



适应高比例可再生能源的灵活电力系统 及其实现路径探讨

**Flexible Power System for High-RE Integration:
Technology Selections and Pathway**

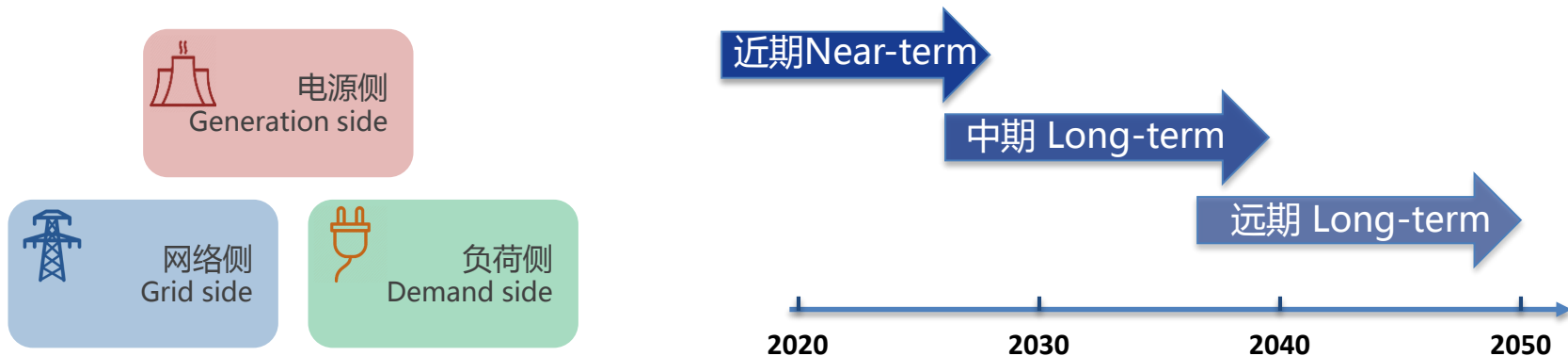


灵活电力系统的技术实现路径

Pathway towards Flexible Power System

主要原则。电力系统灵活性提升应从电源侧、消费侧和网络侧多措并举，按照我国电力系统发展基础和特点，按照技术经济最优的原则，确定不同阶段灵活性提升的**主要措施**、**辅助措施**和**补充措施**。

Main Principles. Multiple measures on generation side, grid side and demand side, could be taken to boost flexibility in power system. The technical roadmap for flexibility enhancement should be stage-wise and scenario-oriented.



近期。我国波动性可再生能源占比在全国范围内看仍然不高，灵活性提升应着眼于存量资产，重点在发电侧提升存量煤电机组灵活性，在电网侧释放跨省区电力调剂潜力；在西部和北部探索适应高耗能负荷的需求侧响应技术。

Near Term. There are still large amount of flexibility in existing assets untapped. In the near-term, focus should be on the large coal-fired fleet and also the existing grid infrastructure.



电源侧 Generation side

- 对存量煤电机组灵活性改造，提升机组灵活调节能力。
- Retrofit existing coal power plants



网络侧 Grid side

- 加强省间互济，释放输电通道跨省区电力调剂潜力。
- Strengthen cross-province coupling

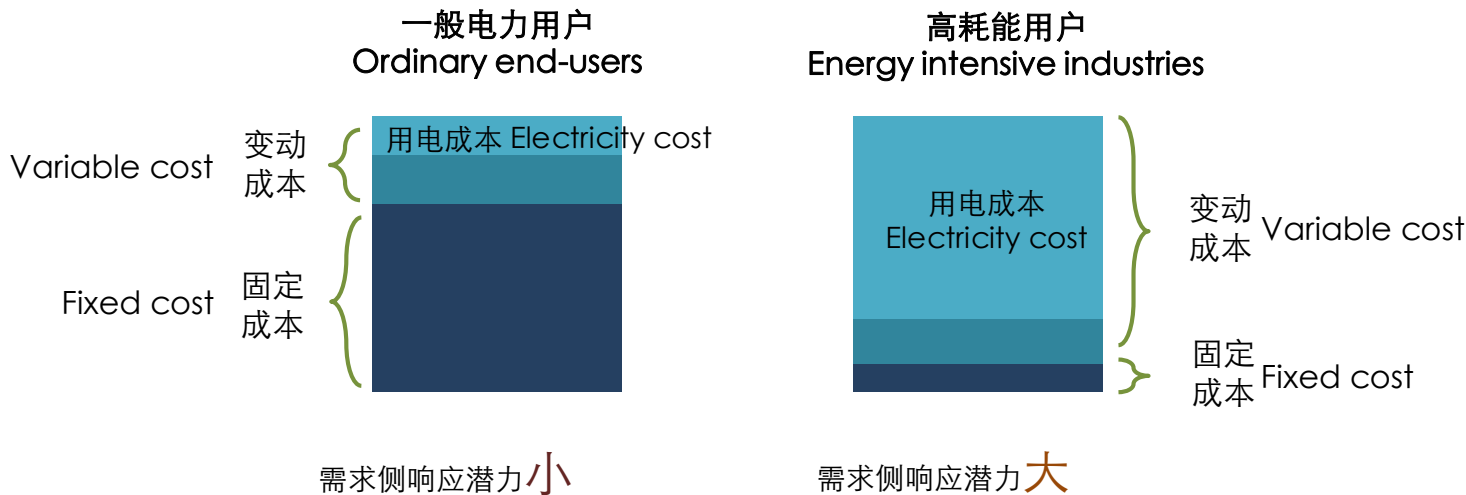


用户侧 Demand side

- 在西部和北部地区探索高耗能负荷需求侧响应技术。
- DSR in energy-intensive industries in Northern and Western regions

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中期。 灵活性提升应着眼于电源结构优化，在煤电灵活性改造基础上，增加气电和抽蓄等灵活性电源比重；同时，为了适应中东部地区分布式电源的增加，应大力推动需求侧响应。

Mid Term. Focus should be on structural optimization of generation mix. In addition to coal power plant flexibilization, the proportion of gas turbines and pumped hydro stations should be increased. In order to accommodate distributed energy, DSR should be further promoted.



电源侧 Generation side

- 增加气电和抽蓄等灵活性电源比重
- Structural optimization of generation mix



网络侧 Grid side

- 进一步增加跨区电力流规模
- Increase the capacity of grid interconnection

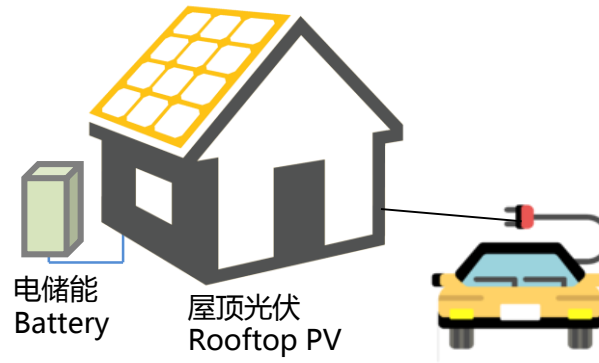


用户侧 Demand side

- 大力推动需求侧响应发展
- Promote distributed DSR in the eastern areas

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远期。 大规模储能技术突破将会成为可能情景，储能和可再生能源将重塑能源系统，电、热、气之间的互转互济成为系统灵活性的主要来源，储能大规模应用，日调节、月调节和年调节的储能设施实现有机结合。

Long term. Energy storage and renewable energy will restructure the energy system. Coupling between different type of energy carriers and flexible load will become major sources of system flexibility.



电源侧 Generation side

- 化石能源机组由基础性电源逐步转变为保障性电源
- Fossil fuel generation will be transformed into safe-guard units.



网络侧 Grid side

- 电力网络、热力网络和输气网络高度耦合。
- Coupling among electricity grid, gas and heat networks



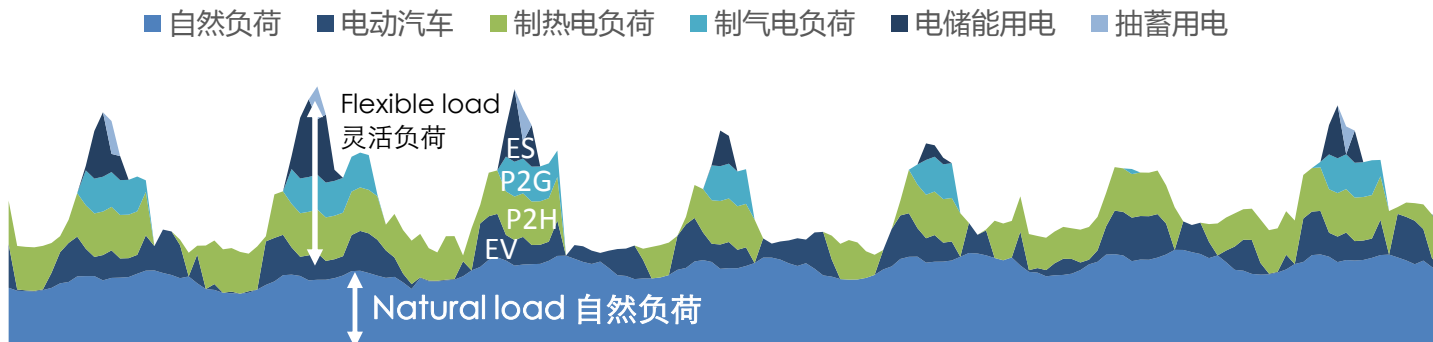
用户侧 Demand side

- 多能源互转互济
- 多类储能设施有机结合
- Power to X
- Combination of different types of energy storages

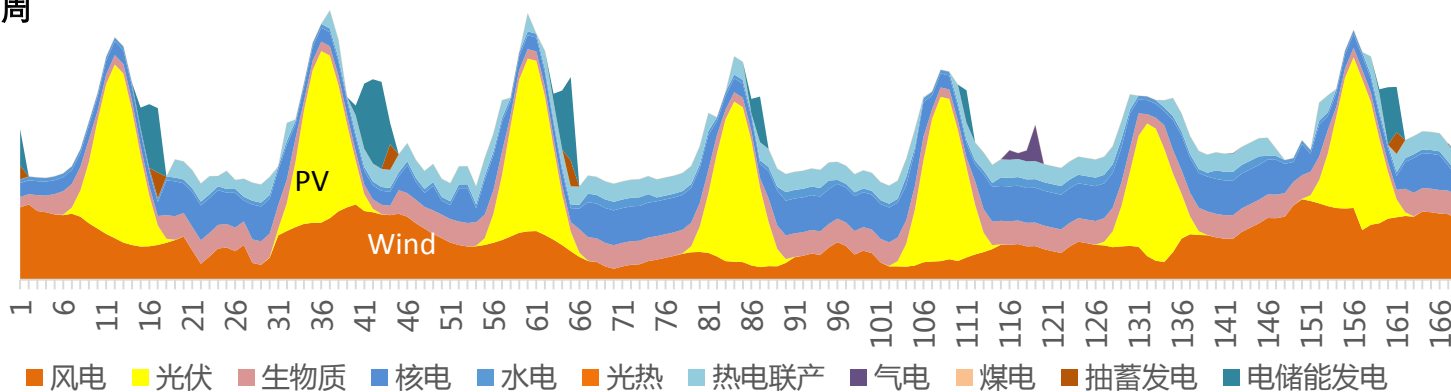
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2050 North Eastern areas 2050年的东北区域



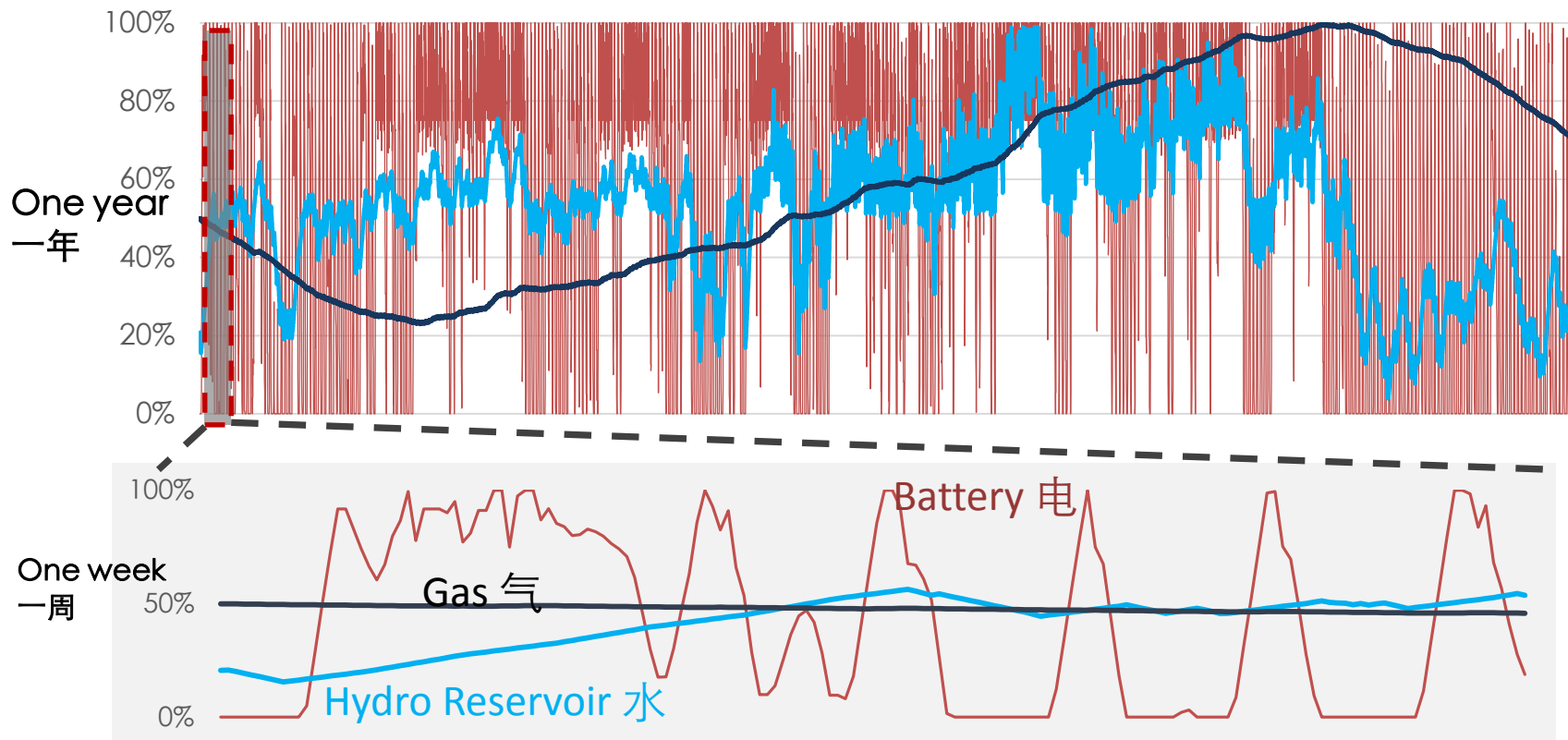
Winter week
冬季一周



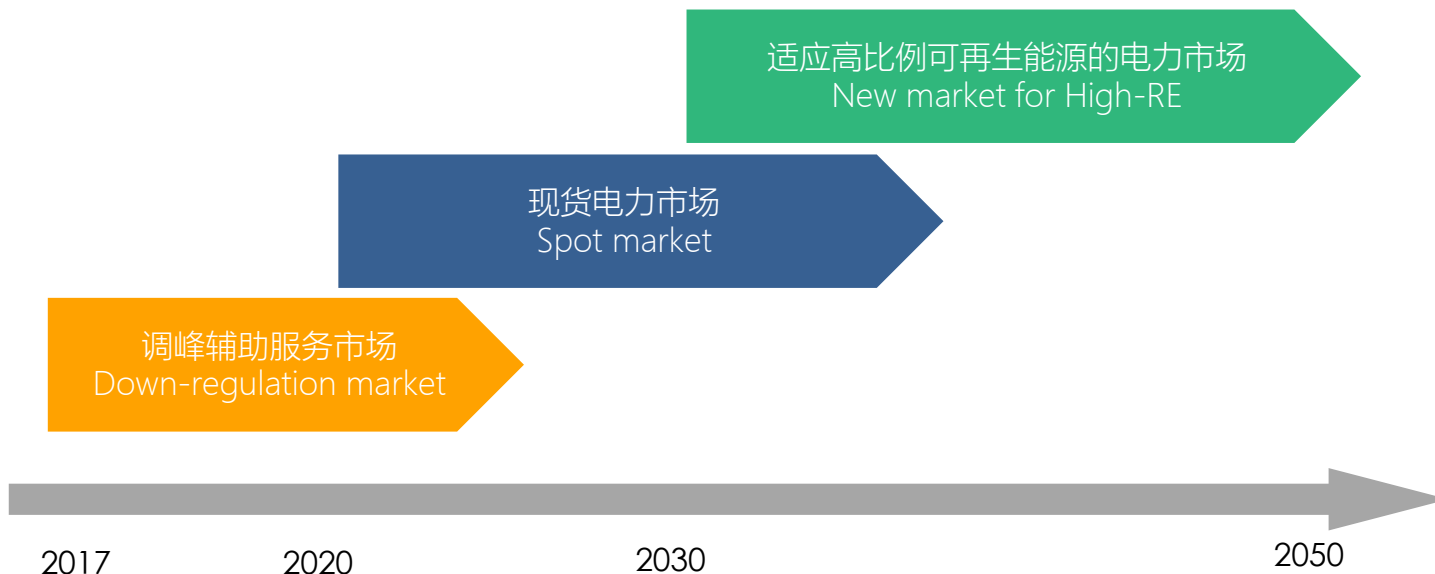
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Residual energy in different types of energy storages 不同类型储能能量余量变化

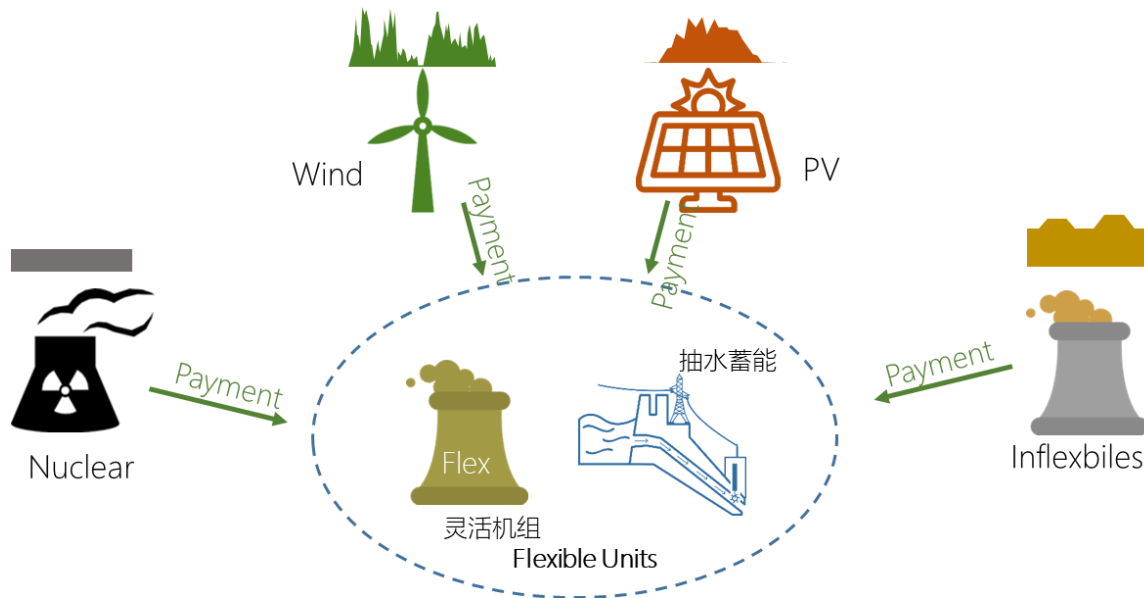


释放系统的潜在灵活性，并鼓励在各类灵活性资源方面的投资，是未来电力市场设计的关键问题。需要根据我国发展基础，分步实施，渐进式优化我国电力市场机制，确保波动性新能源的大规模消纳。Unleashing potential flexibility and encourage investment on flexibility are two major goals of future power market design.



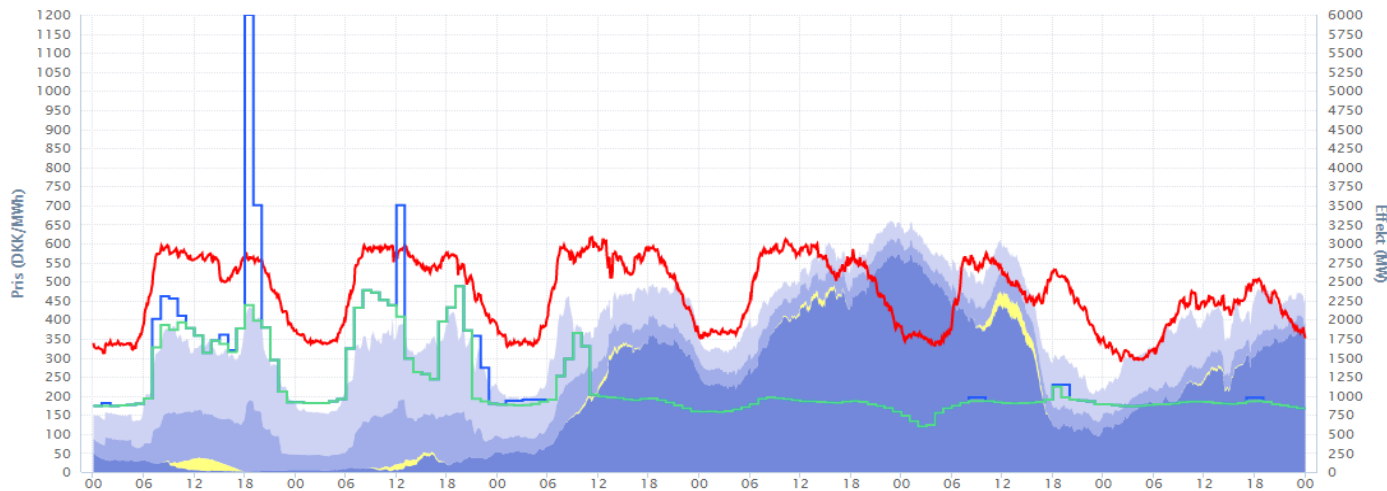
现阶段。 目前，主要依赖调峰辅助市场与目前的体制相结合，通过市场化的奖惩机制，推动传统电厂更多参与调峰，释放电力系统灵活性。

Current stage. down-regulation ancillary service market will provide incentives for power plants to operate more flexibly



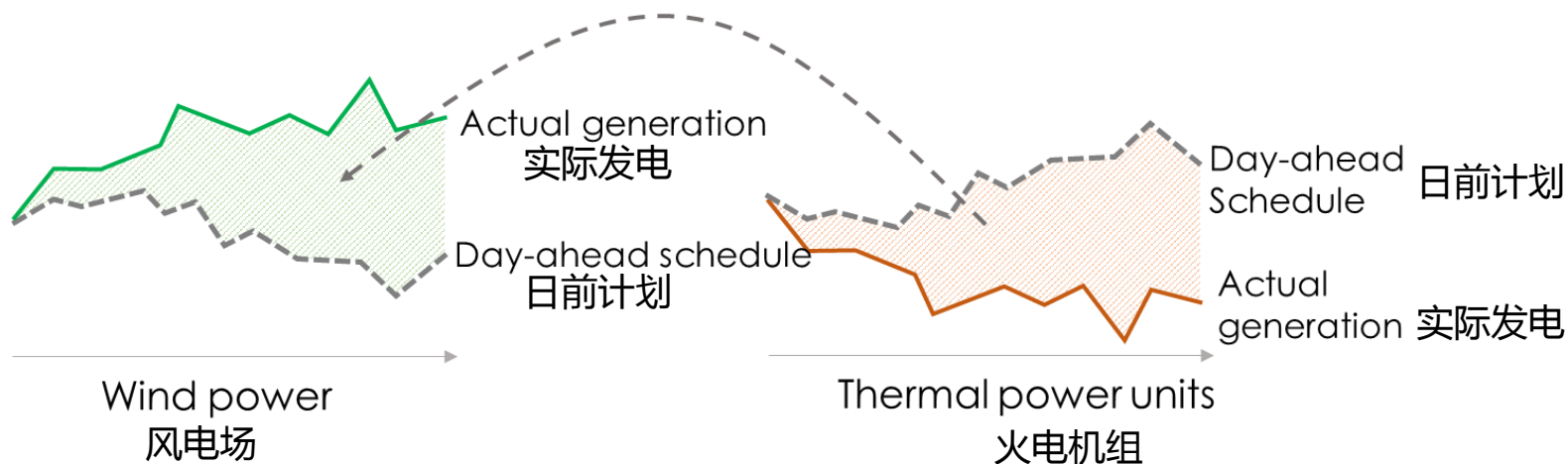
下一步。 建立由日前、日内和实时交易为主要形式的现货电力市场，通过浮动的电价引导传统电厂更为灵活的运行。

Next step. Spot market, consisting of day-ahead, intra-day and real-time market, will provide consistent incentives to flexible power plants.



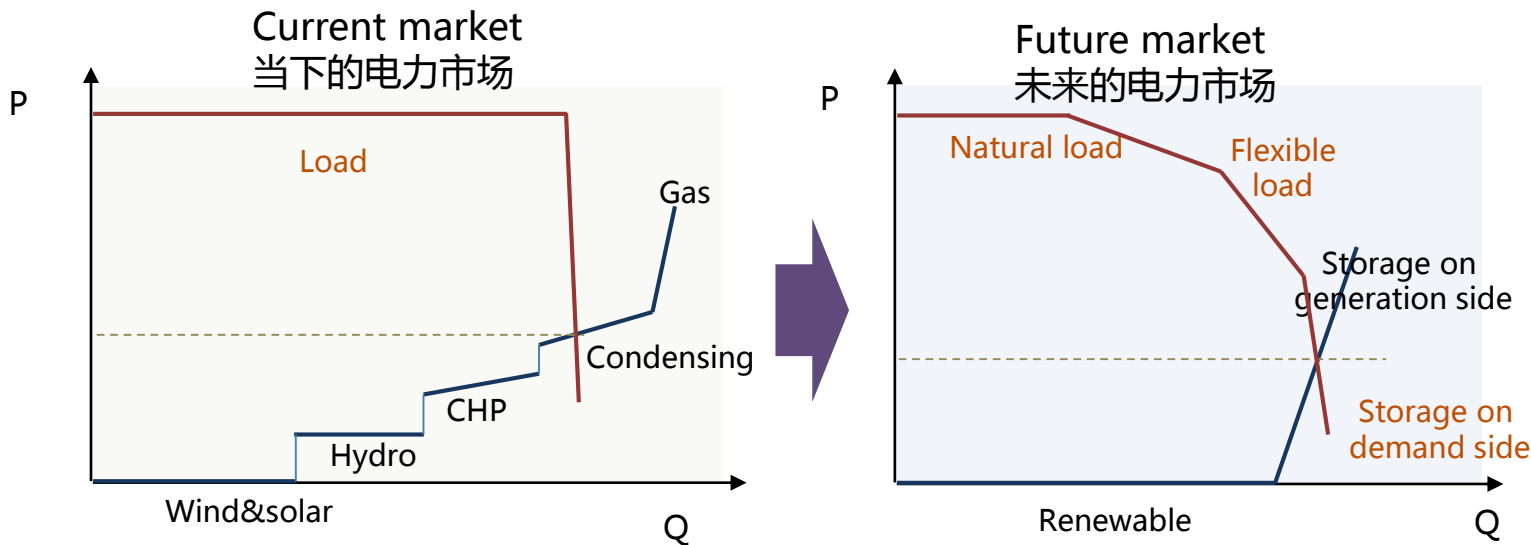
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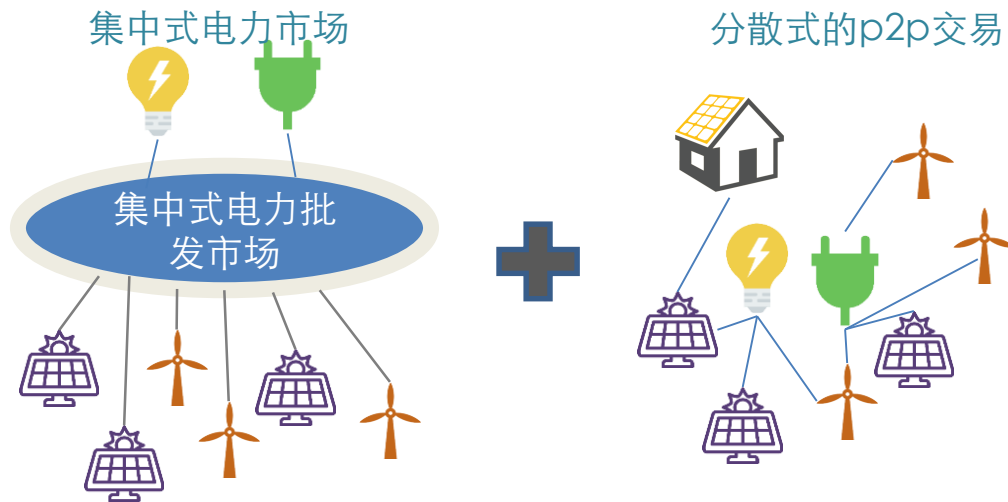
展望未来。 电力市场运行发生根本性变化：一方面，消费侧将在定价中发挥更大作用；另一方面，分布式发电、电动汽车大量接入，参与市场的主体大幅度增加。

Looking into the future. Two fundamental changes: 1) the role of price maker will be shifted from generation side to demand side. 2) The number of market participants will be increased exponentially.



展望未来。 需要建立更为多样的电力市场交易机制，释放海量用电和发电终端的灵活性。在集中式电力市场的基础上，构建适应新型系统的点对点交易机制。

Looking into the future. In addition to the centralized whole-sale market, new trading market place integrated with IT technology need to be established to further release flexibility from large number of prosumers.



THANKS

感谢您的时间