北京大学能源研究院
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Beijing Energy Club
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DECODING CHINA'S ENERGY TRANSITION

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By Dr. Xavier Chen, Ms. Changhua Wu, Dr. Yongping Zhai

With Preface by Dr. Fatih Birol, Executive Director, International Energy Agency

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DISCLAIMER:

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PREFACE

If you want me to name one person who knows best China's energy sector and its complexities, it is my former colleague and dear friend Xavier Chen.

From the angles of the IEA, BP, Equinor, ENN, IGU and ADB – all the organizations where he served, he studied China's energy sector at depth.

Through the Beijing Energy Club he founded in 2008, he brought together the best minds of China's energy industry to discuss challenges facing China and the world, to brainstorm solutions and to take actions.

China plays the most critical role in global net-zero transition, it's very important for the rest of the world to understand what China is doing.

Early 2022, Xavier showed me some samples of his Insight China reports, I said these were exactly what I need to read. And I have been reading them during the course of the past year when they were shared by Xavier.

Now in this volume, Xavier and his fellow colleagues bring us more than 50 such succinct and insightful reports. Together, they provide a highly comprehensive and detailed picture of what's going on in the world's largest energy market, greatly improving the transparency on the grand transition China is undertaking.

I hope you will enjoy reading them as I did.

Fatih Birol
Executive Director
International Energy Agency

PREFACE

China is very big, so big that for those who live inside like myself, can hardly measure the enormity of its global impact.

China is also complex and complicated. Its energy transition which involves technology, economy, infrastructure, society, international, and many other dimensions, is even more complex and complicated, much more complicated than a straight line from today's situation to a net-zero future.

It is for this reason that I highly command Xavier, Changhua and Yongping for having done a meaningful and invaluable work: making big and complex subjects easily understandable.

The reports they produced over the past year are not only helpful for the global community to better understand China's energy transition process, they are also extremely valuable for us to better understand the transition process we are undertaking, and what kind of reforms needed to accelerate it.

I therefore wholeheartedly salute their noble efforts and warmly congratulate the publication of this report.

Chengyu Fu
Executive Vice Chairman
Beijing Energy Club

FOREWORD

China is the world's largest energy consumer and CO_2 emitter today. At the same time, China is one of the most vibrant markets in low carbon technology innovation, holding the global leadership not only in manufacturing solar, wind and battery equipment, but also in their market deployment.

As such, China has a unique position in the global net-zero transition to achieve the Paris Agreement 1.5C target.

Given the Chinese commitments to peaking emissions before 2030 and netting zero before 2060, the world's largest developing economy will undergo profound changes in the coming decades. Till the end of 2022, Chinese policy makers at national and local levels have delivered a total of 75 policy documents, enshrined in what is popularly called "1+N" carbon neutrality policy framework, mostly through the cycle of the 14th Five-Year planning (2021-2025) and the 2035 Vision.

At the PKU Energy Institute, we conduct in-depth studies to advise government officials and companies on decarbonization strategies. We also host many activities to foster collaboration and exchanges between China and the world.

Dr. Xavier Chen is the first energy expert appointed as a senior research fellow at our institute following our establishment in 2020. We are very pleased that Dr. Chen, together with two other renowned experts - Changhua Wu and Yongping Zhai, spent the entire year of 2022 to produce these highly insightful and independent reports on China's energy transition. They together tell a holistic China story of energy transition. I am sure that their publication will improve the international understanding of China's decarbonization efforts, and our institute will be very happy to host more discussions and exchanges with all interested parties.

Lei Yang
Vice President
Institute of Energy, Pekin University

FOREWORD

China's importance for global energy transition is well-understood. However, for the rest of the world, **high-quality information and analysis on China's energy transition is very scarce**. Almost all the country's policy documents are in Chinese, and even when professionally translated, they are often hard to understand without in-depth knowledge of the official jargons. And new policy direction is hard to detect without the ability to compare a policy announcement to its previous versions and seeing what's added what's removed.

When I was head of Statoil (now Equinor) China, one of my brand services to the headquarters was to provide a regular China update informing HQ colleagues and relevant businesses what's happing in China and what they imply for the company. I labelled those reports "**Insight China**", they were short, concise and crisp, and they were very much appreciated by the CEO and other colleagues. Eldar Saetre, the then CEO, said he read every report I sent. That was a big compliment.

Borrowing that experience, we decided to fill the information gap between China and the rest of the world by drawing on the expertise clustered around the Beijing Energy Club. An Insight China editorial team was convened, composed of members who are not only highly experienced in China's energy and climate sector, but also have competent international career with proven capability to communicate complex issues to a global audience. Changhua Wu and Yongping Zhai are the proof of that.

We started to write Insight China reports, each focusing on one subject that is of significance to China's energy transition, on a frequency of one report per week. We call them The Pulse reports, to feel the pulse and grasp the rhythm of the transition.

In the pages that follow, you will find 52 pulse reports we have produced during 2022. In each of them, we tried our best to be **evidence-based, sharply focused, and as informative as possible.** Energy transition topics are complicated, even more so when written in Chinese, but we tried to make them easier-to-understand. Our ambition was for a 3-pager to offer you the same useful information as reading a 100-page report.

These are not research reports with detailed references. They are executive briefings. They show you how the government's ambitious plans are anchored or not in grounded reality, what tools does the central government use to drive up the share of renewables, whether the strong enthusiasm you hear from Chinese local authorities represents hopes or hypes. They will show you how complex the energy transition process is, but also how this complexity can be read and understood in simple ways.

The reports were written at different times of the year. If we put them in chronological order, we are afraid that you might get lost. To ease your reading experience, **we have grouped them into 9 chapters.**

Should you find them of value, **please join me in thanking my two colleagues of the editorial board – Changhua and Yongping,** both have worked tirelessly with me to ensure the quality of these reports.

Many others provided invaluable inputs, but they prefer to remain anonymous. I remain wholly responsible for any inaccuracies or mistakes you may find.

Xavier Chen

Xavier Chen

President, Beijing Energy Club

MAKING THE COMPLEXITIES SIMPLER AND EASIER TO UNDERSTAND

We live in an era of poly-crises, but it's also a pivotal moment when racing against time to fight climate change has become the play of the day among leading economies. China's pioneering endeavors and progresses have made a convincing case that integrated and united national vision, strategy, and front are key to scaling the deployment of green, clean, and smart solutions.

With ambitious goals and targets set through the Five-Year Planning cycle, the country has demonstrated how policy incentives, when well-designed, could drive technology innovation, build competitive supply chain, enhance industrialization of clean technology, and achieve the scale at a pace to match up with the need to decarbonize the economy, infrastructure, goods, and services.

This is a rather complex and overwhelming system change. It requires a new way of narration to inform and engage a broader audience, particularly those outside China. Thus, the three of us - Xavier, Yongping, and myself - decided to take on a task to help an international audience of leaders to grasp the complexities. The outcome is this product in your hand. This publication, to a large extent, showcases or evidences the depth, width, and comprehensiveness of Chinese policy makers in considering and advancing energy transition. When and if effectively and fully deployed and enforced, they are expected to set China on a pathway forward to lead global clean energy revolution.

It takes the best knowledge, expertise, and synergy of three of us to interpret or decode the perplexing reality through the following pages. We have done our utmost effort to use a format of roughly a three-pager for each topic and communicate our analyses clearly and concisely. If you find it relevant and useful, then I would feel relieved and rewarded. And of course, I will always welcome your feedback and input and be delighted to explore how we can join hands on this journey to contribute to China's clean energy transformation.

This one-year journey with my two colleagues has been a fascinating and inspiring experience. Both Xavier and Yongping have been my mentors and dear colleagues in my professional development. I greatly appreciate and will treasure this partnership forever.

Changhua Wu
CEO, Future Innovation Center
Asia Director, Office of Jeremy Rifkin

CERTAINTY AMONG UNCERTAINTIES

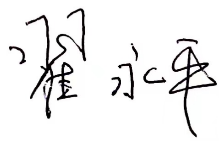
The year 2022 was my first full year of working in China after 37 years overseas experience in several countries in Europe, Africa and Asia, my last position was Chief of Energy Sector Group, Asian Development Bank. So, although being a Chinese national working in the energy field, I had been for a very long time outsider or at best a distant observer on what's happening in the energy sector in China.

When I returned back in China and started my new job as Senior Advisor on carbon neutrality for Tencent Group, I felt strongly that I needed to make up missed lessons on key issues, challenges and potentials in the energy space in China. Indeed, there are many myths and misconceptions that need to be decoded.

As such, I was so happy to see Dr Xavier Chen and Ms Changhua Wu, who took the initiative and worked very hard to produce the weekly insights on energy issues in China. Both of them are highly respected energy experts, and also my long time friends. I still had a vivid fond memory of a young and energetic Xavier in mid-1980s, when were both Ph.D students at Institute of Energy Policy and Economics, Grenoble, France. Since then Xavier has had an admirable professional path in some of the most prestigious energy organizations and companies, and in particular, the founding President of the influential Beijing Energy Club.

And, Changhua, it's always a pleasure to see her more often on various TV channels, highly impressed and inspired by her clear assessment and sharp views on the world current energy and climate events. I appreciate the chance given to me as a member of the editorial team, though my role has been essentially a first reader and reviewer to see if the myths are fully decoded. Reading Xavier and Changhua's work, it's been a huge learning experience every week throughout 2022, so I can now say I am no longer a stranger in energy space in China.

The energy world is experiencing a turbulent era fully of uncertainties, but one thing has not changed and will not change: that is China's role as the biggest energy producer consumer in the world, and in recent years, one of the most important investors and innovators in renewable energy and other low carbon technologies. I am sure that the international readers will find this book very useful to better understand China and further expand the cooperation with China.



Yongping Zhai

Former Chief, Energy Sector Group, Asian Development Bank

Senior Advisor on Carbon Neutrality, Tencent

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DECARBONIZATION STRATEGIES

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1.1 REDUCE FOOTPRINTS, ENHANCE HANDPRINTS AND EXPAND BLUEPRINTS

a simple way of understanding China's green transition plan
Insight China, January 28, 2022

China's ambitious plans of green transition are hard for outsiders to grasp. Usually descriptive and expansive, its Five-Year plans are very much Chinese-centered in terms of way of thinking and narration. In the meantime, English media coverage tends to be "selective" and interpretative with "ideological" biases and geopolitical interpretations.

We try here to sketch the landscape of the planned transition by using footprints, handprints and blueprints, at least trying to do some "justice" to the steadfast endeavor China has been dedicated to addressing the challenges of ecological redlines.

1.1.1 Reducing Footprints:

Four priorities are set in China's current plans to reduce its ecological footprints: 1) carbon emissions; 2) energy consumption and other resources use; 3) loss of nature; and 4) pollution and wastes. To illustrate the progressing in the five-year plan trajectory, Table 1-1 summarizes some priority targets.

Table I-I: Key Targets to Reduce Footprints in Five-Year Plans

Indicator	2016-2020 (actual delivery)	2021-2025	2030
carbon emissions reduction	• carbon intensity down 48.1% over 2005 level • carbon intensity down 18.2% from 2015 level	• carbon intensity down 18% over 2020 level	• GDP carbon intensity down at least 65% over 2005 level • peak carbon emissions before
energy consumption reduction	• energy intensity per unit GDP down 15% over 2015 level • total energy consumption controlled under 5 billion tons of coal equivalent	• energy intensity per unit GDP down 13.5% over 2020 level • peaking coal consumption • more restrictive targets of total energy consumption for such sectors as iron and steel, metallurgical, building materials, among the high-energy consuming industrial sectors	
pollution reduction	• city $PM_{2.5}$ ambient concentration: 28.8% down over 2015 level; • days of good air quality: 5.8% growth over 2015 level; • COD, NH3-N, SO_2, NOx total emissions down, respectively, 10%, 10%, 15% and 15%, over 2015 levels; • VOC total emissions: 10% down over 2015 level	• COD and NH3-H reduction at 8%, SO_2 and NOx reduction at 10%, below 2020 level	
Resources consumption reduction (water)	• water use per unit of GDP: 28% down from 2015 level	• water use per unit GDP: 16% from 2020 level	

Sources: author compilation from14th Five-Year plans, and related national policy documents.

These targets are to be achieved through specific programs involving green upgrading of key industries, industrial parks, urban and rural areas, transport and logistics, public buildings, etc.

1.1.2 Enhancing Handprints:

Three focal priorities to enhance handprints include: 1) dramatically increasing non-fossil fuels; 2) protecting nature and biodiversity; and 3) mainstreaming the circular economy.

Table 1-2: Key Targets to Enhance Handprints in Five-Year Plans

Indicator	2016-2020 (actual delivery)	2021-2025	2030
increasing non-fossil fuels	• non-fossil fuels in primary energy mix: 15.9%	• non-fossil fuels in primary energy mix: 20%	• non-fossil fuels in primary energy supply: 25% • installed solar and wind capacity reaching 1,200 GW
protecting nature and biodiversity	• nature reserves: 18% of total land • forest coverage: 23.2% • forestry stock: 1.3 billion cubic meter above 2005 level.	• forest coverage (%): 24.1 • building more wastewater and municipal waste treatment capabilities with specific targets.	• 25% of land designated as protected to enrich ecological functions and to protect integrity; • forest coverage (%): 25.1% • forest stock: 6 billion cubic meter above 2005 level.
mainstreaming circular economy	• some major resources' recycling output: 26% above 2015 level	• resources recycling and reuse industrial output value reaching RMB 5 trillion • major resources' recycling output (%): 20% growth over 2020 level	

Sources: compiled from the National 14th Five-Year Plan, sector 14th Five-Year plans, and other related national policy documents.

1.1.3 Expanding Blueprints:

While local pollution, climate change and resource deletion remain priority constraints to address, as demonstrated in footprint and handprint targets, its blueprints zoom in on systemic transformation in regions, industries, and infrastructure, enabled by R&D, technology, finance, expertise and talents, as well as institutions and governance. This is clearly reflected in its national design of policy incentives that cut across region and industry, while being further enhanced by local governments' more ambitious commitments of actions.

A top priority is to net out carbon emissions – peaking emissions before 2030 and achieving carbon neutrality before 2060. To deliver the "duo" goal, China has initiated a strategy of "1+N", as popularly known in the society. It has become a leading thread of policy system that aims to pull all the pieces of the puzzle together, vertically and horizontally, not only for the current decade but also for decades to come.

The "1" refers to the "Opinion" or the "overarching" policy guidance on how to deliver the time-bound capping and netting out carbon emissions, issued by the CCP Central Committee and the State Council, on October 24^{th} of 2021, one week before the Glasgow COP26. The guidance sets the "tone" that puts decarbonization and nature positive at the core of national policy-making for a united and well-coordinated front of actions. It enlists all the possible actions needed to make low carbon transition in all major sectors, incentivized by laws and regulations, emission trading, and green financing. In short, it's an "all-of-the-above" framework that aims to leave out no area nor exclude any technology option.

The "N" encompasses all the action plans and roadmaps for specific industry and region, as well as the supporting and enabling tools and instruments. The first of the "N" was published the same day – 24^{th} October 2021 - by the State Council - the "Implementation Plan to Achieving Emissions Peaking Before 2030". To achieve peaking, China plans to cluster actions around ten focused levers – energy supply, energy efficiency, industry, buildings, transport, circular economy, science and technology innovation, carbon sink, all-citizens and all-regions, with the objective of bending the emission curve before 2030.

Those sector-specific plans are being released, e.g. the 14^{th} FYP for energy saving and emission reduction was made public on the 24^{th} January 2022. Given China's tradition of relying on national government plans as guidance or "the bible", and its impressive track record in delivering the set targets, the "duo" decarbonization goal will serve as the lighthouse, incorporated into all "sub-plans", by ministries, provinces and state-owned entities. An important note to make here is that in the past, China has often gone far beyond and overachieved its planned objectives.

Furthermore, in the eyes and minds of Chinese policymakers, environmental and climate protection goals serve a bigger purpose of higher quality growth with industrial and infrastructure revamping. Its success can be measured, on one side, by decarbonization and improved ecological integrity (reduced footprints and enhanced handprint), and on the other, by growth of new and greener economy, competitiveness of industrial products and services, expansion of new infrastructure and growth of new industries and services (expanding blueprints). The outcomes are reflected in "weight loss" of traditional industries that are energy- and pollution-heavy, while those "strategic emerging industries" and "new infrastructure" are gaining weight.

Building a more sustainable and competitive economy through integrated thinking of footprints, handprints, and blueprints. This is how we understand the Chinese effort. Doesn't this sound familiar in your part of the world?

1.2 "COAL AS BALLAST STONE": CHINA RECHARTS ITS DECARBONIZATION COURSE

Insight China, January 10, 2022

- "One can't win the (carbon neutrality) war in just one battle";
- "(Our) carbon neutrality strategy must be based on China's basic national conditions where coal is the main fuel";
- "Phasing out of traditional fossil fuels should be paced with the availability of reliable renewable alternatives";
- "Avoid simplistic downward decomposition of national target, establish incentive mechanisms (to allow market play its full swings)".

These are some of the most powerful statements from the Communiqué of the year-end national economic policy meeting on 8-10 December 2021, which sets China's policy direction for 2022 and onward, where coal is reinstated as the "ballast stone" of China's energy system.

They together redefine China's carbon neutrality narrative and rechart its decarbonisation course.

1.2.1 The Context:

Such a redefinition takes place against the following context:

- Macro-economically, China is facing downward pressure in three aspects: contracting demand, supply shocks and much weaker growth prospective in the domestic market, while external environment becomes increasingly complex and uncertain;
- Energy market: China – a traditionally coal-rich country, experienced coal shortages in 2021 which led to widespread power cuts and rationing, while internationally, energy shortages in Texas earlier in the year, gas and power price surges in Europe, and the tightening of the global LNG market made China's policymakers acutely aware of the need to strengthen energy security before embarking onto more aggressive decarbonization;
- Decarbonisation-wise: following President Xi's September 2020 announcement of the duo goals of peaking emissions before 2030 and achieving carbon neutrality before 2060, and urged by the central government to achieve the "duo targets" with the effort of "clawing iron with a mark" (抓铁留痕), both local authorities and state-owned entities raced to announce their own targets. Some local authorities even resorted to cutting the power supply or shutting down factories to avoid the excess of their energy consumption quota, gravely disrupting economic and social activities. The redefinition follows an earlier call by the central government to "establish first before breaking" （先立后破）- i.e. making renewable energy available, accessible and reliable first before closing the coal-fired power generation.

1.2.2 The Conditionalities for a successful transition:

We believe China's redefined narrative is neither a withdrawal nor a weakened commitment to the Paris agreement or the Glasgow Climate Pact, but a reflection of market realism and policy pragmatism, which is consistent with its macro-economic policies.

Faced with deteriorating external environment and domestic lack of new growth engines, Chinese policy makers in July 2018 proposed the "6 stabilities" (6 稳)

as cornerstones of macro-economic policies, which were restated as “6 securities” (6 保) in early 2020. The “6 stabilities” involve employment, financial system, external trade, FDI, domestic investment and growth prospect, while the “6 securities” involve jobs, basic livelihoods, market participants, food and energy, supply chain and grassroots operations. “Stability and Security” are now officially stated as top policy priorities of the country’s 14th Five-Year Development Program (2021-2025).

The redefined narrative reflects the market realism which begs answers to such questions as whether and how much the society is prepared to accept social and economic disruptions as sacrifices to fight climate change. After over one year of dancing with two steps forward one step back, China’s policy makers seem to have come to the level of sophistication in which carbon neutrality acts as an objective function in operational research that is subject to a set of constraints or boundary conditions, including:

1. Sustained economic growth, now set at 5% and above for 2022, aiming to maintain and create jobs and employment opportunities;
2. Secure and stable energy supply;
3. Secure and stable food supply;
4. Secure and stable carbon-based material supply;
5. Security of financial systems;
6. Lowest social costs, especially how to prevent the risk of wasting the current energy infrastructure, valued at $86 trillion globally; and,
7. Controlling inflation, guaranteeing people with adequate employment, personal freedom, and social justice.

These conditions, if not adequately and effectively addressed, risk to derail the "train" of decarbonization.

China's new decarbonization narrative also approaches the energy system more holistically. Energy systems are designed not only to power the economic activities by delivering energy services - electricity, heat, and mobility, they also produce chemical and petrochemical materials which are indispensable to the existence and well-functioning of human society.

1.2.3 The "Critical Dozen" to Watch:

Through the redefined narrative, we see a new pathway of clean energy transition being drawn in China, by which fossil fuels including coal, will continue to play their role during the transition, but their clean and efficient uses will be emphasized, so are the renewable energy absorption capabilities of the current fossil fuel-based energy system.

Under this new narrative, what trends will hold? We propose the following “critical dozen” to watch on China’s carbon neutrality pathway:

1. Duality: Balancing transition that integrates the "duality" of energy system – the energy (power, heat and mobility) aspect and the materials dimension into transition plans, abandoning the idea that future energy system can be built completely without carbon;
2. Pace: Managing transition risk by pacing the rhythm of coal phase-down based on the available and reliable quantity of renewable power generation;
3. Division and specialisation: Enhancing technology innovation of oil and gas industry while abandoning the expectation or fantasy for all oil and gas companies to become renewable power generators;
4. Energy saving: Innovating business models of energy conservation that would push high ener-

gy-consuming and carbon-emission companies to "proactively" seek solutions from ESCOs, with much reduced transaction costs;

5. Heat, storage and hydrogen: Strengthening the planning for heating services to more effectively tap into all kinds of heat sources and developing end-use applications of energy storage and hydrogen;
6. CO_2 utilisation: Emphasizing the U aspect of CCUS that turns CO_2 into resources instead of waste through carbon-rich agriculture, fossilizing CO_2, and converting CO_2 to fuels and chemical products;
7. Innovation: Gearing up innovation at all fronts by encouraging and incentivizing all technologies to demonstrate their potentials, as well as business model innovation and regulatory innovation;
8. "Two hands": Improving government's capability to effectively combine the power of the "visible hand" and the "invisible hand", with the former creating the demand for carbon reduction and the latter mobilising market forces to meet that demand;
9. Critical minerals: Strengthening the supply chain of energy transition minerals by increasing domestic mining, processing, production and manufacturing while optimizing the value chain through trade and investment;
10. R&D: Investing in R&D of strategic long-shot technologies, including in particular, carbon capture and recycling technologies, energy storage, low-cost hydrogen production, and high-density power generation technologies, as a few examples;
11. Regulation: Reforming the current policies of the "dual energy consumption control" to focus more on carbon emissions reduction, and re-examining the enabling infrastructure for fast and scale renewable energy development; and,
12. Resilience: Refurbishing, renovating, and reinforcing climate adaptation and resilience of the energy systems.

If the Glasgow COP26 could be called a watershed of the global climate agenda, turning ambition into reality proves a much more daunting but must-deliver task. China's pace, to certain extent, defines how successful we will be in halving emissions by 2030 and netting zero carbon emissions by 2050.

1.3 RE-ENERGIZING: THE 14TH FYP FOR BUILDING A "MODERN ENERGY SYSTEM"

Insight China, March 30, 2022

Seemingly long awaited, but here it is, finally. On March 22, the NDRC and the NEA jointly released the **14th Five-Year Plan for "Modern Energy System" Development** (hereafter referred as the Plan). As the blueprint to re-energize the world's largest energy system, the Plan is expected to have significant impacts on China and major repercussions to the course of global decarbonization.

This Insight China report distills its essence and shares our perspective on its aspirations and challenges.

1.3.1 Modern Energy System:

How does China define a "modern energy system"? The Plan focuses on four qualificatives: **green, low carbon, secure and highly efficient**, in addition to accessibility. At the core of it stands energy security as the red bottom line and green low carbon transition as the objective. "**Secure, Green and Moder**n" is what the Chinese policymakers aspire for their future energy system to be.

The year of **2035** is selected as the target year when such a modern energy system shall be primarily built, in alignment with the country's overall modernization ambition and timeline. Between now and then, the Plan clarifies the interim milestones for 2025 and calls for efforts to re-power and reshape the country's energy infrastructure to fill the shortfalls in security, greenness and modernity, while maintaining the already achieved universal accessibility.

1.3.2 2025 targets:

Like all other FYPs, this Plan provides a set of numerical targets for 2025, as enlisted in Table 1-3. **All the 2025 targets are set higher than those for 2020, except for energy and CO_2 intensity of GDP.** It implies that China will continue to undergo a rapid expansion of its energy system while significant changes can be expected in energy structure, energy system flexibility and resilience.

Equally significant is **what's not on the list** when comparing with the previous Five-Year Plan. We have found 6 crucial elements shifted:

1. Total energy consumption is no longer a control target. The 13th FYP set an upper limit of no more than 5,000 million tons coal-equivalent (mtce). **Neither total energy consumption nor total electricity consumption is now given a cap in the 14th FYP.** This indicates a fundamental shift in the country's policymaking.

2. Energy self-sufficiency rate is no longer a target, indicating China is better prepared to embrace the international energy market.

3. Domestic energy production **Volume** is replaced by domestic energy production **Capability**, indicating preference given to the country's ability to respond to changes in international energy market with its own means.

4. Specific shares of gas and coal in total energy mix and share of coal-fired power in total power generation are no more listed, giving way to total energy supply capability and power generation capability. This indicates a policy **preference to energy delivered over its carrier**, no matter whether it is coal or gas.

5. Average coal-fired power efficiency is no longer a target, given the limited room for improvement, but also leaving room for possible efficiency loss due to **flexibility conversion of coal-fired power plants** to accommodate more intermittent renewables.

6. And, in power sector, transmission loss is no longer listed as a target. Instead, **flexibility in the generation fleet and demand side response** are much valued and given specific targets.

Table 1-3: Numerical Targets for China's 14th FYP for "Modern Energy System" Development

	Indicator	2020 Actual	2025 Target
Overall	Energy Consumption	4,980 mtce	**No cap**
	Electricity Consumption	7,520 TWh	**No Cap**
Energy Security	Domestic energy production capacity	4,080 mtce	4,600 mtce
	Domestic oil production	195 mt	200 mt
	Domestic gas production	192.5 bcm	230 bcm
	Installed power generation capacity	2,200 GW	3,000 GW
	Oil and gas pipeline length	175,000 km	210,000 km
	Share of flexible power generation sources (e.g. peaking plants, batteries)	6%	24%
	Demand-side response capacity/ peak power load	<3%	3-5%
	Gas storage	4.5% of consumption or 14.7 bcm	13% of consumption or 55-50 bcm
	Pumped hydro	32 GW	62 GW in operation, 60 GW under construction
Green and Low Carbon	Energy Intensity of GDP	-13.2% over 2015 level	-13.5% over 2020 level
	CO_2 intensity of GDP	- 18.8% over 2015 level	-18% over 2020 level
	Non-fossil fuel share of energy	15.9%	20%
	Non-fossil fuel share of power	30%	39%
	Hydro Power (including pumped hydro)	370 GW	380 GW
	Nuclear power	54 GW	70 GW
	EV share in total car sales	5%	20%
Modernization	End-use electrification	26.5%	30%
	R&D expenditure	7% annual growth	
	Major technology breakthroughs	50	

Note: Conversion between tons of coal equivalent (tce) and tons of oil equivalent (toe) is 1 toe = 1.43 tce. For the sake of easy reading, we continue to use the Chinese unit (tce) as listed in the Plan.

I.3.3 Key tasks and priorities:

To deliver a "secure, green, modern and accessible" energy system, the Plan highlighted following key tasks:

Energy security:

- Improve **energy supply sovereignty** by overcoming shortfalls in domestic production, diversification of import sources and a much-strengthened oil and gas reserves. Domestic production capacity to reach 4,600 mtce by 2025, from 4,080 mtce in 2020;
- Increase **domestic production capability** by 1) continuously expanding new clean energy supplies including wind, solar, hydro and nuclear; 2) stabilize existing coal production and coal-fired power to fully leverage their supporting role in energy transition, release new and advanced coal production capabilities and increase oil and gas production.
- Improve the **energy supply chain** by 1) expanding cross-regional power transmission and oil and gas transportation capabilities; 2) increasing supply flexibility by building coal reserves, and expanding underground gas storage and LNG receiving terminals.
- Strength **the resilience of the energy system**, particularly the power system vis-à-vis natural disasters, cyber-attacks and extreme climate events.

Green transition:

- Accelerate **wind and solar** development, "actively, securely and orderly" develop nuclear power, exploit hydro and other renewable energy resources "according to local conditions" to achieve the 20% target of non-fossil fuels in total energy consumption and the 39% target of non-fossil fuels in power mix.
- Promote the development of a "**new power system**" that would enable high-level penetration of renewables.
- Accelerate the construction of **long-distance transmission** of large-scale renewable plus coal power from the west to the east via the ultra-high voltage (UHV, 800kv DC and 1000kv AC) power transmission lines.
- Reduce **carbon emissions** from both energy industry supply chain and end-use sectors (industrial, transport and buildings);

Modernization:

- **Innovation** is called upon to accelerate, not only in energy **science and technology**, but also in **energy governance** and in new **business models** for emerging energy service companies, smart micro-grids, energy storage and hydrogen energy.
- **Digitalization** is considered a core feature of a modern energy system, integrating modern ICT technologies with advanced energy technologies, new materials and new manufacturing technologies. Demonstration of smart city, smart park and smart district, smart energy infrastructure as well as smart energy platforms is very much called for.
- A **modern energy market** for electricity and gas is considered an integral part of a "modern energy system", with the Plan calling for accelerated reform in the power market to allow market transaction of flexible power resources, green certificate, DSR (demand side response), and the market determination of all the energy and energy-related service prices.

Regional Balance and Accessibility:

- Given China's vast landscape, the Plan spends an entire chapter on **cross-regional optimization** from a national perspective.
- It also spends, for the first time, a few sections on **rural energy** development. All villages covered by either the State Grid or South Grids now have 100% access to electricity, and rural power supply reliability is very high (99.8%). They key challenges are to 1) upgrade the rural energy infrastructure, mainly the power distribution network; 2) turn rural areas as major sources of energy supply; and, 3) convert rural agricultural residues into energy production for both energy and environmental benefits.

International cooperation is very much called for, not only in oil and gas, but more on low carbon technologies, and on global energy governance.

I.3.4 Dilemma: return to the tradition to build a modern energy system?

The shift of policy direction in the Plan is very consistent with our earlier analysis (i.e. "Coal centered: China recharts its decarbonization course" of 10th January 2022). It has significant repercussions to the country's energy security and carbon emissions.

Firstly, it has relaxed incentives on energy saving, given there is no more cap on total energy demand. The energy intensity of GDP is now set to decrease by 13.5% between 2020 and 2025. China's total energy demand was 4,980 mtce in 2020. With an average annual GDP growth rate at 5.5%, China's total energy consumption by 2025 would grow by 13% (550 mtce), to a total of 5,630 mtce. To meet this surge in demand, the Plan calls for domestic production capacity to reach 4,600 mtce, which is 520 mtce more from the 4,080 mtce in 2020.

This poses an unattainable challenge. Where to locate this additional 520 mtce production capacity? Additional oil production capacity is very much constrained (only 5 mtpa is expected, which is equivalent to 7 mtce); gas production is expected to increase only by 37.5 bcm (from 192.5 bcm to 230bcm), equivalent to 46 mtce; and oil and gas together can only add 53 mtce. The addition of hydro (10GW, assuming 5000 hours a year) and nuclear (16 GW, 8000 hours a year) will add 178 TWh or 22 mtce in terms of energy consumption equivalent. And the rest 445 mtce per year of additional energy production capacity will have to come either from solar and wind, or coal. If merely by wind and solar, and assuming they run 2,000 hours a year in full load (the average was 1,580 hours in 2021), it will require 1,200 GW of additional installed capacity over a five-year horizon or 360 GW every year (China added 100 GW of wind and solar in 2021), which seems highly unlikely. Therefore, a massive return to coal is inevitable in order to meet the domestic production capacity target or China will fall short of this domestic production capacity target and rely more on oil and gas imports.

Secondly, China's CO_2 emission is expected to grow by 7.2% or 720 million tons more by 2025 – almost three times France's total annual emission (250 mt in 2020). This number is derived from the 2020 Chinese emissions of 10 billion tons (9.89 bt according to BP statistics), a GDP growth of 5.5% over 2020-2025, and the Plan's target of reducing CO_2 intensity of GDP by 18%. Although this is still in line with the Chinese commitment of peaking before 2030 (since no specific level of peaking has been made clear yet), the growth remains alarming.

And thirdly, the Plan continues the traditional planning philosophy of centralized supply expansion, so consequently, inadequate attention is paid to energy saving and distributed development and use of renewables. For instance, the concept of "District Energy" is a case-made effective tool to develop locally available energy resources to efficiently meet the demand with minimal environmental footprints. It was well proven in Denmark and widely promoted by the United Nations Environmental Program. But what appears in the Plan is "regional energy", which use the same Chinese vocabulary as "District Energy" but focuses on a totally different issue: cross-region energy flows inside China. Despite the rhetoric of encouraging local uses of renewables, preferences are obviously given to long-distance transmission by UHV power lines of bulk supply of centralized renewables plus coal-fired power.

Here appears a major shortfall on the part of China's central planners. The term "decentralization" has been less understood, let alone giving adequate attention or capturing the due opportunities offered.

Should a "secure, green, modern and accessible" energy system be a centralized or decentralized one? Or how to balance and optimize the two modes to maximize the benefits for both energy security and climate protection? It is precisely the answer to these questions that make the difference between China and the west in term of their visions for the future energy system.

1.4 LOW CARBON ECONOMY OR LOW EMISSION ECONOMY?

Insight China, March 12, 2022

We have five Insight China reports (see Chapter 4) covering China's blueprints of green transition in energy, industry, mobility, buildings, and consumption. These blueprints represent a nationwide shared but integrated strategy to lower ecological footprints.

Careful readers may have noticed a delicate but obvious "semantical" discrepancy when comparing the specific term of "green transition" in Chinese government policy papers and that in the West: it's not only about reducing CO_2 emissions, but covering a much wider scope, involving all local pollutants, and mainstreaming circular economy.

Is China trying to build a Western-style "low carbon economy" or does China have a different agenda? Only when this question is clearly answered will we (and our readers) be able to capture the nature of China's transition and what to expect next.

This report is a reflective step we take to offer a more philosophical, but fundamentally important, interpretation: China aims to build a "low emission" economy, not just a "low carbon" one.

1.4.1 Low Carbon Economy vs Low Emission Economy

The term "Low Carbon Economy" first appeared in UK Department of Trade and Industry's policy paper, "Our energy future – creating a low carbon economy", published in February 2003. It gained "popularity" in 2007 across China, where the term "ditan" or low carbon, was introduced and embraced, and later officially adopted in the government policy document of commitment submitted to the Copenhagen COP15 in 2009, in step with global community.

Such a term, if applied à la lettre as the cornerstone defining China's energy transition agenda, could be misleading as it does not reflect the country's basic conditions. We believe the term "low emission" better suits China's circumstances for the following reasons:

- "Low emission" is broader than "Low Carbon". The latter implies the need to reduce CO_2 as the main greenhouse gas, as well as all other GHGs, whereas the former includes not only those GHGs, but also all local air pollution, water pollution and solid waste disposal. See Table 1-4.
- The term "low carbon" focuses on the global climate mitigation, a rightly so top priority of

developed nations that have successfully passed the local pollution curve, whereas "low emission" correctly reflects the "duo challenges" developing nations, including China, face today – climate change and local pollution.

- Communication shall be "science-based". Carbon is a fundamental element of nature upon which human societies are built. It is not the "carbon" element per se but the runaway CO_2 emissions that need to be lowered. It is therefore an emission issue.
- The term "low emission" fits the traditional term of "energy saving and emission reduction" which China has been using in its policy document since the 1990s, well before the term "low carbon" was introduced. It also fits into the "zero waste"or "circular economy" concept that maximises the efficiency of material use across the life cycle through reduction, re-use, recycle and restoration.
- The term "low emission" is also easier-to-understand and "visual" for the public since everyone is "familiar" with the emissions from coal-burning and knows why they shall be reduced; but not the "invisible" carbon emissions. Without the subscription of mass population, any fashionable concept by scholars or policymakers can be hardly translated into actions.

Table I-4: Pollutants for Abatement in Low Carbon Economy vs Low Emission Economy

Low Carbon Economy	Low Emission Economy
Man-made greenhouse gases, namely: • Carbon dioxide (CO_2) • Methane (CH_4) • Nitrous oxide (N_2O) • Industrial gases: ○ Hydrofluorocarbons (HFCs) ○ Perfluorocarbons (PFCs) ○ Sulfur hexafluoride (SF_6)	• Man-made GHGs as per left column. • Local air pollutants: ○ Particle matters (PM_{10}, $PM_{2.5}$) ○ Ammonia nitrogen (NH3-N) ○ Sulfur dioxide (SO_2) ○ Nitrogen oxides (NOx) ○ Volatile organic components (VOC) • Water pollutants: chemical oxide demand (COD); • Industrial waste discharges; • Municipal waste discharges

In summary, we believe what China aims to build is a "zero emission" economy, covering a much broader scope than a "zero carbon" economy.

1.4.2 Policy Implications

Not just a scholastic discussion, this distinction has profound policy implications for China's energy transition.

- "Zero Carbon" economy requires that we get rid of all carbon-based fossil fuels, while "Zero Emission" still values the role of fossil fuels so long as we can get rid of the emissions associated with their production, conversion, and final uses. This is particularly important for natural gas. In the "low carbon" economy, natural gas is considered a "transition fuel" that shall be ultimately eliminated, whereas in "low emission" economy it proves to be a valued "companion fuel" of intermittent renewables.
- "Zero Carbon" promotes non-fossil fuels as the savior of a climate-endangered world calling for immediately "phasing out" of fossil fuels, while "Zero Emission" appreciates importance of fossil fuels during the transition, with a paced "phase down" of fossil fuels in step with the readiness of non-fossil ones, to ensure energy security during the transition.
- "Zero Carbon" treats CO_2 as the most undesired element, trying to bury it through CCS, while "Zero Emission" values CO_2 as a resource, trying to recycle it through CO_2 conversion and utilization (CCU) technologies.

If China's early embrace of the term "low carbon" partly reflects its endeavor to "speak" a common language with the West, we have witnessed it's returning to the essence of "low emissions". Indeed, we can see that the government has spent significant efforts to nuance the term "low carbon", very often by adding a preceding word "green", as demonstrated in all the sectoral green transition blueprints, covered in our five Insight China reports, as well as our "China recharts its decarbonization course" report.

Thus, it is the "low emission" or "zero emission" we should use as the correct lens to interpret China's plans and actions of energy and economic transition.

1.5 CAE CHARTS CHINA'S ROUTES TO CARBON NEUTRALITY

Insight China, April 20, 2022

Chinese Academy of Engineering (CAE) is China's most authoritative advisory body on technological and engineering matters. Established in 1994, the CAE gathers China's best brains in technological and engineering fields as a collective think-tank to advise government agencies and companies on major national strategic and technological options.

Such an important body will not remain silent on China's biggest strategic issue – carbon peaking before 2030 and neutrality by 2060. On March 31st, the CAE revealed its main conclusions and recommendations of a major advisory project titled **"China's Strategies and Routes to Carbon Peaking and Neutrality".**

This Insight China report shares the "highlights" of the findings before the full CAE report is released.

1.5.1 Numerical Milestones:

The CAE study concluded with the following quantitative milestones:

- **By 2027**: to achieve CO_2 emissions peaking at **12.2 billion tons** from a total of 10 bt in 2020.
- **By 2045**: to produce **80%** of power from non-fossil sources, against 30% in 2020; and,

- **By 2060:** to achieve carbon neutrality, with **2.6 billion tons of CO_2 equivalent** GHGs emissions from hard to abate sectors, which will be offset by variety of carbon sink means.

I.5.2 Eight strategies:

CAE drives home 8 nation-wide strategic priorities that shall be deployed simultaneously:

1. **Prioritizing energy conservation:** to uphold the concept of energy conservation as the first energy source, and continuously improve the efficiency of energy use in the whole society.
2. **Reinforcing Energy Security**: to make good use of fossil energy sources for emergencies, properly handle instability risk of new energy supplies, and reduce and prevent the risk of external over-dependence of oil and gas and critical minerals.
3. **Energy substitution**: to replace traditional energy sources with new ones gradually and in a safe and reliable manner, and continuously increase the proportion of non-fossil energy sources.
4. **Re-electrification**: to focus on the replacement of fossil fuels with electrical energy and development of electricity-based raw material and fuel production technologies, and vigorously upgrade the level of electrification of key sectors.
5. **Resource recycling**: to accelerate upgrading, retrofitting and transformation of traditional industries and business process reengineering, and realize multi-level recycling and reuse of resources.
6. **Carbon sink:** to uphold combination and integration of ecological carbon sinks and artificial carbon uses, enhance ecosystems' carbon sequestration capacity and promote research and development of carbon removal technologies.
7. **Digitalization:** to promote digitalization of carbon reduction and management activities and help transform production and consumption to become green.
8. **International cooperation:** to deepen and strengthen international cooperation in all above areas.

I.5.3 Seven routes:

The CAE research charts the following 7 routes to pursue:

1. **Enhancing the quality and efficiency of economic development** and using industrial structural optimization and upgrading as an important means to decouple economic growth with carbon emissions.
2. **Building a clean, low-carbon, secure and efficient energy system** as the key and basis to achieve peaking and neutrality.
3. **Accelerating the construction of a new power system** with renewables as the mainstay, and safely and steadily achieving net zero emissions from the power sector.
4. **Promoting orderly attainment of emissions peaking and progressive neutrality of industrial sectors**, supported by electrification and deep decarbonization technologies.
5. **Achieving low-carbon transition in transport** through high-proportion electrification.
6. **Focusing on breakthroughs in key green building technologies** to achieve zero carbon

emissions from electricity and heat use in buildings.

7. And, **planning for carbon removal technologies** to bridge the "last mile" to carbon neutrality.

1.5.4 Three recommendations:

The CAE has formulated the following three broadline recommendations to the Chinese government:

1. **Maintain the nation's strategic determination and focus**, deliver better co-ordination and, on the premise of ensuring the orderly operation of the economy and society, and the security of energy and resource supply, adhere to the national "one-game-of-chess" strategy and achieve carbon neutrality in an orderly and gradual manner.
2. **Strengthen scientific and technological innovation** by providing strong impetus and support for achieving carbon neutrality, especially, by delivering major breakthroughs in key technologies.
3. And **establish and improve the systems, mechanisms and policy parameters** to ensure the implementation of adopted measures, in the meanwhile speeding up the establishment of a system for total carbon emission control, accelerating the construction of a mechanism to plan, promote and assess the integrated reduction of local pollution and carbon, and continuously improving the supporting and supervision systems.

The CAE's conclusions and recommendations are significant and impactful due to its institutional and "statutory" settings. Different from the Chinese Academy of Sciences (CAS), which is country's biggest research institution with 13 regional branches, over 100 research institutes, 4 universities and over 400 high-tech companies, the CAE is only an advisory body without a heavy-loaded structure, it's life-long membership (920 Chinese members and 93 foreigner members as of January 2020) represents the highest honor in science and engineering of the nation.

The CAE study helps clear some remaining "murkiness" and "suspicion" on the table since the Chinese government announced its 2030/2060 targets. It adds confidence to not only China's own decarbonization and clean energy transition, but also global endeavor and progress towards keeping 1.5C goal alive.

This new CAE research took one-year collective work that had involved 40 CAE members, more than 300 non-member experts and a dozen other research entities.

1.6 A CLIMATE ADAPTIVE AND RESILIENT SOCIETY BY 2035

Insight China, No.33, July 21, 2022

With one fifth of world's population and a quarter of which suffering each year from the impacts of extreme weather events that cost the country nearly 2.5% of its GDP, China is one of the most vulnerable countries to climate change.

Data and evidence show that over the last five decades, China has experienced a much-accelerated warming, at 0.26 degree Celsius every ten years, faster than the global average of 0.15 degree Celsius. The impacts have been extensive both socio-economically and ecologically, challenging the country's existing response capability or climate resilience.

The National Climate Adaptation Strategy 2035 (the Strategy), released in mid-June, led by Ministry of Ecology and Environment, jointly by 16 other national ministries, emerges as a pivotal move. It reflects new understanding of adaptivity on the part of the policy makers, as well as their best-ever systemic re-thinking of how to strengthen the nation's ability to adapt to a warming world.

This Insight report pulls together an overview of China's climate adaptation priorities with the objective of building an adaptive and resilient society.

1.6.1 Adaptation equally important as mitigation

China released its first National Climate Adaptation Strategy in 2013, and then the 2014-2020 National Plan of Responses to Climate Change, which literally uplifted adaptation to the same level of mitigation in a "hand-in-hand" manner. Since 2016, the policy makers have developed and announced sector-focused adaptation action plans, spanning from city and forestry to meteorology, agriculture, water resources, oceans, infrastructure, urban and rural development and ecology and environment.

And yet, all the efforts proved piecemeal and could not match the dire real-life challenges.

A new strategy is required, on one side, to be proactive, preventive, and protective; and on the other, to embrace an integrated, systematic, coordinated, eco-regional and whole-society participatory approach.

1.6.2 New strategic priorities

The Strategy calls for an integrated thinking on climate adaptation with 4 features:

1. Monitoring, forecasting, early warning, and risk management is given an absolute top priority – such as through an integrated ground-air-space network and system, enabled by advanced technology.
2. Adaptivity and resilience is examined and considered from dimensions of both ecosystems and socio-economic systems – that emphasize nature-based solutions.
3. Eco-regional and economic regional perspective and capacity in adaptation are emphasized when planning land use. – through 8 eco-regions and 5 economic strategic regions.
4. And intergovernmental coordination becomes key to deliver the Strategy, with ensured support by funding, technology, capacity building and international cooperation.

It calls on strengthening four pillars of capabilities in building an adaptative and resilient society by 2035, as illustrated in Table 1-5.

Table I-5: Key Capability Pillars in Building a Climate Resilient Society

Capability pillar	Priority focuses
Capability in climate change monitoring, early warning and risk management	1. Better climate observation network 2. Strengthen monitoring, forecasting and early warning 3. Enhance impact and risks assessment 4. Strengthen disaster prevention and reduction
Capability in natural ecosystems' climate adaptivity	1. Water resources 2. Land ecosystems 3. Oceans and coastal belts
Capability in socio-economic systems' climate adaptivity	1. Agriculture and food security 2. Health and public sanitation 3. Infrastructure and key engineering projects 4. Cities and human living environment 5. Sensitive secondary and tertiary industries including energy
Ecoregional capability of climate adaptivity	1. Structure climate-adaptive land space 2. Enhance climate adaptive regional actions 3. Elevate strategically significant regions' climate resilience

I.6.3 Zoom in on ecosystems' adaptivity

One of the highlights of the Strategy is, for the first time, climate change impact on Nature is "officially" recognized and integrated into a national strategy and plan and is put at the same level of significance as socio-economic adaptation. As illustrated in Table 1-6, the Strategy puts an emphasis on integrated protection and systemic approaches -- to align adaptivity and resilience work to focus on mountains, water, forests, farmlands, lakes, grassland, and deserts.

Water is put at the core of the national strategy of resilience through a principle of "four defined by water" (or in Chinese " 四水四定 ") – that decisions on where to locate a city, land use plan, people's settlement, and economic activity shall be made in accordance with the carrying capacity of water resources (or in Chinese " 以水定城、以水定地、以水定人、以水定产 "). Such principles fixate decision-making on water saving and conservation.

Table I-6: Elevating Ecosystems' Climate Adaptivity and Resilience Illustration

Category/time	2025	2035
Water resources: • Structure water resources and flooding-drought smart monitoring system • Advance water resources saving and integrated utilization • Enhance mandatory water resources constraints • Implement state key water network projects • Improve watershed flooding control engineering projects and flooding risk prevention and control • Accelerate flooding diversion and storage infrastructure construction • Strengthen major rivers and major lakes ecological conservation	• Total water consumption nationwide: less than 640 billion cubic meters • Water use intensity per 10,000 RMB yuan GDP reduction: 16% over 2020 level • Scale water supply coverage: 55% of rural population • Rural tap water coverage: 88% • Key rivers and lakes basic ecological runoff reaching standards: 90% and higher • Water and soil conservation nationwide: 73% and higher	• Total water consumption nationwide: less than 700 billion cubic meters • Water saving and recycling/reuse: at internationally advanced level • Effective protection for water ecosystems, water and soil conservation, runoff of rivers and lakes, and in place, beautiful and healthy water ecosystems
Land ecosystems: • Build land ecosystems integrated monitoring systems • Establish land ecosystems protection and oversight systems • Enforcing laws and regulations • Strengthen remediation of degraded landmass • Elevate disaster early warning • Protect biodiversity		• Forest coverage: 26% • Vegetation coverage of grassland: 60% • Wetland protection: 60% • Remediable deserted land treated: 75%
Ocean and coastal regions: • Improve ocean disasters observation, early warning and assessment systems • Elevate disaster prevention and resilience capacity in coastal regions • Strengthen coastal ecological remediation • Sustain to improve ocean environmental quality	• Coastline remediation: 400 kilometers long • Land natural coastline preservation: no less than 35% • Near-coast good water quality: 79%	• Remediated coastal wetlands: 50,000 hectares • Coastal shelter trunk forest belt reaching standards: no less than 98% • Coastline remediation: 1,200 kilometers long • Much improved ocean ecological and environmental quality

I.6.4 Ecoregional focuses

Ecoregions are the unique biotic subregions within the principle biogeographic regions[1] or bioregions of the planet. The Strategy calls for a more holistic ecoregional approach in building a climate resilient society. This can be reflected in the importance attached to diverse climate and natural environments to ensure effectiveness of adaptation and integrity of the ecosystems.

Eight ecoregions are specified in structuring regional climate adaptivity, including 1) Northeast China; 2) North China; 3) East China; 4) Central China; 5) South China; 6) Northwest China; 7) Southwest China; and 8) the Qinghai-Tibetan Plateau. The Strategy makes its utmost effort to embed resilience and adaptivity into land uses and shape up "One Map" in land use planning so that "redlines" for permanent agricultural land and cultivated land, ecology, and urban development be respected.

I.6.5 Reinforcing adaptivity in strategically significant economic regions

In the meanwhile, the Strategy has also set priority actions for the five strategically significant economic regions to advance climate adaptivity. Those are the regions where most of the Chinese population resides and where climate resilient infrastructures – both hardware and software, as well as nature-based solutions – have a crucial role to play to protect people and nature. They are:

1. The Beijing-Tianjin-Hebei Region: where water scarcity has long been a major growth constraining factor and it's now planned to build out an internationally advanced climate adaptive and habitable urban clusters.

2. The Yangtze Economic Belt: where remediation, regeneration and recovery of nature is key along the Yangtze River watershed.

3. The Guangdong-Hong Kong-Macau Big Bay Area: where sea level rise has become a major challenge, as well as typhoons and other oceanic disasters – they pose rising risks to public health, infrastructure, and local ecosystems.

4. The Yangtze Delta Integrated Region – where is expected to lead the transition towards climate smart and adaptive society.

5. The Yellow River Watershed Region – where water saving and control of water consumption, integrated protection, and systemic approaches, and coordinated regional and ecoregional actions are among some of top priorities.

I.6.6 Financing adaptivity and resilience

Embedding the 5 economic regions well in the 8 ecoregions remains a daunting task to deploy, which, to a large extend, will define how well and effectively the Strategy be implemented and goals delivered. To do so would require both public and private funding in place to invest in the transition of climate adaptive society by 2035.

The Strategy, undoubtedly, helps secure national budget and public finance for climate resilience, while policy is expected to incentivize private capital to flow into adaptivity. While green is already designated as the color of finance in China under the national "duo carbon targets" to net out emissions, adaptivity finance, lagging way behind, is to catch up quickly under the new Strategy.

Two trends are emerging with different degrees of certainty. One is that banks, securities, funds, and other commercial financial products are expected to shift at scale towards investing in climate adaptation projects, but it remains highly uncertain how money will get rewarded. The other is that disaster insurance or broadly climate risk insurance are set to play a more mainstream

1 The Earth's eight biogeographical regions are Australasian, Afrotropic, Nearctic, Oceanian. Antarctic, Indomalayan, Neotropic, and Palearctic.

role in building a climate resilient society. This will be a sure thing, isn't it?

1.7 BUILDING "ONE NATIONALLY UNIFIED BIG MARKETPLACE"

Insight China, May 20, 2022

About 2,240 years ago, in AD 221, the ruler of Qin annexed all his six neighboring kingdoms and proclaimed himself the first emperor of the Qin dynasty, now called China. To build a strong and unified big empire, one of his most significant and lasting endeavors was not just destroying all the defense barriers of the conquered kingdoms, but to unify the calligraphs, road widths, cart tracks, weight and volume measurements, currencies as well as market rules.

More than two millennia later, in 2022, can one imagine that a similar action is being undertaken in the Middle Kingdom? Well, everyone knows China is a very large market for everything with its 1.4 billion population, but few may know that the Chinese market is actually not a unified one. There exist what we call **"horizontal barriers"**, whereby each of its 31 provinces sets their own rules to protect local manufacturing and vested interests against goods and services from other provinces, and **"vertical compartmentations"** whereby critical infrastructures such as gas, water, heating and power are managed by different government agencies, preventing companies operating in one compartment from entering into another, thereby impeding market efficiency.

As China nowadays focuses more on domestic market to pursue economic growth, due to both the pandemic and the decoupling with the west, its policymakers have turned their attention to remove domestic trade blockages to ensure an unimpeded flow of products and service inside this big marketplace. This is the purpose of the **"Opinion on Accelerating the Construction of a Nationally Unified Big Marketplace"** (the Opinion), released on March 25, by the Central Committee and the State Council.

This Insight China report sheds some light on its implications and potential repercussions to the country's clean energy transition.

1.7.1 Building a unified national marketplace for efficiency and efficacy

With the objective of building "one nationally unified big marketplace", the Opinion calls to:

1. Advance highly efficient, fluid and open domestic market by breaking down all artificial or systematic entry-exit barriers that inhibit the cross-provincial and cross-industry flow of products and services;
2. Simplify rules and regulations to build a commercial market environment that is stable, fair, transparent and predictable;
3. Further reduce costs of market trading and transactions, particularly the logistics costs;
4. Promote S&T innovation and industrial upgrading; and,
5. Cultivate new competitive advantages to participate in international competition and cooperation.

The following six priority areas are identified for action:

1. Strengthen unification of ***basic market systems and rules***, such as property rights protection, market entrance, fair competition, and social credits;
2. Advance ***inter-connectivity*** of high-standard market facilities, such as modern logistics network, market information exchange channels, and trading platforms' optimization and upgrading;

3. Build a unified **factors and resources market,** including land and labor, capital, technology and data, energy, and ecology and environment. Table 1-7 below shows the focused actions in the five priority markets for factors and resources.

4. Advance unification of high-performance ***goods and service marke***t, such as quality assurance system, standards and metering/measurement systems, and consumption service quality;

5. Advance fair and unified ***market supervision and oversight***, including sound rules, strengthened enforcement, and elevated capacity on all fronts; and,

6. Further regulate ***improper market dominations***, by strengthening anti-monopoly, dealing blows to improper competition behaviors, tearing down local protection and regional barriers, abolishing rules that block legal and fair market entrance and exit, and continuing clearance of existing rules and acts of bidding and procurement that go against construction of a united marketplace.

Table I-7: Five Priority Markets of Factors and Resources

Priority markets	Focused actions
a unified urban-rural land and labor market	• Unify planning and management of land use, both newly increased and in-stock • Better cross-region trading mechanism by coupling increase and decrease of urban-rural construction-purpose land saving quota and supplemented arable land quota • Unify a regulated human resources market system and promote cross-region flow of labor and talents • Link cross-region fiscal transfer policy with size of newly added urban land use and rural population urbanization
a unified capital market	• Unify registration of movable property and right guarantee and develop movable property financing • Unify oversight standard and better entrance management to strengthen key financial infrastructure construction and supervision • Innovate and pilot new systems and businesses in selected regional equity markets that are operated safely and well-regulated, with better risk management capability • Connect bond market infrastructure for free flows • Develop supply chain financing and provide direct passage to operating entities • Build solid security bottom line to prevent and control financial system risks • Prevent "virtualization" of real economy • Set capital "green and red lights" to prevent expansion without order

Priority markets	Focused actions
a unified technology and data market	• Establish and improve national technology trading market, better IPR valuation and trading mechanisms, and promote cross-region inter-connectivity • Encourage cross-region technology information interaction and sharing of key R&D infrastructure and equipment and facilities • Establish basic systems and standard regulation for sound data security, rights protection. cross-border data transfer management. trading circulation, openness and sharing and security certification
a unified energy market	• Preconditioned on effective guarantee of secured energy supply, orderly advance construction of national energy market, in linkage with the duo decarbonization target • Based on unified planning and optimized distribution, improve oil and gas futures system by regulating and standardizing construction of trading centers and transactions • Promote interconnectivity of oil and gas pipelines and open them to market players fairly • Steadily promote natural gas marketization reform and speed up establishment of unified system for natural gas energy measurement, valuation and pricing • Improve a multi-layered and unified electricity market, study and roll out structuring national electricity trading center • Further the function of the national coal trading center and promote improvement of a nationally unified coal trading market
a unified ecology and environment market	• Built upon the public resources trading platforms, establish unified national trading market of carbon emissions rights and water use rights, guided by unified sector standards and trading supervision mechanism • Promote market trading of pollution levy and energy use rights • Promote system construction for green products certification and labels, as well as green production and green consumption

I.7.2 Advance clean energy transition conditioned on energy security

The Opinion is highly oriented towards security risk management and resilience enhancement in the backdrop of increasing system shocks from geopolitical complexity and escalating conflict threats, supply chain disruptions, energy, and food security risks, continued public health threats, as well as intensifying climate change impacts.

This mindset is strongly and clearly stated in the Opinion when clean energy transition is concerned.

Indeed, as specified in the Opinion, ″effective guarantee of secured energy supply″ is a ″fundamental task″ and ″precondition″ that preludes all the other moves and also a mandate to deliver. Domestically, China is ramping up production of fossil fuels, especially coal, and ensuring that the power sector has sufficient capacity and flexibility to guard against shocks as it decarbonizes.

The ″dual″ decarbonization goals or clean energy transition targets will be linked with the national energy market when the preconditions are met. This echoes what President Xi Jinping has remarked that - decarbonization ″should be neither too fast nor too slow; rather, it should progress steadily″, indicating that China must not dismantle its existing energy sources before new, cleaner sources are fully built out.

Under this context, we see the Opinion giving a new push for the unification of rules for market mechanisms such as green power purchase across provinces, trading of China certified emission reduction (CCER) and green certificate, etc. But these improvements remain minor compared to the grand ambition of building a nationally unified energy market.

I.7.3 Challenges in building a "unified big energy marketplace"

Given China's energy industry is dominated by state-owned national companies, it experiences less "horizontal barriers" by local protectionism than "vertical compartmentation". However, the Opinion proposes no solution to the compartmentation problems which involve the more and deeper difficulties of governance. Instead, it chooses to focus its attention on trading platforms, namely:

- Standardize the construction of oil and gas trading centers, optimize the existing exchanges and delivery ports;
- Build a multi-layer but unified power trading market system, and establish a national power trading center at appropriate time;
- Fully play the role of existing national coal trading center in building a unified national coal marketplace; and,
- Build nationally unified trading markets for carbon emissions, for water use rights, pollutant discharge rights and energy use rights, with unified standards and trading rules.

Operational experiences of many of these trading platforms have shown lagging effectiveness in resource allocation and price setting, mainly due to the conflicts between market instruments and command-and-control mentality of the Chinese economy.

One unified national big energy marketplace can be built with the command-and-control approach under continuing state monopolies in power, oil and gas transmission and distribution, and yet this won't be efficient nor desirable. But alas, this is very likely to happen, as incumbent monopolistic companies will use this new directive to strengthen their positions.

1.8 CHINESE NOCs' NETTING ZERO COMMITMENTS

Insight China, September 22, 2022

China has three integrated national oil companies (NOC): CNPC, Sinopec and CNOOC (the "Big Three"). Each has a publicly listed entity, respectively as PetroChina, Sinopec Ltd and CNOOC Ltd, and each of which owns the majority stake of its mother company's operating assets. In 2020, those listed entities had a combined Scope 1 and Scope 2 GHG emissions of 347 mt (million tons) of CO_2 equivalent, which is bigger than the entire UK emissions (329 mt CO_{2e} in 2020).

As state-owned companies, those NOCs are mandated to help ensure the country's oil and gas supply security, while leading the efforts of decarbonization.

This Insight report aims to shed light on what those companies have committed to advancing carbon neutrality and what challenges they face.

1.8.1 Emissions

Before the Paris COP 21, Chinese NOCs were mandated to disclose environmental information and they were reporting energy saving and pollution reduction as part of their CSR (corporate social responsibility) or "sustainability" reports. GHG emissions were added to the scope of reporting after Chinese government officiated its NDCs under the Dec 2015 Paris Agreement.

CNOOC was the 1st Chinese NOC to report its GHG emissions in 2016, followed by Sinopec a year later and CNPC/PetroChina in 2019. Table 1-8 summarizes their time-bound data of emissions. For comparison, the largest IOC - Exxon's Scope 1&2 GHG emissions in 2019 was 120 mt, while Shell – the second biggest, was 80 mt, both far below Sinopec or PetroChina.

Table 1-8: GHG Emissions of Chinese NOCs

		Million tons of CO_2 equivalent				
		2016	2017	2018	2019	2020
CNOOC Ltd.	Scope 1	6.735	7.736	7.345	8.597	9.123
	Scope 2	0.360	0.093	0.135	0.186	0.222
	Scope 1+2	**7.095**	**7.829**	**7.480**	**8.783**	**9.345**
PetroChina	Scope 1				132.17	127.57
	Scope 2				41.91	39.87
	Scope 1+2				**174.08**	**167.44**

			Million tons of CO_2 equivalent			
Sinopec Corp.	Scope 1		123.05	128.57	125.68	128.58
	Scope 2		39.61	42.95	45.01	42.36
	Scope 1+2		**162.66**	**171.52**	**170.69**	**170.94**

Source: Company reports and ERICA DOWNS

1.8.2 Commitments

In September 2020, President Xi announced China's goals of peaking emissions before 2030 and achieving carbon neutrality before 2060. Chinese NOCs have successively announced their respective peaking and neutrality timetables (Table 1-9). Both Sinopec and CNPC published their targets in March 2021, while CNOOC only made its target public in June 2022.

Table 1-9: Chinese NOCs' Carbon Neutrality Objectives and Strategies

Company	Objective	Strategies and actions
Sinopec	• Net-zero by 2050; • Becoming a world-leading clean energy and chemical company. • Becoming China's 1st hydrogen company.	• Building 1,000 hydrogen refueling stations by 2025; • Reducing methane intensity by 50% by 2025; • Building one mtpa size demo CCUS project by 2025; • Converting existing petrol stations into EV charging, hydrogen refuelling, gas refilling and service providing hubs. • Investing in new energy, new materials, new technologies and new businesses to create new engine of growth.

Company	Objective	Strategies and actions
CNPC	• Peaking by 2025; • Oil, gas and new business each one third by 2035; • Net-zero by 2050; • Changing from an oil and gas company to an integrated energy supplier.	• Increasing the share of gas in total production to 55% by 2025; • Investing in renewables including geothermal, wind and solar; • Strengthening energy saving and green electricity substitution in own operations; • Investing in carbon sink and CCUS, achieving a carbon removal capability of 10 mtpa by 2030, 24 mtpa by 2040 and 34 mtpa by 2050; • Enhancing digitalization; • Restructuring the company to give new energy the same status as E&P.
CNOOC	• Peaking by 2028; • Net-zero by 2050, when non-fossil fuels output will be bigger than oil and gas output. • Become a world-class provider of clean energy products and services.	• Reduce CO_2 intensity by 10-18% below 2020 level by 2025; • New energy business investment to account for 5-10% of total Capex by 2025; • Three-step approach: clean energy substitution, low carbon leap-frogging and green development; • Six areas of actions: 1) stabilize oil and increase gas output; 2) improve energy efficiency; 3) accelerate clean energy substitution; 4) business upgrading and transformation; 5) green development; and 6) innovation.

1.8.3 Challenges

As shown in Table 1-9, all three Chinese NOCs have committed to netting out carbon emissions by 2050, up to ten years ahead of the country's target (before 2060). Each will tell you the activities they do in their respective sustainability reports.

However, many challenges must be addressed. The first is ability and expertise in renewable energy. All the "Big Three" have all announced ambitious targets for renewables, but questions abound about their ability and capability to deliver the targets, as Chinese NOCs are much less experienced than their international peers in developing solar and wind projects.

The second is the mandated and expected multitasking. Unlike oil companies in Western countries, Chinese NOCs bear multiple obligations and expectations of being a state economic and industrial tool, a market player and a listed company. Their multiple responsibilities range from implementing the will of the state and ensuring the security of oil and gas supply to participating in market competition and creating value for shareholders, while holding a unique position in China's "socialist market economy". And recent energy crises in Europe have reinforced the Chinese NOCs' role as energy security provider of the country.

And the third is governance. As the backbone of China's state-owned economy, the top executives of those NOCs (above the level of deputy general manager) are appointed by the CPC Party. The bosses are treated as officials at vice-ministerial level. Also, Chinese NOCs carry many government functions and their operating model retains the characteristics of national ministries. The biggest pressure on them comes from the government, and the biggest incentive for those at the helm remains political.

As a result, Chinese NOCs and their CEOs behave rather distinctly from their international peers. Their netting-zero commitments should be understood within the country's overall decarbonization plan in which those companies play their due part, rather than independently decided by their boards.

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2

MACRO-ECONOMIC TRENDS AND INTERNATIONAL LANDSCAPE

2.1 CHINA ON A NEW JOURNEY: CCP CONGRESS SETS NEW TONE ON ENERGY TRANSITION

Insight China, October 24, 2022

Over the last weekend, the Chinese Communist Party (CCP) concluded its 20th National Congress, when Xi Jinping unsurprisingly secured his 3rd term.

The Party's Congress, twice-per-decade, is the most significant political event in China. It not only "elects" and presents the new leadership, but also draws the blueprint for the country's economic and social development. It sets the tone and steps for the energy transition of the world's second largest economy.

This Insight report provides a summary of this blueprint and analyses its implications for energy transition, based on the 72-page report Xi submitted to the Congress on the opening day (the Report).

2.1.1 Modernization in the Chinese way

Xi's report covers many subjects ranging from political to economic, social, and military security, as well as technology, industry and ecological and environmental sustainability. The overarching ambition is to pursue the country's modernization in the Chinese way. According to Xi, China has achieved the first step of eradicating absolute poverty and building a well-off society under his leadership in the last decade. The next mission is to build a "modernized country" by 2035 and a "rich, strong, democratic, civilized, harmonious and beautiful modernized powerful country" by mid of the century.

How to understand the Chinese way? The Report highlights the following aspects to achieve its modernization:

1. Strong unity around one single party and one single leader;
2. Socialism with Chinese characteristics, with focus on state-led economy and self-reliance but balanced with opening to the external world;
3. A more egalitarian society that is people-centered, for people, reliant on people and ensuring people to share the fruits of economic development;
4. Continued reform and opening up while overcoming the systematic barriers that hold back progress; and
5. The spirit of a fighter, daring to face problems and challenges and get them solved.

2.1.2 Security as the foundation

The word "security" is repeated 89 times in the report. It shows how important and imperative it is on the mind of the CCP leadership when drawing the country's blueprint for the coming decades. It refers to a three-dimensional system that covers not only the traditional national security, but also political security, regime security, ideological security, homeland security, economic security, food security, energy security, and key supply chain security. It also encompasses security in such wide-ranging areas as military, science and technology, cultural and social, financial, major infrastructure, cyber-space, data, bioscience, resources, space, and ocean sectors.

But those different aspects of security are not treated as equal. According to the report, "people security" is the ultimate objective, while political security is fundamental, economic security as the foundation, and security in military, technology, culture, and society as the guarantor. The report vows to promote international security and to coordinate external security and internal security, homeland security and national security, traditional security and non-traditional security, and China's security and global common security, in a holistic manner.

The ability to counter foreign sanctions, interventions, sabotages, subversions and “arms-length” interferences is also considered important to the newly defined security system.

Other key elements of the blueprint include “common prosperity” which marks halting a motto of the “Deng Xiaoping era” when capable people were encouraged to get rich first. The emphasis on high-quality growth implies that a slower growth in the coming years would be acceptable.

2.1.3 Energy security by all means

One of the 15 chapters of the Report is dedicated to green development, which defines the color of Chinese modernization. It calls for a well-coordinated planning in industrial structural re-adjustments, pollution reduction, ecological protection and climate response, in achieving its modernization that is ecologically sound, environmentally friendly, less resource-intensive, green and low-carbon.

The Report calls to progress peaking carbon emissions actively and steadily and achieving carbon neutrality, but it also insists that this should be done in a planned and phased manner and based on China’s conditions of resource endowment. It stresses a basic rule that a new system shall be built and fully operational before knocking down the existing one. Energy security is highlighted as key and fundamental when decarbonizing the country’s energy system, with all measures to be taken to strengthen it, including clean and efficient utilization of coal, and domestic exploration of oil and gas resources.

2.1.4 Building a “New Energy System”

What’s new is the call to build a “New Energy System” which appears the first time in an official CCP or the country’s policy document. As a reminder, the CCP called to build a “New Power System with renewables as the mainstay” in March 2021, which attracted a lot of attention. The energy sector’s 14th Five-Year Plan, published in March 2022, is entitled “Modern Energy System” Development Plan. And yet, just as it was the case in March 2021, the CCP did not give any clear definition of what holds as the “New Energy System”, leaving room for interpretations and possible confusion.

It’s well understood that energy is much bigger than power. Thus, building a new energy system has become a clear call and instruction that Xi gives to his bureaucrats to have a bigger ambition, and the “newness” must be compatible to the overall philosophy of the new Xi Era.

2.1.5 Energy transition implications

The Report could also be read as China’s national resilience strategy against the backdrop of global “choppy waters” and “stormy weathers”, where Xi and his colleagues see an increasingly more treacherous global geopolitical contention that threatens China’s security and stability. And energy security is one of the core pillars to stave off the crises in the next five years of Xi’s third term. As stated, China will make available all resources at its disposal to strength the base of energy security, which will include coal, oil and gas.

More efforts will be spent on enhancing the resilience of the energy system vis-à-vis extreme climate events and geopolitical events. In the meanwhile, China remains steadfast to accelerate renewables, nuclear and hydropower development to build a new energy system that is green and low carbon. And emissions trading is expected to play a much bigger role that aligns the nation-wide cross-sector endeavor to drive down emissions.

At the Congress, the CCP also amended its Charter by adding two sentences among others. One is “Green mountains are mountains of gold and silver”, and the other, “China will enforce the most restrictive laws and regulations to protect the environment and ecosystems”.

The former implies a fundamental shift towards a new planetary-view that values nature and embraces nature-based solutions, and the latter implies that the CCP is determined to advance clean energy transition and fight climate change through effective law enforcement and with accountability.

Now the new tone is set, but uncertainties loom large: how will the new leadership stop the economic downfall? And when will China and US resume climate dialogue and cooperation in the new geopolitical landscape?

2.2 PEAKING OIL: YES, CHINA'S OIL DEMAND PEAKED

Insight China, December 27, 2022

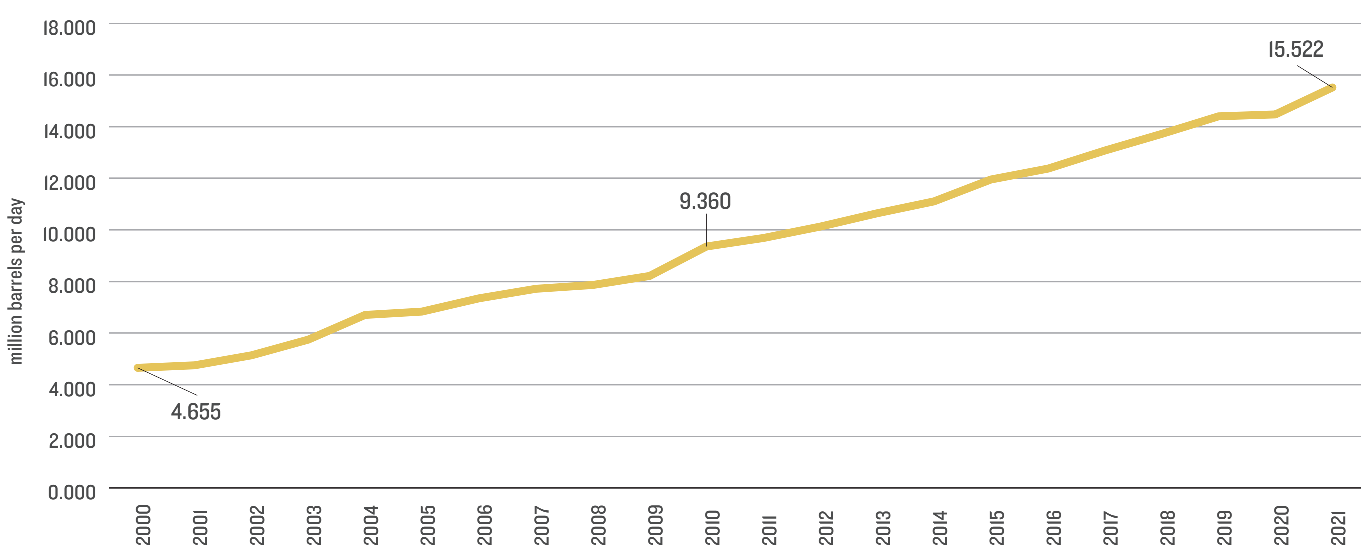
In his exclusive interview at the 12th United Arab Emirate (UAE) Energy Forum on January 12th of 2022, Xavier Chen, President of the Beijing Energy Club and CEO of CN Innovation, argued that Chinese oil demand "is reaching a plateau and may have been already peaked at round15.5 million barrels per day (mbd)". He advised that "we should revise the hypothesis that Chinese oil demand will continue to rise and follow the trend in the last decade". His argument is based on the worsening domestic macro-economic prospect, deteriorating international geopolitics, and new energy vehicle substitution.

At the year end, we would like to dedicate this final Insight report of the year to the Chinese oil market, by zooming in on Dr. Chen's argument and examining how the trend impacts China's energy transition.

2.2.1 The rising demand: historical data

Commensurate with its rapid economic expansion, China's oil demand more than tripled during the decade of 2000-2021 as shown in Figure 2-1. The average annual growth rate is 5.9%. Growth slowed slightly in 2020 due to the Covid-19 lockdowns, but quickly rebounded in 2021.

Figure 2-1: China's Oil Demand 2000-2021



Source: BP Statistical Review of World Energy, 2022

2.2.2 Reexamining the arguments of peaking oil demand

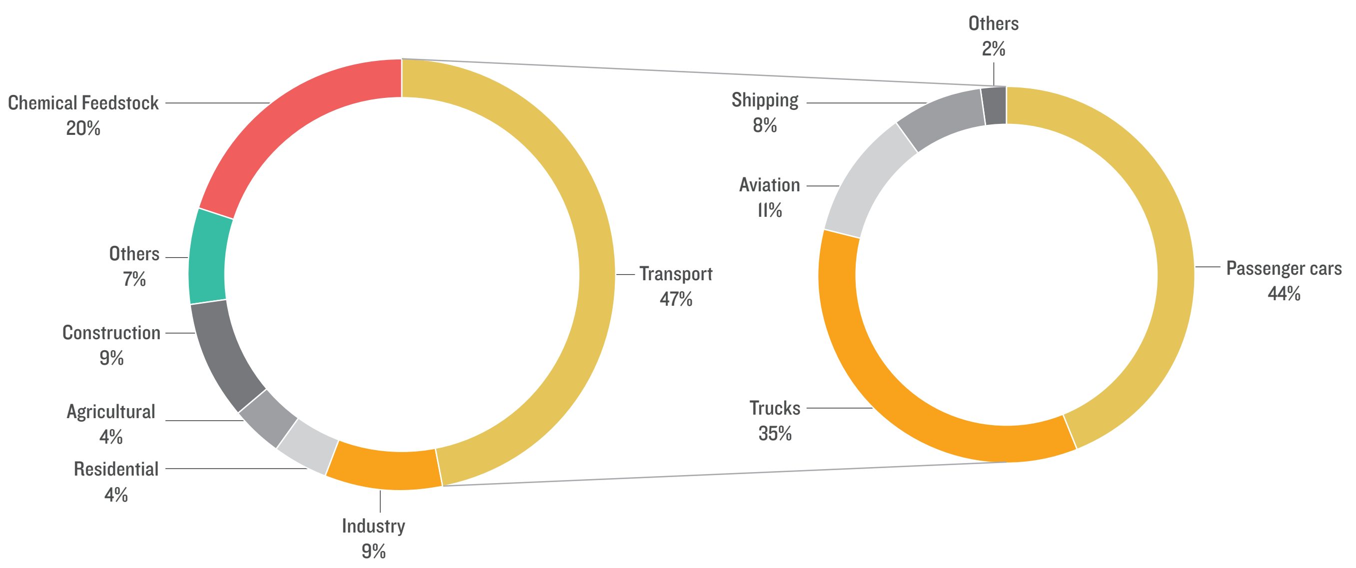
Such a robust trend constituted one of the most important fundamentals of the global oil market since the turn of the new century. To a large extent, it had provided a shelter to the global oil industry during the three market storms – in 2009, 2014 and 2020, and helped its quick recovery.

Will such dynamics hold though? To answer this question, let's take a closer look at Dr. Chen's three arguments.

The first is substitution by electric vehicles. Let's investigate both the significance of EV growth in China's total fleet and its impact on oil consumption. From the fleet perspective, by the end of September 2022, China had a total of 412 million vehicles on road, 76.5% of which or 315 million were passenger cars. In 2021, a total of 21.75 million new cars were sold and registered for road circulation, 3.3 million of which were EVS. By the end of 2021, China had a total of 7.8 million EVs on road.

How does the EV growth impact oil consumption? Figure 2-2 shows China's 2021 mix of oil consumption where transport accounted for 47% of the total, and the passenger cars accounted for 44% of the total transport oil use, or 21% of the country's total.

Figure 2-2: China's Oil Consumption Mix 2021 (Total: 720 mt or 14.4mbd)



Source: Sinopec

EVs mainly replace gasoline-fueled passenger cars. Efforts are also being made to replace heavy duty vehicles with battery-swaps, but their quantity is still limited. Even if with a 40% EV penetration rate by 2030 as the government aims at, China will have 60 million EVs by then, but accounting only for 16% of the total passenger car fleet, thus barely impacting 3% of the country's total oil consumption. Furthermore, as our earlier reports on Chinese EV market have shown, EV sales growth might not go as fast as expected, given the bottlenecks in development of charging piles and the constraints in global lithium supply.

The second is the accelerated deterioration of geopolitics, especially centered around US and China, the world two largest economies and carbon emitters.

The year of 2022 experienced a much-accelerated deterioration of US-China relations. The Biden Administration has literally elevated its contention and decoupling with China on all fronts, including economic, trade, technology and investment, and continues to provoke China on the Taiwan issue. The impacts on China's economy are significant, both short-term and longer-term. Immediately, the trade between the two countries dropped, especially high-tech products and services; and in a longer run, a drastic reduction of US investment in China and the US technology bans on China are set to wreck a havoc for Chinese economic agenda. In the meanwhile, the US Inflation Reduction Act seems attractive to many Chinese private companies that aspire to invest in the US, thus depriving or draining the investment potential China would otherwise have had.

A recent article by Rhodium Group dismissed the official Chinese FDI statistics, attributing the claimed rise in recent years mainly to the "round trip" money of Chinese speculators pulling in money from overseas to benefit from China's high interest rates and remit the profit back. Quoted from fDF Markets by the Financial Times, the value of newly announced greenfield FDI projects in China started to decline from previous trendlines in 2020, then stabilized in 2021 before falling to its lowest level in almost 20 years in 1H 2022. The recorded 1H total was $6 billion, which is only a fraction of the average $69 billion a year China received during 2015 and 2019.

To make the case worse, the Russia-Ukraine war has caused high inflation in many parts of the world, economic recession and high energy prices in Europe, and drastic decline of consumer purchasing power. Statistics show that, in November 2022, China's total exports dropped 8.7%, total imports dropped 10.6%, and the US orders for Chinese manufactured goods dropped 40%.

Given that the US has been China's largest trade partner, the US containment policies are pushing China towards other non-US alliance countries or regions in Southeast Asia, Central Asia, Middle East, Africa and Latin America, and yet, these regions together don't make up the gap left in China's external trade with the US.

And the third is the shifting domestic macro-economic prospects. Three engines used to drive China's growth: foreign trade, domestic consumption, and infrastructure investment. Given that foreign trade is losing steam, what about the two?

On domestic consumption, three years of Covid-9 have largely depleted the pockets and shrunk the asset size of China's middle-class, making them much more cautious in spending. According to the National Bureau of Statistics, China's consumer confidence index dropped to 86.8 in the most recent survey, a record low since 2009. Stock market selling-offs, declining property transactions, and drop in total retail volumes (-5.9% in November 2022) have clouded consumers' outlook.

This has happened against a backdrop of 600 million Chinese people with a monthly income below RMB 1,000 (US$145), or less than $5 per day in 2020 as pointed out by the Chinese Premier Li Keqiang. Their ability to consume is very limited. Real estate used to play a big role in household spending and local governments' revenues, but not anymore. Many big real-estate companies (such as Evergrande Group) are in heavy debt default; and ordinary people cannot afford expensive house prices in big cities, especially when unemployment among young people is as high as 20%.

Infrastructure investment has been saturated too. China's total highway length today is twice that of the

US, and the total length of Chinese high-speed train railways is 10 times that of Japan. Discouragingly, those investments have not yet generated the expected return. More investment in infrastructure, on one side, would further drain the state's purse and compromise state's capability to improve its people's livelihood, and on the other, could also make the debt situation worse.

Be it domestic consumption or infrastructure investment, local governments used to play a significant role, but this engine is also losing momentum. China's coastal provinces and cities used to have budget surplus to support other less developed inland regions, but they are all trapped in severe deficit this year.

In the first eight months of 2022, China's 31 provinces reported a gap between public revenue and expenditure that totals 6.74 trillion yuan ($948 billion). It's the biggest ever since 2012 for similar period, but only a fraction of the total local governments' debt, estimated now at between US$6-7 trillion.

China's most restrictive "zero-COVID" policy in the last three years and the most recent policy U-turn dealt the country double blows. While the "zero-COVID" policy has caused supply chain disruptions and bankruptcy of millions of small and medium sized companies, leading to many irreversible economic and social damages, the lack of preparedness on the health infrastructure for the abrupt policy shift this early this month is imposing unprecedented pains on an already fragile economy and society.

The government has set a 5.5% target for GDP growth this year, but it will probably deliver a growth around or below 3%. Recognizing the urgency to give a new boost to the national economy, the government issued, on 14th December, the "Strategic Outlines to Expand Domestic Consumption 2022-2035", literally putting "all eggs in one basket", but without being concrete enough to give consumers and investors the required confidence that would turn the doomy tide around.

Our October 24th edition of Insight China states that the priorities of the new CCP leadership are security and stability. Economic growth is an absolute prerequisite, thus it is also the CCP's aspiration to halt the economic downfall and recover China's glorious years of strong growth. But what happened over the last three years has increased enduring fears among market participants. Foreign companies are leaving China due to unwarned and repeated severe supply chain disruptions. Private companies are reluctant to invest due to past crackdowns in the name of "common prosperity". Furthermore, an ageing population is draining the "population dividend" that made China the world's hub of manufacturing.

2.2.3 Assessing oil demand in a VUGA world

The above analysis concurs with Dr. Chen's argument that China's oil demand had already plateaued in 2021, expected to fluctuate around 15.5 mbd in the coming years. Timing wise, this is also broadly in line with the earlier forecasts by China's two largest oil companies – CNPC and Sinopec.

In 2020, CNPC's Economic and Development Research Institute said China's oil demand to peak in 2025, while Sinopec's Economic and Development Research Institute said that China's diesel oil demand has already peaked in 2015 and its gasoline demand will peak in 2025. The development over the past two and half years has significantly advanced the peaking time. For 2022, Chinese oil demand is expected to decrease by around 2%.

In a world torn by poly crises and characterized as vulnerable, uncertain, complex, and ambiguous (VUCA), making prognostics of the macro-economic future always proves risky. But we are afraid that the VUCA uncertainties, amplified by the above-mentioned two traps, will only add pessimism to China's growth prospects, thereby further enhancing our assumption of China's peaking in oil demand.

Will petrochemicals add enough volume to bring the country's total oil demand to a new high? Well, by end 2022, China will have 20 mbd of refinery capacity, and 2 mbd more capacity is expected over the next five years. However, domestic oil consumption will not expand because of new refining capacities which are more geared toward petrochemicals. Given that refineries have to produce certain share of oil products as their output, stagnation in domestic oil product demand will either decrease the average run rate of refineries, closing the inefficient ones on the way, or increase Chinese exports of both oil and petrochemical products. Overcapacity of Chinese refinery merits another in-depth research.

One may refer to the peaking of coal demand, which was believed to have occurred in 2014 but rebounded in recent years without reaching the peak yet, to caution that oil demand may follow the same course. Hellas, we don't so for two simple reasons: coal is largely produced domestically, its demand is mainly driven by fast growing power demand, both will not be the case for oil.

Despite demand peaking, China remains the world's 2nd biggest oil consumer but the largest importer. To meet its existing demand in the backdrop of rapidly depleting production capacity remains a big challenge for oil producers both within and outside China. From the perspective of energy transition, peaking oil is good news, but reducing today's volume and replacing it with alternatives remain a daunting task.

2.3 RCEP: A MUCH-ENLARGED BATTLEFIELD FOR CLEAN ENERGY REVOLUTION

Insight China, January 5, 2022

An important milestone may have gone un-noticed by the energy community outside Asia: the entry into force, on 1st January 2022, of the Regional Comprehensive Economic Partnership or RCEP.

In a world still struggling for economic recovery from the pandemic, with fractured international order and rising trade protectionism, RCEP becomes a beacon of hope and a role model of multilateralism, particularly at a time when the WTO is still in paralysis.

For China, we believe it represents a much-enlarged battlefield for clean energy revolution, in addition to other strategic gains from this world's largest free trade agreement.

2.3.1 What is RCEP?

RCEP is the free trade agreement between 15 countries including 10 member states of ASEAN (Association of South East Asian Nations), China, Japan, Korea, Australia and New Zealand. Together, they represent 2.3 billion people (30.2% of world population), US$28.5 trillion GDP (33.6% of world's total) and US$ 10.7 trillion trade volume (30.3% of global total) in 2020, each of the three indicators (population, GDP and trade volume) bigger than the 11-country CPTPP (Comprehensive and Progressive Trans-Pacific Partnership Agreement), the US-Mexico-Canada free-trade zone or the European common market.

Thus, RCEP is the world's largest free trade zone. Through the bilateral commitment mechanism between member countries, the RCEP also represents the first bilateral trade agreement between China, Japan, and Korea.

RCEP was initiated by ASEAN in 2012 with the objective of unifying trade and investment rules and improving goods and people movement between ASEAN and its six regional partners: China, Japan, Korea, India, Australia and New Zealand. After 8 years of negotiation, all countries except India have reached agreement, which was signed on 15 November 2020 by their trade ministers. India opted to leave in 2019 for fear of its domestic industry losing competitiveness. The agreement requires the ratification by simple majority of ASEAN nations and over half of non-ASEAN countries, and by 2nd November 2021, when the ASEAN Secretariat received the instruments of ratification/acceptance by 6 ASEAN countries (Singapore, Brunei, Thailand, Laos, Cambodia, Vietnam) and 4 non-ASEAN nations (China, Japan, New Zealand and Australia). By RCEP provision, it entered into force 60 days after the requirement was met.

The RCEP requires all 15 member countries to commit to lowering tariffs, opening markets and reducing standard barriers. In terms of tariffs, the agreement provides for a one-to-one approach to the liberalisation of bilateral trade in goods between the 15 countries, with each member country making a schedule of tariff reductions for imports of goods from other member countries for each of the 20 years following the entry into force of the agreement. Some goods (namely coal and oil products) will be subject to zero tariffs immediately after the agreement enters into force, while others will be gradually reduced in the future, and it is expected that the coverage of zero tariff goods in the region will reach 90% within 10 years, i.e. faster than the treaty provision.

In terms of investment, the agreement calls for most-favored-nation treatment, a ban on performance requirements for investing companies, a commitment to non-regression in liberalisation, and the adoption of a negative-list (area not listed is regarded as permitted). The agreement also harmonises the previously uneven rules of origin and facilitates cross-border investment activities by allowing the temporary entry of manpower, a key factor of production.

Barriers to Tear Down:

Two provisions will significantly boost the trade flows between member countries.

First is harmonization of **rules of origin** to qualify for lower tariffs that will reduce transaction costs and ease supply-chain management across the region. RCEP requires only 40% of a product's contents to originate within the bloc to qualify for duty-free treatment, compared with the 50% to 60% floors for the US-Mexico-Canada agreement. This makes it easier for companies to set up supply chains spanning multiple countries, making it much easier to manufacture and sell goods in the region. Firms can build and sell across the region with just one certificate of origin without wasting time in juggling different forms and rules.

The second is dramatically **lowered tariffs**. According to the Japanese government, tariffs will be eliminated on 86% of industrial goods exported from Japan to China, up from 8% currently. That includes the elimination of levies on 87% of auto-parts experts worth nearly $45 billion annually. Some 92% of Japanese industrial products will be exported to South Korea duty free, compared with 19% currently.

Strategic Gains for All:

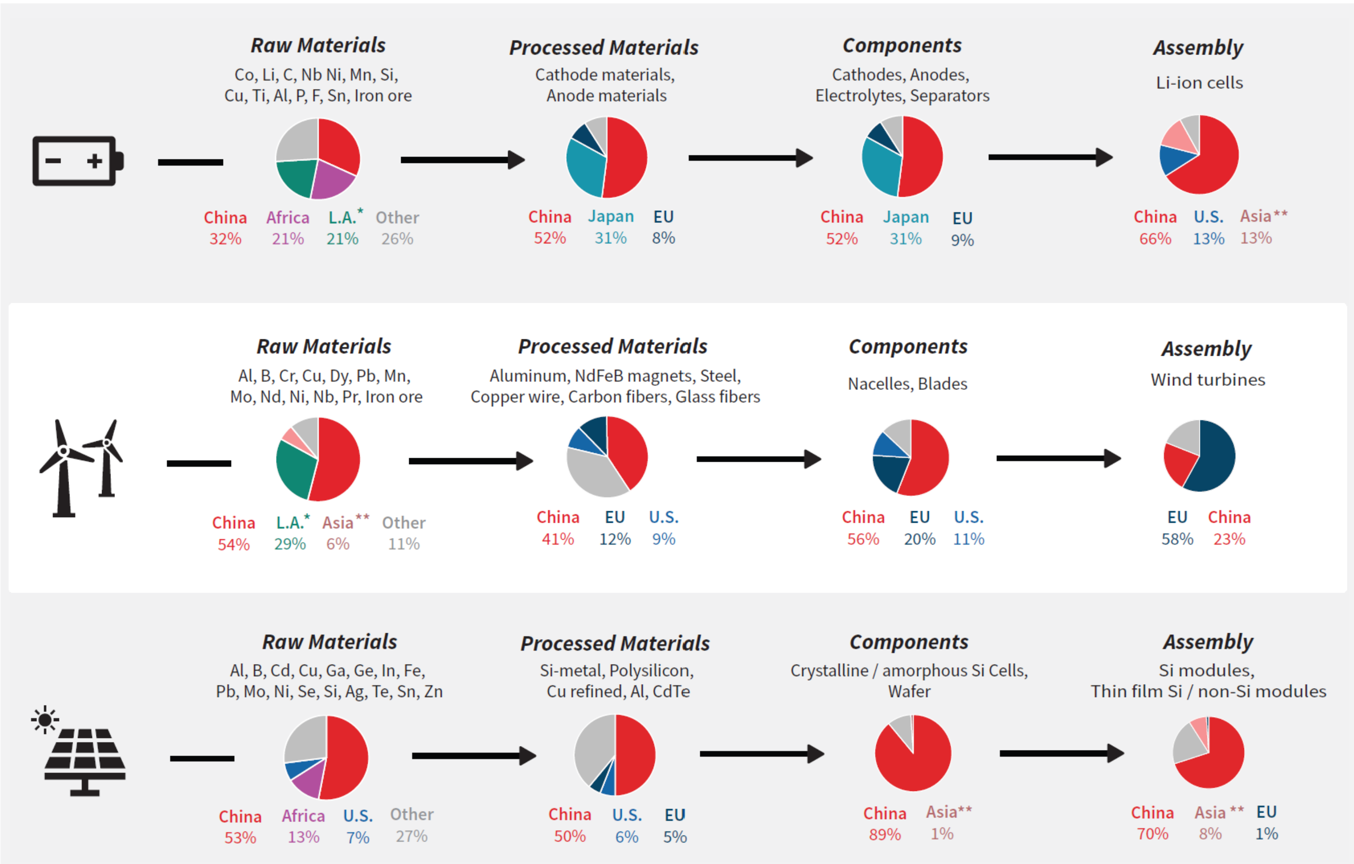
The agreement fulfills ASEAN's original desire to unifies trade and investment rules with its 5 major regional partners, allows Japan, Korea, Australia and New Zealand to have greater access to the Chinese and ASEAN markets.

For China, we believe the RCEP represents a major strategic gain in bolstering its resilience to trade tensions. China could well use the RCEP to counter the US effort to isolate China from global and regional economic networks. It enhances China's regional connectivity and lubricates the flows of finance and investment, goods and materials. Interesting enough, China has also applied for membership in the CPTPP.

2.3.2 A much-enlarged battlefield for clean energy revolution

Another strategic gain for China is the opportunity to optimize the industrial value chain through an expanded "World Factory". Currently, the 15 member nations show industrial complementarity with Japan and South Korea in the upper end of the value chain, Australia and New Zealand as major suppliers of raw materials, China in manufacturing, and ASEAN countries in labor-intensive processing. This will allow companies, including the Chinese clean energy manufacturers to reposition and optimise their industrial capabilities to better meet the demand of the region.

Figure 2-3: China's position in clean energy technology value chains



Source: Jane Nakano, The Geopolitics of Critical Minerals Supply Chain. Centre for Strategic and International Studies, March 2021.

All RCEP nations have committed to carbon neutrality by around mid-century. All will need clean energy technologies and innovations to achieve the carbon neutrality goals, and China dominates the clean energy technology supply chains (Figure 2-3).

With much lower tariffs, originality requirements and growing integration of ESG principles in trade and investment, we believe the RCEP will represent a much-enlarged battlefield for China to extend its clean energy revolution to the free-trade block.

2.4 THE UKRAINE WAR AND IMPLICATIONS FOR CHINA'S ENERGY SECURITY AND TRANSITION

Insight China, March 14, 2022

Although geographically distant from Ukraine, China is not spared from the Russia-launched war. China shares a 4,300-km-long borderline with Russia and China has the biggest portion of its energy (oil, gas, coal, and power) imported from the northern neighbor. Soaring oil and gas prices impact China gravely since it is the world's biggest importer of both oil and gas, let alone the secondary effects of the economic, financial and trade sanctions imposed by the West on Russia – with whom China maintains a "comprehensive strategic partnership".

This Insight China report tries to assess the implications of the war for China's energy security and low carbon transition.

2.4.1 Russia's Role in China's Energy Security

In 2021, China imported 512.98 million tons of oil (or 10.26 million barrels per day) and 145 million tons of gas (78 million tons of which was LNG), accounting respectively three-quarters of China's oil demand and 43% of its natural gas consumption.

Since the start of the war, crude oil price has risen by around $20/bbl, and Asia-Pacific's JKM spot LNG price spike by around $10/mm btu, meaning that imports of these two liquids alone would, theoretically, add US$300 million per day (or US$110 billion per year) to China's energy import bill. What needs to be clarified is that most of China's LNG imports are under long-term contracts, where price fluctuations are not as high as spot prices.

Like the EU, China's energy supply relies heavily on Russia. In 2021, Russia was China's largest source of energy imports (Table 2-1), with the following details.

Table 2-1: Chinese Energy Imports from Russia in 2021

Oil	83.6 million tons	Coal	57 million tons
Gas (pipeline+LNG)	16.8 billion cubic meters	**Electricity**	4 TWh

1. **Oil:** China accounts for 15.4% of Russia's total crude oil exports. China's buying of Russian crude oil averaged 1.59 million barrels per day, or 15.5% of its total imports, only second to Saudi Arabia. Russian oil provides 10% of China's demand. And China received about 40% of this import via the 4,070-km-long East Siberia Pacific Ocean pipeline.
2. **Natural gas:** Russia is China's No. 3 gas supplier, accounting for 10.5% of China's total import and 6.7% of Russian natural gas exports. Russian exports to China totaled 16.8 billion cubic meters (bcm), meeting roughly 5% of China's

demand. The Power of Siberia 1 pipeline has been pumping natural gas from Russia to China since 2019 as part of a 30-year, $400 billion deal, with the Power of Siberia 2 pipeline, or the Soyuz Vostok Pipeline via Mongolia which is still in the design phase, to double the gas exports starting roughly in 2031, adding up to 50 billion cubic meters of Russian natural gas each year to China.

3. **Coal:** China imported an estimated total of 56.7 million tons of coal from Russia, about 17.6% of its total imports of the fuel, only second to Indonesia. Nearly a quarter of Russian coal exports went to China.
4. **Electricity:** Russia is China's largest electricity exporter, reaching 4 TWh. All three Russia-China transmission lines can deliver up to 7 TWh of electrical power per year.

The trade between China and Russia in 2021 bucked the trend by jumping 35% YoY to $147 billion. About 30% of Russian total exports to China is energy, which is the major driver for growth.

It is important to note that the Russia-China energy relationship is very much of a trading nature, and a major part of the trade is through "loan for oil" or "loan for gas" programs, by which China provides a loan to a Russian company, against its future delivery of oil or gas at market prices at the time of delivery. Major portion of the loans was used to build oil and gas pipelines for export to China.

Given European determination to reduce Russian gas imports, a critical question is whether the Russian gas can be divested to China. Well, putting aside the question of political willingness, technical capability does not exist to connect the European dedicated fields to the Chinese market. Oil diversion capability via pipelines will also be limited, given that the ESPO pipeline is already operating in full capacity, and diversion via Kazakhstan needs time to revamp the Russia-Kazakhstan oil pipeline. Any significant diversion will have to be sea-based.

Oil and gas upstream investment by Chinese companies is somewhat limited, involving only three projects: 1) The Yamal LNG project, where CNPC has 20% stake and China's Silkroad Fund has 9.9%, along with Novatek (50.1%) and TotalEnergies (20%); 2) The Udmurtneft oil field in Central Russia where Sinopec has 47% share; and 3) the VCNG gas field in Eastern Siberia, where the Beijing Gas Group has 20% share.

Low level of Chinese participation in Russia's oil and gas upstream businesses is partly due to Russia's unwillingness to open profitable blocks to Chinese companies and partly due to many Chinese national oil and gas companies' lack of capability to navigate through the Moscow complexities.

2.4.2 Energy Transition: the "damning indictment of failed climate leadership", collectively

The drastic and horrific destruction from the war has overtaken everything and become the overwhelming focal topic globally, while climate change continues to intensify.

Energy security imperative is pushing many countries to review and reconsider their energy policy. The EU wants to downsize Russian gas supply by 2/3 by end of the year. Coal is back to the energy mix in many EU countries such as Germany and France, as well as China and US.

This return to coal occurs in the backdrop of record-high GHG emissions in 2021. On March 8, the International Energy Agency (IEA) sent a stark reminder of the likely consequences of further dependence on coal, oil and gas. It reported a global 6% rise of energy-related CO_2 emissions to 36.3 billion tons in 2021, their highest-ever level. The increase of emissions has outweighed the decline seen during the lockdowns of 2020.

Earlier, on February 28, the most recent IPCC report on climate impacts warns that the human-caused climate crisis is driving a "dangerous and widespread disruption in nature" and impacting billions of lives across the globe, emergencies that can only be redressed by immediate and sweeping action that world leaders have thus far failed to take. And the UN Secretary-General Antonio Guterres' immediate comment sent a spinal shiver by calling it "an atlas of human suffering and a damning indictment of failed climate leadership".

2.4.3 Policy Implications for China

Will China follow the EU approach to "reset" its fossil-fuel dependence on Russia? We don't think so. Setting aside the political will, there lacks credible alternatives to the Russian supply in the needed quantity. But two major moves China has already taken will shed lights on a different future.

2.4.3.1 Prioritizing energy security

Well before the war broke out, we have already seen the rewritten China's decarbonization narrative after the nationwide power shortage strike in 2021. This was analyzed in our "Coal-Centered": China recharts its decarbonization course" on 10th January 2022.

More recently, triggered by the energy security concerns over the Ukraine war, the government issued orders to prioritize the security and flexibility of its energy and commodities supply, Specifically, it puts emphasis on: 1) increasing domestic production capacity and output; 2) strengthening strategic reserves; 3) securing supply and stabilizing prices; and 4) safeguarding the energy demand bottom-line of people's livelihoods, while stabilizing imports, prices and expectations and forecasts.

President Xi Jinping was quoted at the recently concluded "Two Annual Sessions" (National People's Congress and CPPCC) in Beijing as saying that "we cannot throw away our means of living first, only to find that our new livelihood has yet to arrive." He has also been popularly quoted in such a saying that describes the importance of energy security, which is to "hold the energy bowl in our own hands".

Coal is definitely "back" to the "mainstay" of China's energy mix short-term. China is adding new coal-fired power plants at an alarming pace. In February, the National Development and Reform Commission approved investments in US$3 billion coal mines as the government seeks to avoid a repeat of the power shortage that dealt a heavy blow to its economy in the autumn 2021. In 2021, China's coal consumption had "reached a new high", amounting to 2.93 billion tons.

2.4.3.2 Adding momentum to invest in clean power system

In 2021, renewable energy including hydro made up 25.5% of China's power mix, up 1.2 percentage points YoY. It's installed renewable energy generation capacity exceeded 1,000 GW.

Consistent with the philosophy of "establishing alternatives first before demolishing the existing coal-fired plants", further acceleration of non-fossil fuel energy development is expected for 2022 and beyond. What has been accomplished so far has become the baseline or launching pad for the next round of clean energy transition as an important strategic move to enhance the country's energy resilience.

For 2022, China is expected to add 180 GW of new power generation capacity from non-fossil fuel sources, driving total non-fossil fuel capacity to 1,300 GW, according to a recent report by the China Electricity Council. That equates to half of the forecast of total installed power generation capacity of 2,600 GW by the end of the year. And this will be the first time ever recorded.

By 2025, the country's 14th Five-Year Plan has set a 18% reduction target for CO_2 intensity and 13.5% energy intensity reduction target. A major goal is to achieve capping coal use, though no bar is set for specific tonnages when capped. And non-fossil energy consumption is to reach a new target of 20%, rising from 15.8% by the end of 2020.

And by 2030, the government has committed to bring total wind and solar capacity to at least 1,200 GW (the officially announced target but proves too conservative) and non-fossil fuel consumption rises to 25%. Recently, the national government has approved two "batches" of projects - the first of 97 GW and the second of 455 GW of renewable energy capacity to be installed, mostly large wind and solar power plants, particularly in desert and barren areas.

2.4.4 An Implication for Europe?

Peace is the prerequisite condition for humanity to work together advancing clean energy transition and fighting climate change. The Russia-Ukraine War has shattered the peace and shaken the needed foundation, with far outreaching consequences on geopolitics, energy, economics, finance, trade and investment, etc.

In the new “iron curtain” falling between Russia and the West, we see a growing sense among nations for self-defense and autonomy, where energy security is back to the top agenda.

As stated in the Versailles Declaration of 11 March, the Ukraine war constitutes a tectonic shift in European history. The EU leaders vowed to defend European security and sovereignty by bolstering defense capabilities, reducing energy dependencies; and building a more robust economic base through reduction of strategic dependencies for critical raw materials, semi-conductors, food, health, and digital infrastructure. And, following the IEA’s ten-point recommendations for Europe to reduce its gas dependency on Russia, EU leaders adopted an eleven-point action plan to deliver the goal of reducing energy dependencies.

Given the tight global LNG market, diversifying European gas supply away from Russia but more towards LNG supply from the Middle East and the US will drive further up the LNG prices. But we believe that other viable options do exist for Europe to reduce simultaneously both external energy dependency and carbon emission. The core is to advance the European Green Deal, by enabling and empowering each individual and every home, company, and community to embrace clean energy solutions. In that landscape, China’s advanced manufacturing capabilities in solar, wind and battery become a natural fit for the purpose.

And very importantly, we foresee from the Ukraine war, the emergence and convergence of a much stronger EU-China cooperation in advancing the shared green and secured energy transition.

2.5 US-CHINA SUSPENSION ON CLIMATE COOPERATION: RESTORING TRUST IN A TRUST-DEFICIT WORLD

Insight China, September 3, 2022

This past week, from 28 August to 1st September, thousands of energy industry leaders met in Stavanger for the biennial ONS Conference and Exhibition, under the theme of “TRUST”.

One of the biggest debates was centered around how to pursue cooperation in an era of trust deficit when climate security threatens humanity’s survival and future. From political leaders and royalties - Norwegian Crown Prince and Prime Minister, Ukrainian President Zelensky (online), Belgium Prime Minister, to energy industry professionals and leaders - Elon Musk, IEA Executive Director, energy company CEOs, all believe trust is essential to advance bilateral cooperation, government-academia-industry cross-fertilization, and multilateral welfare governance.

CN Innovation CEO, Xavier Chen, shared the podium with a top US energy expert, at the opening day on "Co-existence in the Energy Market". Naturally, the US-China trust crisis in climate cooperation was brought up, and Xavier Chen used the ancient Chinese story of "Axe Thief" to metaphorically describe the US-China saga.

"A famer could not find his axe and suspected that his neighbor's son had stolen it. He watched him far and close. Every move and everything the young boy did reflected exactly how an axe thief would have behaved. But when he finally found the axe he had forgotten in his own backyard, he looked at the young boy again. Now nothing he did reminded the farmer of an axe thief any longer."

This Insight China report explores the issue further and discusses climate cooperation in a world of trust deficit.

2.5.1 The Distrust:

In a retaliative response to the US House Speaker Nancy Pelosi's recent visit to Taiwan, Chinese government announced on August 5, 2022, a comprehensive suspension of cooperation with the US, and the last item on the list of eight is climate change. This was followed by both sides pointing fingers to each other, causing wider worries of tic-for-tac escalations of tensions.

It proves demoralizing and devastating when the world's two largest economies and emitters turn against each other, at a time of intensifying climate crisis that harms and threatens lives, health and livelihoods of billions of people well beyond the US and China. A major reckoning is that a country's foreign policy to the other defines and underscores bilateral climate cooperation. As we have learned so far, "champion" the latter without a trustful and cooperative foreign policy as its foundation proves more lip services than deeds.

2.5.2 Foreign policy vs climate cooperation

We argue strongly that bilateral climate cooperation does not exist in vacuum, nor can it survive in an "oasis surrounded by encroaching deserts". Rather, it is nurtured and underscored by a country's foreign policy to the other, guided by the political vision of global governance.

The contrast evidence is reflected by:

- The "US-China Joint Announcement on Climate Change", Beijing, November 12, 2014: after years of absence from international climate process, the Obama administration made a strategic decision to announce the US intended nationally determined contribution (INDC) to the Paris Agreement, jointly with China.
- And the "US-China Joint Glasgow Declaration on Enhancing Climate Action in the 2020s", November 10, 2021, that "unified" a narrative leading up to COP26.

President Obama has said, "The relationship between the US and China is the most important bilateral relationship of the 21st century." This strategic vision, which echoed the Chinese one, had set the foundation for a US China policy that proved constructive and productive. It is a mutually shared vision.

Back then, Biden served as Obama's Vice President, so he is an "insider". But he has abandoned that legacy, instead, he has carried on a confrontational China policy of his rival predecessor – President Trump who framed China as the biggest national security threat and strategic rivalry – the ideal "axe thief" if you like, and his administration has executed a "systematically-designed" communication strategy to incriminate and demonize China. What has been unfolding is escalating contentions on all fronts – technology, trade, market, investment and supply chain disruptions, and accelerated decoupling which debilitates any substantial climate cooperation.

The two countries after Biden took office ramped up communication on climate change, after a few years' status of being a backburner. But it has been "downgraded" to climate envoy level and limited to talks and "continued discussions."

A closer look at the joint agreements also exposes the differentiation in terms of what's included and how bilateral cooperation is stated. The 2014 announcement positively recognizes that "the US and China are two of the world's largest investors in clean energy and already have a robust program of energy technology cooperation", which will be further elevated and enhanced, ranging from US-China Climate Change Working Group, US-China Clean Energy Research Center to Launching a climate-smart/low-carbon cities initiatives. Pretty much all possible clean energy technologies are covered in bilateral cooperation.

By contrast, the 2021 declaration falls short on substance and commitment in most cases and tipping around wording carefully. "Intend to cooperate" sets the tone and level of commitment to cooperation. While we read a laundry list of energy policy, sector focus and some technical solutions, it emphasizes "respective accelerated actions" and cooperation in multilateral processes, including UNFCCC.

The "golden era" of Obama and Hu Jintao set the stage for the successful outcome of the Paris Agreement at COP21. We also admit that the Glasgow declaration at least reduced the risk of collapsing of COP26. But the best era has gone. And this raises the question of what lies ahead?

2.5.3 Alignment vs decoupling

We celebrate the first US climate legislation coming into effect. On one side, we feel inspired to see more shared common ground by the two countries in driving acceleration of clean energy transition and decarbonization from the perspectives of policy, technology, infrastructure, and industry. And on the other, we are deeply concerned with the pace and scope of decoupling between the two economies.

The US progresses in legislation in 2021, represented by the Infrastructure Act, the CHIPs and Science Act, and most recently the Inflation Reduction Act, have demonstrated some far-reaching shift in policy. When decarbonization is concerned, we have observed the US adopting a new way of managing the economy towards unprecedented alignment with the one that China has been practising in the last decade, such as:

- Role of government: The legislations represent the era of passive, hands-off government is over, and to revolve climate change relies heavily on government to push and pull in order to achieve deployment and accelerate market scaling.
- Necessity of industrial policy: An important role of government is put an effective industrial policy in place by applying a wide array of tools and tactics to help domestic industries take off, grow, and reach commercial scale.
- And tools of industrial policy: A toolbox of different approaches that act in concert will help push technologies to grow and reach commercial scale, including demonstration project, supply-push policies, demand-pull policies, and protective policies.

China continues to improve its industrial policy of a clean energy revolution. The Insight China reports since last Fall have done a series of analysis of China's integrated policy planning, targets and incentives to achieve carbon neutrality, ranging from clean power system transformation, clean and smart mobility and acceleration of renewable energy deployment to emerging strategic industries and green finance.

It's no surprise that Washington's consuming anxiety over China's rise has played a major catalytic role to inspire and progress policy making. While competition is given, our concerns reside in how the US has been aggressively pursuing its decoupling with China and what repercussions it will have for global welfares, the most important of which is climate security.

What's frustrating is that US and China are literally stuck in four types of war – trade/economic war, technology war, financial/capital war, and geopolitical war, which are all spiraling up. And Biden's "strategic ambiguity" towards China has created more harm than benefit if any at all.

2.5.4 Restoring Trust amidst high-level conflict Index

According to Ray Dalio, founder of Bridgewater Associates and regular writer of "The Changing World Order" commentaries, the conflict index between the two countries has now reached a dangerously high level of 1.2, higher than the Cuba missile crisis in the 1960s and close to the UK-Germany index of 1.3 before WWI.

How to break the dangerous deadlock? We believe that the two superpowers stand more on common ground of co-existence and co-benefits. Climate change is, arguably, the global challenge that holds both the US and China undeniably accountable. They require both to cooperate for the welfare of the entire humanity. If they fail and won't even talk to each other, the world shall be devasted in the prospect of freefall of the global welfare governance, well beyond climate change.

Undeniably, we are deeply concerned that the lack of trust will lead the US and China to trip over the edge of the cliff and fall into the infamous "Thucydides Trap", when an incumbent power and an emerging power fall into a vicious cycle of rivalry. The tension continues to heighten even today when the US announced $1.1 billion arms sale to Taiwan to boost its air defense.

The dawn on the horizon is the proposed two heads of states meeting this Fall when Biden and Xi could sit down to restore a minimum level of trust through an "ice-breaking" face-to-face conversation at the G20 Summit in Indonesia. Fingers crossed.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3

TECHNOLOGY AND INNOVATION ROADMAPS

3.1 ENERGY TECHNOLOGY: WHERE AND WHAT DOES CHINA WANT TO INNOVATE?

Insight China, April 18, 2022

China's technological strengths in clean energy transition are proven in the last decade. From renewables to energy storage, China has built and demonstrated its leadership in manufacturing and applications of new technologies, while contributing to drive down their costs and accelerate scaling of their deployment, both domestically and globally. Such capability is also reflected in fossil-based power generation where technology innovation plays a key role in reducing emissions and capturing efficiency gains, enabled by digitalization, and driven by most restrictive regulations and standards.

Given the above, the direction China wants to steer its energy technology innovation will not only matter for China to achieve its carbon neutrality goals, but also have much larger global impacts.

This report presents the Chinese priorities in energy technology innovation, on the basis of the 14th FYP for Energy Technology Innovation (the Plan), jointly released by the NEA (National Energy Administration) and the MOST (Ministry of Science and Technology) on the 2nd April 2022.

3.1.1 The Technology Shortboards

Does China have shortfalls in energy technology innovation? Absolutely, and plenty. The Plan has identified the following three major gaps that need to be bridged:

1. Heavy dependency on imports in key technology equipment, as well as some critical components, specialized software, and important base materials;
2. Lack of clear competitive advantage in originality, game-changing and forward-looking technologies even in those Chinese advantaged industries such as solar, wind and batteries; and,
3. "Loose and weak" innovation ecosystem among industry, academia, and research circles where policies and mechanisms fall well behind the need to achieve major technology breakthroughs, to turn the R&D results into market-ready products, and to "tolerate" failures in R&D process.

The Plan sets out detailed strategy and actions of how the world's largest manufacturer will address those clearly identified shortfalls.

3.1.2 The Strategic Goals:

The Plan has laid out the country's strategic focuses to further innovate technologies that will **"overcome the country's current shortboards, consolidate its longboards, achieve real impact via concrete projects and form synergies for collaborative innovation"**.

The objective is fixated on achieving major breakthroughs in key technology equipment and shaping up obvious advantages in a batch of specific energy technologies that are rising quickly and with continued emergence of new businesses and new models. In the meantime, the energy technology innovation ecosphere is further strengthened, and technology innovation strongly supports and guides energy industry's high-quality growth.

The strategy is clustered around five priorities: continue innovation in renewables, re-construction of the power system, safe and efficient nuclear power, clean and efficient use of fossil fuels, and accelerated digitalization.

3.1.3 Five Task Clusters for Innovation:

Accordingly, the Plan has laid out five task clusters for innovation:

1. **Advanced renewable power generation and comprehensive utilization,** which lists 17 key tasks. It stresses the focus on large scale and high penetration of renewables, and also on "higher efficiency, lower cost and more reliable" renewables including hydro, wind, solar, biomass, geothermal, ocean energies. Hydrogen is included in this cluster.

2. **New power system and its supportive technologies**, which puts 12 key tasks on the list. The focus is on grid connection technologies for both large-scale renewables and distributed renewables, as well as smart and generation-grid-load interactive grids. Energy storage technologies are included here too.

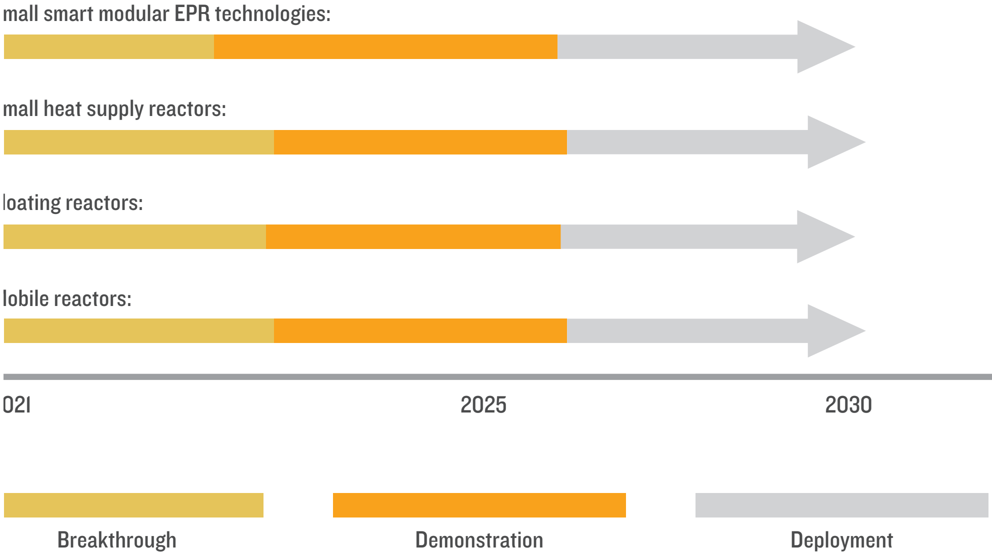
3. **Safe and highly efficient nuclear power technologies**, which covers 11 key tasks to improve the competitiveness of currently applicable technologies, optimize the 3rd generation technologies through standardization, and strengthen innovation in strategic technologies including small modular reactors (SMR), (Super) High Temperature Gas Cooled Reactors, and Molten salt reactors.

4. **Fossil fuel "greening" technologies**, which specifies 37 proposed key tasks, covering conventional and unconventional oil and gas exploration, transport, refining and distribution; clean and efficient utilization of coal including CCUS, and development of gas turbine technologies.

5. **Digitalization technologies**, which contains 16 proposed key tasks, covering common technologies in broad and deep application of digital technologies in traditional coal, oil and gas, power plants and grids that define a new phase of integrated development of "energy and IoT".

For each task of the above clusters, a roadmap is drawn with details on when to achieve those defined breakthroughs, to demonstrate their applications and to deploy the proven solutions, as well as overall expectations during the 2021-2025 period. Table 3-1 provides one of the 95 roadmaps using small modular reactors as an illustrative example.

Table 3-1: Example of Technology Innovation Roadmap: small modular nuclear reactors



Expected deliveries:

2023: achieve breakthrough in key heat supply reactors including new heat exchangers drivers for control rods

2025: complete all technical and safety standards for SMR and related systems

3.1.4 Eight Ecosystem-Building Measures:

To enable innovation in all above clusters, the Plan has listed the following eight ecosystem-building measures:

1. **Collaborative innovation**: all government agencies involved are called upon to work together with clear division of work. To deliver a clearly defined objective, a leading entity is selected through a competitive bidding process, all other entities are then mobilised to make their respective contributions.
2. **Innovation platforms:** a national R&D ecosystem is called for with national key laboratories, national engineering centers, national energy R&D innovation platforms, and all relevant innovation centres hosted by major corporations.
3. **Demonstrative applications**: demo projects or zones will be set up on the basis of clearly identified key tasks, and particular attention will be given to the "first" application of any innovative technology, embraced by stronger tolerance for possible failures.
4. **Corporations' role:** Companies are called upon to be the main entity for innovation, with state-owned energy corporations as the leader in filling in the shortboard gaps and in original innovation, with close collaboration with private companies. In some highly specialized areas, private companies are allowed to take the leadership role in state-assigned tasks.
5. **Technological standards**: new standards are called for to facilitate the industrialization and market deployment of new innovative technologies, so is international harmonization of those standards.
6. **Funding support**: all the key tasks listed in the Plan will be eligible for state-allocated funding, and all relevant entities are called for to contribute their part in addition to the public funding.

7. **International collaboration:** companies, universities and research institutions become lead entities to develop internationally collaborative projects with overseas partners.

8. **Talent incubation**: universities are encouraged to provide the needed talents for energy innovation; people are encouraged to move between research entities and companies; and incentives are called for to reward innovators based on their achievements.

3.1.5 Gaps and Challenges:

Although impressive as it can be in its ambitions and substances, the Plan focuses excessively on the supply side, with no or little attention to demand-side energy efficiency, which is an important part of the energy system. The EU's Strategic Energy Technology Plan, as a reference, attaches great importance to energy efficiency, whereas the Chinese one is very much supply-side-driven.

The second shortcoming of the Plan is its neglect of emerging threats to the energy system, particularly the vulnerabilities induced by climate change and cybersecurity attacks. Resilience of the energy system is very much a hot topic, highlighted by a number of international organisations' studies, such as the IEA's "Power Systems in Transition – challenges and opportunities for electricity security". This issue is somehow absent in the Plan.

And, the third mismatch, which is very critical to innovation, is that the Plan calls for state-owned companies to play the dominating role in energy technology innovation, whereas history has shown how slow moving these state-owned giants could be in innovation. The fact is that most of China's renewable energy innovations are led by private companies so far. If China continues to count on a centralized system with high expectations on state-owned giants to lead innovation, instead of effectively mobilizing the whole society's innovative capabilities and potential, the ultimate consequence will see how the ambitious plan be compromised by this kind of state-dominated mentality for innovation.

3.2 CUTTING-EDGE DISRUPTIVE LOW-CARBON TECHNOLOGIES: WHAT TO EXPECT FROM CHINA?

Insight China, September 12, 2022

In our Insight report of April 18, 2022, we shared where, what, and how China wants to innovate its energy technologies, clustered around five innovation priorities and eight innovation eco-systems.

Now we would like to narrow the scope down to low carbon technologies and seek to answer the title question based on a recently published blueprint - the "Science and Technology Action Plan (2022-2030) for Achieving Carbon Peaking and Carbon Neutrality" (The Action Plan). It was jointly released on 18th August by the Ministry of Science and Technology and eight other relevant ministries.

3.2.1 Objectives

With the belief that science and technology is the "1st motive power" to achieve carbon neutrality, the Action Plan sets the following time-bound objectives that will lay the foundation and define the pathway to achieve carbon neutrality before 2060:

- By 2025, achieve major breakthroughs in key industries and core technological areas, to support the 14th FYP targets of reducing carbon intensity of GDP by 18% and energy intensity by 13.5%.

- By 2030, achieve breakthroughs in some cutting-edge disruptive technologies, shape up a series of highly impactful low carbon technological solutions and deliver 50 demonstration projects with different technologies, to support the country's NDC target of 65% carbon intensity reduction below 2005 level under the Paris Agreement.

3.2.2 Action areas

The Action Plan listed the following 11 areas[2]:

1. **Green and low carbon energy technologies:** 50 categories of technologies are listed, covering clean coal conversion and utilization, renewable power generation, nuclear power, smart grid, energy storage, non-power renewables utilization, hydrogen and energy saving.
2. **Industrial process reengineering**: 30 categories of technologies are identified covering low or zero carbon (LZC) steel, LZC cement, LZC chemicals, LZC non-ferrous, and resource recycling and heavy-machinery reengineering. Integration of digital technologies (big data, AI and 5G) is considered an important element in process reengineering.
3. **Buildings**: 13 categories of technologies are identified, covering direct current (DC) solar energy and storage power distribution, highly efficient electrification of building energy uses, heat and power synergies, and innovative low carbon building materials.
4. **Transport**: 7 categories of technologies are identified, covering new energy driven transport equipment and green transportation system.
5. **Negative carbon and non-CO_2 GHG reduction**: 24 categories of technologies are identified, covering CCUS, ecological carbon sinks (both green and blue), methane, NOx, and carbon sink accounting and monitoring.
6. **Cutting-edge disruptive technologies**: 7 categories. See below in a separate section.
7. **Demonstrative projects:** build 50 demonstrative projects in the 5 areas listed above. In addition, build integrated solution demonstrations in industrial parks, cities, social districts, agricultural zones, etc.; and based on those demos, develop technical standards for LZC technologies and their applications.
8. **Carbon neutrality decision-supporting system**: 5 soft-technology categories are listed, including technology roadmaps, carbon emission MRV, Scope I, II and III standards and accounting, digitally enabled decision-support system, and technology evaluation system.
9. **Innovation eco-system:** create synergies between innovative projects, innovation centers/clusters and the required talents, with public funds geared towards major projects, which will be awarded through bidding by leading scientists.
10. **Company support**: support start-up companies with incubation platforms, label companies with "low-carbon", "zero-carbon" or "negative-carbon" categories to direct social funding to those companies, organize technology competitions, and provide IP support, etc.
11. And **international cooperation**: strengthen cooperation with existing international organizations, explore the possibilities of joint technology R&D centers and cross-country technology transfer agencies with interested countries and parties, and convene international fora around LZC carbon technologies and innovations.

2 Building and transport were grouped together as one sector in the Action Plan, but we choose to separate them in the list due to their respective significance.

3.2.3 Cutting-edge disruptive technologies

What are the cutting-edge disruptive low carbon technologies in which China plans to achieve breakthroughs?

Well, the Action Plan contains a text box that provides the insight, which we literally translate into English as shown in the text box below.

BOX 1

Cutting-edge Disruptive Low Carbon Technologies

1. **New high-efficiency photovoltaic cell technologies**. Research on new photovoltaic conversion technologies that can break the theoretical efficiency limit of single-junction photovoltaic cells, including cell technologies based on new materials and structures such as high-efficiency thin-film cells and laminated cells.
2. **New nuclear power generation technologies**. Research on new nuclear power generation technologies such as the 4th generation reactors and nuclear fusion reactors.
3. **New green hydrogen energy technologies**. Research on green hydrogen production technologies based on biosynthesis and direct solar-driven hydrogen production.
4. **Frontier energy storage technologies.** Research on solid-state lithium-ion and sodium-ion batteries, etc., which are more cost-effective and safer, with longer life and more energy efficient, and not constrained by resources.
5. **Multifunctional and efficient power conversion technologies.** Research on new ways of converting electricity into heat, light or synthetic fuel and chemicals, with the purpose of more efficiently converting and storing renewable electricity, as well as diversifying its uses.
6. **High-value CO2 conversion and utilization technologies**. Research on bio-engineering CO2 conversion system based on light-enzyme and electro-enzyme synergy, bacteria/enzyme and inorganic/organic materials, to produce products such as starch, lactic acid and ethylene glycol. Research on the use of water, CO2 and nitrogen as raw materials to directly and efficiently produce green and renewable fuels such as methanol.
7. **Direct Air Capture (DAC) technologies**. Research and development of high-efficiency and low-cost direct airborne carbon dioxide capture technologies.

3.2.4 What does it imply for China and the world?

The details of the list above offer important clues to where specific technologies could reside. And we ourselves have been following quite a few game-changers.

The Action Plan further strengthens our belief that China is not only the world's biggest carbon emitter but also one of the biggest innovators in the decarbonization space, and not only provides the world with cheaper and high-quality renewables equipment but also plays a major part of future low carbon solutions.

If China were to reach the stated goal of achieving the series of technology breakthroughs and building the 50 high-impact demo projects by 2030, the country will be destined to redefine how it will deliver its 2060 carbon neutrality target, and the spill-over of these achievements will also make irrelevant many of the solutions currently adopted in other parts of the world.

However, we also see this bright prospect overshadowed by many challenges ahead. The biggest is its lack of venture-capital culture that can bring innovations from ideas to market deployment. The deteriorating macro-environment and diminishing availability of private capital will, unfortunately, dramatically shrink our expectations.

And this might be where some major opportunities gather. One is to connect funding value chain for technology innovation between China and the West, as the Chinese funds prefer market-ready technologies and western funds are more experienced in incubating start-up innovators.

The potential of linking technology markets remains significant. China offers the biggest demand market for western ready-to-market technologies which Chinese funds are willing to finance whereas western funds could find a way to identify and finance some of the real game-changing Chinese start-ups. Besides, China does provide a big talent pool where innovation is concerned.

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4

GREEN DEVELOPMENT BLUEPRINTS

4.1 SCALING GREEN FINANCE: CHINA SHAPES UP ITS OWN TAXONOMY

Insight China, February 10, 2022

On 2 February 2022, the EU Commission said it included natural gas (under some conditions) and nuclear power in its "Taxonomy Complementary Climate Delegated Act". Although the proposed Act still awaits the approval of both the European Parliament and the Council before it becomes effective, the inclusion of these two fuels was hailed by Chinese energy and climate professionals as a positive sign of EU returning to rationality and pragmatism.

What does the Chinese green taxonomy cover? What role does it play in shaping China's financial flows, and what challenges lie ahead for China to effectively use the taxonomy as a policy tool to achieve its "duo" carbon peaking and carbon neutrality goals? This report investigates these critical questions.

4.1.1 Defining China's Green Taxonomy:

Green taxonomy plays a crucial role in scaling up sustainable investment that is most needed for low carbon transition. EU, of course, leads the definition and advancement of green taxonomy. With specifications of regulation, policy framework, technical standards, and institutions and governance, EU taxonomy represents an architecture or a system that "pushes and pulls" the flow of financial capital to deliver the goals and targets set in the EU Green Deal, while enforcing clarity and transparency to prevent "greenwash".

As shown in the EU case, green taxonomy not only provides companies, investors, and policymakers with appropriate definitions for which economic activities can be considered environmentally sustainable, but also creates security for investors while helping companies to become more climate-friendly, mitigate market fragmentation and shift investments where they are most needed.

Learning from the EU practice. China's taxonomy is being deployed as an important instrument to meet the country's ambition to decarbonize its energy and economy and achieve harmony with nature. The **2021 China Green Bond Endorsed Project Catalogue (the Catalogue)** is the first joint endeavor by the People's Bank of China (PBoC), the National Development and Reform Commission (NDRC) and the China Securities Regulatory Commission (CSRC) - the three key regulation authorities - to define a taxonomy and provide uniform regulation for China's green bond market.

Published on 21 April 2021, The Catalogue classifies projects into the following six key areas, each includes a few specific sectors with a detailed description of programs:

1. energy conservation, pollution prevention and control, resource conservation and recycling;
2. clean production, including green agriculture;
3. clean energy, which includes all kinds of renewables, but also nuclear, natural gas, hydrogen, energy storage, and CCUS;
4. ecological protection and restoration;
5. sustainable infrastructure;
6. green services, including carbon trading.

In addition, some rapid growth activities in recent years are also added to the list, including green agriculture, sustainable buildings, unconventional water resources utilization, among others. And very important to note is that "clean coal" (e.g. ultra-super-critical coal-fired power) is removed from the Catalogue. Though specifically serving the purpose of green bonds issuance, the Catalogue offers some perspective of policy priorities in China and also insight of a target-based approach to taxonomy.

4.1.2 Unleashing Capital Flow to Scale:

Increasing clarity of definition of taxonomy helps scaling finance and investment at unprecedented pace. And, the year of 2021 has witnessed some landmark progress in China's endeavor to green its finance. A few milestones are highlighted here:

- The PBoC issued the country's first $13.4 billion batch of low-cost loans to financial institutions to promote green projects and corporate efforts to cut carbon emissions, through its first carbon emission reduction facility, focusing on clean energy, energy conservation and environmental protection, and carbon reduction technologies.
- The issuance of Chinese green bonds reached a new high in 2021, surpassing its previous record of $56.18 billion in 2019.
- China sees four-fold surge in issuance of ESG wealth management products in 2021, compared to 2020.
- Chinese banks have issued more than $1.7 trillion of green credit by the end of 2020.
- China Construction Bank helped finance the government-backed National Green Development Fund, which launched in 2020 having raised $12.6 billion for environmental protection in 11 provinces and cities along the Yangtze River.
- China officially kicked off on-line national carbon trading on July 16, when spot carbon credit trading could cover a market of 4 billion tons of CO_2 emissions every year, and other industrial sectors are scheduled to come on board in 2022-2023, such as steel, petrochemicals and chemicals, non-ferrous metals, building materials and financial institutions, This market-based instrument is expected to contribute and scale the country's carbon financing.
- From regulatory perspective, big progress was made towards mandatory environmental information disclosure, first for publicly listed companies and companies that issue green bonds in 2022, and then for all companies by 2025.

4.1.3 Reforming Financial System and Accountability to Fit for Purpose:

Today, finance, both public and private, is mandated, at least "on paper", to take on a mission to effectively support and enable the delivery of high-quality growth. But two major barriers stand in the way that shall be cleared the soonest possible. One is the "disconnects" in a financial system that has been called upon for a high order of transition; and the other is "credibility", or inadequacy of it, that could jeopardize the accountability of the taxonomy and sacrifice the potential to mobilize capital flows to scale.

Three in-depth reforms are urgently needed for the financial sector in the transition:

1. Connecting the dots and integrating monetary policy, oversight, mandated disclosure, rating, sector self-discipline, and product innovation to regulate and guide the financial capital flows towards green growth goals;
2. Enhancing the financial system's climate resilience and capability to manage climate and environmental risks; and,
3. Contributing to pricing carbon through carbon trading, carbon futures and other financial products.

Transparency and accountability are crucial to reduce risks of and strengthen returns on investment and finance. While China is moving aggressively on disclosure, huge gaps remain. For instance, 1) standards, still progressing, fall short of demand to effectively integrate carbon neutrality and nature-positive targets into sustainable finance in alignment with its taxonomy; and 2) capability of financial institutions and companies lag, both strategically and from the perspective of expertise and talents.

4.1.4 Bridging the Gaps:

To deliver the goals and targets of green transition requires a strong taxonomy architecture deployed, that mobilizes the maximum financial capital flows from all possible sources needed, both domestically and globally, while embedding net-zero carbon and harmony with nature into every policy and investment decision.

The estimated finance demands, at upper end, are all at the level of trillion dollars every year. One estimate indicates, over the period 2014-2030, between $320 billion to $1 trillion per year would be needed to address climate and environmental challenges in China. To bridge the remaining gaps, domestically, China shall continue to gear up efforts to align three fundamental elements of the taxonomy:

- Clarity and certainty of time-bound policy targets, literally, the prerequisite that defines the ecological redlines;
- Policy incentives that push and pull investments aligned with the set and endorsed targets; and,
- Transparency, enabled by good governance, to assure accountability.

Against a backdrop of tremendous geopolitical complexity and uncertainty, China has to further strengthen its steps for transparency and accountability in order to "play the game" in a level playing field, at least with EU and some other nations. The purpose is clear and focused – to leverage or better position itself to attract global financial resources and capital flows towards its ambitious goals of transition.

4.2 GREENING ENERGY: CHINA VOWS TO BUILD MODERN SYSTEMS BY IMPROVING MECHANISMS

Insight China, February 19, 2022

As part of the "1+N" policy framework to achieve the 2030/2060 duo carbon goals, and in junction with the 14th Five-Year planning, China has published a number of policy documents, each focusing on green and low carbon development of one particular sector, such as energy, industry, building, transport, urban and rural areas, and consumption, respectively. Our Insight China brings to you a serial of reports that analyze those plans one by one, in-depth.

This report covers the "Opinion on Improving Bodies and Mechanisms and Policy Measures Related to Green and Low Carbon Transition of the Energy Sector" (the Opinion), which was jointly released by the National Development and Reform Commission (NDRC) and the National Energy Administration (NEA) on February 10. It is an illustration of how Beijing's policy mastermind intends to reshape China's energy landscape via a clean, green, and smart energy revolution.

4.2.1 Mechanisms

The title of the "Opinion" contains a term called "Tizhi Jizhi" (体制机制). It is one the most repeated keywords in many Chinese official documents, which proves not easy to capture its essence, even for some old "China hands". Literally translated, it means "body and mechanism".

From the policymakers' perspective, for anything to work, you need two core elements in place. One is the "body", or an organizational setting or architecture, which is called "Tizhi" (体制). It is often set and given. The other is the mechanisms that define the interaction/coordination among different parts of the "body" or

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organization, which is referred to as "Jizhi" (机 制). Therefore, "body and mechanism", together, refer to "the organizational setting or architecture of an industry and the way different components of the organization interact with each other". They determine the operational efficiency and efficacy of an industry in achieving the set targets. They also roughly echo the western term of institutions and governance in the Chinese social and political settings.

4.2.2 Systems

Another term frequently appearing in Chinese official documents is system(s), or "Tixi" (体 系) in Chinese, which appeared 40 times in the Opinion. The word itself is often used in two typical "scenarios". One is the cases where a desirable outcome is referred to, such as building a new, reliable, and sustainable power system, the term here sits in its traditional meaning of "system" with all its components in it.

And the other lies where policy and measures are concerned, the term is more correctly referring to "an integrated set" of tools and instruments. For the policymakers, no single tool or policy will be sufficiently powerful to steer the change or transition. All changes often require an integrated and coherent set of policies and measures which, once "fit" into the right mechanisms, will drive the needed shift.

Table 4-1 shows some of the key mechanisms and systems to improve or to build anew in order to steer the grand transition of China's energy sector, as stated in the Opinion.

Table 4-1: Mechanisms and Systems Proposed for Improvements for China's Green Energy Transition

Mechanisms to improve or build anew	1. Mechanism to collaboratively promote the implementation of national energy strategies and plans; 2. Mechanism to monitor and appraise green and low carbon energy transition; 3. Mechanism for inter-agency coordination on green and low carbon energy transition; 4. Mechanism to promote green energy consumption; 5. Mechanism for clean and low carbon energy resource survey and information sharing; 6. Mechanism to innovatively develop and use rural renewable energies; 7. Mechanism to manage land and space required for renewable energy development; 8. Mechanism for the construction and operation of new type of power system; 9. Market mechanism suitable for the new type of power system; 10. Mechanism for demand side response in power sector; 11. Mechanism for district comprehensive energy services; 12. Mechanism for clean and efficient development and utilization of fossil fuels; 13. Mechanism for energy forecast and energy emergency alert; 14. Mechanism for collaborative innovation along the clean energy value chain; 15. Mechanism of fiscal and financial support for green energy transition; 16. Mechanism to support diversified investment into green energy transition; 17. Mechanism for international collaboration on green energy transition; 18. Mechanism for governance relative to green energy transition.
Systems to improve or build anew	1. An energy supply **system** with clean and low carbon energy as the main source; 2. A power grid **system** suitable both for deep local utilization and for long distance transmission of renewable energies; 3. A fail-safe energy supply **system** during energy transition; 4. A secure and resilient power operation **system**; 5. An energy supply security and emergency response **system**; 6. A technological innovation **system** to support green and low carbon energy transition; 7. A **system** for collaborative innovation on major low carbon energy technologies; 8. An open, fair, and effectively competitive energy market **system**; 9. An energy law and standardization **system**.

4.2.3 Policies

The Opinion also includes a number of policies, including:

- Policies to support green energy consumption in industrial sector;
- Policies to support green energy consumption in buildings, clean heating in particular;
- Policies for clean energy substitution in transport;
- Policies for clean development and utilization of coal;
- Policies for clean and efficiency transition of coal-fired power; and,
- Policies of financial support for clean and low carbon energy transition.

4.2.4 Challenges

Similar to most of the central government's policy papers, this green energy transition blueprint remains highly indicative and directional. It expresses the NDRC/NEA's desire to build a mandated new, green, and low carbon energy system, through improved mechanisms, but lacks concreteness in the proposed mechanisms or policies. This will challenge the deployment and implementation at lower level of state hierarchy, nationwide.

As demonstrated in the Opinion, the NDRC/NEA strongly feel the inadequacy and "outdatedness" of existing energy governance for the highly expected green and low carbon transformation. But, given that they are "powerless" in changing the organizational setting, they can only aspire to reform the "mechanisms" that hold all the parts of the sector together. – the term "mechanism" is mentioned 66 times in the 9-page Opinion paper.

And yet, if the fundamental organizational setting of the energy sector, or institutions and governance, remains "untouched", such as the state monopoly of the power grids, delivery is set to fall short of ambition. As "body and mechanism" always go hand in hand, one cannot help but wonder whether all the proposed improvements in mechanism would be sufficient to deliver the desired signposts and outcome of transition.

More closely, how the "good intensions" of the Opinion will be reflected in the 14th Five-year plan for energy development remains to be seen, since it is not published yet, even though we already stand in the 2nd year of the 5-year planning cycle.

4.3 GREENING INDUSTRIES: CHINA GEARS UP ITS CLEAN REINDUSTRIALIZATION

Insight China, February 25, 2022

Industry contributes about 40% of China's GDP, consumes 66% of its total energy but emits more than three quarters of its total GHGs. It's safe to say that China's duo carbon goals will be untenable without a fundamental shift of its industries. In the "1+N" climate policy framework, industry-specific targets and roadmaps hold many crucial 'N" keys to the puzzle.

On December 3, 2021, China officially released its 14th Five-Year Plan of Green Industrial Development (the Plan), aiming to further elevate its decade-long endeavor of greening its industries. Built upon progresses made, the Plan specifies new milestones for 2025, not only of carbon emissions reduction, but also of many other "greening" indicators. This Insight China report touches the essence of the Plan.

4.3.1 Highlights:

Improving energy and resources efficiency is given as an absolute immediate priority. In the meanwhile, the Plan emphasizes such core guiding principles as technology innovation (material science, digitalization, and design), market-orientation, and systemic advancement to nurture the growth engine of industrial green development, strengthen enterprises' role in leading the marketplace, and coordinate the transition across regions and sectors. Quantitative targets are set for 2025 as shown in Table 4-2.

Table 4-2: Key Targets of the Greening Industry Plan for 2025

Category	Indicator	2025 Target	Additional Note
carbon emissions reduction	reduction of emission per unit added industrial output over 2020 level	1. - 18%	progresses made in total carbon emissions control in such key sectors as iron and steel, non-ferrous metals and building materials
pollutants reduction	reduction of emissions per unit industrial output of key sectors over 2020 level	2. - 10%	sustained enhancement of management and control capability from sources of hazardous materials, and major improvement in cleaner production
energy efficiency improvement	reduction of energy use per unit added industrial output of industries at scale, over 2020 level	3. - 13.5%	energy consumption per unit of industrial output such as crude steel, cement, ethylene and other key industrial products to reach world leading level
improvement of resources uses	• utilization rate of industrial solid wastes of commodities • total quantity of the major recycled resources • reduction of water use per unit of added industrial output over 2020 level	4. 57% 5. million tons 6. - 16%	key industries' rates of resource production continue to grow
green manufacturing system	green and environmental protection industry's industrial output	7. RMB trillion yuan (about $1.7 trillion)	green manufacturing systems of key sectors and regions are basically shaped, with comprehensive industrial green and low carbon standards system, more than 10,000 kinds of green products on the market, and a group of standards and technical public service platforms in place

4.3.2 Priority industries and decarbonization routes:

Four industries (Iron and steel, petrochemicals and chemicals, non-ferrous metals and building materials) were identified as key priority industries, given their weight in the country's total emissions (Table 4-3). How can these industries achieve decarbonization? Well, the Plan also provides eight standard routes.

Table 4-3: Highlights of Decarbonizing Priority Industries

priority	Focus highlights
industries, measured by percentage of China's total carbon emissions	1. Iron and steel: 15% 2. Petrochemicals and chemicals: 12% 3. Non-ferrous metals: 4.7% 4. Building materials: 9% of total emissions in 2020 (from 15 largest cement companies)
8 "routes" to decarbonization	1. Improve ***energy efficiency*** of existing coal and other fossil fuels use; 2. Increase use of ***renewable energy***; 3. Accelerate ***hydrogen*** technology innovation and building out infrastructure to diversity applications of hydrogen; 4. Support enterprises in speeding up ***fuel switching***; 5. Renovate fossil-fuel-burning ***boilers and kilns*** and replace with clean and low-carbon energy; 6. Achieve carbon reduction through ***industrial production processes*** and substitutes of raw materials; 7. Promote products' ***life-cycle*** carbon reduction by adopting green and low carbon materials; and, 8. Explore low-cost ***CCUS*** solutions and pathways.

Furthermore, to guide and regulate the implementation of the Plan, on February 11, 2022, the National Development and Reform Commission (NDRC), Ministry of Industry and Information Technology (MIIT), Ministry of Ecology and Environment (MEE), and National Energy Administration, jointly released the 2022 Implementation Guidelines on Retrofitting and Upgrading of High-Energy Use Sectors with Key Focuses to Save Energy and Reduce Carbon Emissions. The guidelines covering 17 industries[3] with more prescriptions.

3 The 17 high-energy use industrial sectors are steel; cement; coking; modern coal chemicals; plate glass; non-ferrous metal refinery; building and sanitary ceramics; oil refinery; ethylene; P-xylene; synthetic ammonia; calcium carbide; caustic soda; soda ash; ammonium phosphate; yellow phosphorus; and ferroalloy.

4.3.3 Restructuring industry through an integrated narrative:

If we define China's contemporary industrialization that kick-started in the early 1980s, the last two decades of the 20th century experienced the world's most populous country's opening up and reform and standing at the "receiving end" of the outdated technologies, industrial processes and facilities transferred from western developed nations. Those industries, mostly fossil-fuel-based, had proven high-energy and high-resource dependent and heavy pollution and carbon intensive. And yet, by 2000, the country managed to achieve its first economic growth goal of quadrupling its GDP over the 1980 level.

The pinch and pain became stronger and increasingly "unbearable", into the new century when pollution, climate change and resource depletion became the major growth constraints. China became the world's second largest emitter next to the US in historic sense and the largest emitter in terms of current annual emissions. And as the world's factory, its resources were depleted fast. To feed and fuel the manufacturing engine, China became increasingly resource-dependent on imports, which also complicated the supply chains and its national security.

While on its journey to achieve the second quadruple growth goal by 2020 over the 2000 level, China ushered in a new phase of industrial transformation around the second decade of the 21st century. The agenda is clearly carved. Riding on the wave of the third/new industrialization - converging communication technology (AI, IoT, cloud computing, digital twins), renewable energy technology and clean mobility and logistics, Chinese policy makers were determined to act on a united front with an integrated national industrial policy to advance the transition.

Two national programs highlight the strategic moves. One is the national scheme of promoting strategic emerging industries, launched in 2012, that focuses on new energy, new materials, new energy vehicles, green and smart shipping, environmental protection, high-end equipment, and energy electronics; and the other is the national action guidelines on China Make 2025 strategy, kicked off in 2015. Manufacturing is positioned as the main body of its national economy, the foundation and vehicles for prosperity. And China aims to stand in the global leadership league in advanced manufacturing.

The "magic" seems to be working. By the end of 2020 (or end of the 13th Five-Year Plan), China had made its case of leading global EV battery manufacturing and charging infrastructure deployment, and provided 71% of global supply of solar panels, just as a few illustrative examples. Lots of production capacity, often already showing overcapacity, are retired, or phased out much earlier than designed lifespan, such as steel, electrolytic aluminum, and cement, as well as coal-fired power generators. Technology advancements are elevating energy and resources efficiency.

All these further helps shifting the industrial structure towards clean, green, and smart. And very importantly, a green manufacturing system or ecosystem has started to emerge, as championed by 2,121 green factories, 171 green industrial parks, 189 green supply chain companies, and nearly 20,000 green products on the market. The new Plan embodies a geared-up endeavor to continue to green its industries.

4.3.4 Competing a global game to reset new industry rules:

Standards are key, both to define "green" and to guide the greening "long march". Against the backdrop of clearly set targets for 2025, 2030 and 2035 in decarbonization, domestically and globally, through the Paris Agreement and the Glasgow Climate Pact, industries, old and new, are identifying technology needs and gaps; policy makers are zooming in on policy incentives to further enhance and elevate industrial restructuring; and regulators are stepping up efforts in standard setting.

As illustrated by the Plan, some priority standard improvements include:

- Evaluation standard systems: green products, green factory, green industrial park, and green supply chain;
- Sector standards of some key industries and equipment: low carbon, energy saving, water saving and integrated resource use;
- Local standards, group standards and enterprise standards: encouraged to exceed existing national levels;
- Green and low carbon standards' credit gathering and enhancement mechanisms;
- Assessment of technical levels of key standards and evaluation of standards' implementation outcomes;
- Internationalization of standards in such key industries as green design, product carbon footprints, green manufacturing, new energy, and new energy vehicles.

The final point is very important for the current moment. It's literally a moment to reset global industrial and trade rules. The EU has been progressing its regulation on the carbon border adjustment mechanism. The US regulators have also been contemplating a similar concept in the trade policy. China today has its biggest sense of urgency, pressure and incentive to put its own act together and join the competition and partnership with other major economies, developed and developing. Collectively, they will set a new generation of international standards to regulate and direct the clean industrialization.

4.4 INTEGRATED, SMART AND GREEN: CHINA'S BLUEPRINT FOR NEW MOBILITY INFRASTRUCTURE

Insight China, March 4, 2022

In January 2022, China published two blueprints for mobility development. The 14th Five-Year Plan of Integrated Modern Transportation Hub Systems charts the course to develop a 3-dimensional national transportation infrastructure system, covering road, rail, air, river, maritime, as well as inter-city and inside-city mobility by 2025; and the 14th Five-Year Plan of Green Transportation Plan focuses on how to turn the system greener, across all regions and segments. Specific targets are set, often quantitative, as illustrated in Table 4-4.

Table 4-4: Green Transportation Targets for 2025

Category	Indicator	2025
Carbon reduction, vehicles	1. CO_2 emission per vehicle running over 2020 level	- 5%
Carbon reduction, ship and boat	2. CO_2 emission per ship/boat in operation over 2020 level	- 3.5%
Pollution reduction: ship and boat	3. NOx total emission over 2020 level	-7%
New energy vehicle (electric or hydrogen)	4. New energy vehicles percentage in: ○ Nation-wide city public transportation ○ taxi fleet (including online car hailing) ○ urban logistic delivery vehicles ○ new urban public and logistic vehicle fleet ○ international container hub truck fleet	 72% 35% 20% 80% 60%
Port electrification	5. Increase of onshore electricity use at ports and offshore service zones along the Yangtze Economic Belt over 2020 level	100%
Infrastructure integration	6. Container rai-waterway combined transportation annual growth rate	15%
Urban transport	7. Number of cities with population more than 1 million, that provide more than 70% green transportation (public transport, cycling and walking)	60

The two Plans put together also showcase the most comprehensive, inclusive and strategic thinking of Chinese policy makers who view mobility through the lens of a major economic transformation. The objectives are clearly set. By 2025, China's transportation and mobility systems are expected to have made "substantial" breakthroughs in integration, smartness and green, while capability in services, operations, efficiency and flexibility dramatically improved to the world leading level.

4.4.1 A Transformative Vision Combining Digital, New Energy and Mobility

For China, transportation is one of the three interactive operating systems of the economy. Together with an information and telecommunication medium (that manages economic activity and social life) and a power source (that moves economic activity and social life), the three make up a general-purpose technology platform, or a society-wide infrastructure, that enables the economic and social systems to operate as a whole.[4]

New telecommunication (e.g. 5G), clean energy (e.g. renewables), and mobility infrastructure (e.g. EV charging stations) define how the commitments of people and planet positive will be achieved. They also change society's temporal/spatial orientation, business models, governing patterns, built environments, habitats, and even narrative ideology. This is significant for China in advancing simultaneously economic transformation and clean energy transition while honoring its commitments to its people and the world in the context of UN Sustainable Development Goals.

A living case of action is already made. China launched its national "new infrastructure" scheme in 2020. To a large extent, it embodies how deeply such a narrative has been embraced and adopted in the country. The scheme puts seven priorities on the agenda to guide policy incentives to invest in transforming its infrastructure - 5G station construction, super-high-voltage power transmission grids, inter-city high-speed rails and urban rail transportation, new energy vehicle charging piles, big data centers, AI and industrial IoT.

Thus, it is no longer surprising why China, as demonstrated by records, has been moving forward an integrated strategy with a united front to lay down a solid fundamental infrastructure to accommodate the "plug-ins" of all the other pieces in the economic and social systems so that they could act in sync to accelerate the transformation.

4.4.2 Enhancing the Connectivity: Gridding and Webbing

The Plans draw a blueprint of a nationwide transportation system, a physical and digital infrastructure that connects all the possible dots and routes, and facilitates efficient movement of goods, services and people, while reducing costs.

They put emphasis on how to improve, upgrade, green and decarbonize the country's transportation system, enabled by emerging technologies, in the next five years. They also lay out ways and actions to build and strengthen the physical infrastructure, enhance the functionality of the mobility networks to fit for purpose, notably, protecting the climate and nature, and uplift technology innovation in the transportation industry.

Three highlights may provide some "flavor" or "visuals" of how the Plans architecture solutions to clear some identified bottlenecks. First is "Gridding and Webbing" to define and shape the backbone and connectivity of its modernized mobility infrastructure. For instance, built upon its current 8 "vertical" (north-south) and 8 "horizontal" (east-west) high-speed railways that cover 95% of Chinese cities with more than one million population, China is expanding inter-city high-speed rails - at or above 250 km per hour - to cover more than 95% of cities with a population of more than half a million. In the meantime, the highway system across the country will be improved and completed with 7 radiating highways from Beijing, 11 north-south highways, 18 east-west highways, and other supporting highways over its territory that connect inland cities and regions with the eastern coastal more advanced regions.

Second, communication technology is the brain that oversees, coordinates, and manages the mobility and economic organisms. Enabled by the feasibility of

4 This is the basic framework Jeremy Rifkin articulated in his best-seller The Third Industrial Revolution: How Lateral Power Is Transforming Energy, the Economy, and the World, published in 2011. The premise of the book is that fundamental economic change occurs when new communication technologies converge with new energy regimes, mainly, renewable energy, and new mobility solutions, such as EVs. Chinese policy makers have studied the framework inside out and adopted the thinking into the country's transformation.

sensors' ubiquity, "universal" mobile devices, as well as real-time and full satellite coverage, the deepest-ever convergence becomes possible for the transportation system to embrace advanced technologies such as 5G, IoT, big data, cloud computing, and AI. The outcome is an unprecedented level of interconnectivity, efficiency and efficacy, and safety and security of the transportation system in operation.

And, China has made an impressive march on electrification of mobility and charging infrastructure. The new plan is to accelerate further scaling to achieve almost "universality" of charging piles and swap facilities. By 2025, the charging capacity shall support at least 20 million electric vehicles in the country. As far as vehicles are concerned, buses, trucks, passenger cars, taxi fleet, postal and delivery vehicles, trash and waste collection vehicles, and government vehicles, you name it, are all becoming new-energy-fueled, i.e. electric.

4.4.3 Remaining Puzzles to Solve: Trade-offs?

When such trends hold, some studies foresee a dramatic decline of diesel fuel, gasoline, and kerosene consumption in China's transportation sector in this decade. And it is expected to contribute to an earlier peaking of oil, no later than 2030.

While efforts and planned actions are clearly stated in the Plans to contribute to the decarbonization and pollution reduction, two questions beg clarity in answers.

One is the ecological and environmental footprints from the building out of the transportation infrastructure - land, fresh water, coastal and ocean ecosystems, and biodiversity, namely, how to build and operate everything within a shrinking ecological redline. Simple environmental impact assessment won't be an adequate way out. How shall this be rightfully narrated?

And the other is climate resilience nowhere to be seen in the Plans. China, like most other nations around the world, has been suffering tremendous loss and damage from extreme weather events and natural disasters, such as flooding, storms, erosion, and landslides. They often destroy infrastructure, disrupt mobility, and endanger lives and livelihoods. While being smart is always helpful but it alone will be largely insufficient, planners shall pay more attention to climate impacts and resilience in their planning, not only to enhance resilience of existing infrastructure, but to avoid major losses and damages in new projects.

4.5 GREENING AND TRANSFORMING THE BUILDINGS

Insight China, March 4, 2022

The building sector is a major economic pillar for China, spanning the broadest-ever industrial landscape. For a long time, nearly one-fifth of the country's annual GDP comes from the real estate industry, though the ratio has started to decline. It employed nearly 54 million people by the end of 2020.

It is also one of the largest sources of carbon emissions: one third of China's energy is consumed to power construction and operation of buildings, and nearly half (48%) of the country's total carbon emissions come from the life cycle of buildings. To achieve the duo targets of peaking the emission and zeroing out carbon, transforming the sector offers one of the biggest opportunities.

The goals are clearly set and the pathway chosen. On January 19, the Ministry of Housing, and Urban and Rural Development (MHURD) officially released the 14th Five-Year Plan of Construction and Building Sector (the Plan). It eyes on two "historic, pivotal moments" to transform the sector. The first is its unprecedented convergence with advanced manufacturing and new generation of ICT/communication technology; and the second is the pivot from large-scale new construction to parallel importance attached to both uplift the quality of existing building stock and adjust the structure of the newly added stock.

4.5.1 Goals

The Plan is "benchmarked" against the China Vision 2035. The Vision paints a blueprint of a high-quality-centered development systemic framework that, on one hand, guides and regulates sound market operation mechanisms and safety assurance, as well as optimized sector structure, and on the other, is enabled by the converging new industrialization, digitalization and intelligence that transforms how buildings are constructed and operated.

Table 4-5: Five goals and priorities of the 14th Five-Year Plan for Buildings

Goal	Example target
further consolidated and stabilized economic pillar	1. sector value add to GDP: about every year 2. strengthened new economic pillar: new products, services, and business models from deepest-ever integration of new ICT technology and building industry
much modernized industry value chain	1. prefabricated buildings ratio in all newly built: above **30%** 2. policy framework and industrial system in place that support advanced manufacturing and industrialized construction
green and low-carbon production	1. control of on-site construction wastes in newly built construction: less than **tons per 10,square meters** 2. policy, technology, and implementation system in place for green buildings and construction, as well as forming market mechanism for disposal and reuse of wastes
improved construction and building market mechanism	1. amending the Law of Construction and Buildings, and enhancing sector management mechanisms, such as industrial certification and professional accreditation 2. more than **million professionals** accredited at and above mid-level
strengthened engineering quality and safety	1. prevention and control of major safety accidents 2. improved **emergency response to disasters**

4.5.2 Decarbonizing value chains

As sectorally expansive, geographically and climatically diverse, and technically complex as it can be, the buildings sector covers a rather long value chain. To decarbonize it relies on enactment of mandates, incentives, legislation, and standards. While the Plan itself acts as the guiding and integrator document, the Chinese policy makers have taken a holistic value-chain and life-cycle approach.

1. Drawing the upstream boundary to save energy and reduce carbon emissions in materials production: On January 22, the National Development and Reform Commission (NDRC), Ministry of Industry and Information Technology (MIIT), Ministry of Ecology and Environment (MEE), and National Energy Administration (NEA) jointly released the 2022 Implementation Guidelines of Retrofitting and Upgrading to Save Energy and Reduce Carbon Emissions of High-Energy Consuming Industries (the Guidelines).

   It covers 17 industrial sectors, many of which are building- and appliances-related. Specifics are given in the Guidelines. (We will publish a separate paper deep-diving into a framework of energy efficiency.)

Table 4-6: Highlights of the Guidelines for High-energy Consuming Industries

category	focus
17 industrial sectors	steel; cement; coking; modern coal chemicals; plate glass; non-ferrous metal refinery; building and sanitary ceramics; oil refinery; ethylene; P-xylene; synthetic ammonia; calcium carbide; caustic soda; soda ash; ammonium phosphate; yellow phosphorus; ferroalloy
4 key tasks	1. guide retrofit and upgrade 2. strengthen technological breakthroughs 3. promote clustered and integrated development 4. speed up phase-out of outdated capacity

2. Mandating energy conservation, renewable energy use in buildings: On October 13 of 2021, the MHURD issued National Standards for Energy Conservation and Renewable Energy Use in Buildings. Mandatory and to be effective on April 1 of 2022, the clauses represent China's first compulsory national standards covering carbon emissions from buildings.

Table 4-7: An Overview of the Carbon Standards for Buildings

Focus	highlights
Scope	apply to design, construction, receipt and inspection, operation, and management of systems for energy conservation and renewable energy use in buildings that are newly constructed, extended or remodeled, or modified for improved energy efficiency
requirements for calculation of carbon emissions from buildings	a feasibility report, construction plan and initial design plan must include an analysis report of energy consumption, renewable energy use and carbon emissions of the building
requirements for renewable energy use	clear standards and requirements for renewable energy system, including solar energy systems, air source heat pump and ground source pumps, are defined
stricter standards	1. energy efficiency of buildings: the design energy consumption of regular new houses and public buildings will be lowered by 30 and 20 percent respectively, from current standards implemented since 2016 2. energy consumption of new houses: the energy use limits will be lowered by 20 to 30 percent from the current standards depending on the climate of the region 3. carbon emissions: the carbon emissions limits for new houses and public buildings will be lowered by 40 percent and on average by more than 7 kg CO_2/square meter per annum from the current standards implemented since 2016.

According to the Standard for Building Carbon Emission Calculation (GB/T 51366-2019). the calculation of carbon emissions in the operational phase factors in air conditioning equipment, water heaters, lighting equipment, elevators, renewable energy and carbon absorption by carbon sink systems. And relevant mandatory clauses in existing construction-related national standards will be replaced when the new standards take effect.

3. Connecting with green consumption and embedding circularity in the value chain: Two additional interventions - green consumption and circular economy (construction wastes) - are also deeply embedded in the sector's transformation plans, and some analyses of which have already been shared in some of our previous Insight China reports, and many more to come.

To further highlight how significant the sector has been "treated" or positioned in national smart, green and clean transition, below are some key relevant policy documents in the 14th Five-Year planning system:

- Circular economic development plan, July 7, 2021
- Green industrial development plan, December 3, 2021
- Smart manufacturing development plan, December 28, 2021

- Implementation Plan to Promote Green Consumption, January 21, 2022
- Workplan to Build 100 Waste-Free Cities, December 17, 2021

4.5.3 Rolling out Nodal IoT buildings

With all the pieces adding up, a "futuristic vision" and a reality has emerged. Buildings are no longer passive walled-off private spaces, rather, potentially actively engaged nodal entities sharing their renewable energies, energy efficiencies, energy storage, electric mobility, and a wide range of other economic and social activities with one another at the discretion of their occupants. And very importantly, the country's current endeavor of decarbonizing every building, as all the plans have geared towards, offers the green physical foundation for the laying-on of the digital infrastructure to maximize the benefits of people and planet positive.

In that vision, millions of existing buildings will be undergoing a complete retrofit to seal interiors, minimize energy loss, optimize efficiency, and buttress structures to be resilient to climate-related disruptions. Renewable energy installations in both newly built and retrofitting are turning buildings from power consumers to clean power generators. Fossil-fuel heating is replaced by electrical heating powered by green energy across the residential, commercial, industrial, and institutional building stock.

In short, the building sector transformation is destined to be fundamental and profound. Involving the largest physical infrastructure of any country, it will have its perplexities and complexities, but it also represents the biggest opportunity.

4.6 GREENING CONSUMPTION: CHINA PUSHES CONSUMER BEHAVIOR CHANGE ON ALL FRONTS

Insight China, March 10, 2022

Consumption is always the "last mile" to bridge in a value chain - for investors to cash out profits, and for policy makers to deliver goals and targets. This also proves the "trickiest" node to interfere due to the complexity of how purchasing decisions are made, particularly when individual consumers are concerned. And yet, here comes the unprecedented determination and commitment of the Chinese policy makers to "get their feet wet" by directly guiding and demanding what consumers shall buy and how they shall consume products and services.

The goal seems clearly set - to connect all the dots and advance a clean, green, circular and smart transition, specifically, building up and enhancing systemic infrastructure and mechanisms to enable consuming less, reducing wastes and losses, saving energy, and decreasing carbon emissions.

As articulated by the Implementation Plan to Promote Green Consumption (the Plan), released on January 18, green consumption is now "officially" mainstreamed and embedded in the policy landscape as a crucial part of the transition. The National Development and Reform Commission (NDRC), jointly with six other national ministries and agencies[5], aims to "unleash the maximum potential and contribution of consumption to accelerate progress towards decarbonization and green economy".

4.6.1 Goals

Two time-bound signposts are set by the Plan. By 2025, it aims to achieve that green consumption is deeply rooted in society and the green consumption lifestyle becomes ubiquitous. And this can be evidenced by 1)

5 The Plan is released by NDRC, together with the Ministry of Industry and Information Technology, Ministry of Housing, and Urban and Rural Development, Ministry of Commerce, National General Administration of Market Supervision, National Administration Bureau, and Central Committee's Direct Administration Bureau.

halting and reversing extravagance and waste; 2) dramatically increasing market share of green and low-carbon products and services; 3) demonstrating visible progress in greening consumption in some key sectors; and 4) putting in place the consumption-enabling infrastructure and system of green, low-carbon, and circular development.

And, by 2030, the policy makers expect that green consumption will become the public's self-conscious choice, or the mainstream cultural norm, while green and low-carbon products dominate the Chinese market. In the meanwhile, key sectors have totally embraced green consumption. And a sound landscape of policy incentives, mechanisms, systems, and governance is in place to support and be aligned with green consumption.

4.6.2 Canvassing green consumption

This is an "on-all-fronts" endeavor, with the "visible hand" all over the place. The Plan covers the landscape of the basic needs of an individual consumer, or the key sectors of food, clothing, living, mobility, power, appliances, tourism, as well as public institutions.

It emphasizes the importance of the whole value-chain thinking and connectivity of all parts in it, including production, circulation, consumption, recycling, and reuse. The policy makers are also positioned to provide all-dimensional support, such as incentives, technology, services, fiscal and finance, pricing, credit, oversight, and governance.

The tabled highlights below offer a sense of the scope of the government's endeavor to pull the pieces together to deliver a highly ambitious goal to green the consumption.

intervention points	focal targets
food	1. **Agricultural products and food:** standardization of production, storage, transport and processing; reducing wastes and uplifting productivity in processing; promoting organic foods; as well as rational and moderate in food purchasing, storage, cooking, ordering and eating out 2. **Anti-food wastes**: restaurant dining industry standardization and compliance with regulations; new models like "farm-to-central kitchen"; compliance with anti-food waste regulations; oversight over anti-food wastes in food production companies, when dining at schools', government's and institutions' cantines, and dining at receptions, meetings and training sessions; "Clean the Plate" ubiquitous; as well as kitchen food waste **recycling and disposal** 3. R&D and **technical support** platform to strengthen green food consumption

intervention points	focal targets
clothing	1. **Value chain** - promote deployment of green fiber manufacturing, high-efficient and energy-saving dying and printing, equipment, and technology to recycle used fiber, increased use of green fibers such as recycled chemical fibers, and clothing in compliance with green and low-carbon requirements 2. P**rocurement** of green and low carbon labeled uniforms by schools, companies and institutions, and government agencies 3. Rational and **moderate consumption** when purchasing clothing 4. **Reuse and recycle:** standardizing donation of used clothing; used clothing collection stations to enhance recycle and reuse; pilots of integrated utilization of used and wasted textile products and clothing
living	1. Green and low-carbon **buildings**, both newly built and retrofitting, urban and rural; greening **building materials,** newly manufactured and recycled, as well as interiors 2. **Clean heating** renovation in line with climatic locations; encouraging use of energy-saving lighting and cooking stoves, and water-saving toilets; promoting use of indoor temperature and lightness control appliances 3. **Rural clean heating and electrification**, as well as use of renewable energy in rural areas
mobility	1. **New energy vehicles (NEVs),** all types of vehicles for various purposes, such as passenger cars, buses, trucks, post vehicles, etc. 2. **New infrastructure,** such as charging piels, new energy storage and hydrogen filling 3. **Public transportation**, rail transportation, cycling, shared cycling, and pedestrian walking
appliances and products	1. **Household appliances and furnishing:** energy saving, environmentally friendly, smart products 2. Green and low-carbon **products sales and trade (**import and export) 3. Green **packaging** and packaging recycle and reuse, in particular plastics
power	1. **Green power** consumption - connecting green power marketplace, green power certificates, and carbon trading schemes 2. **Leadership** from leading companies, state-owned and MNCs, in purchasing green power, and developed regions shall lead to scale green power consumption 3. **Mandatory** constraints over high energy-consuming enterprises for green power consumption 4. **Grid** companies provide technical and administrative support and guidance for increased green power users, including households

intervention points	focal targets
events and tourism	1. **Large events and exhibitions**: materials, lighting, wastes, pollution prevention and control 2. **Transportation hubs** at airports, terminals, ports: convenient transfer, bicycle-designated, pedestrian-walking friendly, and public transport 3. **Tourism destinations'** design, operation and service: green, energy saving, resources and environmental impact, circular economy 4. **Rural** village tourism: protect arable land, forestland, wetland, as well as carbon sink
public institutions	1. **Leadership in purchasing NEVs and building charing infrastructure as priority** 2. **Green office and green procurement** 3. **Forceful enforcement and compliance with anti-waste regulations**

4.6.3 Consolidating the foundation and incentivizing actions

Immediately, a challenge has emerged and a series of questions beg for answers. How is green consumption defined? What standards are in place to regulate, guide and measure the transition? Does China have sufficient legislation and governance to assure the credibility and accountability of all the actions taken as listed in the table above?

The Plan has identified four priorities as crucial next steps to build a solid foundation and clarity to green consumption at scale and systemically:

1. ***Legislation and Policy:*** Amending at least two relevant laws - the Bidding Law and the Government Procurement Law, while improving green procurement policies;

2. ***Standards and Accreditations***: Labeling, certification and standards as some of the major instruments to help build up market visibility of green products and services; and green design, life-cycle analysis, and green manufacturing standards to support accelerated scaling;

3. ***Statistics, Oversight and Assessment***: Statistic framework, data gathering, monitoring, analysis and forecasting as the "common practices" that shall be clustered around green consumption; and,

4. ***Disclosure and Transparency***: A nationally unified information/data platform to be in place to report and disclose progresses, and also to release periodic product inventories and purchase guidance to ensure accountability and boost consumers' confidence in making informed decisions, conveniently.

Like "business as usual", the policy makers have decided to strengthen the government's push and pull to incentivize accelerated marketplace scaling, such as

1. **fiscal policy,** including tax credits, local subsidies where-ever appropriate, and subsidized interest;

2. **financial support,** such as financial institutions' services to companies and individuals, expansion of issuance of green bonds, and

specially designated funds and insurance products;

3. **pricing policy,** such as tiered, floating and differentiating prices of water, electricity and gas, as well as fees or levies to differentiate such costs as garbage collection and disposal, public transport parking, traffic jams, among others;

4. **market-oriented incentives,** such as green credits system, trade-in of used products for new ones, and deposits system; and,

5. **clear and enforceable liability** that holds violators of laws and regulations accountable.

4.6.4 Campaigning and mobilizing public movement

The Plan, undoubtedly, represents another "aim-high" on the part of the policy makers to close the loops and advance the clean and green transition. And yet, existing inadequacies and gaps in institutions and governance won't accommodate delivery of "overnight" outcomes. Bridging gaps takes time.

And, very important to note here, greening consumption, ultimately, is a question of culture, not materials and technology. However efficient, however regenerative, however useful, materials and technology alone won't ever undo all the negative effects from how we consume today.

Thus, as we see in the Plan, the aspiration of the "visible hand" to drive cultural and societal change. And we see tremendous importance attached to elevating campaign-style movements that will raise awareness, advocate behavior change, pilot various projects and programs, and increase publicity and visibility of both policy and best practices, in parallel with policy makers and regulators' endeavor to remove barriers and close the cracks and build up the infrastructure and mechanisms to shore up greening of consumption.

Mahatma Gandhi of India once said, "The Earth can meet everyone's need, but not everyone's greed". Now in China, we will see how the government is both visible and invisible hands to control the "greedy" part of consumption by the world's most populous nation – an experiment without precedent.

4.7 THE FUTURE OF GREEN POWER MARKET INSTRUMENTS

Insight China, November 23, 2022

China used to lavishly subsidize renewable energy development, normally 20 years at fixed tariff for solar and wind projects and 15 years for biomass power projects. And yet two facts pushed the government to adopt more market-based instruments instead of subsidies:

- High level of subsidies quickly drained the Finance Ministry's pocket, where arrears of subsidy payment overpassed RMB 100 billion (about $14 billion) by the end 2017; and
- Dramatic decline of cost of renewable power sources.

This Insight report reviews two types of market instruments – the green certificate and green power purchase, and examines their links to other instruments such as the mandatory renewable power absorption quota (RPAQ) and the national emissions trading scheme (ETS).

4.7.1 Green Certificate:

Green certificate (GC) was the first market-based instrument China introduced in 2017. It was intended to encourage renewable energy development while reducing the burden of public subsidies. It is issued by the National Energy Administration (NEA) to the renewable power generation companies that meet certain required conditions.

One GC corresponds to 1 MWh of power generation. It's given a unique digital code that describes where this power is generated. It was initially reserved only for onshore wind and large-scale solar projects that are entitled to government subsidies. In 2019, it was extended to non-subsidized projects. A 2020 NDRC regulation further stipulates that when their subsidy entitlement period is over, all renewables' projects can receive GCs and participate in trading. Thus, a GC can be issued either from a renewable project still under government subsidy or outside the subsidy scheme.

The certificate was initially designed for voluntary purchases by individuals or institutions who want to support renewable energy development. Later, it is turned into part of the renewable energy consumption quota. And it can be bought from a designated GC purchase platform. For renewable power generators, once they sold their certificates, the corresponding volume of power will no more be eligible for state subsidies.

The result has been disappointing. China issued a total of 34.21 million GCs from projects under the subsidy scheme, but only 79 thousand or 0.23% were purchased. For projects out of the subsidy scheme, about 11.4 million GCs were issued, only 1.97 million or 17.3% were purchased.

Reasons for this under-performance are simple. Firstly, the price of a GC, averaging at RMB 50 (about $7), is far below the cost of subsidy, which varies between RMB 167.8 (about $23.6) – 269.5 (about $38) per MWh for an onshore wind project. Power generators under the subsidy scheme therefore prefer to await the subsidy payment rather than sell the certificates and lose the subsidy. But for buyers, price for a GC under the subsidy scheme is far too expensive. And secondly, the links to mandatory mechanisms such as the renewable energy consumption quota and the ETS are not yet established. As there is no an active GC trading market, the buyers cannot resell the certificates. The dire reality is that the market cannot achieve scale by merely counting on volunteers to pay a green premium.

4.7.2 Green power purchase

A major gap in designing the GC lies in the fact that a buyer of the certificate does not need to consume the green power. Rather, it bets on a buyer's willingness to support renewable power generation. To overcome this, the NDRC launched a new scheme in August 2021 - "green power purchase". It authorizes both the State Grid and the Southern Grid to start trial operation of the scheme in Beijing and Guangzhou respectively.

The scheme targets consumers who are willing to pay a "green premium" for renewable power. It allows consumers to buy either directly from renewable power generators or from the grid companies. For each MWh green power purchased, the consumer will get a GC for free. Thus, the scheme combines the GC with actual consumption.

On the launch day of 7 September 2021, a total of 259 entities from 17 provinces participated, signing a total of 7.93 TWh of mid- and long-term (3-5 years) green power purchase contracts with a green premium ranging from RMB30 to 50/MWh (about $4.2 - $7/MWh).

The trading volume is expected to ramp up quickly. According to China Electricity Council, the total volume of green power consumption was only 0.63 TWh in 2021, but the year 2022 is expected to see a trading volume reach 10 TWh. The main buyers are those companies that have committed to 100% green electricity by a certain date, and the Chinese branches of international companies or export-driven Chinese companies. Until September 2022, i.e. one year after the scheme launch, some Chinese high-tech companies such as Alibaba and Tencent have purchased a total of 7.3 TWh of green electricity.

A major hurdle in green power trading is how to determine the level of premium the consumer is willing to pay. The regulation leaves the buyer and the seller to negotiate. It also allows the buyer to launch a competitive bidding to select the best seller. In a 25-year long-term green power purchase agreement with a Chinese renewable developer, BASF – the German petrochemical giant, used LCOE (levelized cost of energy) of the project as the pricing basis.

Other main hurdles for further expansion include: 1) barriers in cross-province purchases when consumers in the east coast want to buy directly from renewable power generators in the west drought-ridden and decertified regions; 2) constraints to expand the pool of buyers when a vast number of "normal" companies could not join since they could not pass on high electricity prices to end-customers; and 3) lack of effective linkage to other mechanisms such as renewable consumption quota and national ETS.

4.7.3 Better inter-links for stronger growth

Isolated in design and operation, neither green certificate nor green power purchase will play a significant role in China's power sector transition. However, if they work in synergy with other instruments, administrative or market-based, they may play a pivotal role in accelerating the green and clean transition.

The first link lies between green power purchase and green certificate. Today, not every MWh of the green power purchased has been given a GC, as the latter must be issued by the NEA following certain application and verification procedures. By July 2022, for a total green power consumption of 7 TWh, only 1.08 TWh has the GC, or about 15.4%.

Once each one MWh of green power consumption is given a GC, or a true unification of the two is achieved, they need to be linked to the following schemes:

- **The "energy duo control" mechanism:** this is the mechanism by which each administrative area (province and below) is given an energy consumption quota and an energy intensity target for a given time. Newly added renewable energy capacity, along with fossil fuels used as feedstock, have been exempted from the energy consumption quota accounting. Green power consumption will be boosted if all is exempted from the energy consumption accounting.
- **RPAQ or renewable power absorption quota:** this is a "mandated" obligation for a local administration and all market participants within its jurisdiction to absorb certain percentage of renewables in their total power consumption (see Insight China No. 029/2022). Green certificate needs to be counted as part of the RPAQ for power consumers.
- **CCER or Chinese certified emission reduction:** after years of pause, China just resumed the CCER qualification and issuance. Quantitative equivalence or conversion needs be established between CCER and GC for green power to be considered as the main source of CCER.
- **ETS or national emission trading scheme:** once the amount of carbon reduction is determined for each GC, it can be fully integrated into the ETS, either directly as emission reduction or as offset.
- **ESG or environmental, social and governance:** growing Chinese companies have started ESG reporting. Making green power consumption as part of their environmental commitment will undoubtedly boost the green power market.

Green power promotion proves a systematic effort. Its bright future can become reality only when all the links outlined above are effectively established.

4.8 ZERO WASTE SOCIETY： CHINA PLANS TO TURN 100 CITIES WASTE-FREE BY 2025

Insight China, March 21, 2022

As part of what we call the “low emission economy”, China aims to build a “Zero Waste” society with minimal solid waste generation, and maximum recycle and re-use. The plan is to turn 100 cities ″waste-free″ by 2025, and then expand it to all other cities across the country. And when deployed, it's expected to help mitigate climate change and other pollutants from key waste-generating sectors, including industry, agriculture, construction, and household.

Issued jointly by the Ministry of Ecology and Environment (MEE) and 17 other national ministries and agencies, the 14th Five-Year Work Plan on the Construction of Zero-Waste Cities (the Work Plan) guides and incentivizes cities to invest in infrastructure to capture the benefits of a circular economy. Some assessments indicate that a total of 25% of China's carbon reduction (in the framework of 2030-2060 duo targets) can be attributed to a full deployment of an integrated circular economy. And China aims to grow the output of a circular economy to RMB 5 trillion (about $790 billion) by 2025.

Chinese cities are now home to 64% of its 1.4 billion population, which is expected to grow to 80% by 2035. Urban population and operation of urban systems consume the majority of energy and other resources, emit most of GHGs (80%), generate large quantities of wastes, pollute the air, water and soil which in turn threaten the health of city dwellers and ecosystems.

4.8.1 Unifying Metrics to Rate Performance and Scale Solutions:

The Work Plan is rolling out a proposed metrics to unify measurements and rating among cities. It's composed of three Tiers of indicators - 5 indicators for Tier I, 18 for Tier II, and 58 for Tier III as outlined in Table 4-8. It reflects the in-depth design thinking of how the policy makers plan to drive a more fundamental and systemic change.

Table 4-8: The Proposed Indicator Framework (2021)

Number	Tier I (5 Indicators)	Tier II (18 Indicators)	Tier III (58 indicators)
1	**solid wastes reduction from source**	• **industrial source reduction** • agricultural source reduction • construction source • household source	• **intensity: general industrial solid waste generation per unit GDP** • **ratio: number of cleaner production companies** • **ratio: number of green-factory companies** • **rate: established green mining** • **intensity reduction: CO_2 emissions of key industrial enterprises** • **quantity: household trash collected and transported away**

Number	Tier I (5 Indicators)	Tier II (18 Indicators)	Tier III (58 indicators)
2	solid wastes utilized as resources	• industrial waste • agricultural waste • construction waste • household	• rate: general industrial waste utilized • rate: dangerous industrial waste utilized • rate: animal drops and sewage utilized • rate: construction waste utilized • rate: household trash recycled and utilized • rate: increase of recycling of recyclables
3	solid wastes final disposal	• hazardous wastes • general industrial solid waste storage and handling • agricultural • household	• decrease: industrial hazardous wastes landfill • decrease: general industrial waste storage • rate: number of piling of bulk industrial wastes (including tailmines) • ratio: household trash incineration • rate: urban sewage and sludge turned non-hazardous
4	guarantees and capacity	• governance • market system • technical system • oversight system	• local regulations, policy incentives and action plans • coordination mechanism among different agencies • total investment in zero-waste city projects • number of enterprises that have integrated the targets into environmental credit assessment • green loan balance • green bonds stock • rate: products in government procurements • data-enabled oversight
5	public satisfaction	public satisfaction	• rate: public communication, education, training • participation from government, business, non-governmental environmental organizations and the public • public satisfaction

4.8.2 Sizing the Challenges:

China kicked off the new decade with falling short to meet some of its 2016-2020 (13th Five-year Plan) targets in improved trash handling capacity. According to the National Development and Reform Commission (NDRC), urban waste handling capacity reached 1.27 million tons a day in 2021, up 63% compared with 2015, but some places were struggling to keep up with the growing volumes of trash. For instance, half of Chinese cities had not built waste incineration plants, and many cities in central and western regions had failed to meet targets on treating hazardous wastes.

The national government first launched its pilots in 2019 when 11 cities were selected to lead the scheme, joined later by 5 special regions and then more cities voluntarily. In the end, a total of 46 cities are on board that deploy measures including better sorting of solid waste, improvements in urban planning, and the construction of new treatment facilities. While green development methods and lifestyles changes are encouraged, they have managed to minimize landfill volumes and reduce the environmental impact of trash, at various levels.

China banned imports of foreign waste in 2017 and has been steadily restricting single-use plastics and non-recyclable packaging waste. And yet, dealing with the growing volume of waste has emerged as one of the biggest challenges facing China's regulators, with a rising urban population consuming increasing amounts of consumer goods and most major cities surrounded by rings of landfill. And China today faces a solid waste treatment backlog of up to 70 billion tons.

4.8.3 Seizing the Opportunity:

By 2025, China has set more ambitious goals to close the loops, enabled by innovative technologies and further strengthened institutions and governance, especially at city level, aiming to:

- Reuse 60% of its urban household waste, up from 50% in 2020;
- Raise incineration levels to about 65%, up from 45% in 2020;
- Utilize 60% of newly generated bulk solid wastes, up from 56% in 2020, while reducing the existing stocks;
- Reuse 60% of construction wastes. up from 50% in 2020; and,
- Maintaining agricultural waste utilization at 86% and above.

Measured by weight, targets of some specific items' utilization are also set by 2025:

- Used paper: 60 million tons;
- Strap steel: 320 million tons; and,
- Recycled nonferrous metals: 20 million tons, of which 4 million tons of recycled copper, 11.5 million tons of aluminum and 2.9 million tons of lead, respectively.

The 100 waste-free cities program has taken on a mission to help deliver those clearly set time-bound targets and maximize the co-benefits - protecting the environment, reducing wastes of resources, and enhancing the foundation for green transition.

4.8.4 What Has Been Learned?

A zero-waste city is about rehaul and redesign of the existing urban systems - infrastructure, industrial supply chain, production and consumption, institutions and governance, and also people's behavior change, to fit for purpose.

Earlier pilot schemes have taught us many things. First, cities offer the best and more effective enabling systemic infrastructure, both soft and hard, that connects all the possible dots and closes the loop(s), especially in the last mile, so that barriers and blocks are cleared for transition.

Second, do not expect "quick wins" since daunting difficulties stand in the way that need to be overcome. That is why progress has been made in those earlier pilots but with mixed outcomes due to the complexity. For instance, only Suzhou presents a well-established model of closed loops now advocated to scale, while most others continue to face deadlocks to break.

Third, scaling the pilots to 100 cities and more offers an important part of the solution to the challenge of materials/minerals and industrial supply chain, in the context of an increasingly more complex geopolitical landscape and also the constraining environmental footprints. One example is co-associated ore of black metals, nonferrous metals, and rare and precious metals. China is rich in such resources, easily accessible, from mining. And the mainstream recycling or circular economy is playing a big role to support the country's clean energy revolution and decarbonization.

And fourth, the clarity of goals, targets, and plan, supported by feasible technologies and infrastructure, determines the fit of zero-waste cities and the broader circular economy in China's green finance taxonomy and their attractiveness to finance and investment for accelerated transition.

5

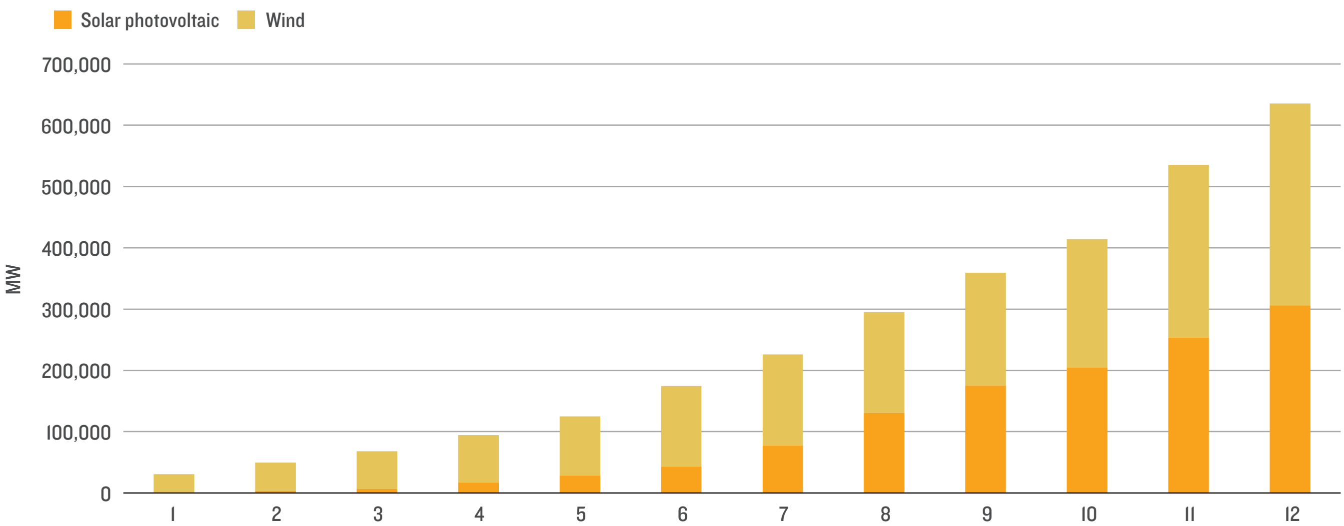
RENEWABLES TO NEW HEIGHTS

5.1 POWERING RENEWABLES TO NEW HEIGHTS

Insight China, June 1, 2022

With a total of 636 GW of solar and wind power capacity installed at the end of 2021, China has been the leader in global renewable energy development. Thanks to the economy of scale in both domestic and international markets, dramatic cost reduction was achieved by the Chinese manufacturers, enabling an on-grid parity with the traditional fossil fuel power in China and elsewhere.

Figure 5-1: Cumulative Installed Wind Turbine and Solar PV Capacity in China



Source: International Renewable Energy Agency

As renewables continue to grow and China is expected to add over 100 GW of solar capacity this year, constraints have also become very apparent in power grid's capacity to absorb an increasing share of intermittent renewables, in availability of land resources, and in policies and regulations that would support a new business model to substitute the traditional one.

If not being squarely addressed, those constraints could jeopardize the future development of China's renewables. The policymakers are fully aware of how imperative it is, and decided to focus on tackling them, "eye-to-eye", with a new "Action Plan for High Quality Renewable Energy Development," (the Action Plan) released by the State Council on May 30th .

This Insight China report provides the following eight "Newness" as a high-level summary of the Action Plan:

5.1.1 New pattern of renewable energy exploitation

The Actions Plan calls for:

- Accelerate the construction of large-scale wind and solar power generation bases in the desert, Gobi, other barren land, and wasteland left behind coal mining. These projects will be supported by advanced coal-fired power projects to provide stable power output for transmission with ultra-high voltage grid lines to the power consuming regions;

- Promote the development of distributed wind and rooftop solar PV in rural areas to form new energy cooperatives as new rural energy development entities, in a similar manner as rural agricultural cooperatives, making rural areas not only as source of food supply but also source of clean energy supply; and,
- Promote the application of solar PV and wind technologies in industrial estates and industrial parks in the form of green energy microgrids and promote solar PV and solar heating in all buildings, including achieving 50% PV coverage in all new public buildings by 2025.

5.1.2 New Pattern of Renewable Energy Consumption

- Start direct sale of renewable power to industrial customers as a way to increase the share of electricity in end-use energy consumption;
- Launch green electricity trading pilot;
- Improve green electricity certificates, and promote trading of such certificates with effective connection to the carbon emission trading scheme; and,
- Encourage consumers to purchase manufactured products powered by green electricity.

5.1.3 New Type of Power System to Accommodate Growing Share of Renewables

- Bring power grid into full play as platform and hub for renewable energy connection and absorption;
- Upgrade power distribution system capability to absorb distributed power sources by turning it smarter and more interactive, and experiment with renewable-based DC power distribution system;
- Increase the flexibility of the power system, such as in coal-fired power plant retrofitting and upgrading, hydropower expansion, pumped hydro and other new types of energy storage, solar thermal power and demand-side responses; and,
- Create a new type of power system that could be able to accommodate gradually increasing quantity of renewables, by establishing new market, new operation mode, new technology system, new business models and new governance system.

5.1.4 New Breakthroughs in Regulatory Reform

- Increase the renewable energy project approval efficiency by creating a "green fast-track approval system" for collective approval of renewable energy projects;
- Waive the requirement for regulatory approval of wind power projects and integrated and interactive renewable-grid-storage projects; and,
- Simplify the grid-connection procedure by proving "one-stop" service platform.

5.1.5 New Momentum for Renewable Energy Technology Upgrading

- **Establish national renewable energy laboratories and R&D platforms with collaborative inputs from industry, academia and research communities;**
- **Increase R&D inputs for advanced game-changing renewable energy technologies;**
- **Search for solutions to major technological challenges through both bidding and competition schemes;**

- **Continue to achieve breakthroughs in high-efficiency solar cell, wind turbines, key basic materials, and key components of the renewable energy industry;**
- **Promote creation of new value chain in the recycling of solar panels and wind turbines;**
- **Promote the integration of electronic industry with renewable energy industry to collectively ensure the silicon supply chain security; and,**
- **Participate international standardization work and promote global recognition of Chinese standards.**

5.1.6 New Market Mechanisms for Renewable Energy Development

- Support direct sales, via long-term power purchase agreement, between renewable energy developers and end-use consumers, with grid companies having the wheeling obligations;
- Encourage renewable energy projects to participate through CFD (contract for difference) in electricity spot-trading markets;
- Include renewable energy projects in the pilots of "Real Estate Investment Trust" (REIT) to increase the scope of financial support for renewable energy development; and,
- Include CERs from renewable projects in the carbon offset pool of national ETS.

5.1.7 New Ways of Evidencing Financial and Fiscal Support

- Consider those renewable projects with public good nature as targets for support by local governments' debts;
- Strengthen the support of green bonds and green credits for renewable project development, under the condition that risks are manageable, and under the same risk management condition,
- Allow banks to provide loans to renewable project developers against their unpaid over-due subsidies from the government.

5.1.8 New Public Service Platforms

- Establish a database for exploitable renewable resources across the country and make it accessible by all;
- Establish a sharing mechanism for wind data;
- Improve the comprehensive service system for disaster prevention and mitigation of renewable projects;
- Accelerate the establishment of renewable equipment standards and certification system; and,
- Build a national renewable equipment quality control and key product testing platforms.

These eight Newness reflect the policymakers' good intention to debottleneck the country's renewable energy development.

In our view, the most important will be the 3rd one - how to build a new type of power system that would gradually accommodate an increasing share of renewables.

This raises an interesting question: should the power system change rapidly to accommodate the rapid increase in renewables, or should the renewable development pace with the "new type of power system" construction?

The former is unlikely, given that the state-owned monopoly nature of China's power grid, one might fear that the latter will be the case, meaning that renewables will continue to fight hard with the incumbent power monopolies.

5.2 RENEWABLES IN THE 14TH FYP: GALLOPING IN THE POST-PARITY ERA

Insight China, June 9, 2022

China's progress in renewables has been admirable. With renewables at 1042 GW accounting for 42% of its total installed power generation capacity in 2021, China's ranks number one globally in annual addition of hydropower for 17 consecutive years, in wind power for 12, in solar PV for 7 and in biomass power for 4 consecutive years. Renewables are moving at a faster pace from the edge to the center stage of China's energy/power system, leading the country's transition towards decarbonization.

However, a decade-long steadfast scaling has led to a reality that much of the lower-hanging fruits have already been harvested. Further development will require existing hurdles be cleared and new breakthroughs achieved on a number of fronts, as outlined in our previous Insight China report – Powering Renewables to New Heights, for renewables to gallop in the post-parity era. It also demands a much closer collaboration among government agencies that involve resource assessment, land and sea surface utilization, meteorological service, ecological protection, financial and fiscal support, among others.

That's why China decided to publish a most comprehensive-ever 14th FYP for Renewable Energy Development (the FYP), on June 1st, not conventionally by the NDRC/NEA, but jointly by 9 ministries or agencies[6], that will sync and propel the new phase of scaling renewable energy, and turn it a major fuel in the country's energy mix.

This Insight China report provides a summary of key elements of the FYP.

5.2.1 Targets:

China's NDC commitment under the Paris Agreement was, by 2030, to have 25% share of its total energy consumption generated from non-fossil fuels, i.e. renewables plus nuclear, in which 1,200 GW will be installed wind and solar capacity. By the end of 2021, the country had already reached 636 GW of solar and wind capacity. With solar and wind installation growing over 100 GW per year, the confidence of overshooting the 2030 target is very high. The major issue therefore is not installed capacity but the energy volume generated from renewables.

To meet the 2030 target of 25% of non-fossil fuel consumption volume, the Energy 14th FYP has set a 2025 target of 20% total energy consumption from non-fossil fuels.

To delivery those targets while taking into consideration resource availability, economic feasibility and project readiness, the FYP has specified a set of quantitative targets as shown in Table 5-1.

6 Nine ministries/agencies include NDRC, NEA, Ministry of Finance, Ministry of Urban and Rural Construction, Ministry of Agricultural and Rural Affairs, National Meteorological Agency, National Forest and Grassland Agency.

Table 5-1: Targets for Renewable Energy Development 2021-2025

Indicator	Targets
Total renewable energy consumption	• one billion tce (tons of coal equivalent) in 2025 (up from 680 million tce in 2020); • renewable energy: >50% of incremental energy demand, 2020-2025
Renewable power generation	• 330 TWh per year in 2025 (up from 221 TWh in 2020); • Renewable power >50% of incremental electricity demand during 2020-2025. • double the wind and solar power generation, 2020-2025.
Renewable power absorption quota	1. 33% nation-wide of renewables/total electricity demand in 2025 (up from 28.8% in 2020); 2. 18% nation-wide of non-hydro renewables/total electricity demand in 2025 (up from 11.4% in 2020).
Non-power renewable energy production	3. 60 million tce by 2025 (including solar heat, geothermal, biomass heat and biofuels).

As noticed, all targets involve production or consumption volume, either in kWh or in tons of coal equivalent (tce), none about installed capacity. Among them, two sets of targets merit particular attention:

1. **Renewables are set to take more than 50% share in both incremental energy demand and incremental electricity demand during 2021-2025; and,**
2. **Renewables power absorption quota** was introduced, for the first time, during an official FYP. This is the "mandated" obligation for a local administration to consume renewables within its jurisdiction. Such a top-down command-and-control tool is expected to push local authorities to absorb more renewables in their power consumption portfolio. We will explain this mechanism in another Insight China report.

5.2.2 Supply side: scale up production

Now that renewables are already at power parity with coal and no subsidy is required, the FYP calls for scaling up production from both large-scale production bases and distributed sources:

- Build **large-scale (>10 GW) renewable production bases:**
  - Accelerate the construction of **wind and solar power generation bases** in the

north, north-west and northeast regions of the country, with focus on desert, Gobi, other barren land, and wasteland left behind coal mining. Seven such large-scale production bases are listed in the Plan;

  - Build **hydropower plus wind and solar production bases** in the southeast region where hydro resources are abundant, with two such bases on the list;
  - Scale up **near-coast wind** power development to achieve grid-parity, promote **remote offshore wind** technology innovation and application, build offshore integrated resource utilization projects combining wind, tide, energy storage, hydrogen production and seawater desalination, with five large-scale offshore wind power generation bases on the list.

- Actively exploit distributed **wind power** resources in:
  - Industrial parks, economic zones, oil and gas fields, mineral mines, barren hills and coastal beaches; and,
  - Rural areas with a national program of "ten thousand villages capturing wind", spanning 100 counties.
- Full flung promotion of **distributed solar PV**:
  - Promote PV installation in industrial parks, economic zones and public buildings;
  - **Urban rooftop solar program**: increase PV coverage of existing roofs, with at least 50% of new roofs in industrial zones and public buildings mandated to be equipped with solar PV by 2025;
  - **Rural PV program**: build 1,000 solar PV villages by 2025; and,
  - Promote joint development of **"PV +"** in agriculture, fish farms, railways, highways, EV charging stations, highway service stations, 5G base stations and data centers.
- Promote orderly development of **hydropower,** with due consideration of ecological impacts;
- Steadily develop **biomass** power generation and biomass heating, accelerate the development of biogas;
- Actively promote the development of mid-to-high-depth g**eothermal** heating and cooling, fully exploit shallow-depth geothermal energy via heat pump technologies, and orderly promote geothermal power generation; and,
- Promote demonstration of **ocean energy** exploitation, including tidal and wave power, and support the construction of 10 MW tidal power demo project.

5.2.3 Energy storage: increase capability

- Accelerate construction of **pumped hydro** storage capacity (see Insight China report of April 12, 2022);
- Build **terrace or cascade hydropower storage** pilot projects along the Yellow River;
- Promote the development of long-duration solar thermal storage with the goal of improving output stability of renewable energy systems; and,
- Promote the development of **other new types of energy storage applications**. Grant them the status of an independent power generation entity with unique role in peak-shaving, frequency adjustment, emergency power and capacity support.

5.2.4 Demand-side: debottleneck absorption

- Strengthen power **grid's capability to absorb renewables** both for long-distance transmission from production bases to consumption centers, and for local consumption;
- **Increase the share of renewables in the existing large-scale power transmission lines** from the west to the east;
- Improve the **flexibility of coal-fired power fleet** so that they can better support the integration of intermittent renewables;
- Promote the **direct uses of renewables** with dedicated customers, dedicated transmission lines or through the construction of micro-grids or DC-based distribution grids;
- Promote the **direct use of non-power renewable energy sources**, with particular focus on heating;
- Build pilot application projects in industrial parks, airports, railway stations, schools and hospitals for **heating, cooling and electricity,** with renewables taking a higher percentage share;
- Build demo projects for **large-scale hydrogen production** with renewables;
- Expand the use of renewables in rural areas; and,
- Develop **new patterns of renewable energy utilization** with new business models, supported by new professional services.

To enable the above actions, the FYP calls for the strengthening of regulatory measures, both administrative and market-based, to overcome the existing hurdles and drive renewables to new heights.

Among them, "**renewable power absorption quota**" (**可再生能源电力消纳责任**) is the most intriguing, if not most innovative. It is full of Chinese characteristics, but also very imperative when accelerated scaling of clean energy transition is the priority. We will explore that in our next Insight China report.

5.3 RPAQ: CHINA'S SCREW-DRIVER TO EXPAND RENEWABLE ENERGY CONSUMPTION

Insight China, June 16, 2022

As stated in our two previous reports, China's PV and onshore wind have already reached grid-parity with coal-fired power, requiring no subsidy for further scaling their deployment. At the same time, much of the "lower-hanging fruits" have already been harvested, so next-phase development will require the remaining hurdles be cleared and new policy tools be invented.

Inspired by the RFS (renewable portfolio standards) practices in the US and also based their own experiences in fostering energy conservation (see Insight China report of April 25, 2022), the Chinese policymakers have found a new tool - the RPAQ or "renewable power absorption quota", to accelerate the green transition. This Insight report decodes how it works.

5.3.1 RPAQ in a nutshell:

RPAQ is a "mandated" obligation for a local administration and market participants within its jurisdiction to absorb certain percentage of renewables in their total power consumption. It was designed by the National Development and Reform Commission (NDRC)/ National Energy Administration (NEA) as a top-down command-and-control policy instrument that forces market participants to absorb more renewables in their portfolios.

The RPAQ was first promulgated by the NDRC/NEA in May 2019, with detailed methodological guidance and procedures for calculating the numbers for each of China's 30 provinces (Tibet is exempted). In May 2022, the 2021-2022 RPAQs for each and every province were published. They are aligned with the targets set in the 14th FYP for Renewable Energy Development, released on June 1st 2022, which has set the 2025 target of RPAQ at 33% (or 18% of non-hydro renewables) of total electricity consumption as a national average.

5.3.2 How RPAQ works?

Calculation:

RPAQ consists of two indicators: RPAQ total renewables (RPAQ-TR) and RPAQ non-hydro renewables (RPAQ-NHR). To further complicate the system, each province is imposed with a minimum quota and an incentivized quota for both RPAQ-TR and RPAQ-NHR as illustrated by Table 5-2.

Table 5-2: Renewable Energy Absorption Quotas for Year 2021 in Select Provinces

Province	Total Renewables Quota		Non-hydro Renewables Quota	
	Minimum	Incentivized	Minimum	Incentivized
Beijing	18.0%	19.8%	17.5%	19.3%
Tianjin	17.0%	18.7%	16.0%	17.6%
Hebei	16.5%	18.2%	16.0%	17.6%
Shanxi	20.0%	22.0%	19.0%	20.9%
Inner Mongolia	20.5%	22.6%	19.5%	21.5%
Liaoning	15.5%	17.1%	13.5%	14.9%
Shanghai	31.5%	35.0%	4.0%	4.4%
Jiangsu	16.5%	18.2%	10.5%	11.6%
Sichuan	74.0%	82.0%	6.0%	6.6%
Yunnan	75.0%	83.0%	15.0%	16.5%

RPAQ-NHR is the share of all non-hydro renewables in the total electricity consumption of a province.

- **RPAQ-NHR**-minimum = (total non-hydro renewable energy production within the province over the target year + net import of non-hydro renewables from neighboring provinces)/total electricity consumption of the province.
- **RPAQ-NHR**-incentivized = **RPAQ-NHR**-minimum plus 10%.

RPAQ-TR is the share of all renewables in the total electricity consumption of a province.

- **RPAQ-TR**-minimum = (total renewable energy production within the province over the target year + net import of renewables from neighboring provinces)/total electricity consumption of the province. When calculating total renewable energy production, a 10% discount is given for hydropower production in a normal hydraulic condition year.
- **RPAQ-TR**-incentivized = **RPAQ-NHR**-incentivized + expected share of hydropower in total power consumption in a normal hydraulic condition year.

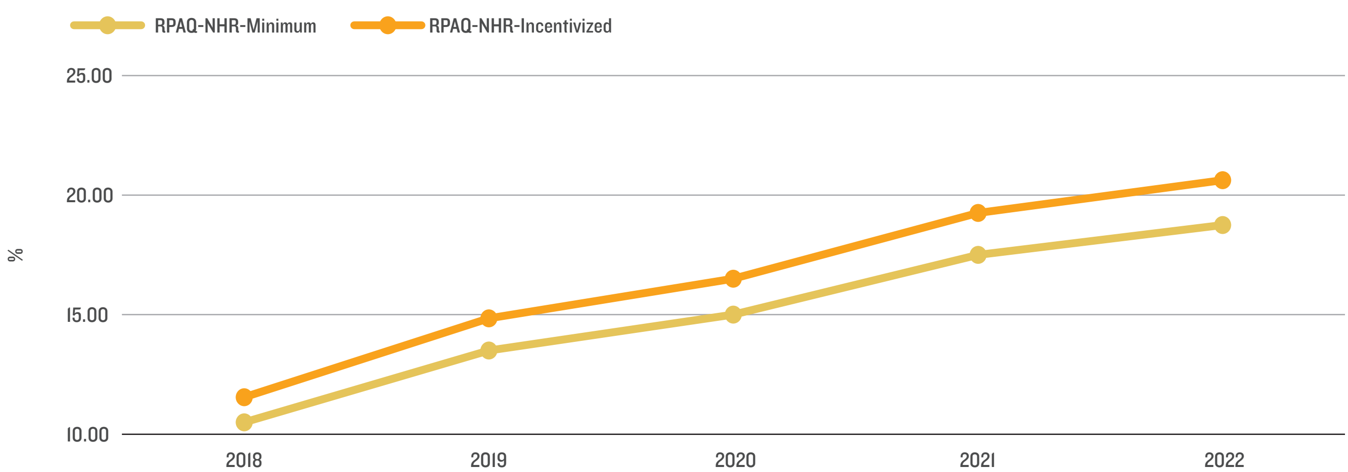
Process:

The provincial quotas are determined by a four-step approach:

1. the NDRC/NEA provides an initial draft to seek feedback from provincial authorities;
2. provincial authorities study the proposed quotas with the assistance of local grid companies and provide feedback to NDRC/NEA; and,
3. the NDRC/NEA, assisted by a professional third party, studies the received feedback and publishes the quotas before end of March each year, which contains the compulsory RPAQ targets of the current year, and the expected targets for the following year, for each of the 30 provinces.
4. Provincial governments are mandated to submit their year-end result to the NDRC/NEA for verification by February of the following year.

Both RPAQ-TR and RPAQ – NHR are getting higher and higher each year, as illustrated in Figure 5-2 for RPAQ-NHR of Beijing. Nationwide, such a trend literally demonstrates how steadfastly the national government has been screw-driving a rising share of renewables in the country's power/energy mix.

Figure 5-2: Beijing City's Non-Hydro Renewable Power Absorption Quotas for 2018-2022



Fulfillment:

Provincial authorities deconstruct their respective quota and allocate downwards to two kinds of market entities: 1) those who distribute and sell electricity, for them to force power consumers to take more renewables; and 2) those end-users who buy electricity from the wholesale power market and those who have their own power generation facilities. Each of them is tasked to take a certain share of renewable energy in their power consumption portfolios.

To fulfil their quota, market entities can buy a portion from those whose actual consumption has already exceeded the allocated quota, or purchase the "green certificates" of renewable electricity to offset the actual consumption.

There are some exemptions in quota accounting, particularly when the calculation of total power consumption is concerned. For example, agricultural uses of electricity, electricity used by "strategically important projects" located in the province, or consumption related to some specific programs such as winter-heating in northern rural areas will not be counted in the total power consumption, making the denominator smaller, therefore the RPAQ higher.

Assessment:

For a given province, RPAQ = (volume of renewable power produced and consumed within the province + net-import volume of renewable power from other provinces + volume of net-quota transaction among market entities within the province + volume of green certificate purchased – volume of renewable power exempted from the assessment) / (total power consumption within the province - volume of power consumption exempted from the assessment).

While the minimum quota forms part of the provincial governments' KPI which is compulsory, the incentivized quota does not have much incentives beyond the reduction of the over-consumed volume from the province's energy consumption quota.

More detailed rules were provided in the May 2019 NDRC/NEA document, they are being refined with gained experiences.

5.3.3 RPAQ vs RFS

One might say that the Chinese RPAQ looks like the US equivalent of RPS (Renewables Portfolio Standards) which is created by some states, e.g. California, to diversity their energy portfolio by requiring power utilities to procure a specified percentage of electricity from renewable resources. But differentiations are notable.

RPS is started at state level and imposed as a legislative measure to encourage renewable energy development, in which electric utilities and other electricity retailers are required to supply a specified minimum percentage (or absolute amount) of total power demand with eligible resources of renewable electricity.

RPAQ is designed as a national top-down administrative tool that imposes specific renewable electricity quotas to provinces, which are then further cascaded down to power market participants.

As such, the RPAQ features Chinese "command-and-control" mentality, which may not be reproducible in many other countries. Despite the hurdles in its implementation, it is a tool which the Chinese policymakers are so used to and so eager to deploy, to bring renewable energy development to the next phase.

5.4 BIOENERGY: REPOSITIONED FOR TACKLING NON-ENERGY SUSTAINABILITY PROBLEMS

Insight China, June 24, 2022

Bioenergy or biomass energy is believed to be a sustainable fuel, given its life cycle effect of net-zero emission. CCS integrated bioenergy, or BECCS, is believed to have a major role in global netting-zero roadmap.

However, China seems to have a rather differentiated consideration. Although bioenergy development is still very much encouraged, two recently published 14th FYP documents, namely the 14th Five-Year Development Plan of the Bio-based Economy (the Bioeconomy Plan) published on May 10 by the NDRC, and the 14th Five-Year Plan of Renewable Energy Development (the RE Plan), jointly released by eight ministries/agencies on June 1, chart a new course of China's biomass energy development.

This Insight China report makes an effort to interpret this new positioning of biomass energy in China's green transition.

5.4.1 Bioenergy as part of a broader bio-economy:

Contrary to the earlier five-year planning when a specifically designated FYP would be made for bioenergy, the current FYP planning, instead, has it covered in two broader plans - one on bioeconomy and the other on renewables.

The Bioeconomy Plan covers a very large spectrum of activities covering medical, healthcare, agriculture and food, forestry, energy, environment and material sciences and industries. The policymakers believe these activities are inter-related to one another, and prefer to see bioenergy development as part and within the framework of "strategic emerging industries around the bioeconomy", much broader in coverage and larger in scale.

The Bioenergy Plan is more focused on innovation, including identification of fast-growth, high-yield, and highly resilient energy crops; conversion of municipal wastes into ethanol, biodiesel and bio-methane; utilization of municipal wastes for heat and power generation, utilization of solid biomass materials for heat and power co-generation and to replace coal for residential heating, etc. No specific target is set for any time horizon.

5.4.2 Bioenergy as a member of renewables:

Biomass energy is harnessed in three essential ways: heating, power generation and conversion into liquid and gaseous fuels. A combination of them offers often better economic efficiency.

Heating is the oldest practice ever since human existence. Over the past four decades, replacing fuelwood by coal for heating and by LPG for cooking has been the norm, along with improved stoves for better efficiency and less pollution, as part of China's modernization process. Reversing the trend and return to fuelwood for heating and cooking represent a significant challenge in supply chain and cultural acceptance due to low climate sensitivity of the population.

In power generation, bioenergy has been dwarfed by the leapfrogging growth of solar and wind. By the end of in 2021, the total installed capacity of biomass power generation reached 3.8 GW, accounting for 0.36% of total installed renewable capacity (1,042 GW). This is tiny compared to an annual addition of 100GW of solar and wind power capacity. However impressive the growth of biomass-fired power can be, it will remain marginal in China's power mix.

One of the problems of biomass power generation is the low energy density of municipal/agricultural wastes, which requires blending coal to sustain power output.

Lack of control on the proportion of coal in the feedstock mix has witnessed biomass power plant owners burning coal as the main feedstock and yet still awarded the benefit of the highly-subsidized on-grid power tariffs. The discovery of this fraud in 2016 had caused a serious blow to biomass power development.

Biomass conversion involves mainly converting agricultural residues to bio-ethanol, for 10% blending with gasoline, converting municipal wastes into bio-methane or converting used cooking oils, animal greases and some agricultural products (e.g. jatropha) into bio-diesel. China's biofuel program was initially developed based on the need to absorb expired corns in the national grain reserve, to find an outlet for the replaced old grain stocks. But the situation got a bit out of control when new corns were being used for biofuel production too.

As corn stocks were down and grain prices were high, corn-based ethanol market became unsustainable. In late 2020, China suspended a nationwide plan for blending gasoline with 10% ethanol from 2020 onward after a sharp fall in the country's corn stocks and limited harvest due to unprecedented flooding. Major part of the biodiesel production, 1.5 million tons in 2021, mainly from spent oils and animal greases, was exported, mainly to Europe, while agricultural-based production never took off.

A dear lesson learned is that biofuel development must safeguard the food security bottom line, be it for ethanol, biodiesel or bio-jet fuel, without disruption to either grains or arable land.

5.4.3 Biomethane as a means to manage municipal wastes

Biomethane in China was initially used in rural areas as a clean cooking fuel in southwest provinces where abundant organic agricultural residues, household waste and animal drops were available with favorable temperature conditions which facilitate the fermentation.

Now and in the future, it will be in the cities where biomethane will find its biggest potential, in terms of both feedstock availability and market for new capacity and projects. In terms of feedstock, China produces about 6.3 billion tons of organic waste on average every year. Currently, only about 5% of the organic waste is processed and converted to energy in the form of gas, heat and power. In terms of market, bio-methane can be easily blended into existing urban gas distribution system to meet the growing gas demand.

Managing the mountains of municipal wastes is a top priority for both central and local government, with the desire to build a zero-waste society. A national program for building zero-waste cities is underway (see Insight China, No. 015/2022). Biomethane offers a new way of getting these mountains removed beyond traditional landfills and incineration.

Biomethane is expected to grow from about 2 bcma (billion cubic meters per annum) in 2020 to more than 15 bcma in 2025 and 30 bcma by 2030, according to a draft guideline issued by the NEA back in 2019.

5.4.4 Bioenergy development priorities:

The RE Plan provides four major tracks for biomass development including power generation, clean heating, bio-natural gas, and non-grain liquid fuels, as highlighted in Table 5-3.

Table 5-3: Four Tracks of Bioenergy Development

Track	Focus
Power generation	1. Optimize biomass power generation development, with steadfast development of **urban household waste-to-energy** and explore the development of combining biomass power generation with CCS, or **BECCS** technology. 2. Orderly develop biomass combined heat and power **(CHP),** with accelerated retrofitting and upgrading of biomass power generation to CHP that match local resources and demand. 3. Develop biomass **heating** for urban areas and county villages with high population concentration where resources are available, and provision of centralized heating for small- and medium-sized industrial parks. 4. Demonstrate "marketization" of biomass power generation, better **levy system** at regional garbage incineration and disposal, and restore environmental value of biomass power generation.
Clean heating	1. Rationally develop **biomass boiler heating** from **agricultural and forest biomass and biomass formed fuels**, encourage adoption of large- and medium-sized **boilers**, provide centralized heating at areas with high population density in cities and towns, and pilot thermal and heat supply from agricultural and forest biomass 2. In villages not included in key air pollution prevention and control regions, promote **household stove heating** with formed fuels wherever resources fit, following principles of local sourcing
Bio-methane	1. In large planting and breeding counties located at regions designated for major grain production, three forestry residue enrichment areas and where livestock and poultry breeding are concentrated, build **county-based industrial system** and actively pilot **biomethane** projects 2. Coordinate planning and construction of **large scale biomethane projects** with an annual production capacity of ten million cubic meters, and shape up application models that connect with urban gas pipelines and network, and is used as vehicle fuel, boiler fuel and for power generation
Non-grain liquid fuels	1. Actively develop **cellulose and other non-grain ethanol** and encourage demonstration of **poly-generation** of alcohol, electricity, gas and fertilizer 2. Support R&D and deployment of advanced technology and equipment in such areas as biodiesel and bio-jet fuel

5.4.5 Demonstrating how to scale:

The RE Plan has put forward three demonstration routes, as summarized in Table 5-4, to develop, at scale, biomethane, biomass-fired power, and biomass heating, taking into consideration materials/resources availability and accessibility.

Table 5-4: Demonstration priorities for bioenergy development

Route	Geographic focus
Biomethane	**Provinces:** Hebei, Shandong, Henan, Anhui, Inner Mongolia, Jilin and Xinjiang **Regional features:** rich in organic wastes, high pressure on disposal of livestock and poultry wastes, and high demand on gas **Pilot counties:** each county to build one to three bio-methane projects at production capacity of 10 million cubic meters per year, and drive the establishment of circular industrial systems that dispose of rural organic wastes, produce and consume organic fertilizer, and utilize clean gas
Biomass power generation	**Regions:** the Yangtze River Delta and the Pearl River Delta regions **Regional features:** economically advanced with good foundation of practicing garbage disposal levies **Pilots:** operationalize household waste to energy market, and implement competitive electricity pricing mechanism in reference to local coal-fired power plant
Biomass heating	**Regions:** villages at Northern China, Northeast China and Central China **Pilots:** promote various uses, such as formed biomass fuels for household stoves and centralized biomass boilers

5.4.6 The future of bioenergy:

Two conclusions can be drawn from the above analysis. One is that bioenergy in China cannot be developed as an energy carrier and for the energy purpose like other fuels. It must not interfere with food security and its supply chain, and its main purpose is to address non-energy problems such as disposal of municipal wastes and agricultural/forestry residues.

And the second, because of the first, is that bioenergy development must be assessed within the context of broader environmental cleaning up. Except for a few cases where resources are abundant, bioenergy project can hardly be developed as stand-alone. Its business model involves more environmental economics than energy business and its potential will depend more on the environmental policy rather than the energy need.

These considerations are, in our view, behind the modest target in the 14th RE Plan, which sets the target for non-power renewables (mainly bioenergy) to reach 60 million tons of coal equivalent by 2025. This will represent only 6% of the total renewables or 1% of China's total energy consumption.

5.5 CHINA'S DOMINANCE IN SOLAR PV SUPPLY CHAIN: QUO VADIS?

Insight China, July 12, 2022

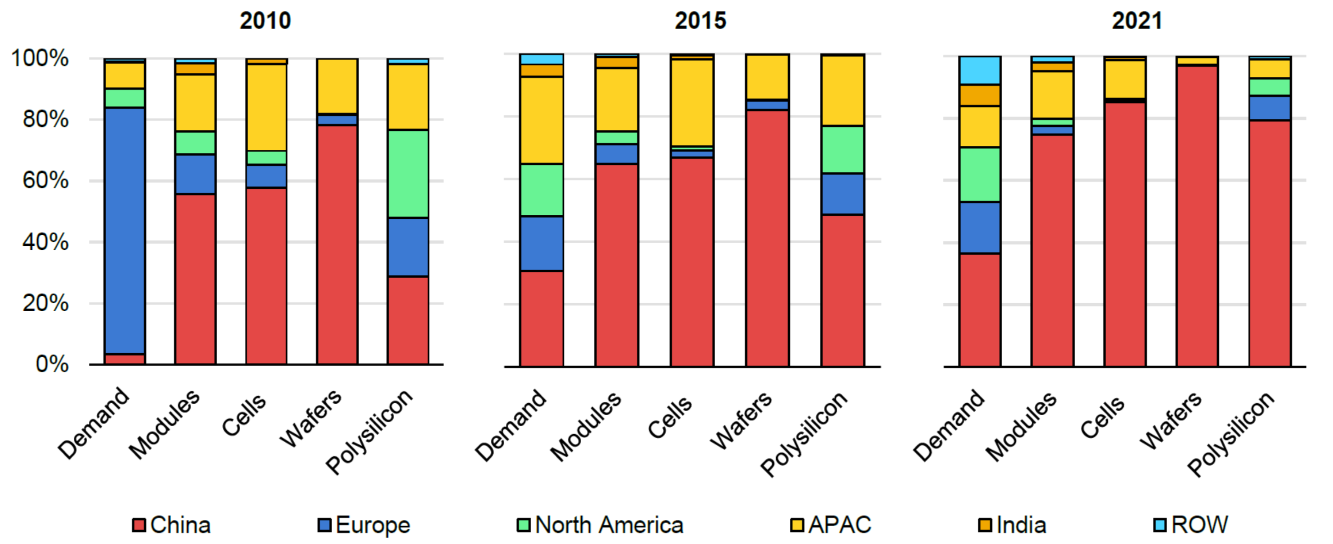
On 7th July, the International Energy Agency (IEA) released a highly substantive Special Report on Solar PV Global Supply Chains, highlighting China's dominance in that landscape and calling for diversification to ensure a secure transition to net-zero emissions.

This Insight China report offers additional perspectives on how China's dominance emerged, what are the hurdles for diversification, and a new thinking on tackling the dilemma facing the OECD countries.

5.5.1 How China built its dominance?

According to IEA, China accounts for over 80% of global shares in solar PV supply chain from polysilicon, wafers, cells to modules (Figure 5-3), and China's current investment plan would further elevate its share of global polysilicon, ingot, and wafer production to almost 95% soon. China today is also home to the world's 10 top suppliers of solar PV manufacturing equipment.

Figure 5-3: Global Share of Solar PV Supply Chain



Source: IEA.

The IEA attributes China's success to the country's industrial policies and cost competitiveness. The report states that Chinese industrial policies focusing on solar PV as a strategic sector and on growing domestic demand have enabled achieving economy of scale and supported continuous innovation throughout the value chain. These policies have contributed to a cost decline for more than 80% over last 10 years, helping solar PV to become the most affordable electricity generation technology in many parts of the world. On cost competitiveness, the IEA says costs in China are 10% lower than in India, 20% lower than in the United States, and 35% lower than in Europe. These discrepancies are mostly due to large variations in energy, labor, investment and overhead costs.

While in generally agreement with this broad assessment, we would add three points to further explain the causes leading to the current situation.

The first is the market dynamism of Chinese private entrepreneurship. Contrary to the conventional wisdom that China's industrial policies are better carried out by state-owned enterprises, its solar PV supply chain has been built essentially by private entrepreneurs who seized the global market opportunity in the early 2000s and who persisted despite bumpy road with rounds of reconsolidation and fatal bankruptcies Thus, this is a success of Chinese private entrepreneurship.

The second is the fact that solar manufacturing is just part of the overall manufacturing capability China has built since its WTO membership in 2001, which created the window of opportunity for it to become the "world's factory". With that capability, China provided what is needed for every segment of the solar PV supply chain to succeed, such as raw materials (minerals and metals), industrial clusters (industrial parks), financial loans, engineers and skillful workers, etc in the backdrop of a national development strategy to build a manufacturing-based economy.

And the third is the failure or inadequacies of OECD countries' industrial policies. While China has successfully translated its climate commitments into industrial policies to develop renewables, Europe stayed, to certain extent, at lip services and US has undergone a few rounds of in-and-outs in the global climate pacts.

5.5.2 Hurdles to diversification

When China faces growing energy security risks by importing more and more oil, with large concentration in the Middle East, the government takes steadfast steps to diversify its energy supply as important means to energy security. Thus, the IEA's call for diversification would not be strange to the Chinese ears, even though crude oil and solar panel are fundamentally different products.

However, building an entirely new supply chain in Europe or America requires the two afore-mentioned elements in place: private entrepreneurship and overall engineering and manufacturing capability, to be supported by stable and down-to-the-earth industrial policies to make the projects bankable.

But building a factory is one thing, making it competitive is another. Given China's current dominance in the global supply chain, any new factory outside will have to source most of its inputs from China. Transportation costs, plus higher electricity cost, particularly in Europe nowadays, will make the factory hard to compete with those in China. No investor will put money if the products can't compete in the market even with protective policies.

5.5.3 Way forward

The China PV dominance, overwhelmingly, has created a "love-and-hate" sentiment in the OECD countries, as reflected in the most of the headlines following the IEA report release. On one hand, the world needs the made-in-China PV panels to achieve the net-zero goals, and on the other, China's leading position in the sector has been turned into a cause of concern, or even a threat for those with a zero-sum game mindset. Diversification, although highly desirable, is unlikely to achieve the scale needed to fulfil the 2030 climate targets under the Paris Agreement.

One practical way forward would be for the OECD countries to attract Chinese private entrepreneurs to jointly set up manufacturing facilities. Those entrepreneurs, mostly family-run businesses, have built a successful solar business in China. They also feel an urgent need to diversify their investment portfolio and therefore would appreciate the opportunity to build capacities closer to markets. Their skills and know-how, accumulated over last twenty years will be indispensable for building a successful supply chain outside China.

More strategically, if climate change remains one of the few common causes that can still unite China and the OECD economies, one should think it an opportunity for cooperation, rather than a security threat that would draw the parties further away.

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6

POWER SECTOR TRANSITION

6.1 CAN A NEW "BODY" FIT IN AN OLD "SKIN"?

Insight China, September 29, 2022

A country's electric power system plays an instrumental role in its energy transition. As part of China 2030/2060 peaking/neutrality commitment, Chinese policymakers vowed to build a "new power system" (NPS) with new and renewable energies at core of its architectural foundation.

But delivering such an ambition requires fundamental reform of the existing power regulatory regime. Clarity is needed on what features the NPS in comparison with the old one, and how could the old power regulatory "skin" accommodate a growing new power "body".

This Insight report makes an attempt to answer these questions.

6.1.1 The "New Body"

China's NPS, by design, is expected to have the following attributes:

- **Low carbon** as its defining characteristic, the NPS requires a rapid expansion of renewables and nuclear power.
- **Secure and reliable** at its foundation.
- **Smart and interactive,** massive amount of power electronics and digital technologies are connected and also connecting all devices in the power value chain in a coordinated manner.
- **Flexible,** as the NPS must have enough capability and flexibility to accommodate the connection of intermittent renewables to the grid at large scale.
- **Integrative** and as the backbone of modern society, the NPS shall offer the foundational infrastructure that allows other infrastructures (such as mobility) to **plug and play** in all the nodes in the system.
- **Robust and resilient**, the NPS must be able to effectively respond to threats from climate-induced extreme weather events and other disasters, as well as those of cyber security threats.
- **And efficient and cost effectiv**e, it shall prove to be efficient from a system perspective and shall be affordable for the end users.

Such a system distinguishes itself from the traditional fossil-fueled system, and Table 6-1 below compares the two systems in technical terms.

Table 6-1: Differences between Old and New Power Systems in China

Area	Old Power System	New Power System
Generation	Centralized large-scale coal-fired, gas-fueled or hydropower units, with stable output which can be dispatchable based on load curve. Storage is only needed for peaking purposes.	Massive number of decentralized small-scale generation sources with strong intermittency and output fluctuation. More flexible sources of stable power will be needed to overcome the shortcomings of renewables, with pumped hydro energy storage, electro-chemical energy storage, peaking gas units, flexible coal units and hydrogen as a means of energy storage. Storage is indispensable for grid stability, to avoid renewable curtailment, to keep grid stable through frequency modulation, etc.

Area	Old Power System	New Power System
Grid: Transmission and Distribution	Grid system is characterized by high voltage, long distance, and high degree of cascading and synchronization. Ultra-high voltage (1,000kV) long distance transmission lines play as backbones of the grid.	Grid becomes flattened, distributed and localized. UHV transmission lines are no more needed if renewables are consumed locally.
End-uses	Consumers are passive users of power	"Prosumers": consumers also produce power and feed into the grid. Demand side response: consumers adjust their demand according to price signal and other incentives. EV and other storages serve as peaking facilities.
System Operation	Central dispatching according to merit order of different generation units. Dispatching system is organized in five pyramid levels: national, cross-provincial, provincial, city, and county level, with lower-levels obeying orders from the above. System inertia and short circuit capacity increase as generation capacity and power grid expand; No generation sources connected to the distribution grids and power flows only in one way. Transmission and distribution are integrated in a master-slave relationship. Storage is not strictly required. It is a "nice to have" option. Flexibility is not strictly required. Digitalisation focuses on synchronization of generation-side electro-mechanical operations.	Less need for central dispatching as renewables are mainly connected to the distribution gids and consumed locally. Dispatching is more efficient at regional level: region can be a province or a few provinces, depending on complementarity of different provincces. System inertia and short circuit capacity decrease with high penetration of renewables and power electronics. Massive amount of generation sources connected to the distribution grid, making its power flow bi-directional, and changing it to self-balancing local micro-grid network. Transmission and distribution in a mutually supportive, two-way interactive, collaborative and symbiotic relationship. Storage is an integral part of the NPS along with generation, grid and loan. Flexibility is the key feature of the NPS, required in all its components. Digitalisation focuses on data synchronization, with synchronization of physical and cyber systems through a massive deployment of power electronics and digital technologies that connect all devices of the power value chain.

6.1.2 The "Old Skin"

Given the above differences, the NPS which Chinese policymakers have in mind represents a disruptive remodeling of the country's existing power system. It begs the question whether such a new system can be built within the "old skin" of the existing system.

Historically, China went through two major rounds of power regulatory reform.

The first round, carried out in 2002, separated generation from transmission and distribution. It created five large-scale power generation companies, two grid companies, and a dozen specialized service companies. The two grid companies, the State Grid covering the major part of the country in the north and the Southern Grid covering five southern provinces of Guangdong, Guanxi, Guizhou, Yunnan and Hainan, are unique buyer and seller in their respective territory[7].

The second round, carried out in 2015, broke the monopoly of grid companies in purchasing and selling electricity, by allowing big consumers to purchase electricity directly from generators. From there it introduced a national power trading market, where a growing portion of power is traded in the market, reaching 45% in 2021.

No major reform was carried out since the 2015 round despite repeated calls, particularly since the building of a NPS was called for in March 2021. Successive government plans all called for the reform of the old "skin" to accommodate the growing new "body".

6.1.3 Can the "old skin" accommodate a growing "new body"?

From energy transition perspective, China's current power regulatory system, featured by the super monopoly of two grid companies and suitable for the old power system, appears increasingly inadequate to the construction of the new one.

First, the old system which is protected by the outdated 1996 Electricity Law, forbids the private entities in selling electricity across the fence to their neighbors. All generated power from distributed sources must feed into the grid system with low prices, which significantly reduces the financial return of the distributed power system.

Second, the distribution today is considered part of the transmission system. As part of the very rigid state-owned monopoly, it does not encourage the connection of distributed renewables, not to mention the interactions with the load, through demand side responses and other flexibility measures.

Third, the power trading market, designed for large scale coal-fired plants, is not suitable for distributed renewables. New regulations were tried to incentivize renewables power trade which changes faster than the fossil-fueled power, requiring a quicker, shorter and larger balancing system, and a more sophisticated trading rule.

And last, but not the least, there is no apparent political will to reform the state-owned power monopoly. Beside vague mention of "power system reform" in all government papers, there is no clear idea how to reform the old system so that it can accommodate the NPS.

Either the "old skin" be reformed to support the growth of the NPS, or the construction of the NPS will be slowed

7 Around 15 small and independent grid companies still exist within the territories of the State Grid and Southern Grid, the largest one is the West Inner Mongolia Power Grid or Mengxi Grid.

due to the constraints of the "old skin". Unfortunately, we believe the latter will prevail, and the bottlenecks will appear soon.

6.2 BREAKING UP A MONOPOLY GIANT? UNLIKELY!

Insight China, October 12, 2022

Our previous report highlighted the urgent need for China to reform the power regulatory "skin" to suit a growing new power "body" which is drastically different from the old one. In this edition, we'll investigate how a "new skin" may look like and how feasible it is to change the "skin".

6.2.1 The current grid "skin"

As briefly described in the previous report, China's current power sector regulatory regime was set up in 2002, by the famous reform "Document No.5" of the State Council. That reform separated generation from transmission and distribution. It created five large-scale power generation companies, two grid companies, and a dozen specialized service companies.

The two grid companies, the State Grid covering major part of the country in the north and the Southern Grid servicing the five southern provinces of Guangdong, Guanxi, Guizhou, Yunnan and Hainan, became the "single" buyer and seller of power in their respective territory. Figure 6-1 s hows the current setting of China's power grid system since 2015. It's worth mentioning that within the territories of these two state grid giants, there still exist a dozen small "independent" grid companies, the biggest of which - the Mengxi Grid - covers the western part of the Inner Mongolia.

Two most important features of this setting are: 1) transmission and distribution are integrated; and 2) grid companies enjoy both natural monopoly and administrative monopoly in buying and selling electricity in their respective jurisdictions, which allow them to purchase electricity from generators and sell it to end users, both on an exclusive basis. They further set up fully owned subsidiary companies at regional, provincial, city and county levels, making China's grid a pyramidal structure of five layers.

Such a "super grid" model is unique in size from a global perspective. European power grid, for example, is composed of over 20 national grids, and the much smaller Japanese grid is composed of and managed by 9 independent grids. And the US grid is even more sophisticated, comprising 4 regional transmission organizations, 3 independent system operators, and around 500 companies.

Figure 6-1: China's Power Grid System

(within the territories of these two state grid giants, there exist a dozen small "independent" grid companies, the biggest of which - the Mengxi Grid - covers the western part of the Inner Mongolia)

6.2.2 Growing inadequacies

One can argue that China is different, and a super grid model may fit suit better China's national conditions. But the problem is that the super grid proves increasingly difficult to cope with the power sector diversities at regional and local levels, with the rigidity in its operational and dispatching rules lagging seriously behind the market development. To make things worse, the State Grid, taking benefit of its monopolistic position over such a vast land, has built a number of ultra-high voltage (1,000kv AC and 800 kv DC) transmission lines, in the name of connecting the western resources to the eastern market, to further consolidate its monopoly position.

Chia vows to build a new power system with high penetration of renewables and high integration with digital devices, where grid acts as the backbone of a modern energy system that combines all other sources of energy in a complementary way. This new power system should be flexible in matching up production and demand, resilient in coping with extreme weather events and other major threats, stable in operations, smart in responding demand interactively, reliable in supplying the needed power without interruption, and affordable for end-customers.

These requirements make the current grid system increasing inadequate. The monopoly in buying and selling electricity rules out the possibility for a solar project owner to sell electricity to his neighbor without going through the grid company, thus inhibiting the development of decentralized renewables, energy storages and demand side response measures.

6.2.3 Policymakers' efforts

China's policymakers have recognized these problems. They tried to solve part of them through the 2nd round of reform in 2015, with the main philosophy of "managing the "middle segment" of transmission and distribution but opening up the "two ends" of power generation and power sales for competition. The two grid companies were requested to divest non-grid assets to focus on grid operations and to open up the power transmission lines to third parties.

This round of reform has "created" two main businesses, while maintaining the grid companies intact:

- The first is direct power sales and purchases between big power users and generators, which laid the basis for what is called today a "national power trading market".
- And the second is the so called "incremental distribution network" business, where private companies are allowed to build and own a new power distribution business, for a new industrial zone or a new city district.

The National Power Exchange now covers 45% of the country's total power consumption volume, but none of the pilots in "incremental distribution network" was proven successful. Given the apparent "success" of power trading, merely measured in terms of increased trade volume, the Chinese regulators have decided to focus their efforts on building up further the power trading market. They have also worked out more detailed technical regulations regarding the participation of renewables in the power market, which we shall cover later in a green power market report.

Despite these attempts, the fundamental problem remains: how can the highly integrated and vertically organized grid companies, particularly the State Grid, be reformed to support the energy transition?

6.2.4 What are the options?

Pro-reform voices are rare nowadays given the macro-political context in favor of state-owned entities, but there do exist some independent views. According to those voices heard, China needs to undertake another major reform of the power sector with two major operations:

1. Re-organize the State Grid into regional companies.
2. And separate distribution from transmission, and reform the distribution regime.

One pro-reform expert proposed to reorganize the State Grid into 6 regional grid companies including North East Grid, Northern China Grid, North West Grid, Central China Grid and South West Grid. Together with existing Southern Grid, China would have 7 regional grids.

According to this proposal, the State Grid's role is reduced to managing cross-regional transmission projects and conducting national power system planning, and the country would have only 4 layers instead of 5 in operational hierarchy – regional, provincial, city-level distribution grids, and micro-grids. Micro-grids and distribution grids will serve as the basic balancing units, absorbing most of the intermittent renewables. Provincial grids and regional grids each will try to balance the system at their respective level.

6.2.5 Will there be a new "skin"?

Despite the good wishes, such a proposal is unlikely to work for two basic reasons:

1. The State Grid won't easily give up its monopolistic position. It will find all excuses to resist any reform plan that is not compatible to its own interest.

2. And no one in Beijing's policymaking circle will ever envisage such a radical plan which may pose risks to the country's power supply security which, as seen in Europe right now, is a pre-condition for any reform plan and which prevails in the energy transition discussion.

Another approach, which might be relatively easier, is to separate distribution from transmission, upgrade and reform the distribution network. A much more interactive and reformed distribution network is urgently needed if the power sector is to play its enabling role in China's energy transition. We will have a deep dive into this issue in our next Insight report.

6.3 THE CRITICALITY OF DISTRIBUTION REFORM

Insight China, November 11, 2022

Our report No. 042 stated that China's distribution network is in urgent need for upgrading and reform if the power sector is to play its enabling role in energy transition. This report explains why.

6.3.1 Importance of distribution network in energy transition

Distribution network is referred to power grid with voltage at mid and low level at 10 kv and below but two levels above the end-user voltage of 220v or 380v, through which electricity is either transmitted from the transmission grid or gathered from local generating sources and distributed to the end-users.

It is where most of the distributed power sources, including renewable power (wind, solar, etc.), energy storage, gas or hydrogen-based heat and power cogeneration, and vehicle-to-grid (V2G) power, are connected to the power grid. It is also where electricity is provided to an increasingly diverse set of new customers – prosumers, data centers, 4G/5G telecom stations, and electric vehicles, all requiring uninterrupted and high-quality power supply. Increasingly, distribution networks, particularly micro-grids, are connected to the gas and heat distribution networks and digitalized to form the backbones of smart buildings, smart industrial parks and smart cities.

Therefore, distribution networks have become the core foundation of a modern power system where energy transition actually takes place, not only through the connection of more low carbon power sources, but also through innovative demand-side response tools such as virtual power plants.

Much effort worldwide has been spent on greening the generation side with increasing share of non-fossil fuels, but little or much less on the distribution side. The irony is that, without a strong and green distribution network, strong and green grid does not exist, nor could power sector succeed its transition.

6.3.2 Differences between new and old distribution networks

As stated in our earlier reports, China vows to build a new power system with high penetration of renewables and high integration with digital devices, where grid acts as the backbone of a modern energy system that combines all other sources of energy in a complementary manner. This new power system should be **flexible** in matching up production with consumption, **resilient** in coping with extreme weather events and other major threats, **stable** in operations, **smart** in responding demand interactively, **reliable** in supplying the needed power without interruption 24/7, and **affordable** for end-customers.

Such a new power system requires a new distribution grid which differs fundamentally from the existing one (Table 6-2). It shall embody such features as 1) availability of multiple power sources at distribution grid level; 2) sophisticated customer base; 3) self-balancing nature of distribution grid; 4) two-way direction of power flow; 5) high level of digitalization; and 6) role as an open encompassing platform.

Table 6-2: Differences between traditional distribution network and new distribution network

	Traditional Distribution Grid	New Distribution Grid
Power source	No power source available	Many sources including renewables, energy storage and EVs
Customer base	Simple passive users	Diversified customer base with growing sophistications in their power demand, eg prosumers
Nature of grid	Passive end of the power grid, dependent on transmission grid	Self-balancing regional and local networks, forming the basic units of the new power system
Power flow direction	One way flow of power from transmission to distribution	Power flows both ways in an interactive way
Degree of digitalization	Low penetration	High degree of digitalization making the grid partially or fully controllable
Platform role	Closed monopolistic supplier within a given geography	Open platform for renewables interconnection, for data acquisition, for power trading, for new technology applications and for business model innovation

In short, the traditional distribution grid sits passively at the end of the power value chain, where no power generating source exists and where power flows in one direction, while the new distribution grid is an active and interactive platform where power flows in both ways, where diverse sources of power and diverse types of loads are connected and where digital technologies are fully deployed to make the platform partially or fully controllable.

6.3.3 Distribution has been the weakest segment

In the current wave of energy transition, China's power distribution network appears to be the weakest segment, due to the following reasons:

Firstly, distribution forms part of the so called "Transmission and Distribution Network", which is considered a natural monopoly and run by an administrative monopoly for a given geography, i.e., the State Grid for the north and the Southern Grid for the south. For both the country's power sector planners and grid companies, the focus has been on backbone high-voltage transmission lines, with little attention paid to the vessel-level distribution network.

Secondly, and because of the first, distribution network was poorly laid down and is now aged. China was the first large developing country to provide access to electricity for all with a strong electrification campaign. The way to achieve it was to extend the distribution network to all city districts and rural villages with simple wires and cheap transformers. This hardware is now inadequate to support heavier and more sophisticated power loads. For example, EV chargers are now one of the hurdles to scale further China's EV fleets in residential quarters, simply because the power transformers there wouldn't support a large number of charging piles (see Insight China No. 35). The aged distribution hardware is also inadequate to support the bi-directional flow of electricity, which is a pre-requisite for the integration of distributed power generation sources. These weaknesses impede the progress to build a flexible and interactive platform or the so called "energy internet" that would act as enabler for energy transition.

And thirdly, the administrative monopoly by the grid company prohibits a renewable power developer from selling surplus power "over the fence" to his neighbor while at the same time, offering very low on-grid tariffs or very high connection fees when taking the surplus power from the developer. To overcome the problem, the central government has tried a pilot of "incremental distribution network", where private companies can develop and own a new distribution grid in a new geography, such as a new industrial zone. The pilot has failed to meet expectations. Some provincial authorities also tried to break down the monopoly by issuing local regulations to allow "over the fence" sales of electricity, but they remain too weak against the state-owned grid giants.

6.3.4 Need for a "revolution" in power distribution

Clearly, given the critical role distribution network plays in China's power sector transition, a more flexible, open, inclusive and interactive distribution grid is called for to meet supply-side changes with locally available generation sources, demand-side variations with new loads from digital infrastructure, EVs and demand-side response measures, as well as the availability and penetration of digital technologies.

This in turn suggests that a revolution in the distribution network is urgently needed if China is serious about energy transition. Thus, we would like to propose the following sign-posts to watch:

1. A separate five-year or long-term development plan dedicated to building out a new generation of distribution network;
2. A significant amount of money ear-marked for investment in distribution network upgrading and modernization;
3. Separation of distribution from transmission, with the restructuring of the two State-owned grid companies, giving appropriate role to local authorities in managing the power distribution business;
4. A totally new philosophy of regulating the distribution business: instead of treating it as part of the transmission and distribution

monopoly, encouraging its development as an innovation platform that fosters interactions among generation, grid, load, and storage to promote the development of localized energy internet; and

5. A much stronger business integration of the distribution network with other infrastructure facilities, such as telecommunication, water, and gas distribution, with the development of new business models of an interactive platform enabled by digital technologies.

None of these is within our foresight yet, and we don't expect to see them emerge in the short term, given the country's priority is on security rather than transition in the coming few years.

7

ELECTRIC VEHICLES: BOOMS AND BOTTLENECKS

7.1 HOW CHINA LEAPFROGS IN GREEN MOBILITY?

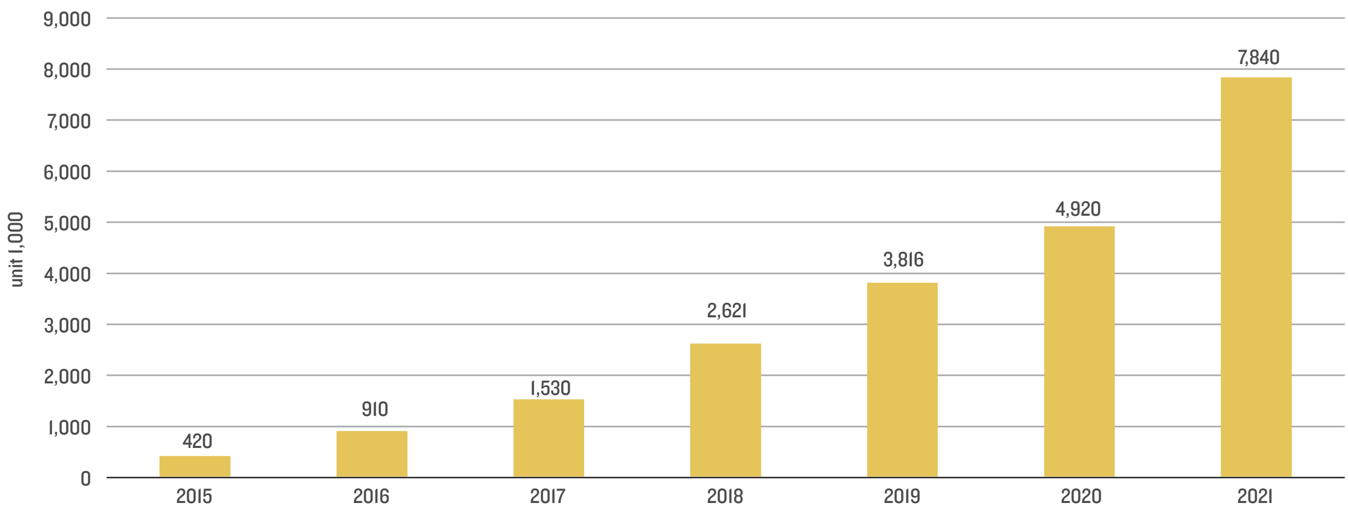
Insight China, August 1, 2022

With the electric vehicles (EVs) fleet breaking the 10-million mark by end June 2022, China leads the world in mobility electrification. During 1H2022, EV sales amounted to 2.66 million units despite economic downturn due to Covid lock-down, accounting for 21.6% of total vehicle sales. The whole-year sale, expected at 5 million, will easily break 2021's record of 3.3 million.

This Insight China report investigates the forces that drive China's EV success and looks into its future development.

7.1.1 Steady-fast growth

Figure 7-1: China's Fleet of Electric Vehicles



As shown in Figure 7-1, China's EV stock rose steadily over the last seven years, from less than half a million to over 7.8 million by the end of 2021 and over 10 million by now, ranking No.1 in the world in terms of EV stock, well ahead of the US (around 2.5 million by end 2021). EVs today account for 3.2% of China's total vehicle fleet but the Chinese EV fleet accounts for half of the global passenger EVs and 90% of electric buses and trucks.

7.1.2 Driving Forces:

Back in 2009, China officially positioned the EV industry as one of the "emerging strategic industries", based on three strategic considerations:

- **Energy security:** China became a net oil importer in 1996 and since then, oil import dependency has continued to rise, reaching 75% now. Electrification of transport is an important means to reduce oil dependency.
- **Local air quality:** Road transportation is a major source of local air pollution, so replacing

oil with electricity would help eliminate the tailpipe emission, thus improving the local air quality.

- **And auto industry leap-frogging:** Despite the fact that China became the world's biggest auto market in 2009, the country did not have its own technology and national champions, and all the vehicles running on streets were either imported or produced in China by joint ventures with Japanese, Korean and Western companies. The policymakers have realized that China could not compete on traditional internal combustion-engine technology， but faced with an opportunity to compete in the EV industry, given everyone standing at the same departing line, let alone that China has competitive advantages in domestic market, manufacturing capability and battery supply.

A joint study by the International Council on Clean Transportation (ICCT) and the China EV100 (a Chinese EV industry association), published in January 2021, provided a retrospective review of the journey traveled by China's electric vehicle industry. According to the study, China's EV industry has gone through four successive stages:

1. Prior to 2009: **exploratory phase** to determine what pathway to select toward a world-leading auto industry and when the new energy vehicles (including pure battery EV, plug-in EV and hydrogen fuel-cell vehicles) were chosen as a fast lane.
2. Between 2009 and 2012: **pilot program phase** with the confirmation of an EV development strategy and introduction of pilot programs on a massive scale such as "ten cities each having 1000 EVs" program, supported by government in R&D and direct subsidies.
3. Between 2013 and 2017: **market gaining attraction phase** with rapid growth of EV sales particularly driven by air quality goals and enabled by both subsidies to consumers and a "double credit" (CAFE standards and EV quota) system for manufacturers.
4. And, since 2018: **market openness and competition stage**, with a policy shift from mere subsidies to a combination of incentives and regulations to further release the market's potential. The waiver in 2018 of joint-venture shareholding restrictions for the auto industry allowed Tesla to build its super factory in Shanghai in 2019.

The study provides an excellent account in great details of the Chinese EV development in these different stages, which contains lots on relevant data and information.

7.1.3 Success factors:

Measured in EV market penetration rate, China lags some countries such as Norway, Sweden and Iceland, but it stands well-ahead compared against major economies such as US, Japan and EU. This success can be attributed to the following eight main factors:

1. **A clearly articulated and regularly updated industry development strategy** with targets, policies and regulations adapted to match the development stage of the industry. More details can be found in the ICCT and China EV100 study.
2. **A booming domestic market with ready-to-buy consumers**: before the EV was introduced, there were hundreds of millions of electric scouters already in the Chinese streets, familiarizing the consumers with this new means of battery-powered transportation.
3. **A growing technology maturity improving performance and driving down cost:** energy

intensity of power batteries grew from 105Wh/kg in 2016 to 200Wh/kg in 2021, and cost of power battery system was reduced from RMB5000/kWh in 2005 to RMB1000/kWh in 2020, with growing number of manufacturers having mastered core technologies (power battery, power drive and control system) of an EV.

4. **A competitive domestic supply chain**: China has built a rather complete and sophisticated value chain to support the leapfrogging, from rare metals and materials to industrial processing and manufacturing and now further down to lifecycle closed-loop battery recycling. With this supply chain availability, Tesla's Shanghai super-factory was built within 9.5 months ground-breaking on 7 January 2019 to first car delivery on 23 October 2019.
5. **A charging infrastructure,** that is sufficiently leading ahead to support the EV expansion.
6. **A highly efficient eco-system**, to turn government plans into implementable company actions. Different government-industry-academic-research partnerships were formed to quickly bring laboratory prototypes to market products, with clear roadmaps charted by top academic experts.
7. **A strong mobilization of local authorities and private entrepreneurship,** exemplified by Shenzhen and BYD, where the national EV champion has electrified all public transport (both buses and taxis) of its host city.
8. **And a burden free mentality**, free from constraints by the heavy burden of traditional car industry, to drive a new growth with innovations in both technologies, regulations and business models.

7.1.4 Future prospect:

China has set the target of 20% EV penetration in total new vehicle sales by 2025, 40% by 2030 and at least 50% by 2035, up from 5% in 2020. The 2025 target had already been achieved in 1H2022, with EVs accounting for 21.6% of total vehicle sales.

With an important consumer base, economic competitiveness per mile driven and positive user experience, and driven by the "dual carbon" goal in addition to the triple objectives of "energy security-local air quality-auto industry revitalization", China's EV market is poised to continue to grow, with the following two trends:

The first is digitalization that makes new generation of EVs more intelligent and digitally connected, and forms a new "smart electromobility". The participation of digital high-tech companies (such as Tencent, Huawei, and Baidu) in the EV industry will help accelerate this trend.

And the second is the penetration of the Chinese EVs into the global high-end markets. Norway is a good example - having the highest EV penetration rate and being open to all EV models. Even though Norway is a relatively small market, four Chinese EV brands (BYD, Nio, Li Auto and Xpen) are competing there along with Tesla and other global brands, with very impressive performance outcomes.

These two trends – digitalization and globalization - are likely to define the fifth development stage of the Chinese EV industry, but two uncertainties loom large:

The first is whether charging infrastructure can match and support the continuous booming of the EV market. This will affect the near-term development of the Chinese EV industry, and we will discuss this in a follow-up report.

The second is whether the world have sufficient supply of lithium and other rare metals to support the accelerated electrification of global transportation fleet. This question is particularly important with the announced ban of selling oil-fueled cars in Europe by 2035.

This latter question concerns the EV development in the longer term. If not properly addressed, we may see lithium resources constitute a limiting factor. In that context, the dramatic price increases in the last two years of both lithium carbonate (raw material) and lithium iron phosphate or LiFePO4 (the key component of a power battery) are particularly concerning.

7.2 DEBOTTLENECK THE CHARGING INFRASTRUCTURE

Insight China, August 11, 2022

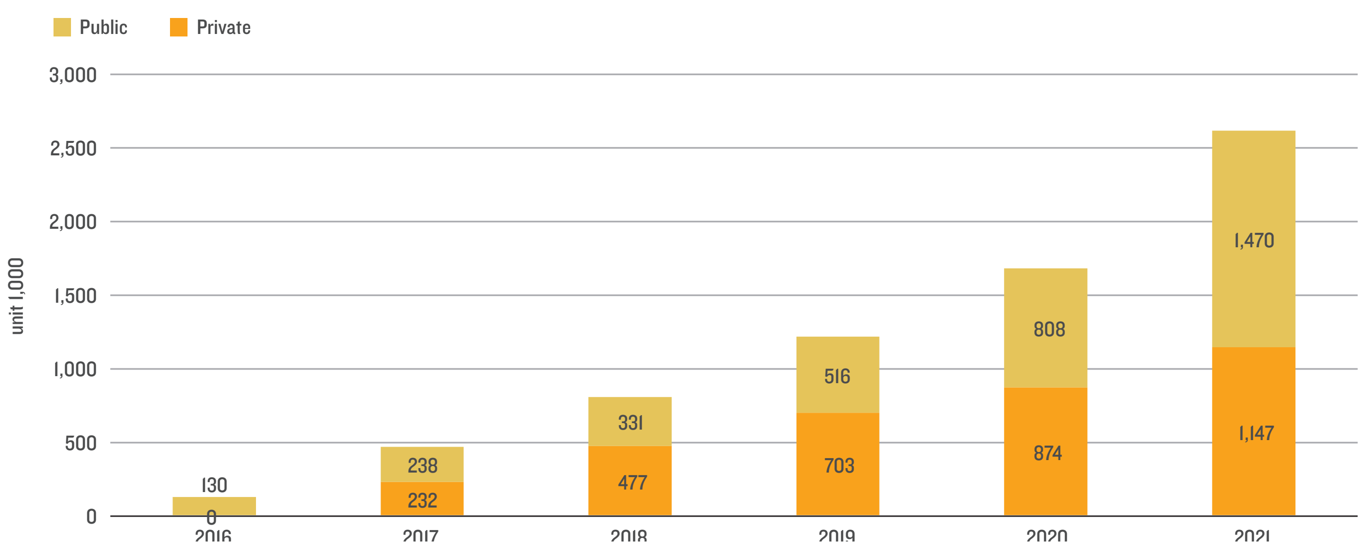
Charging infrastructure twins EV rollout. And, a universal charging network that matches fleet deployment is a must-have to accelerate the electrification and decarbonization of mobility.

In the previous Insight China report, we discussed China's championship in the EV industry, focusing on vehicles. This report discusses development of charging infrastructure and its potential bottlenecks.

7.2.1 Steady expansion

Charging infrastructure has been one of the enabling factors of China's EV leap-frogging. And yet, it may also bottleneck its future development.

Figure 7-2: Growth of China's EV Charging Piles



By the end of 2021, China had 2.617 million charging piles (Figure 7-2) for an EV fleet of 7.84 million, thus averaging one charging pile for every 3 vehicles. Such aggregate numbers mask, however, important disparities:

- The first is disparity between public and private: half of the 2.6 million charging piles are private and the other half public. As individual private EV owner is likely to have his/her own charging pile, the ratio of EVs per public charging pile stands at 6 or 7, showing lagging public charging facilities. Highway charging stations, numbered 13,800 in total or only 1% of the public charging facilities nation-wide, are particularly short of demand, limiting the use of EVs to intra-city mobility.

- And the second is geographical and regional disparity: over 50% charging piles are located in top 5 provinces (Guangdong, Shanghai, Beijing, Jiangsu and Zhejiang), and 72% are in top 10 provinces (previous five plus Shandong, Hubei, Anhui, Henan, and Hebei). Most charging piles are built in big cities, restricting EVs from traveling to suburbs and villages where charging facilities are scare and scattered.

These disparities depict where China stands today for the next stage of EV deployment: charging infrastructure remains a constraining factor and as a result, one can drive an EV home when travel distance stays within the battery range but can hardly go farther out of a city's boundary or to a far-away village.

In our view, two fundamental factors will hold back the rapid deployment of the charging infrastructure: poor business model for public charging stations and hurdles to upgrade power supply system at residential areas.

7.2.2 Poor business model for public charging stations

When China opened the public charging business for private investment in 2014, it attracted a big rush of private capital, with more than 1,000 companies competing to build the charging infrastructure in 2017.

With a relatively low entry bar, charging turns out to be a business without much a profit margin. A charging pile operator charges an EV by taking electricity from the grid and gets paid by the difference in electricity prices. A razor-thin margin, a low utilization rate, a high land rental price and high maintenance fee, together, affect the profitability of an charging pile operator. As a result, by 2019, half of the operators had bankrupted and exited from the market, while a third remaining were struggling on the profit/loss survival line. Even for those that survived, their balance sheets stay depressing.

Today, five operators (TELD, Star Charge, State Grid, YKC and Southern Grid) occupy three quarters of China's public EV charging market. Two of them, State Grid and Southern Grid, are state-owned entities, which care less about profitability. Three others are venture-capital-backed companies. According to the financial reports of TELD, the biggest public charging operator, it has never made any profit since in operation - from 2016 to 2020, with a total cumulated loss of RMB 370 million (or US$57 million) by the end of 2020.

Without profits, it's hard for the current operators to expand their public charging pile network. New business models, such as battery swap, of which China has already built 1,298 stations, are being tried out at this moment, so is the mobile charging station that walks to the EV in a parking slot to provide charging service instead of the EV looking for a charger and queuing up.

Hurdles to upgrade power supply system in residential areas

More charging piles are needed to enhance growth momentum of private EV ownership, especially in locations where they will be parked: the residential areas.

Chinese urban residential areas are often organized and clustered into "small districts" (小区), where residents share such utility infrastructure as water, electricity and other basic services that are managed by a property management company. For a residential area with 500 homes, normally, a 3,000-kVA power supply capacity is required, assuming 6 kW for each home. Such power capacity is usually obtained by the real estate developer of the residential area from the local power distribution company. Physically, power supply to the residential area is assured by two to three transformers, which are expensive to buy and install.

Residential EVs generally opt for a slow charging pile, with a power output capacity of 5 to10 kW, that supplies power at 220V (single phase) or 380V (triple phase). As such, building one charging pile in the residential area is equivalent of adding one more home-unit in terms of power capacity requirement.

Given that power transformer is part of the common infrastructure provided by the real estate developer, the latter has all the incentives to minimize the cost by providing a "just-level" to meet the regulatory requirement to sell the homes. As a result, most of China's urban residential areas have a very tight or distressed power supply system, while upgrading the transformer is a complicated process to get the approval from the local power distributor and let all home owners share the related costs.

Transformer upgrading is therefore critical to the expansion of private EV fleet in China's residential areas.

7.2.3 New Government actions

Charging infrastructure buildout in China has been a target of government support with numerous directives. EV charging was included, in March 2020, as one of the six pillars of "New Infrastructure", where $1.4 billion was earmarked to charging infrastructure.

Recognizing the current bottlenecks outlined above, the NDRC and 9 other government agencies issued, in January 2022, a new "Opinion to Further Improve the Service Delivery Capability of EV Charging Infrastructure" (the Opinion). The Opinion aims to further break the identified bottlenecks and improve EV charging service capacity, forming a charging infrastructure system that is moderately advanced, balanced in layout, intelligent and efficient.

Specifically, the Opinion calls to:

- Accelerate construction of charging facilities in residential communities, both existing and newly built. From now on, new residential buildings must provide 100% charging facility in all the parking spots.
- Optimize the construction of public charging network within cities and accelerate the construction in suburban areas;
- Strengthen the construction of charging network in counties and towns, with priority in public buildings, transportation hubs and public parking areas;
- Accelerate highway fast-charging networks;
- Support construction of dedicated battery swap stations around mines, ports, and urban transit, as well as explore shared battery swap models in such sectors as cabs, logistics and transportation;
- Promote new charging technologies such as fast super chargers, wireless and automatic chargers, and unify the technical standards for different types of charging piles.
- Prioritize use of land resources, including stock parking lots, and give priority to public charging stations with new land supply; and,
- Optimize financial support policies and provide financial support to construction of charging piles as public facilities.

More actions are also being taken at municipality level. The Beijing municipality for example, recently published its 14^{th} five-year program for EV charging infrastructure, aiming to have 700,000 charging piles and 310 battery swap stations by 2025, with an EV being able to find a charger within 3km in plain areas and within 0.9km in core business areas.

Significant moves as they may represent, these measures are yet inadequate to remove the hurdles in place today – lack of business models for public charging piles and hurdles to upgrade of power system in residential areas. Consequently, we will continue to see these two hurdles standing in the way to slow down the desired growth of EV fleet after its initial stage of acceleration.

7.3 DEBOTTLENECK THE GLOBAL LITHIUM SUPPLY

Insight China, August 18, 2022

Our two previous reports discussed China's EV prospect, highlighting charging infrastructure bottleneck in the near term, and potentially, lithium supply constraint in a longer term.

This Insight China report zooms in on the lithium supply issue, from a global perspective, given its global nature, to address an important question: does the world have enough lithium resources to support car fleet electrification?

7.3.1 Lithium uses

Lithium is the lightest metal and the most reactive one in the first group of the Periodic Table. In a power battery, lithium is used in both cathode and electrolyte. In cathode, lithium use is in the form of either lithium carbonate (Li2CO3) or lithium hydroxide (LiOH), both in the form of white salt powder. In electrolyte, lithium carbonate is mixed with other elements to form a power charging and discharging solution. Lithium carbonate has been the predominant manufactured material for power batteries, and that's why all lithium uses are conveniently calculated in terms of lithium carbonate equivalent or LCE - 5.3 tons of LCE provide one ton of lithium metal.

In 2020, a total of 3.12 million EVs were sold worldwide, and the EV industry consumed 122,030 tons of LCE. A simplified calculation gives therefore, on average, each EV requiring 39 kg of LCE. In 2021, the total EV sales of 6.6 million and LCE consumption of 244,603 tons mean approximately a similar LCE use per vehicle at 37 kg. These numbers fall within the industrial expectation of 30-50kg of LCE per EV.

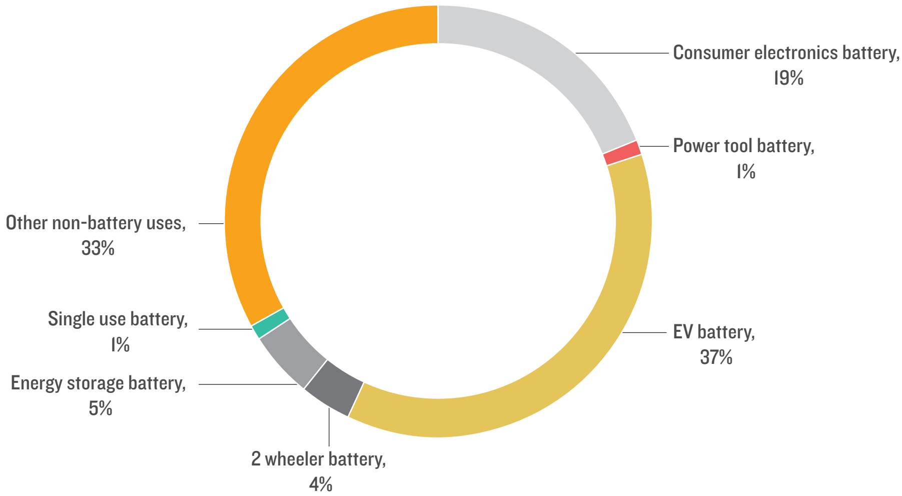
According to Minmetals Securities, a subsidiary of China Minmetals Group, global demand of lithium stood at 334,477 tons of LCE in 2020, of which EVs were the biggest user, accounting for 37% (see Figure 7-3). This was followed by non-battery uses, accounting for 33%, including ceramics and glass, lubricating greases, polymer production, continuous casting mold flux powders, air treatment, and even as medicine additive to control mood disorder, then consumer electronics at 19%, energy storage in power systems at 5% and two-wheelers at 4%, power tools at 1%, and another 1% by single use batteries.

7.3.2 Future Demand

Demand for lithium is poised to grow rapidly, not only for EVs but also for consumer electronics, two-wheelers, energy storage solutions and other traditional uses.

But EVs will be the single largest driver of global growth in lithium demand. As stated in our earlier report, China's 20% EV penetration target by 2025 had already been reached early this year, and the next milestone targets are to reach 40% by 2030 and 50% by 2035. The EU has announced a ban on selling oil-fueled cars by 2035, meaning an EV penetration rate of 100% by then.

Figure 7-3: Global lithium demand by use category in 2020



Source: Minmetals Securities

Globally, according to the IEA's latest Global EV Outlook, new EV sales will grow from less than 10% now to 35% by 2030, by when there will be 250 million EVs on road.

Worldwide, 77 million new cars were sold in 2021, 6.6 million or 8.57% of which were EVs. Let's assume a global auto market of 100 million units by 2030, a 35% market share means 35 million new EVs will be manufactured. If each EV takes 30kg of LCE, taking into account technical progress, then 35 million EVs will require 1.05 million tons of LCE, triple the global total lithium demand in 2020. Unless global lithium supply grows rapidly from now on, the 35% EV penetration rate by 2030 is highly unlikely.

At the same time, let's not forget another major driver of lithium use: energy storage solutions. With the growing penetration of intermittent renewables, more and more energy storage solutions, either at homes, buildings, factories, or on grid-side, will be required. So far, lithium-based $LiFePO_4$ (lithium iron phosphate) battery is dominating the energy storage solutions.

To meet the growing demand, a total of 4,725 GWh per year of power battery capacity expansion has been planned for 2025 worldwide, led by industry's leading players (CATL, LG, BYD, etc), with some 300 giga-factories at different stages of planning and construction.

If each GWh of power battery requires 600 tons of LCE, then 4,725 GWh will require a total of 2.835 million tons of LCE, 4.7 times the current global supply of around 600,000 tons per year.

7.3.3 Supply constraints

According to the US Geological Survey (USGS), by the end of 2021, the world had a total of proven lithium reserves of 22 million tons of lithium metal or 117 million tons of LCE. Chile, Australia, Argentina and China were the four largest reserve holders, accounting for 85% of the global total. From the perspective of resource availability, the USGS listed a global total of 89 million tons of lithium metal, of which Bolivia (21 million), Argentina (19 million), Chile (9.8 million), USA (9.1 million), Australia (7.3 million) and China (5.1 million) and Congo Kinshasa (3 million) are the biggest owners.

Lithium is found mainly in brines of closed basins, oil fields and geothermal reservoirs, and in solid minerals including pegmatites, clays and zeolite. Lithium brines and minerals are refined to produce lithium compound including lithium carbonate, lithium hydroxide, lithium fluoride and lithium chloride that are ready to use by battery manufacturers.

Production-wise, the same four countries but in different order, Australia, Chile, China and Argentina account for 96% of the raw lithium mineral production, but China dominates the downstream supply chain, from mineral processing, cathode and anode manufacturing to battery cell production, accounting for over 60% of the global total in each segment. But China's domination is constrained by a bottleneck: over 70% of its raw lithium materials are imported.

Faced with a growing lithium demand, many industrial analysts including the IEA have expressed concerns that global lithium production will not expand as rapidly to match up with the demand. Australia, the biggest producer today, faces labor shortage and ESG challenges in expanding mineral extraction activities, while global "lithium-triangle" formed by three Latin American countries (Chile, Argentina and Bolivia) with 60% of global lithium resources all face significant hurdles to quickly expand production: harsh conditions linked to high altitude of brine basins, scarcity of fresh water, ecological vulnerability of the mineral sites, local community issues, regulatory uncertainties and economic and political fragilities.

According to the IEA, lithium mines that started operations between 2010 and 2019 took an average of 16.5 years to develop. Bolivia, which has nationalized lithium production activities, spent about $900 million to build a factory and related infrastructure, but produced nothing out of it since the factory's operation in 2013. In 2021, Bolivia, the country that owns the biggest resource base, produced just 540 tons of lithium carbonate. Chilean new government is stepping up efforts to nationalize its lithium resources and production too.

As a result, the MinMetals Securities and other industrial analysts bet more on the Chinese domestic production, along with Australian one. They believe the Chinese production is destined to increase, despite its limited volume of lithium reserves, from 170,000 tons to 350,000 tons of LCE between 2022-2025. Despite this, globally, they foresee a supply shortage from 2025 onwards: global lithium demand will grow from 750,000 tons of LCE in 2022 to 1.6 million tons of LCE in 2025 and 3.92 million tons of LCE in 2030, while lithium supply is expected to be at 1.65 mt of LCE in 2025 and 2.47 mt LCE in 2030. This is very much in line with what the IEA had warned in its May 2021 report that the world could face lithium shortages by 2025.

7.3.4 Does the world have enough lithium resources to electrify the car fleet?

The world today has a total of 1,446 million cars on road. To electrify all, at today's lithium use level, would require 10 million tons of lithium metal, a bit below half of the global lithium reserves of 22 million tons. The availability of lithium resources at 89 million tons seems adequate to support electrification of all the current global fleet. Besides, new optimism can be added if we include lithium contained in global sea water, estimated at 230 billion tons of lithium with average concentration of 0.17 parts per million (ppm). Furthermore, lithium-based battery is unlikely to be the only option to electrify the car fleet in the future.

However, turning resources into actual supply is easier said than done as illustrated by the Bolivian case. Global lithium supply constraint will limit the level of EV production, thereby the pace of mobility electrification. For example, if half of global lithium supply in 2025 is used for EVs, at today's technology level, the world could only produce 23 million EVs a year in total.

The lithium supply debate leads to two important questions:

- One is that, in the light of looming shortages, lithium mineral price will continue to remain high, harming the economics of the downstream supply chain, from battery's giga-factories to EV manufacturers, as well as competitiveness of EVs against conventional cars. China is a case of the point. Its LCE supply had experienced a price spike of an 8-fold increase, from RMB 51,500/ton (US$7,626/t) in January 2021 to RMB 467,500 /ton (US$69,225/t) in June 2022. Can the world accept such a volatility in lithium commodity price?
- And the other, which might be more imperative from the energy transition perspective, is that lithium application in power batteries of the auto industry enjoys an upper hand in business model in comparison with its use in energy storage solutions of the power sector, so what lies ahead for the latter then, particularly in the face of supply shortages?

New solutions need to be discovered to simultaneously electrify the auto fleet and provide energy storage solutions. They include non-lithium batteries, lithium recycling (according to the IEA, only less than 1% of lithium use has been recycled currently), sea water extraction, use of retired EV batteries for energy storage purposes, or even use EVs as power storage means with the bi-directional vehicle to grid (V2G) chargers. However, none of them will be an easy go.

8

FUELS AND MINERALS

8.1 ENERGY SAVING: THE CHINESE WAY OF HARNESSING THE "FIRST FUEL"

Insight China, May 25, 2022

Energy saving or efficiency is now called "the first fuel" both in China and worldwide. About seven decades ago, it was still regarded as "the 5th" in China, when its major energy sources were coal, oil, gas and hydropower in the 1950s. Today, policy makers and energy analysts put it high up as a priority when energy transition is concerned. And yet, significant barriers exist to harness its maximum potential.

This Insight China report reviews the Chinese practices in energy saving, the existing hurdles and future prospect.

8.1.1 The "duo control" mechanism as the Chinese way:

Since joining WTO (World Trade Organization) in 2001, China experienced sharp surge of energy demand and local pollution, driven by rapid expansion of export-oriented manufacturing activities. Fearful that the energy supply system would fail to match rampant and unchecked demand, Chinese policymakers decided to take steps to address the demand side as the key vehicle to capture efficiency.

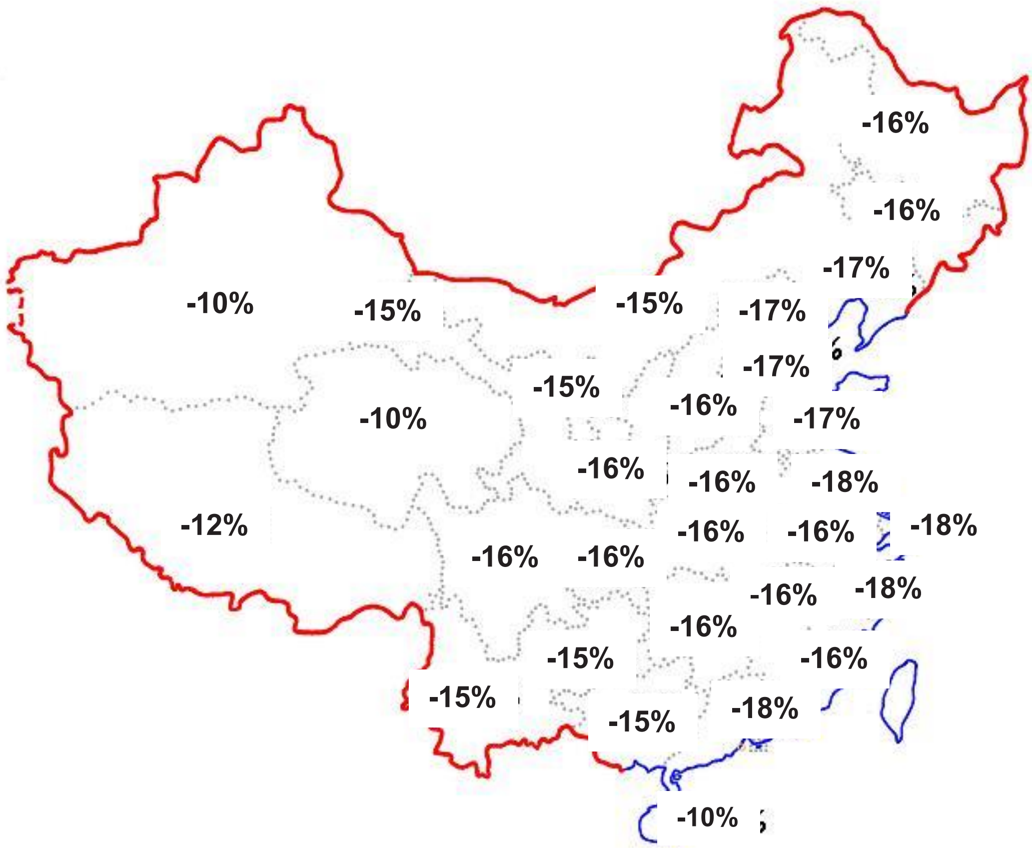
The first step was an introduction of per-unit GDP energy intensity reduction, setting targets to reduce energy use per RMB10,000 yuan of GDP produced. Started in the 11th Five-Year Plan (FYP, 2006-2010), a compulsory target of 20% was set over the 2005 level. Such practice has been carried on in the subsequent Five-Year plans: 16% for 2011-2015 (12th), 15% for 2016-2020 (13th) and now 13.5% for 2021-2025 (14th).

The national target was then "deconstructed" into provincial ones, with each of China's 31 provinces agreeing upon a target, some higher than the national target, some are lower, as illustrated in Figure 8-1.

The second step, introduced in the 12th FYP, was imposing a national ceiling of total energy demand at 4 billion tons of coal equivalent by the end of 2015. The target was also similarly deconstructed into provincial level, just as how the energy intensity target was handled. Those two targets together, total energy consumption volume and energy intensity, are called the "duo control" targets. They were further cascaded vertically down to municipal and county levels. Officials at different levels, measured by their KPIs, are held accountable to their higher-level administration, and the central government to the National People's Congress. Ever since 2017, such targets had been evaluated and reported on a quarterly basis.

The "duo control" mechanism, since 2011, has become the key policy tool to capture energy efficiency and saving. Worldwide, such practice is seen as unique and mainly applicable to command-and-control economies, such as China.

Figure 8-1: Deconstruction of the 16% energy saving target for the 12th FYP



The policy has certainly slowed the growth of its energy demand, but it has also hampered economic activities and even created hardships for many ordinary people. Very often, when the "assigned" energy consumption quotas are about to be used up, local governments tend to halt any new investment projects proposed by lower-level administrations that would add energy demand in their jurisdictions. And local governments, sometimes, even use such extreme measures as bluntly cutting energy supply, when the performance review cycle approaches, just to meet their targets, temporarily.

8.1.2 Relaxation and fine-tuning:

Such challenges and growth pressures at local levels have forced the national government into a position to relax its stringent measures. As reported in our Insight China report of 30th March on the 14th FYP for Energy, China has scrapped its total energy demand control target, but the energy intensity reduction target of 13.5% by 2025 below the 2020 level is kept. And each of the 31 provinces still takes on an energy consumption quota for the 14th FYP period, but the mechanism is "fine-tuned":

- Energy intensity is given top priority, while total energy consumption only used as a reference;
- Energy intensity target is divided into two categories: a compulsory base-line target and an incentive target that is above the baseline one, with corresponding incentives;
- Energy used as raw materials are no more counted in total energy;

- Renewable energy consumption is largely encouraged;
- More consumption quota is allocated to provinces with lower energy intensity;
- Provinces can trade energy consumption quotas cross-border;
- Central government retains some energy consumption volume to support some strategically important investment projects, which does not enter the provincial accounts; and,
- Review is called out on a yearly basis, rather than quarterly.

The longer-term plan is to scrap the whole "energy duo control" system and replace it with "carbon duo controls", only with targets of carbon intensity and total carbon emission load for each province.

8.1.3 Hurdles and prospect:

The success of the "duo control" approach heavily depends on the government's "visible hands", with little recourse to market-based instruments. Despite government's claim that the approach is successful, it has been difficult to ascertain how much is attributable to government control, because technological progress has become a major force driving China's energy intensity reduction. On the contrary, the limitations of this approach are protruding, as witnessed in practice.

Energy saving is different from energy supply which is often centralized to achieve economy of scale. Energy saving involves multiple, dispersed energy users, often in millions or more. Energy saving projects on the demand side, if taken individually, is relatively small, but often incurs very high transaction costs, even though each project might appear to have significant saving potential with good economics.

This explains why no national champion has yet emerged in the energy saving sector. In 2018, China had 6,439 registered companies with energy saving as main business, each trying to sell one particular energy-saving device/equipment, but none or very few have offered integrated solutions from the client perspective. No sustainable business model has yet evolved to rapidly scale up energy saving business as desired.

Government policies remain in broad brush, lack of concrete and tenable measures to support practitioners on the ground. Supply-side-mindedness dominates the picture of energy saving, as reflected in the national focus on building big energy saving projects. The "14th Five-Year Action Plan for Energy Saving and Emission Reduction" has listed 10 such significant projects, including green upgrading of key industries, energy saving at industrial parks, green renovation in urban areas, energy saving in mobility and logistics, energy saving in agriculture and rural areas, and energy efficiency improvement in public buildings.

Despite high hurdles, two megatrends - decarbonization and digitalization - offer opportunities to break the deadlock. China's "duo carbon" commitment of carbon peaking before 2030 and neutrality before 2060, when deployed at company level, will force large energy-consuming, carbon-emitting companies to proactively seek energy saving solutions. This is expected to dramatically alter the current dilemma small energy saving companies are facing when trying to sell equipment to bigger corporations.

In the meanwhile, the application of digital technologies can help companies and other parities to size more accurately the energy use of a given activity and achieve energy saving by matching up the required supply. Crypto-currency technologies, such as blockchain, can also help to record and track, real-time and tamper-proof, the amount of energy saved by taking steps to improve efficiency, thereby significantly reducing the transaction cost.

Despite these hopes, one fundamental question remains: how can an economy that is so used to centralized actions change its mentality to encourage decentralized activities? This question is also relevant not only to the debate around energy efficiency, but also to the development of renewable energy supplies.

8.2 NATURAL GAS: TRANSITION FUEL OR MAJOR FUEL?

Insight China, January 14, 2022

In the global race to netting-zero, natural gas' position is somewhat ambiguous: as a fossil fuel, it is to be substituted by renewables, but as the cleanest fossil fuel, it plays a critical role in the progressive decarbonisation of the global energy system. Therefore, in many parts of the world, OECD countries in particular, natural gas is widely considered as a "transition fuel", bridging the transition from fossil energy system to a clean and renewable one.

In China, however, natural gas is considered a clean fuel, a major grip for low carbon energy transition, and a companion fuel that will go along with renewables in the foreseeable future.

8.2.1 A Major Clean Fuel

This difference is explained by the fact that China is a large and still growing economy, needing all kinds of energies to provide heating, cooling, power, mobility as well as carbon-based materials. For Chinese policy makers, low carbon energy transition must take place under the precondition of energy supply security and economic competitiveness. Renewables such as solar and wind are set to accelerate, but they do not have the required energy density, and they alone cannot meet the industrial heating requirement, even though their costs are decreasing rapidly.

Gas is the most readily available fuel to replace coal to reduce carbon emissions, ensure energy security, and enable economic competitiveness. Compared to coal which accounts for 60% of Chinese energy supply, natural gas emits only half of the CO_2 per unit of energy delivered. In addition to climate change, China must address a more urgent and immediate problem - the local air pollution. Replacing coal with gas has contributed to a continuously improving air quality in many Chinese cities. The latest data shows that the year of 2021 witnessed the best air quality ever in Beijing. Though still falling behind the WHO recommended guidelines of healthy air quality, Beijing, at least, managed to meet the Chinese standard of good air quality for a total of 288 days, thanks to the highest gas share in energy mix among Chinese cities.

Natural gas is the most important energy source in Europe, accounting for 24.6%. But its share in China's primary energy mix was barely 8.4% by 2019. For energy security at end-user level, a duo energy supply of both electricity and gas is more secure than electricity alone.

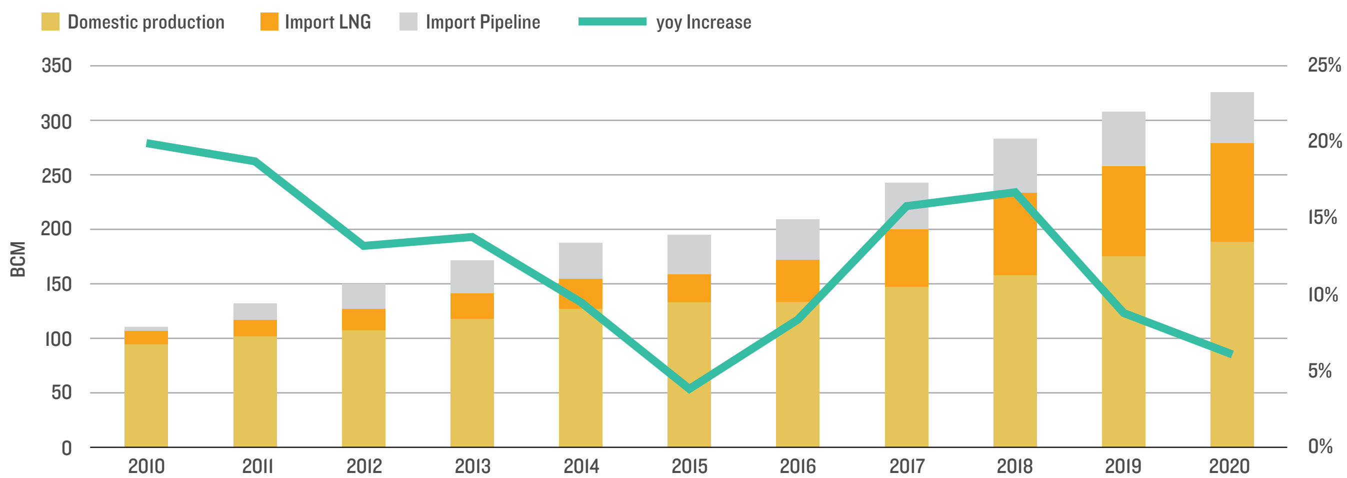
Considering the goals of environmental and climate protection and concerns of energy security, the Chinese government officially classified natural gas as a "**major fuel**" in its 13^{th} Energy Five-Year Plan (2016-2020). The Energy Supply and Consumption Revolution Strategy (2016-2030), released in 2017, sets the target to expand the share of natural gas to 15% of total primary energy consumption by 2030, along with the 25% target for non-fossil fuels by the same timeline.

At the time of writing of this report, China has not yet published any revised 2030 target for natural gas, nor have we seen any changed government position on natural gas. If China maintains the cap on carbon emissions before 2030 and the carbon neutrality targets before 2060, while barring any major downward disruption of the Chinese economy, we see a continuing growth of gas demand in the coming decades and beyond.

8.2.2 Growing demand

In 2020, China consumed 326 billion cubic metres (bcm) of natural gas, representing a year-on-year growth of 7.2%. Domestic production was 188.8 bcm, while imports were 137.2 bcm, of which 94 bcm in the form of LNG from 24 countries, whereas pipeline gas from Central Asia, Myanmar and Russia amounted to 43.2 bcm.

Figure 8-2: China's gas supply 2010-2020



Source: National Bureau of Statistics.

Infrastructure side, by end 2020, China had a total of 79,100km of high-pressure gas pipelines, 22 LNG receiving terminals with 90 million tonnes per year (mtpa) capacity, and 27 underground gas storages with a total yearly peaking capacity of 13 bcm.

Consumption side, city gas (mainly residential and commercial) is the largest user, accounting for 38.4% of total gas demand in 2018, followed by industry (34%), power generation (18.5%) and petrochemical feedstock (9.1%). Gas-fired power will be increasingly needed to support de deployment of intermittent renewables.

Preliminary data suggest that in 2021, China's gas demand grew by 12.3%, reaching a total of 368.4 bcm. It is expected to grow at 6-7% during the 14th FYP (2021-2025) period. The Beijing Gas Group expects Chinese gas demand to reach 420-450 bcm by 2025, while China Oil & Gas Pipeline Corporation (PipeChina), China's newly created national pipeline constructor and operator, forecasts gas demand at 400-450 bcm by 2025, when China will surpass EU to become the world's second largest gas market after the US. In 2021, China surpassed Japan and became world's largest LNG importer.

For the medium-term outlook leading up to 2035, all forecasts point to a continuing growth of gas demand in China, although the level of growth varies a bit by different institutions. Table 8-1 provides the forecasts of China's gas demand at 2025, 2030 and 2035, respectively, by some Chinese and international institutions.

Table 8-1: China's Gas Demand Forecasts by Various Institutions (bcm)

Institution	Time of forecast	Scenario	2025	2030	2035
US EIA	2019	Basic	340	435	498
IEA	2020	Stated Policy	425	500	568
		Sustainable Dev	398	446	478
Japan IEEJ	2020	Reference		463	523
		Advanced		418	492
BP	2020	Basic	490	601	651
		Fast transition	490	585	672
		Net Zero	460	520	517
CNPC	2020		460	550	620
Sinopec	2021		450	508	554
CNOOC	2021			559	600

Source: CN Innovation compilation

Reasons for the expectation of continued growth of gas demand, at least till 2035, include:

- Continued economic growth, industrialization and urbanization will increase energy demand, but there is no other readily available energy resource at scale that can meet the demand while reducing both local and global pollution at a competitive price;
- Continued substitution of coal by natural gas, pushed by clean air campaigns, with even stricter anti-pollution regulations in the coming decade;
- Regulatory reform, that would allow direct access by gas suppliers to large customers, and other regulatory measures that would reduce the end-use prices of natural gas; and,

- Abundance of supply: not only domestic production will increase with more investment in conventional and unconventional gas exploration and production, international sources of supply also show no sign of scarcity, with pipeline gas from Russia, Central Asia, and LNG from across the world.

Given Chinese 2030/60 duo carbon targets, the emerging consensus among most of the Chinese research institutions seems to point to peaking of China's gas demand at 600 bcm around 2040. Even by 2060 when China reaches carbon neutrality, natural gas demand will remain at around 400 bcm, with its carbon emissions to be neutralized by CCUS technologies.

8.3 NUCLEAR ENERGY IN-BETWEEN PROMISE AND PERPLEXITY

Insight China, January 21, 2022

China has 53 reactors in operation and 16 under construction, running the world's 2nd largest nuclear power fleet (surpassing France which has 56 reactors but 15 of which are permanently closed) after the US. The largest construction market for new reactors, it is also the most vibrant market in terms of piloting all kinds of new reactors, from R&D in nuclear fusion and fast-reactors to nuclear heating and SMR demonstration plants.

A non-fossil fuel along with renewables, nuclear power is expected to play a more important role to deliver China's commitment to increasing non-fossil fuel energy in its total energy mix from 15.3% in 2020 to 25% by 2030, under the Paris Agreement. Nuclear is also poised to grow as part of China's technology portfolio in achieving the stated goal of carbon neutrality by 2060. However, uncertainties loom large on its future, given the sharply divided positions among experts and a growing NIMBY effect.

This Insight China report investigates issues surrounding the domestic development of this important fuel. Overseas expansion is a totally different story.

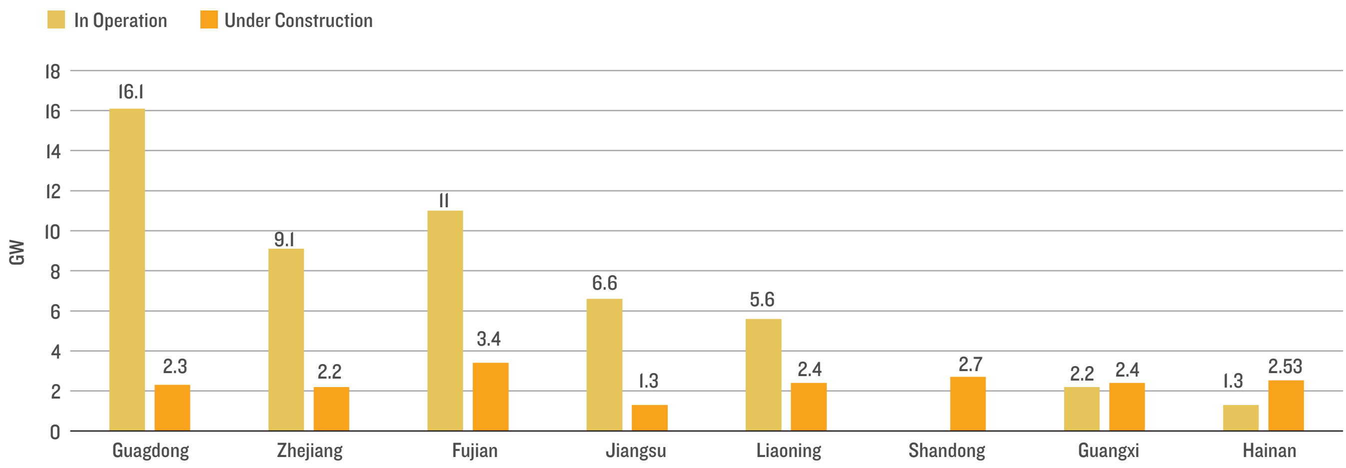
8.3.1 The largest construction market:

On 1st January 2022, the 6th reactor of the Fuqing Nuclear Power Plant in Fujian Province was connected to the grid, bringing China's total number of operating reactors to 53, with a total capacity of 54 GW.

By the same date, China had 16 reactors under construction, with a total capacity of 16.5 GW, larger than India (6 reactors, 4.2 GW) and Korea (4 reactors, 5.4 GW), and continues to lead the world in both the number of reactors and total capacity.

All reactors in operation and under construction spread across 8 coastal provinces as shown in Figure 8-3, and none is located inland yet.

Figure 8-3: China's Nuclear Power Reactors in Operation and Under Construction



8.3.2 The most vibrant market:

While technologies for those in operation mainly come from foreign sources, including France, US, Canada and Russia, and Chinese technologies adapted from foreign ones, those under construction almost exclusively deploy Chinese adapted technologies, except for two reactors with Russian VVER-1200 technology.

Ten out of the 16 reactors under construction deploy Chinese brand Hualong I, which was developed jointly by China Nuclear Power Group (CNP) and Guangdong Nuclear Power (CGDNP) based on French M310 and its Chinese improved version of CPR1000. What's particularly worth noting is that two sodium-cooled pool-type fast-neutron reactors, 600 MW each, and one 125 MW multi-purpose SMR (small modular reactor), are also under construction. They put China in the leading rank among nations in fast-reactor and SMR commercialization.

On 28th September 2020, China Power Investment Corporation announced its own prototype of GuoheOne, or CAP1400, which was adapted from the US AP1000. New projects can be expected during the 14th five-year plan period (2021-2025).

In addition, China is also actively experimenting the following:

- **Nuclear heating**: in 2021, the Haiyang Nuclear Power Station in Liaoning Province divested 4% of the steam generated from two nuclear reactors to provide heating for 600,000 residents in the city of Haiyang. The nuclear heating replaced 12 coal-fired boilers, reduced residents' heating bill and improved the energy efficiency of the nuclear power station by 3.25 percentage points (from 36.69% to 39.94%);
- **4th generation technology**: on 20th December of 2021, the world's first commercial pebble-bed reactor (PBR, 200 MWe) built by the Huaneng Group using Tsinghua University's technology, was connected to the grid and started commercial operation;
- **Nuclear fusion**: on 28th May of 2021, the EAST, one of China's experimental nuclear fusion facilities, achieved repeatable 120 million °C of plasma operation for 101 seconds and 160 million °C for 20 seconds. On 30th December, it achieved 70 million °C for 1056 seconds, breaking the current world record.

- **Nuclear for hydrogen production:** a few industrial pilots is under planning, including in particular China Nuclear Power Corporation's PBR 600 MWe project which includes hydrogen production.

8.3.3 Bright prospects:

The above capabilities, underpinned by the world's largest nuclear R&D, engineering and service professional team, ensure a bright future for nuclear power in a country with strong growth of electricity demand, often blanketed by heavy air pollution but firmly committed to the Paris Agreement and the Glasgow Climate Pact.

The Chinese NDC to the Paris Agreement requires non-fossil fuels (including nuclear, hydro and other renewables) to grow one percentage point each year. Given the constraints of building more large-scale hydropower plants, and the limited load factor of solar PV and wind turbines (1281 hours a year for solar and 2073 for wind in year 2020), nuclear proves indispensable for China to reach the 2030 target. Nuclear power, in particular the 4^{th} generation pebble-bed reactors, can also be an important source of heating to replace coal in northern part of the country.

China Nuclear Industry Association expects the country to approve the construction of 6-8 third generation reactors per year (either Hualong I or Guohe I) to scale their deployment. With such a rhythm, the total installed nuclear power capacity could reach 70 GW by 2025 and 120 GW by 2030, accounting for 8% of the country's total electricity demand.

8.3.4 Looming Challenges:

Such prospect may become a wishful thinking of the nuclear industry professionals. Critics and opponents in the country say that at this rate China shall have 40 reactors under construction simultaneously at a given future time, given the construction cycle of 5-6 years. This will be well beyond the country's technical and regulatory capabilities, particularly when its own 3^{rd} generation technologies are yet to be proven, with safety remaining the top risk and concern.

Domestic debates have been centered around the following six points:

1. Safety: while the technical jargons of 3^{rd} and 4^{th} generation may sound cutting-edge to reassure safety, opponents believe absolute safety does not exist, and the society won't accept the potential immense consequence from an accident, even though with an extremely low probability. They argue that human mistakes are very often at the origin of major historical disasters, so technical advances cannot possibly guarantee 100% safety;

2. Inland sites: China was reported to have selected 31 inland sites for nuclear power stations, and some had actually started ground preparation, but was halted due to opposition from some experts and the public. Those firmly against inland nuclear sites argue that given China's heavy population density and water scarcity, experiences of other countries (e.g. France) in building inland nuclear power become irrelevant. They further argue that Chernobyl accident was much more severe than Fukushima, precisely because it was located inland while Fukushima was at the seaside;

3. Strategically important and sensitive areas: opponents also argue that nuclear safety is essentially a homeland security issue and that China should clearly ban building any nuclear power upper stream of the Yangtse River, the Beijing capital economic zone, and other defense-sensitive areas. They even argue that the Bohai Bay area, although coastal, should be

kept nuclear free, given its strategic importance to national economy, and that all the already approved projects should be moved away;

4. Negative impact assessment: instead of promoting nuclear power's advantages, opponents propose to have a thorough and independent "negative impact" assessment of nuclear sites on homeland security;

5. Economics: solar, wind and battery costs are falling rapidly, while nuclear power cost is increasing due to the increasingly more stringent safety requirements. In 2020 alone, China connected 120 GW of new solar and wind capacity to the grid, outstripping by far the total nuclear capacity developed over last 30 years; and

6. Waste disposal: this is a common global issue for which no satisfactory solution is available yet.

Nuclear professionals and their opponents speak in different languages, and there lacks formal channels of communications. The traditional mindset shows that Chinese decision-makers are very cautious on issues where expert and public opinions are starkly divided. And from governance perspective, government officials are now held accountable for decisions they make "for life", not only while in office, but also after retirement. The consequence is much less likelihood for those in office today to take any bold decisions on siting inland nuclear power projects for the 3rd generation technologies. It remains to see whether the "intrinsically safe" 4th generation modular PBR reactors will prove to be more acceptable for inland provinces, given that an experimental 10 MWe reactor has been in operation in Beijing – the inland capital city, providing heat and power for 20 years.

The question remains how China can achieve its 2030 ambition without a dramatic expansion of nuclear energy over the current decade.

8.4 CRITICAL OR STRATEGIC MINERALS: WHAT MATTERS MOST FOR CHINA?

Insight China, February 4, 2022

Energy transition proves mineral-intensive. From lithium, cobalt to rare earth elements, the phrase of critical minerals rings aloud for their fundamental roles in decarbonization technologies: solar panels, wind turbines, power batteries, hydrogen fuel cells, you name it. In their recently published studies, both the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA) have detailed the roles of those minerals, highlighted the importance of their supply security to meet growing demand, and indicated the urgency for better global governance[8].

Through the two US presidential executive orders (13817 and 13953) in 2017 and 2020 respectively, and the European Commission's foresight study in 2020[9], both the US and EU have highlighted China's dominant role in supplying those critical minerals and refined products, and called for increasing domestic production and diversifying their supply. Indeed, a March 2021 report of the

8 https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions and https://irena.org/-/media/Files/IRENA/Agency/Technical-Papers/IRENA_Critical_Materials_2021.pdf.

9 Executive Order 13817: "A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals," issued in 2017, and Executive Order 13953: "Addressing the Threat to the Domestic Supply Chain from Reliance on Critical Minerals from Foreign Adversaries and Supporting the Domestic Mining and Processing Industries," issued in 2020. European Commission, Critical Materials for Strategic Technologies and Sectors in the EU - A Foresight Study (Brussels: European Commission, 2020), https://ec.europa.eu/docsroom/documents/42881. European Commission, Study on the EU's list of Critical Raw Materials – Final Report (Brussels: European Commission, 2020), 7, https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en.

CSIS (Centre for Strategic and International Studies)[10] highlighted prominent role of China in the supply of raw materials for batteries (32% of global production), wind turbines (54%) and solar PV (53%). Other studies have estimated that China produces 60% of the global rare earth elements and processes 90% of their refining capacity.

Does China have the real prowess over the global critical mineral supply chain? How do the Chinese policy-makers and experts view the situation? This Insight China report explores the Chinese view, as we understand it, by highlighting its differences with that of the West.

8.4.1 Differentiating definitions

For the US, critical minerals are defined in the EO 13817 as: (i) a non-fuel mineral or mineral material essential to the economic and national security, (ii) the supply chains of which are vulnerable to disruption, and (iii) that serve an essential function in the manufacturing of a product, the absence of which would have significant consequences for its economy or national security.

EU uses the term of “critical materials” or “critical raw materials”, defined as those that are most important economically and have a high supply risk. Economic importance and supply risk are the two main parameters used to determine criticality for the EU.

But for China, the term used is “strategic minerals”, defined as those of strategic value for the country, that require high attention from the state in terms of resource allocation, financial input, and preferential policies to ensure economic security, defense security and the development of strategic emerging industries, which cover 9 industries including new-generation information technology, biotechnology, high-end equipment manufacturing, new materials, new energy, new and smart energy vehicles, energy conservation and environmental protection, digital creative industry, and their related services.

8.4.2 Listing Differences

"Criticality" is the keyword in both the US and EU definition, which represents the significance of those minerals to their economic growth and low-carbon transition. The level of risks to their supply and supply chains, if not well managed, threatens to compromise the advancement of the planned clean energy revolution, as well as national security of supply chain and national defense.

Such definition and narrative are echoed in the US when its Interior Department put 35 critical metals in its final inventory in 2018, and then in 2020 when EU revised its 2017 list to include 30 metal and non-metal minerals in its own inventory. Both US and EU lists focus on non-energy minerals, but do include a few energy minerals such as uranium (US list) and coking coal (EU list).

10 https://www.csis.org/analysis/geopolitics-critical-minerals-supply-chains

Table 8-2: Declared Critical or Strategic Minerals in USA, EU and China

US	Energy minerals	Uranium
	Metal minerals	Aluminum, antimony, beryllium, bismuth, cesium, chromium, cobalt, gallium, germanium, hafnium, indium, lithium, magnesium, manganese, niobium, platinum group, rare earths, rhenium, rubidium, scandium, strontium, tantalum, tellurium, tin, titanium, tungsten, vanadium and zirconium.
	Non-metal minerals	Arsenic, barite, fluorite, natural graphite, helium, Potassium chloride
EU	Energy minerals	Coking coal
	Metal minerals	Beryllium, bismuth, titanium, strontium, cobalt, tantalum, vanadium, antimony, bauxite, platinum group metals, heavy rare earths, light rare earths, lithium, scandium, gallium, germanium, hafnium, indium, niobium, tungsten, magnesium;
	Non-metal minerals	Natural graphite, phosphate rock, boron, phosphorus, Silicon metal, barite, natural rubber, coking coal, Fluorspar
China	Energy minerals	Petroleum, natural gas, shale gas, coal, coal-bed methane, uranium
	Metal minerals	Iron, cadmium, copper, aluminum, gold, nickel, tungsten, zinc, molybdenum, antimony, cobalt, lithium, rare earth, zirconium
	Non-metal minerals	Phosphorous, sylvite, crystalline graphite, fluorite

Source: CN Innovation compilation from US Presidential Orders, European Commission studies and Chinese sources.

In the Chinese case, the "strategic" nature is measured from at least three dimensions: 1) those in big domestic demand but heavily dependent on imports; 2) those in growing demand to support the development of "strategic emerging industries"; and 3) those that China today dominates the global market, such as rare earth elements.

Along those criteria, China published its first Catalog, in 2016, of strategic minerals as part of the National Mineral Resources Plan (2016-2020) by the Ministry of Land and Natural Resources (MLNR). A total of 24 minerals were first selected, but the list is now being expanded by MLNR (not yet published) to a total of 36. It includes 6 energy minerals, 25 metal minerals, and 5 non-metal minerals. Twelve out of the 36 minerals are classified as strategic minerals in shortage of domestic supply, which correspond to what the US and EU call as critical minerals. They include: Iron, copper, aluminum, manganese, oil and gas, chromium, cobalt, niobium, tantalum, zirconium, lithium, nickel.

Table 8-2 provides the critical or strategic minerals declared by the US, EU, and China.

While security of supply is the common policy objective behind the listing of minerals either as critical or strategic in the world's three largest economies, the Chinese Catalog includes all fossil fuels – coal, oil and gas as "strategic", given the country's rising energy demand and high energy import dependency.

The Chinese Catalog also has iron, which is the most common metal. This is due to China's heavy dependence on imported iron ores for its steel industry, a situation like the EU listing of coking coal.

Another difference is the growth-driven mentality in the Chinese definition of strategic minerals. Many of the minerals serve the purpose of developing "strategic emerging industries". It contrasts a "defensive mentality" that tends to focus on possible choke points along the supply chain.

8.4.3 Securing a shared future over differences

Despite differences, the three major economies share the need to ensure adequate supply to match the rising demand of energy transition to net out carbon emissions by mid-century.

It's therefore high time to agree on a common list of "energy transition minerals", and set up a new global forum bringing together the three with all other relevant countries and stakeholders for constructive and productive dialogues.

8.5 HYDROGEN IN CHINA: HOPE OR HYPE?

Insight China, January 14, 2022

With an annual production of 33 million tons in 2019, China today is the world's largest hydrogen producer. It also appears to be the world's most ambitious country in hydrogen development, if you take the announced targets as given. Indeed, the plans by Chinese provinces and municipalities aim to build a hydrogen market of RMB 600 billion (US$90 billion) by 2025. During the first seven months of 2021, over RMB 250 billion ($38 billion) of investment were announced across the country in the name of hydrogen.

But those numbers could be misleading. Our analysis concludes that it's a hype rather than a hope story.

8.5.1 Fossil-based production, with no clear technology advantage

As can be seen from Table 8-3, 98.5% of China's hydrogen production came either from fossil fuels or industrial processes, only 1.5% from electrolysis. The China Energy Group – a coal-based conglomerate, and the Sinopec Group – an oil refinery giant, dominate the market development with 16% and 14% respective market shares. Barely any production from renewables yet, all the made-in-China hydrogen was very grey as of 2020, despite announcements of large green hydrogen projects.

Table 8-3: Chinese hydrogen production and consumption in 2019

<table>
<tr><th colspan="2">Production (33.42 million tons)</th><th colspan="3">Consumption (33.42 million tons)</th></tr>
<tr><th>Source</th><th>Share</th><th colspan="2">End-user</th><th>Share</th></tr>
<tr><td>Coal</td><td>63.5%</td><td rowspan="3">Feed stock</td><td>Ammonia production</td><td>32.3%</td></tr>
<tr><td>Industrial processes (steel and chlore-alkali)</td><td>21.2%</td><td>Methanol production</td><td>27.2%</td></tr>
<tr><td>Natural gas steam reform</td><td>13.8%</td><td>Oil refinery and coal conversion</td><td>25%</td></tr>
<tr><td rowspan="2">Electrolysis</td><td rowspan="2">1.5%</td><td rowspan="2">Energy</td><td>Industrial fuel</td><td>15.4%</td></tr>
<tr><td>Transportation</td><td>0.1%</td></tr>
</table>

Source: China Hydrogen Alliance, China Investment Association and Tencent Research Institute.

From consumption side, only 0.1% of the produced hydrogen was used to fuel buses and cars, most of it went to industrial feedstocks.

How about technology? Well, the China-made chlore-alkaline electrolizers are said to cost only half (for small units of 50kW) or one sixth (for large units of 2-3 MW) of their western peers. But further proofs are required, given the very limited amount of hydrogen produced from electrolysis, and the data today is insufficient to support the claim. The alkaline electrolizers have very different performances in terms of efficiency, longevity, and environmental impacts, so one needs to compare apple with apple.

China shows no advantage in proton exchange membrane (PEM), solid oxide electrolysis

(SOE) or other electrolysis technologies, nor in fuel cells that convert hydrogen into electricity.

No green hydrogen, little energy-purposed use, and no clear advantage in technology. Furthermore, neither industrial standards for hydrogen-production equipment, nor safety standards for hydrogen handling and uses (such as refueling stations) are put in place yet. Consequently, conditions for large-scale development don't exist today in China.

8.5.2 Local over-enthusiasm

Despite the above facts, over two thirds of Chinese provinces have included hydrogen in their low carbon energy development plans, and more than 50 provincial, municipal and other local authorities have published dedicated hydrogen development plans with time-bound targets.

Beijing, for example, has vowed to achieve an industrial size of over RMB 100 billion ($15 billion) by 2025 (from a 2020 level of RMB 3 billion), with 10-15 "leading companies of global impact", 3-4 world-class innovation platforms, over 10,000 fuel cell vehicles and over 10 MW of distributed hydrogen-fueled power systems. Inner Mongolia, the northern province rich in coal but having turned to wind energy powerhouse, aims to build 500 ktpa of green hydrogen production capacity by 2025, with 100 hydrogen refueling stations for its own trucks and buses. Investment projects totaling RMB 90 billion (about USD 1.4 billion) have been revealed.

All pooled together, these local plans add up to 3 GW of fuel cell capacity, with over 100,000 fuel cell driven vehicles by 2025. These local governments' plans, when compared against one another, sound alarming similarities:

1. Everyone believes hydrogen is the future "ideal" energy carrier, and wants to nurture global or national champions in its own jurisdictions;
2. Everyone desires "green hydrogen" from renewable energy sources;
3. All excessively focus on transportation sector as the main user, with specific targets on fleet size and refuel stations. As of July 2021, China had a total of 190 hydrogen refueling stations in operation and more than 100 still under construction, for a total hydrogen fleet of 1,500 vehicles.
4. All are committed to provide subsidies for hydrogen-fueled vehicles, key components and refueling stations. Shanghai has put aside a total of RMB 5 billion (nearly USD 900 million) for potential subsidies. To attract investment, the Fuyang city in the relatively poor Henan province announced they will provide subsidy equivalent to 10% of the total investment, if the investment is over RMB 30 billion (USD 4.7 billion).
5. None of those plans has seriously investigated the economics of such investment, nor any business model to support their implementation.

Given those characteristics, these plans will either remain "plans" in the foreseeable future or become the source of low-level, repetitive and inefficient investments with huge waste of money.

8.5.3 Driven by local demand for investment and a myth created to believe

The question is why such "blinded" enthusiasm exists in many places that are supposedly run by technocrats? Well, we see the following four factors:

The first is the need to attract investment. Traditionally, local authorities attract investment by giving a piece of land in their industrial zones. With the land use right, project developers can either lease land out to others or to get bank loans using the land use right as mortgage/collaterals, very often for other purposes. In both cases, both local authorities and project developers can claim success: local authorities have completed their assigned tasks while the project developers have made money, but no real progress has been made for the original purpose. This model has been widely repeated in other sectors, such as chips and software or any other high-tech industry. It worked in the past, not sure it will work forever.

The second is the need for a myth. Even though local officials in general have received higher educations, they know little about the complexity of the hydrogen industry. They were persuaded by the media that hydrogen is ready to take off as the solar PV industry did 15-20 years ago, particularly when they saw reports on ambitious hydrogen strategies in the western world. Most importantly, many are short of options to achieve their carbon reduction goals, so they count on hydrogen as a "mythical magic" for help.

The third is the herding effect. When leading cities like Beijing and Shanghai have all published ambitious hydrogen development plans, others do not want to be left behind. Making an even more ambitious plan will show they are at the cutting edge of the technology as well.

The last but not the least, the vested interest. The China Energy Group (merger of formerly Shenhua Group and State Power Investment Group), the world's largest coal producer, sees hydrogen as the future outlet of their coal; and Sinopec – the world's largest oil refiner - sees energy use as the future destination of their hydrogen production, which is currently only used as feedstock. Sinopec targets for 1000 hydrogen-refueling stations by 2025, without knowing whether there will be enough vehicles to serve. Across the country, over the past five years, more than 1,000 hydrogen companies have been created and a few got listed in the local stock markets.

8.5.4 Central government's dilemma

For the forthcoming 2022 Winter Olympic games, China will roll out a fleet of 700 hydrogen-fueled buses as a show case of low carbon transport, but similar buses were already operated in both the 2008 Beijing Summer Olympic and the 2010 Shanghai Expo. Since then, little progress has been achieved in hydrogen-fueled cars in China, while EV buses and cars dramatically improved their performances.

There will certainly be more pilot projects for green hydrogen production, hydrogen steel reduction, hydrogen-natural gas blending, hydrogen as flexible power source and small scale hydrogen applications. Some may achieve breakthroughs, but all these pilots are unlikely to support a large-scale hydrogen market in the coming years.

Contrary to the frenzy of the local authorities, the central government, represented by the NDRC/NEA, has been calm and cautious. Although hydrogen has now officially been classified as an energy carrier instead of just being a chemical element, and hydrogen refueling stations have been written into the 14^{th} Five-year Plan, the NDRC has not yet announced any specific strategy or plan on hydrogen.

We believe the central government is acutely aware of the local hypes on hydrogen. They are weighing out how to encourage technology development while not adding "fuels" to the fire that is already burning a lot of money across the country.

8.6 HYDROGEN: CHINA'S BLUEPRINT FOCUSES ON CAPACITY BUILDING AND DEMONSTRATIVE APPLICATIONS

Insight China, April 7, 2022

In our precedent report of "Hydrogen in China: Hope or Hype?", we reviewed over 50 local hydrogen development plans and concluded that they were "over-enthusiastic zealots" on the part of regional governments. We observed that in contrast to the frenzy of the local authorities, the central government, represented by the NDRC/NEA, has shown more calmness and cautiousness. "They are weighing out, in their forthcoming hydrogen strategy or plan, how to encourage technology development while not adding 'fuels' to the fire that is already burning a lot of money across the country."

Now the much-awaited plan is out. Released by the NDRC/NDRC on March 23^{rd}, the "Mid-to-Long-Term (2021-2035) Hydrogen Development Plan" (the Plan) clarifies China's hydrogen development priorities and focal areas. With this Plan, China joined other major economies (US, European Commission, and Individual EU Countries such as Germany, UK and France, Japan, Australia, Korea, Canada, etc.) in having a national hydrogen strategy.

What are the differences between the Chinese plan and those of other countries? Well, this Report does not intend to answer this question, but tries to help you make your own judgement by proving the following key elements of the Plan.

8.6.1 A much watered-down ambition

The Plan acknowledges the importance of hydrogen as a clean energy carrier with potentially big contributions to the netting-zero goals but putting a strong emphasis on the fact that conditions are not yet mature for large-scale deployment. The highlighted inadequacies China faces include innovation capabilities, sophisticated equipment manufacturing, critical core technologies, key components, and high cost. For instance, the end-user cost of hydrogen today in China is between RMB 50-80/kg (US$7.8-12.6/kg), much higher than oil-derived fuels.

Taking into consideration all those constraints and with an attempt to cool down the overheated local enthusiasm, the Plan sets rather qualitative and aspirational targets for 2025, 2030 and 2035:

- By 2025: build a complete industrial value chain with both "grey hydrogen" (industrial byproducts) and "green hydrogen" (from renewables). Emphasis is given to technology innovation aimed to master the core technologies and acquire manufacturing processes and improve hydrogen's competitiveness through demonstrative applications. The target is to have 50,000 hydrogen fuel cell vehicles on road, matched with adequate number of refueling stations, and 100,000-200,000 tons of green hydrogen produced.
- By 2030: construe an integrated innovation system and industrial value chain, where green hydrogen is embedded in broad areas of applications.
- By 2035: form a hydrogen application ecosystem covering mobility, energy storage and industrial applications, with the share of green hydrogen in total energy use significantly increased to play its due supporting role in energy transition.

As shown above, specific numerical targets are only set for 2025. As of July 2021, China had only 1,500 hydrogen vehicles on road. Growing the fleet to 50,000 represents a growth of 240% per year over 4 years, but it remains negligible given China's 395 million vehicles fleet in total.

100,000-200,000 tons of green hydrogen production will require an installed electrolysis capacity of 1-2GW, much less than the EU target of 6 GW by 2024. It represents a much-watered down ambition, given China's solar and wind manufacturing capabilities, and particularly in comparison with all the local governments' hydrogen plans.

8.6.2 Green hydrogen:

The Plan has clearly spelled out renewables as the future source of hydrogen supply, although today almost all China's hydrogen production is sourced from coal, gas and industrial processes. The growth rate of green hydrogen from almost zero in 2021 to 100,000 - 200,000 tons within 5 years may appears phenomenal, but not so when compared to China's existing total hydrogen production volume (33.42 million tons) nor to its total energy consumption of 3,400 million tons of oil equivalent.

Consequently, the essence of the Plan is much more about capacity building rather than any material target on hydrogen development.

8.6.3 Technological capabilities

The Plan calls out four areas of efforts to improve China's technological capabilities in hydrogen production, transport, storage, and utilization.

- The first involves core technologies. Efforts are called upon to improve both the efficiency of green hydrogen production and the unit size of production devices. PEM fuel cell technology is specifically mentioned for improvement in key performance indicators and modular production capacity, so are those for fuel cell's reliability, stability, and durability. Photodecomposition of water is mentioned as a new hydrogen production technology to pursue next. And all elements involving safety along the hydrogen supply chain are also classified as core technologies for the hydrogen industry.
- The second is to build hydrogen innovation clusters in key regions at different levels to achieve breakthroughs by collective efforts combining talent, technology and money. Companies, universities, and academic institutions are encouraged to create cross-industry hydrogen technology innovation centers, engineering hubs, and manufacturing innovation clusters. Small companies with highly specialized technologies are encouraged to develop into global champions in their specialty fields.
- The third is to attract talents and build the necessary professional team and capability.
- And the fourth is to expand international cooperation, joint up R&D, and build international hydrogen innovation value chain, while establishing common standards involving all elements of the hydrogen industry.

8.6.4 Hydrogen infrastructure

The Plan calls for an orderly construction of hydrogen infrastructure in pace with market development and building a "safe, stable and efficient" hydrogen supply network and value chain.

- Hydrogen production should be based on local conditions of resource endowment and industrial layout. In regions where grey hydrogen is available, local uses are given priority. In regions with abundant solar, wind and hydropower resources, green hydrogen production is to be deployed. R&D activities in new hydrogen production technologies, including solid oxide electrolyzer, photolytic water, seawater and high temperature heat from nuclear reactors, are all encouraged. Large hydrogen production bases should be explored only in regions with large-scale applications.
- For hydrogen transport, safety is given as the pre-condition for all new innovations involving high-pressure gas transport and storage, low-temperature liquid transport and storage, and hydrogen-natural gas blending, among others. Solid state, deep-cold and high-pressure, and organic liquid ways of hydrogen transport and storage are also encouraged for experiment. The objective is to build a high-density, light, low-cost and diversified hydrogen storage and transport network.
- Refueling stations should be demand driven, where safety is again given absolute priority. Retrofitting existing petrol stations to add hydrogen refueling service is allowed to save land. Integrated stations combining onsite production, storage and refueling are also allowed as a new operational model.

8.6.5 Demonstrative applications

The Plan attaches great importance to the demonstrative applications of hydrogen in all potential areas except for passenger cars. In transportation, priority is given to commercial vehicles with heavy trucks as the starting point, gradually expanding to public transport, logistic vehicles, ships and aviation (drone) uses. Table 8-4 provides the pilot hydrogen application programs in key sectors.

Table 8-4: Programs for Demonstrative Applications of Hydrogen in the 14th Five-Year Plan

Sector	Programs
Transportation	• In areas with high operation intensity and fixed driving routes, such as mining areas, ports and industrial parks, explore and demonstrate hydrogen fuel cell trucking and verify the application of the 70MPa hydrogen storage cylinders; • In locations with suitable conditions, pilot deployment of fuel cell commercial vehicles for public services such as of urban public transportation, logistics and delivery, sanitation and garbage clearance; • Explore to pilot hydrogen fuel cell applications in shipping vessels and aircrafts.
Energy storage	• Where renewables are abundant and hydrogen demands are high, pilot centralized renewables-to-hydrogen projects and explore commercial operation models that syn hydrogen storage with intermittent renewable power generation; • In regions that have concentrated hydrogen demands from pilot fuel cell bus routes, encourage deployment of integrated storage plus hydrogen-refueling stations based on distributed renewable energy or low grid load, fully utilize the advantage of lower costs from hydrogen-making within stations, and promote distributed hydrogen making and local or nearby uses.
Power generation	• In combination with incremental power distribution reform and integrated energy service pilots, demonstrate microgrids that integrate hydrogen and electricity, and promote application practices that combine fuel cell's heat and power supply; • In combination with newly built and renovated telecommunication base station projects, encourage pilots of hydrogen fuel cell as backup power for the base stations, and gradually integrate applications of hydrogen fuel cell into financial institutions, hospitals, schools, commercial, industrial and mining enterprises.
Industrial uses	• In combination with domestic market environment and industrial foundation of metallurgical and chemical industries, explore demonstration of hydrogen-powered metallurgical processes and also using renewables-made hydrogen to replace fossil fuels in synthetic ammonia, methanol, refinery, coal-to-oil and coal-to-gas conversion plants.

8.6.6 Challenges:

Given the startup nature of the "hydrogen as energy" business, the Plan calls for policy and regulatory support and for timely promulgation of rules and standards concerning the effective and sustainable operation of the hydrogen industry.

With time and the acquired learning by doing, we believe all pieces will gradually be put in place.

In our view, the biggest challenge ahead will be the creation of sound business models. That is how hydrogen can find its appropriate value in all the end-use applications where everyone involved in its production, storage, transport and final uses gets "rewarded" and R&D activities are well funded more by commercial entities rather than only by government grants. Commercial value creation depends not only on reducing the cost of hydrogen delivered, which is difficult over the short term, but also on industry-specific regulations that involve heavy duty transport, shipping, energy storage, and also as flexible sources of power generation and in all new industrial applications.

This is a complicated but a "must-be-resolved" issue before we see hydrogen business truly taking off in China.

8.7 ENERGY STORAGE: CHINA DECIDES TO WALK ON TWO LEGS

Insight China, April 12, 2022

Energy storage plays a critical role to secure energy transition by moving energy across time and space: storing energy when and where it is cheap and abundant, and delivering it to where and when it is needed and expensive.

What's the Chinese approach to energy storage[11]? How do Chinese decision-makers see priorities for future development? And what do they plan to do in this important sector?

This report addresses these questions on the basis of Chinese government's plans made public recently, including the "2021-2035 Plan for Pumped Hydro Energy Storage Development" of 17 September 2021 (the Pumped Hydro Plan), the "Guiding Opinion on the Acceleration of New Energy Storage Technologies" of 15th July 2021 (the Opinion) and the "14th Five Year Implementation Plan for New Energy Storage Technology Development" published on March 21, 2022 (the 14th FYIP).

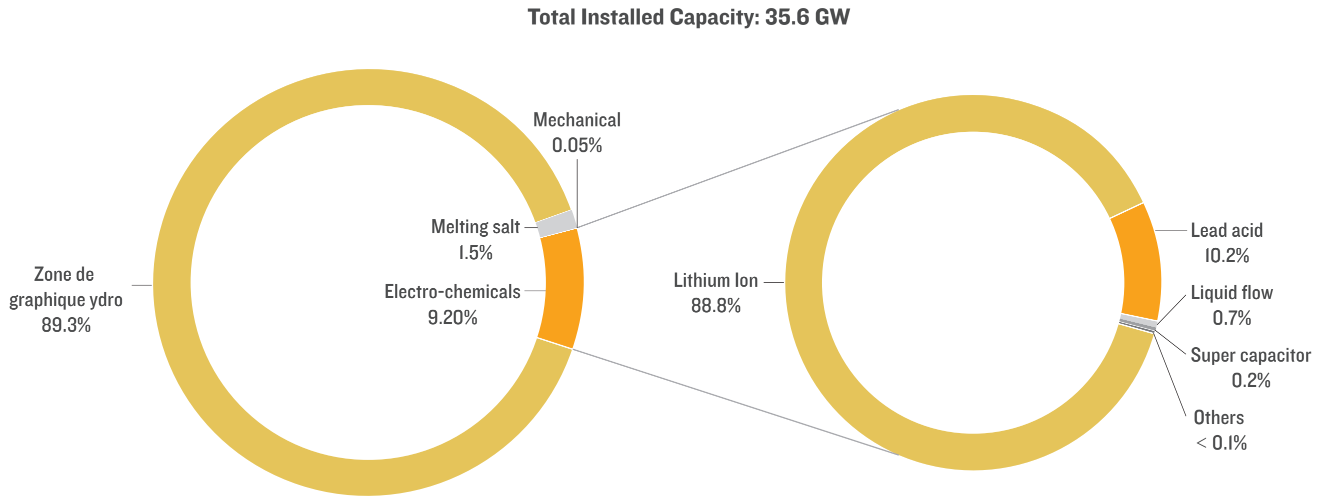
8.7.1 The Current Situation

By the end of 2020, China had a total of 35.6 GW of energy storage capacity in operation, 89.3% of which is pumped hydro, 9.2% is electro-chemicals, the rest 1.5% is split among melting salt, compressed air and flying wheels. Electro-chemical storage is dominated by lithium-ion batteries (88.9%), followed by lead-acid (10.2%) and liquid flow (0.7%), super capacitor (0.2%) and others.

As illustrated by Figure 8-4, currently, the overwhelming majority (90%) of energy storage capacity in China is provided by pumped hydro, with the rest broadly referred as "new energy storage" technologies.

11 In this report, energy storage is only about the power system, not involving the mobility system.

Figure 8-4: China's installed energy storage capacity by end 2020



Source: China Energy Storage Alliance

8.7.2 Walking on Two Legs: pumped hydro and new storage technologies

Pumped hydro:

Pumped hydro is the largest in scale, most mature and cheapest way of storing electricity today. China not only has the world's largest installed capacity, but also the strongest engineering and construction capacity – the world's largest single site of 3.6 GW and the largest single turbine of 400 MW are currently under construction.

Given these advantages, the 2021-2035 pumped hydro storage plan has set a 2025 target of 62 GW - almost doubling the 2020 level, and 120 GW by 2030. To achieve those targets, a total of 340 sites with a total capacity of 420 GW have been identified as the key getting-ready projects for implementation, and another 247 sites with a total capacity of 300 GW identified as reserve projects.

However, pumped hydro sites are not "universally" available and cannot be deployed wherever storage is mostly needed, for example, in combination with renewables at the generation site to avoid curtailment, or in urban areas for demand responses and peak shaving. As a result, the government has decided to accelerate the development of the 2nd leg – the "new energy storage technologies".

New Storage Technologies:

What does "new energy storage technologies" mean in China? Well, neither the Opinion nor the 14th FYIP has given a precise definition, but both documents have referred to the following: 1) compressed air energy storage, 2) flying wheel, 3) lithium-ion battery, 4) sodium-ion battery, 5) lead-carbon battery, 6) super capacitor, 7) liquid metal battery, 8) metal-air battery, 9) hydrogen and ammonia energy storage, and 10) heat and cold energy storage technologies. Interestingly, "high-temperature steam-vapor energy storage" (called pumped steam energy storage) is also mentioned as a new energy storage technology for nuclear power plants and conventional thermal power plants.

In total, they stood at 4.15 GW at end of 2020. The Opinion of last July sets a target to reach 30 GW by 2025, while the 14th FYIP of March this year does not mention this target, nor does it propose any specific action plan to achieve it. The FYIP only sets the target to reduce the cost of these new storage technologies by 30% against the 2020 level.

The intention of the Chinese planners is clear: maximise the potential of pumped hydro for large-scale system optimisation while accelerating the development and deployment of the new technologies, with some reservation on a specific target for the latter. The objective is to turn the new technologies from the early phase of commercialization to large-scale deployment during the 14th FYIP, with particular attention to R&D and manufacturing capabilities for highly safe, low-cost, high-reliability and long-duration energy storage solutions.

8.7.3 Key Tasks:

The 14th FYIP has listed the key tasks in the following six areas:

1. **Systematic innovation**: encourage the blossom of "a hundred flowers" of all new energy storage technologies, including 100-MW scale of compressed air, MW scale of safe, cheap and long-life lithium-ion batteries, 100-MW scale of flow batteries, MW scale fly wheel, MW scale of super capacitor, sodium-ion, solid lithium-ion, lead-carbon, liquid-metal and metal-air batteries; achieve breakthroughs in cross-board technologies related to battery safety, as well as smart control technologies for battery integration to different types of applications; and build an innovation eco-system with corporations as leading sponsors, in close collaboration with academic and research institutions.

2. **Demonstrative applications**: encourage demonstrative applications of all kinds of new technologies with different storage durations for different uses, particularly for those technologies that are considered major equipment. Differential policies should be made based on demonstrative applications in some key areas.

3. **Scaling deployment across the power value chain**: encourage generation-side deployment of new storage technologies to enable effective harvest of renewables and long-distance transmission of highly concentrated renewable generation. Grid-side applications will focus on enhancing grid safety and strengthening grid resilience; and end-use-side new technologies are encouraged to support distributed energy system, to provide customers with tailor-made and flexible energy solutions.

4. **Finding sustainable business models**: new storage technology deployers are regarded as independent market entities in the same way as solar and wind power developers. They can participate in all relevant power market. New regulatory measures such as pricing reform will be made to create a viable market and a sustainable business model for new energy storage solutions.

5. **Getting standards and regulations in place**: make or update relevant industry standards for safe operation of new energy storage technologies. Emphasis will be given to the mitigation of safety-related risks.

6. **Deepening international cooperation**: by both importing new advanced technologies and exporting made-in-China technologies, create new platforms to strengthen international cooperation.

8.7.4 Challenges:

Given China's ambitious climate-related target, such as one percentage point growth per year (from 15% in 2020 to 25% by 2030) of non-fossil fuels in total energy consumption and the duo-decarbonization goals, renewables are poised to continue growing rapidly in the coming decade. Energy storage will be a critical piece of the puzzle in next phase of renewable energy development, and the two-leg approach to energy storage seems spot-on and fit for purpose.

Commercial viability has become key. Although the government has vowed to turn the energy storage business commercially viable through a number of reform measures, we do see power sector reform to be the biggest hurdle to energy storage deployment, in particular for the new technologies. This may also be the main reason for the NDRC/NEA to drop the 2025 new energy storage target which was set in the Opinion, for fear of a "great leap forward" while their viability is not yet proven.

The government's intention is to allow all "flowers" to blossom, but lack of clearly focused and differentiated priority could become a source of concern. For example, lithium-ion battery for power system application will face tough user competition from EVs, where there already exists a sound and proven business model. But, if lithium-ion is the main player of what is called "new energy storage technologies" for the power system, we would be worried not only about its commercial viability, but also the global availability of lithium minerals to support aspired large-scale deployment of these technologies.

8.8 RE-ELECTRIFICATION: CHINA RAMPS UP ELECTRIFYING EVERYTHING

Insight China, No.23, May 4, 2022

With universal access to electricity already achieved in 2015, China has completed the initial process of electrification. Here comes a new round of electrification that consists of replacing end-use consumption of coal and oil with electricity – which is called re-electrification. Indeed, end-use electrification is regarded as an effective tool to improve energy efficiency, reduce both local pollution and GHG emissions, while modernizing the end-use equipment and technologies.

Recognizing these benefits, back in 2016, the Chinese government, led by the NDRC and 9 other relevant ministries and agencies, released the "Guiding Opinion on the Advancement of Electricity Substitution" (the 2016 Opinion), calling for electricity substitution in residential heating, industrial manufacturing, public buildings and transportation. The objective was to bring the share of electricity in final energy consumption – a key indicator of a country's electrification rate, to 27% by 2020. The final figure for 2020, at 26.5%, although below the target, was already a significant boost compared to the 2015 level of 22.9%.

Now, the new 14^{th} FYP has set the electrification target at 30% by 2025. To achieve this, on March 9 this year, the same 10 ministries and agencies jointly issued the new "Guiding Opinion on the Accelerated Advancement of Electricity Substitution" (the 2022 Opinion), providing further measures to accelerate end-use electrification.

8.8.1 What's new?

Comparing the 2022 Opinion with the 2016 version, we have seen the following noticeable enrichments:

- **Higher purpose and ambition:** while in 2016 version, the purpose of electrification was mainly to replace dispersed coal consumption as a means of reducing local pollution, the 2022 Opinion has given it a more mainstreamed mandate in light of the country's carbon peaking and neutrality goals. Electrification is regarded as a major tool for green energy transition in end-use sectors, a major means to absorb renewable energies, to improve energy system efficiency and to build a modern energy system that is secure, efficient and low carbon – in short, a major route to decarbonization.

- **Wider scope of coverage:** if the 2016 guidelines were cautious, calling only for "progressively expanding the scope for electricity substitution, case by case and step by step", the 2022 Opinion demonstrates no hesitation in calling for "advancement on all fronts" to promote electrification in industries, buildings, transportation and agriculture. Even aviation is included in the scope of transportation sector electrification.

- **More detail-oriented:** the 2016 guidelines only listed manufacturing sector, but the 2022 Opinion provides very concrete sector-focused actions for iron & steel, building materials, non-ferrous and petrochemical industries. Listed technologies for electrification have also expanded from 5 categories and 18 technologies to 21 categories and 50 application fields. Table 8-5 provides an overview of the proposed priorities in different sectors.

- **Clearer systematic consideration:** six years are long enough for the new guidelines to incorporate new enabling technologies in the toolbox for accelerated electrification. One such enabler is digitalization. The 2022 Opinion calls for "electric substitution + digitalization", to elevate smart controls and management by utilizing advanced digital technologies such as cloud computing, big data, IoT, mobile internet and AI. With both electrification and digitalization, the Opinion calls for "integrated energy services" for buildings and industrial energy management, while encouraging V2G (vehicle to grid), big data centers, and 5G base stations to participate in and interact with the systems via demand-side response measures and virtue power plants.

- **And stronger policy support:** according to the Opinion, electric switching projects will be supported by green finance via green bonds and green loans. They are eligible to participate both in the power trading market and in carbon emissions trading. But the Opinion does not give specifics on how to get it delivered in an effective and integrated manner.

Table 8-5: The Sector-focused Priorities for Clean Electrification

Sector	Priority levers
Industry: **sub-sector priorities** • **Steel** • **Building materials** • **Non-ferrous metals** • **Petrochemicals** • **Chemicals**	1. Electrify casting, heating, drying and steam supply; 2. Phaseout non-compliance coal boilers; and industrial kilns burning coal, petroleum coke, residual oil and heavy oil; 3. Promote electric furnace, electric boiler, electric kiln and electric heating; promote electric driven high-temperature heat pumps and high-power electric energy storage boilers; 4. Speed up construction of industrial green microgrids, including workshop rooftop solar, distributed wind, multiple energy storage, heat pump and residual heat and pressure utilization; 5. Promote electric belt gallery to replace fuel truck transportation; 6. Promote electric drilling and other electric motor units; and increasing level of electrification in mining
Transportation	1. Implementing national integrated vertical transportation plan; Promote electrification of road transportation and water transportation; and build integrated vertical transportation network that is green and low-carbon; 2. Accelerate electrification of urban public transportation; prioritizing use of new-energy vehicles in public transportation, taxi fleets, urban sanitation services fleets, postal fleet and logistic fleet; 3. Prioritize use of new energy vehicles in ports, newly-add and substitute airport vehicles in key air pollution prevention and control areas; 4. Promote household EVs; and accelerate installations of EV charging piles; 5. Renovate and retrofit with electrification of enterprises' internal operation on site of factories and mines; and promote electric ship and cruise along inland rivers, with matched charging infrastructure; and explore feasibility to retrofit inland river shipping electrification; 6. Increase shore facility electrification coverage and usage at inland river ports and ships; solidly promote shore facility electrification at coastal ports and ships in coordinated manner; 7. Prioritize airport electric shore facility; Increase usage of substitute facility of aircraft APU (auxiliary power unit); and promoting innovation and application of electric aircrafts

Sector	Priority levers
Buildings	1. Promote electric heating in areas not well-covered by centralized heating networks by using electric heat pumps, heat-storage electric boilers. distributed electric heaters; 2. Synchronize coal-to-electricity in cooking with electric heating, particularly in key plain regions with mandate to zero out dispersed coal; 3. Pilot to supplement heating with electric heating at end points of municipal heating network; 4. Encourage combined cooling and heating technology in regions with right conditions; and adopt electric cooling and electric heating; 5. Encourage government agencies, schools and hospitals and other public institution buildings and offices, hotels, commercial complexes to retrofit for electrification; 6. Utilize self-owned rooftops and sites to expand new energy power generation for self-use.
Agriculture	1. Sustain promotion of rural electrification to deliver rural revitalization; 2. Broadly deploy farmland wells' electric-powered irrigation and drainage, high-efficiency and energy-saving sunshine greenhouses and integrated nurseries, and develop ecologically-friendly cultivation; 3. Promote electric drying and processing in cultivation, grain storage and agricultural side-products processing and increasing production quality and efficiency; 4. Develop on-site pre-refrigeration, storage for preservation and cooling logistics in fruit and vegetable fresh produce and specialty agricultural products production areas; 5. Promote electric substitutes in husbandry and aquaculture, and increasing digitalization and intelligence in husbandry environmental control and precision feeding.

8.8.2 What're the implications?

The re-electrification will no doubt significantly boost China's electricity demand and add further stress on the country's power supply system, which had already experienced severe power shortage in 2021. It also puts new challenges in decarbonizing the power sector.

In 2020, China consumed 7,520 TWh of total electricity, 30% of which from non-fossil sources. Forecast by the Industrial Economics Research Institute of the Chinese Academy of Social Sciences puts the country's total power consumption in 2025 at 9,000 TWh, representing 4.8% of annual growth between 2020 and 2025. The government's 14^{th} FYP is to have 39% of this power from non-fossil fuels, 9 percentage points above the 2020 level.

Ensuring supply security for the growing electricity demand and assuring that a growing part of this electricity is generated from non-fossil fuels represent thus a formidable "duo challenge" for China's re-electrification process. We will further explore these trends in our future Insight China reports.

9

EMERGING SUBJECTS

9.1 TRANSFORMING ENERGY SYSTEM WITH 5G MOBILE COMMUNICATION TECHNOLOGIES

Insight China, April 25, 2022

Information and Communication Technologies (ICT) are transforming our societies. They also have the potential to accelerate energy transition by making the infrastructure-heavy energy system "lighter and more flexible". Energy companies worldwide have been among the biggest users of ICT digital technologies.

However, in no other country than China, have we witnessed a government-directed national action plan to promote one particular ICT technology in the energy field. The "Implementation Plan for the Application of 5G Mobile Communication Technology in the Energy Sector" (the Plan), jointly released by NDRC (National Development and Reform Commission), NEA (National Energy Administration), Ministry of Industry and Information Technology (MIIT) and State Council's Network and Information Office in July 2021, not only shows how strong the policymakers' aspiration is in transforming the energy system with ICT technologies, it also demonstrates how detailed a government-directed plan could be around one specific technology.

9.1.1 Advantages of 5G mobile communication technologies:

From the appearance of the first generation (1G) mobile phone in 1986, mobile communication has evolved from simple transmission of voice to text and email enabled 2G in 1994, videos and games supporting 3G in 2000, App supporting 4G around 2010, to today's 5G with bigger data transmission capability, faster speed and lower latency. Starting from 4G, smart phones have enabled and empowered a large number of Apps allowing online shopping and digital payment on your palm at your fingertip, but it is only with 5G that industrial applications become viable thanks to its powerful data transmission capability.

As shown in Table 9-1 below, 5G technology is 60-100 times faster in data transmission speed than 4G, 20 times bigger in capability to connect (as reflected by Bandwidth) and 100 times shorter in response latency. In ICT professional terms, 5G has the following three key features:

1. **Massive Machine-Type Communication (mMTC)** allowing for machine-to-machine communication that is the basis of all internet of things (IoT) industrial applications;
2. **Enhanced Mobile Broadband (eMBB)** allowing for connections of larger number of machines to the communication system; and,
3. **Ultra-Reliable Low Latency Communication (URLLC)** allowing for remote surgeries and automatic driving, among other applications.

Table 9-1: Evolution of Mobile Communication Technology and Its Applications

	Frequency Band	Speed	Bandwidth	Latency	Applications
5G	0.41-7.125GHz or 24.25-52.GHz	10Gbps	400MHz	<1ms	Real time industrial IoT and control, surgical operations, automatic driving. emersed gaming, smart grid, smart cities, etc
4G	850-4,600MHz	100-150Mbps	20MHz	<100ms	High resolution voice, pictures and videos. with internet connection and mobile APPs
3G	800-2,100MHz	2.8-14.4Mbps	1.25-5MHz	a few 100ms	Voice and high speed data transmmission, including videos and games
2G	800-1,800MHz	14.4kbps	0.2-1.23MHz		Voice, text, email and internet connection
1G	900MHz	2.4kbps	0.025MHz		Voice transmission via analogue signals

Source: CN Innovation

Given these advantages of and China's leadership in 5G technology, the Chinese policymakers regard it as a crucial strategic resource and a major element of new infrastructure for the country's deeper digital transformation.

Due to high energy consumption of 5G stations and high cost in building them, it appears that its application for people-to-people communication or online App supporting functions (generally referred to as to C or "2C") would be an over-kill, the focused attention has therefore shifted to greater industrial applications (to B or "2B"), where energy ranks as one of the top priority sectors.

9.1.2 The Objectives:

According to the Plan, the objective is to achieve, over the next 3-5 years, the following five core deliverables described as "a number of" that apply 5G technology to power plants, power grids, coal mines, oil and gas fields, comprehensive energy services, and energy equipment manufacturing, while building up the enabling context and foundation to scale next phase of deployment. They are:

1. A number of typical 5G application cases;
2. A number of 5G-dedicated industrial data transmission and processing networks;

3. A number of duplicable, easy-to-promote and competitive business models;
4. A few 5G related technologies and products that are specifically designated for energy industry applications; and,
5. Several technological standards that are urgently needed for wider adoption of the 5G technology.

9.1.3 The Targeted Applications:

The Plan has also listed a few specific actions in each of the following energy infrastructure areas:

1. **Smart Power Plants:** deploying the capabilities of 5G and related technologies to achieve smart production control, smart surveillance, smart maintenance and emergency response.
2. **Smart Grids:** achieving smart surveillance of transmission and distribution grids, grid protection and control; as well as better renewable energy integration, collaborative dispatching and grid stability.
3. **Smart Coal Mines:** achieving "smartness" in extraction and production control, environmental monitoring, and safety protection, underground well surveillance, automatic driving of coal transport vehicles, and virtual interactions between of mining operation and remote expert assistance.
4. **Smart Oil and Gas:** achieving smart E&P, smart operation of oil and gas fields, smart and safe refineries, and smart and safe transportation.
5. **Energy Services:** achieving intelligent flexible integration of power, gas, heat and cold energy sources to efficiently meet energy demand through interactions among energy sources, networks, load, energy storage, virtual power plants and distributed energy systems.
6. **Smart manufacturing and construction:** applying 5G capabilities for real-time data acquisition and control, remote monitoring of manufacturing process and workshop safety.

Each of these areas is detailed with concrete actions.

9.1.4 Challenges:

Just as the Plan's "narrative" has illustrated, it's not a simple-minded focus on one particular technology, but rather, it shall be read as another national strategic intention to tap into the biggest technological potential of digitalization to accelerate clean energy transition and build a modern clean energy system.

To achieve the adopted objectives, the Plan emphasizes the cruciality of innovation and standardization. It calls for the creation of **a technology innovation platform** dedicated to 5G applications in the energy sector, **a public service platform** and **a resilient cybersecurity system** to support the broader integration of 5G technology into the energy system. And, it has identified priority focuses to develop both commonly used technologies and sector-specific technologies, the promulgation of industrial standards for 5G applications, the certification of key application technologies and the development of a cyber-security system.

What appears inadequate or lack of clarity is, as usual, who will and how to foot the bills. The Plan is titled as "implementation" and to implement the called-for actions costs money. But just as all the other plans released so far, this Plan remains "constrained" in a broad brush, without specifics yet on how to finance the desired "a number of"s.

9.2 ALIGNING WITH GLOBAL STANDARDS TO ACCELERATE DECARBONIZATION

Insight China, May 9, 2022

Standards, be them technological (involving one particular technology such as 5G), technical (involving one particular product such as cell phone), or practical (involving a particular way of doing things such as CO_2 measurement) establish consistent and common protocols for the modern society to get factories built, goods and services developed and exchanged, and manufactured products moved across borders. They are indispensable for measuring, reporting and verifying (MRV) GHG emissions under any national climate scheme or global climate pact.

What will happen, if China, the world's biggest GHG emitter, defines its own technical specifications for decarbonization products, and its own norms in GHG MRV and in green financing that are very different from the rest of the world? Well, it will significantly increase the cost of global decarbonization, and create trade frictions.

Fortunately, this won't be the case. This Insight report reviews Chinese standardization and sheds some light on the challenges in its global alignments.

9.2.1 The target of 85% alignment by 2025

As part of the effort to revamp the old standards system to match up with a new world powered by new technologies, filled with new products and operated by new practices, and to tackle the new challenges such as carbon neutrality, China released its "Outline for National Standardization Development" last October, setting goals for the country to build a standards system that is "structurally optimal, advanced and rational, and internationally compatible" by 2035. It is aimed to support the country's Vision 2035 to build a modernized, high-quality, and globally-leading economy.

The Outline sets an interim target that, by 2025, China will align 85% of its domestic standards with global ones, on all fronts. A very ambitious target, if achieved, will have significant global implications.

9.2.2 Standards for carbon peaking and neutrality

The Outline, along with all other governmental policy declarations on carbon peaking and neutrality, has mentioned the following work focuses that are deemed as urgent needs for standardization:

- Terminologies and measurement system related to GHG emissions;
- MRV: standards for GHG emission monitoring, accounting, reporting, and verification;
- Energy saving: standards for energy saving equipment, energy efficiency, energy accounting, verification, assessment and auditing; and management of energy metering equipment; and,
- Carbon accounting: standards for carbon emission MRV at regional, industrial, corporate and product levels;
- Key industries and key products: standards for GHG emissions, and labelling system for low-caron products from life-cycle perspective;
- Renewables: standards for both production process and products;
- Standards for carbon sinks and CCUS;
- Standards for building a new power system with renewables as mainstay;
- Standards for power dispatching, power system security, power storage, and new energy vehicle high power charging;
- Standards for hydrogen production, storage, transport and uses;

- Standards for green and low carbon industries; and,
- Standards for green consumption.

9.2.3 Align with whom?

While international exchange and collaboration are called upon to promote mutual recognition of standards, China gives priority to International Standards Organization (ISO) and International Electrotechnical Commission (IEC) as two major global benchmarked standards for alignment.

Table 9-2: Examples of International Standards Benchmarking: ISO and IEC

Sector/Focus	Benchmark Standards
Energy saving and energy efficiency	ISO/TC301, TC205, TC163, TC274, ISO 50001 IEC/SMB/ACEE
Solar energy	ISO/TC180 IEC/TC82, TC117
Wind energy	IEC/TC88
Hydrogen energy	ISO/TC197, ISO/TC22/SC37 IEC/TC105
Biomass energy	ISO/TC238, ISO/TC255
New energy vehicle	ISO/TC22/SC37 IEC/TC69
Nuclear energy	ISO/TC85
Tidal wave energy	IEC/TC114
CCUS	ISO/TC265
GHG management	ISO/TC 207, ISO 14068, ISO/TC17, ISO/TC 59/SC17, ISO/TC 146/SC1, ISO/TC130 IEC/TC111/WG17, IEC/TR 62725 2013, IEC/TR 62725 2014

Institutionally, the National Carbon Emission Management Standards Committee takes on the mandates to lead the development of decarbonization standards and global alignment. In its assessment against the relevant global benchmarks and best practices, the Committee has identified at least six key areas of further work to best support the transition:

1. Standards system that improves carbon emissions management;
2. General standards that stipulate GHGs management terminology, and improve data quality;
3. Improve national standards of existing enterprise-level and project-level GHGs and clearance accounting and reporting, maintain consistency between Chinese and international standards, and stipulate accounting standards of product and service carbon footprints;
4. In verification standards, improve specification of general rules for examination and verification as well as accreditation of institutions and personnel;
5. In technical standards, stipulate direct online monitoring technology standards; and,
6. In management service standards, stipulate GHG information disclosure standards.

9.2.4 Challenges

While the target of 85% global alignment by 2025 reflects a sense of urgency in China to accelerate standard setting, we see important challenges ahead.

The first is the lack of expertise, capability, and capacity on the part of players, be them government agencies, research institutions or companies. So far, China has achieved much in getting the terminology, the language, and the narrative together in aligning with global climate governance, but barriers remain such as the "murkiness" of terminologies, inadequacies in coverage, and gaps in accountability to upgrade the existing standard systems.

The second will be international conflicts in standards setting. A real-life case has emerged between EU and China on standards for embedded carbon emissions in products and services. The EU "carbon border adjustment mechanism" (CBAM) targets imports of carbon-intensive products to avoid carbon leakage and will impose its own standards for the MRV. As Europe largest trade partner, will China accept and follow the European standards? Or will it make Europeans accept the Chinese standards? Or will the two parties forge a common "middle ground", cooperatively?

Well, this question seems to go beyond the currently focused issues of standards harmonization.

9.3 BATTERY RECYCLING: MINING THE ABOVE GROUND MINERALS

Insight China, March 24, 2022

China is the world's largest EV manufacturer and market with 6 million of "new energy" (i.e. electric) cars and trucks already on roads. In 2021, China sold 3 million EVs, plus 400,000 electric buses and millions of electric bikes and mopeds running in cities and rural areas. According to the New Energy Vehicle Industrial Development Plan 2021-2035, at least 20% of China's annual vehicle sales will be new-energy by 2025.

However, EVs are metal-intensive, particularly those metals that are considered "critical" or "strategic" (see Insight China report 006/2022). The explosive growth of battery-driven EVs raises concerns over critical mineral supply security, while price spikes, supply chain disruptions and tightening ESG regulations and standards offer the biggest incentive for China to fixate its efforts on recycling[12] retired or spent EV batteries.

Chinese regulators and policy makers have been literally "ON" it. The 14th Five-Year Green Industrial Development Plan (2021-2025), released last December, is a recent move to further implement the New Energy Vehicle Industrial Development Plan 2021-2035 and contains specific priorities to advance EV battery recycling to the next level, which put emphasis on regulation, standardization, oversight, internet+recycling, shared value-chain infrastructure, technology R&D, business and service model innovation, and incentives for financial flows.

This Insight China report offers an in-depth analysis of how the country, already leading global EV deployment, plans to maintain its next EV advantage by closing the material loop.

9.3.1 Sizing the market of "moving metal mines"

China's first EV fleet appeared around 2008 when the national government rolled out its pilot scheme of "10 cities and 1,000 electric vehicles each". Most manufacturers have a five-to-eight-year warranty on their battery. By the time around 2016 to 2018/2019, the first crop of EVs started coming to the end of their life and the batteries are ready for recycling.

And, the year of 2015 becomes the starting point of "explosive" growth of new energy vehicle (NEV) sales in China - when more than 330,000 vehicles were sold, 343% YoY growth.

Technical feasibility of recycling has already been proven. Theoretically, existing technology in China can recover around 80% of the components of different battery types, which means that today's low rates of recovery lie more in the standardization of systems, regulations and pathways than immature technology.

China is bracing for a recycling climax of retired EV batteries in its current Five-Year Plan period (2021-2025), when some market analysts forecast a 31.3% CARG. In 2020, it was estimated to be at 2.4 billion yuan (~$380 million). By 2025, the current forecast is to reach as much as 100 billion yuan (~$15.5 billion). Between 2026-2030, the CARG is expected to reach 35.6% and between 2031-2035 at 19.4%.

9.3.2 Laying down the regulatory foundation

The Ministry of Industry and Information Technology (MIIT) takes charge of policy, regulation and standard of retired EV battery reuse and recycling. In 2016, MIIT first issued its Technology Policy on EV Battery Recycling. This kicked off a "stream" of regulatory endeavor, summarized in Table 9-3, to guide, regulate, support, nurture and incentivize investment in recycling of retired EV batteries.

12 Two ways to handle retired EV batteries are **ladder reuse**/energy storage and **recycling** that disassembles retired batteries, recycles high-value metals such as lithium, cobalt, nickel among others, and remanufactures. This report focuses on the latter.

Table 9-3: Chinese Government Policy Highlights for Retired EV Battery Recycling

year	policy	key points	agency
2016	technology policy on EV battery recycling	• establishing tiered reuse or utilization of EV batteries and recycling management system, • guiding EV battery producers to enhance recycling of used batteries, - encouraging development of specialized recycling companies	MIIT
2017	plan to promote EPR (extended producers' responsibility)	• by 2020, EPR policy framework in place, major progresses made in product eco-design, and average 40% waste recycling rate for some key products • by 2025, EPR laws and regulation in place, average 50% waste recycling rate for some key products	State Council
2017	standards on EV Battery Recycling Disassembling	• safety, operation procedure, storage and management • specialized technologies and recycling system	State Standardization Management Committee
2018	• temporary method to manage EV battery recycling • temporary standard on managing EV battery recycling and source tracing	• a "traceability management platform" • local recycling systems, 17 cities and regions piloting • clarification of car makers to hold major responsibility in recycling, following the principle of "makers recycle" • encouraging "internet+recycling" business models	MIIT
2020	implementation guidelines on scrap car recycling management	• further regulation on EV battery recycling • companies in recycling and disassembling taking charge of value chain whole-process safety management - disassembling, collection, storage, transportation and recycling and reuse	Ministry of Commerce, MIIT
2020	coordinated transition and uplifting plan of integrated industrial resources utilization in Beijing-Tianjin-Hebei and surrounding region (2020-2022)	• regional complementarity and coordination in shaping recycling system • promotion of ladder reuse and recycling pilots in Shanxi, Shandong, Hebei, Henan and Inner Mongolia • supporting EV battery recycling projects • increasing regional capacity and capability	MIIT

year	policy	key points	agency
2020	new-energy vehicle industry development plan (2021-2035)	• EPR • strengthening establishment of platform to manage EV battery source tracing and 100% life-cycle traceability	General Office of State Council
2021	management measures for gradual utilization of new-energy vehicle power batteries	• battery inspection and test, sorting, disassembling, repair or regroup to ladder products • collaboration between national and regional departments and business and industry • traceability and accountability of ladder 2nd utilization industries	MIIT/5 agencies
2021	14th Five-Year Green Industrial Development Plan （2021-2025）	• a more complete battery recycling system • 480 million yuan ($76 million), recycled resources industrial output • 57% recycling rate of solid wastes of key commodities • green manufacturing systems in place for key sectors and regions • also including reuse and recycling in the Circular Economy Development Plan	MIIT
2022	implementation plan on accelerating industrial resources integrated utilization	• bettering management system, life-cycle tracing, and management • promoting **upstream-downstream co-building** of recycling channels, across region systems • piloting in **key regions** such as Beijing-Tianjin-Hebei region, Yangtze River Delta region, and Guangdong- Hong Kong-Macau region, in testing and inspection, **automated disassembling**, and R&D in high-value metals extraction	MIIT, NDRC/8 agencies

Standardization is critical. The current national technical standards on retired EV battery recycling focus on 1) pre-treatment; 2) package disassembling; and 3) module disassembling.

9.3.3 Shaping up a closed-loop marketplace ecosystem

The proactive moves in policy, regulation and standards have helped to establish and prove industrial and value chain processes, architecture and ecosystems of the marketplace. Local governments have also started to promote the battery recycling sector. Currently, China has over 10,000 battery recycling centers across the country.

There are four major categories of recyclers active on and leading the market, as summarized in Table 9-4, each with its own strengths and inadequacies to improve as learned from market practices.

Table 9-4: Recycling Models in China

recycler category	operation model	strengths	inadequacies
new-energy auto makers	battery swap and recycling through • agreement with scrap car disassembly companies • existing 4S car dealers • post-sale service stations	• strong applicability • high incentives • less interest conflicts	• expertise • safe concerns
EV battery manufacturers	• reverse logistics through coop with automakers, 4S car dealers, post-sale service stations and EV battery rent stations • change logistic dispatch centers to recycling centers for storage, inspection and sorting • some batteries for tiered reuse market and others for recycling back to battery manufacturers as raw materials	• strong expertise in battery • recycling process learning feedback to improve battery performance	• high demand on management skills
3rd party recyclers	• recycling network spots • clustered storage spots • scrap car disassembly companies	• mature operation • stable networks • incentivized active expansion of networks	• higher costs
EV battery industrial alliances	• organize industrial alliances clustered around battery producers, automakers and 3rd party recyclers to strengthen specialized expertise, infrastructure and network	• low costs • high recycling rate	• management challenge • information feedback delay • regional constraints

In 2018, five Chinese recycling companies were initially listed on the market. Two of those companies - Brunp (acquired by CALT) and GEM now represent about 50% of all official battery recycling business in China. By now, a total of 47 enterprises have entered the list of "New Waste Power Battery Comprehensive Utilization Industry Specification" issued by MIIT (or whitelisted companies). And those leading companies define the dynamics and innovation of the marketplace today and chart its future development in China and beyond.

9.3.4 Racing for the global market

As our analysis has shown, Chinese policy makers and regulators are unifying industry standards, enhancing infrastructure, and nurturing the marketplace to help connect the dots and enable a sector-wide acceleration that brings benefits to storage, disassembly, safety and environment. In the meanwhile, the market leaders have taken steps to explore diverse, cross-region, and cross-border partnerships and innovate feasible business models. Together, they have prepared the ground for unified battery recycling and management, as well as scaling the marketplace.

But this doesn't mean China has reached the final stop yet. The domestic market is far from being sound and healthy. Thousands of smaller recycling businesses, ill-equipped with technology and expertise, "disrupt" the market and business model by offering cheaper than the officially allowed recycling businesses. In most cases, they do not necessarily recover all of the precious resources, and often improperly dispose of precious and environmentally hazardous materials.

A global race is already ON. Driven by clean energy transition, energy security, mineral/metal supply chain security against the backdrop of highly complex geopolitics, intensifying climate change, and price spikes of commodities, China, accounting for 77% of the EV battery recycling market in Asia, is gearing up its actions. And the EU and US are catching up.

But, many more questions remain. A recent Nature research paper finds that battery technology and recycling advancement, two widely acknowledged strategies for addressing supply risks, cannot solve supply shortage of cobalt in short- to medium-term (2028-2033). This "happens" in the timeframe of planned leapfrogging of clean mobility. Therefore, collaboration beyond competition is more urgently needed than ever, particularly among the major economies to scale reuse and recycle of spent power batteries.

9.4 THE ENERGY DEMAND REPERCUSSIONS OF ADVANCED DIGITALIZATION

Insight China, June 30, 2022

Digitalization and decarbonization feature the trends of our time. They are intertwined in that digitalization enables carbon emission reduction via improving energy efficiency, bettering integration of renewables and optimizing power system while empowering the broadest social participation in clean energy transition. But it also requires electricity to drive the digital infrastructure that captures, transmits, processes and stores data, as well as displays data in customized format and executes the desired instructions.

Therefore, stable and uninterrupted power supply is a pre-requisite to operationalize telecommunication systems, IoT, big data, cloud and edge computing, bitcoin mining, etc. As digitalization accelerates, what are the repercussions on power demand?

This Insight China report assesses the energy demand implications of China's digital revolution.

9.4.1 I. The digital revolution

With over one billion netizens, China is the world's largest digitalized society. It is also the world's 2nd largest "digital economy" next to the US. In 2020, the Chinese "digital economy", measured by both the value-add of digital ICT industries and the value created by the digitalization of industries and services, amounted to US$ 5.4 trillion (compared to $13.6 trillion in the US), accounting for 38.6% of the country's GDP (64% in the US) in 2021.

The Chinese government launched a largely digital driven "New Infrastructure" scheme in mid-2020 amidst the pandemic, aiming to lay a strong foundation for the expected post-pandemic recovery and growth. The plan has seven focuses, including 5G base stations, ultra-high voltage power transmission lines, inter-city and intra-city rails, charging piles for EVs, big data centers, AI and industrial IoT.

And, in November 2021, the Ministry of Industry and Information Technology (MIIT) published China's 14th Five-Year Development Plan (2021-2025) for the ICT Industry, aiming to build and enhance a digital infrastructure that is high-speed, ubiquitous, integrated and interconnected, smart and green, secure and reliable. Some specific growth targets for 2025 are set: grow the number of 5G base stations from 0.7 million in 2020 to 3.64 million in 2025; data center computing power from 90 eflops[13] to 300 eflops; and smart terminal devices from 3.2 billion in 2020 to 4.5 billion in 2025.

9.4.2 Power requirements of digital infrastructure

The digital infrastructure is built with basic digital devices, all need electricity to power them. These devices can be grouped into the following three categories: data acquisition, data transmission and data processing/storage.

9.4.2.1 Data acquisition and display devices

These include sensors that convert the property or status of a physical system into digital signals (e.g. smart meters, digital surveillance), and smart interactive devices (such as phones, tablet computers, Wi-Fi boxes, TVs) that both capture data and display results. Even though individually, the energy consumption of sensors and devices is miniscule, only a few watts in most cases, but when multiplied by their number – often in millions or even billions, the energy use becomes very significant. The 2018 IEA study on digitalization and energy estimated a total of 15.5 billion such devices in operation worldwide and that each consumed 22kWh per year on average.

9.4.2.2 Mobile communication stations

Mobile telecommunication has evolved from first generation (1G) in 1986, to 2G (1994), 3G (2000), 4G (2010) and then today's 5G deployment, with faster speed, wider bandwidth and lower latency. Most of the smart-phone-based Apps were made possible only after 4G was introduced, and today, 5G is the enabling telecom infrastructure required for industrial IoT, remote medical operations and automatic driving systems.

Due to its limitations in signal transmission distance and obstacle penetration capability, a 5G station is not just one transmission tower. It is composed of one macro site (also called base station), plus many lower-level micro-sites, pico sites and femto sites in order to cover a given area. Table 9-5 below provides some technical specifications (transmission distance, number of connections and power requirements) of different 5G sites.

13 Eflops stands for Exa (10 ^18) floating operations per second.

Table 9-5: Power Requirement of Typical 5G Sites

Basic digital device	Transmission Distance	Number of Connections	Power requirement (full load)
5G station			
• Macro site	>200 meters	>1000	8.2-8.7kW
• Micro site	50-200 meters	128-512	2kW
• Pico site	20-50 meters	64-128	800 W
• Femto site	10-20 meters	8-16	10-50W

Running a typical 5G macro-site (or base station) requires an average 8.5 kW of power, 2.5 times that of a 4G site. About 45% of its power is dedicated to run the main electronic device, 40% for air conditioning, and 15% for electrical system. It's estimated that, in the next three years, with the deployment of more powerful signal emitting and receiving antenna (Massive MIMO), as well as introduction of edge computing, a 5G macro site will consume 13.7 kW in full load; and, in the next five years, future new technologies, such as mm wave, may further push up the power requirement to 19kW per base station.

9.4.2.3 Servers and data centers

Data center is where data is processed and stored, and the basic element of the server is composed of integrated circuits or chips. The size of a data center varies depending on need. It could occupy a small room or an entire big building. Its computing power is determined by the number of server racks – a big data center could have tens of thousands server racks packed one after another.

Server racks are divided into 3 categories: low-density racks require less than 4kW power; medium-density ones 5-8 kW; and high-density ones between 9-15 kW. High performing and new server technologies such as GPU (graphic processing unit) is expected to push up power consumption of a server rack to 20-30kW.

Data center has two specific needs for "normal" operation: to power the servers and to keep the room temperature within 18~27°C and the humidity level below 60%. The energy efficiency of a data center is measured by the ratio between total energy consumption and the amount that is strictly consumed by the servers. It is called PUE (Power usage effectiveness). The closer to 1, the better and more efficient. Given it's hard to achieve efficiency in pre-installed servers, the focus of data center efficiency has been on reducing the PUE, i.e. getting rid of the energy needed to run the non-server part of the data center, and aircon becomes the most important area.

Data centers can be located close to the operational sites to provide what is called "edge computing" services, or located far away (in the "cloud" given that the user doesn't care where it is actually located) in cooler areas with cheaper and abundant electricity supply.

9.4.3 Aggregating the digitally induced energy demand

9.4.3.1 Smart devices

If we assume 20kWh power consumption per smart device per year (10% reduction from the IEA average of 22kWh per year taking into account efficiency improvement), then, achieving China's 2025 target of 4.5 billion devices, of which 1.3 billion newly added, will cause an additional annual power demand of 1.3 x 20 = 26 TWh.

Assuming these devices only operate 8 hours a day, it means an additional power generation capacity demand of 9 GW.

9.4.3.2 5G deployment

By end 2021, China had 1.42 million 5G base stations already in operation, forming the world's largest 5G telecommunication network. These stations are mainly for people-to-people communications, but there is a new focus to deploy 5G technologies in industrial activities, as we outlined in the April 25th edition of Insight China series[14].

If China were to achieve the 2025 target of 3.64 million 5G base stations, it would mean an increase of 2.22 million more stations in the next four years. If using 2020 as the baseline year, the 5-year increase is expected to be around 3 million.

If, on average, one macro site requires 8.5 kW power, Then, 3 million new sites will add 3 x 8.5 = 25.5 GW of power capacity. These sites are expected to run 24/7, adding extra 223.4 TWh of power consumption.

However, if 1 macro site is accompanied by 5 micro site and 25 pico sites, we would expect 38.5 kW (8.5 kW + 5x2kW + 25x0.8kW) for each 5G macro-site as its subsites. Then, 3 million new sites will add 3 x 38.5 = 115.5 GW of power capacity. These sites are expected to run 24/7, adding extra 1,012 TWh of power consumption.

How many micro- and pico-sites will accompany one macro site will have significant impact on power consumption. As outlined earlier, introduction of new generation 5G technologies such as Massive MIMO, will push up significantly the power consumption.

9.4.3.3 Data centers

According to China's State Grid Corporation and China Data Centre Energy Conservation Association, data centers consumed a total of 300 TWh of electricity in 2020. A computing power increase as programmed in the 14th Five-Year Plan from 90 eflops to 300 eflops will push the data center power consumption further. Given the 2020 baseline and China's target is to reduce the average data center PUE from 1.4 in 2020 to 1.3 by 2025 nation-wide, a 3.3 fold increase in computing capacity will bring total data center power consumption to 930 TWh in 2025. Deducting the 2020 baseline of 300 TWh, the additional data center power consumption from 2020-2025 would be 630 TWh. As data centers are expected to operate 24/7, this implies an additional power capacity of 72 GW.

9.4.3.4 Aggregation

To sum up, the acceleration in digital infrastructure development will add between 106.5 to 196.5 GW of extra power capacity and between 880 to 1,668 TWh of electricity consumption between 2020 and 2025. These increases (i.e. not including the 2020 base numbers) will account respectively for 3.7-6.8% of the country's total installed power capacity (2,900 GW in 2025) and an astonishing 9.8-18.5% of total power consumption (estimated at 9,000 TWh for 2025).

9.4.4 Implications for energy security and decarbonization

Additional digital infrastructure alone during 2020-2025 will consume between 9.8-18.5% of China's total electricity by 2025. Unbelievable, isn't it? Well, the numbers above don't lie.

5G stations make the main difference between 9.8% and 18.5% in 2025, and the difference is attributable to the number of sub-sites by which each macro-site will be accompanied.

Building only macro sites without satellite sites would significantly reduce power consumption, but it would

14 Transforming Energy System with 5G Mobile Communication Technologies. Insight China, April 25, 2022.

also reduce the value of the 5G deployment as it is less covered geographically.

Another major issue is the poor business model of 5G technology for people-to-people communication, due to excessive energy bill. A fully loaded 5G macro-site alone would consume 74,460 kWh a year, costing RMB 59,568 (US$9,455), which is hardly recoverable from increased customer bills. Consequently, the 5G promotion program for people-to-people communication could be hampered, simply due to high energy bills.

These factors together explain the shift of focus of 5G application from people-to-people communication to machine-to-machine communications, which can be found in industrial, medical and transportation sectors.

Data centers will provide the steadily growing baseload of digital infrastructure energy demand, rising from 4% of the country's total power generation in 2020 to 10% in 2005, if the computing power is to grow as planned. This growth could have larger structural repercussions to energy demand:

- Firstly, an increasing number of "edge computing" data centers will be built in the eastern more developed coastal cities, to support industrial IoT operations, automatic driving and 5G deployment, adding further stress to the existing load curve;
- Secondly, more data centers are expected to "migrate" to the western part of the country, driven by the government's campaign of "Data from the East processed in the West" to make data travel instead of power travel between power rich West and demand heavy East. This will reduce the western regions' capability to transmit power to the East via the large-scale electricity super-highways.

Traditionally, digitalization has been an important tool in reducing energy demand and carbon emissions. But as digitalization accelerates, we need to pay a serious attention to its energy demand and carbon emission implications. This is not only true in China, but also worldwide.

9.5 NEW WAVE OF POWER SHORTAGES LIKELY TO PUSH FOR MORE FOSSIL-FIRED POWER

Insight China, August 25, 2022

Power shortage hits China again. The scorching record-high temperatures have brought dramatic spike of power use to stay cool, challenging the power grid which is further exacerbated by the drought-induced decrease of hydropower.

This seems already a recurring situation. Almost one year ago, China experienced widespread power shortages. Factors contributing to the shortages of that time include surge in power demand, decline in coal supply partly due to the Chinese embargo of Australian coal imports, and mismatch between "marketized coal and regulated electricity". To ease the pressure of that time, the national government adopted measures that increased coal supply and incentivized coal-fired power generators.

This Insight report focuses on this new round of power shortage and examines its implications for energy transition.

9.5.1 Record high temperatures

Like other parts of the world, China has lived its hottest heat waves this summer. For nearly 70 days, all provinces except the northern east Heilongjiang experienced high temperature which is defined as above 35 °C. 28 out of the 31 provinces experienced sustained temperatures above 40°C, and 26 of them broke their respective historical levels. And 277 weather observation stations across the country recorded their historically highest temperatures, with the highest reaching 45°C.

The heat waves, more frequent and intensive with longest duration since recorded history in 1961, has pushed up by 26.8% the July 2022 residential power demand nation-wide, mostly driven by air conditioning. The total power demand grew YoY by 6.3% in July, which has exceeded the planned growth of 4.7% and stressed out the power grid. In Sichuan province, July aircons power demand increased by 25% YoY, accounting for 30% of the total power load of 60GW, 10% above its total installed capacity.

9.5.2 Drought and hydropower output

The heat wave, combined with severe drought, has dried out rivers and reservoirs and dramatically reduced the hydropower output. As the world's largest hydropower station, the Three-Gorges project has an installed capacity of 22.5 GW, but now operates at its lowest level, in terms of both reservoir water level and water flow rate. Sichuan province, which relies on hydropower for 80% of its power supply and provides 21% of China's total hydropower, produced only 60% of the province's hydropower capacity in July and then further down to 50% in August.

9.5.3 Supply rationing

The economically more developed coastal provinces, such as Shanghai, Zhejiang, Jiangsu and Guangdong, rely heavily on power imports from some western provinces including Sichuan. The drop of hydropower there has significantly reduced their power export.

Emergency supply measures were called upon to increase coal-fired power generation locally and/or to import more power from those less affected northern provinces, but alas, the shortage remains daunting. As a result, power rationing is the only way to avoid large system failure. As residential sector is given the top supply priority, industry is taking the biggest hit. Factories after factories were ordered to halt operations by the local authorities, severely disrupting global supply chain disruption, again, on top of the long COVID lockdown earlier.

9.5.4 Coping with climate-induced shortages

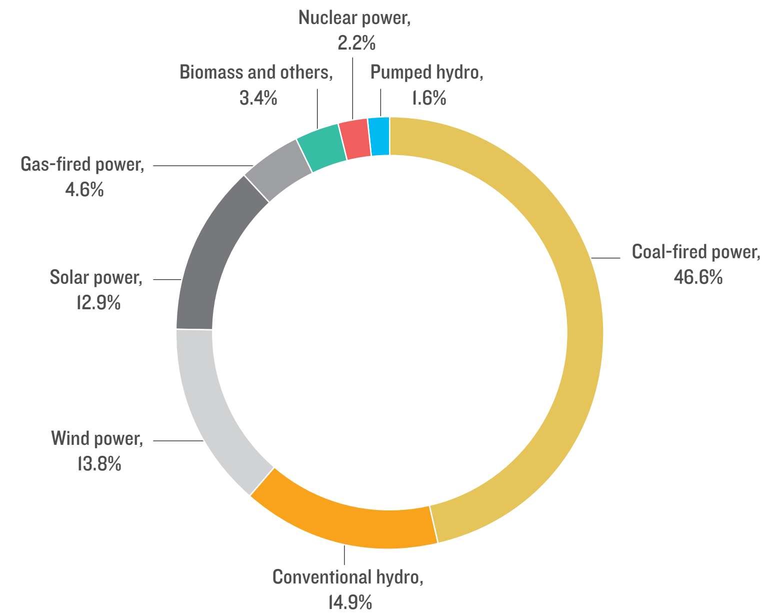
According to the weather forecast, the heat wave is expected to die down in September, so this round of power shortage is expected to ease by then. However, at an age of accelerated climate change, extreme weather events, including heat waves, will become the new normal. A serious question requires immediate answers – how should a country build resilience into its power system to prevent and manage climate-induced shortages?

As shown in Figures 1 and 2 below, non-fossil fuels accounted for 48.8% of China's total 2,380 GW installed power generation capacity, but only 36.7% of its total power output of 8,400 GWh in 2021. Solar and wind accounted for 26.7% of the installed capacity but only 11.8% of the generation. Hydropower has roughly the same share of 15% in both installed capacity and generation.

What the power planners have learned from this new round of power shortage is that hydropower is not as reliable as it is thought to be, particularly in the backdrop of intensifying global warming, and they should be better prepared to cope with the most extreme drought conditions. The same goes for wind power, with climate change impact on the wind availability and speed in different parts of the world. Solar radiation is comparatively less affected, but not free from climate impacts. This demands planners to include a new risk factor when assessing reliability of all kinds of renewable energy resources in extreme weather events.

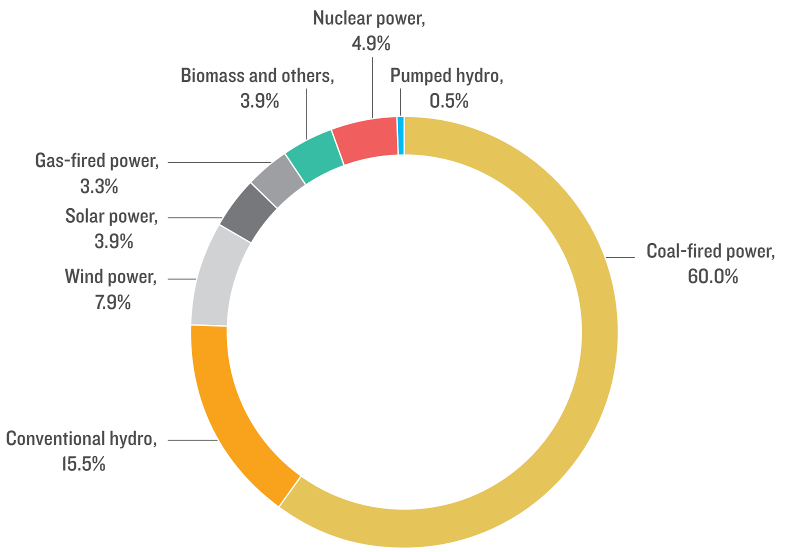
In a scenario where Chinese growth resumes with the ease of Covid induced controls, the country's electricity demand is poised to grow, at a faster rate than anticipated, to somewhere between 9,500 and 10,000GWh in 2025, which is well above the previous highest forecast of 9,000 GWh. Total installed power capacity is expected to reach 3000 GW by 2025. The growth will be driven by government's plans and programs to end-use electrification, which is expected to reach 30% by 2025 from 26.5% in 2020, to accelerate the deployment of digital infrastructure (data centers, 5G stations, and smart devices) and the electric vehicles. All will stress out further the already tight power supply.

Figure 9-1: Structure of China's Installed Power Capacity (2,380 GW) in 2021



Source: China Power Development Report 2022.

Figure 9-2: Structure of China's Power Generation (8,400 TWh) in 2021



Source: China Power Development Report 2022.

Renewables are being developed at unprecedented rate, and yet the pace of growth won't be sufficient nor resilient enough to the unprecedented extreme weather events. Energy storage solutions are simply not yet at the needed scale with competitiveness.

As a result, we have witnessed the sudden surge of fossil fuels supply not only in China, but also in US, Europe, India, and many other economies, as an immediate or short-term response to the disruption of power availability due to climate change on top of the war in Ukraine.

At this critical moment, fossil-fired power generation is, unfortunately, acting as the peaking power reserve in the case of shortage. The more weather-dependent, renewable energy sources are developed, the more fossil-fired reserve power will be needed.

This will push a new round of construction of fossil-fired power plants, at demand centers, to act a peaking power reserve, for mobilization in case of shortages of whether-dependent hydro or wind resources.

9.6 MAKING CHINA'S RURAL ENERGY GREAT AGAIN!

Insight China, December 5, 2022

China has 65% of its population living in urban areas today. Thus, it's no surprise that security of urban energy supply has been given top priority in the backdrop of fighting air pollution and decarbonizing its energy mix in the last two decades.

However, growing attention has been paid to rural areas in recent years when policy makers reckon that urban air pollution won't be effective tackled without grappling with the surrounding rural energy woes. And very importantly, rural energy is an integral part of the "modern energy system" the country aspired to build. For the first time, China's national energy development plan – "14th Five-Year Plan on Modern Energy Systems" (FYP) – has dedicated, for the first time, one entire chapter on rural energy.

9.6.1 A role model for the developing world in the 1980s

Four decades ago, China's rural energy development was widely regarded as a role model for developing countries. Its achievements were exemplified in the following four areas:

1. Prioritizing energy conservation, with over 100 million wood-saving cookstoves installed in rural households in the 1980's;
2. Building small-scale hydropower as a means to achieve rural electrification;
3. Using local resources to produce biogas for clean cooking; and
4. Developing analytical energy models and formulating comprehensive energy development plans for rural areas, integrating energy as an important part of economic development agenda.

It is particularly worth mentioning that, when President Xi Jinping served as the Chief of the Liangjiahe Village in Shaanxi Province in the mid-1970s, his biggest wish was to find an entry lever to promote economic growth. One day, he read on the People's Daily that many areas in Sichuan Province had deployed biogas for clean cooking. He was very excited and decided that his village should also adopt biogas as a solution to its lack of coal and firewood. With Xi's efforts, the Liangjiahe Village became the first "biogas village" in Shaanxi Province, with more than 70% of households in the village using biogas.

China's achievements in developing rural energy were well recognized by the international community during that time. The FAO (Food and Agriculture Organization of the United Nations) issued a special pamphlet on China's rural energy development planning which was widely distributed in and studied by other developing countries.

The success in rural energy development also made a great contribution to China's policy agenda of providing universal access to electricity, and China was the only large developing country that has achieved this UN millennium goal by 2015.

9.6.2 The new challenges and opportunities

For more than two decades, rural China seemed a "forgotten" place and rural energy agenda was put on a back burner. Majority of the country's resources and efforts were put to accelerate urbanization and industrialization. But now it has resurfaced and resurged back to the government's energy policy priority, due to one simple reason - haunting urban air pollution due to rural energy mix.

Indeed, the rural population in northern China mainly relies on coal for space heating in winter and agricultural residuals are burnt directly after harvest. Both have become main sources of air pollution severely affecting major cities like Beijing and Tianjin. Cooking is another culprit. According to the IEA, by the end of 2020, 34% of China's population or 484 million people were still using solid fuels (coal, firewood, charcoal, crop waste, animal manure, etc.) for cooking, and majority of these people reside in rural or suburban areas.

Dispersed uses of coal for cooking and heating in rural areas, as opposed to centralized uses of coal in power plants and industrial boilers, became the target for crackdown. In 2017, the government launched a major campaign to promote clean heating for the northern regions, banning the use of coal and subsidize heavily to replace coal with natural gas or electricity. The campaign failed largely because both gas and electricity are far too expansive than coal. Laying gas distribution pipelines to rural villages proves to be a poor and hazardous business. Heating homes with electricity is not only far too expensive, but also without support from the rural power grid system.

Such failure got the policymakers to rethink the country's rural energy strategy. Instead of considering rural areas as passive energy consumers at the end of fossil fuel supply chain, why not to reposition rural areas as sources of clean energy of a modern energy system by riding the wave to synchronize the dramatic cost reduction of renewables and the immensity of rural areas?

9.6.3 Turning rural areas to an energy producer

It is with this new strategy that the 14^{th} FYP for energy calls to actively develop small hydro, wind, rooftop solar, hybrid solar PV with agriculture and fishery, biomass and geothermal energy wherever available, not only for local uses but also for supplying urban areas with clean energy.

The objective is to make rural areas a clean energy producer in addition to their current role as a food supplier. Vast and massive programs are being undertaken, including:

- **Comprehensive uses of biomass resources:** Each year, China produces over one billion tons of crop straws and 3.8 billion tons of animal wastes. Different technologies are being deployed to turn them into solid granules, biogas, bioethanol or electricity, through which to find the best use of the biomass in accordance to local resources and market conditions.
- **Solar PV:** PV panels are massively being deployed on rooftops and in combination with agriculture and fishery. One such program, launched by the National Energy Administration in May 2021, is called "County-wise Promotion" (整县推进). It mandates a solar PV deployment plan for the whole county that is

supported by government authorities. Counties participating in the program are required to include at least 50% of their office buildings roofs, 40% of schools and hospitals roofs, 30% of commercial and industrial buildings roofs and 20% of residential buildings roofs. By September of 2021, there were 676 out of the total of 2,860 counties in the country that had decided to join the program.

- **Integrated heating solutions:** no single technology has yet emerged as the winner in providing winter heating for China's rural residential buildings. But different technologies are being tried and deployed, including energy saving measures such as building insulation, solar water heaters, passive solar houses, people-tailored heating, granular burners, heat pumps and electric or thermal energy storage facilities.

- **Integrated electricity solutions:** with rooftop PV, low speed wind turbines and energy storage technologies, some "zero carbon microgrids" are being piloted in rural communities to provide daily electricity needs, plus heat-pump for heating, and electrified mobility with e-scouters or electric vehicles. Some "fancy" ones even deploy digital technologies to optimize the system operation.

9.6.4 Making rural energy great again!

Will the above endeavors be sufficient to make China's rural energy great again? The short answer is too early to be affirmative. Indeed, when compared with where the issue stood four decades ago, it becomes clear that China's rural energy priority has shifted dramatically from merely providing clean cooking fuel and improving access to electricity to being part of a much larger ambition to uplift quality of life in villages, create new revenue opportunities, curb local pollution, and make rural areas more livable and enjoyable than big cities.

To get there requires many hurdles to be removed, be it financial or technical. And yet, China's rural areas today are already actively participating in the global energy transition. When those pilots or cases are proven successful, they can be quicky duplicated to other parts of China, while contributing to accelerate clean energy transition of other developing countries.

9.7 CHINA ETS: WHAT NEXT AFTER FIRST COMPLIANCE CYCLE?

Insight China, December 8, 2022

ETS (emissions trading scheme) has been regarded as one of the "cornerstones" of climate policy and a key tool for reducing carbon emissions cost-effectively.

As a major step forward after nearly a decade-long piloting endeavor at regional level and three years of preparations, China officially launched its national ETS on July 16th of 2021, focusing on the power sector emissions during the years of 2019 and 2020 as the first compliance cycle.

On 3rd November 2022, the Ministry of Ecology and Environment (MEE) that oversees the ETS operation published a draft quota allocation plan for the years 2021 and 2022 or the second compliance period, for delivery by the end of 2023.

This Insight report offers a review of where China's ETS stands today and what to expect next.

9.7.1 Learning by doing: emission trading pilots

A significant EU-China cooperative project in ETS capacity building, kicked off in 2011, led to a major milestone on China side. In 2013-2014, China launched provincial pilot emissions trading schemes in two provinces and five cities, including Shanghai, Beijing, Tianjin, Hubei, Guangdong, Shenzhen and Chongqing. Sichuan and Fujian provinces joined in 2016. Those schemes in 4 provinces and 5 cities covered 3,443 companies, involving such industrial sectors as petrochemicals, chemicals, cement, steel, non-ferrous metals, paper, power, and aviation.

The year of 2019 witnessed a total trading volume in those pilots amounting to 69.6 million tons of CO_2, with prices ranging from RMB 9.7 ($1.5) per ton in Chongqing to RMB 78.6 ($12) per ton in Beijing, averaging 22.4($3.4) per ton (see Table 9-6)

Table 9-6: Carbon Prices at China Provincial Emission Trading Pilots (RMB/ton)

Beijing	Shanghai	Guangdong	Shenzhen	Tianjin	Chongqing	Hubei	Fujian
78.8	40.5	23.1	13.7	13.6	9.7	32.1	16.3

By the end 2019, the total cumulative trading volume since pilot launch reached 395 million tons, with an average price of RMB 23 ($3.5) per ton.

Those pilots provided valuable learning experience and capacity building needed to launch the national ETS. In December 2017, the NDRC published its "National ETS Construction Plan", officially starting the pre-launch readiness preparation. The Plan proposed to start with the power sector, to progressively expand to include 7 other emission-intensive industries of cement, iron and steel, non-ferrous metals, petrochemicals, chemicals, paper and pulp, and aviation. Shanghai was designated to host the trading activities, while Wuhan/Hubei was tasked with all the administrative components such as registration and MRV.

9.7.2 Kicking off national ETS: power sector trading

The national ETS requires mandatory participation of all fossil fuel-fired power and heat producers with CO_2 emissions of 26,000 tons or above for any single year between 2013-2019. A total of 2,162 fossil-fired power plants were included, which were responsible for over 4.5 billion tons of CO_2 emissions annually or 45% of China's total.

The ETS inauguration on July 16th of 2021 created an immediate "blast" and "cheering" from all around, and many foresaw the dawning of the world largest carbon market and expected much enhanced carbon pricing to drive decarbonization. But the momentum of trading quickly cooled down. Daily trading volume started at 4.1 million tons on day one, but dropped to about 100,000 tons five months later. Trading prices went up and down but pretty much within the range of $6 to $9 per ton. The liquidity remains low and the trading seems losing steam.

By July 15th of 2022, the first anniversary marked a total of 194 million tons of CO_2 traded at an average price of RMB 43.8 ($6.24) per ton. Despite the overall compliance level of 99.5% for the first compliance period, both traded volume and liquidity were extremely low. The trade volume of EUR 1.3 billion for 2021 was far below the EUR 683 billion at the EU ETS, and the turnover rate, at 2%, was also terribly low compared to 758% at the EU ETS.

The low turnover rate – and the resulting low traded volume can be attributed to two factors:

- Firstly, lack of experience and consequent passive attitude of most of entities that had joined the ETS for the first time. They behaved to wait until the last minute to fulfill their regulatory/mandatory requirements. This explained the sudden surge of trading activities and much higher prices towards the end of the compliance period.
- And, secondly, reluctance to sell the allocated allowances by large groups, such as the Huadian Group or National Energy Group that were given large surplus of allowances but not willing to sell, thus causing shortage of supply in the market, leaving 6% of market participants, mostly independent power producers, failing to comply.

What's more revealed in the first-year experience also includes significant inadequacies in market design. And how to resolve them will define how China's ETS will evolve next.

9.7.3 Sizing inadequacies in market design

In theory, the number of carbon emissions permits shall be reduced annually so that it will push up the permit price and incentivize companies to reduce their emissions. The recent review of EU ETS shows that the free allowances had undermined the ETS, causing emissions from heavy industry not falling as originally designed. What have we learned from China's first year experience?

The first is naturally the allowances allocation mechanism. Emission quota were freely allocated to participating companies of the basis of emission benchmarks of individual power generating units. A unit's allowance is calculated based on its total electricity or heat generated multiplied by a given emission benchmark assigned to the type of generator, using 300-MW-generator as a reference divide (See Table 9-7). The benchmarks are generally based on high carbon content of the feedstock. As a generator's actual emission is affected by the type of coal it uses and also by its load factor, the allocation system gives advantage to those companies that took the actual measurement of the carbon content of their feedstocks, but punishes those that do not have the capability to do so. The gap could be as high as 20-30%.

The second is lack of differentiation in generation technologies, which makes it difficult to use the price signal to incentivize emission reduction in individual plants. The majority of generating units participating in the ETS are coal-fired ones using similar technologies, so technically, room for efficiency improvement and emission reduction is very limited.

The third is lack of "teeth" in non-compliance. As all allowances are issued free of charge and liability remains minimal or symbolic at the current stage, it does not provide strong enough incentive for companies to move away from coal and drastically reduce emissions.

And the fourth is severe latency of the offset mechanism. China Certified Emission Reduction (CCER) is not revived yet to play its offset role. The Beijing Green Exchange (formerly Beijing Environmental Exchange) has been tasked to host the national CCER trading scheme. But it has not yet been in operation, as rules for certification and trading remain under review. Proper design of offset mechanism will be crucial for power companies to invest or purchase CCERs from renewables or other emission reduction projects.

9.7.4 What to expect: the outlook

Now the MEE is getting ready to launch the second compliance period of trading for 2021 and 2022 that is to be delivered by the end of 2023. We have seen a trend of progressive tightening of the emissions benchmarks, that is to reduce the free allowances on an annual basis. For a 300 MW coal-fired generator, the benchmarks have decreased by 6.5% for power generation and by 12.7% for heat production for the year 2021 compared to those in 2019 and 2020 (Table 9-7). This means corresponding reduction of the freely allocated allowances. In the meanwhile, a break-even-point benchmark for 2021 is introduced to better reflect the real situation where a generator can make profit only when running a certain number of hours. This will be used in calculating the 2022 benchmarks.

Table 9-7: Carbon Emission Benchmarks for Different Categories of Generators

Category	Generator Category	Power Generation (tCO_2/MWh)			Heat Production (tCO_2/GJ)		
		2019-2020	2021	2022	2019-2020	2021	2022
I	300 MW and above, conventional coal-fired unit	0.877	0.8200	0.8159	0.126	0.1108	0.1104
II	300 MW and below, conventional coal-fired unit	0.979	0.8773	0.8729	0.126	0.1109	0.1104
III	Non-conventional coal-fired unit with coal gangue and coal water slurry (including circulating fluidized bed unit)	1.146	0.9350	0.9303	0.126	0.111	0.1104
IV	Gas-fired unit	0.392	0.3920	0.3901	0.059	0.056	0.0557

The new benchmark system, based on actual numbers of 2021, help, to certain extent, remedy the first market design inadequacy mentioned above, but it does not address the other three. As such, we expect to continue to see a low turnover rate, a low trade volume and relatively stable but low carbon price at the end of the second commitment period.

Three impetuses become key to the future of China's ETS:

- The first is to auction part of the allowances rather than all for free issuance now. The revenues collected can be used to create a just energy transition fund; 100% of the money shall be invested in climate actions aligned with national decarbonization goal; companies that receive the funding must meet strict conditions on cutting their emissions; and very importantly, funding shall also be geared towards helping power plant workers reskill and upskill and find new jobs after plant closure, or poor regions to support their energy transition.
- The second is to boost market liquidity by restarting the CCER issuance process. An offset tool, CCERs are expected to be issued by MEE and traded at the Beijing Green Exchange after all rules are reviewed and approved. Furthermore, we expect to see green power certificates either traded via CCERs or directly as an offset mechanism.
- And the third is to expand the national marketplace by including other industries into the ETS. This will not only increase dramatically market liquidity, but also diversify the profiles of participants. Among the seven industries on the "waiting list", at least three shall become priority focuses, namely non-ferrous metals, cement and steel since they are covered by European Union's proposed Carbon Border Adjustment Mechanism (CBAM). Inclusion of these will help create the foundation for bilateral dialogue with the EU. Those three industries account for 25% of China's total emissions. Together with the power sector, such a step will cover 70% of China's total emissions, making it by far the world's largest market in terms of coverage.

To enable rapid decarbonization, Tsinghua University's research shows that China's carbon price needs to go from the current level of $7 per ton to $15 per ton by 2030, $25 per ton by 2035 and $115 per ton by 2050. Some optimists foresee China's ETS to reach 200 RMB billion ($28.6 billion) by 2025 from the current level of $1.3 billion.

We remain cautious on both price level and trade volume.

9.8 CCS OR CCUS: WHAT CHINA PREFERS?

Insight China, December 14, 2022

Carbon capture and sequestration (CCS) is believed to have a critical role in global decarbonization, in helping the hard-to-abate sectors (cement, steel, refinery and petrochemicals) to reduce emissions, producing low carbon hydrogen from fossil fuels, providing low carbon but easily dispatchable electricity from coal or gas-fired plants, removing ultimately CO_2 from atmosphere with direct air capturing (DAC) technology, and ensuring a "fair transition" by maintaining employment in high emission sectors.

However, simply sequestrating CO_2 in geological structures represents a pure cost, with many technological and legal challenges. Its business feasibility relies mainly on a sufficiently high carbon price which may not be realistic for many parts of the world in the foreseeable future.

China proposes an alternative way of dealing with CO_2: converting it to useful products for utilization, as an intermediate step. This is why U was added to form the new term: CCUS.

This Insight China report reviews China CCUS activities and explains why China emphasizes the utilization aspect.

9.8.1 Overview of activities

China preference for CCUS, as opposed to CCS, can be seen in statistics. Globally, by end of 2020, there were a total of 5 CCS (pure geological sequestration) projects in commercial operation and 21 new sequestration projects, none is from China.

By 2020, China had 40 CCUS projects already in operation or under construction, with a total CO_2 capturing capability of 3 mtpa and a total utilization volume of 1 mtpa. Most of those projects are for conversion and utilization, including enhanced oil recovery (EOR), enhanced coal-bed methane recovery (ECBM), dry-ice production, conversion into useful products, concrete mineralization, carbonized steel slag and algae cultivation.

The only Chinese CCS project completed so far was the one by the Shenhua Group (now the State Energy Group) – China and the world's largest coal producer. It injected a total of 300,000 tons of highly concentrated CO_2 captured from the company's coal-to-oil conversion project but stopped after the injection well was full.

Table 9-8: Overview of China's CCUS Activities as of End 2020

Capture	Conversion and Utilisation	Sequestration
• 13 pure CO_2 capture projects totaling 0.86 mtpa; • DAC technology is in demo stage.	• EOR: by PetroChina, Sinopec, totaling 1.65mtpa • ECBM, E-Uranium recovery, algae cultivation, greenhouse plantation, CO_2 fossilization • CO_2 for food industry • CO_2 for industrial applications • CO_2 conversion into methanol: CNOOC and Chinese Academy of Sciences (CAS) • CO_2 as medium in power generation: Huaneng • CO_2 conversion into hydrocarbons with high efficiency and low cost: GH New Energy • CO_2 conversion into carbon fibers: Carbon for X (C4X) • CO_2 conversion into starch: CAS • CO_2 for carbon enriched agriculture and concrete mineralization: LingHe	• two pure sequestration projects by Shenhua Group: one project based on coal conversion was abandoned after 300kt injection; another 150ktpa project under construction. • one sequestration project as part of natural gas separation project by CNOOC.
10 small scale integrated research projects, funded by state but abandoned once budget depleted.		

Source: China CCUS Development Report, 2021, and CN Innovation

It is no surprise that the largest CCUS projects are in the oil and gas industry and by oil companies, mostly for EOR as shown in Table 9-9. Only CNOOC ones are pure CCS, but CO_2 for geological sequestration is separated from natural gas production. In 2021, CNPC used 0.65 mt of CO_2 for EOR activities while Sinopec used 1.52 mt.

Table 9-9: China's Large CCUS Projects

Company	Project Description	Size (mtpa)	Completion
CNPC	**EOR** in Jilin oil field with five demo zones	0.35	2021
	EOR in Changqing oil field: 0.1 mtpa already operation. 2nd phase cooperation with Huaneng with CO_2 from coal-fired power plant.	1.5	Study
	EOR in Songliao oil fields	3	2025
Sinopec	**EOR** in Shenli oil field with CO_2 from nearby Qilu refinery. The project has 10.68 mt total CO_2 injection capacity, can increase 2.27 mt of total oil production.	1	2022
	EOR in East China: collaborative CCUS project with Shel, BASF and Baowu Steel	10	MOU signed
CNOOC	Offshore **CCS** project in South China Sea, with CO_2 from natural gas separation from its Enping gas field, with a total sequestration capacity of 1.46 mt	0.3	2022
	Offshore **CCS** project: JV with Shell and Exxon in the Peer River Delta	10	MOU signed
Yanchang Oil	**EOR** project: 0.15 mtpa already operational. A 5 mtpa project is under study	5	Study
Guanghui Energy	**EOR** project: first phase 0.1 mpta started in 2022	3	Unknown
Tongyuan Oil	**EOR** project with CO_2 from Huadian coal-fired power plant	1	MOU signed

Source: CN Innovation

Many large and ambitious projects are under study, either by Chinese companies alone or in cooperation with international companies. At this stage, it's not certain that these announced projects will be implemented.

9.8.2 Pure sequestration or conversion and utilization?

CCS or CCUS certainly plays a critical role in China's net-zero strategy. According to China CCUS Development Report (2021), China would need to sequester between 1 billion to 1.8 billion tons of CO_2 by 2060, given that it will still burn a significant amount of fossil fuels even when reaching the accounted net-zero target.

But pure sequestration projects represent only costs without any revenue. We believe the following factors have led the Chinese to prefer CCUS over CCS:

- **High Cost:** China's largest CCS project is completed by the Shenhua Group (now the State Energy Group). It injected 300,000 tons of highly concentrated CO_2 captured from its coal-to-oil conversion project. The cost is estimated at RMB 250/ton (or $38/ton). But where CO_2 concentration is not high, such as from a power plant or steel plant, the cost of geological sequestration rises to RMB 396 – 448/ton ($56-69/ton), including that for a 100-km transport pipeline. Compared with the Norwegian "Long Ship" project, which is estimated to cost US$388/ton on a 10-year and 8-million-ton-storage basis, Chinese costs don't seem high. And yet, they far exceed the current domestic carbon market trading price of RMB 50/ton ($7.7/ton).
- **Increased energy consumption**: With current technology, capturing CO_2 and improving its concentration to the required level of sequestration would lower a power plant's energy efficiency by 20-30%, increasing fuel consumption needed to send the same amount of electricity to the grid.
- **Sequestration siting: No sequestration, no CCS.** In theory, China has significant aquafer capacity to permanently store CO_2, but the sites need to be close enough (less than 250 km for pipeline transportation) to the emitting sources. Given that most of the Chinese cement, steel and power plants are located in developed regions with high population density, NIMBY (not in my backyard) at local level becomes a major barrier. People are concerned with risk of leakage which could impact public health with much deprived oxygen level.
- **Legal liability**: CCS project requires to store CO_2 permanently over thousands of years, but not many companies can guarantee such a longevity to be held accountable. So far, only Norway and Australia can offer the precedence for China to look into that governments are mandated legally to be responsible.
- **Business model:** The wide deployment of CCS projects requires a sustainable business model whereby everyone across the value chain is adequately paid. Pure capture and sequestration projects do not have the revenue stream to support, while the utilization aspect of CCUS can overcome it. Even if the revenue is not coming from CO_2 utilisation, it can come from either oil and gas sales such as the CNOOC case, or from coal converted projects such as Shenhua case. This explains why there is no pure CCS project from the power sector, as it is difficult for power plants to get additional revenue to cover the cost.

Chinese philosophy emphasizes treating a symptom wholistically. In policy practices, Chinese policymakers tend to believe that carbon issue should be resolved through recycling and utilization, instead of simply burying it. This is where the U joins the picture of CCS, as important intermediate step toward ultimate solution to climate change.

As China actively pursues CO_2 conversion and utilization activities, when and if some of which are proven both technically and commercially viable, and can be deployed at scale, they may help the country or even the world to redraw the course to decarbonization.

9.9 ESG: MANDATED DISCLOSURE FOR GREATER ACCOUNTABILITY

Insight China, December 16, 2022

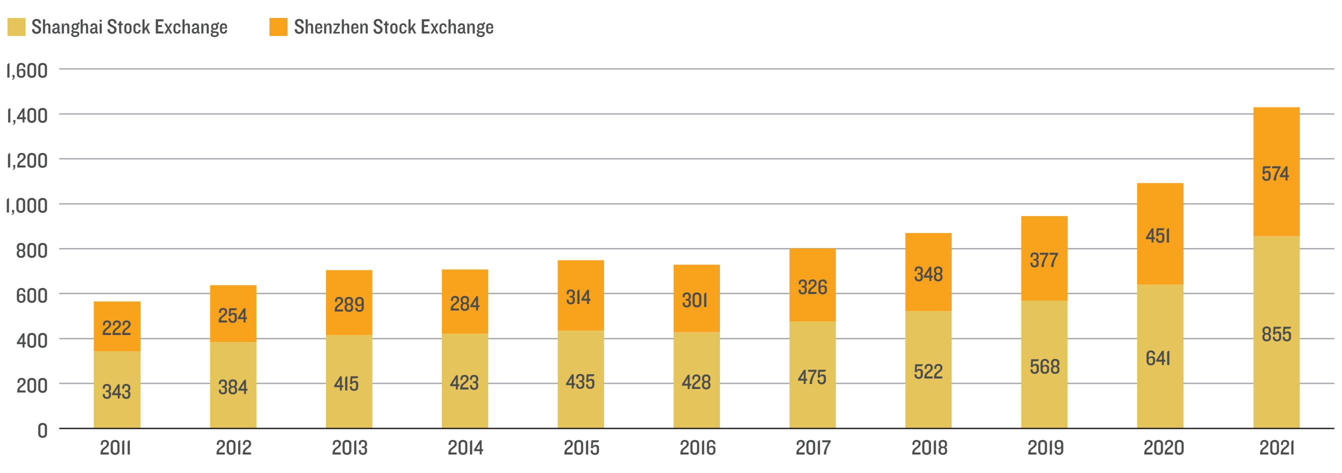
ESG reporting has been adopted as the leading matrix and vehicle to measure and disclose the environmental and social behavior and performance of a company, a financial institution or any other organizations. In a world with growing constraints from polycrises and dire deficit of trust, such steps are key to demonstrating a company's integrity and trustworthiness, thus helping enhance its competitiveness.

This Insight provides an overview of Chinese companies' ESG reporting, with an interpretation of the convergence and/or divergence between Chinese practices and those in EU and US.

9.9.1 Catching up with global trend

According to an ESG rating report by Morgan Stanley Capital International (MSCI), published in June of 2021, which surveyed all listed companies in 50 countries, measuring the quality of their reporting. China standards at 47 out of the 50, i.e. among the lowest, with a rating barely reaching 3, while UK stands out at a rating close to the highest of 8.

Figure 9-3: Chinese Listed Companies ESG Reporting, 2011-2021



However, China is catching up quickly (Figure 9-3), mostly through regulating listed companies. According to the latest statistics, by July 20th of 2022, there were 1,429 companies listed on the Shanghai and Shenzhen stock exchanges that had published their 2021 ESG reports, or 29.6% of all the listed companies. This shows 337 more companies joining the league compared to one year before.

9.9.2 Disclosing environmental information as a priority

Chinese regulators have played a significant role in accelerating such a trend, particularly moving to standardize the fragmented ESG reporting landscape.

Four crucial steps taken define the dynamics of corporate ESG reporting in China today:

- The first is, in May 2021, the Ministry of Ecology and Environment (MEE) issued new disclosure rules that require domestic entities to disclose a range of environmental information on an annual basis, effective on February 8th of 2022, but to become mandatory by 2025 for all publicly listed companies. The Rules apply to listed companies and bond issuers that are subject to certain environmental penalties in the previous year and other entities identified by MEE, including those that discharge high levels of pollutants. All the covered entities must disclose information on:
    - Environmental management
    - Pollutant generation
    - Carbon emissions; and
    - Contingency planning for environmental emergencies.
- The second is, on June 28th of 2021, the China Securities Regulatory Commission (CSRC) published the final set of amendments to the disclosure rules applicable to annual reports and half-year reports, respectively, together with relevant explanation to the amendments.
- The third is, on June 1st of 2022, "The Guidance for Enterprise ESG Disclosure" became effective. This is regarded as China's first ESG disclosure guidline, issued by China Enterprise Reform and Development Society. It applies to all companies and industries and follows the environmental disclosure rules issued by MEE which came into effect early in February 2022.
- The Guidance sets out a framework for Chinese companies to report under three primary indicators of ESG metrics, which are further divided into 10 secondary indicators, 35 tertiary indicators and 118 level IV metrics. It is applicable to voluntary or mandatory disclosure requirements that may apply to Chinese companies. Each company can choose the applicable time cycle for making its disclosures. The final deliverable is an official ESG report that is made available on a platform designated by the regulatory authority or chosen by the Chinese company. This official ESG report is for use by various bodies including regulators, investors, media and the general public.
- And the fourth is the new financial institutions' sector practice standards, released by the People's Bank of China (the central bank) in August 2021. "The Guidance of Environmental Information Disclosure of Financial Institutions" provides a systemic framework for financial institutions to disclosure environmental information with principles, format and content requirements. This marks the beginning of China's nation-wide trial and piloting endeavor to accelerate ESG reporting in the financial sector.

9.9.3 Converging domestic and global standards

China shares at least three major global priorities to further strengthen ESG investment, including: 1) Close the loop to green the financial landscape; 2) Align green finance with time-bound goals to achieve planet- and people-positive; and 3) Enhance disclosure and transparency to achieve accountability.

While compliance with the Guidance remains voluntary, it serves as a good starting point for Chinese companies to begin exploring the application of ESG standards adapted for and developed in a local context. This approach has been applied in other jurisdictions in Asia, such as Hong Kong and Singapore, that adopted a flexible "comply or explain" approach initially before moving to more prescriptive or mandatory. It is likely that broader, mandatory reporting for ESG is on the horizon in China.

9.9.4 Bridging the gaps

Recent studies and surveys have reflected some of the major cracks in the ESG ecosystem in China today though. Data and evidence are often in "poor" quality. Third-party ESG service sector fails to provide the urgently needed support. At a very practical level, most of Chinese companies are still struggling with lack of capability and experience in ESG-related reporting, beyond conventional mandated CSR reporting.

Very importantly, inadequacies in standards and regulations make the ESG reporting more aspirational than compulsory. This inadequacy constitutes a fundamental barrier to effectively deploy this policy instrument to help accelerate the scaling of investments aligned with such nationally-embraced goals as carbon neutrality.

There are currently a dozen standards and guidelines being used by Chinese companies for their ESG reporting, about 67.7% adopted the GRI (Global Reporting Initiative) Standards, but many companies have also chosen to adopt Chinese national standards or those developed by the stock exchange where they are listed.

9.9.5 Overcoming the uncertainty challenges

ESG is an instrument and product created by public policy to serve the purpose of policy targets and incentives. And ESG investment is a vehicle to mobilize financial capital flows at pace and scale to achieve those set goals and targets at national and local level, with industrial and sector specificities. Bearing these two purposes in mind, three questions beg answers regarding the future of ESG.

The first is how to align domestic policy targets with global markets from the perspective of time and space. ESG regulators have to figure out such alignments of the frameworks, guidelines and regulations with the time-bound targets on 1) the domestic front, in particular around the 14th Five-Year Plan (2021-2025), 2) outbound FDIs, in particular through the Belt and Road Initiative (BRI); and 3) inbound FDIs through multilateral foreign companies in China and foreign investments to China. Misalignments and gaps have already been experienced, such as human rights, and more are expected, such as governance and security risks.

The second is how to ensure high-quality, credible and relevant data to back up the ESG reporting. A latest domestic debate is centered around the discrepancies of the National Bureau of Statistics data and information with the reality of the country's social and economic development. The final 2021 Central Government's economic work meeting has identified three major pressures on China's economic growth - disrupted supply, shrinking demand and weakened prospect. And yet such difficulties are not reflected or witnessed in the Bureau's data at all. Instead, all the official public data continues to paint a bright and promising landscape of economic growth. As reflected in data around jobs and unemployment, wages and debt-ridden consumers, as well as global supply chain disruption and corporate bankruptcy, among many others, the lack of credibility of the state statistics machine endangers the country's trustworthiness and credibility of its policy targets.

And the third is where to draw the lines between security protection and data disclosure. Increasing granularity and expanding coverage of data helps to unlock unprecedented potential of transparency, Satellite images, government monitoring data, and citizens' participation, enabled by digital and AI technologies, have formed the ubiquitous planetary surveillance. While regulators worldwide are strengthening their grips on disclosure, guardrails are also up to defend national security. Data security, financial security, technological security. supply chain security, biosecurity, and even ideological security, you name it, pose some toughest questions for regulators in China to address when designing ESG standards. The essence of ESG is transparency through data disclosure.

There are no simple answers to all those questions. Given that ESG is a must-do, both from domestic and international perspective, we would expect China to deploy its traditional wisdom of striking a balance and tradeoffs among all the key elements in a complex landscape, to break the deadlock of accountability challenges domestically and to reconcile with the West through a common ESG language and narrative.

9.10 TACKLING METHANE EMISSIONS

Insight China, December 22, 2022

The 14th Climate Change Greenbook of China attracted attention to methane emissions in the world's largest emitter. Released on 21 December 2022 in Beijing by the joint Lab between the Chinese Academy of Social Sciences and the State Meteorological Administration, the Greenbook, subtitled Implementing Policies and Practices for the "Duo-carbon" Goals, made a strong call for the country to urgently improve key technologies and the administrative policy system for methane emission prevention and reduction.

9.10.1 Why it matters:

Methane, the second largest greenhouse gas, traps 80 times more heat than carbon dioxide in a 20-year timeframe and accounts for 16% of global GHG emissions, responsible for about 30% of the world's warming since industrialization.

China's emissions are the highest in the world, around a fifth of the global total. In 2021, China emitted 58.3 metric tons of methane, more than any other country, according to the Global Methane Tracker.

Since 2014, methane has been included in various government plans for emission reduction and comprehensive resource utilization, and China's most recent communication to the UNFCCC vowed to control the emissions of non-CO_2 greenhouse gases including methane. The Chinese oil and gas companies are also taking active steps to tackle the methane emissions, with CNPC joining the Oil and Gas Climate Initiative's methane action plan, while 10 of China's largest gas distribution companies have jointly launched an initiative. What is missing is the coal companies' participation.

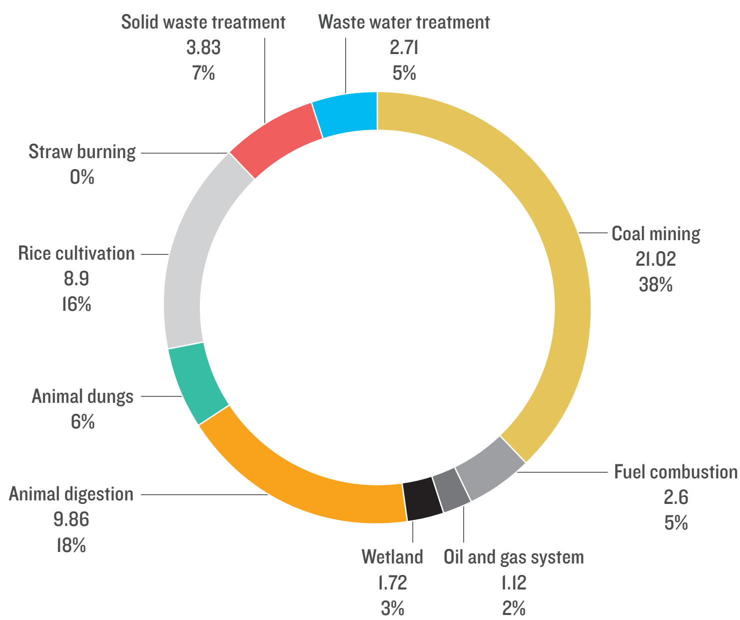
According to China's Climate Envoy Xie Zhenhua at COP27, the national government has drafted a new plan to rein in methane emissions, focusing on oil and gas, agriculture and urban wastes management. He said China will promote new technologies and financing mechanisms to slash rising methane emissions, and yet would have to improve its methods and means in quantifying methane emissions. But it's also known that many of the methane sources are fugitive emissions, which are usually difficult to accurately account for.

9.10.2 The big picture:

Tackling methane has become a major part of global efforts to limit temperature rises to 1.5C. In 2021 at COP26, the Global Methane Pledge was first initiated, aiming to slash 30% of world methane emissions from 2020 level by 2030. And at COP27, around 40 countries revealed methane abatement plans. But methane is not yet included in China's current NDCs (nationally determined commitments) to the Paris Agreement, which only covers carbon dioxide.

Nearly half (44%) of China's methane comes from the energy sector, followed by agriculture, as shown in Figure 9-4 on the country's latest available sectoral data, from 2014.

Figure 9-4: Sources of China's Methane Emissions in 2014 (million tons, %)



Source: China Mining Magazine, Feb. 2022. http://www.chinaminingmagazine.com/uploads/pdf/1644910124102.pdf

In 2021, it's estimated that China's coal supply and mine emitted 25 million metric tons of methane, according to a Global Energy Monitor report. Abandoned mines are another coal methane source, which are expected to grow more quickly than those from established mines, according to study.

Agriculture is the second-largest source of methane emissions - from animal digestion, excretion, and rice cultivation. China is the world's biggest meat producer and consumer.

The Greenbook has identified some gaps to bridge, particularly around monitoring of emissions and key technology breakthroughs to reduce and manage emissions. A US-China collaborative opportunity exists to put scientific expertise together to figure out how to make the most of much improved satellite observations and advance the technologies by leaps and bounds.

9.10.3 Zoom in:

Top highlights from attending the Greenbook's launch offer some insights and recommendations:

- Monitoring: China has set up its safety alert and inspection systems, but shall further integrate ground, aerial, observation tower and satellite tools, combine the monitored ambient concentration with atmospheric transmission model and generate regional emissions estimates.

- Economics of utilization technologies: Technologies have greatly progressed in low-density methane utilization and recycle emissions from oil and gas leaks, but constrained by scale, costs and geographies, there is no economics in many cases, thus it's hard to achieve scale for commercial benefits. Most projects have adopted foreign technologies, with high costs for both project construction and operation and maintenance.

- Policy vacancy: China today stands at a very early stage of "mapping the landscape" for methane emissions, prevention and control, thus lacking national policies and measures, as well as inadequate financial subsidy, market mechanism, standard system and administrative measures.

- Inventory, MRV, and roadmap: Efforts are needed to study the accounting methodology and the roadmap of methane emissions reduction, add methane to its NDCs and take the impacts into consideration, while establishing national emissions inventory and information platform, regulating management in key regions and sectors, and setting specific requirements for MRV.

- Technology breakthroughs: Acceleration shall be advanced for key technology breakthroughs for both emissions reduction and utilization, such as CBM (coal-bed methane), LDAR (leak detection and repair) from oil and gas drilling, and biogas digesters for agricultural wastes.

Yes, but: China's current commitment to peak its emissions before 2030 does not include methane, though the goal of achieving carbon neutrality before 2060 will embrace all GHGs including methane. The contention between US and China continues to hold back progress of bilateral cooperation. And, without China's commitments and active participation, the goal of reducing 30% by 2030 outlined in the Global Methane Pledge will be difficult to reach.

THE 2022 YEAR ENDER

IN COVID DESPAIR, CHINA OFFERING PLANETARY OPTIMISM IN 2023

Insight China, December 28, 2022

The 2022 Christmas in China is marked with shock, fear and despair. Once again, the country has become a global COVID pandemic epic center. The government's sudden U-turn of its policy, from the most restrictive zero-COVID to total relaxation on December 7th, has rushed the whole country into unexpected and unprepared herd immunity. The consequences are extremely dire and saddening. Hundreds of millions of people and their families are bearing the sufferings and loss of loved ones.

The unpreparedness could be witnessed by the CCP Central Committee's annual Central Economic Work Conference (the Conference), on December 15th and 16th, when the top decision makers made decisions on the country's 2023 growth plan and strategic priorities. The core is clearly put on rapid economic recovery. Stability, security and resilience continue to be the top taglines against the backdrop of daunting triple pressures - demand deflation, supply shock and weakening growth expectations, with further exacerbated geopolitical complexity not in China's favor.

As 2022 draws to a close, it seems emotionally and psychologically difficult to remember that good things happened this year too. And even as we face many challenges, such as the pandemic, climate crisis, threats to energy and food security, and shocks to the supply chain, there are reasons to be hopeful about 2023 and beyond. And very importantly, we see China offer some planetary optimism.

Creating demand: "1+N" decarbonization policy system forward: As our reports have shown, the year 2021-2022 heralds unprecedented clarity to accelerate clean energy transition in the world's largest carbon emitter. Through the cycle of the 14th Five-Year planning of national economic and social development and the 2035 Vision, Chinese policy makers at national and local levels delivered a total of 75 policy documents for decarbonization and carbon neutrality, thus creating the largest-ever market demand for environmentally friendly, resource-efficient, and low-caron products and services and redirecting financial flows towards green and clean infrastructure. The design of the policy architecture is also the most comprehensive-ever and based on an integrated, systemic and unified approach. The outcome is the body of "1+N" policy papers that guide, push and pull an economy-wide transformation across all sectors and in all regions.

Painstaking transition: a record year of both new clean and dirty power: China's total power demand in 2022 has been curbed by repeated COVID-19 lockdowns, which have hampered manufacturing activity and slowed industrial output. And the current "voluntary" shutdown is expected to further hold back the planned recovery.

- The year of 2022 saw China set to delight and depress climate trackers in equal measures. Its use of coal-fired power generation climbed by roughly 30% in December from October's total. And, the full-year carbon emissions from coal power generation is expected to top 4.5 billion tons in 2022, which is more than all of Europe's energy sector emissions in 2021.

- It also set new global records in both clean power utilization. Its continued expansion in solar and wind power has put it on track to hit 3,000 terawatt-hours of clean energy power generation this year, far exceeding any other country, and lifted its share of clean energy in its electricity mix to a national record of 31.9%, compared to a 26.3% share in 2015.
- And China's share of global EV sales has gone from 26% in 2015 to 28% in 2021 and to 56% in the first half of 2022. By the end of June, there were more than 10 million EVs running on road, and it's poised to seize 60% share of global EV sales by year end of 2022.

Integrating nature and climate change for solution: planetary optimism for 2023: The newly adopted Kunming-Montreal Global Biodiversity Framework, brokered by the Chinese COP15 Presidency, marshals the beginning of a new age to safeguard the planetary boundary. Highlighted by the popularly knowns "30x30x30x30", our collective commitments by 2030 are to: 1) Protect 30% of land and ocean; 2) Restore 30% of degraded ecosystems – land, inland water, coastal and marine areas; 3) And at least $30 billion each year from rich nations to the poor to protect biodiversity and ecosystems.

Also called nature's "Paris Agreement moment", the landmark deal now aims to "sync" actions and solutions with both the global climate change agenda and the UN SDGs. China champions the implementation and has shown signs of progress on "decoupling" growth from both carbon and resource intensity, as well as policies and actions on conservation.

Yes, but: China's economy is now under great downward pressure, coupled with shrinking demand and fragile supply chains. According to the Conference, restoring domestic consumption and improving its GDP are top priority for 2023. The core focus falls on "high quality" growth and "efficiency". And yet such endeavor is destined to be further disrupted by the current wave of COVID cases. Therefore, we will continue to zoom in and zoom out on China's endeavor in clean energy transition and protecting ecological integrity, but getting down to more specific steps of delivery in 2023.

And we look forward to having your feedback and input and jointly we can make the world a better place in the new year!

INSIGHT CHINA EDITORIAL TEAM

- **Xavier Chen, Editor-in-Chief**

Dr Xavier Chen is Senior Researcher at the Pekin University's Institute of Energy. He is also founder and President of the Beijing Energy Club – a Beijing-based high-level forum and think-tank on Chinese and global energy issues.

He is a well-known expert on Chinese and global energy issues, with nearly 30 years working experiences in the French Institute of Energy Economics and Policy (1 year as research engineer), Asian Institute of Technology in Bangkok (3 years) as Assistant Professor, International Energy Agency in Paris (8 years, as India Program Manager, Chief of Staff and China Program Director), BP China Vice President (10.5 years), Statoil/Equinor China President (4.5 years), and ENN Group's Chief Strategy Officer (2 years).

Dr. Chen spearheaded the creation of the Beijing Energy Club in 2008. He played a critical role in securing the Chinese presidency of the International Gas Union for 2022-2025. He is author of two books and numerous publications. He was one of the four "Good Business" Award Winners of Bloomberg's Business Week (Chinese edition) in 2017.

- **Ms Changhua Wu, Deputy Editor-in-Chief**

Changhua Wu is a seasoned policy analyst, capable advocate, social entrepreneur, current affairs media commentator and frequent public speaker, and strategist for public and private partnership in clean energy transformation and broader sustainability agenda. Having worked with some global and local leaders at the Climate Group as Greater China CEO for nearly a decade, she successfully led strategic engagement with public and private sectors in China to advance low carbon economy and clean energy revolution. Her leadership and contributions have been recognized in China and beyond, including one of the 15 global women leaders fighting climate change recognized by the Time Magazine in 2019.

Changhua holds numerous positions including the CEO of Future Innovation Centre (Beijing); China/Asia Director of the Office of Jeremy Rifkin; Vice Chair of Governing Council of Asia-Pacific Water Forum; board member of Global Infrastructure Basel Foundation; and member of Asia Water Group of ADB, among others. A leading ESG expert, she also sits on the sustainability advisory boards of some leading multinational corporations.

And in the capacity of research fellows and advisors, she also works closely with some leading think tanks and organizations in China and globally to advocate policy changes.

- **Yongping Zhai, Senior Advisor**

  Dr. Yongping Zhai is a highly experienced in international energy and low carbon financing, with 7 years (1993-2000) work at the African Development Bank (AfDB) and 21 years (2000-2021) at the Asian Development Bank (ADB).

  After graduating from Tsinghua University, he went to Grenoble (France) for post-graduate and doctoral studies, and after obtaining the PhD in energy economics, he was seconded by the French government to work at the Asian Institute of Technology in Bangkok.

  At the AfDB, Dr. Zhai worked as Senior Public Utilities Economist, Principal Program Coordinator for the South Region. At the ABD, he worked in the Energy Division as Lead/Principal/Senior Energy Specialist, mainly in charge of energy investment in Southeast Asian countries (2000-2010); Director for South Asia (2010-2015), leading the lending and grant operations in the energy sector in India, Bangladesh, Bhutan, Nepal, Sri Lanka and Maldives; Chief of Energy Sector Group (2015-2021) in charge of the whole bank's energy sector operations.

  Dr. Zhai retired from ADB in August 2021 but is still very active in the energy/carbon area, holding numerous advisory and academic positions.

FURTHER CONTACT

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