POLICY BRIEF

iGDP

China Province-by-Province Carbon Neutrality Roadmap Analysis: Challenges and Opportunities

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About iGDP

The Institute for Global Decarbonization Progress (iGDP) is a non-profit think tank focusing on green and low-carbon development. Established in 2014, iGDP is committed to China's decarbonization and the global effort to address climate change. iGDP provides policymakers, impact investors, and practitioners with forward-thinking solutions and knowledge products from an international perspective.

Through interdisciplinary, systematic, and empirical policy research, iGDP promotes robust energy and climate solutions with high implementation and investment feasibility. iGDP works with its partners to promote a zero-emissions future.

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PREFACE

The urgency and significance of establishing medium-to-long-term carbon reduction targets and exploring low-carbon transition pathways across China's provinces are becoming increasingly prominent.

China is developing a dual-control system for carbon emissions that encompasses total carbon emissions and carbon intensity which will be implemented in two phases. During the 15th Five-Year Plan period (2026-2030), the focus will primarily be on controlling carbon intensity (carbon emission per unit of GDP), with supplementary measures to address total carbon emissions. After carbon emissions peak, the emphasis will shift to stricter controls on total emissions.

A key component of the dual-control system is the establishment of a local carbon emission target evaluation and assessment framework. This includes the rational breakdown of carbon emission dual-control indicators and allocation to different provinces, evaluations and assessments for each province, promoting the implementation of carbon emission budget management at the provincial level, and carrying out annual analysis of carbon emission trends and target predictions. This means that achieving nationwide carbon neutrality will require long-term and continuous carbon emissions management in each province. Research on provincial carbon neutrality pathways is critical for supporting both national and provincial efforts in breaking down target setting, evaluation and progress tracking.

Additionally, carbon-neutral pathway studies play a crucial role in enhancing international cooperation and inter-regional exchanges in addressing climate change. These studies not only assist provinces in developing forward-looking, long-term local action plans that align with the goals of the Paris Agreement but also identify key areas for knowledge sharing and the exchange of best practices across regions.

There are significant regional differences in carbon emissions among provinces in China. The pace of low-carbon transition, target setting, and key emission reduction measures also vary. To better understand these differences, using the Energy Policy Simulator China created by Energy Innovation (EI) and the Institute for Global Decarbonization Progress (iGDP), iGDP constructed[1] EPS base models covering 30 provinces in China (referred to as EPS provincial base models), and developed two scenarios to analyze the emission reduction impacts of energy and carbon reduction policies.

EPS provincial base modeling and scenario analysis offer a deeper understanding of the variations in carbon emission pathways across provinces. This research is designed to support provincial authorities in proposing more ambitious carbon emissions control targets and policy measures for 2035 and 2060, in alignment with the national dual-control policy and the specific circumstances of each province.

This policy brief presents the analytical results from the EPS provincial base modeling research across 30 provinces. It highlights the disparities in economic development, energy consumption, and historical trends in carbon emissions among these provinces. The “Policy Scenario,” reflecting the implementation of the "1+N" policy framework, compares and analyzes the carbon emission trend and the achievement of key climate goals by 2030. This policy brief also assesses carbon emissions from major energy-consuming industries and overall greenhouse gas (GHG) emissions trends for 30 provinces under a “Dual Carbon Scenario,” which targets achieving national carbon neutrality by 2060. Finally, the policy brief identifies key emissions reduction policies at critical time points across provinces and outlines future policy opportunities and challenges faced by the ten provinces with the greatest emissions reduction potential.

[1] In this study, due to data availability reasons, we included only the 30 provincial regions that have an energy balance table in China’s Energy Statistical Yearbook.

Transition Progress

This section highlights the differences in economic development, energy consumption, and historical carbon emissions trends across China's provinces through decoupling analysis. To understand the main regions driving emission trends, this section also shows the historical emissions by sector from 2005 to 2022 for the 11 provinces that account for more than half of total emissions in China.

Diverse Paths and Progress

There are significant differences in socioeconomic development and emission levels across China's provinces. Among the 30 provincial regions, 11 provinces account for more than 55% of the country's CO_2 emissions. High-income regions are concentrated along the eastern coastline, while provinces with high emissions tend to rely heavily on carbon-intensive industries and the coal industry.

Table 1 – GDP and CO_2 Emissions by Province

Province	Share of CO2 emission	Share of GDP	CO2 per capita	GDP per capita (2005 CNY)
Shandong	9%	8%	9.2	61211
Jiangsu	8%	10%	10.0	95777
Hebei	8%	4%	11.4	39803
Inner Mongolia	7%	2%	28.8	68483
Guangdong	6%	11%	5.2	69757
Liaoning	5%	3%	12.6	52655
Zhejiang	5%	7%	7.7	79249
Henan	5%	6%	5.0	44529
Xinjiang	4%	1%	17.2	39760
Shanxi	4%	2%	12.8	38743
Anhui	4%	4%	6.2	45435
Hubei	3%	4%	5.5	53017
Hunan	3%	4%	4.4	48316
Shaanxi	3%	2%	7.0	45341
Fujian	3%	4%	6.3	77105
Heilongjiang	2%	2%	8.4	47995
Guangxi	2%	2%	4.8	29999
Jiangxi	2%	3%	5.1	43577
Shanghai	2%	4%	9.0	129550
Sichuan	2%	4%	2.5	42174
Guizhou	2%	1%	4.9	26916
Ningxia	2%	0%	25.1	33209
Jilin	2%	1%	7.3	37771
Chongqing	2%	3%	5.1	62237
Tianjin	2%	2%	12.1	89655
Gansu	1%	1%	6.2	30828
Beijing	1%	3%	5.4	114932
Yunnan	1%	2%	2.4	35607
Qinghai	0%	0%	7.6	35159
Hainan	0%	0%	4.1	36956

legend

CO2 per capita	GDP per capita
Higher than national average	Higher than national average
Between national and global average	
Lower than global average	Lower than global average

As shown in Table 1, provinces like Shandong lead in both GDP and emissions, contributing around 9% of CO_2 emissions and 8% of GDP. Meanwhile, Liaoning contributed 5% of CO_2 emissions but only 3% of GDP. Regions like Beijing contributed 3% of the nation's GDP, but only 1% of emissions.

Provinces with abundant renewable energy resources, like Sichuan, or special demographics, like Hainan, have very low emissions per capita. Comparing China's provincial emissions to the global average of around 4.4 tons of CO_2 per person in 2022, we found that four provinces are already below this global average.

Decoupling from Emissions

Decoupling economic growth from emissions growth marks a key milestone for successful low-carbon transition. Based on CO_2 emission trends from 2005 to 2022, we found that 23 out of 30 provinces' CO_2 emissions have likely plateaued (Table 2). Most provinces in China have achieved decoupling, with about one-third achieving strong decoupling, meaning absolute emissions are in decline despite a rising GDP.

Among high-income provinces, Beijing, Shanghai, and Tianjin have reached strong decoupling, while Guangdong, Zhejiang, Jiangsu, and Fujian show weak decoupling (Figure 1).

Figure 1 - Example of Provinces with Various Decoupling Status and Income Groups

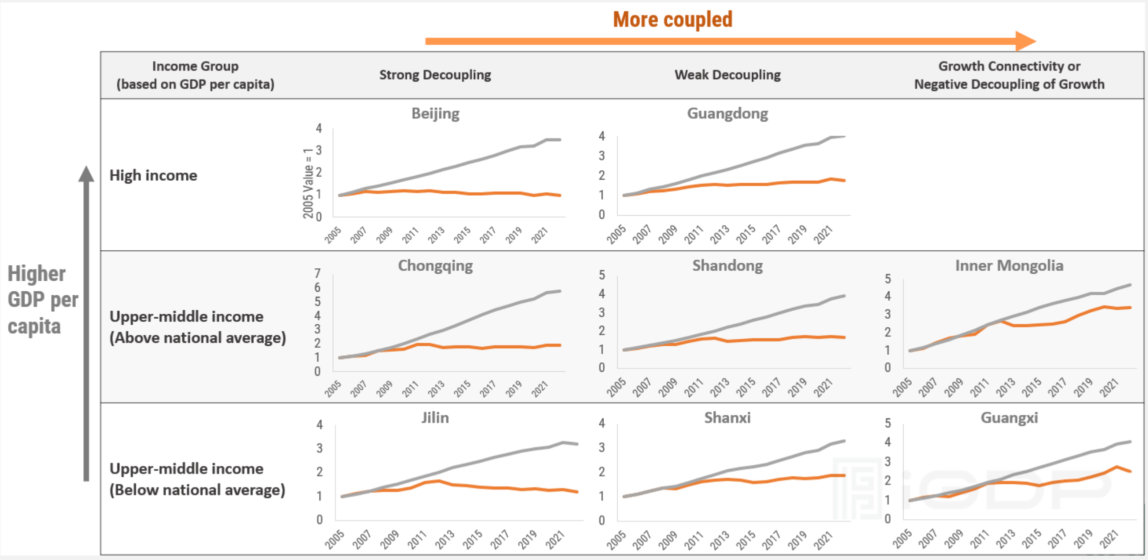


Table 2 - Decoupling Status (2015-2022) and Income Groups

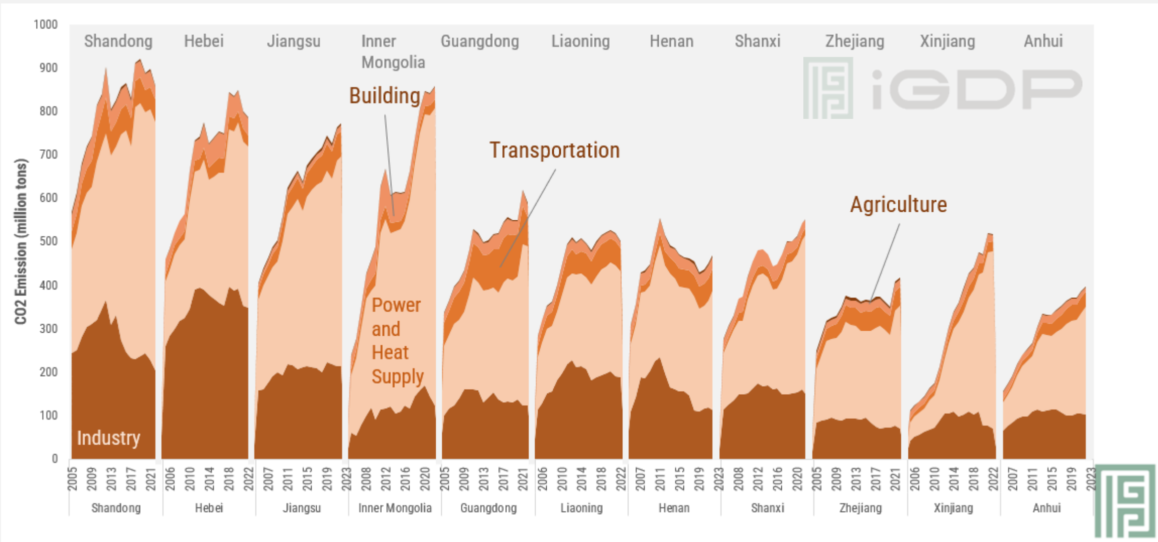
Province	Income Group	Decoupling Status	
Anhui	upper-middle income	41%	weak decoupling
Beijing	high-income $ $	-18%	strong decoupling
Fujian	high-income $ $	26%	weak decoupling
Gansu	upper-middle income	22%	weak decoupling
Guangdong	high-income $ $	29%	weak decoupling
Guangxi	upper-middle income	86%	growth connectivity
Guizhou	upper-middle income	9%	weak decoupling
Hainan	upper-middle income	19%	weak decoupling
Hebei	upper-middle income	12%	weak decoupling
Henan	upper-middle income	-1%	strong decoupling
Heilongjiang	upper-middle income	-6%	strong decoupling
Hubei	upper-middle income	23%	weak decoupling
Hunan	upper-middle income	-1%	strong decoupling
Jilin	upper-middle income	-55%	strong decoupling
Jiangsu	high-income $ $	36%	weak decoupling
Jiangxi	upper-middle income	35%	weak decoupling
Liaoning	upper-middle income	-1%	strong decoupling
Inner Mongolia	upper-middle income	107%	growth connectivity
Ningxia	upper-middle income	90%	growth connectivity
Qinghai	upper-middle income	-30%	strong decoupling
Shandong	upper-middle income	11%	weak decoupling
Shanxi	upper-middle income	34%	weak decoupling
Shaanxi	upper-middle income	53%	weak decoupling
Shanghai	high-income $ $	-16%	strong decoupling
Sichuan	upper-middle income	-28%	strong decoupling
Tianjin	high-income $ $	-29%	strong decoupling
Tibet	upper-middle income	Data not available	
Xinjiang	upper-middle income	62%	weak decoupling
Yunnan	upper-middle income	9%	weak decoupling
Zhejiang	high-income $ $	47%	weak decoupling
Chongqing	upper-middle income	10%	weak decoupling

Top 11 Emitters

The top 11 emitting provinces in 2022 are Shandong, Hebei, Jiangsu, Inner Mongolia, Guangdong, Liaoning, Henan, Shanxi, Zhejiang, Xinjiang, and Anhui. These provinces contribute to more than 55% of total emissions nationwide.

The industrial and power sectors are the biggest sources of emissions in these provinces. From 2005 to 2022, emissions from the industry sector have slowed down in the top 11 emitting provinces. However, driven by rapidly growing electricity demand, the power sector has become the major driver of emissions in these provinces. Emissions from the transportation sector in provinces like Guangdong, China's top 1 GDP contributor, are also rising significantly (Figure 2).

Figure 2 - Sectoral Emission Structural Changes in the Top 11 CO_2 Emitting Provinces from 2005 to 2022



Methodology

In this study, 30 Provincial Energy Policy Simulator (EPS) base models were constructed based on EPS China (iGDP, 2024). The model inputs are derived entirely from official and publicly available statistics and authoritative research. Sectoral emissions and activities in the base year (2020) of all base models have been calibrated against regional energy balance tables from the China Energy Statistical Yearbook 2021.

We created three scenarios to better reflect regional characteristics and identify sectors and regions that require more attention and actions for China to achieve overall net-zero no later than 2060. Details are shown in Table 3[2]:

Table 3 - Scenario Settings

Scenario	Definition	Used as
2020 Frozen Policy Scenario	Considers only policies issued before 2020 (2015 NDC and 13th FYP)	Baseline for comparison
Policy Scenario	Includes NDC, "1+N" policies, and 14th FYP Policies	Pathway reflecting current policies, which helps evaluate abatement effect
Dual Carbon Scenario	Before 2030: current policies. 2031 to 2060: practical and best practices in China and abroad that help the region achieve net-zero	Net-zero pathway that helps identify gaps

[2] Boundary for emission analysis in this policy brief: Although calculated in the model, analyses in this report do not include impact from LULUCF. All end-use sector emissions include Scope 1 and Scope 2 unless otherwise noted.

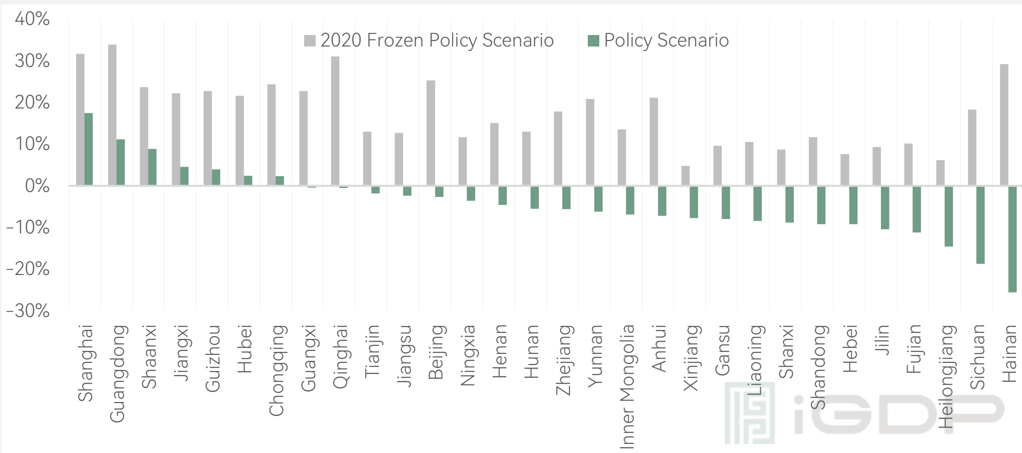
Towards 2030

This section examines carbon emission trends and the achievement of key climate targets by 2030 for 30 provinces under the Policy Scenario aligned with the "1+N" policy framework.

Carbon Dioxide Emissions

Under the Policy Scenario, most provinces show a decreasing trend in carbon dioxide emissions in 2030 compared to the level of 2020, especially Hainan (-26%), Sichuan (-19%) and Heilongjiang (-15%). Compared to the 2020 Frozen Policy Scenario, all provinces have greater abatement, suggesting that the current "1+N" policies and the 14th FYP polices have a high abatement contribution (Figure 3).

Figure 3 – CO_2 Emissions Change from 2020 to 2030 by Province



Carbon Intensity and Renewable Consumption

Table 4 – Progress in Achieving National Commitments by Province

Province	Carbon Intensity Decrease%	Renewable Consumption%
Anhui	65%~75%	<40%
Beijing	>75%	<40%
Chongqing	>75%	40%~80%
Fujian	65%~75%	<40%
Gansu	>75%	40%~80%
Guangdong	65%~75%	<40%
Guangxi	<65%	40%~80%
Guizhou	>75%	40%~80%
Hainan	>75%	<40%
Hebei	<65%	<40%
Heilongjiang	65%~75%	40%~80%
Henan	>75%	40%~80%
Hubei	>75%	40%~80%
Hunan	>75%	40%~80%
Jiangsu	65%~75%	<40%
Jiangxi	65%~75%	<40%
Jilin	>75%	40%~80%
Liaoning	<65%	<40%
Inner Mongolia	<65%	<40%
Ningxia	<65%	<40%
Qinghai	65%~75%	>80%
Shaanxi	<65%	<40%
Shandong	65%~75%	<40%
Shanghai	65%~75%	<40%
Shanxi	<65%	<40%
Sichuan	>75%	>80%
Tianjin	65%~75%	<40%
Xinjiang	<65%	<40%
Yunnan	>75%	>80%
Zhejiang	>75%	<40%

Carbon Intensity	<65%
	65%~75%
	>75%
Renewable Consumption	<40%
	40%~80%
	>80%

- Carbon Intensity

Under the Policy Scenario, the carbon intensity reduction rates from 2005 to 2030 in several provinces are smaller than the average target of 65%. This underscores the need for enhanced climate actions in provinces such as Guangxi, Hebei, Liaoning, Inner Mongolia, Ningxia, Shaanxi, Shanxi, and Xinjiang, which have either reached weak decoupling or demonstrated economic growth connected with emissions.

- Renewable Consumption

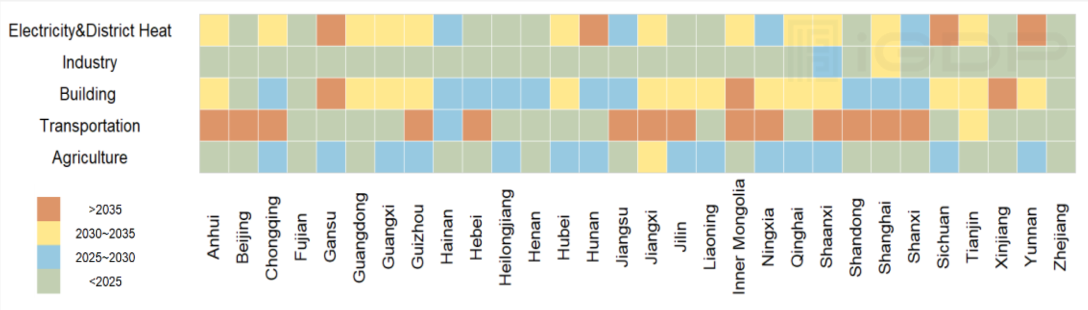
The National Energy Administration has set up a target for the renewable generation share to reach 40% across the nation by 2030. On the generation side, excluding imports and exports, most provinces are unlikely to reach 40% under the Policy Scenario. However, provinces rich in renewable energy resources, such as Sichuan, Qinghai, and Yunnan, have a renewable energy consumption ratio exceeding 80%.

Peak Years by Sector

Under the strategy of "A Unified National Chessboard," different provinces and sectors will have various pathways, priorities, and timelines for achieving carbon peaking.

Considering Scope-2 emissions, in most provinces, industry sectors are projected to peak by 2025. In contrast, transportation sectors are anticipated to peak after 2035, while the building sector is expected to peak after 2030. Peak years in these two sectors are closely linked to level of renewable penetration of the power sector.

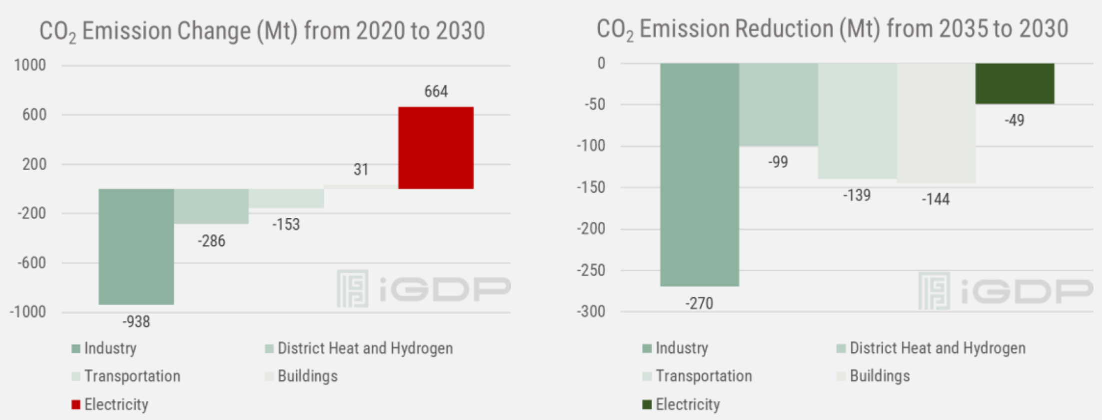
Table 5 – Sectoral Peak Years by Province (include Scope 2 Emissions)



Carbon Emissions by Sector

Emissions are projected to increase primarily from electricity generation over the next 10 years if current policies remain unchanged. Reduction in emissions is observed for all other end-use sectors, especially the industry sector, by 2030. From 2030 to 2035, all sectors are expected to experience substantial mitigation, including electricity generation. Substantial abatement will largely depend on accelerated electrification across all end-use sectors and a higher share of clean energy in the generation mix.

Figure 4 - Change in Emissions by Sector



From Peaking to Neutrality

This section evaluates carbon emissions from major energy-consuming industries and overall GHG emissions trends across 30 provinces within a Dual Carbon Scenario designed to achieve the national carbon neutrality target by 2060. It also identifies key emissions reduction policies at critical milestones across provinces and outlines future policy opportunities and challenges faced by the top ten provinces with the greatest emissions reduction potential.

Key Manufacturing Industries

This policy brief focuses on iron and steel, cement, chemicals, and nonferrous industries from following perspectives:

1) Identifying key provinces that contribute over 60% of national CO_2 emissions.
2) Examining the peak year of CO_2 emissions for each province under various scenarios.
3) Evaluating the rate of CO_2 emission reduction by 2035 relative to 2020 levels under both Policy and Dual Carbon Scenarios and comparing the emissions reduction potential both within and across provinces.

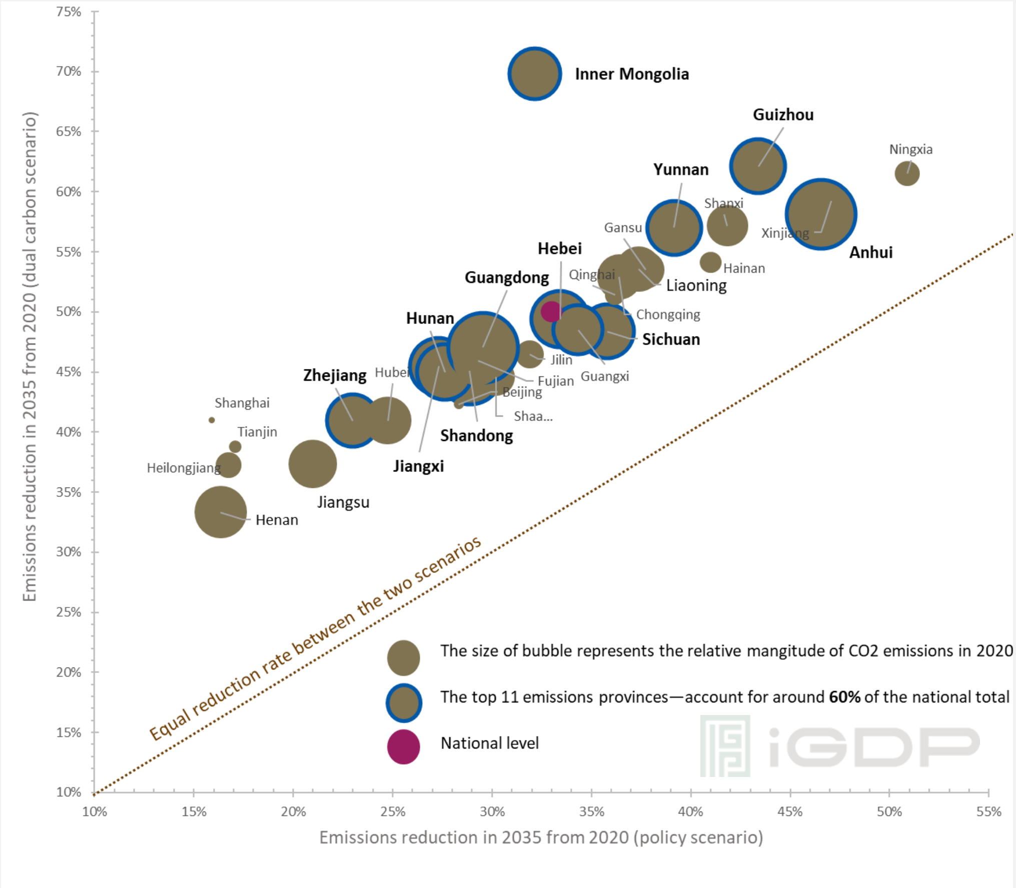
Cement Industry

Guangdong, Anhui, Shandong, Jiangxi, Hebei, Hunan, Guizhou, Yunnan, Sichuan, Zhejiang and Inner Mongolia collectively accounted for about 60% of national CO_2 emissions in 2020. Shanghai, Beijing, and Tianjin had the lowest emissions. CO_2 emissions will peak in all provinces by 2025, followed by a downward trend.

There are considerable differences in emissions reductions among provinces despite similar policy scenarios. Under the Policy Scenario, the decline in carbon emissions by 2035 relative to 2020 will range from 15% to 50%, with Ningxia, Anhui, Xinjiang, Guizhou, and Shanxi leading the decline.

Under the Dual Carbon Scenario, reductions range from 30% to 70%, with Inner Mongolia showing the highest decline.
Among the provinces with the highest emissions, some, such as Anhui, Guizhou, Inner Mongolia, Yunnan, Shanxi, and Liaoning, tend to outperform national averages. In contrast, provinces like Henan, Jiangsu, Zhejiang, Jiangxi, Shandong, Hunan, and Guangdong lag behind the national average.

Figure 5 - CO_2 Emissions Reduction Rate from the Cement Industry by 2035 Compared to the 2020 Level for China's 30 Provinces under the Policy Scenario and the Dual Carbon Scenario



Note: CO_2 emissions include direct emissions and indirect emissions associated with electricity consumption

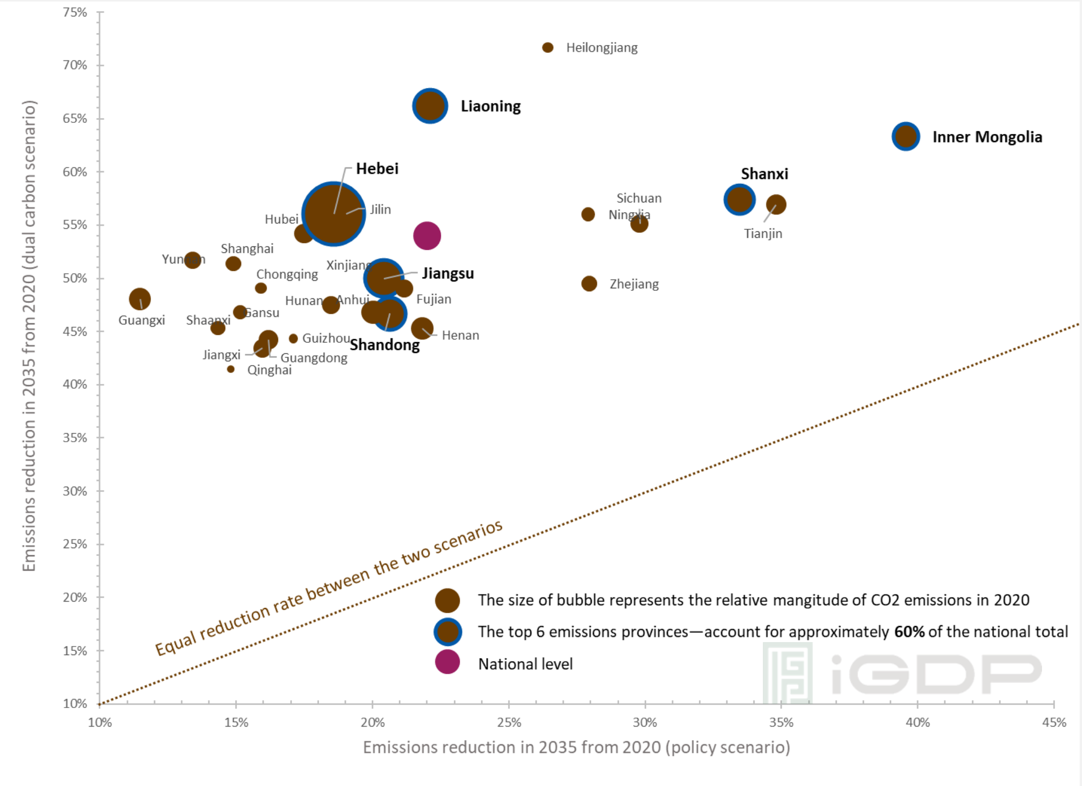
Iron and Steel Industry

The top six emitters—Hebei, Jiangsu, Liaoning, Shandong, and Shanxi—account for approximately 60% of total CO_2 emissions from the 30 provinces, with Hebei alone taking up 25%. Emissions across all provinces are expected to peak before 2025, followed by a steady downward trajectory thereafter.

Under the Policy Scenario, the rate of decline in carbon emissions by 2035, compared to 2020 levels, varies from 10% to 40% across provinces, with Inner Mongolia, Tianjin, Shanxi, and Sichuan leading the reductions. Under the Dual Carbon Scenario, emissions are projected to decline by 40% to 75% by 2035, relative to 2020 levels, with Heilongjiang, Liaoning, Inner Mongolia, and Shanxi at the forefront of these reductions.

Among the top emitting provinces, Inner Mongolia, Shanxi, and Liaoning achieve greater reductions than the national average in both scenarios. Hebei surpasses the national level under the Dual Carbon Scenario. Jiangsu and Shandong show lower reductions than the national level in both scenarios.

Figure 6 - CO_2 Emissions Reduction Rate from The Iron and Steel Industry By 2035 Compared to the 2020 Level for China's 30 Provinces under the Policy Scenario and Dual Carbon Scenario



Note: CO_2 emissions include direct emissions and indirect emissions from electricity consumed

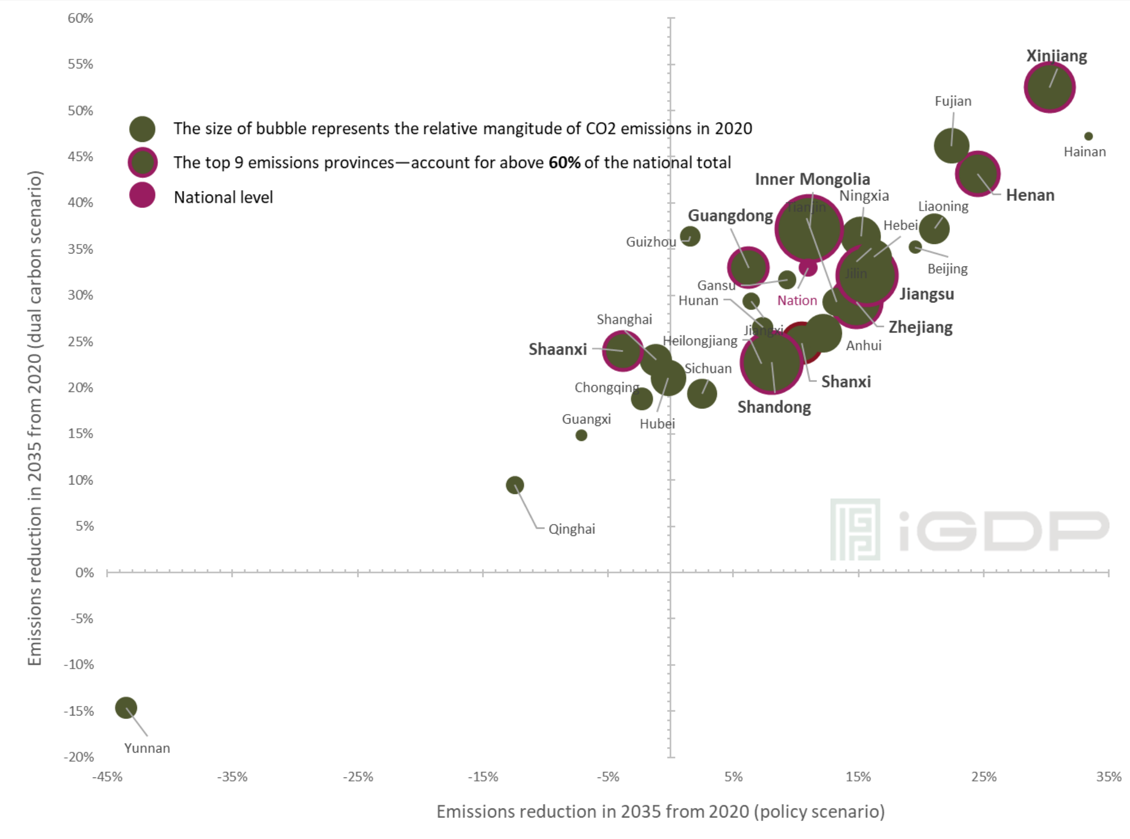
Non-ferrous Industry

The main provinces emitting CO_2 from the non-ferrous industry—Inner Mongolia, Shandong, Jiangsu, Zhejiang, Xinjiang, Henan, Shanxi, Guangdong, Shaanxi—account for about 60% of the total emissions from the 30 provinces. Hainan and Beijing have negligible emissions, while Jilin, Shanghai, Tianjin, Heilongjiang, and Hebei contribute very little. Most provinces are expected to peak in emissions by 2030 under current policies, with Guangxi, Yunnan, and Gansu anticipating delays until 2035. In the Dual Carbon Scenario, all provinces are projected to peak by 2029.

The carbon emissions reduction from 2020 to 2035 varies significantly, ranging from -33% to 44% under the Policy Scenario. In the Dual Carbon Scenario, emissions are anticipated to decline between -15% and 53%, with Xinjiang, Henan, Fujian, and Liaodong leading the reductions. Notably, Yunnan's emission in both scenarios were still growing and requires special attention.

The four major emitting provinces—Xinjiang, Henan, Inner Mongolia, and Ningxia—perform better than the national average in both scenarios, while emission reduction in Shandong, Guangdong, Shaanxi and Shanxi are lower than the national average.

Figure 7 - CO_2 Emissions Reduction Rate from The Nonferrous Metal Industry by 2035 Compared to the 2020 Level for China's 30 Provinces under Policy Scenario and Dual Carbon Scenario



Note: CO_2 emission include direct emissions and indirect emissions from electricity consumed

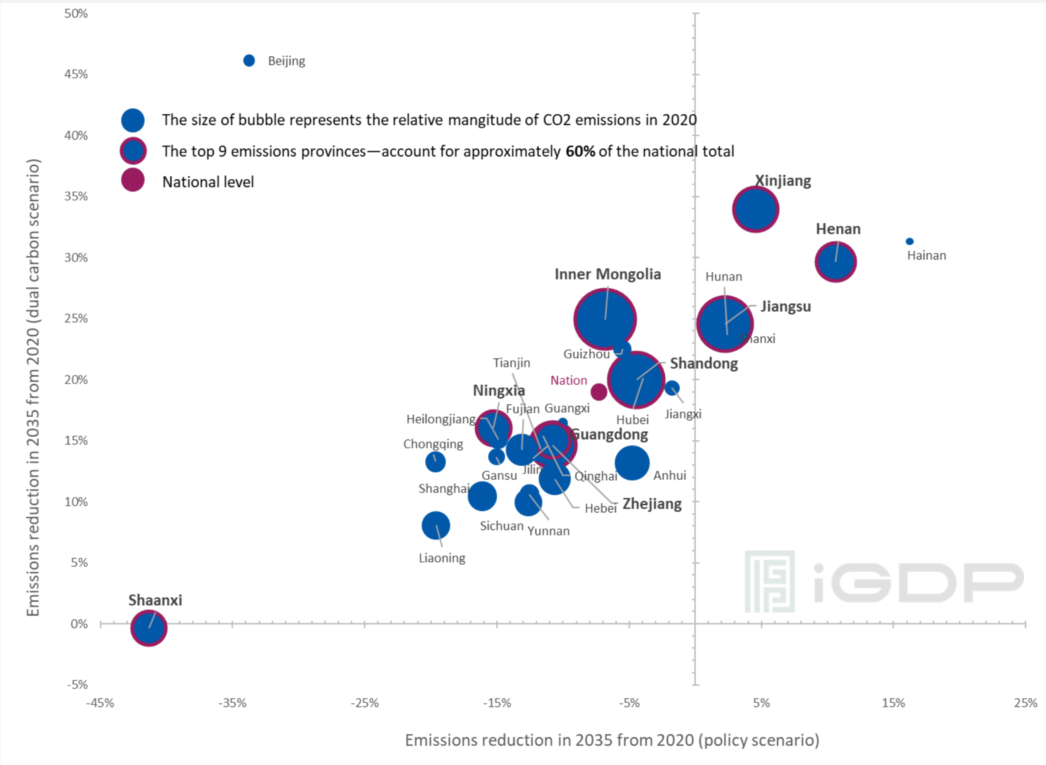
Chemical Industry

Inner Mongolia, Shandong, Jiangsu, Zhejiang, Xinjiang, Henan, Guangdong, Ningxia, and Shaanxi contribute over 60% of the total CO_2 emissions from 30 provinces. In contrast, Hainan and Beijing have the lowest emissions. Most provinces are expected to reach carbon peaking by 2030 under the Policy Scenario, though Inner Mongolia, Ningxia, and Shanxi might see delays. Under the Dual Carbon Scenario, all provinces peak by 2029.

Under the Policy Scenario, the decline rate of emissions by 2035 relative to 2020 range from -16% to 41%. Notably, Henan shows the most significant decrease, while Shaanxi's emissions continue to rise.

Under the Dual Carbon Scenario, emission reductions will range from 0% to 46%, with Xinjiang, Henan, Jiangsu, and Inner Mongolia leading, while Shaanxi is noticeably slower than other regions.

Figure 8 - CO_2 Emissions Reduction Rate from the Chemical Industry by 2035 Compared to the 2020 Level for China's 30 Provinces under Policy Scenario and Dual Carbon Scenario



Note: CO_2 emissions include direct emissions and indirect emissions from electricity consumed

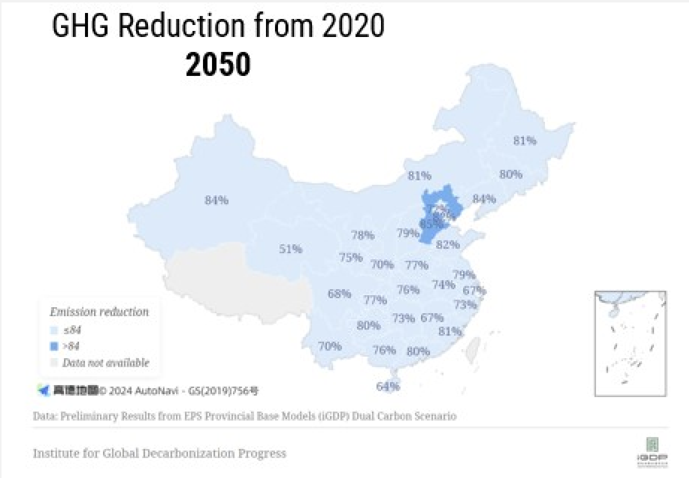
GHG Emissions

There are significant variations in emission reduction potential across provinces under the Dual Carbon Scenario (Figure 9). This means that one-size-fits-all GHG control actions may not yield similar reductions across different regions. Therefore, it is crucial to implement tailored reduction targets and policy measures that address the unique issues of each region.

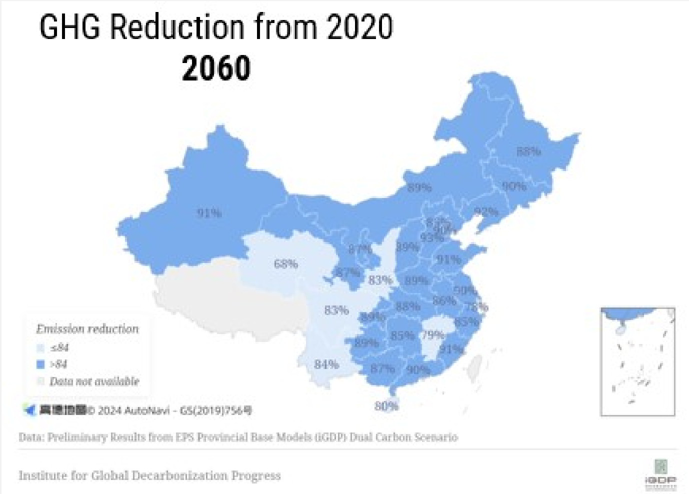
Figure 9 - GHG Reductions Compared to 2020 under the Dual Carbon Scenario

By 2035, GHG reductions will range from 5% to 40%. Nine provinces are expected to achieve an over 30% decline. The top 5 reductions are seen in Hebei, Liaoning, Heilongjiang, Shanxi, and Xinjiang.

By 2050, GHG reductions will range from 50% to 85%, with nine provinces anticipating declines exceeding 80%. The top five provinces in emission reduction potential are Hebei, Xinjiang, Liaoning, Tianjin, and Shandong.



By 2060, reductions are projected to range from 68% to 91%, with 21 provinces exceeding an 85% decline. The leading provinces for potential reductions are Hebei, Liaoning, Xinjiang, Fujian, and Shandong



Note: GHG emissions excluding LULUCF

Electrification of End-Use Sectors

Industry

The average electrification rate of the industry sector will increase by 7% from 2020 to 2030, and 26% from 2030 to 2060. In 2020, industrial electrification levels ranged from 12% to 44%, with the highest levels in Qinghai, Guangdong, Guizhou, Gansu, and Zhejiang.

Between 2020 and 2035, provinces with the largest increases in electrification are Guangdong, Chongqing, Sichuan, Heilongjiang, and Beijing. From 2030 to 2060, the provinces with the largest increases in electrification are Jiangxi, Sichuan, Hunan, Heilongjiang, and Anhui.

Buildings

The average electrification rate of the buildings sector will increase by 17% from 2020 to 2030, and 42% from 2030 to 2060. In 2020, the electrification level in buildings ranged from 13% to 82%, with higher levels in Hainan, Fujian, Guangxi, Guangdong, and Shanghai. From 2020 to 2035, the provinces with the largest increases are Guizhou, Xinjiang, Inner Mongolia, Henan, and Gansu. From 2030 to 2060, the provinces with the largest increases are Heilongjiang, Inner Mongolia, Jilin, Xinjiang, and Tianjin.

Transportation

The average electrification rate of the transportation sector increased by 16% from 2020 to 2030, and 56% from 2030 to 2060. In 2020, the electrification levels in transportation were relatively similar across provinces, ranging from 1% to 4%, with higher levels in Shanxi, Hebei, and Qinghai.

From 2020 to 2035, the largest increases are observed in Zhejiang, Tianjin, Jiangsu, Guangxi, and Chongqing; from 2030 to 2060, in Qinghai, Liaoning, Xinjiang, Yunnan, Heilongjiang, and Hunan.

Table 6 – Electrification of End-Use Consumption under Dual Carbon Scenario

Province	Industry			Buildings			Tranportation		
	2020	Additional increase 2020 vs 2035	Additional increase 2030 vs 2060	2020	Additional increase 2020 vs 2035	Additional increase 2030 vs 2060	2020	Additional increase 2020 vs 2035	Additional increase 2030 vs 2060
Beijing	22%	10%	32%	43%	15%	57%	2%	16%	32%
Tianjin	15%	7%	29%	28%	20%	63%	2%	21%	50%
Hebei	14%	4%	23%	26%	19%	57%	3%	16%	55%
Shanxi	18%	6%	29%	25%	20%	51%	4%	15%	51%
Inner Mongolia	25%	7%	22%	15%	22%	65%	1%	14%	63%
Liaoning	12%	4%	16%	29%	20%	61%	1%	16%	72%
Jilin	12%	5%	14%	26%	17%	65%	1%	13%	68%
Heilongjiang	15%	10%	33%	13%	14%	73%	1%	14%	60%
Shanghai	20%	6%	25%	57%	12%	28%	1%	10%	15%
Jiangsu	31%	7%	29%	71%	10%	17%	1%	22%	56%
Zhejiang	32%	6%	14%	51%	17%	30%	2%	27%	48%
Anhui	22%	7%	33%	49%	19%	30%	1%	21%	63%
Fujian	27%	7%	33%	82%	6%	10%	2%	17%	49%
Jiangxi	24%	7%	37%	54%	17%	25%	1%	15%	60%
Shandong	27%	6%	23%	35%	19%	57%	2%	16%	57%
Henan	26%	6%	24%	43%	24%	42%	1%	19%	62%
Hubei	20%	8%	32%	38%	22%	36%	1%	18%	59%
Hunan	17%	8%	35%	34%	21%	38%	1%	18%	67%
Guangdong	35%	12%	32%	64%	13%	19%	1%	19%	54%
Guangxi	24%	6%	31%	68%	9%	19%	2%	20%	63%
Hainan	13%	3%	7%	82%	6%	11%	1%	13%	19%
Chongqing	18%	11%	29%	57%	14%	27%	1%	20%	56%
Sichuan	21%	10%	35%	48%	18%	33%	1%	19%	55%
Guizhou	34%	8%	30%	27%	25%	42%	1%	19%	66%
Yunnan	27%	7%	31%	50%	12%	32%	1%	15%	69%
Shaanxi	22%	7%	26%	37%	20%	52%	2%	16%	54%
Gansu	33%	6%	27%	25%	22%	58%	3%	14%	68%
Qinghai	44%	7%	26%	23%	21%	54%	1%	11%	73%
Ningxia	23%	4%	16%	28%	20%	61%	2%	6%	51%
Xinjiang	30%	8%	20%	23%	23%	63%	2%	11%	69%

>=20%
>=15%,<20%
>=10%,<15%
>=5%,<10%
<5%

>=70%
>=45%,<70
>=30%,<45%
>=15%,<30%
<15%

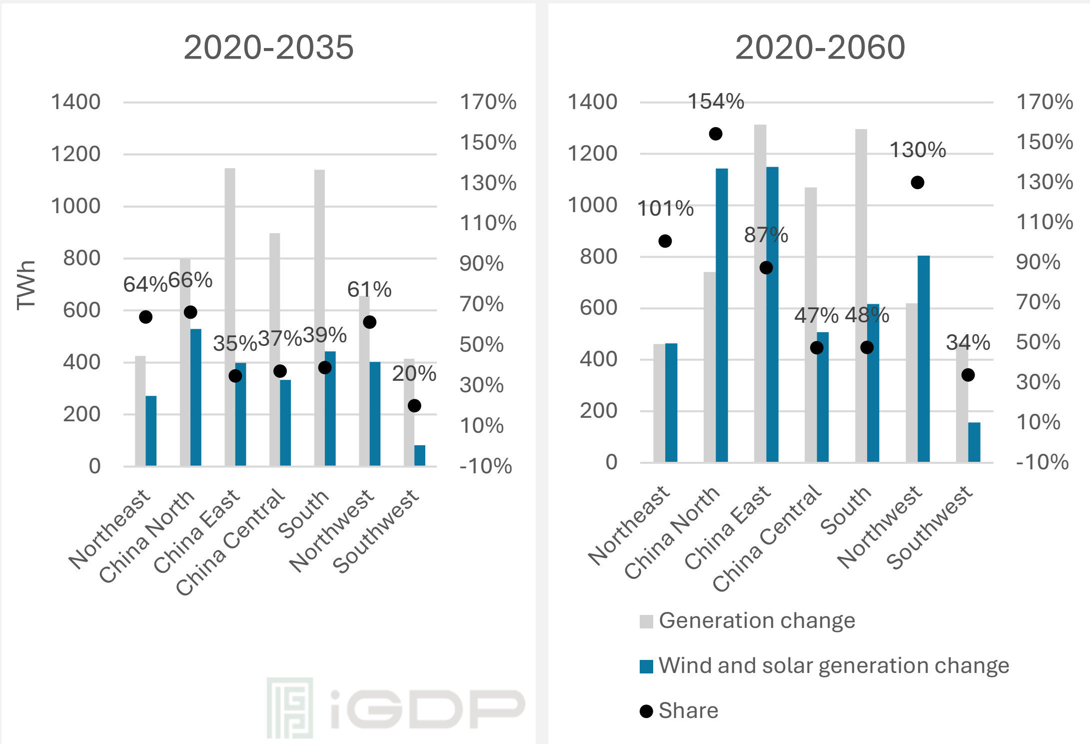
Above the 2020 sector
Below the 2020 sector

Note： Industrial electrification takes into account the consumption of energy used as a raw material
Building electrification including distributed electricity consumption
Transportation electrification includes all modes of transport, including road, rail, air, and maritime

Renewable Development

Between 2020 and 2060, the share of wind and solar power in newly added electricity generation gradually increases, becoming the dominant sources of power generation. Under Dual Carbon scenario, the cumulative growth in wind and solar generation surpasses total electricity generation growth in China North, Northwest, and Northeast China. In China East, wind and solar generation account for approximately 87%, while the shares in Central China, South China, and Southwest China range from 30% to 50%.

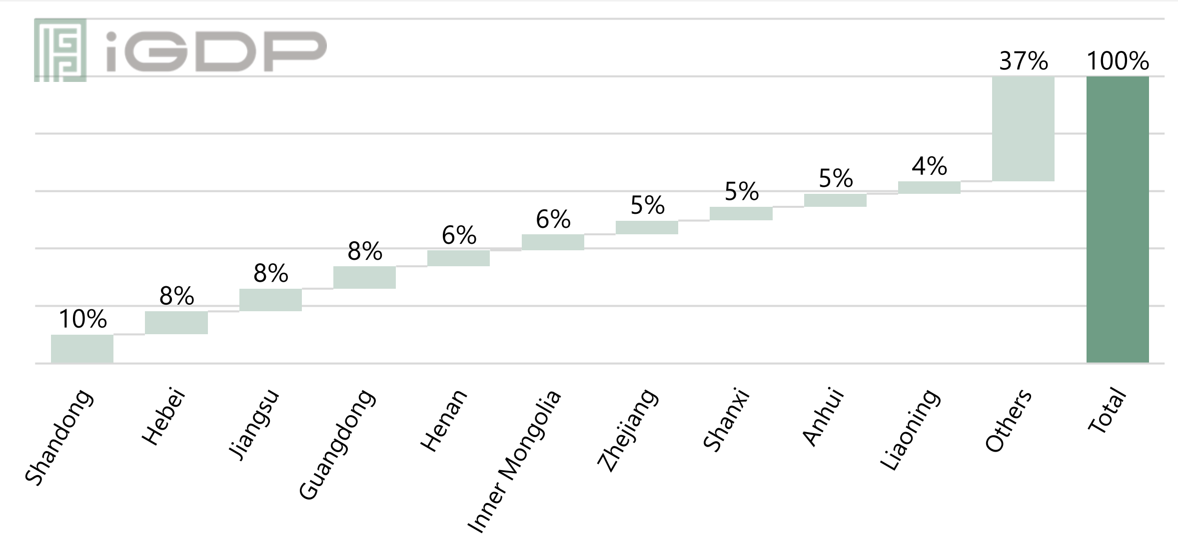
Figure 10 – Regional wind and solar generation change versus total generation change



Key Regions and Policies

Ten regions show the greatest GHG abatement potential from 2021 to reach net-zero in 2060, as shown in the figures below. These regions include Shandong, Hebei, Jiangsu, Guangdong, Henan, Inner Mongolia, Zhejiang, Shanxi, Anhui, Liaoning, accounting for roughly 63% total emissions abated compared to 2020 Frozen Policy Scenario.

Figure 11 – Emission reduction by key province in 2021~2060



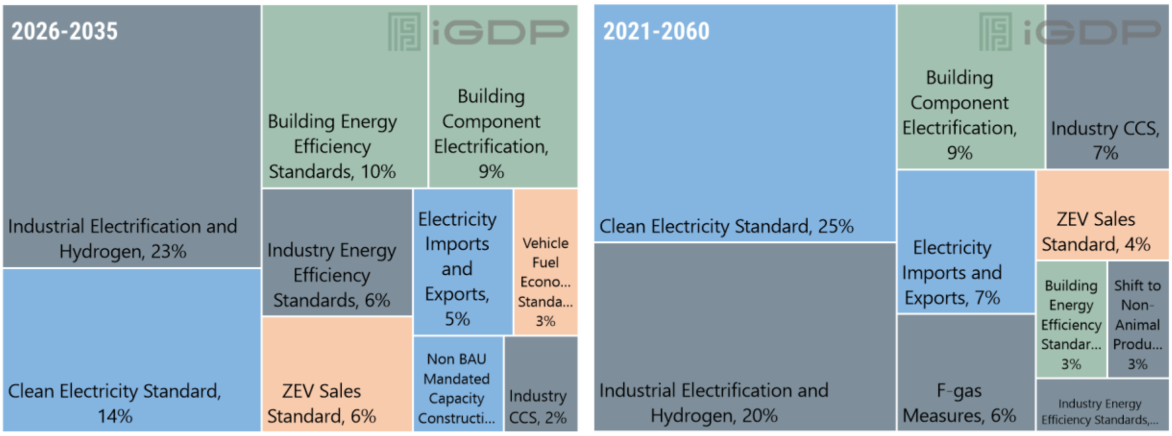
Comparing the Dual Carbon Scenario with 2020 Frozen Policy Scenario, we identified policies and actions with the greatest abatement potential for each province and total abatement potential for all 30 provinces. The policy focus will need to evolve over time, with different strategies emphasized in different phases of the transition. Developing renewable generation and electrification of industry, building and transportation are crucial impacts on abatement throughout the next four decades.

From 2026 to 2035, industrial electrification stands out as the most potent policy, contributing 23% of the emissions reduction potential, closely followed by developing and integrating clean electricity (14%), improving building energy efficiency standards (10%), and building component electrification (9%). Industry energy efficiency standards (6%), and ZEV (Zero-Emission Vehicles) sales standards (6%) are also key policies for abatement.

For the extended horizon from 2021 to 2060, the clean electricity standard takes the lead with a 25% abatement potential, industrial electrification and hydrogen substitution continues to be significant with 20% contributions. Meanwhile, building component electrification and improving cross regional renewable imports remain impactful at 9% and

7% respectively. F-gases control measures take up 6% of abatement contribution. ZEV Sales and building energy efficiency standards contribute at 4% and 3%, respectively.

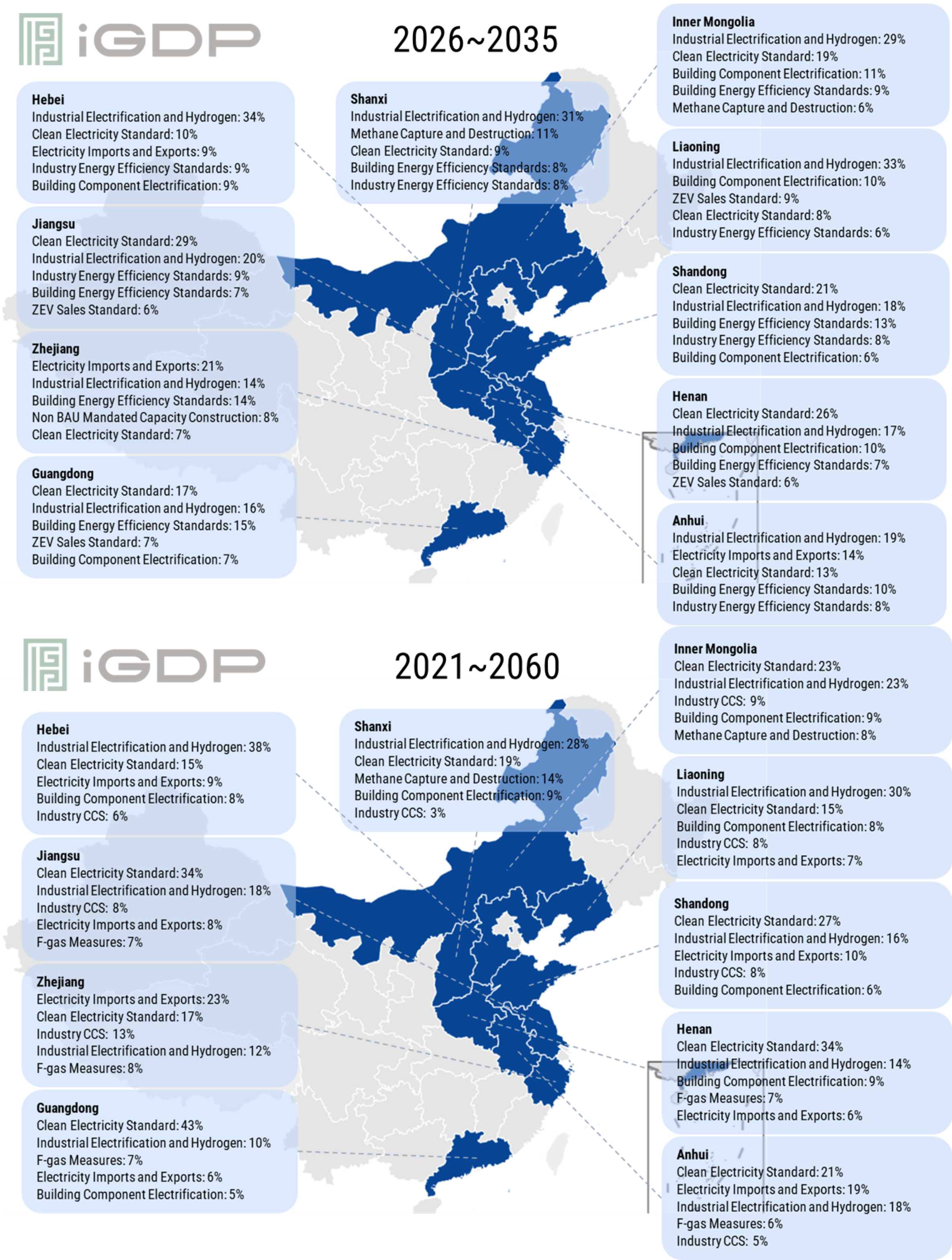
Figure 12 – Top 10 Policies by GHG Abatement



We also identified province-by-province key policies for the abovementioned ten key regions. From 2026 to 2035, clean electricity standards, i.e., increasing the share of clean energy in the generation mix will be critical among top 10 provinces. Electrification across industry and building sectors will also play an essential role broadly. However, in regions with an already very high building electrification rate driven by substantial cooling demand (represented by Guangdong), improving building energy efficiency standards should be prioritized. ZEV promotion should be expedited in Guangdong, Liaoning, and Henan. For non-CO_2, Shanxi will have to develop standards and technology for coal-mining methane capture and destruction over the next decade.

For the extended horizon from 2021 to 2060, industry CCS and F-gas mitigation will gradually play a part in industry mitigation. Besides, the clean electricity standards and electrification across industry and building sectors will remain critical.

Figure 13 – Province-by-province GHG abatement contribution



Conclusion

China's provinces have made significant progress in controlling CO_2 emissions while ensuring economic development, driven by ambitious targets and policies that promote renewable energy adoption, improve energy efficiency, and encourage electrification and fuel switching.

By revealing the diversities in socioeconomic development and carbon emissions across China's provinces, our study highlights the complex relationship between economic growth and climate mitigation. A small number of high-emission provinces are responsible for most CO_2 emissions, with the power and industry sectors being the primary contributors. However, many provinces are successfully decoupling economic growth from emissions, and a significant number are likely reaching an emissions plateau.

To assess the carbon reduction of energy and low carbon policy and to project the long-term carbon emissions trajectory for 30 provinces, we developed two policy scenarios using the EPS model. The Policy Scenario is aligned with current policies, while the Dual Carbon Scenario explores more ambitious actions to achieve carbon neutrality.

We found that all provinces in China have the potential to peak carbon emissions by 2030, particularly with the prospect of the industry sector peaking before 2025. Current policies are poised to facilitate significant reductions in carbon emission during the period of 2020-2030 compared to the scenario without these policies. The power sector is anticipated to play a crucial role in determining the peaking timeline of the transportation and building sectors in various provinces as end-use sectors continue to electrify.

Under the Dual Carbon Scenario, the industry sector emerges as a critical component for achieving carbon neutrality by 2060. To meet this ambitious target, it is essential that the industry sector implements more stringent regulations aimed at reducing CO_2 emissions substantially by 2035, significantly more proactive actions than current policies. The report also reveals significant variation in the potential for reductions within key carbon-intensive manufacturing sectors and overall GHG emissions across provinces, indicating that a one-size-fits-all policy may not be effective, and that tailored policy measures, adapted to local conditions and challenges, will be necessary in regional low-carbon transitions.

From 2026 to 2035, industrial electrification stands out as the most effective strategy for reducing emissions, closely followed by the integration of clean electricity and improvements in building energy efficiency. Looking ahead from 2021 to 2060, implementing clean electricity standards becomes the primary focus, while industrial electrification and hydrogen substitution remain essential components of the long-term strategy.

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