilin	medium	medium	6.0%
Heilongjiang	low	medium	5.0%
Shanghai	high	high	7.5%
Jiangsu	**medium**	**high**	**5.5%**
Zhejiang	**medium**	**high**	**5.5%**
Anhui	**high**	**low**	**9.0%**
Fujian	**medium**	**high**	**5.5%**
Jiangxi	low	low	6.0%
Shandong	**low**	**high**	**4.5%**
Henan	**medium**	**medium**	**6.0%**
Hubei	**high**	**medium**	**6.0%**
Hunan	**medium**	**medium**	**6.0%**
Guangdong	**medium**	**high**	**5.5%**
Guangxi	high	low	9.0%
Hainan	high	medium	6.0%
Chongqing	high	medium	6.0%
Sichuan	**Low**	**low**	**6.0%**
Guizhou	high	low	9.0%
Yunnan	Low	low	6.0%
Tibet	Low	low	6.0%
Shaanxi	low	medium	5.0%
Gansu	low	low	6.0%
Qinghai	medium	medium	6.0%
Ningxia	medium	medium	6.0%
Xinjiang	medium	medium	6.0%

Notes: pink = high growth; purple = high GDP/capita; yellow = medium; blue = low. **BOLD** = largest energy-use provinces.

Table 8 shows the net rates for Other energy allocated for the 12th FYP. For example, a province that experienced medium growth in Other energy during the past five years, with a medium GDP per capita, is assigned a net annual growth rate of 6.0% in Industrial Energy (net rate of 6.0% = 5.0% underlying growth + 1.0% additional growth). For each province, Table 9 presents the growth trends, industrial intensity, and resulting net growth rates for Other energy for the 12th FYP, under Scenario 1. An important result of the allocation methodology, shown in Tables 7 through 9, is that annual rates of growth are higher for Other energy than for the Industrial and Residential energy sectors. Because the share of Other energy in the total energy mix was much smaller than the Industrial share during the past 11th FYP (19% for Other energy, compared to 71% for Industrial energy), and because the share of Other energy is targeted to increase, in an effort to shift economic structure toward less energy-intensive activity, growth rates for Other energy can be higher while still slowing down total energy use.

Scenario 2 Results - Equal Growth Rates and Targeted Energy Savings

Scenario 2 recognizes the dynamic nature of China's provinces and considers that future developments during the 12th FYP period may not follow historical trends; instead, equal rates of underlying growth in energy consumption are assigned to all provinces. Scenario 2 still aims to set targets based on each province's potential for energy saving, and consider goals for encouraging the service sector. In Scenario2, Industrial energy savings rates are allocated based on industrial energy intensity, while additional growth in Other energy is allocated based on GDP per capita. Residential energy allocations are based on a per capita convergence. Industrial energy rates are targeted to slow down during the 12th FYP, while more room for growth is allotted to Other energy, to encourage a shift toward less energy-intensive economic activity.

Scenario 2 – Industrial Energy Growth and Saving Rate Allocation: Tables 10 and 11 summarize the industrial energy consumption growth and energy saving rates assigned under this allocation scenario. Table 10 notes that a national average industrial energy growth rate is allocated to all provinces regardless of their past growth trends during the 11th FYP. It also summarizes the energy saving rates allocated for high, medium, and low industrial intensity provinces, based on their recent intensity, along with the net industrial energy rates allocated for the 12th FYP. For example, in Scenario 2, a province that experienced medium growth in its industrial energy during the past five years, with a medium industrial intensity, is assigned a net annual growth rate of 2.5% in Industrial Energy (net rate of 2.5% = 8.0% national average underlying growth - 5.5% savings target).

Table 10. Industrial Energy – Scenario 2: Growth Rates and Targeted Savings

Provincial historical energy trends	**Assigned Energy growth rate based on *national* average**	**Indicator: Industrial energy intensity in 2007**	**Targeted Energy Saving rate based on industrial intensity**	**Net Annual Growth Rate for Industrial Energy in 12th FYP**
11th FYP	**2015**	**11th FYP**	**2015**	**2015**
hi growth	8.0%	hi intensity	-6.5%	**1.5%**
med growth	8.0%	med intensity	-5.5%	**2.5%**
low growth	8.0%	low intensity	-5.0%	**3.0%**

Table 11 presents the industrial intensity and resulting net growth rate for industrial energy in each province, during the 12th FYP, under Scenario 2. We see a similar range in the rates of Industrial energy use, compared to Scenario 1, but with a shift in distribution. Provinces that had slower growth rates during the past 11th FYP period fare better under Scenario 2, as they are allotted the national average rate, which gives them more room to grow. Provinces that had high industrial energy growth during the past are required to slow down under Scenario 2, as they are allotted the slower national average rate. Thus the heavy industrial north-central provinces of Shanxi and Inner Mongolia are expected to curb industrial energy growth in the 12th FYP under Scenario 2.

Table 11. Industrial Energy – Scenario 2: Provincial Target Rates

Region	Indicator: Industrial energy intensity in 2007	Net Annual growth Rate for Industrial Energy in 12th FYP
Beijing	Low	3.0%
Tianjin	Low	3.0%
Hebei	**Medium**	**2.5%**
Shanxi	**High**	**1.5%**
Inner Mongolia	**High**	**1.5%**
Liaoning	**Medium**	**2.5%**
Jilin	Medium	2.5%
Heilongjiang	Low	3.0%
Shanghai	Low	3.0%
Jiangsu	**Low**	**3.0%**
Zhejiang	**low**	**3.0%**
Anhui	**medium**	**2.5%**
Fujian	**low**	**3.0%**
Jiangxi	medium	2.5%
Shandong	**low**	**3.0%**
Henan	**medium**	**2.5%**
Hubei	**medium**	**2.5%**
Hunan	**medium**	**2.5%**
Guangdong	**low**	**3.0%**
Guangxi	medium	2.5%
Hainan	medium	2.5%
Chongqing	medium	2.5%
Sichuan	**medium**	**2.5%**
Guizhou	high	1.5%
Yunnan	high	1.5%
Tibet	low	3.0%
Shaanxi	medium	2.5%
Gansu	high	1.5%
Qinghai	high	1.5%
Ningxia	high	1.5%
Xinjiang	high	1.5%

Notes: tan = high intensity; yellow = medium; blue = low. **BOLD** = 15 largest energy-consuming provinces.

Residential Energy - Scenario 2: For the Residential Energy sector, the 12th FYP allocation methodology utilized a per capita convergence approach, aimed at achieving a well-off society in an equitable way. All scenarios used the same approach for Residential energy; see Figure 7 for the provincial allocations. Recognizing that China is still lifting millions of its citizens to more comfortable living standards, Residential energy is targeted to increase during the 12th FYP, but at a slower rate than during the 11th FYP. The national average Residential energy growth rate allocated from the convergence approach is 3.8% per year during the 12th FYP; rates for most provinces range from 1.1% to 5.9%.[26] With progress in standards for buildings, heating, and appliances, greater comfort could be achieved with less energy.

Other Energy Results – Scenario 2. In Scenario 2, Other Energy is calculated from a combination of: (a) national average annual energy consumption growth rates assigned to all provinces, and (b) annual rates of additional growth in Other energy, based on GDP per capita as an indicator of economic development level. Other Energy calculations utilize an indicator of economic development to allot *additional growth* to poorer provinces. These calculations reflect Chinese policy goals for shifting economic structure away from energy-intensive industry and toward less-intensive service-oriented economic activity; the Other Energy sector includes energy used by the service sector (tertiary economic sector).

Tables 12 and 13 summarize the Other energy consumption growth rates and additional growth assigned under Scenario 2. Table 12 notes that a national average Other energy growth rate is allocated to all provinces regardless of their past growth trends during the 11th FYP. It also summarizes the additional growth allocated for high, medium, and low levels of economic development, based on GDP per capita as an indicator of economic development, along with the net Other energy rates allocated for the 12th FYP. For example, a province that experienced medium growth in Other energy during the past five years, with a medium GDP per capita, is assigned a net annual growth rate of 7.0% in Industrial Energy (net rate of 7.0% = 6.0% underlying growth + 1.0% additional growth).

Table 12. Other Energy – Scenario 2: Targeted Growth Rates

Provincial historical trends in Other Energy	Assigned Energy growth rate based on *national* average	Indicator: GDP per capita in 2007	Targeted Additional growth based on GDP per capita	Net Annual Growth Rate for Other Energy in 12th FYP
11th FYP	**2015**	**11th FYP**	**2015**	**2015**
hi growth	6.0%	high GDP/capita	0.5%	**6.5%**
med growth	6.0%	med GDP/capita	1.0%	**7.0%**
low growth	6.0%	low GDP/capita	2.0%	**8.0%**

Table 13 presents the growth trends, industrial intensity, and resulting net growth rates for Other energy in each province, during the 12th FYP, under Scenario 2. Compared to Scenario1, the growth

[26] The nearly flat growth in Residential energy allocated to Beijing is due to the high per capita consumption of the capital city, and possibly due to population statistics; the statistics before the 2010 census don't account for the fairly large non-resident population in Beijing.

rates for Other energy are in a tighter range, with less variation among the provinces. Since all provinces are assigned the same national average rate for underlying growth, provinces with previously slow growth in the service sector are given more room to grow in Other energy, under Scenario 2. All provinces are allotted more growth in Other energy, compared to Industrial energy.

Table 13. Other Energy - Scenario 2: Provincial Indicator and Target Rates

Region	Indicator: GDP/capita in 2007	Net Annual growth Rate for Other Energy in 12th FYP
Beijing	high	6.5%
Tianjin	high	6.5%
Hebei	**medium**	**7.0%**
Shanxi	**medium**	**7.0%**
Inner Mongolia	**high**	**6.5%**
Liaoning	**high**	**6.5%**
Jilin	medium	7.0%
Heilongjiang	medium	7.0%
Shanghai	high	6.5%
Jiangsu	**high**	**6.5%**
Zhejiang	**high**	**6.5%**
Anhui	**low**	**8.0%**
Fujian	**high**	**6.5%**
Jiangxi	low	8.0%
Shandong	**high**	**6.5%**
Henan	**medium**	**7.0%**
Hubei	**medium**	**7.0%**
Hunan	**medium**	**7.0%**
Guangdong	**high**	**6.5%**
Guangxi	low	8.0%
Hainan	medium	7.0%
Chongqing	medium	7.0%
Sichuan	**low**	**8.0%**
Guizhou	low	8.0%
Yunnan	low	8.0%
Tibet	low	8.0%
Shaanxi	medium	7.0%
Gansu	low	8.0%
Qinghai	medium	7.0%
Ningxia	medium	7.0%
Xinjiang	medium	7.0%

Notes: purple = high GDP/capita; yellow = medium; blue = low
BOLD = 15 largest energy-consuming provinces.

Scenario 3 –Targets based on GDP per capita

Scenario 3 gives highest priority to the provinces' level of economic development, in terms of GDP per capita, as an indicator for target setting, and does not set targets based on the potential for energy saving, nor on recent trends. Scenario 3 considers equity mainly in economic terms. For Industrial energy and Other energy, allocations are based solely on GDP per capita in Scenario 3. Residential energy is based on convergence of per capita energy use, as in all the scenarios.

Scenario 3 – Industrial Energy Growth and Saving Rate Allocation: Tables 14 and 15 summarize the industrial energy consumption growth and energy saving rates assigned under this allocation scenario. Table 14 notes that under Scenario 3, industrial energy growth rates are allocated to all provinces based solely on GDP per capita. For example, in Scenario 3, a province with a medium level of economic development, in terms of GDP per capita, is assigned an Industrial energy growth rate of 3.0%, regardless of its growth trend or industrial intensity during the past five years. For each province, Table 15 presents the level of GDP per capita and the allocated growth rate for industrial energy for the 12th FYP, in Scenario 3.

Table 14. Industrial Energy – Scenario 3: Targeted Growth Rates

Indicator: GDP per capita in 11th FYP	Assigned Net Industrial Energy growth rate based on GDP per capita
11th FYP	**12th FYP**
Low GDP/cap	**4.0%**
med GDP/cap	**3.0%**
High GDP/cap	**2.0%**

Table 15. Industrial Energy - Scenario 3: Provincial Indicator and Target Rates

Region	Indicator: GDP/capita in 2007	Net Annual growth Rate for Industrial Energy in 12th FYP
Beijing	high	2.0%
Tianjin	high	2.0%
Hebei	**medium**	**3.0%**
Shanxi	**medium**	**3.0%**
Inner Mongolia	**high**	**2.0%**
Liaoning	**high**	**2.0%**
Jilin	medium	3.0%
Heilongjiang	medium	3.0%
Shanghai	high	2.0%
Jiangsu	**high**	**2.0%**
Zhejiang	**high**	**2.0%**
Anhui	**low**	**4.0%**
Fujian	**high**	**2.0%**
Jiangxi	low	4.0%
Shandong	**high**	**2.0%**
Henan	**medium**	**3.0%**
Hubei	**medium**	**3.0%**

Hunan	**medium**	**3.0%**
Guangdong	**high**	**2.0%**
Guangxi	low	4.0%
Hainan	medium	3.0%
Chongqing	medium	3.0%
Sichuan	**low**	**3.0%**
Guizhou	low	4.0%
Yunnan	low	4.0%
Tibet	low	4.0%
Shaanxi	medium	3.0%
Gansu	low	4.0%
Qinghai	medium	3.0%
Ningxia	medium	3.0%
Xinjiang	medium	3.0%

Notes: purple = high GDP/capita; yellow = medium; blue = low
BOLD = 15 largest energy-consuming provinces.

Residential Energy - Scenario 3: For the Residential Energy sector, the 12th FYP allocation methodology utilized a per capita convergence approach, aimed at achieving a well-off society in an equitable way. All scenarios used the same approach for Residential energy; see Figure 7 for the provincial allocations. Recognizing that China is still lifting millions of its citizens to more comfortable living standards, Residential energy is targeted to increase during the 12th FYP, but at a slower rate than during the 11th FYP. The national average Residential energy growth rate allocated from the convergence approach is 3.8% per year during the 12th FYP; rates for most provinces range from 1.1% to 5.9%.[27] With progress in standards for buildings, heating, and appliances, greater comfort could be achieved with less energy.

Other Energy Results – Scenario 3. In Scenario 3, Other Energy is based solely on GDP per capita as an indicator of economic development. Rates are determined iteratively, such that the sum of Other energy from the provinces meets the national target. Other Energy calculations utilize an indicator of economic development to allot *additional growth* to poorer provinces. These calculations reflect Chinese policy goals for shifting economic structure away from energy-intensive industry and toward less-intensive service-oriented economic activity; the Other Energy sector includes energy used by the service sector (tertiary economic sector). Tables 16 and 17 summarize the Other energy consumption growth rates and additional growth assigned under Scenario 3.

[27] The nearly flat growth in Residential energy allocated to Beijing is due to the high per capita consumption of the capital city, and possibly due to population statistics; the statistics before the 2010 census don't account for the fairly large non-resident population of workers in Beijing.

Table 16. Other Energy – Scenario 3: Targeted Growth Rates

Indicator: GDP per capita in 11th FYP	**Assigned Net Other Energy growth rate based on GDP per capita**
11th FYP	**12th FYP**
Low GDP/cap	**7.5%**
med GDP/cap	**6.5%**
High GDP/cap	**6.0%**

Table 17. Other Energy - Scenario 3: Provincial Indicator and Target Rates

Region	**Indicator: GDP per capita in 2007**	**Net Annual growth Rate for Other Energy in 12th FYP**
Beijing	high	6.0%
Tianjin	high	6.0%
Hebei	**medium**	**6.5%**
Shanxi	**medium**	**6.5%**
Inner Mongolia	**high**	**6.0%**
Liaoning	**high**	**6.0%**
Jilin	medium	6.5%
Heilongjiang	medium	6.5%
Shanghai	high	6.0%
Jiangsu	**high**	**6.0%**
Zhejiang	**high**	**6.0%**
Anhui	**low**	**7.5%**
Fujian	**high**	**6.0%**
Jiangxi	low	7.5%
Shandong	**high**	**6.0%**
Henan	**medium**	**6.5%**
Hubei	**medium**	**6.5%**
Hunan	**medium**	**6.5%**
Guangdong	**high**	**6.0%**
Guangxi	low	7.5%
Hainan	medium	6.5%
Chongqing	medium	6.5%
Sichuan	**low**	**7.5%**
Guizhou	low	7.5%
Yunnan	low	7.5%
Tibet	low	7.5%
Shaanxi	medium	6.5%
Gansu	low	7.5%
Qinghai	medium	6.5%
Ningxia	medium	6.5%
Xinjiang	medium	6.5%

Notes: purple = high GDP/capita; yellow = medium; blue = low
BOLD = 15 largest energy-consuming provinces.

Table 16 notes that Other energy growth rates are based solely on GDP per capita for Scenario 3. Table 17 shows that the poorer provinces are given the most room to grow in Other energy, while wealthier provinces may be required to slow. While Scenario 3 focuses on equity in terms of economic development, it does not consider the physical potential for energy savings or growth, nor does it take into account past experience of energy growth trends in the provinces.

5.3 Provincial Energy Intensity Target Allocations: Results

The preceding section presented allocated growth rates in three energy sectors (Industrial, Residential, and Other) needed to meet a 20% national intensity target for the 12th FYP. This section combines the energy allocations with GDP projections to present resulting energy intensities and energy intensity improvement targets for the provinces for the 12th FYP. As noted earlier, all provinces were assigned a national average rate of GDP growth in the three allocation scenarios presented here.

Table 18 presents the energy intensities for each province, in terms of tce per 10000 RMB, in 2005, 2010, and 2015, resulting from the target allocation under Scenario 1. These provincial energy intensities are the result of allocating a national target of 20% intensity reduction in both the 11th FYP and the 12th FYP. This table illustrates the range of intensities across the provinces, and the magnitude of intensity change from 2005 to 2015. Among the largest energy-consuming provinces (noted in **bold** in Table 18), Guangdong has the lowest overall energy intensity, followed by Zhejiang, Jiangsu, and Fujian. In contrast, the large energy-consuming provinces of Shanxi, Inner Mongolia, and Hebei have high overall energy intensities. In between, the large energy-consuming province of Shandong and Anhui show a strong progression toward a less energy-intensive economy.

Table 19 presents 12th FYP energy intensity targets resulting from application of the sectoral methodology under three scenarios (S1, S2, and S3), all of which meet a 20% national energy intensity target. (Additional scenarios are presented in the Appendix.) The table also compares the 12th FYP estimated targets with actual targets and provincial progress during the 11th FYP. In comparison with 12th FYP intensity targets allocated by the sectoral methodology presented in this report, the 11th FYP targets appear to be a blend of scenarios. For the largest energy-consuming provinces, such as Guangdong and Shandong, the 11th FYP targets are most consistent with Scenario 1 allocation for the 12th FYP. For the heavy industrial provinces of Shanxi and Inner Mongolia, 11th FYP targets fit best with Scenario 2 targets for the 12th FYP. For the poorer provinces of Sichuan and Yunnan, 11th FYP targets appear to match Scenario 3 of the 12th FYP. The municipalities and provinces that were ahead of target (Beijing, Tianjin), or behind target (Sichuan, Guizhou, Xinjiang), support the use of Scenario 3, which bases targets primarily on level of economic development. Provinces with the greatest variation across target scenarios, namely Hunan, Guizhou, and Yunnan, have growth trends that differ quite a bit from the national average.

All the scenario results for 12th FYP energy intensity target allocations provide a basis for decision making on the target level, as well as implementation support. By using common indicators and a consistent data set across the provinces, the allocation methodology provides a scientific and transparent approach for target allocation.

Table 18. Provincial Energy Intensities for National 20% Targets in 11th FYP and 12th FYP

Province	2005 Intensity (reported) tce/10000 RMB	2010 Intensity (est.) tce/10000 RMB	2015 Intensity (est.) tce/10000 RMB
Beijing	0.80	0.64	0.51
Tianjin	1.11	0.78	0.60
Hebei	**1.96**	**1.43**	**1.11**
Shanxi	**2.95**	**2.12**	**1.63**
Inner Mongolia	**2.48**	**1.58**	**1.25**
Liaoning	**1.83**	**1.23**	**0.98**
Jilin	1.65	1.18	0.96
Heilongjiang	1.46	0.88	0.71
Shanghai	0.91	0.73	0.57
Jiangsu	**0.92**	**0.73**	**0.57**
Zhejiang	**0.90**	**0.75**	**0.59**
Anhui	**1.21**	**0.96**	**0.80**
Fujian	**0.94**	**0.74**	**0.59**
Jiangxi	1.06	0.78	0.68
Shandong	**1.28**	**0.92**	**0.72**
Henan	**1.38**	**1.03**	**0.85**
Hubei	**1.51**	**1.08**	**0.85**
Hunan	**1.40**	**1.02**	**0.79**
Guangdong	**0.79**	**0.71**	**0.59**
Guangxi	1.22	1.01	0.87
Hainan	0.92	0.86	0.77
Chongqing	1.42	0.98	0.78
Sichuan	**1.53**	**0.99**	**0.80**
Guizhou	3.25	2.32	1.82
Yunnan	1.74	1.29	0.98
Tibet	ND	ND	ND
Shaanxi	1.48	0.96	0.76
Gansu	2.26	1.74	1.37
Qinghai	3.07	2.40	1.91
Ningxia	4.14	3.07	2.39
Xinjiang	2.11	1.38	1.09
National Avg.	**1.23**	**0.98**	**0.78**

Notes: tan: intensity ≥ 1.0; yellow: 0.8 ≤ intensity <1.0 light green : intensity < 0.8.
BOLD = 15 largest energy-consuming provinces. All economic data are expressed in terms of fixed 2005 RMB.

Table 19. 12th FYP Provincial Energy Intensity Targets for a -20% National Target: Allocation Scenarios and Comparison with 11th FYP Progress

Province	12th FYP Target Scenarios				11th FYP Targets & Progress	
	Trend Analysis & Targeted Savings (S1)	Equal Growth & Targeted Savings (S2)	GDP-based Growth & Equal Savings (S3)		Actual 11th FYP Target [2]	Reported Progress (2005 - 2009)[3]
Beijing	-20%	-20%	-22%		-20%	-24%
Tianjin	-23%	-21%	-24%		-20%	-22%
Hebei	**-23%**	**-21%**	**-20%**		**-20%**	**-18%**
Shanxi	**-23%**	**-25%**	**-21%**		**-25% [-22%]**	**-20%**
Inner Mongolia	**-21%**	**-24%**	**-23%**		**-25% (-22%]**	**-20%**
Liaoning	**-21%**	**-23%**	**-24%**		**-20%**	**-17%**
Jilin	-19%	-20%	-19%		-30% [-22%]	-19%
Heilongjiang	-19%	-17%	-17%		-20%	-18%
Shanghai	-21%	-19%	-22%		-20%	-18%
Jiangsu	**-21%**	**-20%**	**-23%**		**-20%**	**-19%**
Zhejiang	**-22%**	**-21%**	**-24%**		**-20%**	**-19%**
Anhui	**-17%**	**-17%**	**-13%**		**-20%**	**-17%**
Fujian	**-21%**	**-19%**	**-22%**		**-16%**	**-14%**
Jiangxi	-13%	-15%	-11%		-20%	-17%
Shandong	**-22%**	**-20%**	**-23%**		**-22%**	**-20%**
Henan	**-17%**	**-20%**	**-18%**		**-20%**	**-18%**
Hubei	**-21%**	**-19%**	**-19%**		**-20%**	**-20%**
Hunan	**-23%**	**-18%**	**-18%**		**-20%**	**-20%**
Guangdong	**-17%**	**-19%**	**-22%**		**-16%**	**-15%**
Guangxi	-14%	-17%	-13%		-15%	-14%
Hainan	-10%	-11%	-11%		-12%	-7%
Chongqing	-20%	-19%	-18%		-20%	-18%
Sichuan	**-19%**	**-17%**	**-15%**		**-20%**	**-16%**
Guizhou	-21%	-22%	-16%		-20%	-16%
Yunnan	-24%	-22%	-16%		-17%	-15%
Tibet	ND	ND	ND		-12%	ND
Shaanxi	-21%	-18%	-17%		-20%	-18%
Gansu	-21%	-19%	-13%		-20%	-18%
Qinghai	-20%	-23%	-19%		-17%	-11%
Ningxia	-22%	-25%	-20%		-20%	-18%
Xinjiang	-21%	-19%	-16%		-20%	-9%

Notes: pink = high; yellow = medium; blue = low; bright green = ahead of target; light green = on track; tan = behind target as of 2009. **BOLD** = 15 largest energy-consuming provinces.

[1] 11th FYP Targets for Shanxi, Inner Mongolia, and Jilin were revised to -22% in 2010. [2] The official reported target progress (shown here) is based on the sum of annual percent changes (2005 – 2009). Progress calculated on cumulative Intensity Change (not shown) yields different results. Cumulative Energy Intensity Change (2005 - 2009) = (EI,2009 - EI,2005) / EI,2005.

Explaining the Connection Between Indicators and Targets

The target allocations under Scenario 1 have a similar spread but somewhat different distribution of targets compared to the 11th FYP. The majority of provinces (19 out of 31) have targets in the range of 18% to 22% reductions. Overall, targets ranged from 10% to 24%. Most of the largest energy-consuming provinces received targets tougher than 20% under this methodology (e.g., Hebei at 23%, Jiangsu at 21%, and Shandong at 22%). The tougher targets are mainly influenced by a combination of industrial energy shares and industrial energy intensity levels. For example, Hebei has a high share of industrial energy (81%, refer to Table 1) as well as a high industrial intensity (2.96 tce/10000 RMB, refer to Table 1 and 18). Thus its overall tougher target is strongly influenced by the condition of its energy-intensive industrial sector. Jiangsu has a similarly high share of industrial energy (82%), but has a relatively low industrial energy intensity (1.41 tce/10000 RMB); thus Jiangsu's overall target is lower than that for Hebei, but still fairly high. Shandong lies in between, with a 75% share of industrial energy and a medium industrial energy intensity, resulting in a 22% overall intensity target.

A look at targets for Guangdong province illustrates application of the allocation methodology under three scenarios. Guangdong is China's second-largest energy-consuming province, and experienced high growth in industrial energy consumption during the 11th FYP, yet has the lowest industrial energy intensity, 1.09 tce/10000RMB (refer to Tables 1 and 18). One of China's wealthy provinces, Guangdong has a high GDP per capita, yet the residential energy consumption per capita is moderate. In terms of energy and economic structure, Guangdong's Industrial share of energy (67%) and Industrial share of GDP (51%) are a few percentage points below the national average.

Estimated energy intensity targets for Guangdong ranged from -17% in Scenario 1 to -22% in Scenario 3 (see Table 19). Why the difference in targets? Since Scenario 1 emphasizes the potential for energy saving and intensity improvement, it recognizes that Guangdong has achieved the lowest industrial energy intensity of all the provinces and has been growing its tertiary economic sector; as a result, Guangdong is allotted a lower target of -17%. Because Scenario 3 focuses only on the level of economic development, in terms of GDP per capita, in allocating targets, the wealthy province of Guangdong is assigned a tougher target of -22%.

Looking more deeply, we see that in 2007, Guangdong had the highest GDP and second-highest energy consumption of the provinces, in absolute terms (refer to Figures 1 and 3); in per capita terms, its total energy per capita is near average, while its GDP per capita is the sixth highest. The Industrial share of Guangdong's energy structure is moderate among Chinese provinces, although still quite large (67%, as shown in Table 1). Industrial energy experienced high growth during the 11th FYP, while industrial energy intensity was relatively low (refer to Table 3). With its low intensity and high historical growth, Guangdong was allotted a lower saving rate for industrial energy, and therefore a relatively higher industrial energy rate, based on the methodology developed in this study. In the Residential energy sector, which accounts for 12% of the province's total energy, Guangdong has a relatively low per capita consumption (see Table 1) and was therefore allotted more room to grow under the per capita convergence approach utilized in this study's allocation methodology (see Figure 7). In the Other energy sector, which accounts for 22% of the province's total energy, Guangdong was allotted a relatively smaller growth rate, since its tertiary GDP and GDP per capita are already higher than many interior provinces (refer to Table 4). The combination of savings rates and growth rates across the three energy sectors and GDP resulted in Guangdong's estimated target of 17% intensity reduction for the 12th FYP under Scenario 1.

In comparison, Shandong—the largest energy-consuming province—has a larger share of Industrial energy (75%) than Guangdong, a more moderate historical growth rate, and a medium (rather than low) industrial energy intensity. As a result, Shandong was allotted a tougher saving rate and a lower growth rate for Industrial energy than Guangdong. This means that Shandong is estimated to have greater potential for energy saving in its industrial sector, even as its economy develops and shifts more toward tertiary sector activities. Shandong has made important and lasting progress toward an energy-efficient economy during the 11th FYP, and these efforts can continue to bear fruit in the upcoming years (World Bank, 2010). In Residential energy (8% of total energy) and Other energy (12% of total), Shandong was allotted relatively smaller growth rates, since its Residential energy per capita is already near average, and its GDP per capita is already higher than many other provinces. Because Shandong's energy structure is so dominated by Industrial energy, the targeting for the industrial sector strongly influenced its overall intensity target of 22% for Scenario 1.

6 Conclusions and Recommendations

The sectoral allocation methodology presented in this report is a scientific methodology that makes transparent connections between the choice of indicators, and resulting targets, enabling decision-makers to clearly set priorities and explain the targets. The methodology accounts for varying potential to improve energy intensity by identifying measureable indicators; these indicators can also facilitate monitoring progress toward the targets. An equitable distribution of targets is achieved by aiming for a common level of residential energy and comfort for all citizens (convergence approach), and by encouraging the development of low-energy economic activity for all provinces, with extra encouragement for poorer provinces. The methodology is effective in that it allocates provincial targets that can achieve the national target, and it works within the constraints of available data. While relatively simple, this methodology is suited to data availability and the organization of statistics in China, as well as the structure of energy use and economic output. The allocation approach for China builds on the EU triptych approach for carbon targets, which effectively engaged EU member states in working toward a common goal.

This 12th FYP allocation methodology can be applied for different target levels; when the official national target is announced, corresponding provincial allocations can be quickly calculated. The methodology can be modified to allocate a carbon intensity target by incorporating data on fuel mix and non-fossil energy. Structural change of the economy is considered indirectly; the methodology allows for simple adjustment of energy structure (e.g., shares of energy in Industry, Residential, Other) in national (top-down) target projections.

The target methodology acknowledges the overall energy and economic situation in each province at present. Some provinces will find their targets challenging, while other provinces will find themselves well prepared to meet their targets. For example, the northern central provinces will need to lessen investment and production in heavy industry and shift toward lower-energy economic activity. At the same time, growing urban centers will need to reduce their high demand for energy-intensive industrial materials. The eastern municipalities (Beijing, Shanghai) have already been expanding the tertiary, lower-energy, share of their economies and are poised to reduce their energy intensity even more.

6.1 Conclusions

Application of the target allocation methodology offers several findings about the structure and rate of energy and economic growth in China's provinces.

Energy Rates

Key findings regarding energy growth rates during the 12th FYP include:

- **Significant slowing in Total Energy** growth is needed to meet 2015 energy intensity targets. To meet a national 12th FYP energy intensity target of -20% by 2015, provincial total energy growth rates should average **3.4%** annually, ranging from 1.5% to 4.5% across the provinces in 2015. This compares to a Total Energy average growth rate of 9.6% in 2007.
- Industrial Energy growth should slow the most, while Residential Energy and Other Energy are allowed to grow more, to achieve a well-off society and development of a less energy-intensive economy.
- **Industrial Energy** annual growth at an average of **2.5%**, ranging from 1.5% to 4.0% across the provinces in 2015. This compares to an Industrial Energy annual average growth rate of 12.5% in 2007.
- **Residential Energy** annual growth at an average of **3.8%**, ranging from 1.1% to 6.1% in 2015. This compares to a Residential Energy annual average growth rate of 7.4% in 2007.
- **Other Energy** annual growth at an average of **6.4%**, ranging from 6.0% to 7.5% in 2015. This compares to Other Energy annual average growth rate of 9.2% in 2007.

Structure and Size

The energy and economic structure of the provinces—the relative shares of industry and the service sector—are important influences on targets. Provinces are assigned savings rates based on indicators like industrial intensity and GDP per capita; the resulting intensity targets differ due to each province's energy and economic structure. The absolute size of energy consumption and economic output are also important influences on target allocation. Indicators and trend analysis were utilized to assign equitable targets to the provinces in terms of *percent change* in energy intensity. A 1% change in the large energy consumption of Shandong accounts for more absolute savings than a 1% change the smaller energy consumption of Shanghai, yet provinces were allocated targets based on *relative* indicators, not on size.

Economic Growth Rates

Growth rates of GDP also matter. In the three scenarios presented in this paper, the same GDP rate was assigned to all provinces. However, economic growth rates vary both in the development plan of each province and in reality, which in turn influence the national target. Rapid economic growth accompanied by an expansion of energy-intensive sectors experienced since 2000 led to a surge in China's energy consumption over the past decade. Since one goal of the energy intensity target is to promote structural change, it might be reasonable to assign higher target to faster growth regions, given the strong ability of these local governments to mobilize resources, either in a favorable way or not.

6.2 Recommendations

The development and application of a target allocation methodology for China identified a number of data needs, as well as needs for further analysis and policy implementation. On the data front, one important data issue that arose in the analysis was discrepancies in provincial data compared to national data, even when accounting for differences in energy definitions and electricity conversion factors. Because the sum of provincial energy did not equal the national total, and the sum of provincial GDP did not equal national total, provincial numbers were adjusted based on their proportion of the national total. The choice of Indicators, and estimates of potential energy savings, are limited by data availability at the provincial and city level. Additional data are needed to improve target setting and allocation, as well as to develop implementation plans to achieve the targets.

Following are recommendations for enhancing the target allocation methodology:

- To better estimate the potential for improving physical and economic energy intensity, industrial sub-sector data on energy, production, and economic (value-added) data are needed for each province, in iron and steel, selected chemicals, and other sub-sectors.
- Published data on provincial-level overall energy intensity or industrial energy intensity was often not accompanied by the energy and economic data used to calculate intensity. It is crucial to distinctly report and publish data on: energy by sector, by fuel, and by province; economic data by sector; as well as production and physical energy intensity by product.
- A deeper level of analysis is needed at the provincial level, to address the variety of economic and industrial structures in the provinces.
- To better estimate the potential for structural improvements in energy intensity, data are needed on enterprise size, ownership structure, product and pricing mix.
- The estimates of weather correction developed for residential energy calculations could be improved, by additional data gathering (via surveys and metering) on the shares of residential energy used for heating and cooling in the provinces.

Since target setting and allocation are only the first steps toward achievement of the targets, we offer recommendations for reporting and monitoring progress, and for further analysis.

- *Data reporting* must include energy data, and economic data, as well as the combined metric of economic energy intensity (tce/10000 RMB).
- A wide variety of *implementation strategies* are needed to achieve the targets, taking into account the particular energy-consuming sub-sectors in each province.
- Even though the target metric is *economic* energy intensity, ongoing attention is needed at the provincial and city level on improvement of *physical* energy intensity, through benchmarking and energy management in industry. International experience has shown that ongoing efficiency improvements are achievable (Price, 2010).
- Further examination of the *demand for energy*—especially in *urban areas*—is needed to better understand the drivers of energy consumption and opportunities for energy saving. Programs are needed to develop thriving urban centers with less energy, fewer materials, and less carbon.
- Further analysis is needed on the mechanisms for energy savings through *economic structure changes* at all levels of the economy, from macro-economic policies and energy pricing, to local taxes and land-use policies, within industrial sub-sectors, to enterprises-level choice of business activities and products.
- As China moves into the 12th FYP period, after undertaking the hard task of closing hundreds of small inefficient enterprises during the 11th FYP, an important new task will be development of low-energy and low-carbon economic activities and jobs.

In closing, we highlight the following recommendations:

Target Methodology: Attention should be paid to energy intensity of GDP, industrial energy intensity, GDP per capita, trends in growth rates of GDP, etc., when adopting a methodology to allocate targets to provinces, cities and counties, or to sectors and enterprises.

Additional Data: To clearly track progress on energy intensity, provinces and sectors within provinces, should distinctly report energy consumption and corresponding value-added economic output, as well as the aggregated intensity data. Data are also needed on physical and economic energy intensities for industrial sub-sectors (e.g., iron and steel, cement, chemicals), to better characterize energy-saving potential and help provinces develop specific policies to meet their targets.

Additional Metrics: A 'mixed' target like economic energy intensity is challenging, in that energy and GDP interact in so many ways to yield economic energy intensity. It is crucial to specify additional metrics and goals—such as absolute energy savings or other physical limits—to help provinces achieve their intensity targets.

Policy Analysis on Energy and Economic Structure: Further analysis is needed on the mechanisms for energy savings through *economic structure changes* at all levels of the economy, from macro-economic policies and energy pricing, to local taxes and land-use policies, within industrial sub-sectors, to enterprises-level choice of business activities and products. Further examination of the *demand for energy*—especially in *urban areas*—is also needed to better understand the drivers of energy consumption and opportunities for energy saving. Programs are needed to develop thriving urban centers with less energy, fewer materials, and less carbon.

Support for Provincial-level Implementation Plans: A deeper level of analysis is needed at the provincial level, to help the provinces develop *implementation strategies* to achieve the targets, taking into account the variety of economic and industrial structures in the provinces.

The next five years will be a mix of past momentum and strong new efforts toward a low-energy, low-carbon economy. The sectoral methodology developed for China presented in this report offers a scientific and transparent approach for allocating intensity targets among the provinces for the 12th FYP. The scenarios presented here show target outcomes based on measurable indicators, which can also help to track progress toward the targets. The methodology presented here provides a strong basis for negotiating, final target setting, and implementation support.

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APPENDIX: SEVEN TARGET ALLOCATION SCENARIOS

The Appendix describes a total of seven target allocation scenarios analyzed for the provinces in the 12th FYP. The first three scenarios are presented in the main report, while the latter four of the seven scenarios are only presented in the Appendix. The purpose of analyzing multiple scenarios is to check the sensitivity of the target allocation methodology to assumptions and choice of indicators on the energy and economic situation of each province. Table A-1 provides a summary description of the scenarios; further description and discussion of results follows. Table A-2 provides the resulting target allocation from each scenario, allowing for comparison.

Table A-1. Description of Energy Intensity Target Allocation Scenarios for Provinces in the 12th FYP

<table>
<tr><th>No.</th><th colspan="2">1</th><th colspan="2">2</th><th>3</th><th colspan="2">4</th><th>5</th><th colspan="2">6</th><th colspan="2">7</th></tr>
<tr><th>Scenario Name</th><th colspan="2">Scenario 1
Energy Trend Analysis
& Targeted Savings</th><th colspan="2">Scenario 2
Equal Rates &
Targeted Savings</th><th>Scenario 3
GDP-Based
Targets</th><th colspan="2">Scenario 1a
Energy Trend
Analysis
& Equal Savings</th><th>Scenario 2a
Equal Rates &
Equal Savings</th><th colspan="2">Scenario 4
Energy & Econ Trend
Analysis
& Targeted Savings</th><th colspan="2">Scenario 4a
Energy & Econ Trend
Analysis
& Equal Savings</th></tr>
<tr><td>Energy End-Use Sectors</td><td colspan="12">Scenario Drivers and Sectoral Indicators</td></tr>
<tr><td>Industrial Energy</td><td>Energy growth rates: provincial trends</td><td>Energy saving goals: provincial industrial intensity</td><td>Energy growth: equal rates (national average)</td><td>Energy saving goals: provincial industrial intensity</td><td>Energy growth rates based on provincial GDP/capita</td><td>Energy growth rates: provincial trends</td><td>Energy saving goals: equal rates</td><td>Energy growth and savings: equal rates (national average)</td><td>Energy growth rates: provincial trends</td><td>Energy saving goals: provincial industrial intensity</td><td>Energy growth rates: provincial trends</td><td>Energy saving goals: equal rates</td></tr>
<tr><td>Residential Energy</td><td colspan="12">Convergence of residential energy use per capita</td></tr>
<tr><td>Other Energy</td><td>Energy growth rates: provincial trends</td><td>Additional growth: GDP per capita</td><td>Energy growth: equal rates (national average)</td><td>Additional growth: GDP per capita</td><td>Energy growth rates: provincial GDP/capita</td><td>Energy growth rates: provincial trends</td><td>Additional growth: equal rates (national average)</td><td>Energy growth: equal rates (national average)</td><td>Energy growth rates: provincial trends</td><td>Additional growth: GDP per capita</td><td>Energy growth rates: provincial trends</td><td>Additional growth: equal rates (national average)</td></tr>
<tr><td>GDP</td><td colspan="8">GDP growth: equal rates (national average);
all values in terms of fixed 2005 RMB</td><td colspan="4">GDP growth rates: provincial trends</td></tr>
</table>

[1] Scenario 1: Energy Trend Analysis & Targeted Savings
Scenario 1 allocates targets based on each province's potential for energy saving, along with consideration of economic development level. Scenario 1 considers equity based on past performance and potential for improvement. This main scenario for the target allocation takes into account the historical variation in energy consumption trends among the provinces, and applies similar energy consumption trends for the five years of the 12th FYP (2011 – 2015). This main scenario considers that the surge in energy consumption in the early 2000s calmed somewhat in the latter 2000s, due to the global financial crisis and efforts during the 11th FYP. Provincial energy trends are assumed to remain similar (e.g., fast-growing provinces still grow faster than slow-growing provinces), although at slower rates (e.g., all growth rates for the 12th FYP are lower than during the 11th FYP). The same rate of economic (GDP) growth was assigned to all provinces in Scenario 1.

[2] Scenario 2: Equal Rates & Targeted Savings
Scenario 2 recognizes the dynamic nature of China's provinces and considers that future developments during the 12th FYP period may not follow historical trends; instead, equal rates of underlying growth in energy consumption are assigned to all provinces. Scenario 2 still aims to set targets based on each province's potential for energy saving, and consider goals for encouraging the service sector.

For the Industrial Energy sector in Scenario 2, all provinces are assigned an equal (national average) rate of change in energy consumption, rather than differentiated rates based on recent trends. Savings goals are then assigned based on industrial energy intensity levels. Tougher savings goals are assigned to provinces with high Industrial intensity.

As in all the scenarios, targets for Residential Energy under Scenario 2 utilized a per capita convergence approach, with adjustments for weather conditions across the provinces. For Other Energy, Scenario 2 set an equal growth rate for all provinces, then allotted additional growth for poorer provinces, based on GDP per capita. All provinces were assigned the same rate of GDP growth.

[3] Scenario 3: GDP-Based Targets
Scenario 3 gives highest priority to the provinces' level of economic development, in terms of GDP per capita, as an indicator for target setting, and does not set targets based on the potential for energy saving, nor on recent trends. Scenario 3 considers equity mainly in economic terms.

For the Industrial Energy sector in Scenario 3, targets are based solely on GDP per capita, with poorer provinces allotted more room for growth, and wealthier provinces allotted less growth.

Residential Energy utilized a per capita convergence approach, as in all the scenarios. For Other Energy, Scenario 3 based all targets solely on GDP per capita. All provinces were assigned the same rate of GDP growth.

[4] Scenario 1a: Energy Trend Analysis & Equal Savings
Similar to Scenario 1 (the main scenario for this report), Scenario 1a takes into account the historical variation in energy consumption trends among the provinces, and applies similar energy consumption trends for the five years of the 12th FYP (2011 – 2015). The difference is that Scenario

1a assigns equal (national average) energy savings rates for Industrial energy, rather differentiating savings goals based on industrial intensity in each province. For Other energy in Scenario 1a, underlying growth rates are based on recent trends for each province, but equal (national average) rates are applied for allocation of additional energy growth. In contrast, Scenario 1 presented in the main report allocates additional growth in Other energy based on differing levels of economic development (GDP/capita) among the provinces. The variation between Scenario 1 and 1a highlights the influence of energy indicators on the target allocations for Industrial and Other energy. Residential energy, and GDP growth rates, are treated the same as the main scenario.

As shown in Table A-2, the targets resulting from Scenario 1a are quite similar to those in Scenario 1. Since the allocations are based mainly on recent trends rather than need for improvement, provinces with fast-growing energy consumption – such as Inner Mongolia and Shanxi – are expected to continue growing, and they receive slightly easier targets under Scenario 1a compared to Scenario 1.

[5] Scenario 2a: Equal Rates & Equal Savings

Similar to Scenario 2 in the main report, Scenario 2a recognizes the provinces are dynamic and trends might change from the 11th FYP to the 12th FYP. Scenario 2a assigns equal (national average) rates of underlying growth in Industrial energy and Other energy consumption to all provinces. In contrast to Scenario 2, Scenario 2a did not assign varying savings goal among the provinces based industrial intensity and GDP per capita as indicators of differences among the provinces. Rather, Scenario 2a assigned equal (national average) savings goals to all the provinces. The variation between Scenario 2 and 2a highlights the influence of energy indicators on the target allocations for Industrial and Other energy. The variation between Scenario 1 and 2 highlights the influence of trend analysis and assumptions about future growth trends. Residential energy, and GDP growth rates, are treated the same as the main scenario.

As shown in Table A-2, Scenario 2a has the tightest distribution of targets among the provinces, with the least variation. The resulting targets may be politically appealing, as most provinces have similar targets, appearing very equitable a first glance. However, the resulting targets do not take into account past variation among the provinces nor the potential for energy saving.

[6] Scenario 4: Energy & Economic Trend Analysis & Targeted Savings

The key difference between Scenario 4 and preceding scenarios is the use of varied GDP growth rates derived from analysis of provincial trends. Scenario 4 utilizes trend analysis to set varied energy rates as well as GDP rates among the provinces. Thus Scenario 4 is similar to Scenario 1, with the addition of varied GDP growth rates among the provinces. For the GDP projections, provinces were placed into three groups, based on recent GDP growth trends: high, medium, and low GDP growth. The same trend was assumed to continue for the 12th FYP. The GDP growth rates were set iteratively, such that the sum of provincial GDP projections will meet the national GDP projection. (In this analysis, a national annual rate of 8.5% was used; the methodology can be applied for different rates.)

The resulting target allocations, shown in Table A-2, highlight the strong influence of GDP trends on the intensity targets. The distribution of targets is the widest among the scenarios, with a high of 26% and a low of 4%. Very few provinces are allocated targets close to the national level; instead, many more provinces have targets of 23% or higher, and more provinces have targets of 17% or lower. Thus even though Scenario 4 gives the greatest consideration to actual differences among the provinces, the resulting target allocations may be the least appealing from a political perspective.

[7] Scenario 4a: Energy & Economic Trend Analysis & Equal Savings

As a further test on the sensitivity of target allocation to projections of GDP growth, Scenario 4a allocates varied energy and GDP growth rates based on trend analysis, but assign equal (national average) savings goals to the provinces. In other words, Scenario 4a (like Scenarios 1a and 2a), does not utilize the indicator of industrial intensity to distinguish the potential for Industrial energy saving among the provinces. Nor does it use GDP per capita to allocate additional growth in Other energy to provinces at a low level of economic development. Rather, Scenario 4a is dominated by recent trends in energy and economic growth across the provinces.

The resulting intensity target allocations in Table A-2 show nearly identical results between Scenario 4 and Scenario 4a. This comparison highlights the strong influence of energy and GDP growth trends on target allocation results, showing that trend assumptions have an even stronger influence than indicator data. As in Scenario 4, Scenario 4a is not politically appealing, since the targets differ so widely among the provinces.

Table A-2 Energy Intensity Target Allocation Results for 7 Scenarios

	1	2	3	4	5	6	7
Scenario Name	VT_VEnrg_Eecon	VT_EG	GDP/capita	ET_VEnrg_Eecon	ET_EG	VT_Venrg_Vecon	ET_Venrg_Vecon
Scenario Number	S1	S2	S3	S1a	S2a	S4	S4a
Beijing	-20%	-20%	-22%	-20%	-20%	-15%	-14%
Tianjin	-23%	-21%	-24%	-24%	-22%	-28%	-29%
Hebei	**-23%**	**-21%**	**-20%**	**-23%**	**-21%**	**-17%**	**-17%**
Shanxi	**-23%**	**-25%**	**-21%**	**-20%**	**-22%**	**-18%**	**-14%**
Inner Mongolia	**-21%**	**-24%**	**-23%**	**-18%**	**-21%**	**-26%**	**-23%**
Liaoning	**-21%**	**-23%**	**-24%**	**-20%**	**-22%**	**-26%**	**-26%**
Jilin	-19%	-20%	-19%	-18%	-20%	-24%	-24%
Heilongjiang	-19%	-17%	-17%	-20%	-18%	-21%	-22%
Shanghai	-21%	-19%	-22%	-21%	-20%	-15%	-16%
Jiangsu	**-21%**	**-20%**	**-23%**	**-22%**	**-21%**	**-23%**	**-24%**
Zhejiang	**-22%**	**-21%**	**-24%**	**-23%**	**-22%**	**-16%**	**-17%**
Anhui	**-17%**	**-17%**	**-13%**	**-18%**	**-18%**	**-19%**	**-20%**
Fujian	**-21%**	**-19%**	**-22%**	**-21%**	**-20%**	**-26%**	**-27%**
Jiangxi	-13%	-15%	-11%	-14%	-15%	-15%	-16%
Shandong	**-22%**	**-20%**	**-23%**	**-23%**	**-21%**	**-23%**	**-24%**
Henan	**-17%**	**-20%**	**-18%**	**-17%**	**-20%**	**-19%**	**-19%**
Hubei	**-21%**	**-19%**	**-19%**	**-20%**	**-19%**	**-26%**	**-26%**
Hunan	**-23%**	**-18%**	**-18%**	**-22%**	**-18%**	**-25%**	**-25%**
Guangdong	**-17%**	**-19%**	**-22%**	**-18%**	**-20%**	**-11%**	**-12%**
Guangxi	-14%	-17%	-13%	-15%	-18%	-16%	-16%
Hainan	-10%	-11%	-11%	-10%	-11%	-4%	-4%
Chongqing	-20%	-19%	-18%	-20%	-19%	-25%	-25%
Sichuan	**-19%**	**-17%**	**-16%**	**-19%**	**-17%**	**-13%**	**-13%**
Guizhou	-21%	-22%	-16%	-20%	-20%	-17%	-14%
Yunnan	-24%	-22%	-16%	-22%	-20%	-26%	-24%
Tibet	ND	ND	ND	ND	ND	ND	ND
Shaanxi	-21%	-18%	-17%	-21%	-18%	-26%	-26%
Gansu	-21%	-19%	-13%	-19%	-17%	-16%	-13%
Qinghai	-20%	-23%	-19%	-17%	-20%	-22%	-19%
Ningxia	-22%	-25%	-20%	-19%	-22%	-24%	-21%
Xinjiang	-21%	-19%	-16%	-18%	-17%	-23%	-20%
Projected Target (Bottom-Up)	**-20.3%**	**-20.0%**	**-20.0%**	**-20.1%**	**-20.0%**	**-20.3%**	**-20.2%**
Nat'l Intensity Target (Top-Down)	**-20.0%**	**-20.0%**	**-20.0%**	**-20.0%**	**-20.0%**	**-20.0%**	**-20.0%**

Notes: ET = Equal Targets; VT = Varying Targets; EG = Equal Growth; VEnrg = Varying Energy Growth; EEcon = Equal Economic Growth; VEcon = Varying Economic Growth.

Notes: pink = high; yellow = medium; blue = low. **BOLD** = 15 largest energy-consuming provinces.