



The role of flexibility sources in China's power system transition

灵活性资源在中国电力系统转型中的作用

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The IEA is the global energy authority 国际能源署是全球能源领域的权威机构

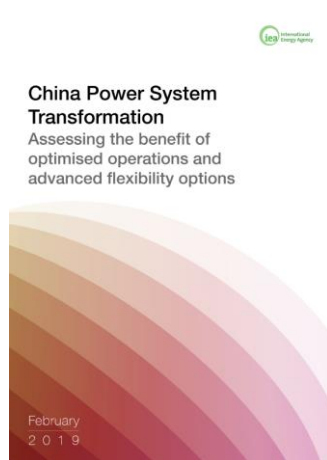
- Founded in 1974 设立于1974年
- Providing data, analysis and solutions on all fuels and all technologies 提供关于各能源领域和技术的数据、分析和解决方案
- Helping governments, industry and citizens to make good energy choices 协助政府、企业和个人优化能源选择

• Four main areas of focus

- Energy security
- Economic development
- Environmental awareness
- Global engagement

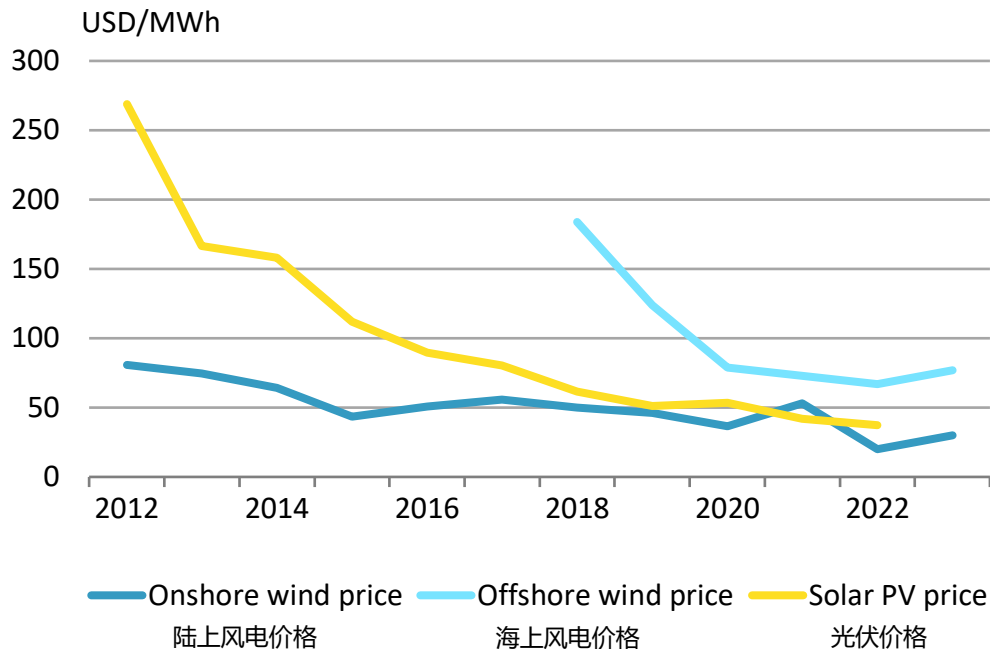
四大工作重点

- 能源安全
- 经济发展
- 环境意识
- 全球合作



First trend: low-cost Variable Renewable Energy 趋势之一：低成本波动性可再生能源

Average auction price by project commissioning date 平均拍卖价格（按项目投产期）

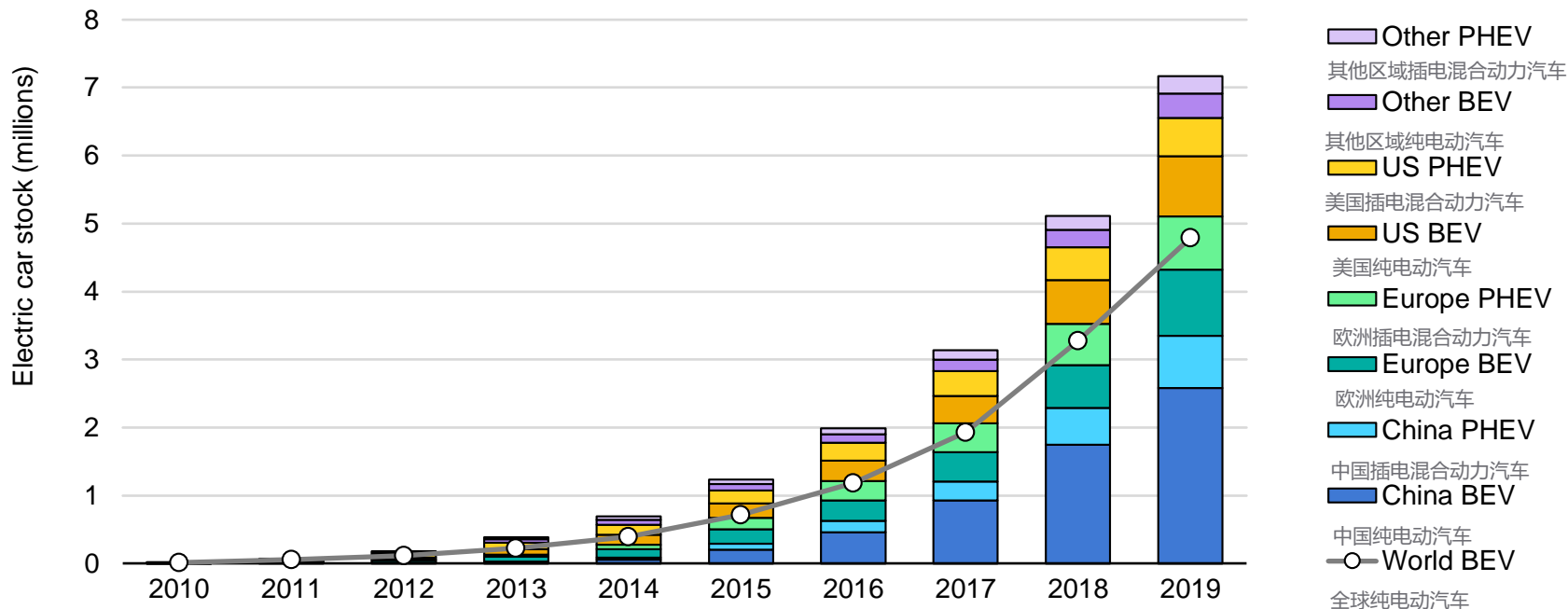


Competition has led to a sharp reduction in VRE costs around the world.

全球范围内，波动性可再生能源成本随着市场竞争大幅下降。

Second trend: distributed energy resources 趋势之二：分布式能源

Global electric car stock, 2010-2019 全球电动汽车保有量 (2010 - 2019)



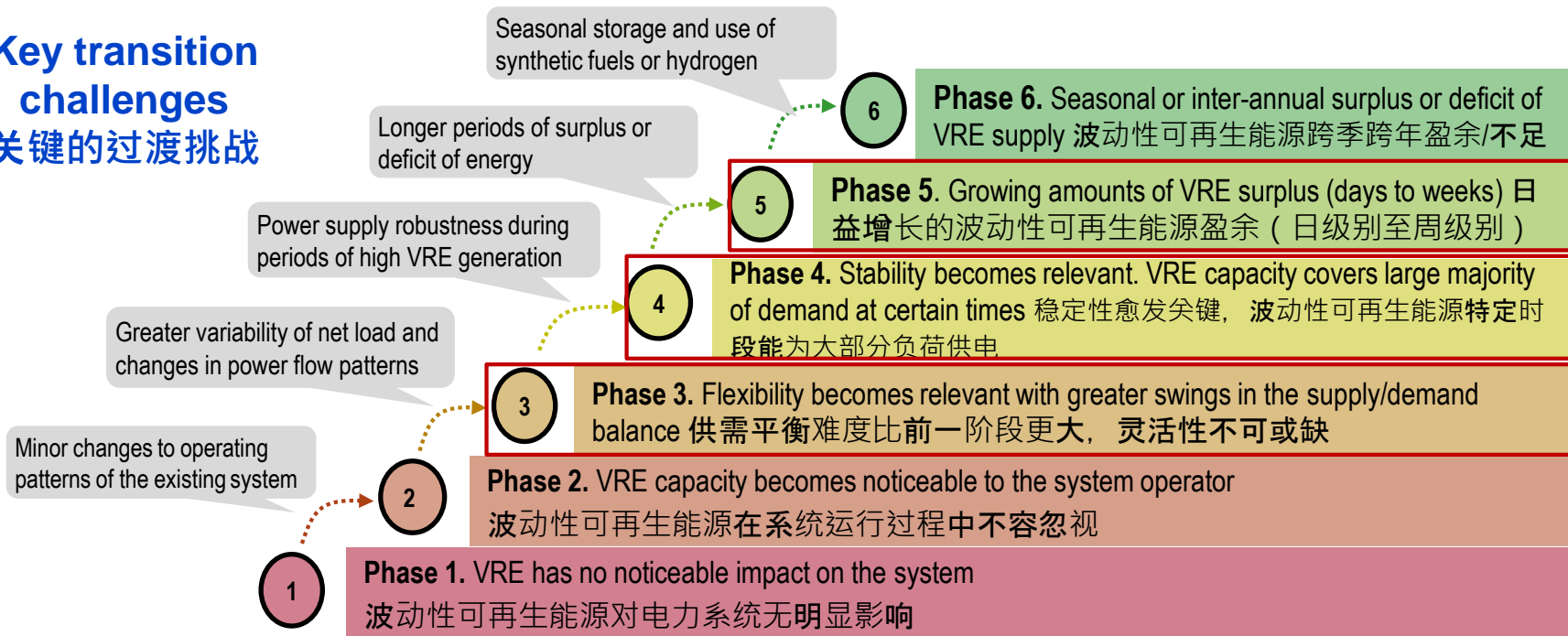
There were 7.2 million electric passenger cars on the road worldwide by the end of 2019, of which 47% were in China. However, electric cars still only represent about 1% of the global car fleet. 截至2019年底，全球已有720万电动汽车在运，其中47%在中国。但是，电动汽车仍然只占全球车辆的不到1%。

Different Phases of Variable Renewable Energy (VRE) Integration

波动性可再生能源并网的阶段划分

Key transition challenges

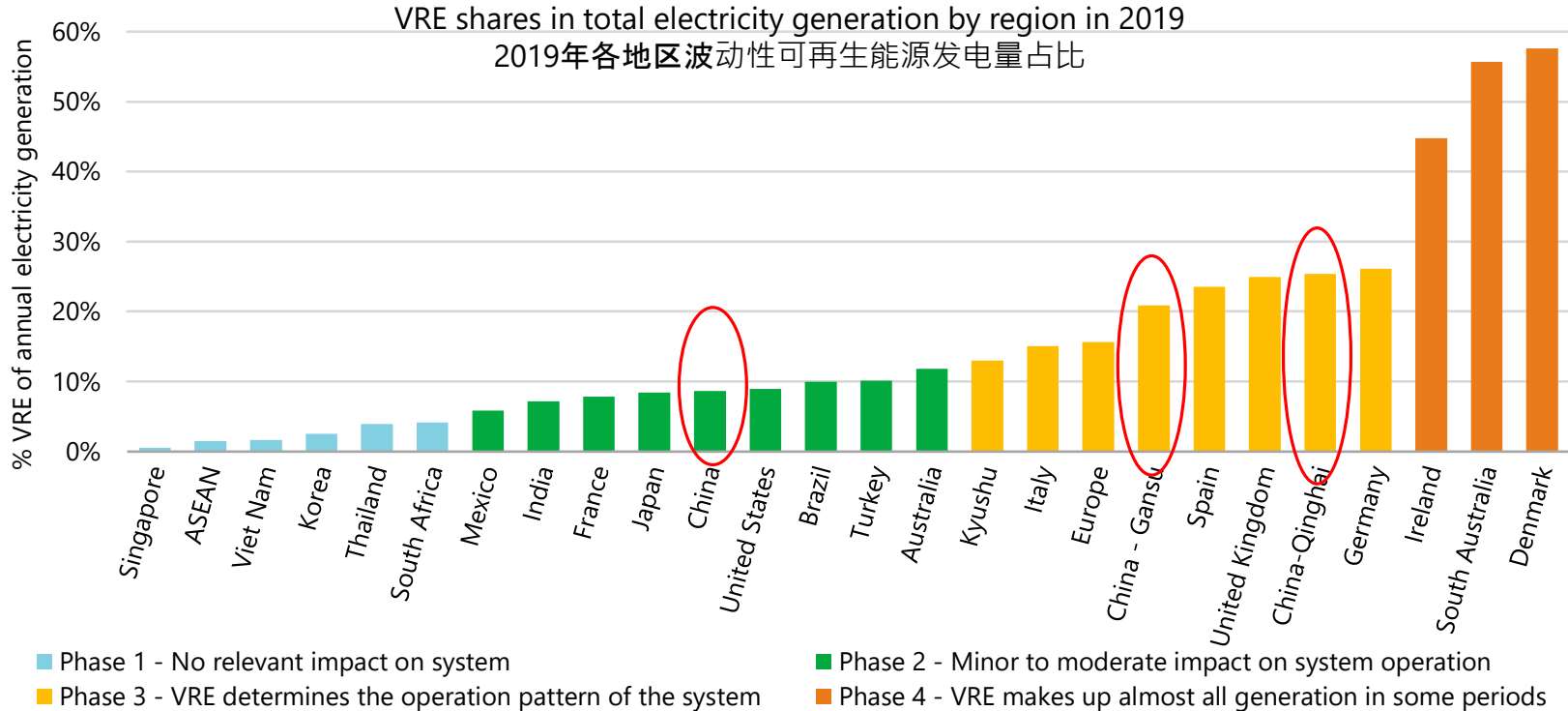
关键的过渡挑战



Key challenges in each phase that should be addressed for moving up to higher phases of VRE integration 为推动波动性可再生能源消纳向更高阶段转变，应有效应对各个阶段面临的挑战。

Flexibility is the cornerstone of future power systems

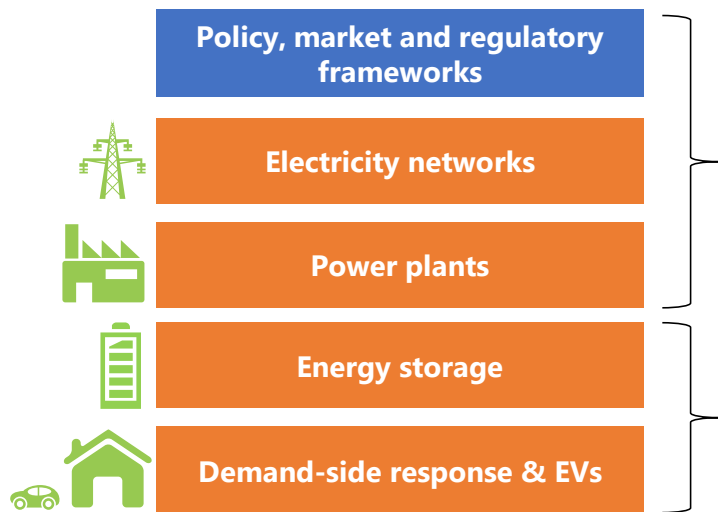
系统灵活性: 未来电力系统的基石



Various regions have demonstrated successful integration of VRE in Phases 3 and 4 with dedicated efforts for system flexibility. Many countries are expected to reach Phase 4 within the next 5 years. 部分地区通过着力提高系统灵活性, 已具备波动性可再生能源消纳第3和第4阶段成功实践。许多国家预计将在未来5年内进入第4阶段。

Modelling China power system transformation 中国电力系统转型的模型分析

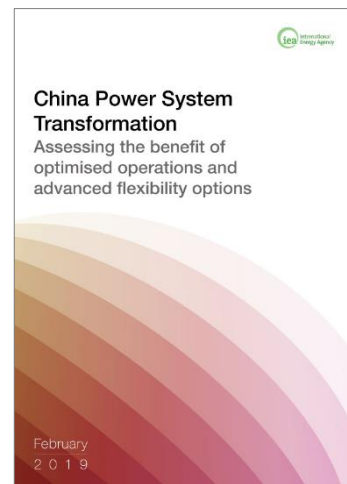
- Advanced energy modelling exercises to highlight the possibility of achieving a transformed power system in China. 先进的模型仿真凸显出中国电力系统转型的可能性。
 - Performing detailed power sector modelling analysis in 2035 for two possible configurations for the Chinese power system in 2035 and looked at different system flexibility measures : 对2035年中国电力系统的两种可能配置进行了详细的建模分析，并研究了不同的系统灵活性指标：



Stated Policies Scenario (STEPS) aims to provide a sense of where today's policy ambitions seem likely to take the energy sector in China (Aligns with China's Doc No. 9 reforms).

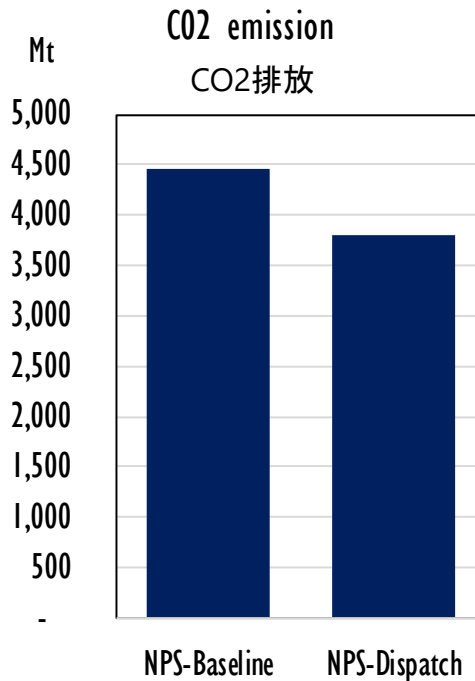
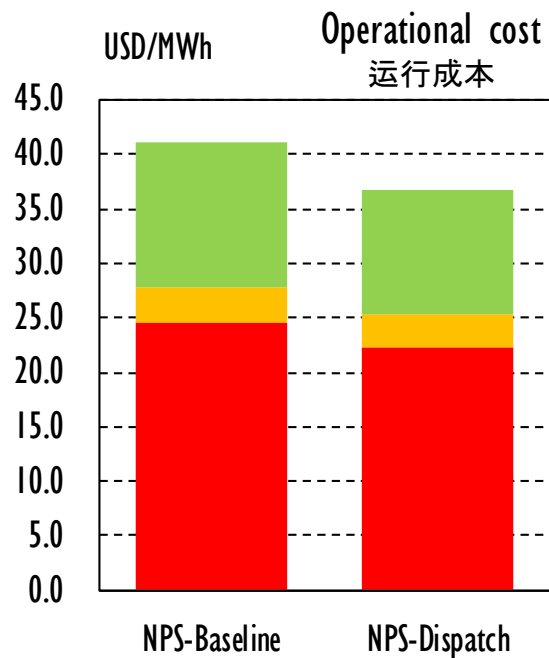
现有政策情景与中国9号文框架下的电力体制改革相关联，目标是分析当前中国雄心勃勃的政策将引导能源行业走向何方。

Sustainable Development Scenario (SDS) offers an integrated way to achieve a range of energy-related goals crucial for sustainable economic development 可持续发展情景提供了实现一系列能源相关目标的路径方式，这些方式将支持中国经济未来的可持续发展。



China's ongoing market reforms will have strong benefits

中国正在进行的电力市场化改革将带来巨大效益



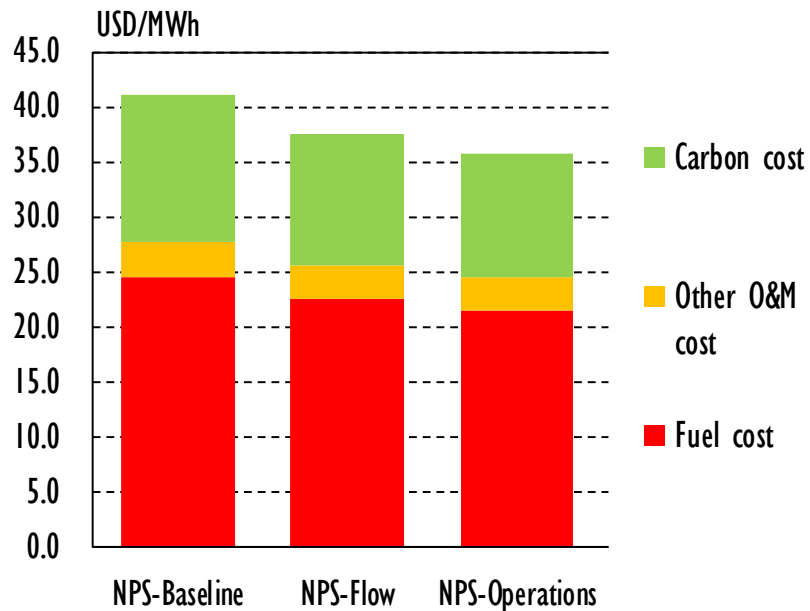
Operational cost savings by 11%
(45 Billion \$/year)

CO2 emission reduction by 15%
(0.75 gigatons)

Transition to economic dispatch results in lower energy prices and support economic competitiveness in the NPS in 2035 转为经济调度将降低能源价格、并保持2035年中国经济的持续竞争力

Regional trading is a key flexibility source which yields substantial benefit

跨区交易是关键灵活性来源之一，可产生巨大的效益



Operational cost savings by 15% (almost 60 \$Billion/year) by adopting Economic Dispatch and Regional Trade

- “Base” to “Flow” saves 36 \$Billion/year
 - Optimised regional trade
- “Flow” to “Operations” saves 19 Billion \$/year
 - Economic dispatch with optimised regional trade

Enhanced trade across provinces brings substantial cost savings in 2035; these are further maximised by economic dispatch and increased transmission investment.

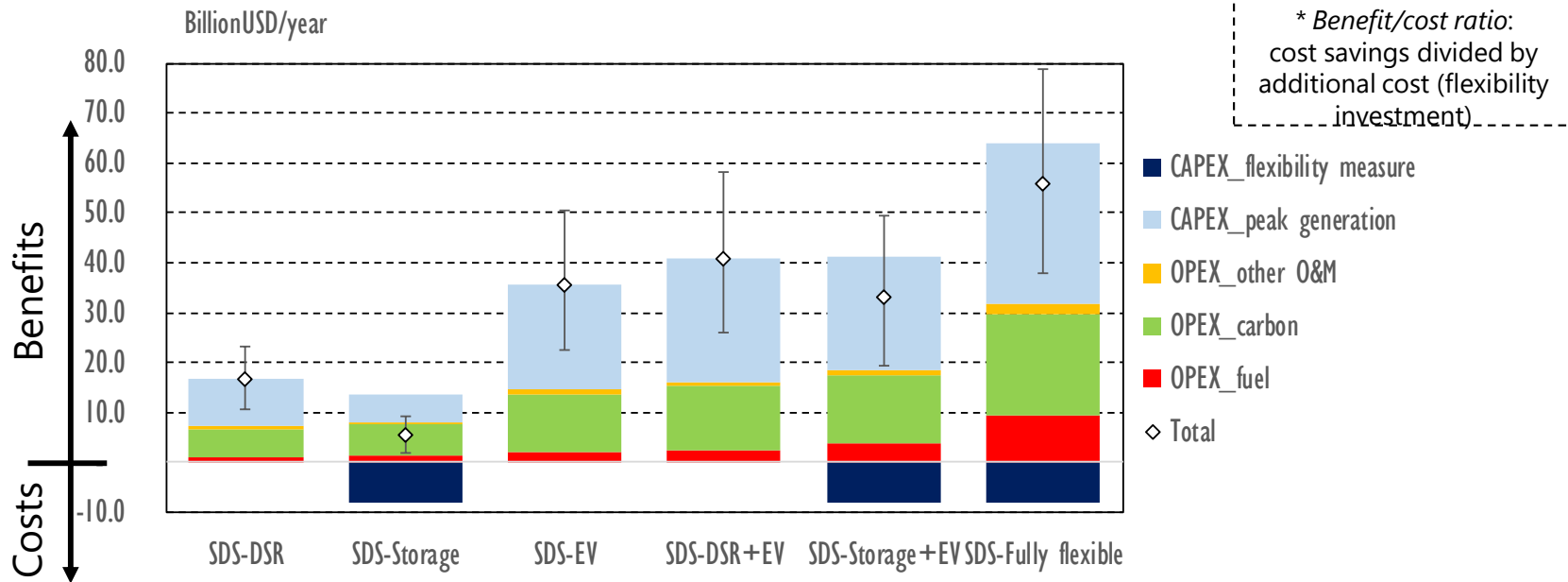
现有政策情景下增强跨省区电力交易将为2035年的电力系统带来显著效益；如果推动实施经济调度并增加输电线路投资，则将进一步最大化系统效益。

Adopting all flexibility options can bring net economic benefit

采用各种灵活性选项能够带来系统净收益

System cost savings by technology options (compared to SDS-Baseline)

不同技术选择带来的系统成本节约 (与SDS-Baseline案例比较)

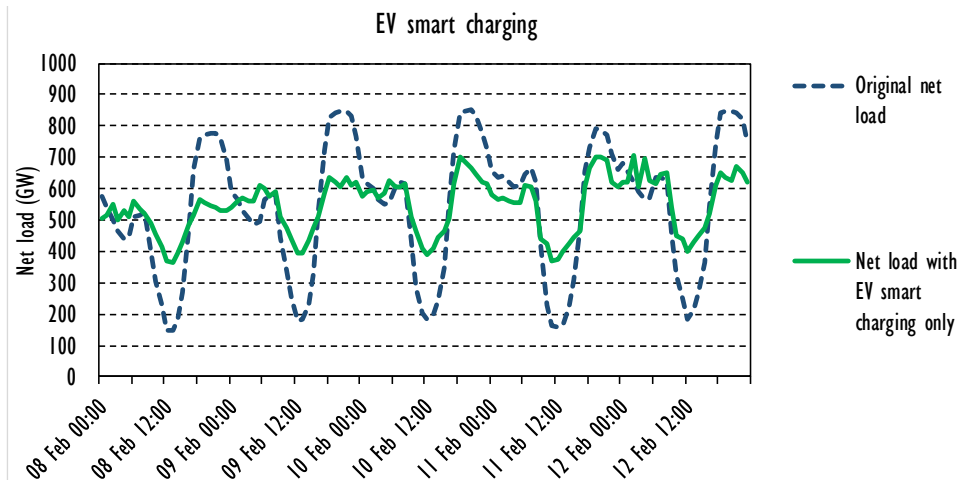


Use of advanced flexibility options leads to substantial savings in 2035.

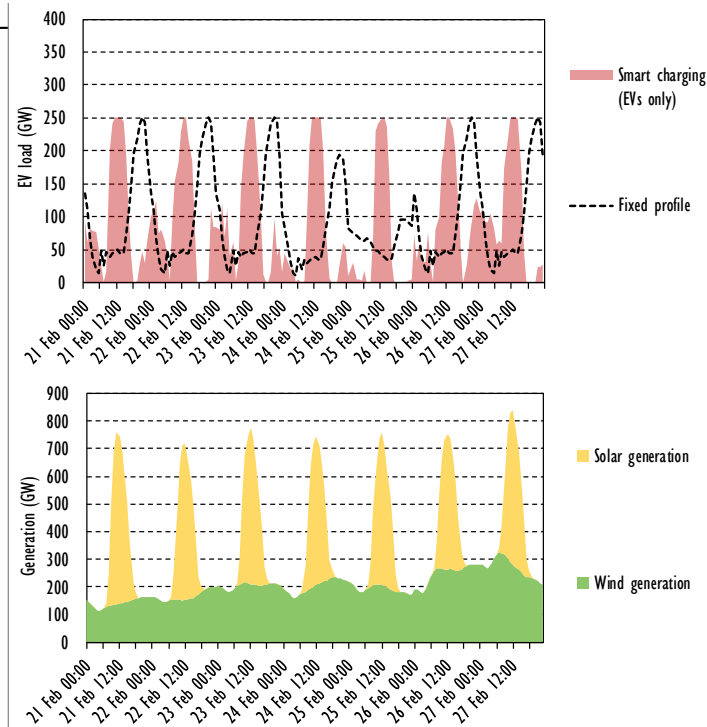
可持续发展情境下，采用先进灵活性选项可为2035年中国电力系统带来显著的系统成本节约。

Optimised use of demand shaping techniques is critical

优化负荷曲线非常重要



Impact of smart charging to peak load:
-164GW (13% of the original load)



Electric mobility has great potential for integrating renewable energy, but only if charging patterns are optimised. This calls for much closer inter-sectoral policy coordination

电动车对于波动性可再生能源接入系统非常重要，但这建立在优化充电方式的前提下。这也需要更为紧密的跨行业政策统筹和协调。

Summary and key takeaway 结论

- Power system flexibility is the most important cornerstone of a transformed power system with high shares of variable renewable energy. 电力系统灵活性是电力系统转型、接入高比例波动性可再生能源的最重要基础。
- Effective spot markets and better utilisation of interconnections brings a more efficient power system that can absorb high-share of VRE 有效的现货市场和更好地利用电网互联可实现更高效的电力系统，支撑高比例波动性可再生能源消纳
 - Economic dispatch is bound to trigger the market exit of inefficient coal plants, and this process is likely to need active management 经济调度可引导低效煤电机组逐步退出，这一过程很可能需要积极的管理
 - Increasing regional trading and broader coordination can substantially boost system efficiency and reliability, but efforts to coordinate and harmonize markets are required 增加跨区交易和扩大资源优化配置范围可以显著提高系统的效率和可靠性，但需要努力协调市场
- Advanced technologies (EVs, storage and demand side response) allow for the reliable integration of very high shares of variable generation 可持续发展情境下，先进技术的应用可实现极高比例的波动性可再生能源接入，且不存在显著弃电
- Optimisation of the Chinese power system has immediate global effects, considering the substantial share of Chinese power system. 考虑到中国电力系统的体量，中国电力系统优化工作会对全球产生直接影响。

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