



# 中国能源转型展望 2023

## CHINA ENERGY TRANSFORMATION OUTLOOK 2023

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2023年12月9日 / December 9, 2023

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# 构建人类命运共同体的全球格局

*Building a community with a shared future for human being*



## 面向2060年前碳中和开展能源绿色低碳转型发展路径研究

*Research on development paths on the green and low-carbon transformation of energy towards carbon neutrality before 2060*



中国能源转型展望 2023

*China Energy Transformation Outlook 2023*

# 能源？与我们的关系？

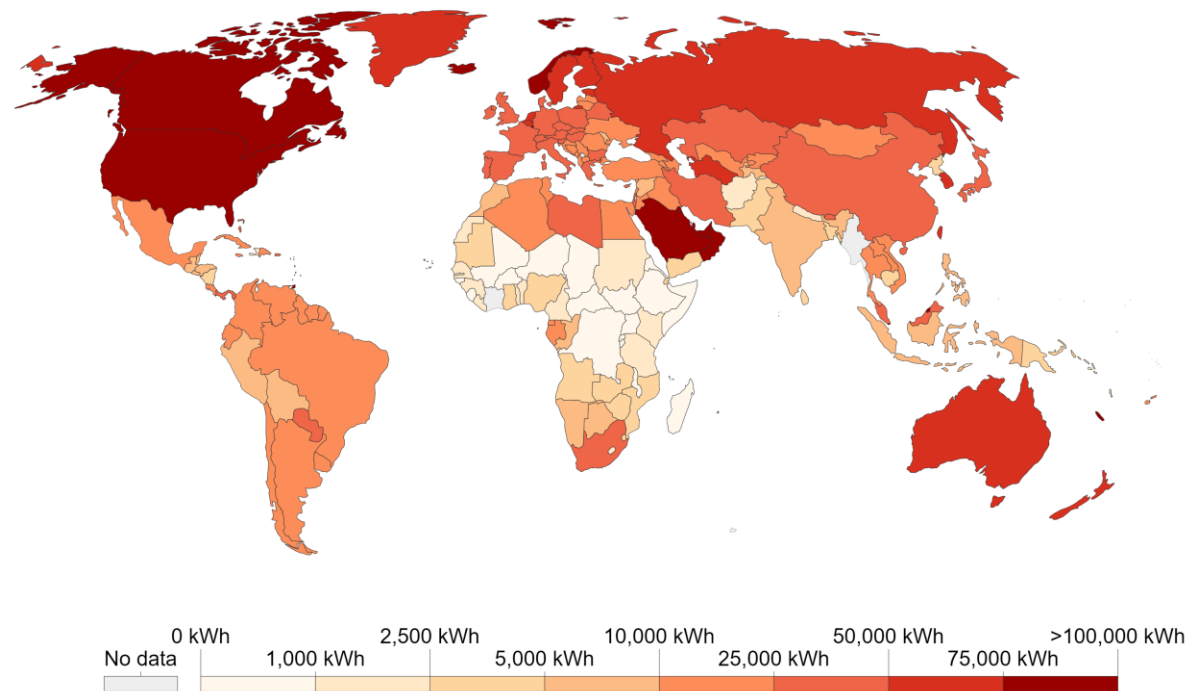
*Energy? The relationship with us?*



能源是人类活动的物质基础，在社会经济体系中占据重要地位。英国著名经济学家E.P.舒尔茨在1964年指出：“能源是无可替代的。现代生活完全是架构于能源之上的。**能源是与空气、水和土地等同的要素**”。

*"Energy is irreplaceable as modern life is completely structured on the basis of energy, **energy is an essential factor just as important as air, water and land.**"*

——*Theodore W. Schultz*



2019年的全球人均能源消费（千瓦时）

2019 Global energy consumption per capita (kWh)

# 应对气候变化是大势所趋，中国能源转型必须要走绿色低碳发展的道路



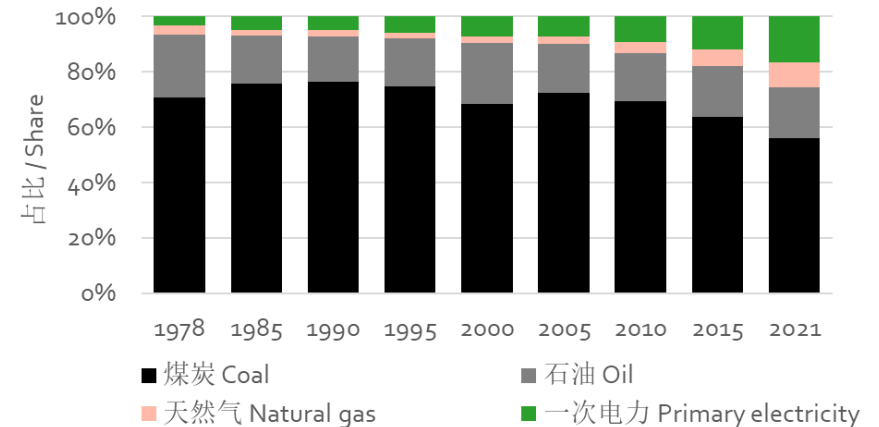
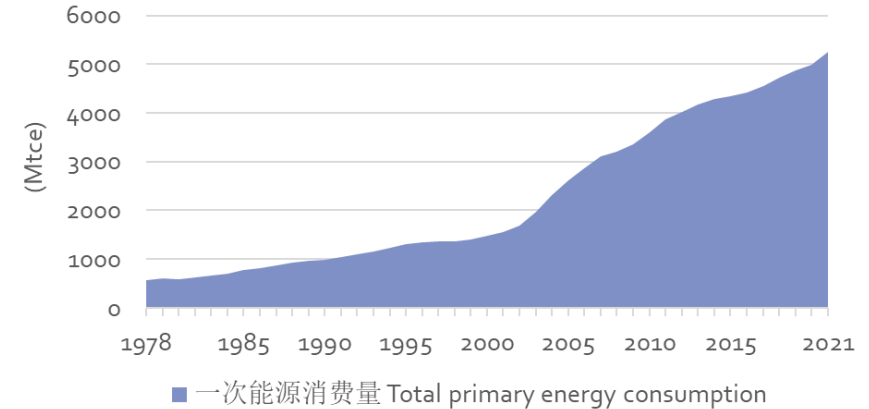
*Addressing to Climate Change is a necessity, for China to taking the path of green and low-carbon development in energy development*

## 统筹国内国际两个大局

中国需要主动、创新实施能源系统性变革，否则国内生态环境进一步恶化、高碳能源结构下的商品在国际市场上也将处于不利的竞争地位。

## Coordinate both domestic and international situations

*It is necessary for China to proactively and innovatively implement systemic changes in the energy sector. Otherwise, the domestic ecological environment will further deteriorate, and the products under the high-carbon energy structure will be in a disadvantageous position in the international market.*



1978-2021年一次能源消费总量及结构

1978-2021 Total primary energy consumption and its structure



# 能源发展面临的新挑战：主要矛盾发生了变化，矛盾的主要方面也发生了变化



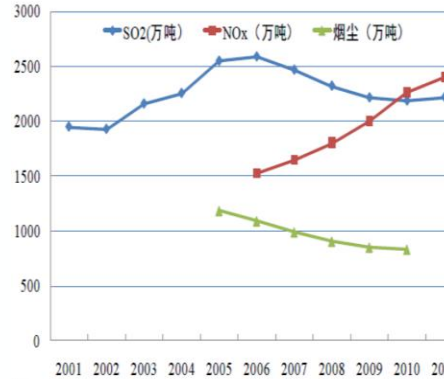
*New challenges faced by energy development: The principal contradiction has changed, so as the main aspects of the contradiction*

- **主要矛盾：**过去是能源总量供给不足与经济社会发展对能源迫切需求的矛盾、现在是能源供给高碳结构制约甚至可能倒退经济社会发展的矛盾；

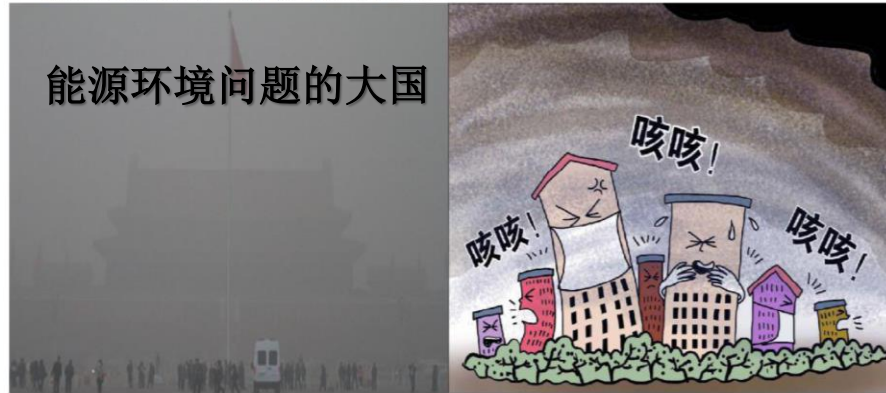
*The principal contradiction: Used to be the contradiction between insufficient total energy supply and the urgent demand for energy from economic and social development. Now it is the contradiction between the high-carbon structure of energy supply that restricts and may even set back economic and social development;*

- **矛盾的主要方面：**过去是保障煤炭供应以满足总量供给不足、现在是要大力风、光、水等可再生能源电力以优化能源供给结构（低碳直至零碳）。

*The main aspect of the contradiction: Used to be ensuring coal supply to meet the total supply shortage, now turned into the vigorously use wind, solar, hydro and other renewable energy sources to optimize the energy supply structure (low carbon to zero carbon).*



## 能源环境问题的大国



- The emissions of SO<sub>2</sub>, NO<sub>x</sub>, dust and particulate matter are the highest in the world
- 我国二氧化硫、氮氧化物、烟（粉）尘以及可吸入颗粒物高居世界第一；
- The emission of SO<sub>2</sub> in China is as much as 2 times than that in US and 3 times in EU
- 我国SO<sub>2</sub>排放量约为美国的2倍、欧盟的3倍；
- The emission of NO<sub>x</sub> is 1.5 times than that in EU
- 氮氧化物排放量是欧盟的1.5倍；
- The man-made emission of Hg into the atmosphere account more than 30% of the total
- 人为源大气汞排放量占世界的30%以上；
- The acid rain acreage increase
- 酸雨面积继续呈扩大态势。
- The haze affect 0.6 billion people and 25 provinces
- 雾霾已影响到全国25个省份，受影响人口达6亿。

# 从2050高比例可再生能源到可再生能源展望到面向碳中和的能源转型展望



*From a high proportion of renewable energy in 2050 to a renewable energy outlook to an energy transition outlook towards carbon neutrality*



## 执行单位 *Implementation Unit*



## 资金支持单位 *Financial Support*



MINISTRY OF FOREIGN AFFAIRS  
OF DENMARK

## 技术支持 *Technical Support*





# 研究思路暨方法学

Methodologies



坚持全球格局：目标导向、问题导向、系统分析

*Adhere to the global pattern: goal-oriented, problem-oriented, systemic analysis*



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China Energy Transformation Outlook 2023



# 以中国式现代化，建设社会主义现代化强国——2060年前经济社会系统实现碳中和

*Building a great modern socialist country by the Chinese path to modernization --- achieving carbon neutrality of the economic society by 2060*

## ■ 经济社会发展：

*Economic and Social Development:*

- 人口：13-13.5亿人

*Population: 1.35-1.4 billion people*

- 人均GDP（2020年价）：4.2-4.4万美元

*GDP per Capita (at 2020 prices): \$42,000-\$44,000*

- 生态环境：PM2.5达到世卫组织宜居标准，2060年前二氧化碳排放实现中和

*Environment: PM2.5 meets the WHO standard; achieve carbon neutrality by 2060*

**能源系统：以高端化、智能化和绿色化的制造业为支撑，建立起以风、光为主体的新型电力系统，以新型电力系统为核心建设清洁低碳、安全高效的新型能源体系。**

*Energy system: Supported by advanced, intelligent and green manufacturing, a new type of electricity system with wind power and solar PV as the main body will be established, and a clean, low-carbon, safe and efficient new type of energy system will be built with the new type of electricity system as the core.*



# 打破“不可能”三角——建设以新能源为主体的新型能源体系

Breaking the impossible triangle-- building a new type energy system

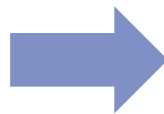


**Economic**  
经济增长

**Environment Friendly**  
生态环境

**Safety**

化石能源为主的  
能源系统



**Ecological civilization society**  
生态文明社会

New-type energy  
system

新型能源体  
系

**Modernized  
economic system**

现代化经济  
体系



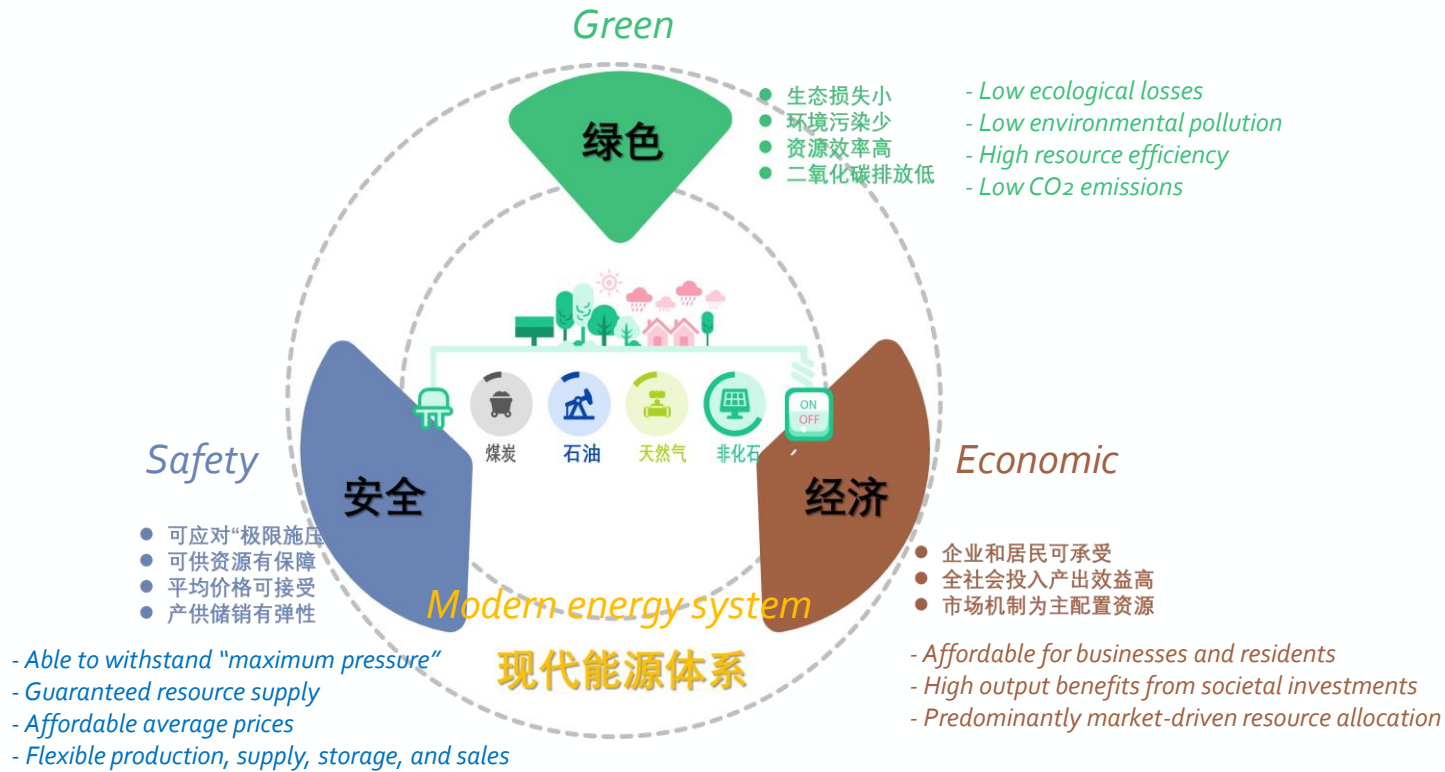
面临问题：能源供需安全、能源与环境安全、能源与气候安全，乃至国家经济安全

Faced issues: Energy supply and demand security, energy and environmental security, energy and climate security, and even national economic security



# 坚持系统观念：坚持全国一盘棋建设清洁低碳、安全高效的新型能源体系（产供储销有机衔接），新型能源体系一定是绿色的、也是安全的、更是经济的

*Adhere to the system concept: insist on building a clean, low-carbon, safe and efficient new energy system nationwide (effectively connecting production, supply, storage and marketing). The new energy system has to be green, safe and economical*



# 坚持系统观念：建立模型决策支持系统

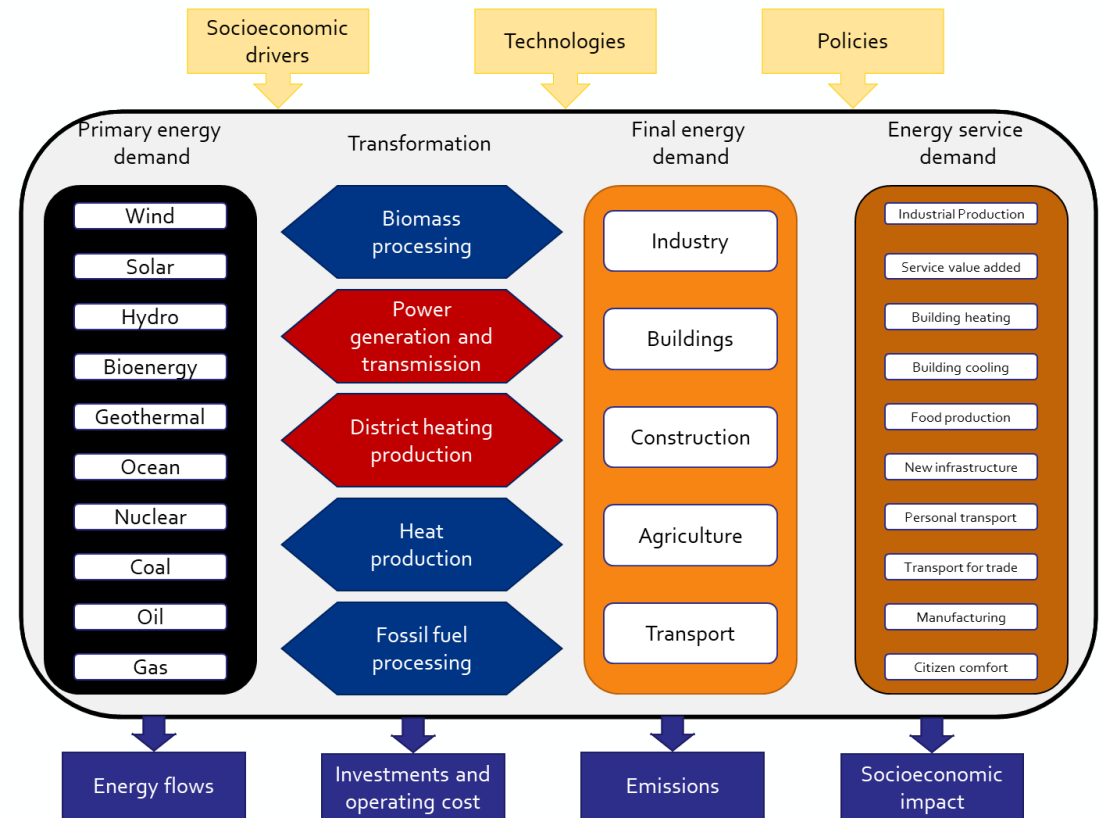
Adhere to the systemic concept: To establish modelling-based decision-making support system



CETO使用能源研究所自主知识产权模型系统进行所设定情景的定量化分析。该模型系统涵盖了能源供应，能源转换和最终用能等部门的整个能源系统，由三个核心模型和两个辅助模型组成。

*CETO uses the ERI's proprietary model system for quantitative analysis of the defined scenarios. This model system encompasses the entire energy system, including energy supply, energy conversion, and final energy consumption sectors, aided by three core models and two auxiliary models.*

- “中国终端能源需求分析模型” (ERI-LEAP)  
*"China Long-range Energy Alternatives Planning Model in End-use Sectors" (ERI-LEAP)*
- “中国电力部署优化模型” (ERI-EDO)  
*"China Electricity and District heating Optimisation Model" (ERI-EDO)*
- “中国经济社会评价模型” (ERI-CGE / CETPA)  
*"China Economic and Social Evaluation Model" (ERI-CGE/CETPA)*



# 情景设置

## Scenario design



- **参考情景 (BLS)** : 以当前能源系统发展趋势进行外推的情景, 并以实现《巴黎协定》确定的本世纪将全球平均气温上升控制在2摄氏度之内的愿景进行倒逼。在分析过程中, 考虑当前世界范围内发生的政治、经济冲突, 也包括重点区域、重点国家提出的新政策, 对由此可能对新能源与可再生能源产业发展、全球及中国能源转型的影响进行分析, 提出转型力度相对较小的中国能源转型参考情景, 用于提供与两个碳中和情景进行定量比较的参考。
- **碳中和情景1 (CNS1)** : 积极发展可再生能源, 到2055年, 生物质能发电和遗留的煤电、天然气发电机组全面采用碳捕集、利用与封存 (CCUS) 技术, 力争能源系统**2055年前后**实现净零排放。
- **碳中和情景2 (CNS2)** : 大力发展可再生能源的基础上, 进一步扩大风电和光伏发电装机容量, 煤电机组发电小时数和发电量下降更快, 2055年前, 生物质能发电和遗留的天然气发电机组逐步采用CCUS技术, 力争能源系统**2055年前**实现净零排放。
- **Baseline Scenario (BLS)** : Projecting current trends in energy system development and is carefully recalibrated to align with the objective of the Paris Agreement to limit the global average temperature increase to within 2 °C degrees Celsius this century. The analysis incorporates considerations of prevailing political and economic tensions across the globe, alongside newly proposed policies from key regions and countries. It assesses the likely impacts on the evolution of new and renewable energy sectors, as well as on the energy transition both globally and within China. A Baseline Scenario for China's energy transformation, characterized by relatively lower intensity, is presented. This serves as a standard for quantitative comparisons with two scenarios that envisage carbon neutrality.
- **Carbon Neutrality Scenario 1 (CNS1)**: Advocates for renewable energy development, and by 2055, biomass power and remaining coal and gas power units are fully installed Carbon Capture, Utilisation and Storage (CCUS) facilities, targeting net zero emissions in the energy system **around 2055**.
- **Carbon Neutrality Scenario 2 (CNS2)**: Based on advocating renewable energy development, it is required to further expand wind and solar PV power generation capacity. The full load hours and power generation of coal power units both drop faster till naturally retired as consequence. Prior 2055, biomass power and remaining gas power units are gradually installed CCUS facilities, aiming for net zero emissions in the energy system **before 2055**.



# 实现能源绿色低碳转型：任务一

*Energy transformation: mission 1*



实现终端用能高比例电气化是  
能源绿色低碳转型发展的基础

*Achieving a high proportion of electrification in  
end-use energy is the basis for the green and  
low-carbon transformation*



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# 终端电气化是经济社会发生系统性变革的必要条件

Terminal electrification is a necessary condition for systemic changes in the economy and society

- 工业用能电气化  
Electrification in industry

Blast furnace



Electric furnace



Industrial heat pump



- 建筑用能电气化  
Electrification in Building

Coal stove



Gas stove



Electric tea stove



Solar PV integrated building



- 交通运输用能电气化  
Electrification in Transport

Electric car



Charging pile



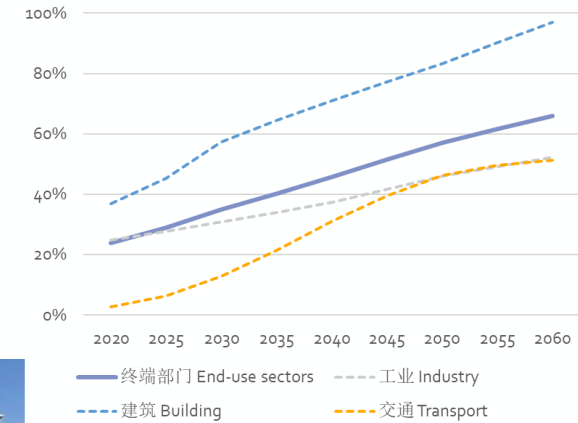
Electric truck



Battery swap station



CNS2情景下终端部门电气化率  
Electrification rates of end-use sectors in CNS2



Heating pump



Smart meter



Household power storage



Intelligent management system



# CNS2: 2060年全国电力需求展望

CNS2: Total electricity demand outlook in 2060

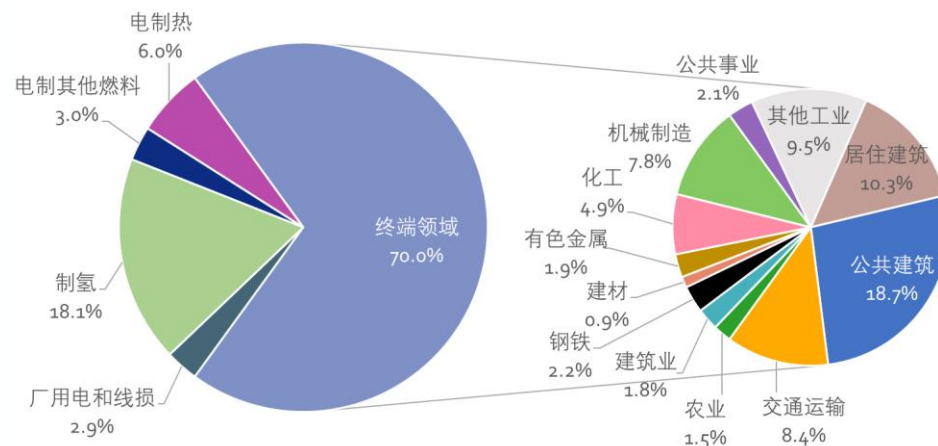


## 全社会电力消费持续增长

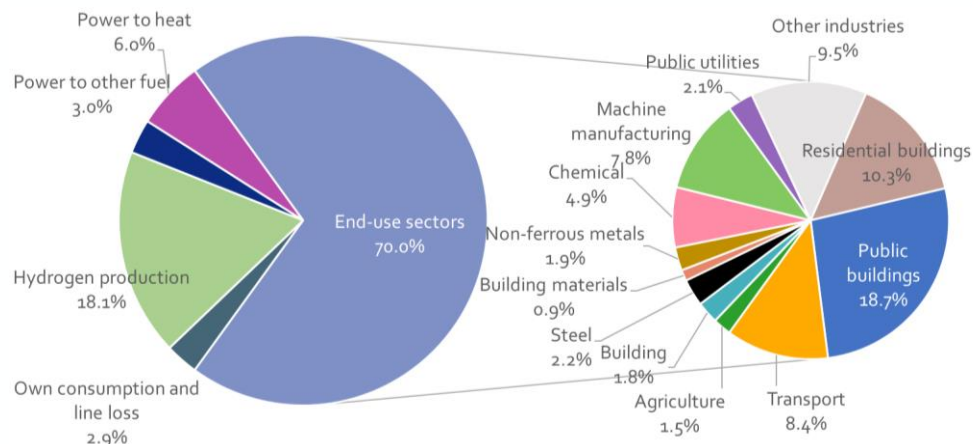
终端用能行业的高比例电气化和电制氢规模化发展是拉动用电量更快提升的主因；到2035年，全社会用电量达到**16万亿千瓦时**；到2060年，全社会用电量进一步达到**20万亿千瓦时**。

## Total electricity consumption continues to grow

The high proportion of electrification in the end-use sectors and the development of electric hydrogen production on a large scale are the main drivers of a more rapid increase in electricity consumption; by **2035**, society as a whole uses **16,000 TWh** of electricity, and by **2060**, society as a whole uses a further **20,000 TWh** of electricity.



CNS2情景下2060年分行业全社会用电量



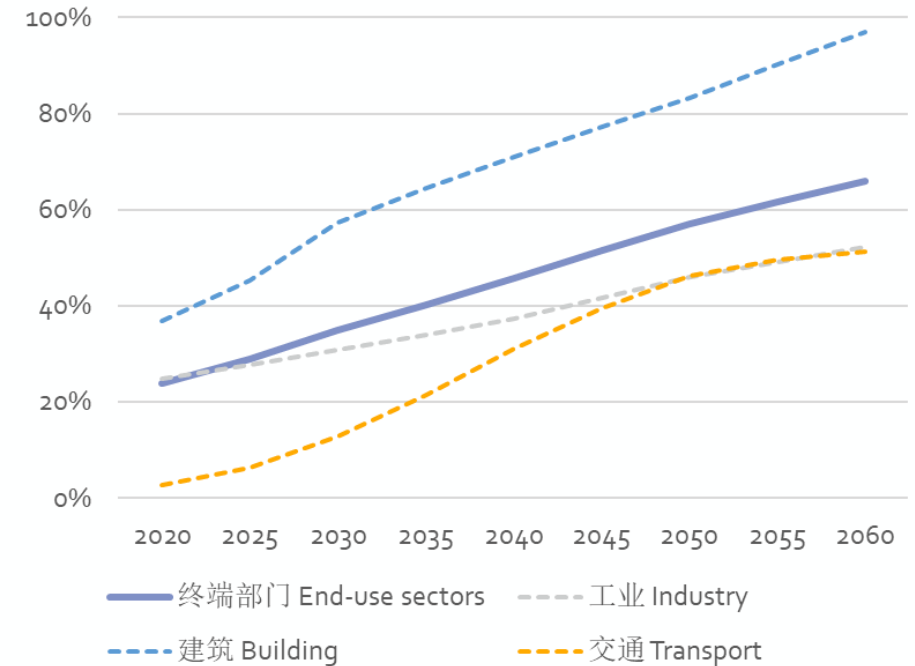
2060 Total electricity consumption by sector in CNS2



# CNS2: 终端部门电气化率66%

CNS2: End-use sector electrification rate reaches 66%

- 三个情景终端部门总体电气化率都在持续增加。在CNS2中，终端能源消费中电力比重从2020年的23.9%增加到2035年的40.2%和2060年的65.8%。  
*The overall electrification rate of end-use sectors continues to increase in all three scenarios. In CNS2, the share of electricity in end-use energy consumption increases from 23.9% in 2020 to 40.2% in 2035 and 65.8% in 2060.*
- 交通运输部门**是电气化发展速度最快的领域，在CNS2中，电力占交通部门能源消费比重将从**当前的3%**增长到**2060年的51.4%**；  
*The transport sector sees the fastest electrification growth, with the share of electricity in transport energy use growing from the current 3% to 51.4% in 2060 in CNS2.*
- 建筑部门**是电气化程度最高的领域，在CNS2中，电气化率从**当前的37%**进一步大幅增长至**2060年的96.9%**；  
*The building sector has the highest level of electrification, with the electrification rate growing from the current 37% to 96.9% in 2060 in CNS2;*
- 工业部门**的电气化率持续稳定提升，在CNS2中，从**当前的25%**增长到**2060年的52.2%**。  
*The electrification rate of the industrial sector sees steady increases, growing from 25% currently to 52.2% in 2060 in CNS2.*



CNS2情景下终端部门电气化率  
Electrification rates of end-use sectors in CNS2



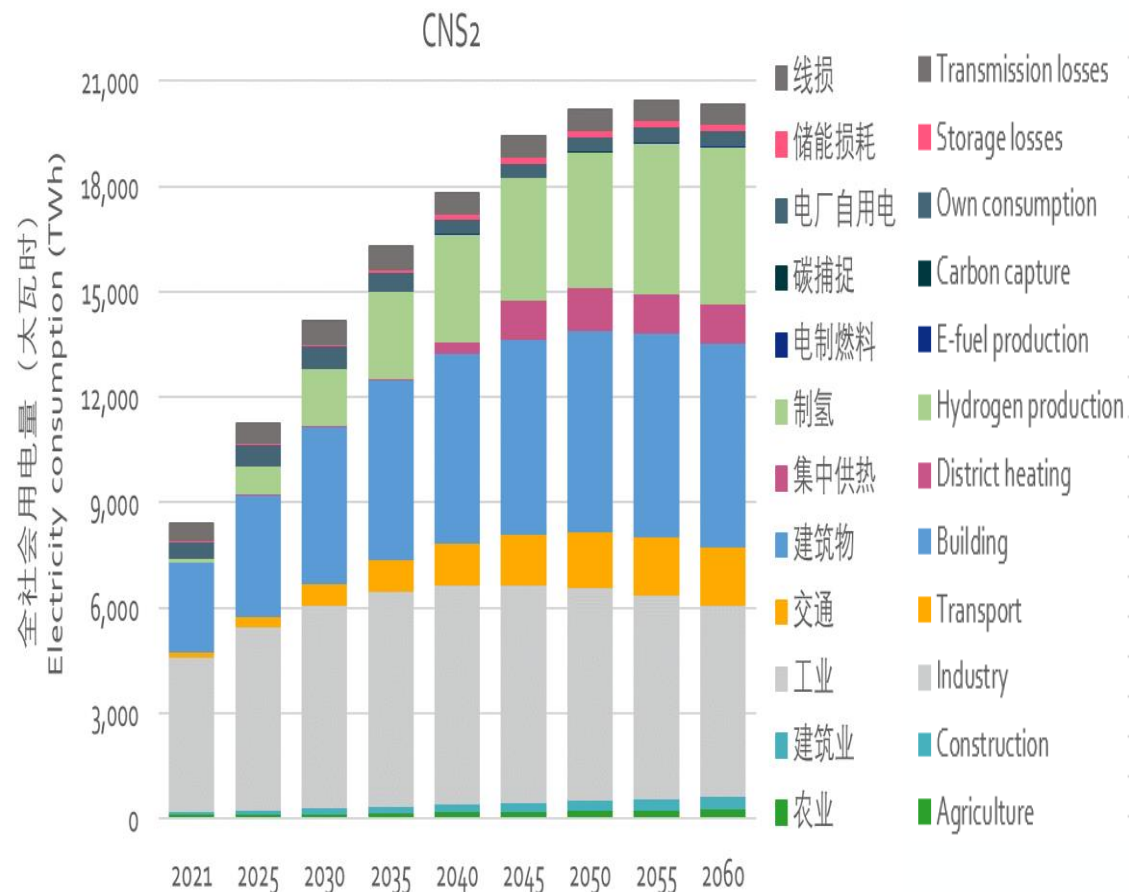
# CNS2: 2060年发用电总量和电源结构暨CO<sub>2</sub>排放量

CNS2: Total power Generation, power capacity mix and CO<sub>2</sub> emissions in 2060



全社会用电量**20.2万亿千瓦时**（其中，直接消费14万亿千瓦时，PtX和电制热1.1万亿千瓦时，制绿氢4.5万亿千瓦时）。

Total electricity consumption: **20,200 TWh** (Among them, **14,000 TWh** for end-use sector, **1,100 TWh** for PtX, **4,500 TWh** for green hydrogen production).



CNS2情景下全社会用电量

Total electricity consumption in CNS2

# 实现能源绿色低碳转型：任务二

*Energy transformation: mission 2*



大力发展风电和光伏发电是实现电力绿色化的源头和前提

*Developing wind power and solar PV power generation is the source and pre-condition for a green power system*



中国能源转型展望 2023

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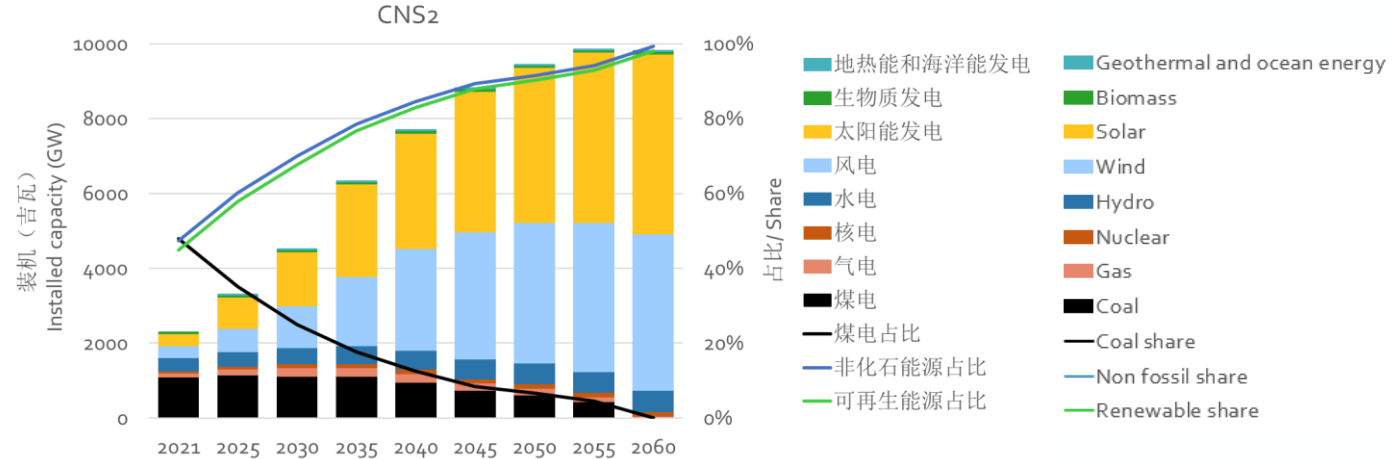
# CNS2: 风电和光伏支撑新型电力系统

CNS2: Wind and solar power support the new-type power system



## 可再生能源（风电和光伏）成为主体电源

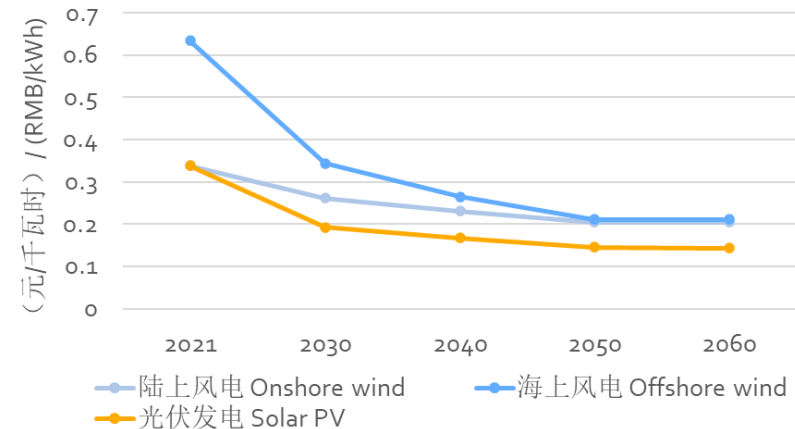
电力系统全面实现清洁转型，风电光伏装机规模化增加；2035年发电总装机将突破**63亿千瓦**，可再生能源占比**77%**；2060年发电总装机达到**98亿千瓦**，可再生能源占比**98%**；风电光伏LCOE降至0.14~0.21元/千瓦时。



## Wind power and solar PV will become the absolute dominant power source

The power system fully realises the clean transition, and wind power PV installations increase in scale; by 2035, the total installed power generation capacity exceeds 6,300 GW, with renewable energy accounting for 77% of the total; by 2060, the total installed power generation capacity reaches 9,800 GW, with renewable energy accounting for 98% of the total; and the wind power PV LCOEs are reduced to 0.14~0.21 RMB/kWh.

CNS2情景下发电总装机  
Total installed power generation capacity in CNS2



CNS2情景下风电和光伏发电LCOE  
Wind and solar PV LCOE in CNS2

# CNS2: 风电发展

CNS2: Wind power development

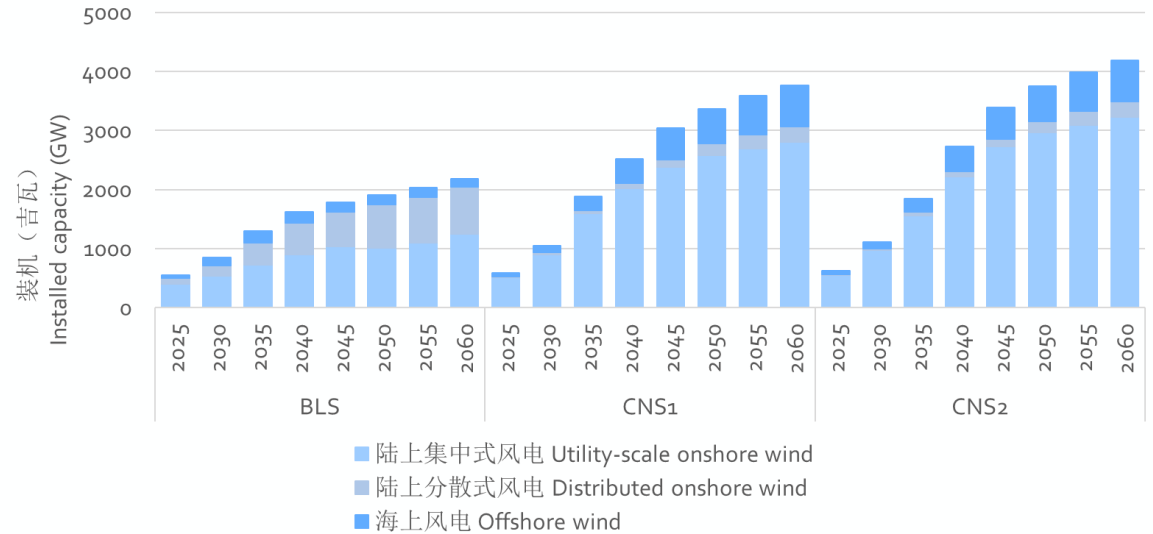


## 2040年是风电发展的关键时期

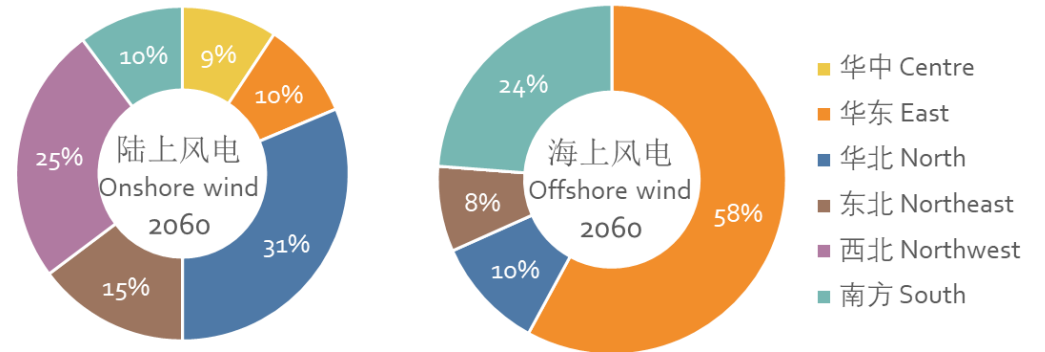
到2040年，陆上风电仍占新增装机主导，低风速集中式风电、分布式风电和海山风电都实现了规模化发展；到2060年，风电总装机将达到**4.2亿千瓦**，其中海上风电超过**7亿千瓦**；从区域部署来看，陆上风电**71%**位于“三北”地区，海上风电**58%**位于华东地区。

## The timeline leading up to 2040 is pivotal for wind power development

By 2040, onshore wind power still dominates the new installed capacity, and low wind speed utility-scale wind power, distributed wind power and offshore wind power all achieve large-scale development; by 2060, the total installed capacity of wind power reaches 4,270 GW, of which offshore wind power is more than 700 GW; from regional deployment, 71% of the onshore wind power is located in the "Three North" region, and 58% of the offshore wind power is located in the East China region.



风电发电总装机  
Total installed wind power capacity



CNS2情景下2060年陆上风电和海上风电区域部署  
Onshore and offshore wind power regional deployment in 2060 in CNS2



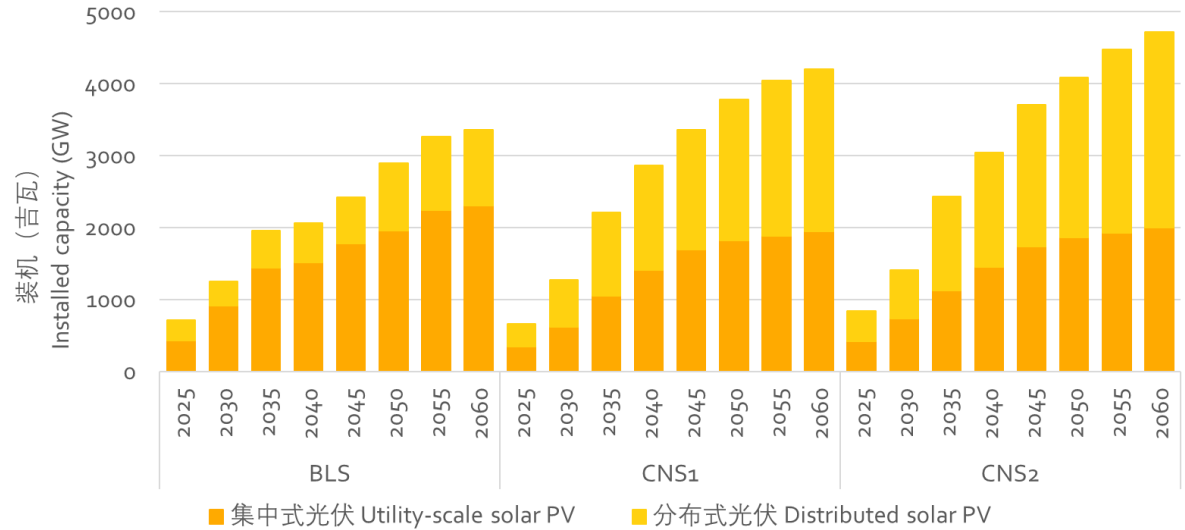
# CNS2: 光伏发展

CNS2: Solar PV development



## 集中式、分布式光伏发展齐头并进

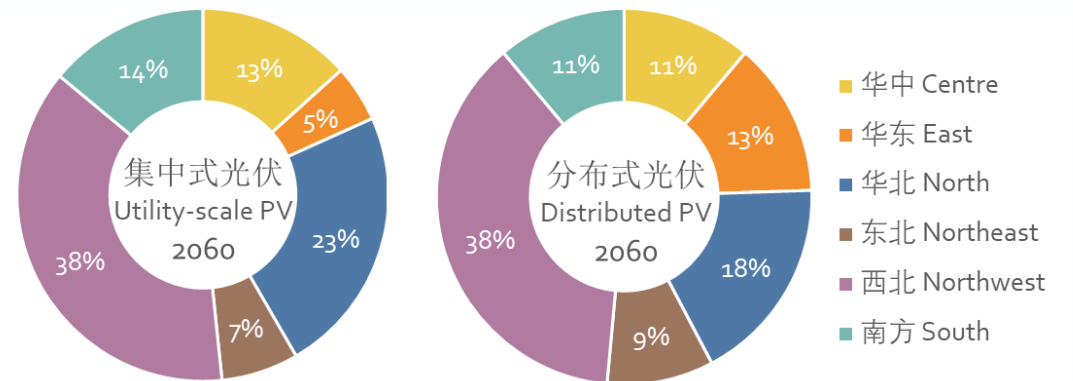
到2040年，集中式光伏仍占新增装机主导，分布式光伏新增装机增速更快；到2060年，光伏总装机达到**48亿千瓦**，集中式光伏**68%**位于“三北”地区，分布式光伏**35%**位于中-东-南部地区。



## Utility-scale solar PV and distributed PV develop in parallel

By 2040, utility-scale PV still dominates new installations, with distributed PV installations growing faster; by 2060, total PV installations reaches **4,800 GW**, with **68%** of utility-scale PV located in the **"Three Norths"** region, and **35%** of distributed PV located in the **central-eastern-southern region**.

光伏发电总装机  
Total installed solar PV capacity



CNS2情景下2060年集中式光伏和分布式光伏区域部署

Utility-scale PV and distributed PV regional deployment in 2060 in CNS2

# 实现能源绿色低碳转型：任务三

*Energy transformation: mission 3*



## 建立新型电力系统和高度智能化的电网新形态

*The establishing of a new type of power system and a highly intelligent new form of power grid*



中国能源转型展望 2023

*China Energy Transformation Outlook 2023*



## CNS2: 灵活性资源加快发展，煤电角色逐步转变

*CNS2: flexible resources will be developed fast, and the role of coal fired power plants will change*

- 到2060年，抽水蓄能、新型储能和需求侧响应资源成为电力系统的主力调节资源，总资源量达到**28.7亿千瓦**。

*By 2060, pumped storage, new-type energy storage, and demand-side response resources become the primary regulating resources of the power system, with the total resource capacity of **2,870 GW**.*

- **煤电**装机在“十四五”至“十五五”期间达到平台期后逐步下降，部分机组转为备用，到2040年仍是重要的灵活性调节资源；到**2060年**煤电逐步减少。

*The installed capacity of **coal power** will peak between the 14th~15th Five-Year Plan period and then gradually decline, with some of the units being put on reserves, and will remain an important flexible regulating resource by 2040; coal power will be reduced by **2060**.*

# 电动汽车储能对电力系统的稳定运行发挥重要作用

Energy storage by EVs play a significant role in the stability of power system operation

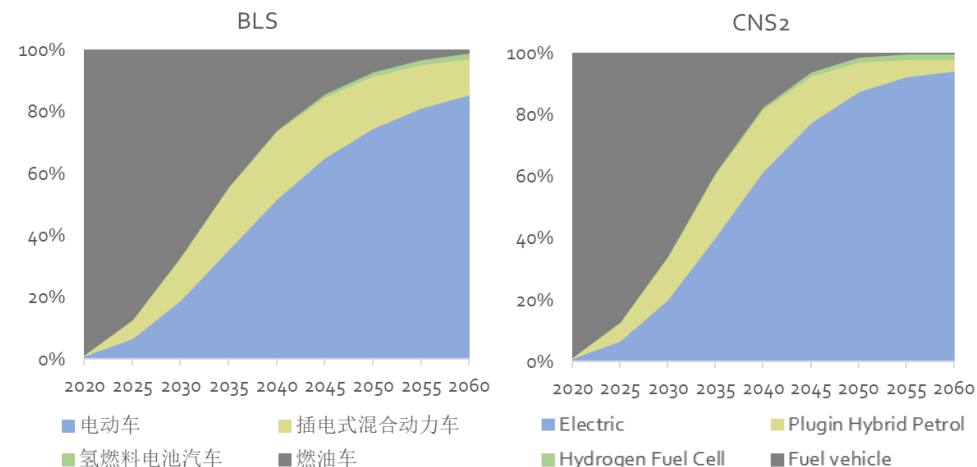


- 预计2060年，BLS情景下纯电动汽车达4.2亿辆，CNS2情景下纯电动汽车为4.7亿辆除此以外则是少量的插电混合动力汽车和极少量的氢燃料电池汽车。

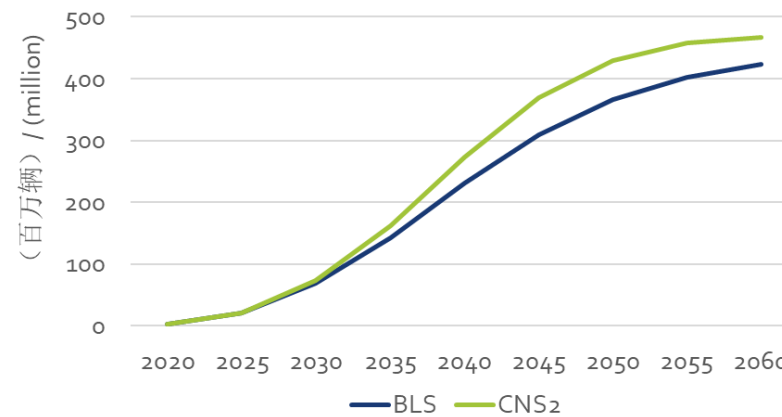
*It is projected that by 2060, there will be 420 million pure EVs in BLS and 470 million in CNS2. The remainder will be a small number of plug-in hybrid vehicles and very few hydrogen fuel cell vehicles.*

- 在CNS2情景下，电动汽车比重为94%，插混汽车已基本被替代，占比仅4%。

*In CNS2, the share of EVs will be 94%, while plug-in hybrids will be almost completely replaced, accounting for only 4%.*



2020-2060年私家车分燃料类型市场份额  
2020-2060 Market share of private cars by fuel type



2020-2060年电动汽车保有量  
2020-2060 Electric vehicle ownership



# P2X燃料在航空和航运中的应用

## P2X in aviation and maritime

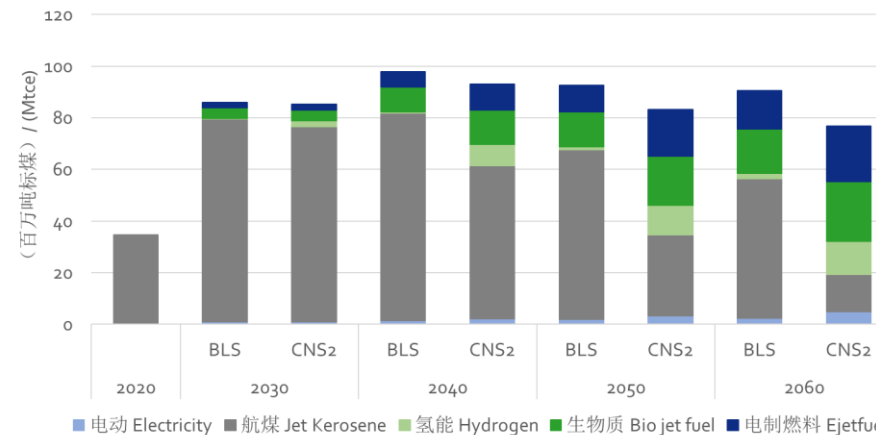


- **航空领域**，在CNS2情景中，2060年，生物燃料和电制燃料比重有望达到28%-30%，氢能将占有17%左右的份额，航空煤油则降至不足两成，对化石能源的依赖进一步降低。

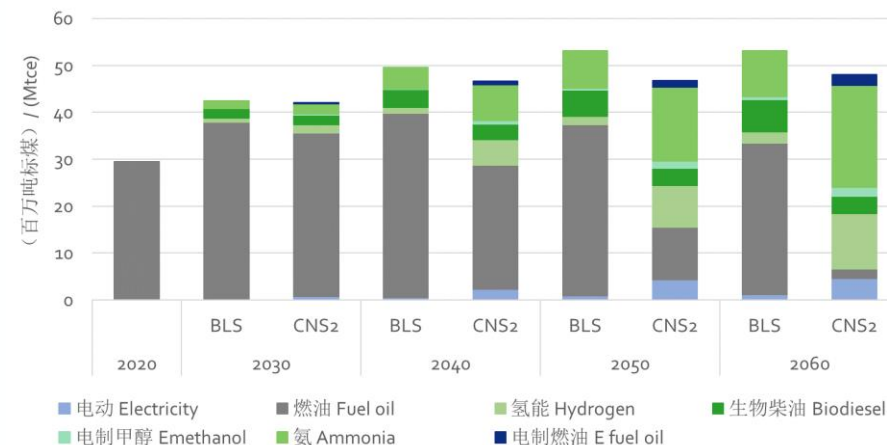
In the aviation sector, it is anticipated that by 2060, the combined share of biofuels and e-fuels will reach 28%-30% in CNS2. Hydrogen is expected to constitute around 17% of the energy mix, while the share of aviation kerosene will decline to less than 20%, thereby further diminishing the dependency on fossil fuels.

- **航海领域**，在CNS2情景中，非化石能源的替代进程进一步得到加强，氨能、氢能、电制甲醇、电制燃油（Efuel oil）等比重均稳步上升。到2040年之前，预计石油产品比重仍保持57%以上，但到2060年，石油比重将仅剩不足5%，而氢能和氨能的比重则分别来到24%和45%，撑起了航运燃料的半壁江山。

In the maritime sector, CNS2 predicts the process of replacing non-fossil fuels to gain momentum, with a steady ascent in the shares of energy sources such as ammonia, hydrogen, electro-methanol, and e-fuel oil. Prior to 2040, petroleum products are projected to maintain a presence exceeding 57% in the energy portfolio; however, by 2060, this figure is slated to reduce to less than 5%. Conversely, the shares of hydrogen and ammonia will elevate to 24% and 45%, respectively, commanding a substantial portion of the maritime fuel landscape.



2020-2060年航空燃料需求 (含客运及货运)  
2020-2060 Aviation fuel demand (encompassing passenger and cargo transportation)



2020-2060年航运燃料需求  
2020-2060 Maritime fuel demand

# CNS2：绿氢在支持工业转型的同时，对平衡电力系统负荷发挥重要作用



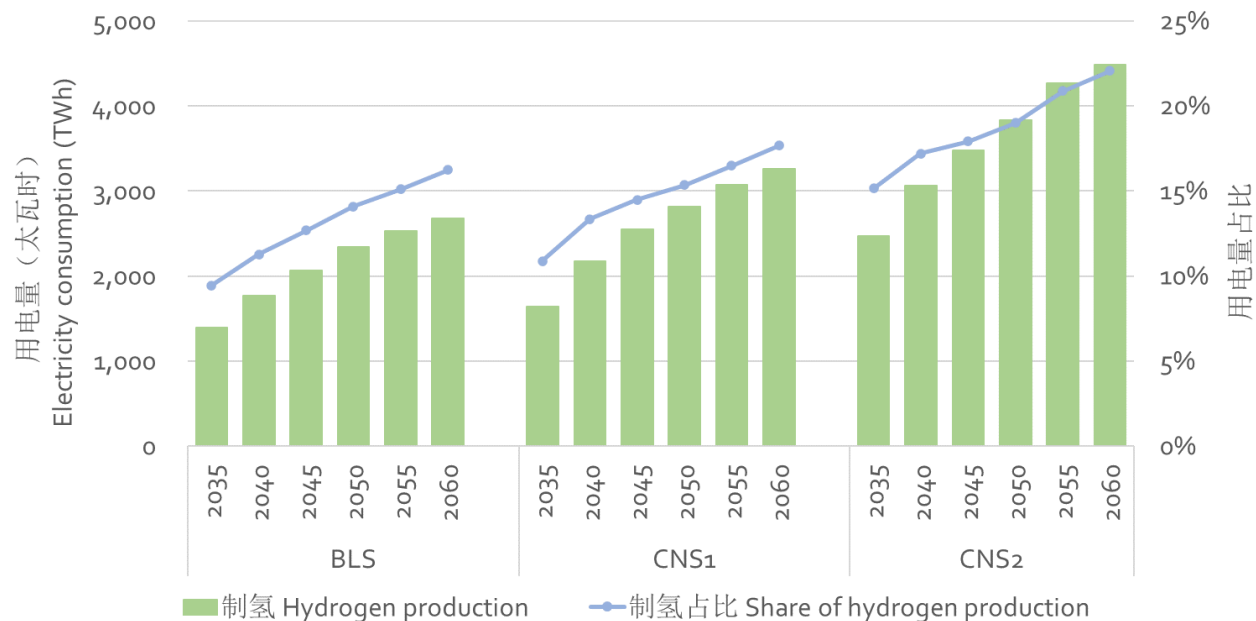
CNS2: Green hydrogen greatly contributes to balance power load in parallel with supporting industrial transition

## 绿色电力制氢中长期角色凸显

绿电制氢在2035年后对电力需求增长的贡献加大；到2035年，制氢用电量达到**2.5万亿千瓦时**，占全社会用电量**15.2%**；到2060年进一步增加至**4.5万亿千瓦时**，占比达到**22.1%**。

### Green hydrogen plays an important role in the mid to long-term future

The contribution of green power-based hydrogen production to electricity demand growth increases after 2035; by 2035, electricity consumption for hydrogen production reaches 2,500 TWh, or 15.2% of total electricity consumption; it further increases to 4,500 TWh by 2060, or 22.1%.



制氢用电量及用电量占比  
Electricity consumption of hydrogen production and its share in total electricity consumption

# CNS2: 电网互联电力互济的电网新形态

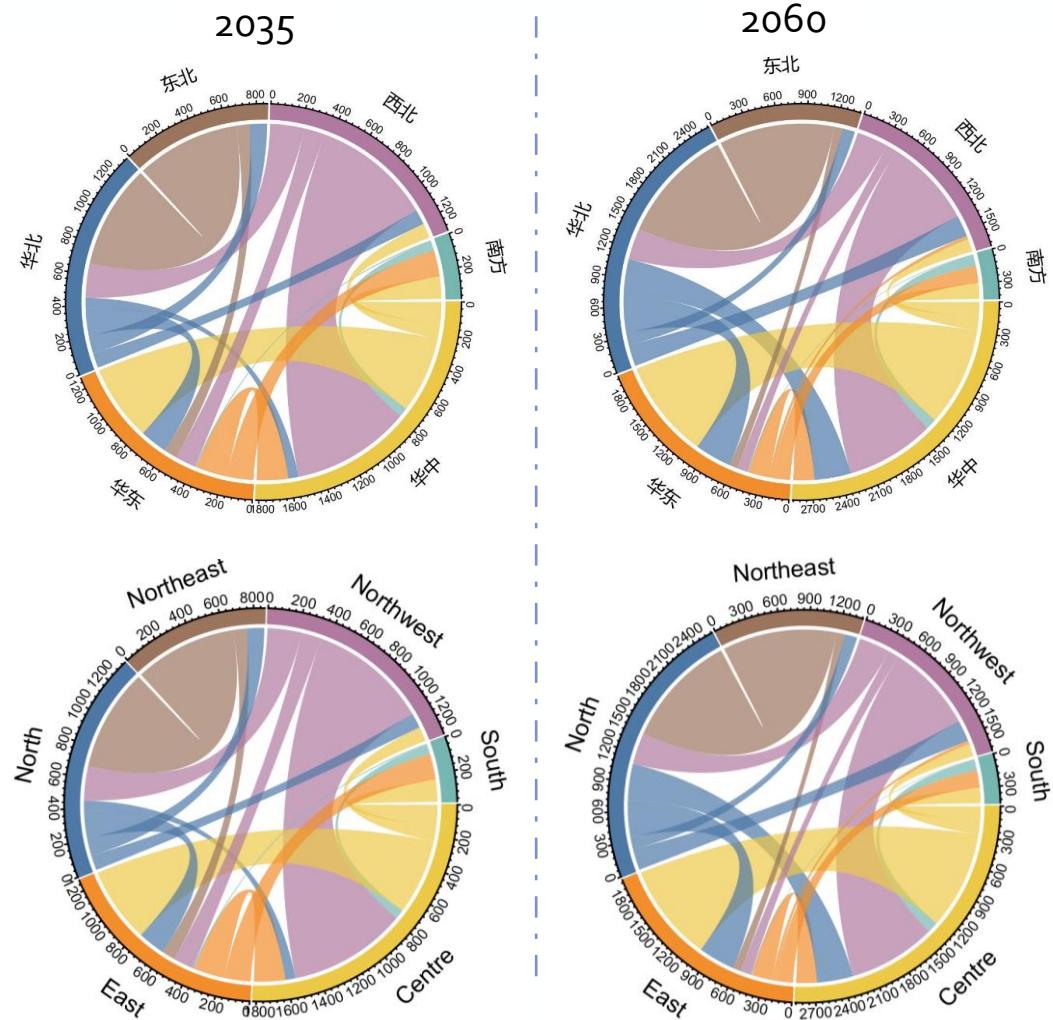
CNS2: Interconnections and power mutual aids form the new power grid pattern

## 跨区电力互济与电网格局优化

到2035年，西北-华中、东北-华北、华中-华东仍是主要的跨区输电通道；到2060年，将形成“西电东送、东电西济、北电南送、南北互供”，“省为实体，区域互联，全国平衡”的电网新形态，预计东中部地区受电规模在当前基础上增加2倍左右。

### Inter-regional power mutual aids and grid optimisation

By 2035, Northwest-Central, Northeast-North, Central-East are still the main inter-regional transmission corridors; by 2060, the grid pattern of "**West power to the East, East power to aid West, North power to the South, North and South mutual aids**" is formed, and the scale of the recipient of the power in the East and Central regions will be increased on the basis of the current about **two times**.



CNS2情景下2035年和2060年跨区电量输送示意图  
2035 and 2060 Inter-regional power transmission sketch map in CNS2



# "West power to the East, East power to aid West, North power to the South, North and South mutual aids"

## Northwest spongy

Wind power 870 GW

Solar power 1820 GW

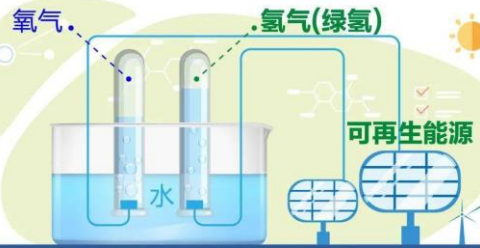
## Regulation capacity

Energy storage 900 GW

EV 1020 GW

DR 40 GW

## Green hydrogen production



## V2G



## High-end, green and intelligent

## Northeast spongy

Wind power 870 GW

Solar power 1820 GW

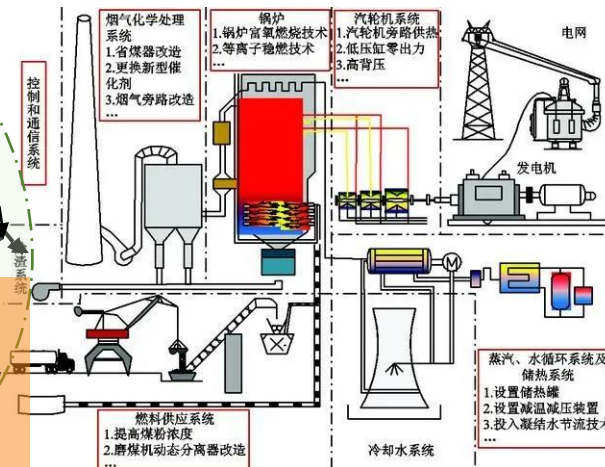
## Regulation capacity

Energy storage 1080 GW

EV 1530 GW

DR 130 GW

## Thermal power flexibility retrofit



## Southeast spongy

Wind power 1580 GW

Solar power 1620 GW

## Regulation capacity

Energy storage 1230 GW

EV 1760 GW

DR 290 GW

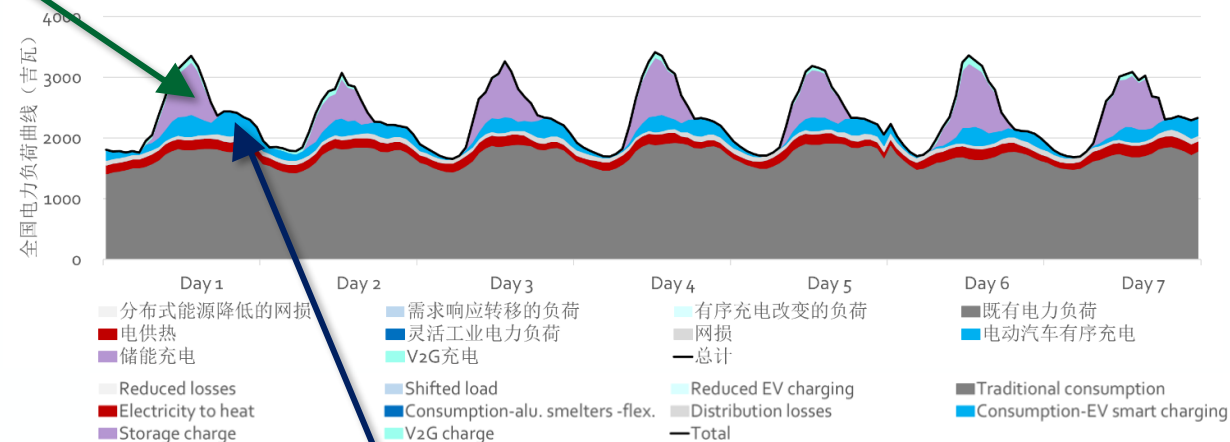
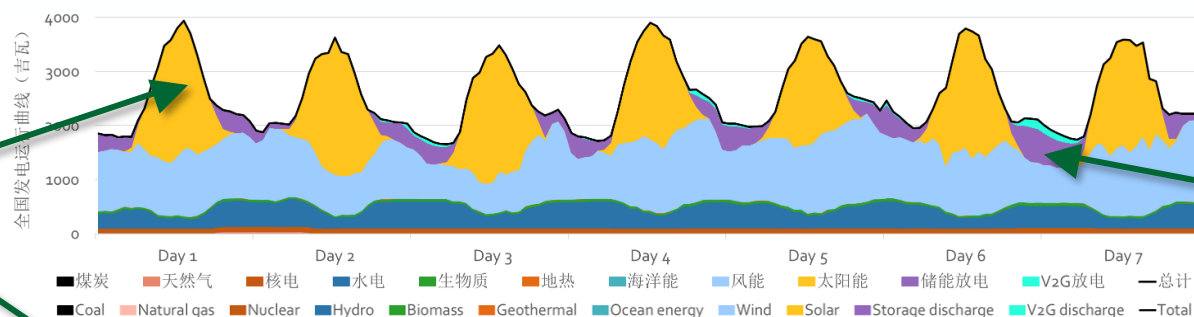


# CNS2: 以风光为主体的安全、绿色电力系统

CNS2: A safe and green power system with wind power and solar PV dominance



## 2060新型电力系统生产模拟 2060 Power balance of the new-type power system



CNS2情景下2060年夏季小时级电力平衡 Hourly power balance in summer 2060 in CNS2

**午间光伏大发**  
抽水蓄能、储能电池和EV大量充电，充电容量合计占总负荷的37%；EV-V2G充电帮助消纳盈余电量。

**Noon with high PV output**  
pumped storage, battery and EV undergo substantial charging, accounting for 37% of the total load; EV-V2G helps to absorb excess electricity from the grid

**晚间风电出力不足**  
抽水蓄能、储能电池和EV-V2G大量放电，放电容量合计占总发电容量的38%。

**Evening with low wind output**  
pumped storage, battery and EV-V2G discharge a considerable amount of electricity, contributing to 38% of the total power generation capacity

**晚间风电大发**  
电动汽车有序充电进一步发挥作用，在总用电负荷中的占比达16%。

**Evening with high wind output**  
EV smart charge plays a more substantial role, reaching 16% of the total power load

# 实现能源绿色低碳转型：任务四

Energy transformation: mission 4



能源系统绿色低碳转型发展,推动经济社会发生系统性变革

*The green and low-carbon transformation of the energy system to trigger systemic changes of the whole society*



中国能源转型展望 2023

China Energy Transformation Outlook 2023

# 清洁能源产业成为国民经济新的主导产业

clean energy industry become a new pillar of social economic development

- **可再生能源技术持续跨越式发展**：CNS2下，2035年**光伏、陆上风电、海上风电**的装机规模分别达到2021年的**8.2倍、5.4倍和近30倍**

■ Sustained leapfrog development in renewable energy technologies: CNS2 predicts, from 2021 to 2035, the annual average growth rates for installed capacities of photovoltaic (PV), onshore wind, and offshore wind are 16.2%, 15.6%, and 27.4%, respectively. By 2035, the cumulative installed capacities will be 8.2, 5.4, and nearly 30 times the levels of 2021.

- **电力灵活性技术指数型发展**：CNS2情景下，2021~2035年，**新型储能技术（含V2G）**年均增速约**达26%**。2030~2060年间，V2G年均增速约**达14%**。

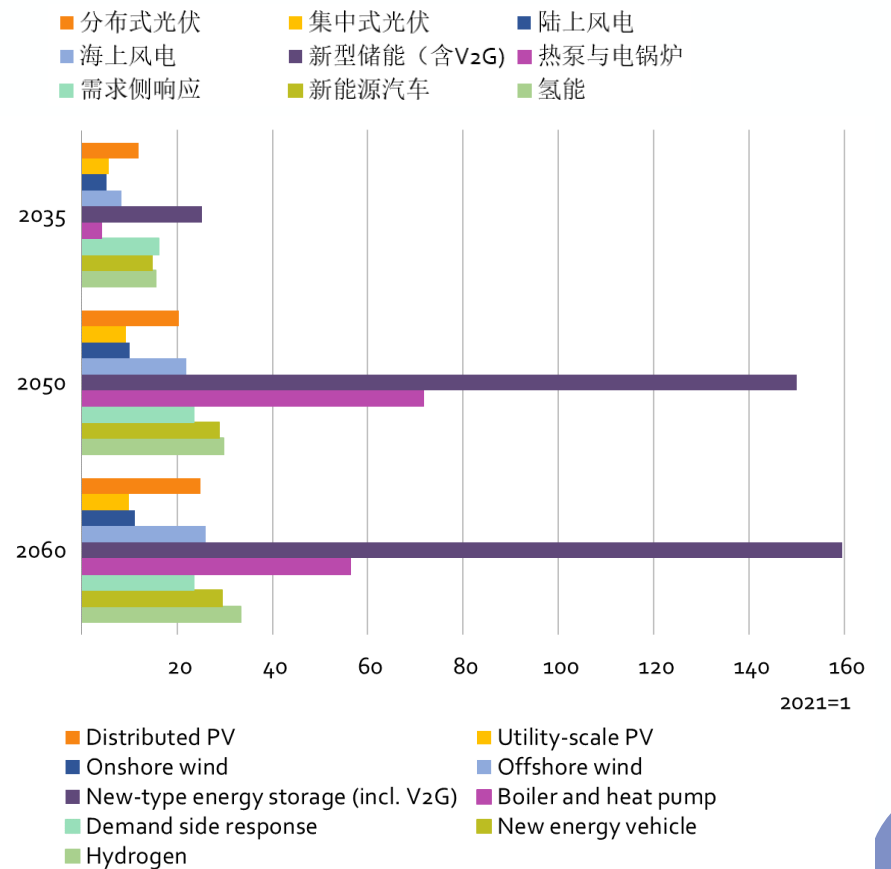
Exponential progress in power flexibility technologies: CNS2 predicts, from 2021 to 2035, the annual average growth rate of new storage technologies (including V2G) is approximately 26%. Between 2030 and 2060, V2G experiences an annual average growth rate of about 14%.

- **需求侧响应技术（DR）潜力巨大**：**电动汽车智能充电、工业响应**等多种DR技术，2021~2035年年均增速约**达22%**，2035年部署规模达到**2021年的16倍以上**。

Enormous potential in demand response (DR) technologies: Multiple DR technologies, such as intelligent charging for EVs and industrial responses, are projected to have an annual growth rate of around 22% from 2021 to 2035 in CNS2. By 2035, the deployment scale is expected to exceed 16 times that of 2021.

- **新型终端用能技术大规模部署和深度替代**：CNS2下，2060年**热泵与电加热技术、新能源汽车、氢能技术**的规模分别达到**2021年的56倍、29倍和33倍**。

Massive deployment and deep substitution with new end-use technologies: CNS2 predicts, from 2021 to 2035, the annual average growth rates of deployment scales for heat pumps and electric boiler technologies, new energy vehicles, and hydrogen technology are 10.5%, 21.2%, and 21.7%, respectively. From 2035 to 2060, these rates are forecasted to be 11%, 2.8%, and 3.1%, respectively. By 2060, the deployment scales for these technologies will be 56, 29, and 33 times their 2021 levels, respectively.



CNS2情景下部分清洁能源技术增长倍数  
Growth multiples of selected clean energy technologies in CNS2

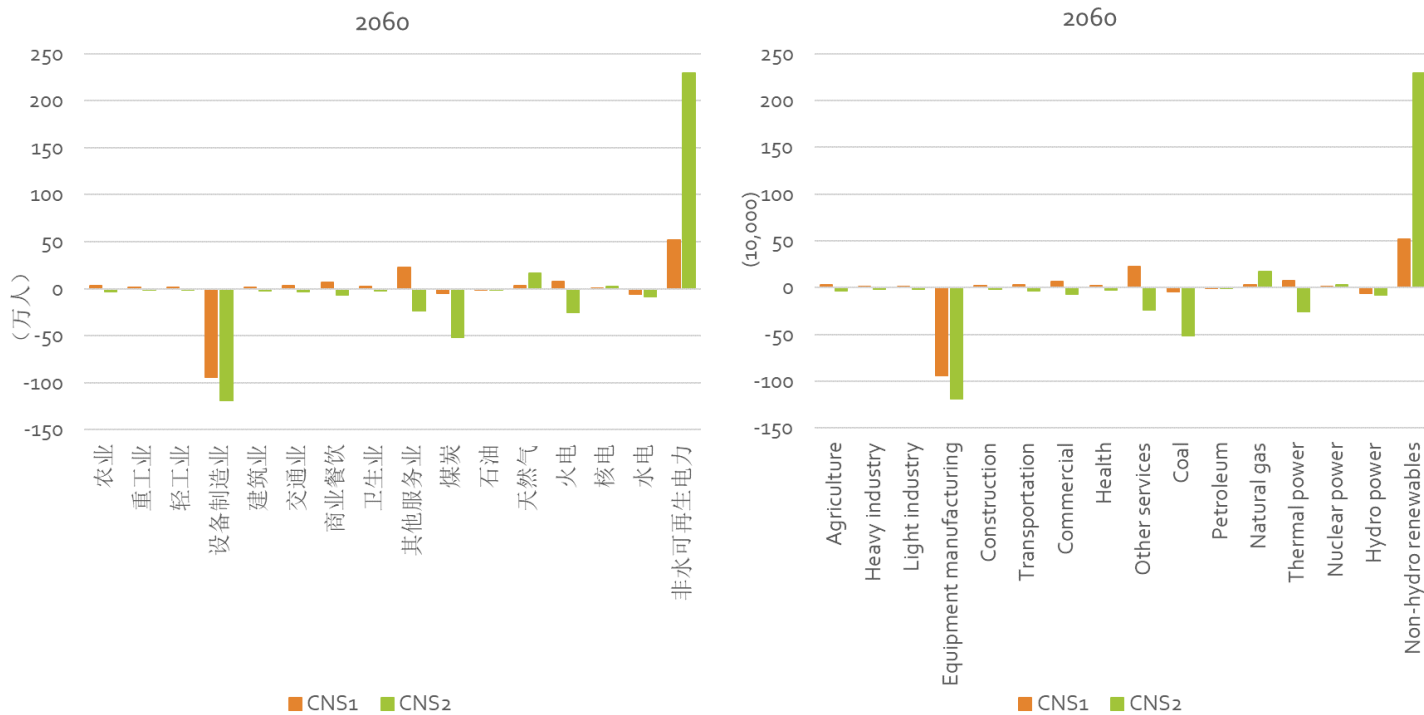
# 可再生能源创造的绿色就业，可弥补化石能源的就业岗位损失

Renewable energy creates more green jobs



- **碳中和创造就业机会：**碳中和情景CNS1和CNS2之下，与BLS情景相比，非水可再生能源创造了更多的就业岗位，这些新增的就业机会，**弥补了能源转型导致的煤炭、火电等行业的就业岗位损失。**

Carbon neutrality spurs employment opportunities: In the carbon-neutral CNS1/2, non-hydro renewables create more jobs compared to BLS, offsetting job losses from coal, thermal power and other conventional sectors.



2060年CNS1和CNS2与BLS相比的各部门就业量变化

Sectoral Employment Variations in CNS1/2 Compared to BLS in 2040 and 2060



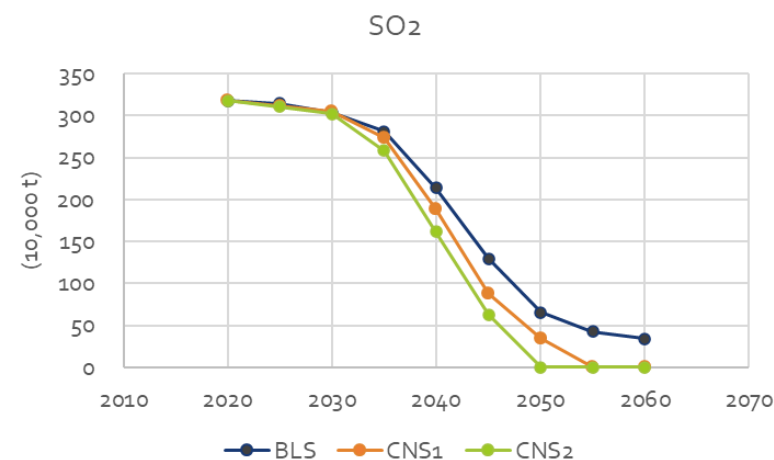
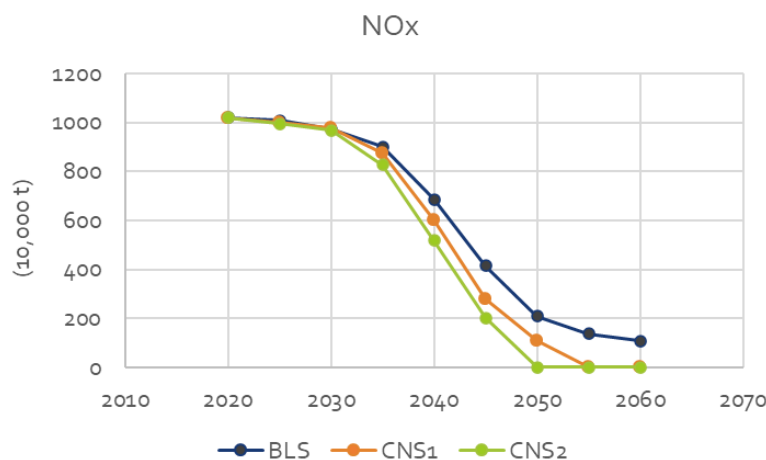
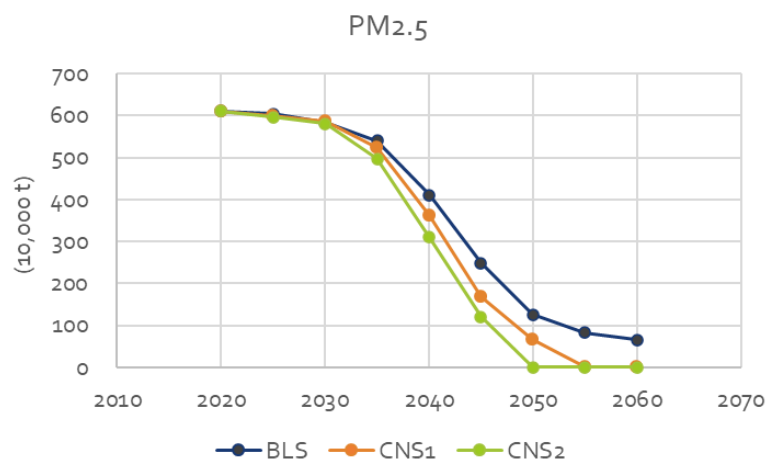
# 能源转型助力实现大气污染物源头减排建设美丽中国

Energy transition facilitates the reduction of atmospheric pollutant emissions and achieves a Beautiful China



- PM<sub>2.5</sub>、NO<sub>x</sub>、SO<sub>2</sub>等主要大气污染物排放量在能源转型情景下进一步降低：CNS<sub>1</sub>和CNS<sub>2</sub>情景下，到2060年彻底解决了大气污染物排放问题，对改善空气质量和建设美丽中国提供了关键支撑。

Under energy transformation scenarios, the emission levels of major atmospheric pollutants such as PM<sub>2.5</sub>, Nox and SO<sub>2</sub> are further reduced: Both CNS<sub>1</sub> and CNS<sub>2</sub> fully address the issue of atmospheric pollutant emissions by 2060, offering pivotal support to enhancing air quality and realising the vision of a Beautiful China.



PM<sub>2.5</sub>、Nox和SO<sub>2</sub>排放趋势  
Emission trends of PM<sub>2.5</sub>, Nox and SO<sub>2</sub>

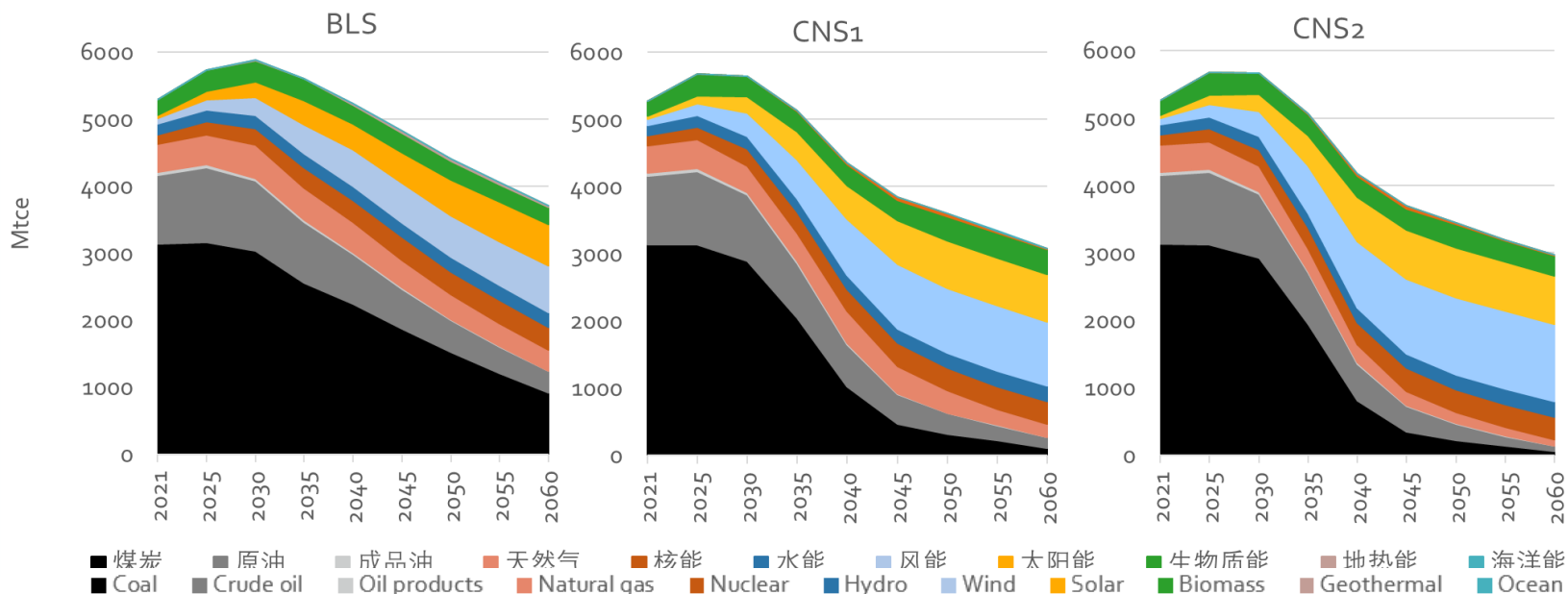
# 能源结构实现革命性转变助力经济社会广泛而深刻的系统性变革

Revolutionary transformation of the energy structure



- 非化石能源与可再生能源成为主体能源：CNS1/2情景下，2035年非化石能源在一次能源需求占比均超过35%；2060年，CNS1和CNS2情景下分别提升至85%和92%（电热当量法）

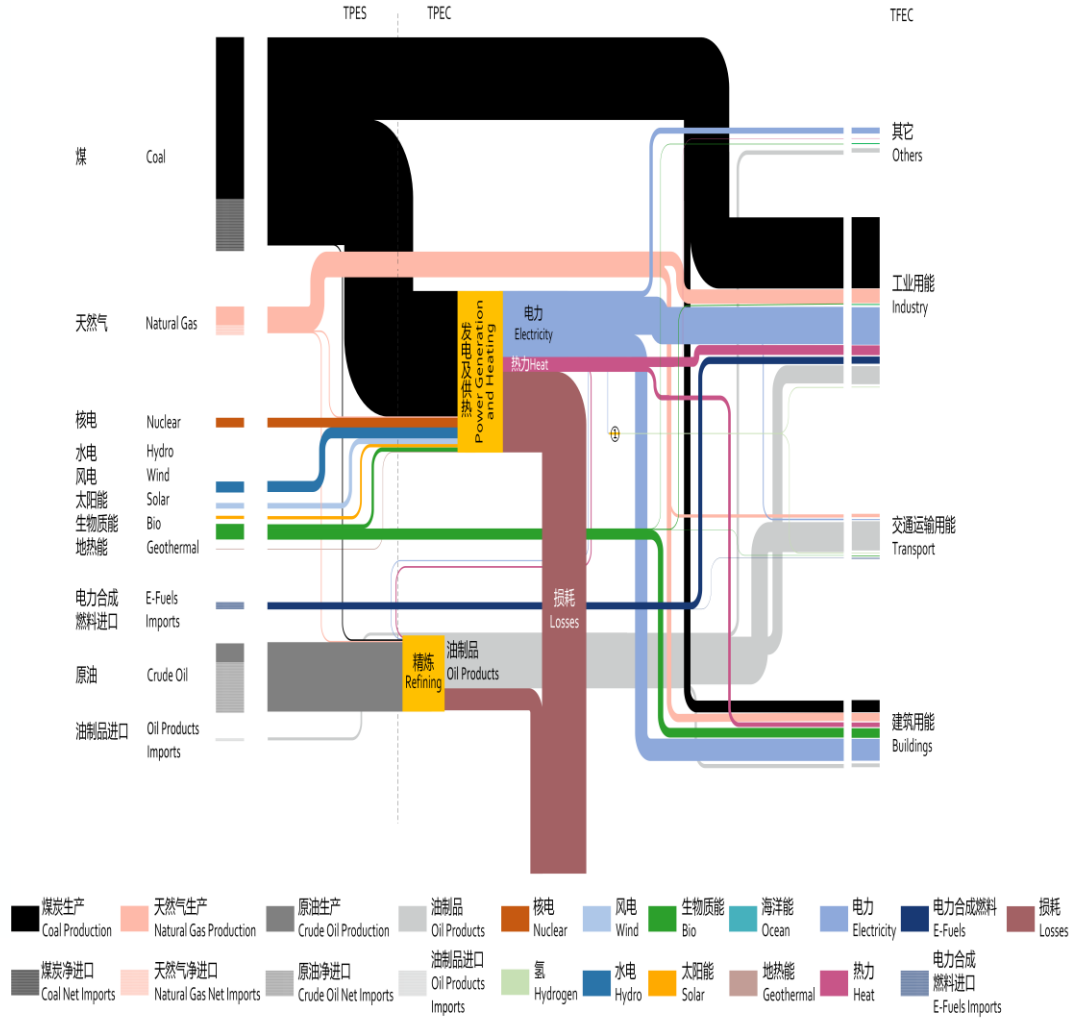
Non-fossil and renewable energies emerge as dominant sources: In CNS1/2, non-fossil energies account for over 50% of the primary energy demand by 2035; by 2060, this increases to 92% and 96% respectively. (heating-value basis)



# 2021年中国能流图

## Energy flow chart in 2021

2021年中国能流图 / 2021 China Energy Flow Chart (CETO 2023)



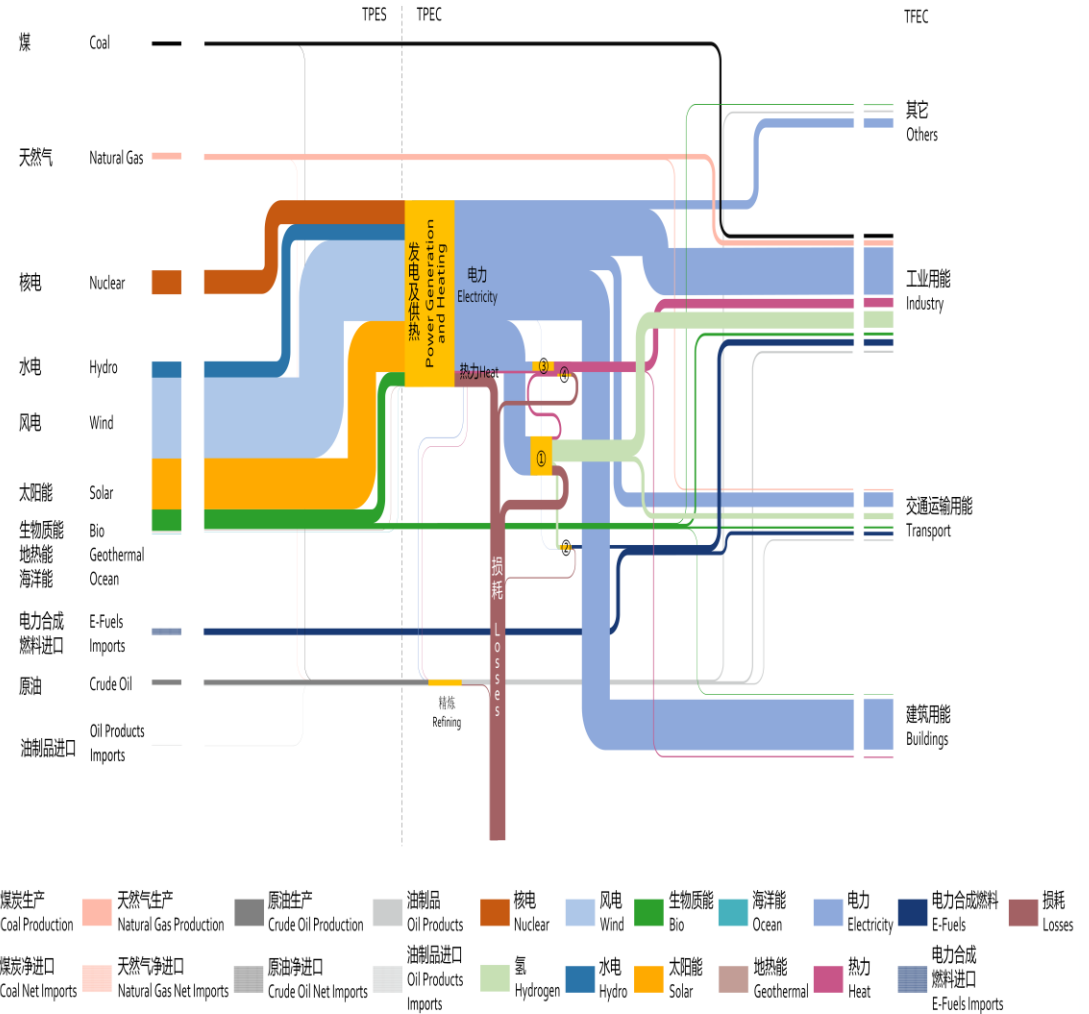
注: ①制氢 Hydrogen Production; ②制电力合成燃料 E-Fuels Production; ③电制热 Power to Heat; ④工业碳捕集 CO<sub>2</sub> Industry Capture

TPES: 一次能源供应量 (Total Primary Energy Supply); TPEC: 一次能源消费量 (Total Primary Energy Consumption); TFEC: 终端能源消费量 (Total Final Energy Consumption)

# 2060年中国能流图 (CNS2)

## Energy flow chart in 2060 (CNS2)

2060年中国能流图 / 2060 China Energy Flow Chart - CNS2 (CETO 2023)



注: ①制氢 Hydrogen Production; ②制电力合成燃料 E-Fuels Production; ③电制热 Power to Heat; ④工业碳捕集 CO<sub>2</sub> Industry Capture

TPES: 一次能源供应量 (Total Primary Energy Supply); TPEC: 一次能源消费量 (Total Primary Energy Consumption); TFEC: 终端能源消费量 (Total Final Energy Consumption)





Thank you for  
your attention 😊

