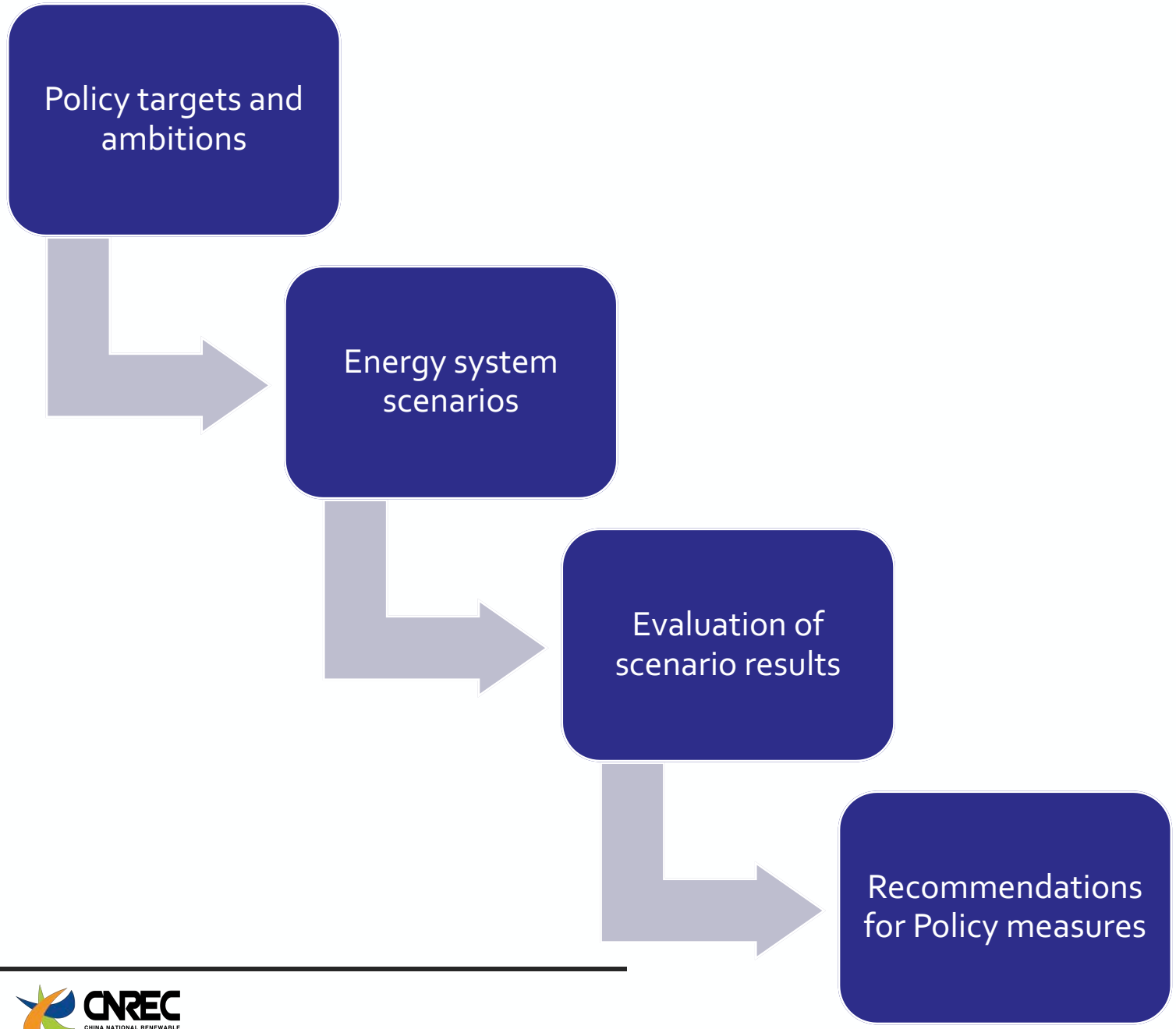
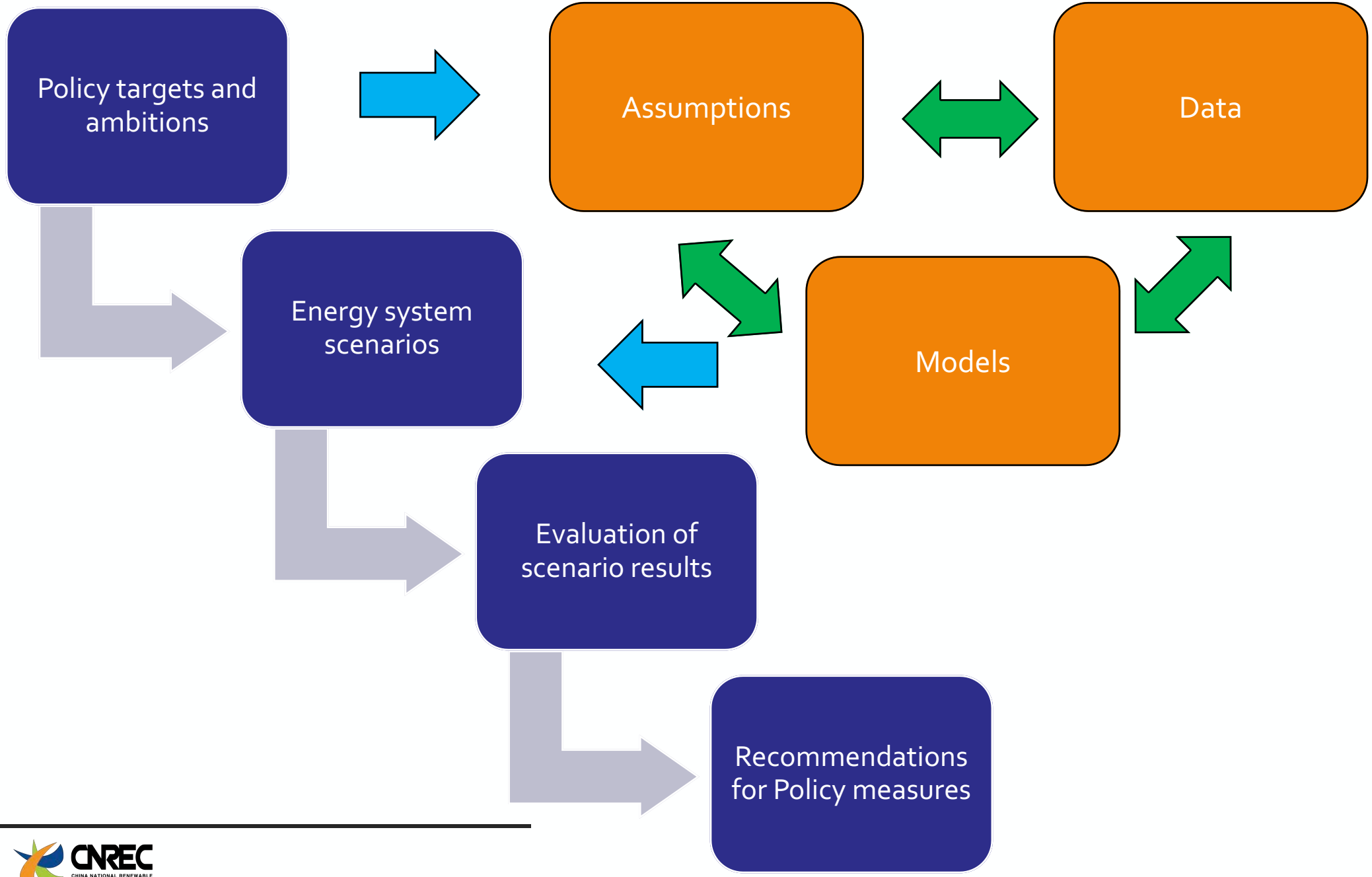
How scenarios can make policy targets concrete and actionable

Kaare Sandholt
Chief Expert, China National Renewable Energy Centre


Policy targets and ambitions
Energy system scenarios
Evaluation of scenario results
Recommendations for Policy measures


Policy targets and ambitions
Assumptions
Data
Energy system scenarios
Models
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THE STARTING POINT: CHINA'S LONG-TERM TARGETS FOR THE ENERGY TRANSITION

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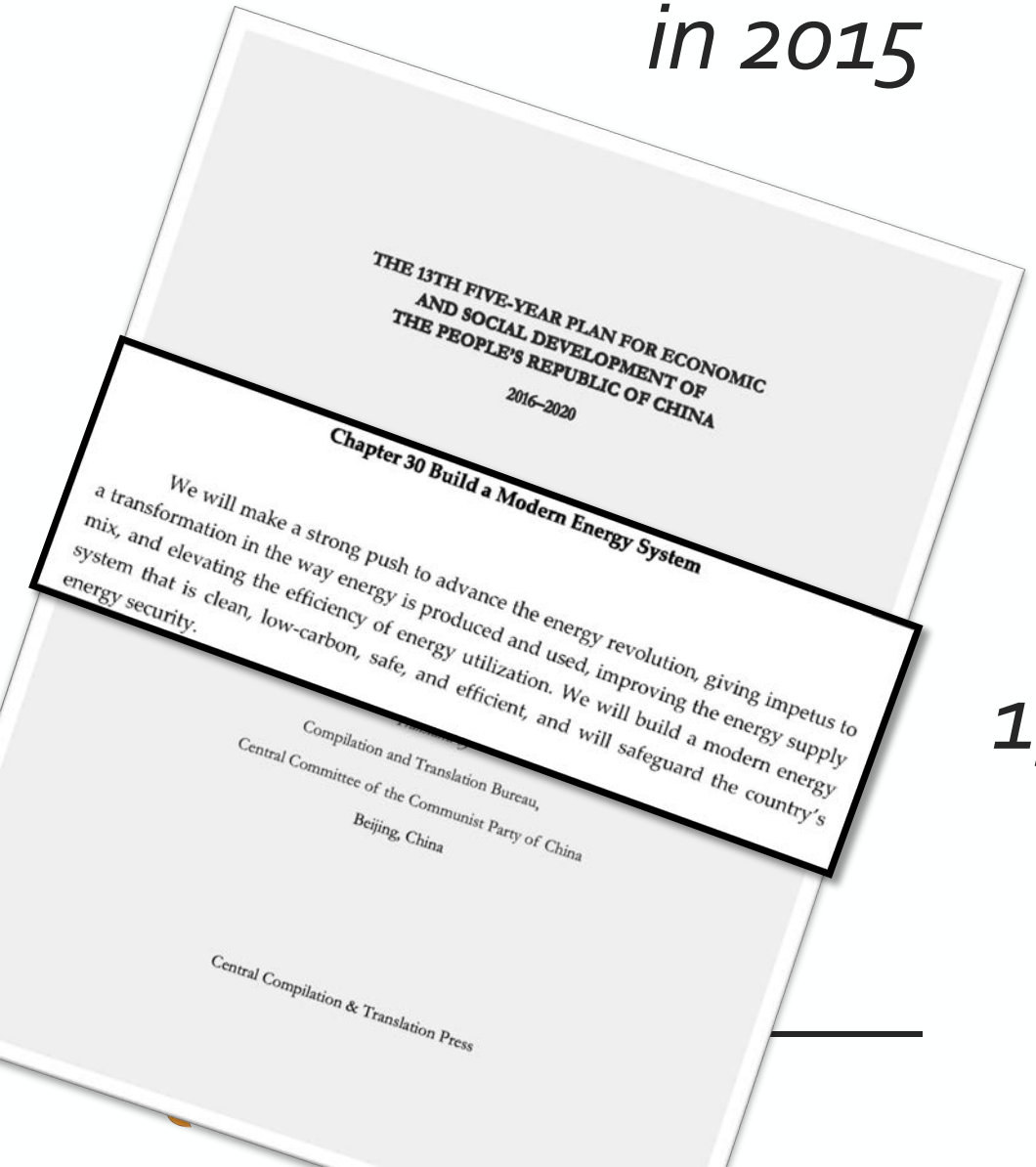
13th five-year plan in 2015


THE 13TH FIVE-YEAR PLAN FOR ECONOMIC
AND SOCIAL DEVELOPMENT OF
THE PEOPLE'S REPUBLIC OF CHINA
2016–2020

Chapter 30 Build a Modern Energy System

We will make a strong push to advance the energy revolution, giving impetus to a transformation in the way energy is produced and used, improving the energy supply mix, and elevating the efficiency of energy utilization. We will build a modern energy system that is clean, low-carbon, safe, and efficient, and will safeguard the country's energy security.

Compilation and Translation Bureau,
Central Committee of the Communist Party of China
Beijing, China

Central Compilation & Translation Press

- **Ambitious targets**: "We will build a modern energy system that is **clean**, **low-carbon**, **safe**, and **efficient**, and will safeguard the country's energy security".

19 Party Congress October 2017

CHINA RENEWABLE ENERGY OUTLOOK - METHODOLOGY

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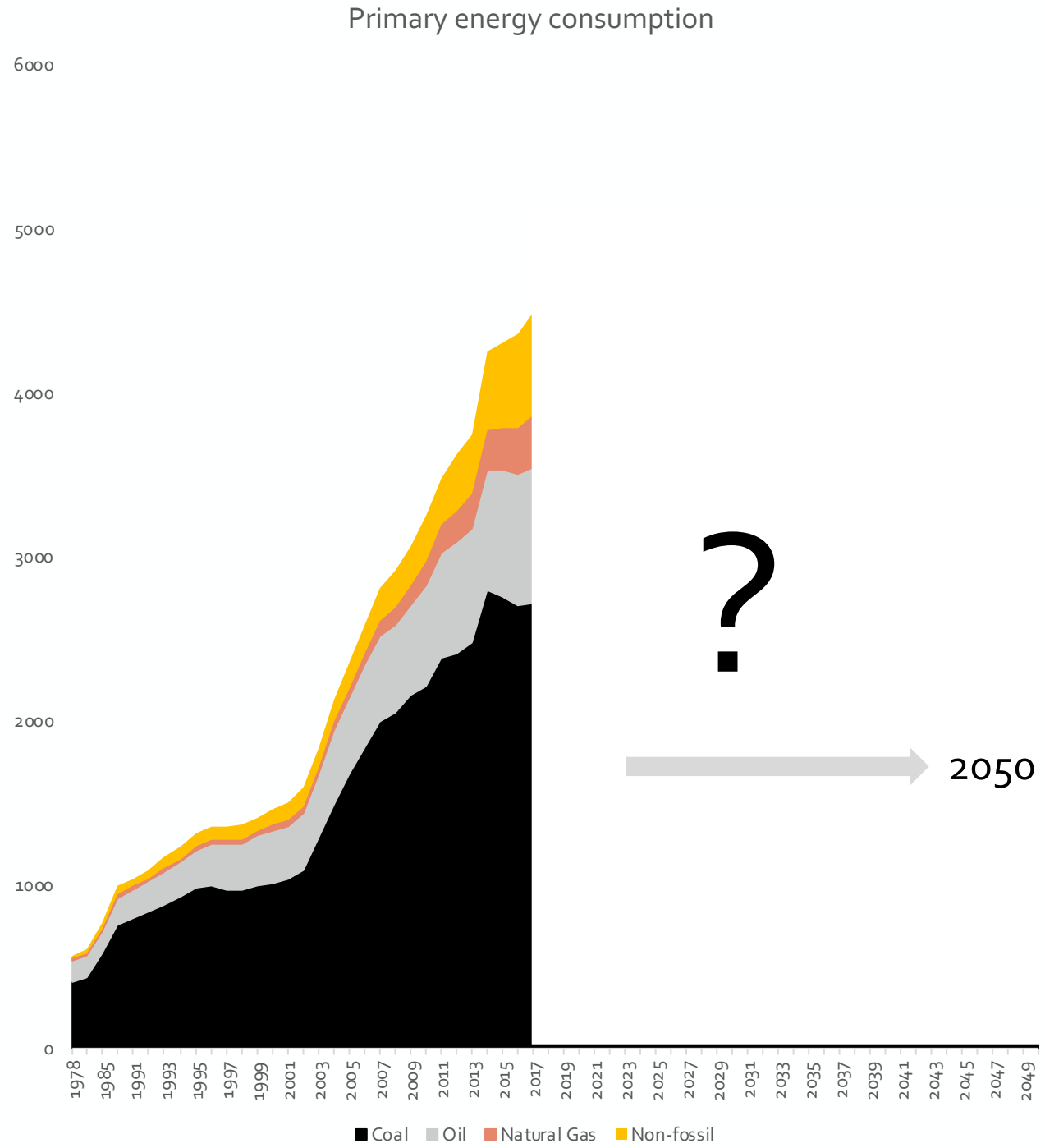
The big question: How should the energy system develop to comply with the ambitious targets for 2035 and 2050?



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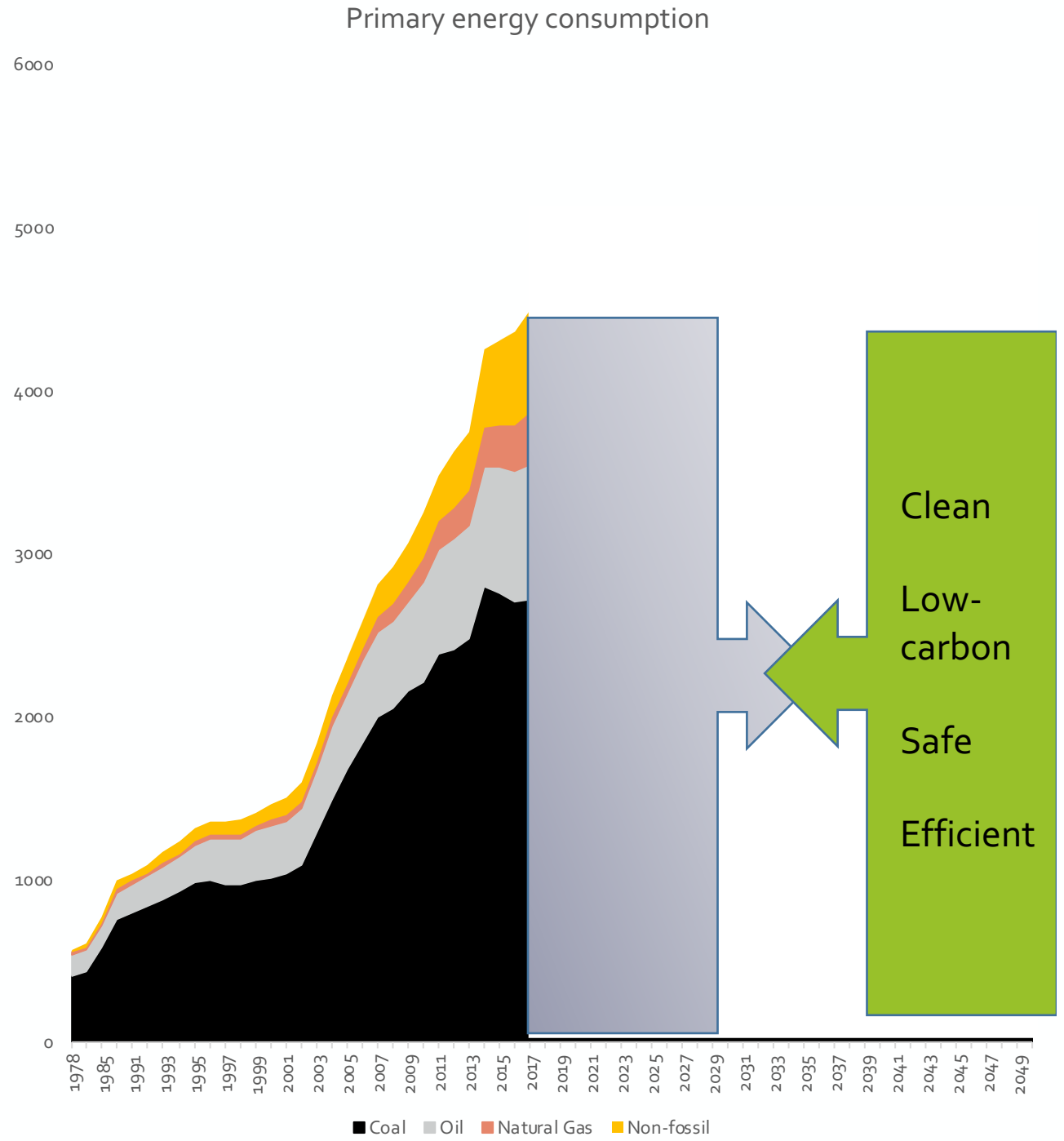
Our research methodology

- We start with the vision and the end-goal in 2050
- Then look at the necessary pathway from todays system
- Compare it with a development based on the current and stated policies influencing the energy system development
- Finally look at the additional needed policy measures



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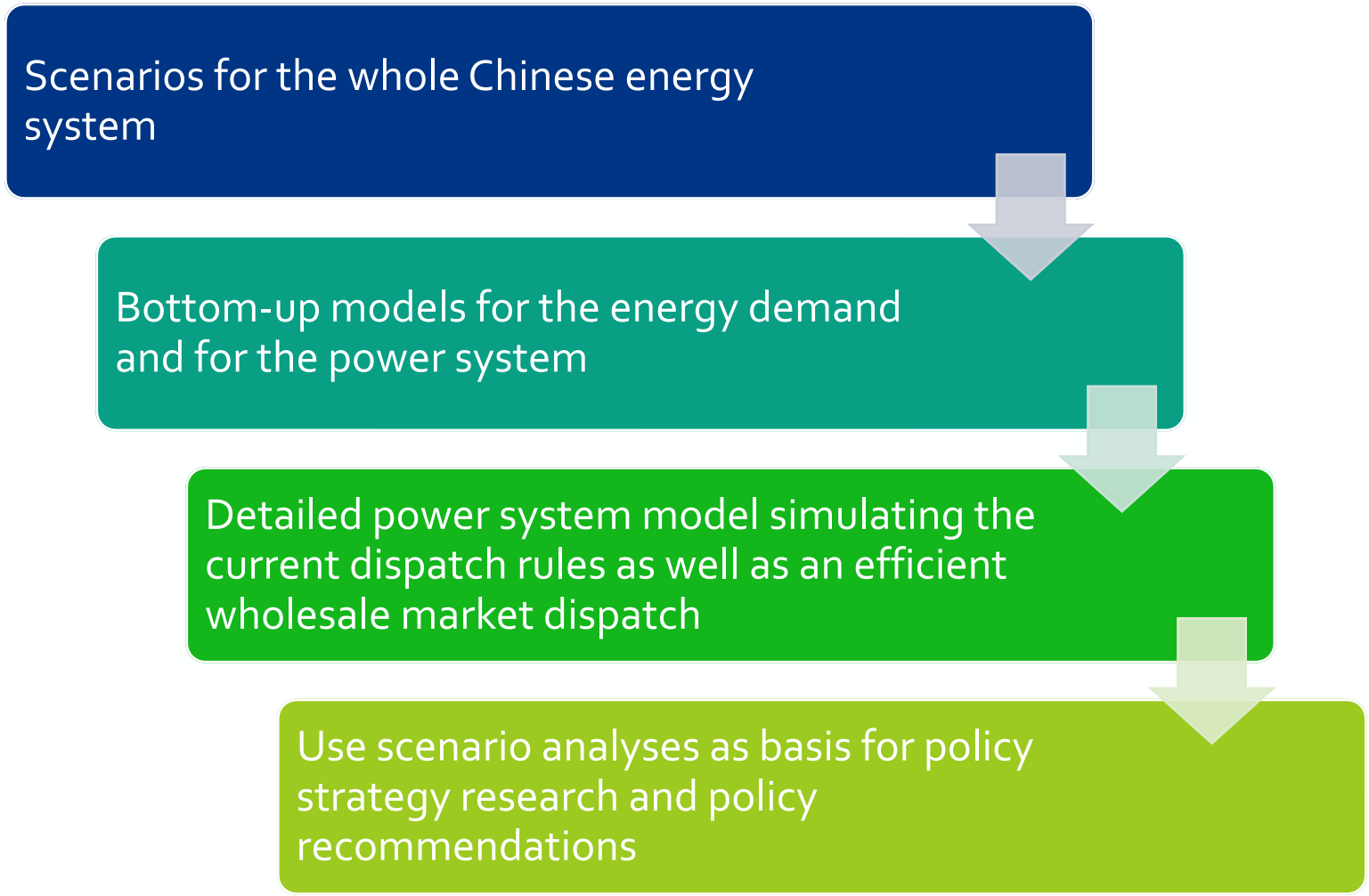
CREO approach

Two main scenarios in CREO

- **Stated Policies scenario**, estimating the energy system development based on current and stated policies
- **Below 2 °C scenario** with added restrictions on CO_2 emission to comply with the Paris agreement goals



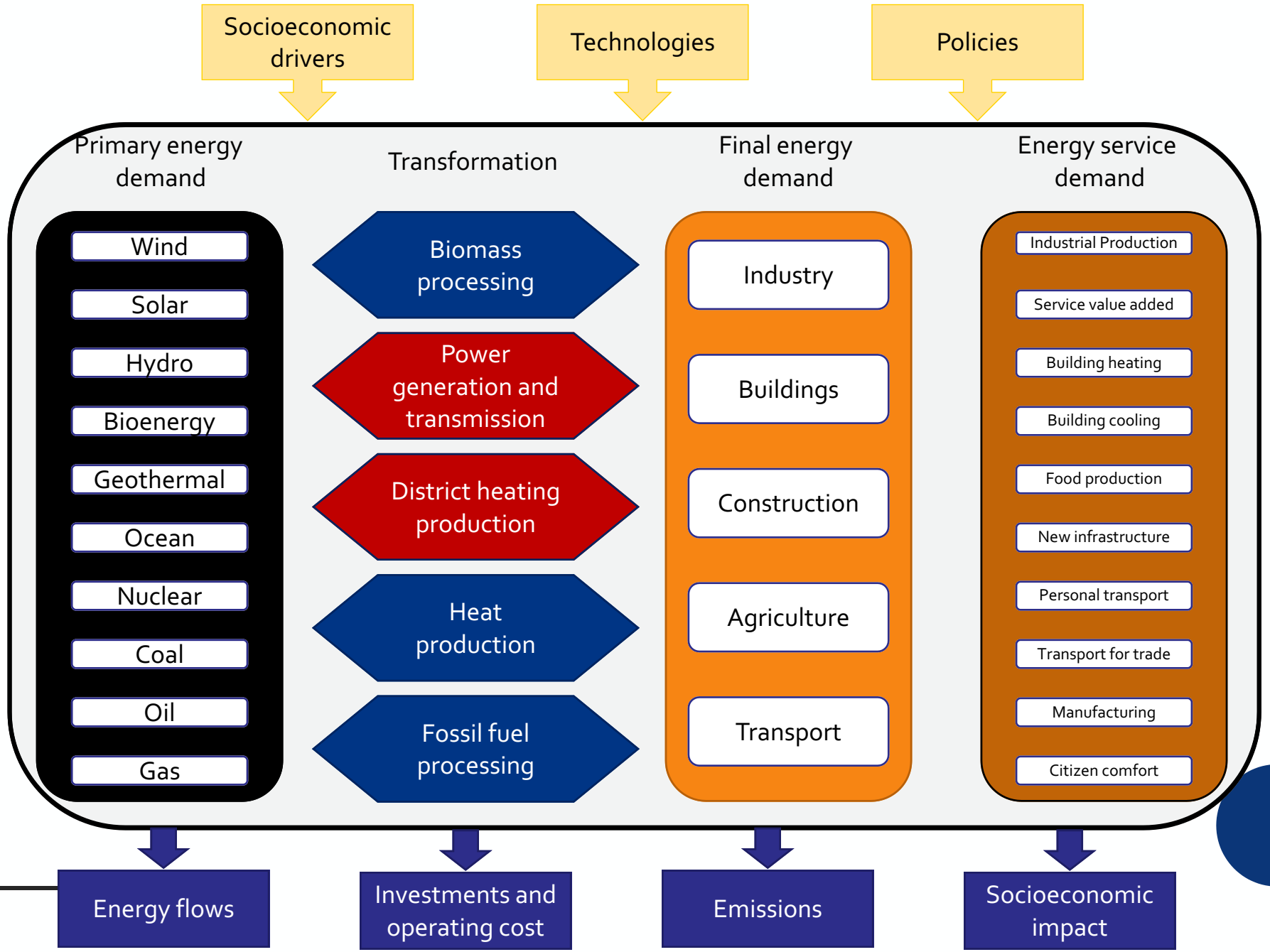
Energy system modelling

The scenarios are modelled in the CNREC modelling suite, covering energy supply, energy transformation and end-use sectors.

The production of power and district heating is modelled in the bottom-up, least-cost optimisation model **EDO** in order to reflect cost effective integration of variable energy production.

The end-use sectors and the other energy transformation is modelled in **END-USE** model based on the LEAP modelling tool and a bottom-up approach.

The socioeconomic impact of the transformation of the energy system is modelled in the **CGE** model – a computerised general equilibrium model with special focus on the energy and RE sector.



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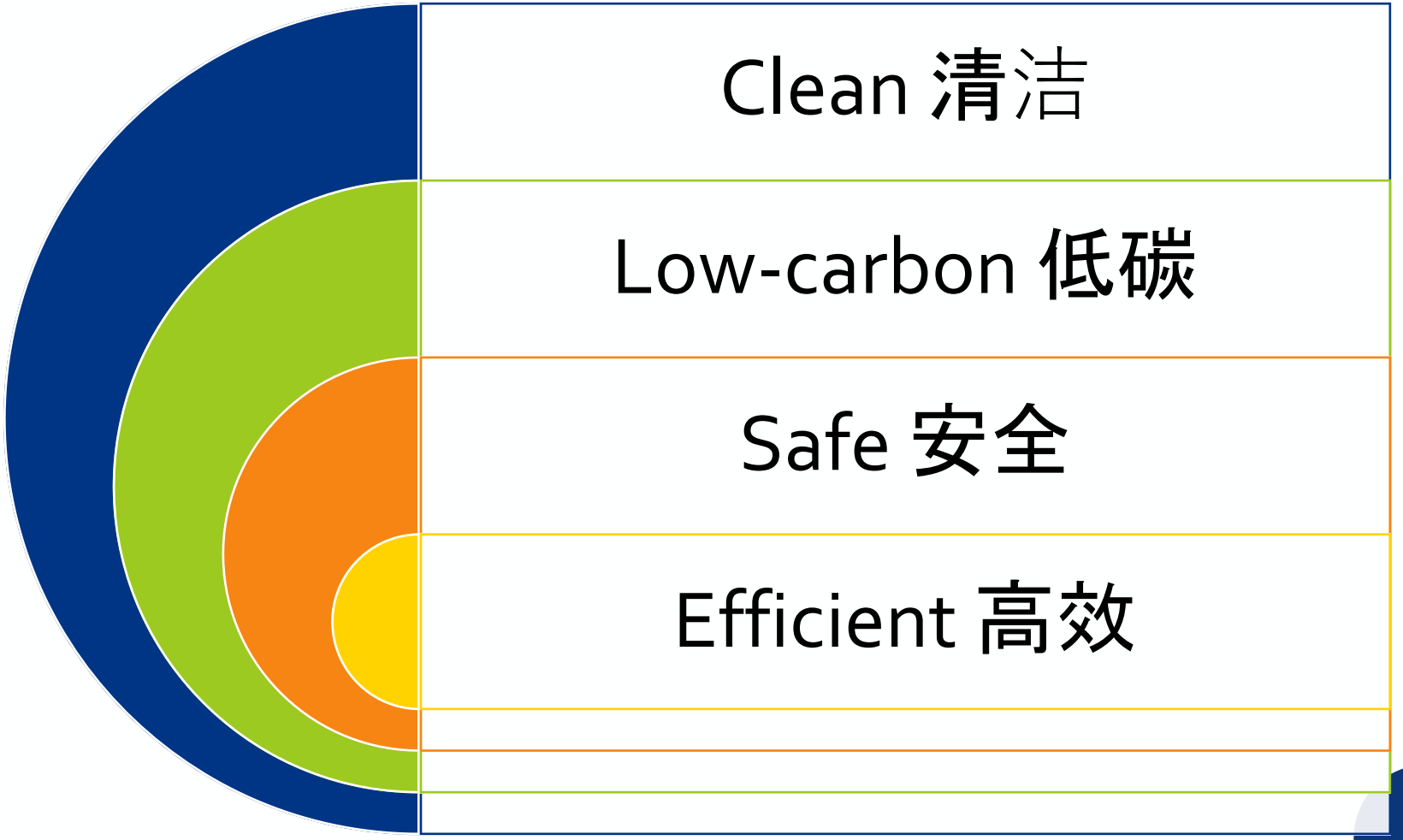
CREO 2018 results

THE 2050 ENERGY SYSTEM

2050



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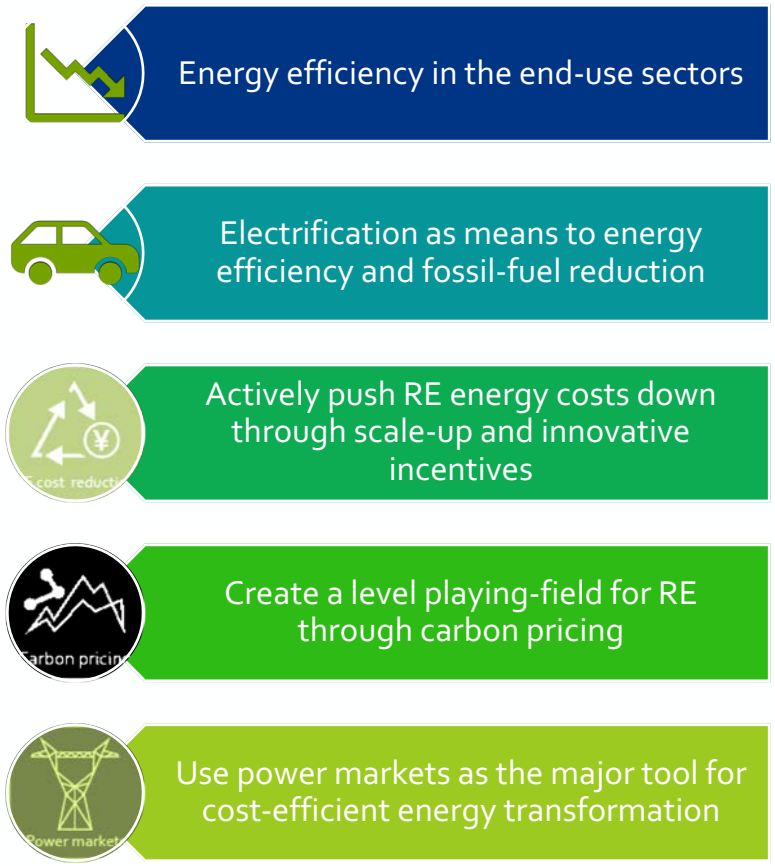
Principles for the energy system development



- Clean and low-carbon means the dependency of fossil fuels, in particular coal, is reduced as much as possible, and substituted by non-fossil fuels in all sectors
- Energy efficiency is obtained by
  - ambitious energy efficiency measures in the end-use sectors,
  - replacing thermal power plants with solar and wind,
  - electrifying the end-use sector, primarily the industry and transport sector.
  - Efficient deployment of distributed energy sources
- The economic efficiency of the energy system is ensured by efficient power market dispatch, and an incentive and taxation system, reflecting the direct and indirect costs of energy supply, including efficient costing of CO_2 emission and other external costs.

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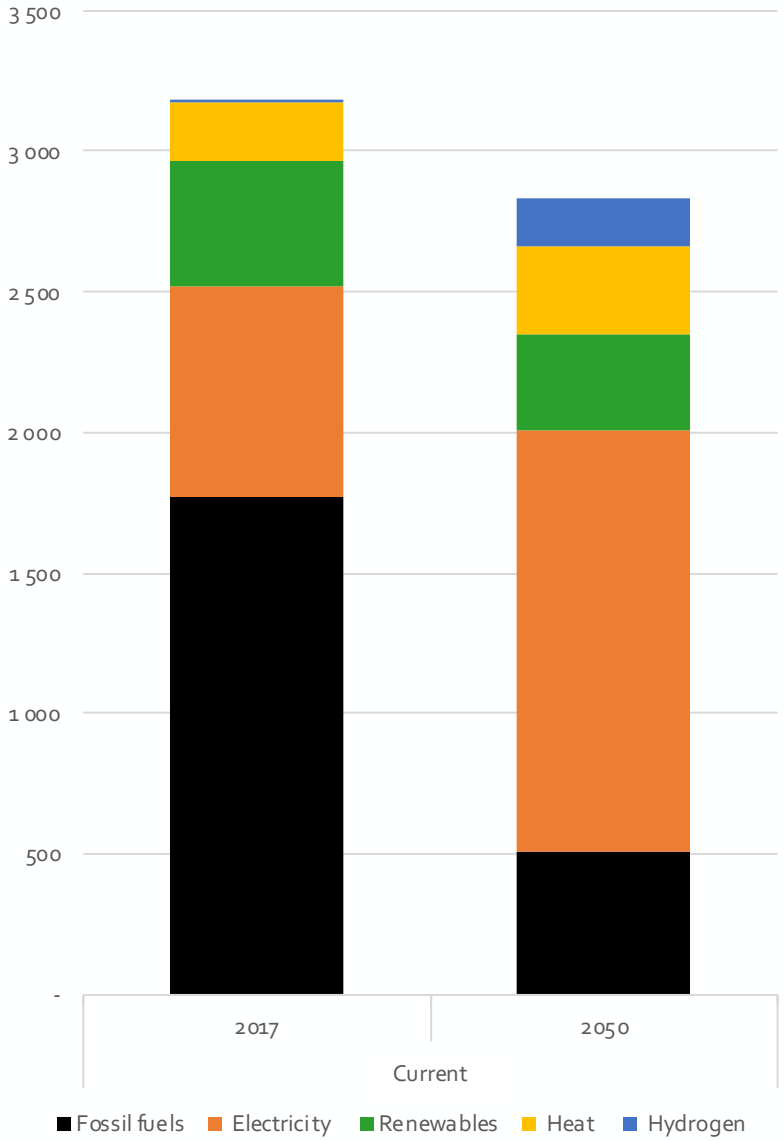
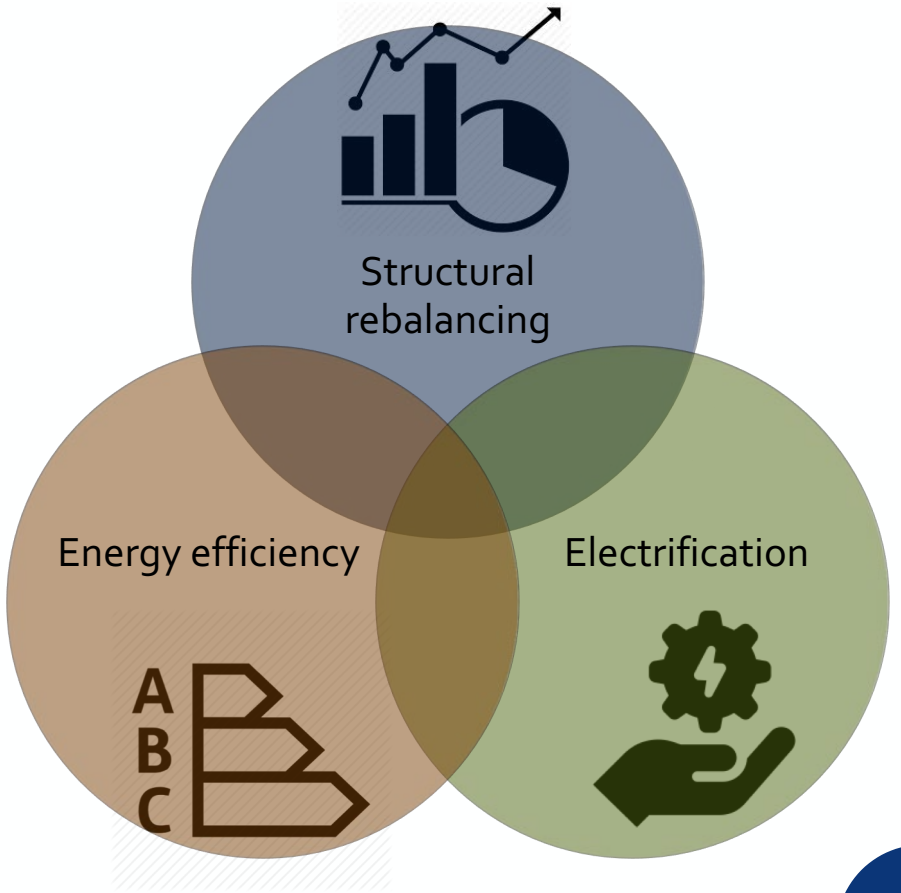
Final energy consumption

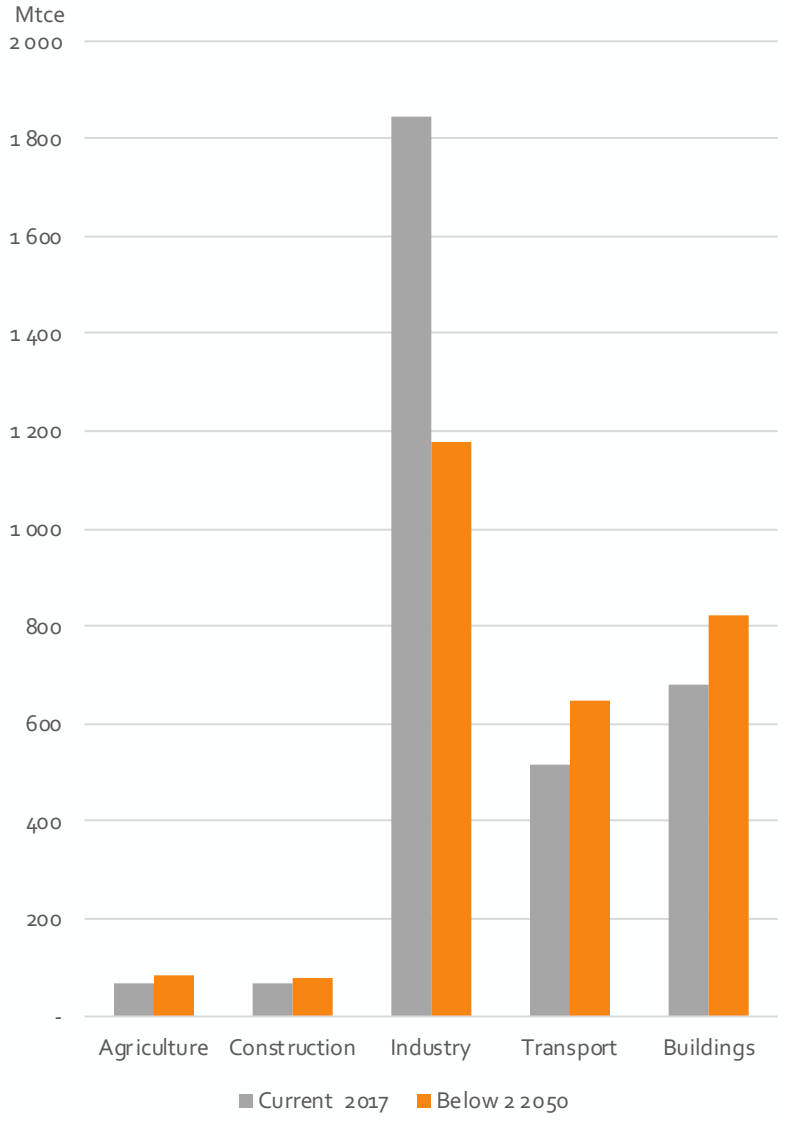
- The final energy consumption is lower in 2050 than in 2017 due to the economic transformation, energy efficiency measures and electrification of the end-use sectors
- The use of fossil fuels is less than one third in 2050 compared with today, while use of electricity is doubled
- Hydrogen is a new energy carrier in the end-use sectors in 2050

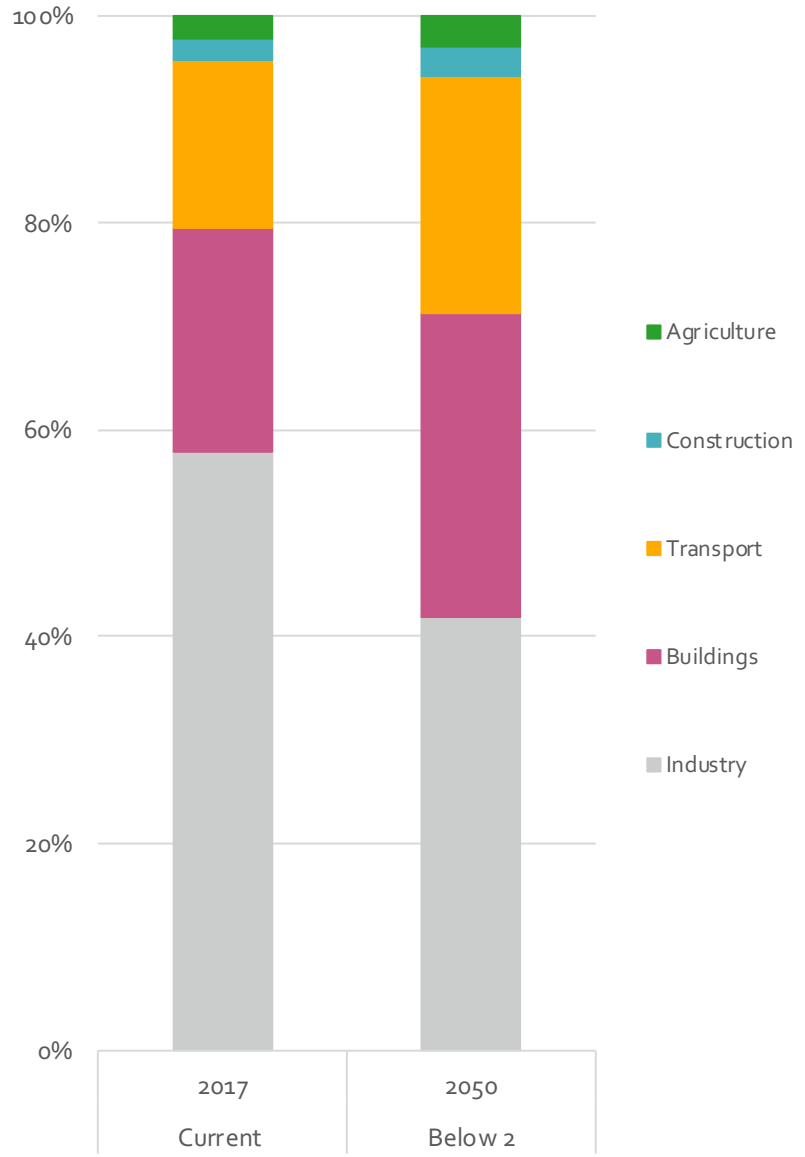




Final energy demand

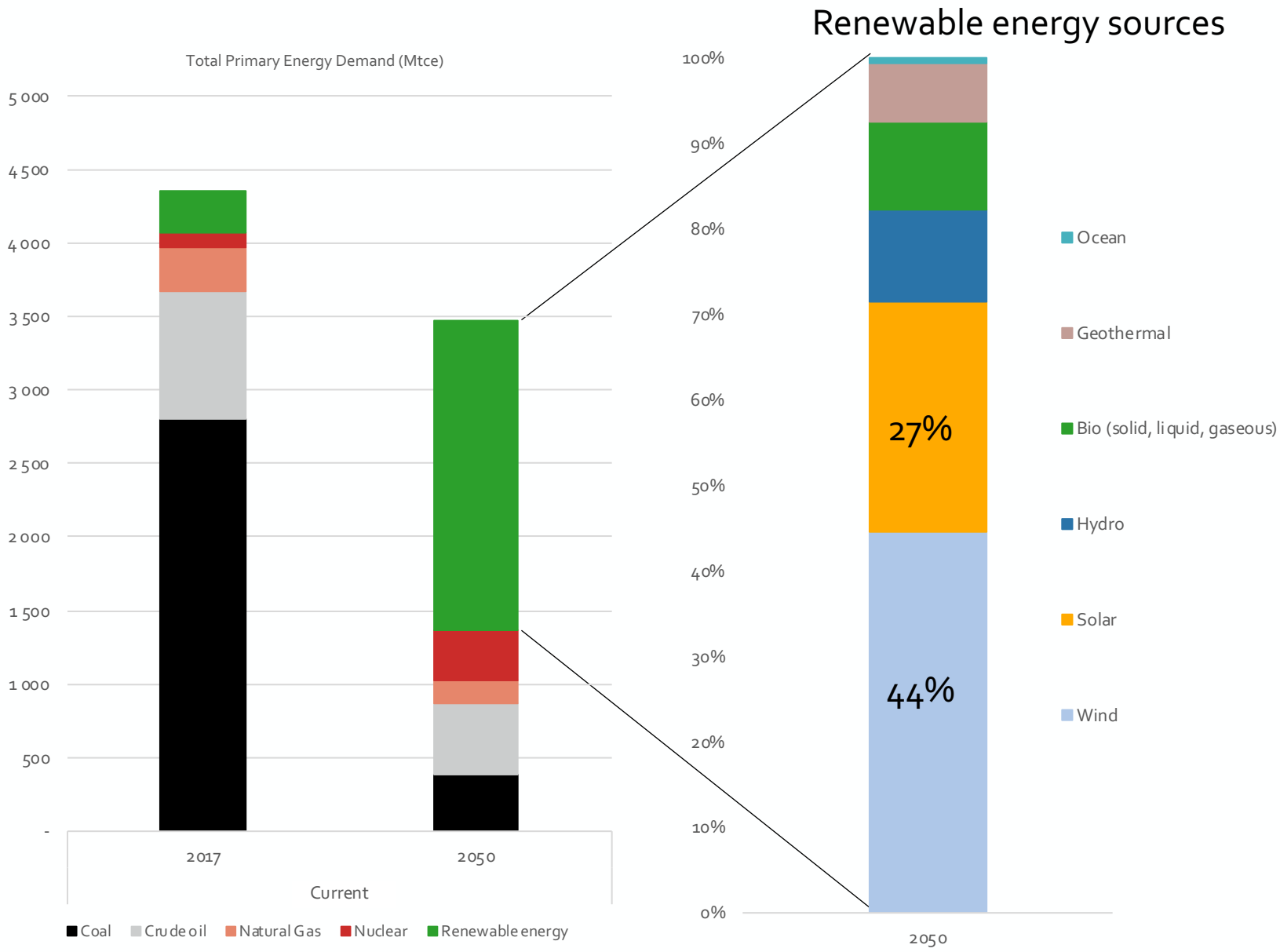
- Energy consumption in the industry is significantly lower in 2050 than today, while the other sector have a slightly higher consumption than today





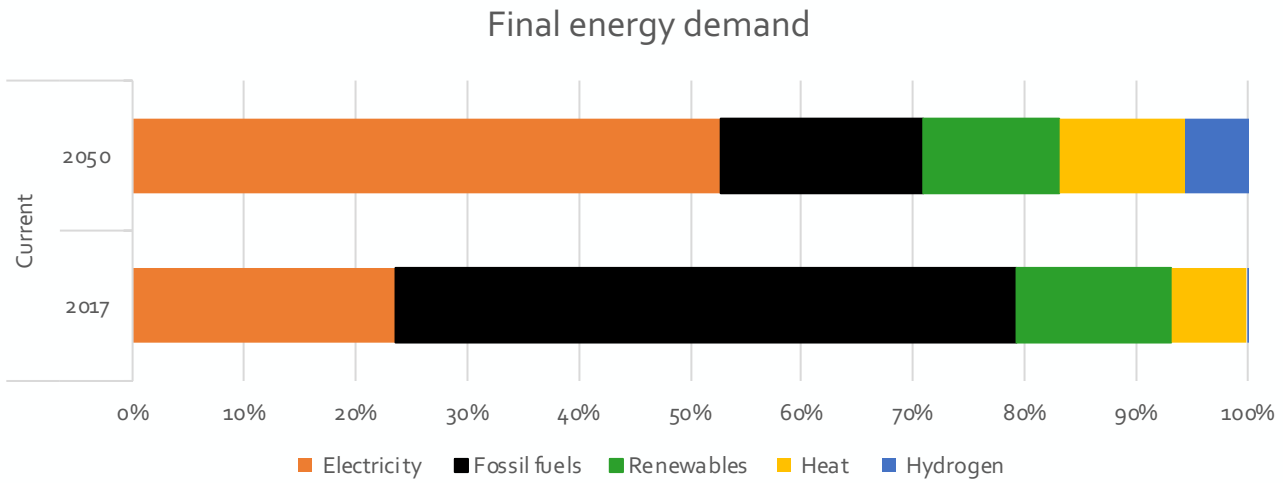
Shift from fossil fuels to renewables in the energy supply

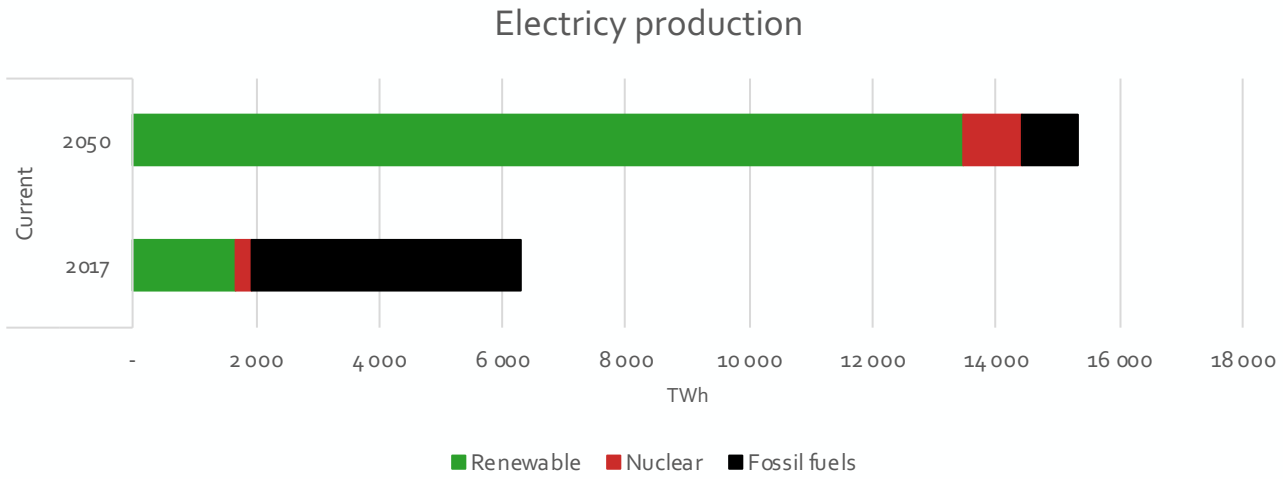
- The primary energy consumption is significantly lower in 2050 compared to 2017
- Renewable energy is the back-bone of the energy system in 2050, while coal has a minor role
- Also natural gas has a marginal role in the long-term energy system, since it is more expensive than renewable energy
- Wind (44% of RE supply) and solar (27% of RE supply) dominate the renewable energy supply



Electricity supply

- The energy system is electrified in 2050, shifting from coal to electricity. In 2050 electricity covers 53% of the total final demand in 2050 compared to 24% in 2017
- Hence, the electricity production is more than doubled from 2017 to 2050
- Renewable energy is dominant in the electricity production in 2050, replacing coal as the primary fuel





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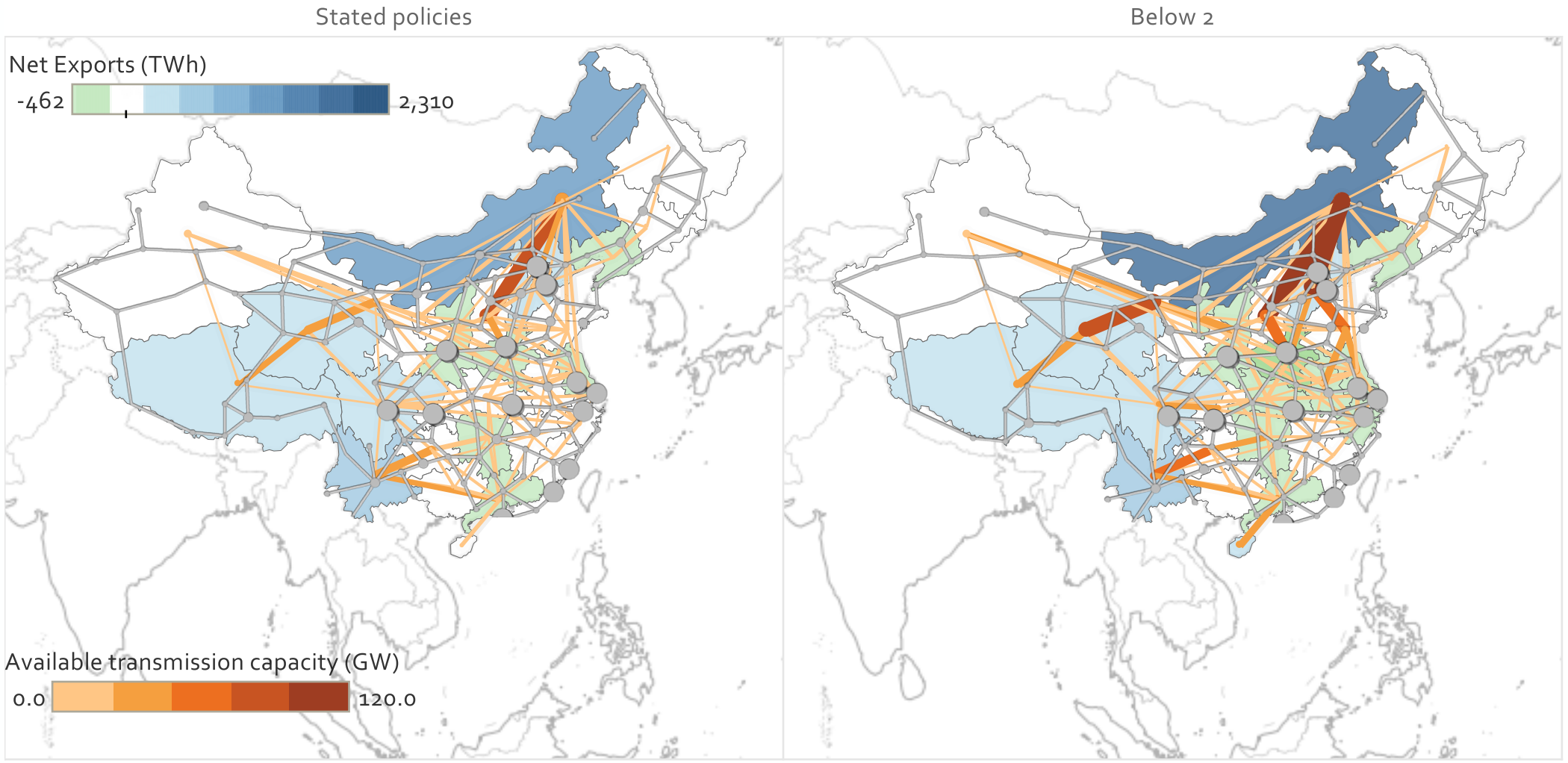
The power grid essential as integrator and distributer of RE in 2050



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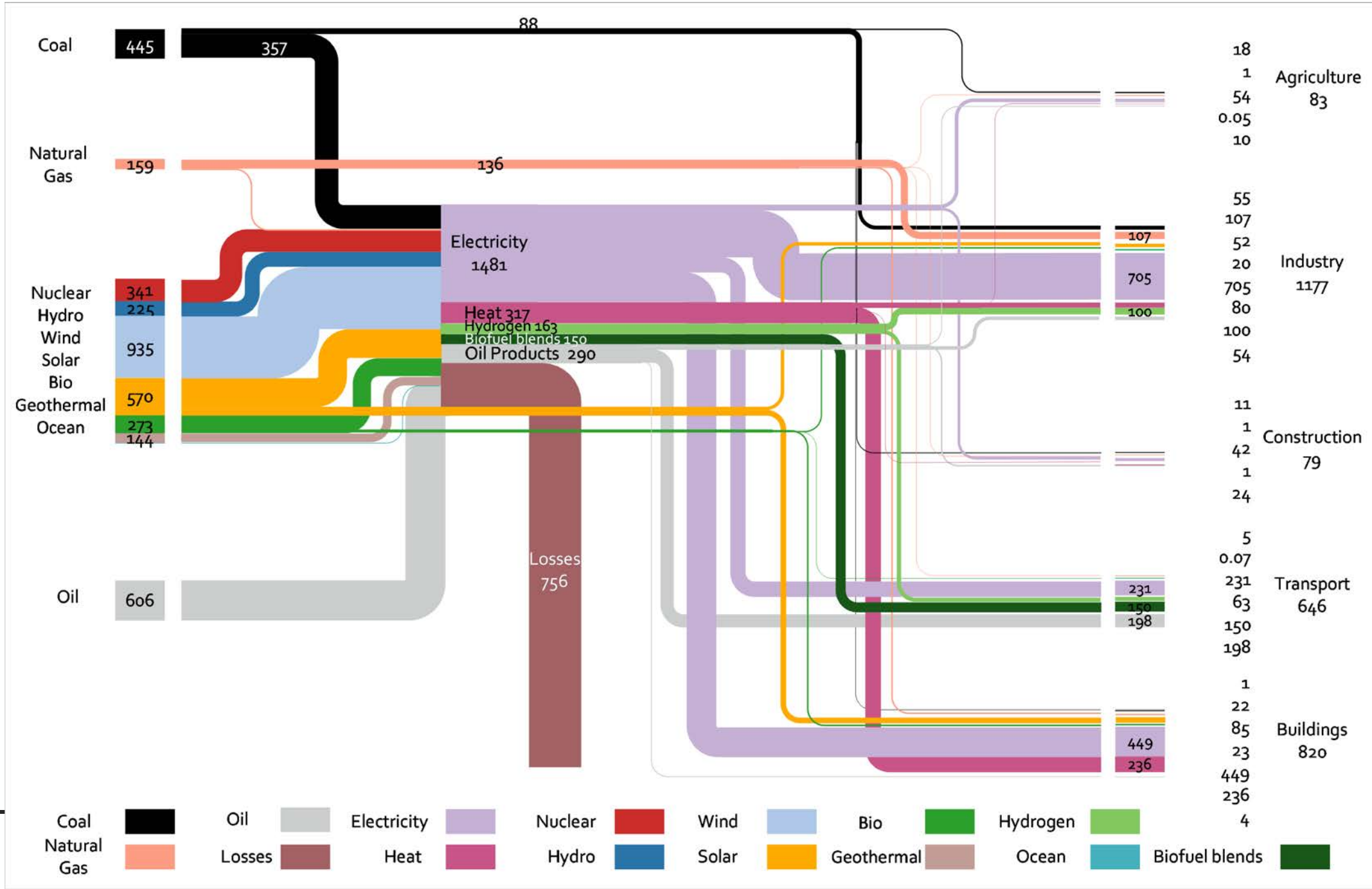
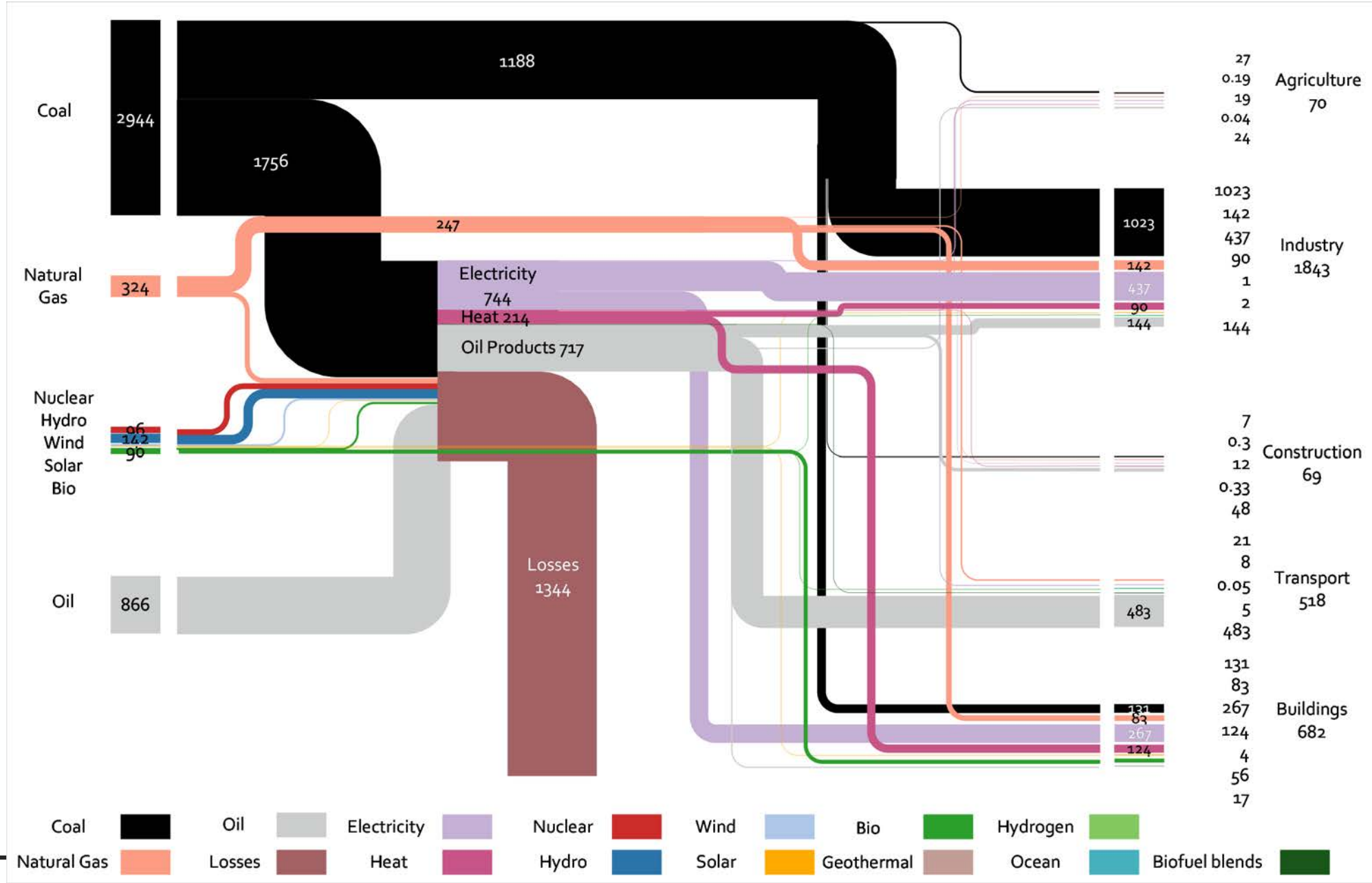
China's energy balance (Mtce) in 2050 in the Below 2 °C scenario



2017 Energy flow

- Dominated by fossil fuels
- Coal consumption in power sector and industry sector
- Big losses in energy transformation, especially in the power sector
- Oil dominates in the transport sector



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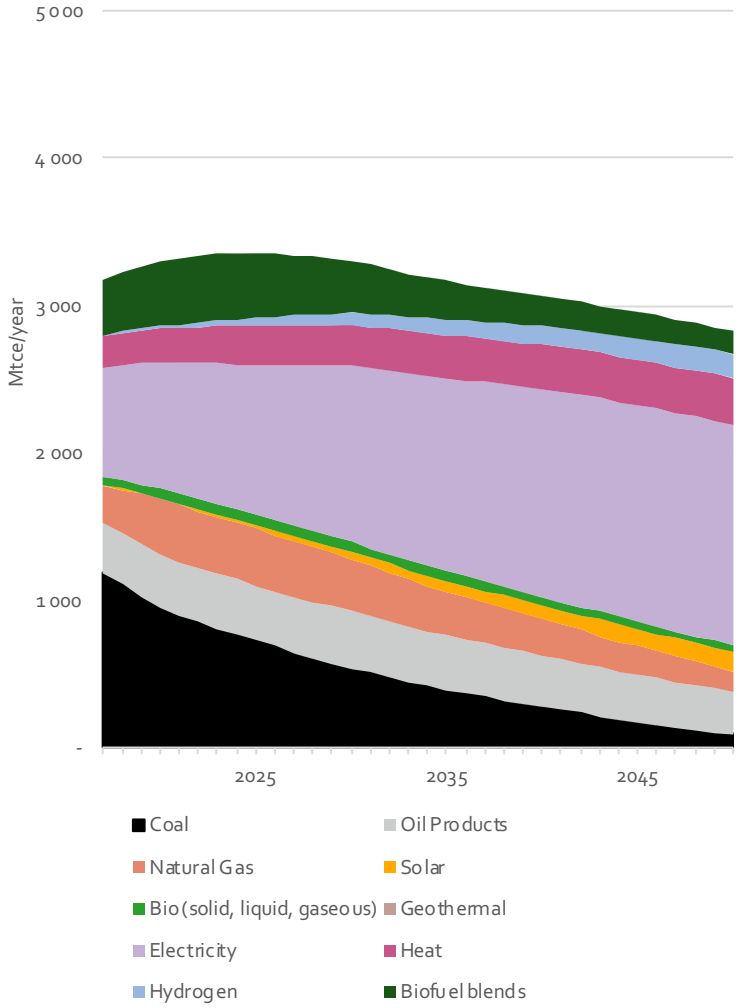
CREO 2018 results

THE ENERGY SYSTEM DEVELOPMENT TOWARDS 2050

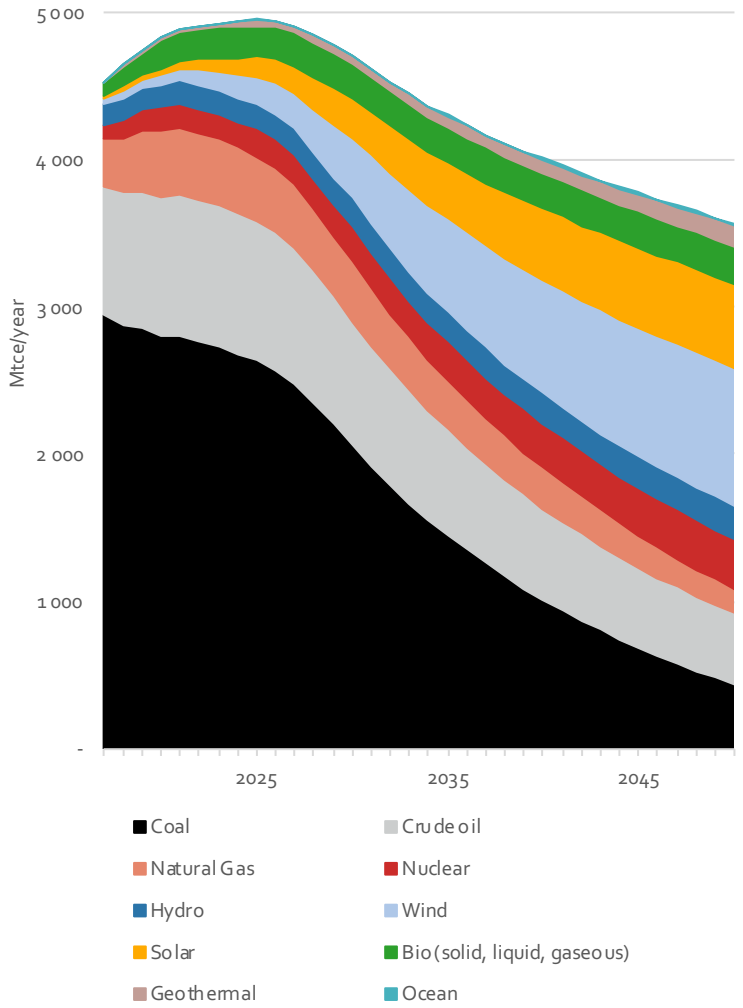
Development in final and primary energy consumption in the Below 2 °C scenario

- Quick shift from coal to electricity in the end-use sector
- In the power sector coal consumption is significantly reduced, solar and wind power production increased

Total Final Energy Demand 2017 - 2050



Total Primary Energy Demand 2017 - 2050



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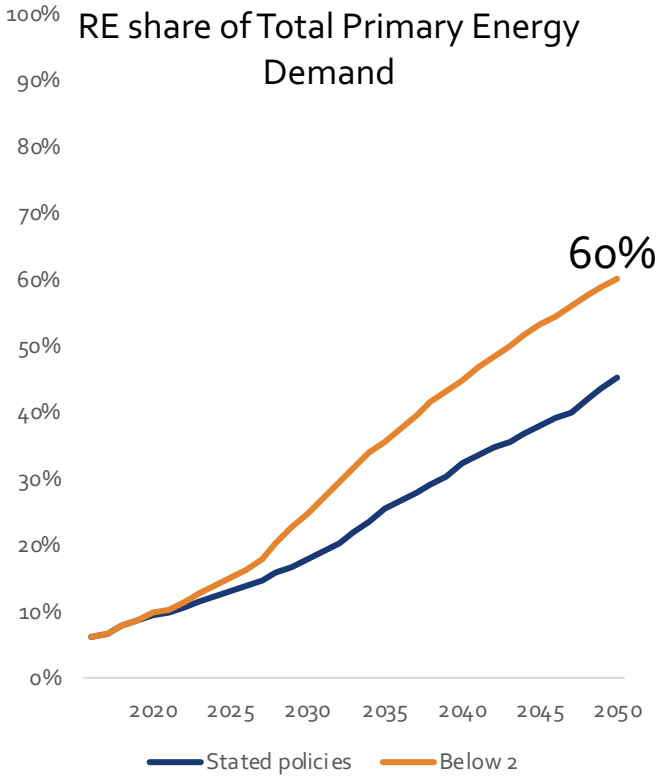
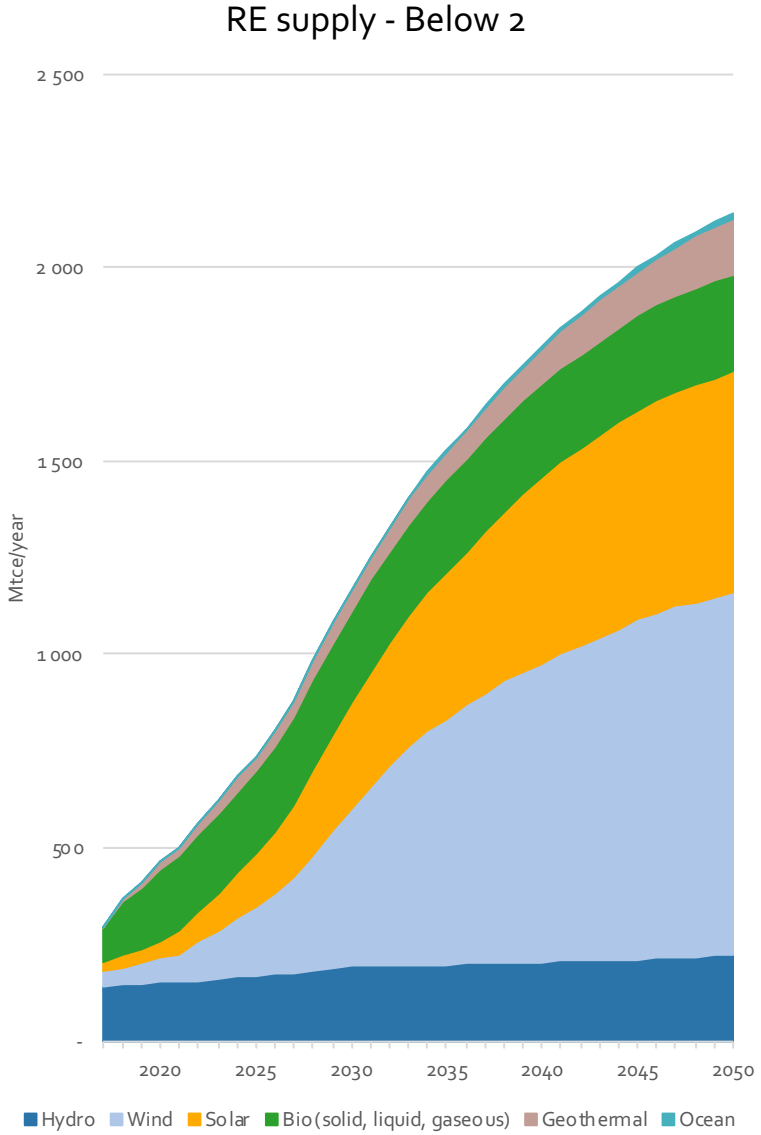
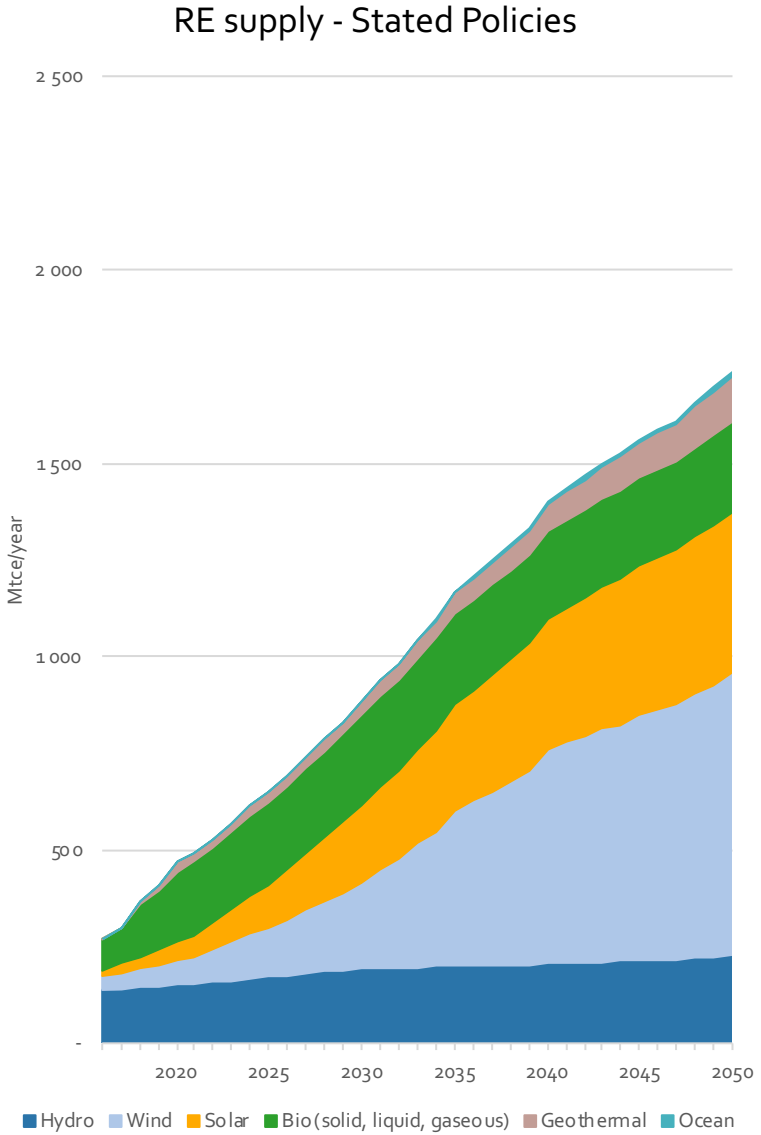
The Below 2 °C scenario in comparison with the Stated Policies scenario

Compared to the Stated Policies scenario, the below 2 scenario have more renewable energy and less use of fossil fuels to comply with the tighter CO_2 emission targets

RE becomes the energy system back-bone







CREO 2018 results

EVALUATION OF THE ENERGY SYSTEM IN THE BELOW 2 °C SCENARIO IN 2050

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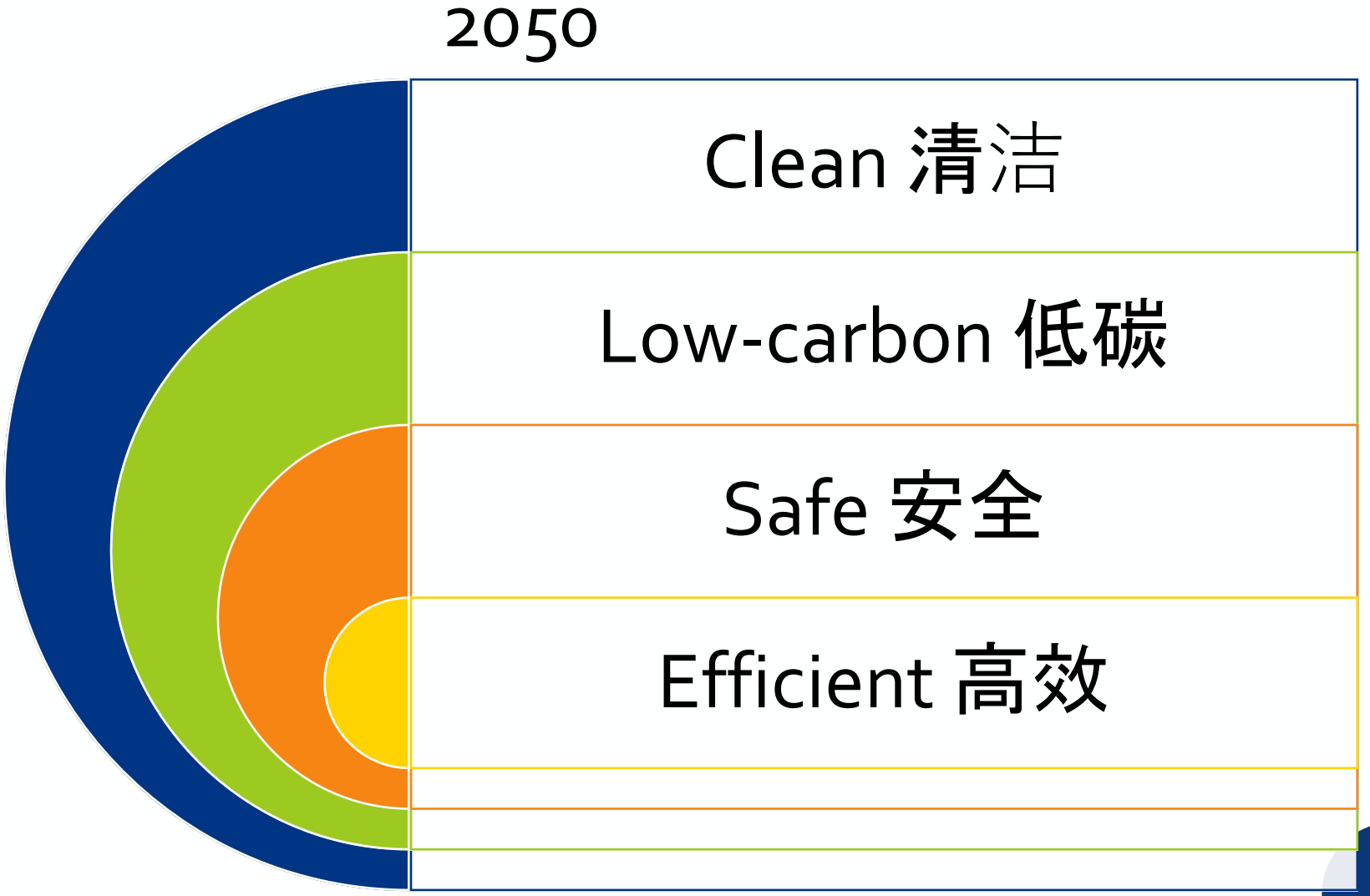
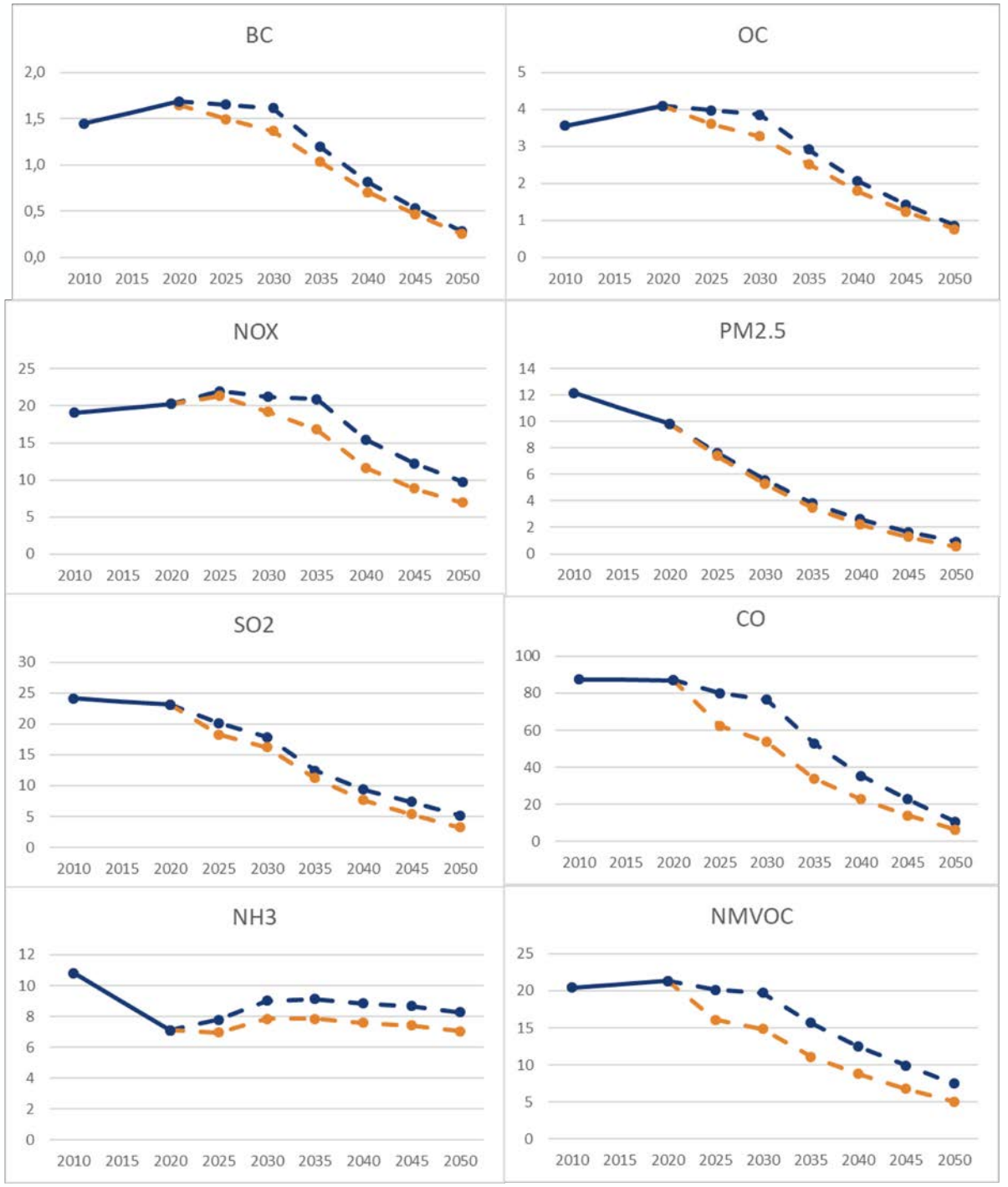
How does the 2050 energy system perform on the key targets?



Clean energy system I: Air pollution

Both scenarios will significantly reduce the air pollution from the energy sector by 2050.

However, the Below 2 °C scenario gives a more clear air in the 2030s compared to the Stated Policies scenario



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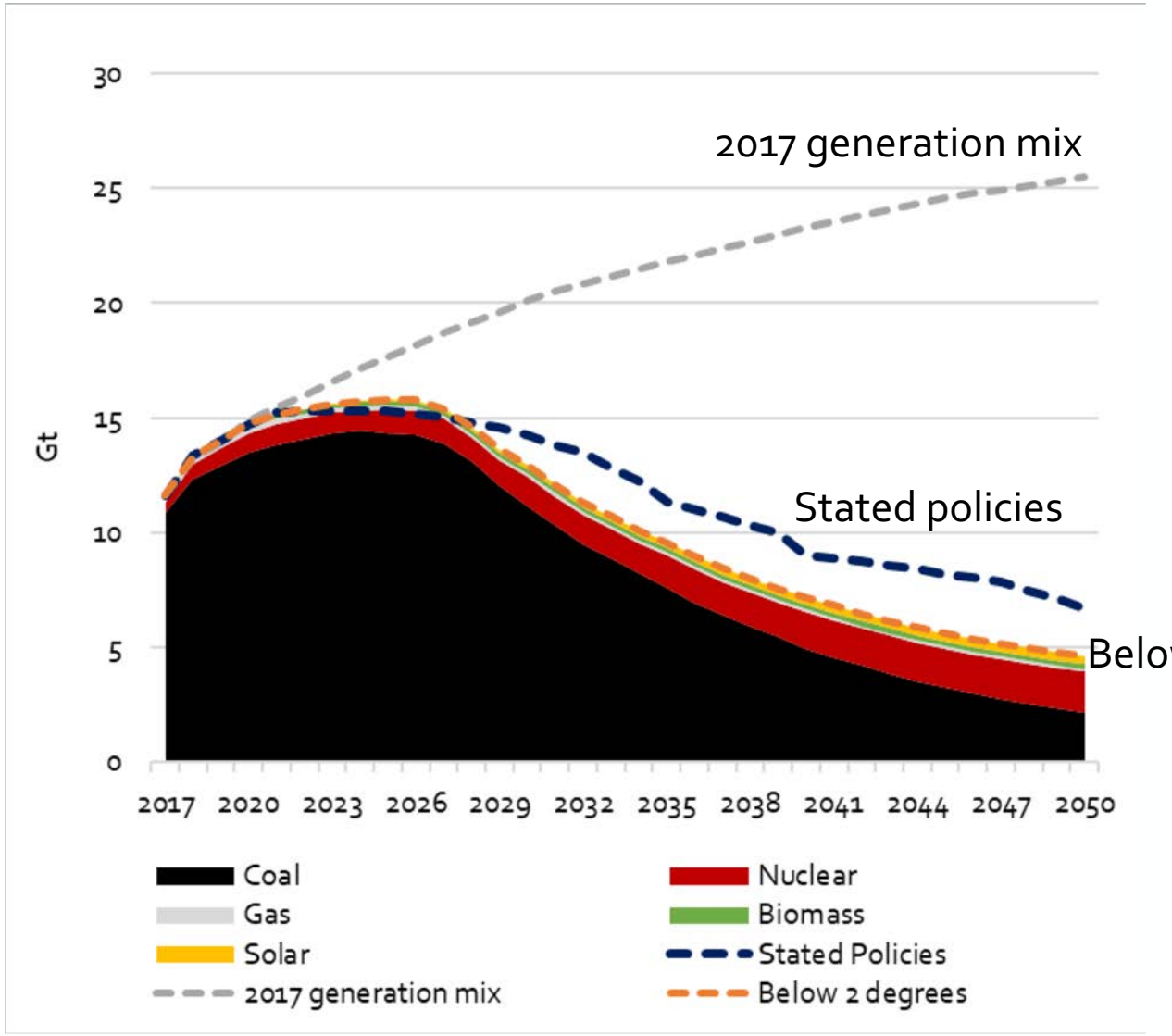
Clean energy system II: Water consumption

- In both scenarios, total water consumption for energy falls despite a doubling of power production.



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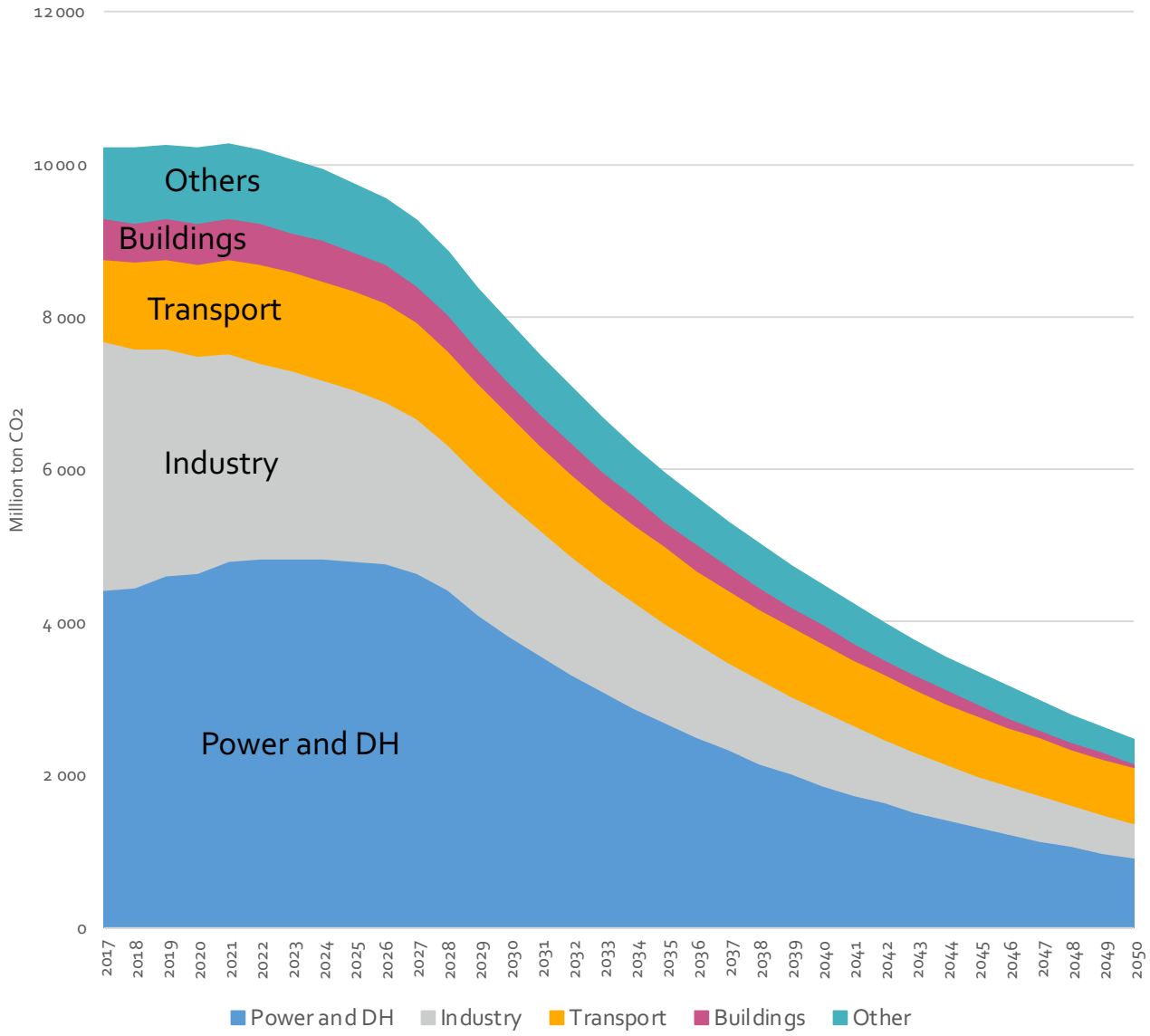
Low-carbon: Development in CO2 emission

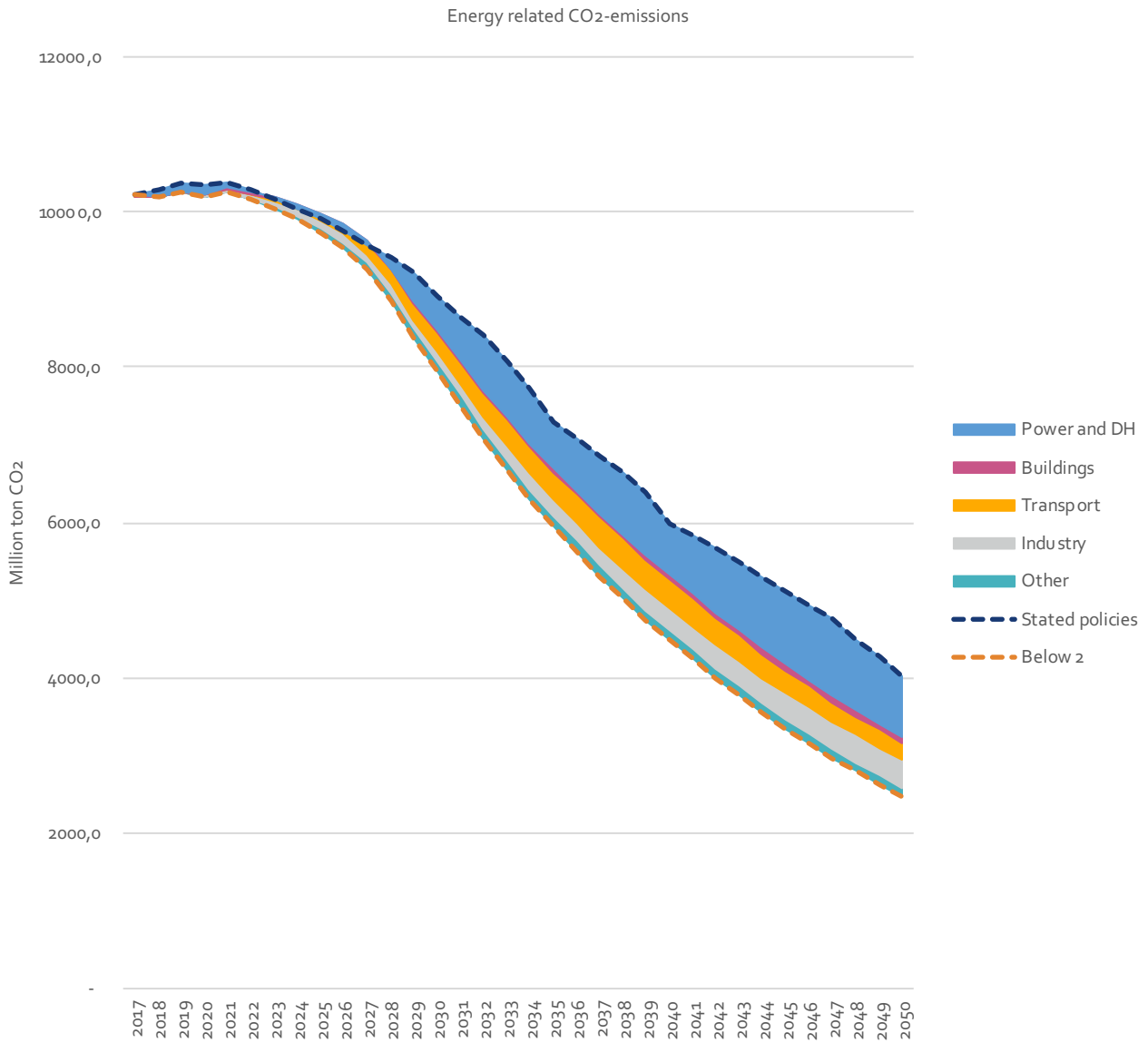
The CO2 emission from the energy system is reduced to one third of the emission in 2017 in the Below 2 °C scenario

Today the main emission is from power and industry. In 2050 the emission is more diverse, with the power and transport sectors as main emitters



The Stated Policies scenario do not comply with the low-carbon cap

The Stated Policies scenario has higher CO_2 emissions than the Below 2 °C scenario from 2020 and forward. It is mainly the power sector that has a higher emission, and to a minor degree the transport and the industry sectors



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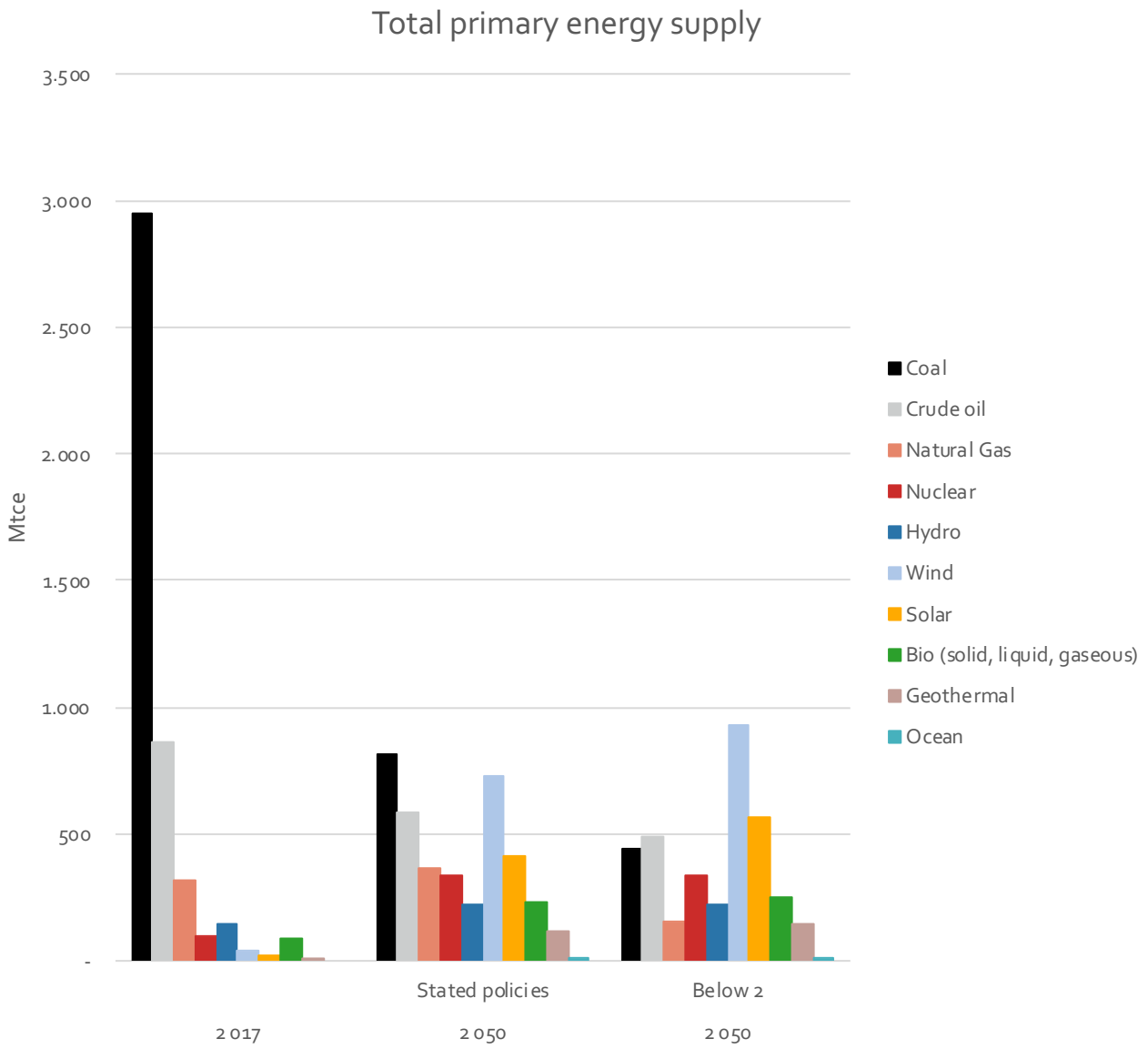
Safe energy system I: Diversity

- The energy supply is much more diversified in 2050 than today in both scenarios
- No fuel dominates the supply in 2050



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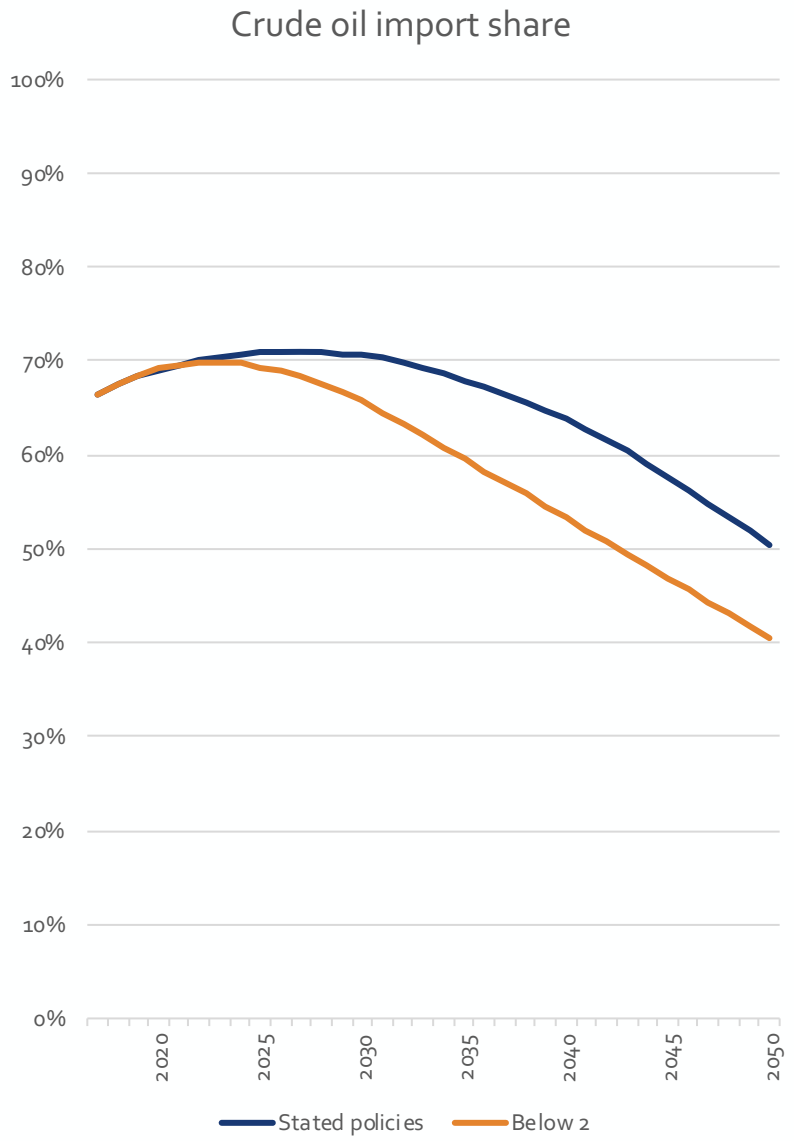
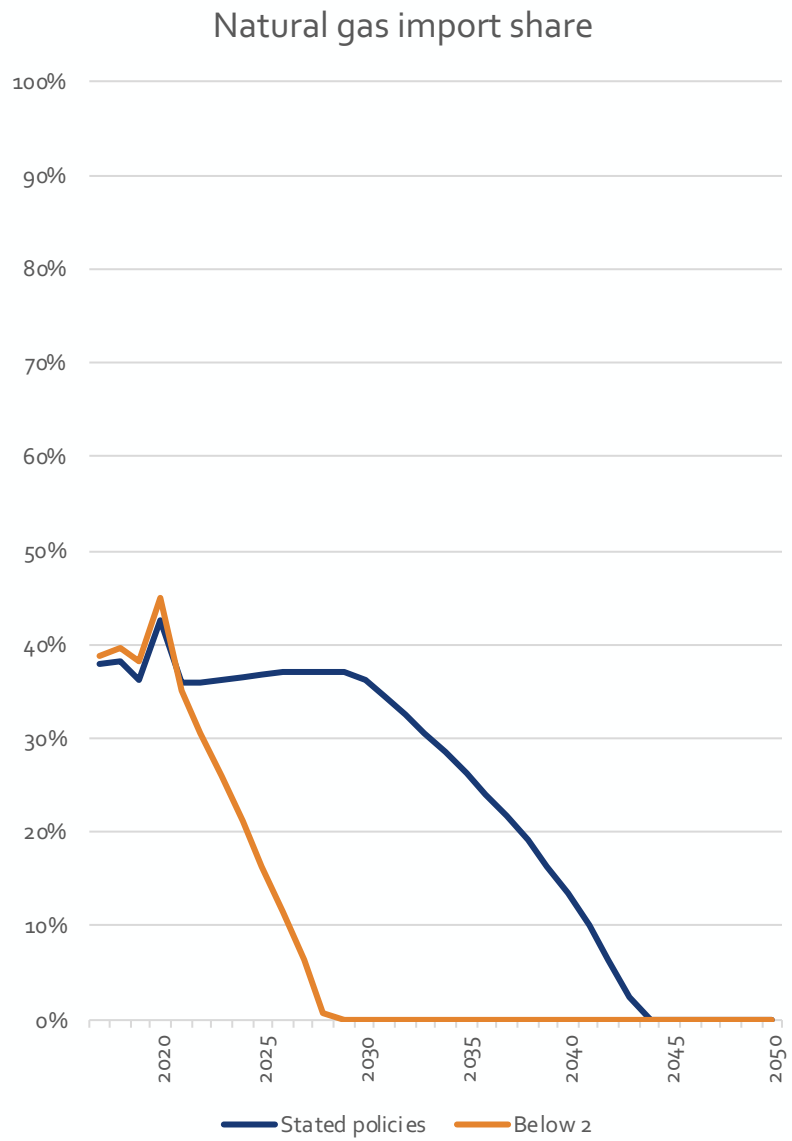
Safe energy system II: Import share

- The severe dependency of oil will gradually be reduced in both scenarios, most significant in the Below 2 scenario. China will, however, continue to be dependent on import of oil for the whole period
- Natural gas import dependency will disappear after 2026 in the Below 2 scenario and after 2040 in the Stated policies scenario





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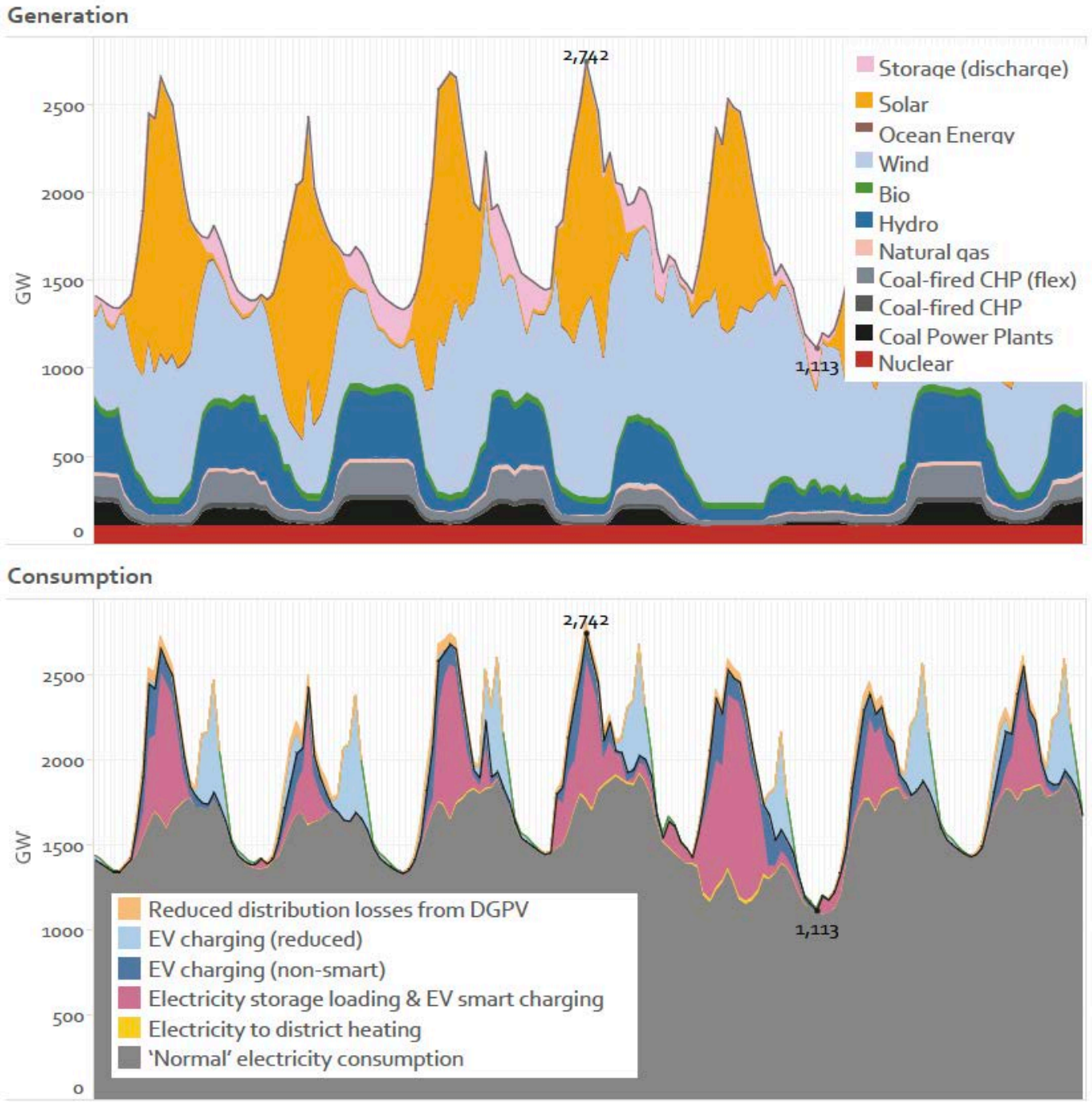
Hour-by-hour dispatch of the power system

Demand side measures

- Peak load shaving
- Industrial load shifting
- EV smart charging
- EV charging
- Storage loading
- Electricity to heat

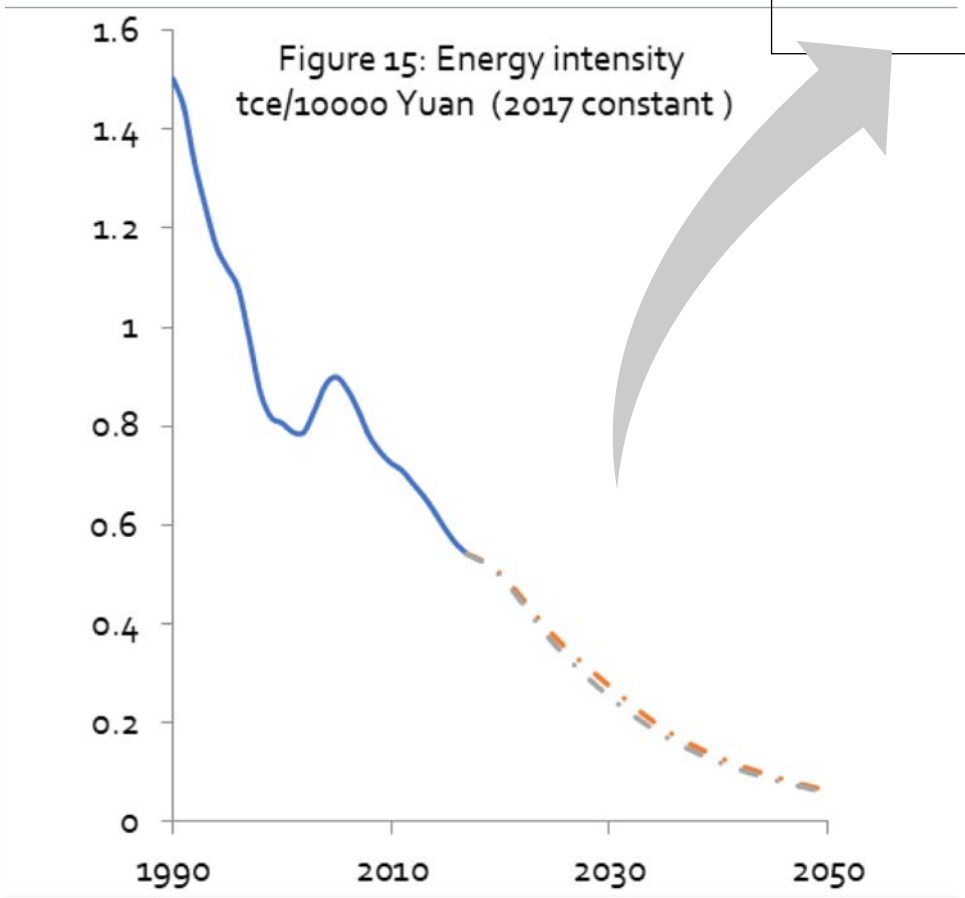
Supply side measures

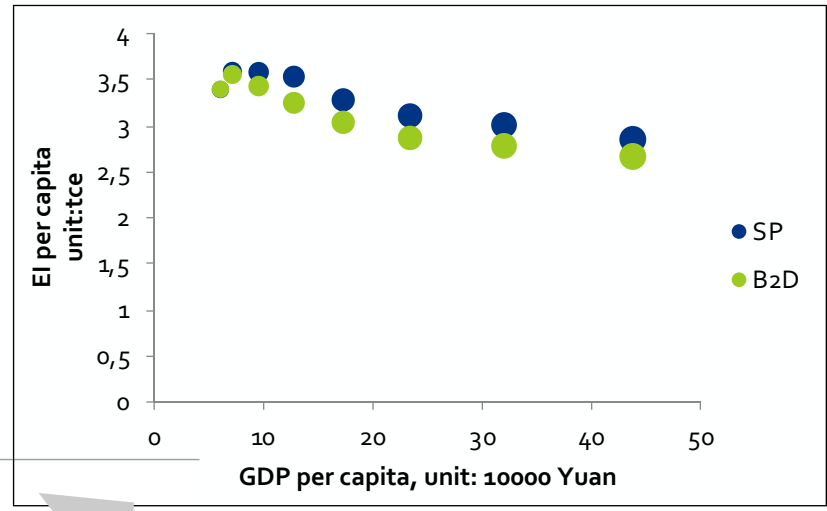
- Flexible thermal power plants
- Flexible hydro
- Storage discharging
- Market value based VRE remuneration incentives



Efficient energy system I: Energy efficiency

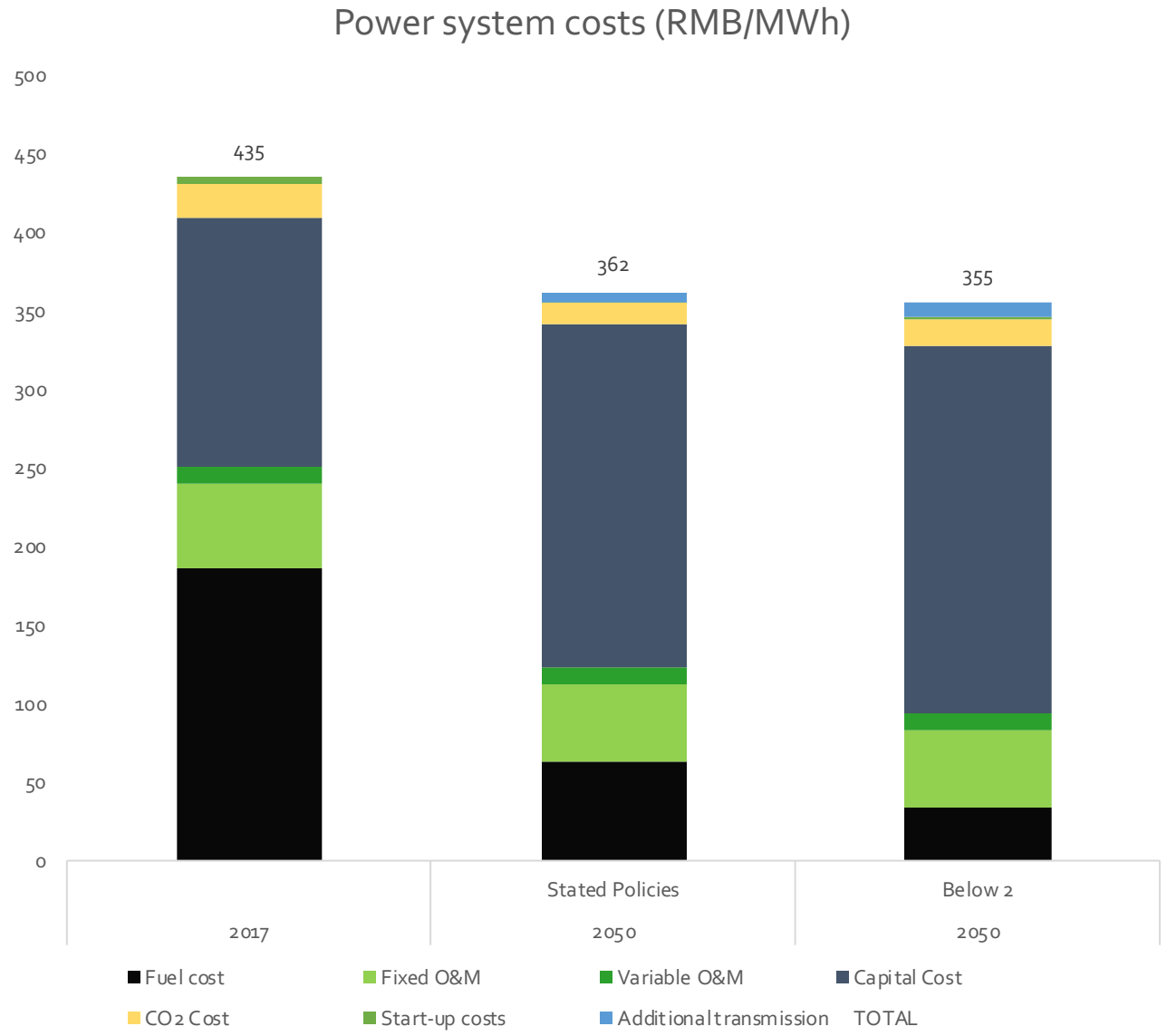
The energy intensity will be significantly improved in both scenarios and the economic growth will be genuinely decoupled from the energy consumption growth.





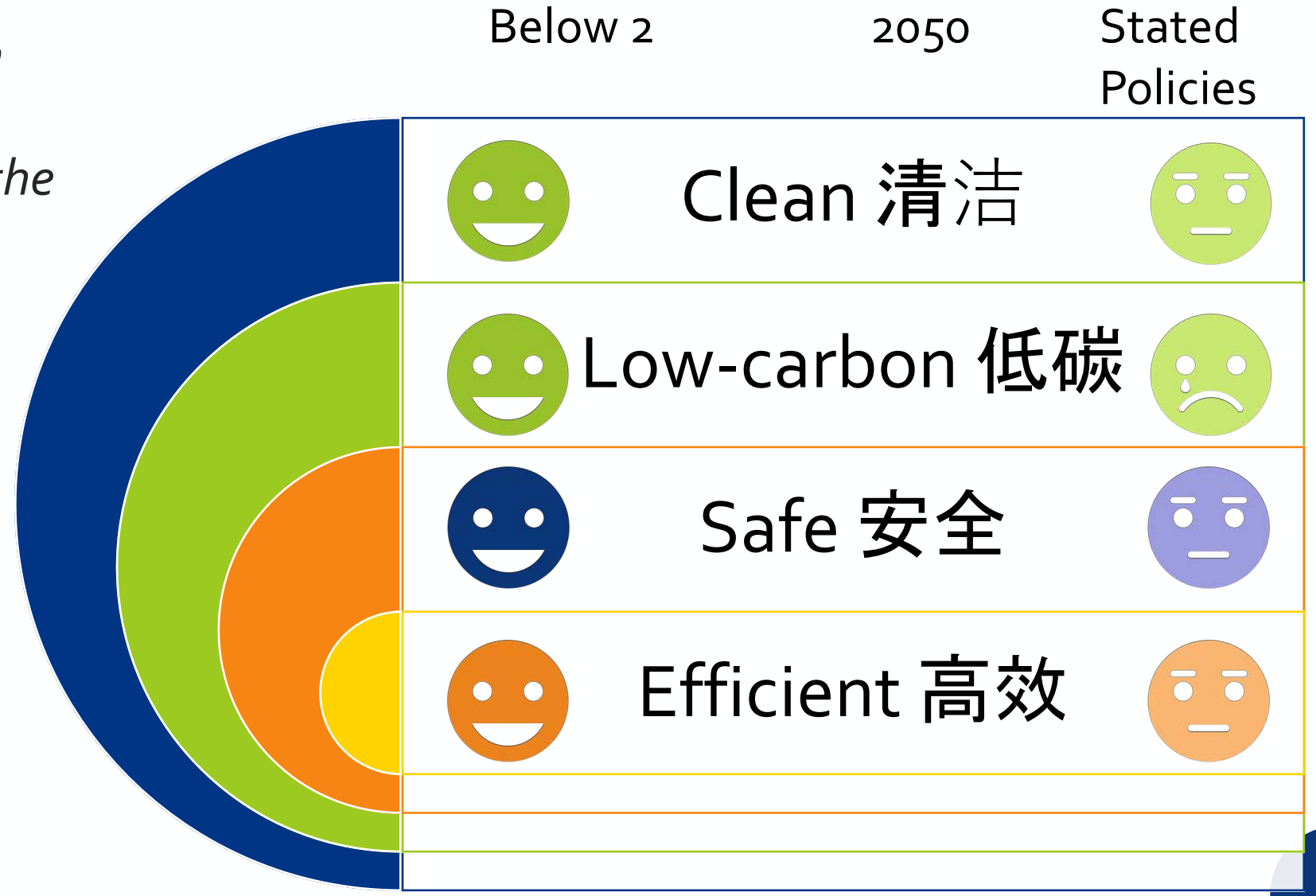
Economic Efficiency: Lower and more stable electricity cost

- The cost of producing electricity is lower in 2050 than in 2017 in both scenarios
- In 2017 the fuel costs are around 43% of the total costs, while in 2050, fuel costs are only 9% in the Below 2 °C scenario and 18% in the Stated Policies scenario. The impact of volatile fuel prices are thereby reduced considerable



The 2050 energy system in the Below 2 °C scenario ***fulfils all key targets*** *for the Beautiful China energy system*

- Today's energy system is dirty, high-carbon, inefficient and dependent on imported fuels
- This can be improved significantly in the future with the right implementation of the central visions
- A low-carbon energy system is superior in all key criteria for a modern, sustainable energy system



CREO 2018 results

POLICY RECOMMENDATIONS

Key recommendations

Strictly enforce coal reduction

- Efforts to reduce coal usage must be accelerated by halting new coal power, promoting electrification in industry and clean heating in buildings, efficiently pricing carbon, and providing targeted support to coal-dependent provinces for energy and economic transition.

Create a level playing field for renewable energy

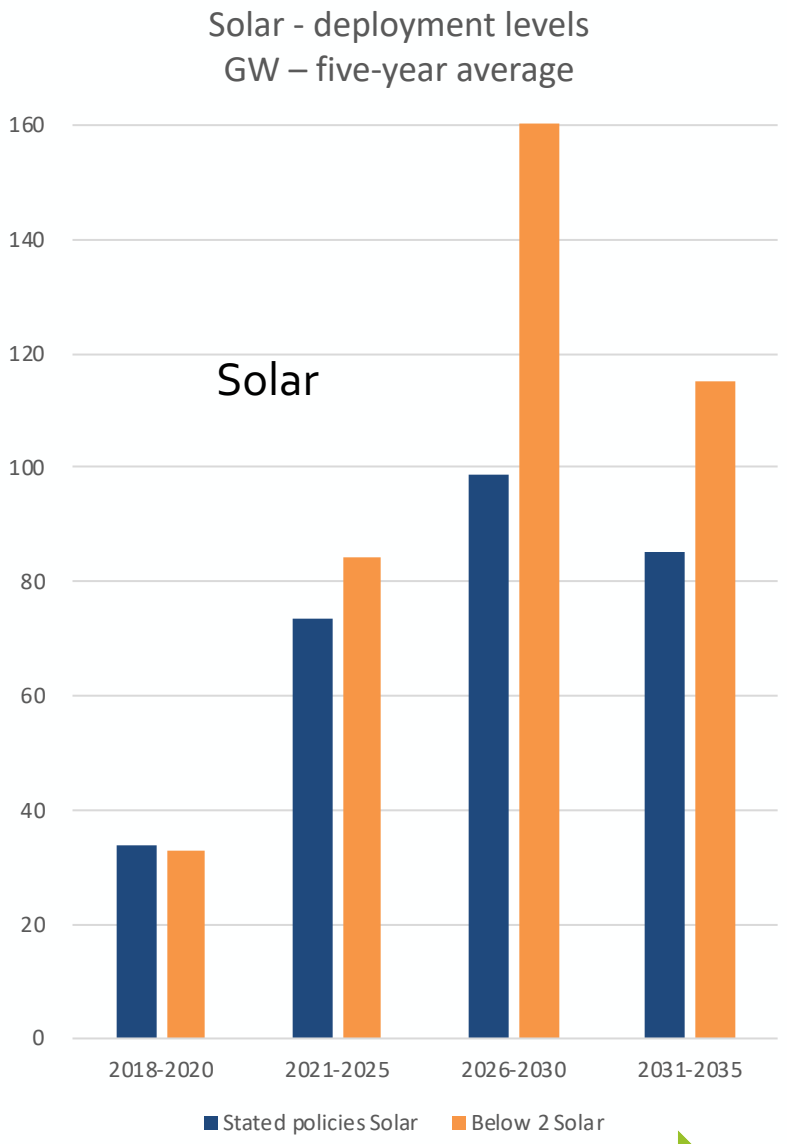
- The current barriers for promoting renewable energy must be removed by improving coordination between authorities, giving adequate incentives for developers, de-risking investments, and rapidly implementing power markets that work for renewables.

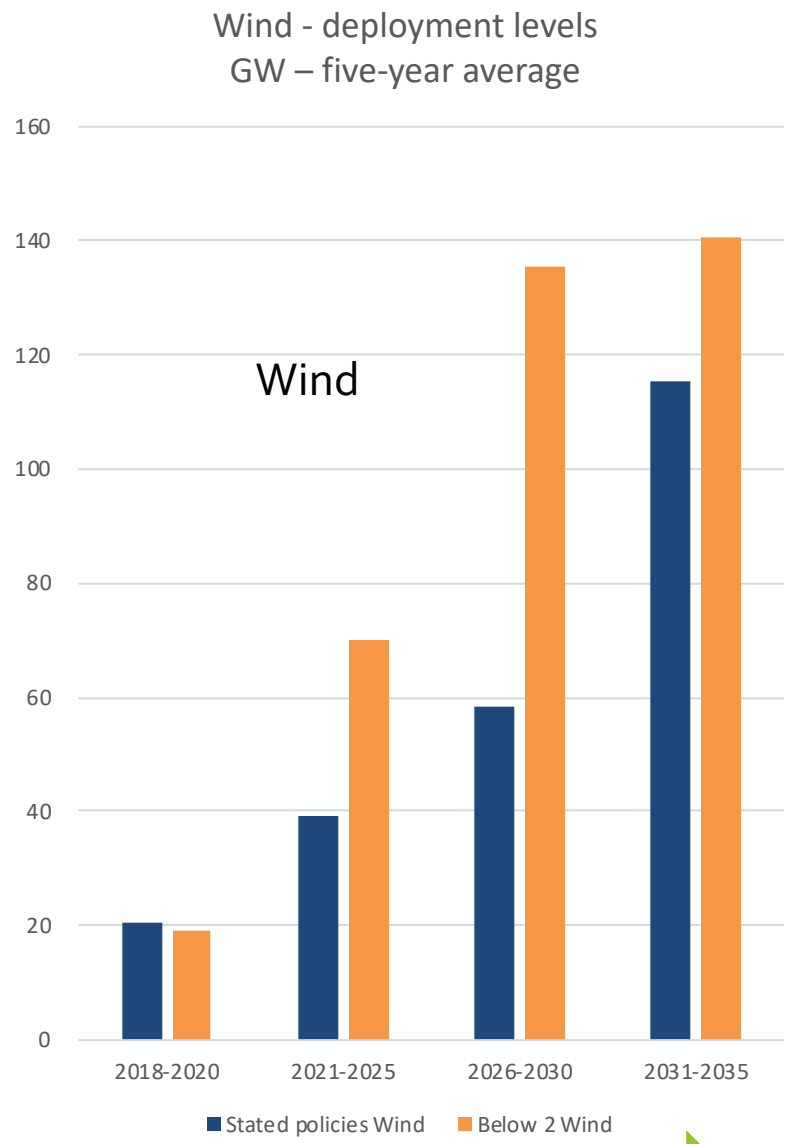
An institutional reform process towards ecological civilisation

- The 19th Party Congress emphasised the overall targets towards 2050 of building an ecological civilisation. These ambitions must be anchored in all administrative levels.
- The power sector reform must ensure that the incumbent players become driving forces for renewables, that grid companies develop planning methods to ensure full uptake of variable renewables, and that local governments have strong motivation to take a proactive role in the transformation process.

Deployment levels for wind and solar in the 14-16 five-year plan periods

- In the next ten year period, investments in solar power capacity should be raised to a level of 80 GW per year in 2021-2025 and 160 GW per year in 2026-2030. After 2030 the level would be around 115 GW per year
- For wind power, the levels should be around 70 GW per year in 2021-2025 and around 140 GW per year in 2026-2035
- Stated Policies scenario has slower and lower capacity deployment levels





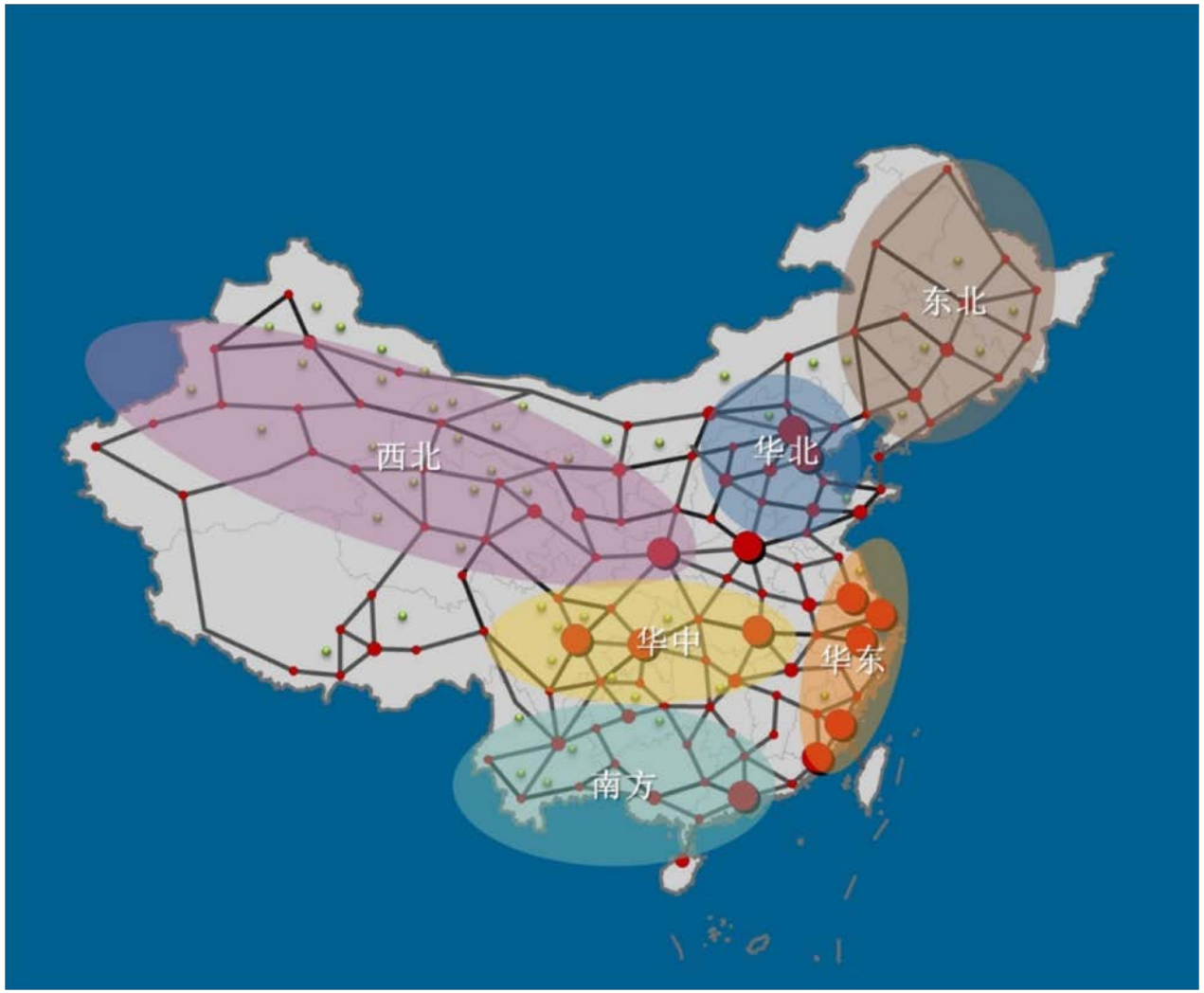
Five-year plans

14, 15, 16

14, 15, 16

Grid development

- The long-term grid development strategy should be based on province-to-province interconnectors combined into regional grids
- Grid planning should take into account the power market development and flexible, market-based dispatch of the transmission lines



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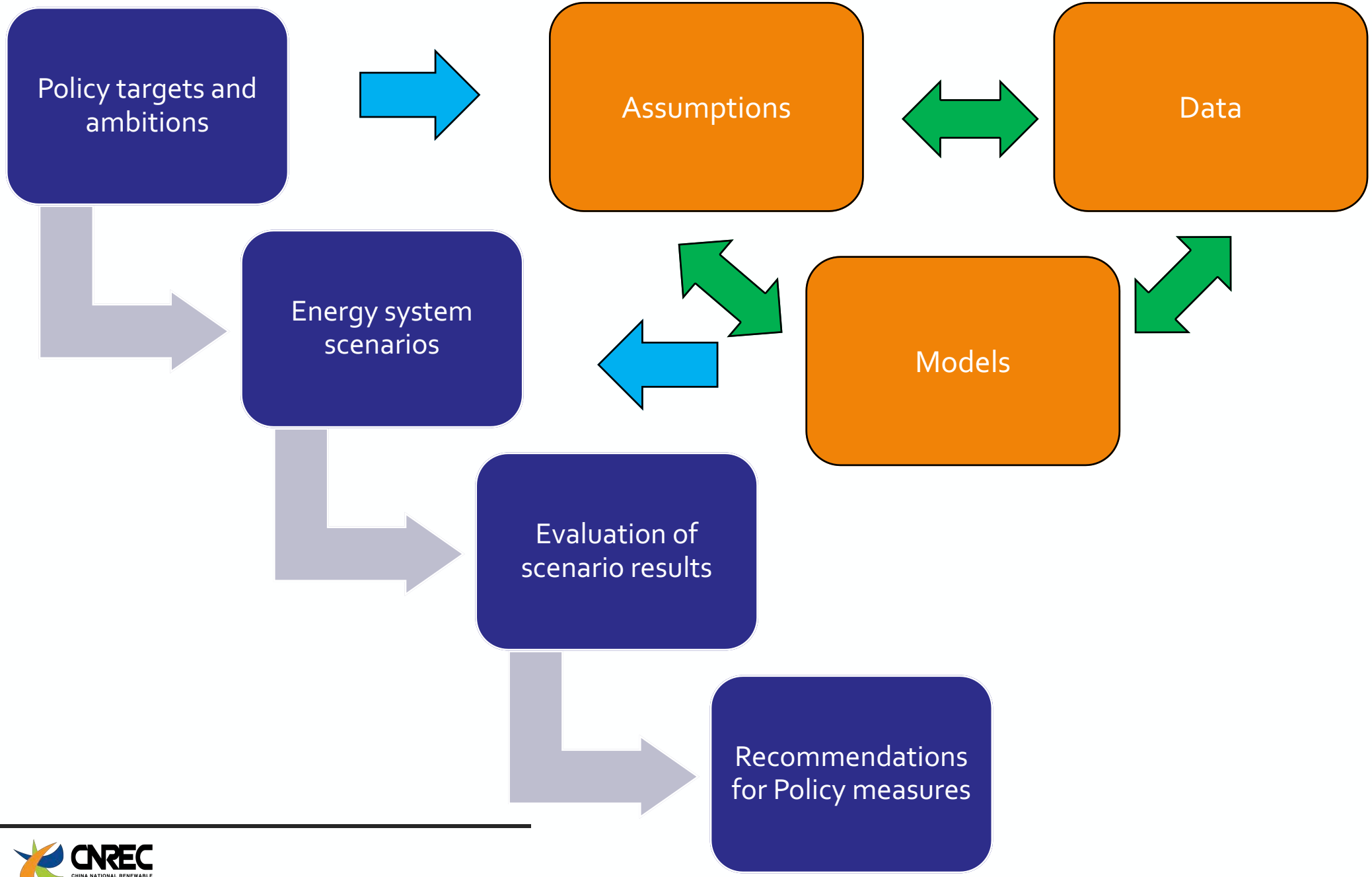
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