



# Smart power system - Harnessing distributed energy resources

## 智能电力系统——分布式能源利用

Pauline Henriot, Energy Policy Analysts

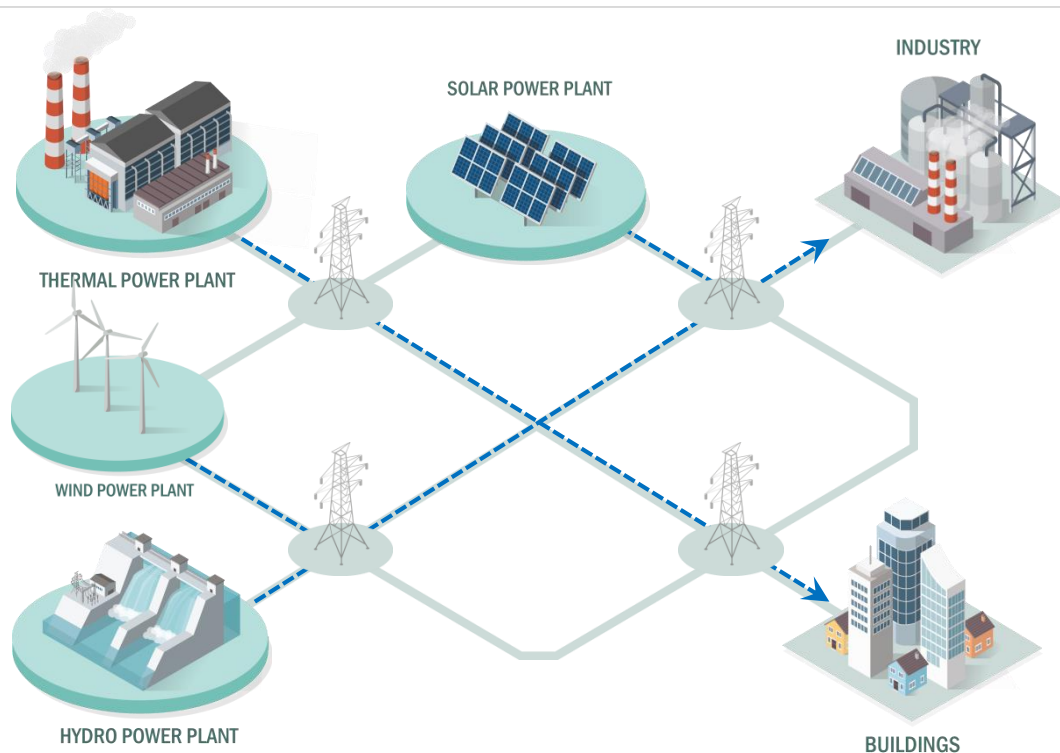
China's Electric Power sector transformation

中国电力行业转型

# Trends in Power Systems

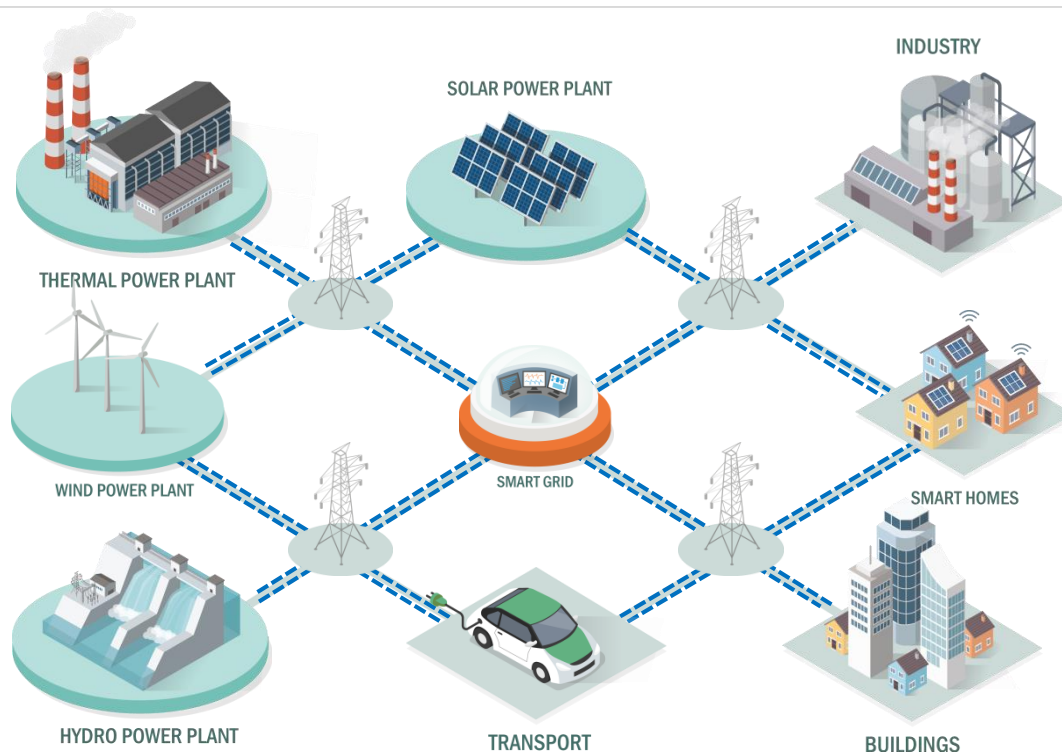
## 电力系统的发展趋势

# The digital transformation of the energy system 能源系统的数字化改造



**Pre-digital energy systems are defined by unidirectional flows and distinct roles**  
数字时代之前的能源系统是由单向流动和不同的角色定义的

# The digital transformation of the energy system 能源系统的数字化改造



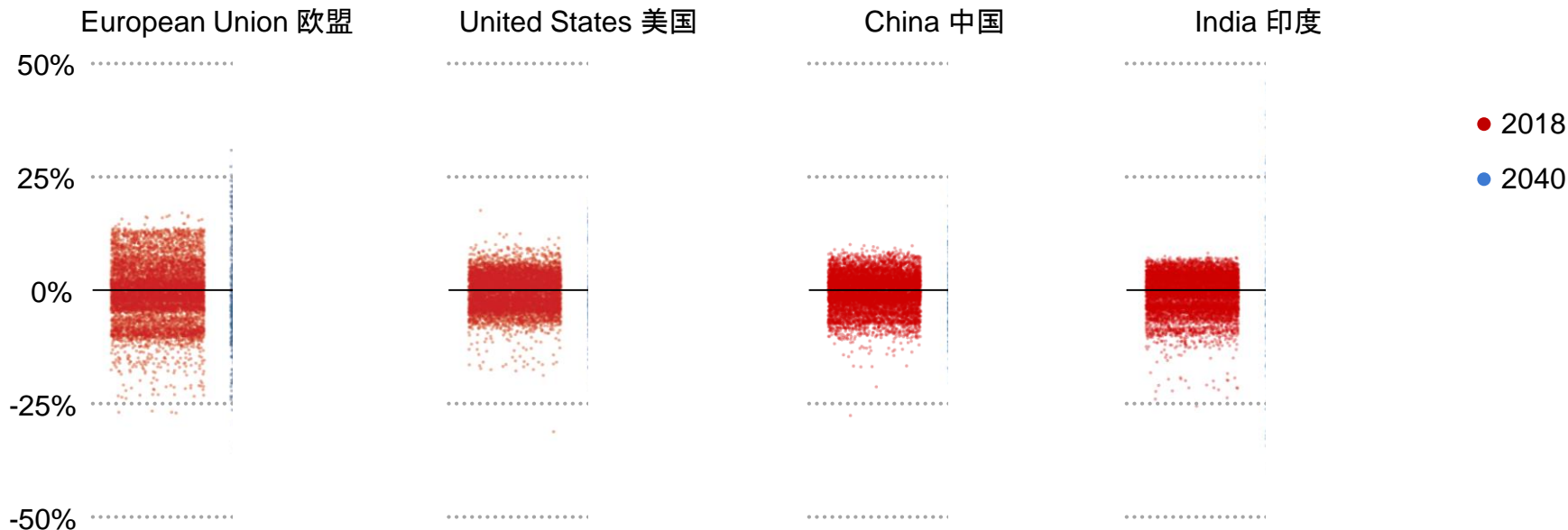
**Pre-digital energy systems are defined by unidirectional flows and distinct roles, digital technologies enable a multi-directional and highly integrated energy system**

**数字时代之前的能源系统是由单向流动和不同的角色定义的，数字技术使多向且高度集成的能源系统成为可能**

# Electricity and flexibility move to the heart of modern energy security

## 电力和灵活性成为现代能源安全的核心

Hour-to-hour adjustments required in power systems due to variability in demand, wind and solar PV, in the Stated Policies Scenario



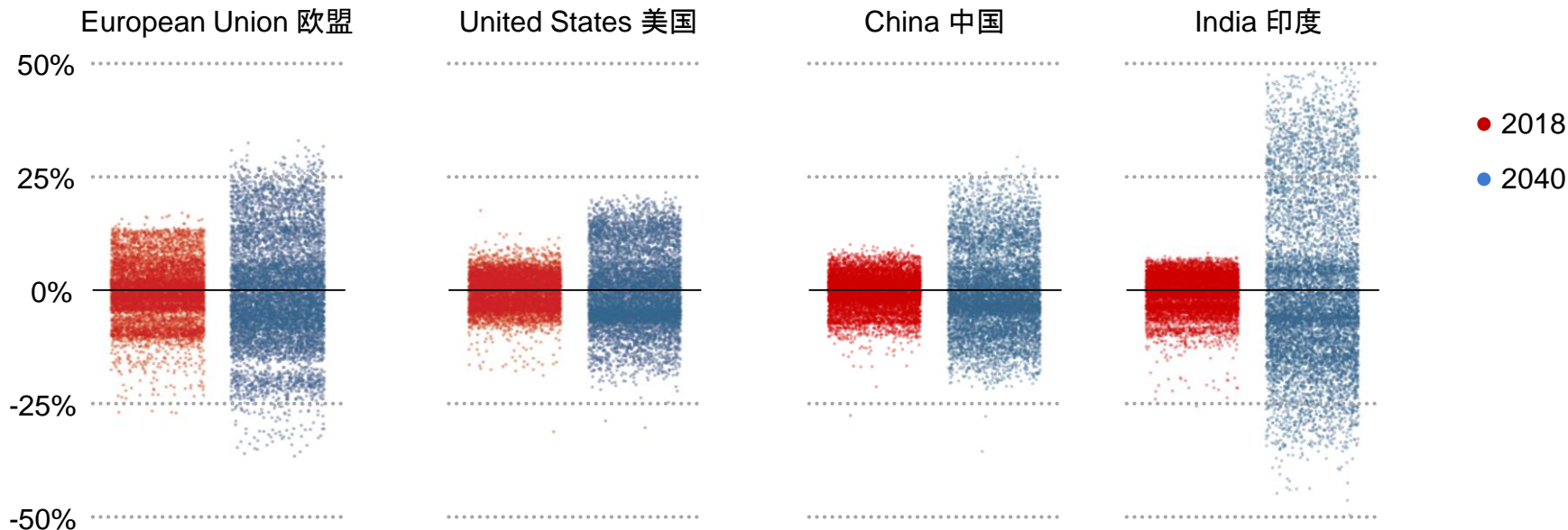
**Flexibility requirements in China is expected to double by 2040. A wide set of distributed flexibility sources, including storage and demand-response will be needed to ensure electricity security**

**到2040年，中国的灵活性需求预计将翻一番。为了确保电力安全，将需要一套广泛的分布式灵活电力来源，包括存储和需求响应**

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2000

2019

6.1 billion 61亿



Population 人口



7.7 billion 77亿

68 trillion 68万亿



GDP 国内生产总值



130 trillion 130万亿

14 PWh 14 千兆瓦时



Electricity use 用电

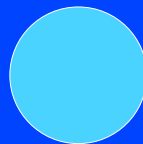


23 PWh 23 千兆瓦时

0.4 billion 4亿



Internet users 互联网用户



4.1 billion 41亿

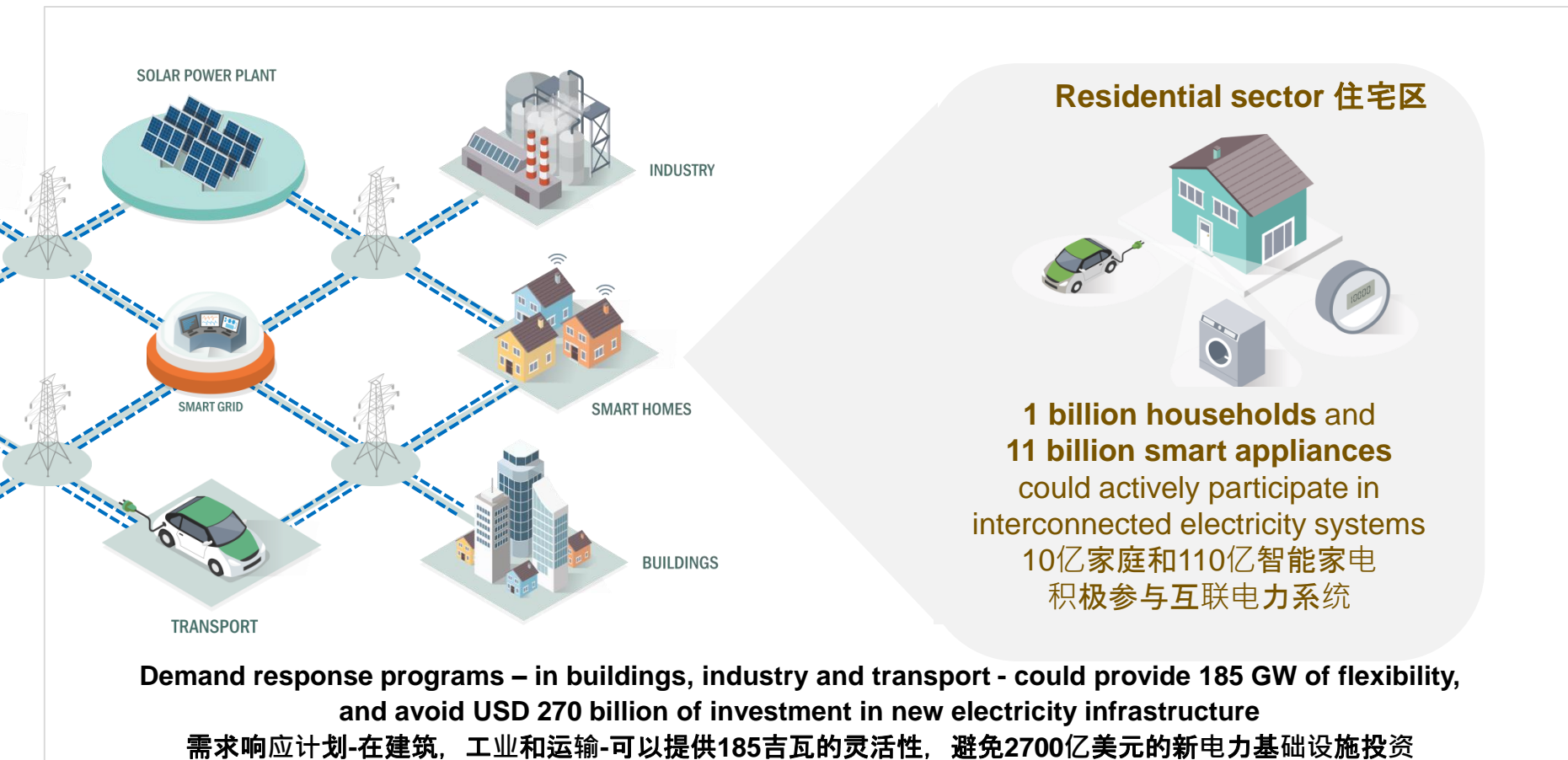
0.9 EB 0.9 艾字节



Internet traffic 网络流量

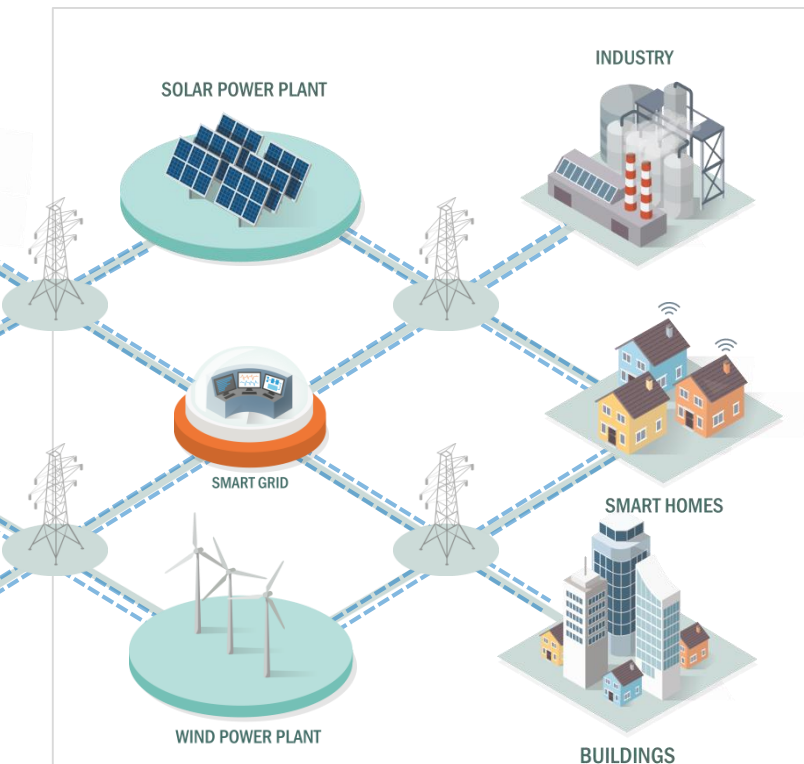
2000 EB 2000 艾字节

Sources: UN (2019), World Population Prospects 2019; World Bank (2020), Data Bank: GDP, PPP (Constant 2017 International \$); IEA (2020), Data and statistics; ITU (2020), Statistics; Cisco (2015), The History and Future of Internet Traffic; Cisco (2018), Cisco Visual Networking Index: Forecast and Trends, 2017–2022

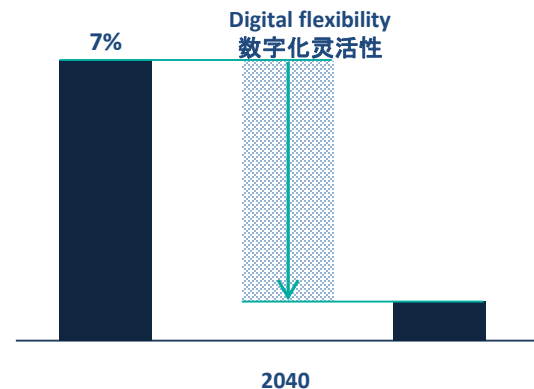




# Integration of variable renewables 整合可变可再生能源

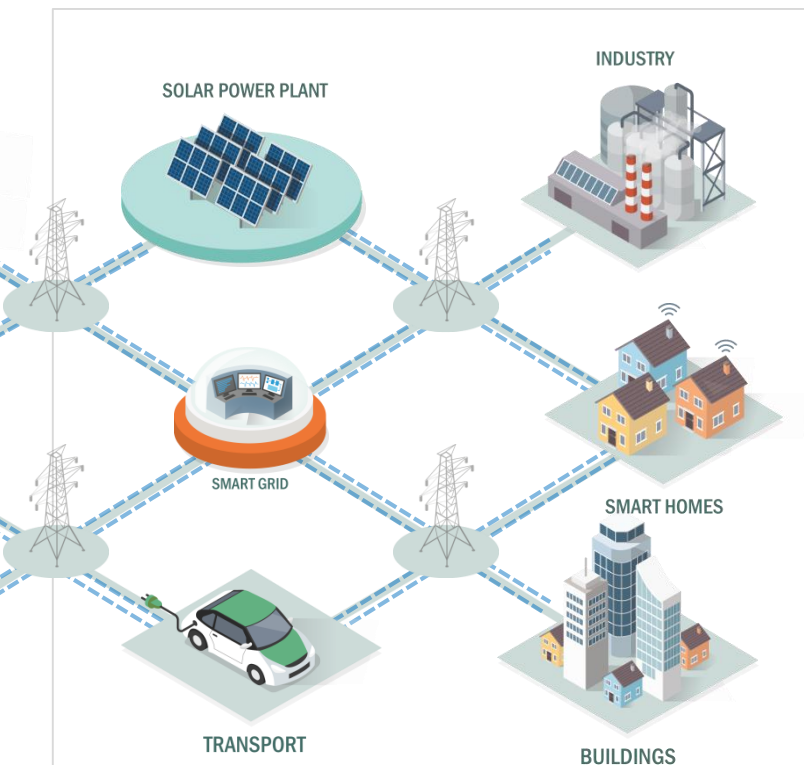


## Curtailment of solar PV and wind 削减太阳能光伏和风电



**Digitalization can help integrate variable renewables by enabling grids to better match energy demand to times when the sun is shining and the wind is blowing**

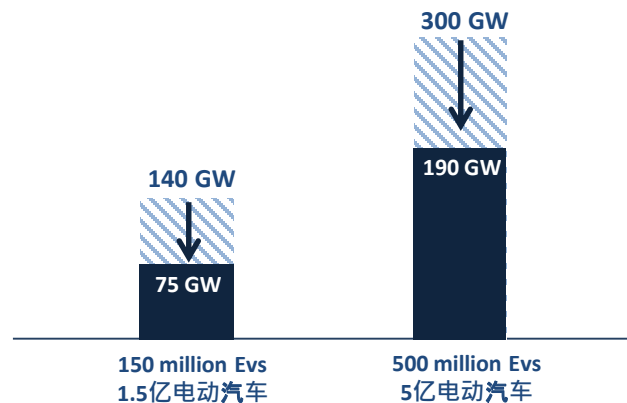
**数字化可以帮助整合可变的可再生能源，使电网能够更好地匹配阳光明媚、起风时的能源需求**



## EVs standard vs smart charging

### 标准充电vs智能充电

Capacity requirement 容量要求



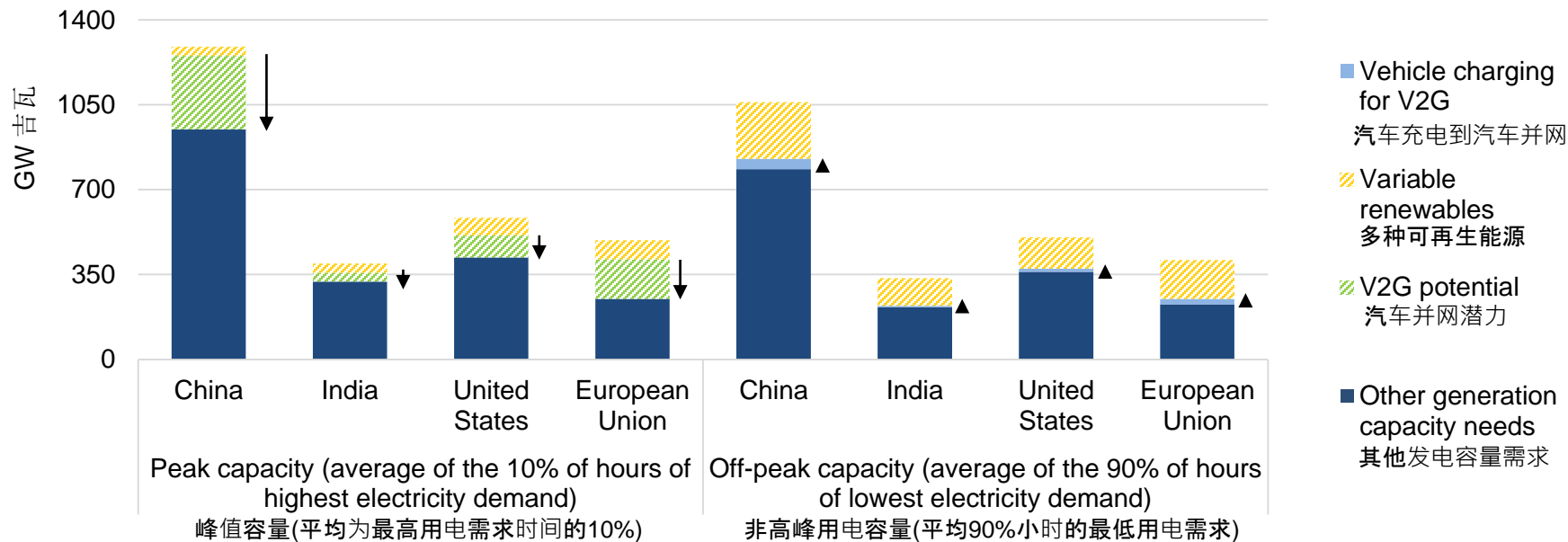
Standard charging  
标准充电  
Smart charging  
智能充电

**EVs smart charging would provide further flexibility to the grid  
saving between USD 100-280 billion investment in new electricity infrastructure  
智能充电将为电网提供更多的灵活性节省1000 - 2800亿美元的新电力基础设施投资**

# EVs hold the potential to be a prominent grid service provider

## 电动汽车有潜力成为卓越的电网服务供应商

Vehicle-to-grid potential relative to total generation capacity, 2030  
(EV deployment of the Sustainable Development Scenario)



**Vehicle-to-grid services could unlock up to 600 GW of flexible capacity in 2030 (distributed across EV markets).**  
**到2030年，汽车并网服务可释放高达600吉瓦的灵活容量(分布在电动汽车市场)。**

# Harnessing demand-response

## 需求响应利用

Digitalisation enables flexibility to be harnessed at affordable costs, and in enough quantity.

数字化使人们能够以可负担的成本和足够的数量利用灵活性。

## Demand Response Capacity 需求反应能力

**4000 TWh**

Theoretical potential in 2020  
4000太瓦时--2020年的理论潜力

**15%**

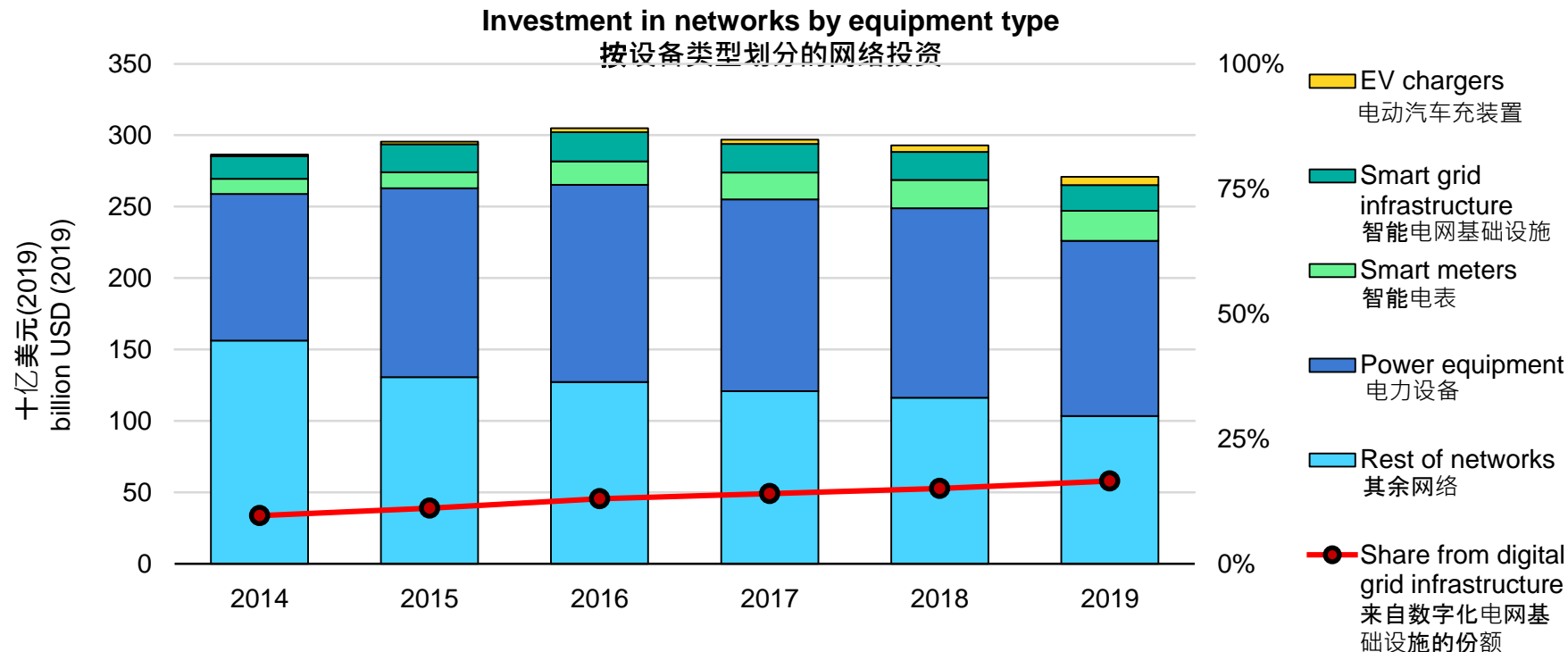
of today's potential is tapped  
如今15%的潜力已被开发

**7400 TWh**

Theoretical potential in 2040  
7400太瓦时--2040年的理论潜力

# Grids transform slowly – but digital is accelerating in many regions

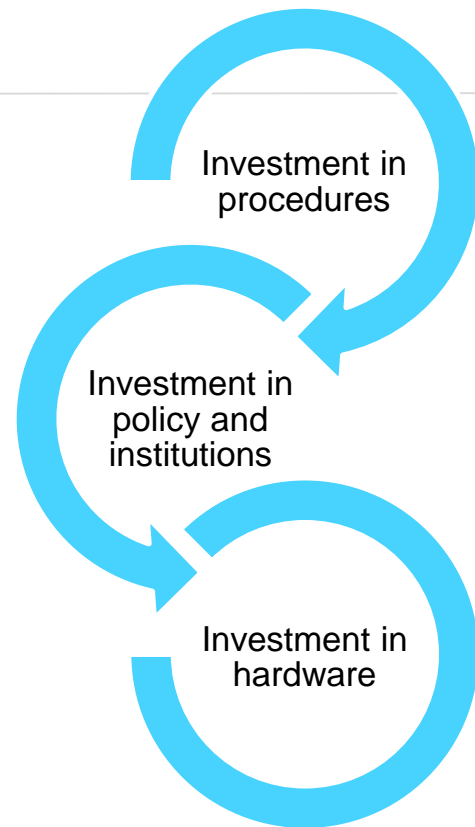
## 电网转换缓慢——但在许多地区，数字化正在加速



Investment in electricity grids is declining ... **but technology is becoming smarter** : Smart meters, utility automation and EV charging infrastructure now make up more than 15% of total spending.

对电网的投资正在减少.....**但技术正在变得更加智能**:智能电表、电力自动化和电动汽车充电基础设施现在占总投资的15%以上。

- Investments in operational procedures
  - Updating current practises (including software enhancement)
  - Use existing technology
  - Updating procedures for new technology
- Investments in policy and institutions
  - Incentivising uptake
  - Tracking of uptake and utilisation (including software)
  - Requirements for new investments
- Investment in hardware: *smart-ready* infrastructure
  - Sensors and Meters
  - Connected appliances



**To yield the benefits of digitalisation,  
procedures, policy and institutions must support hardware**

- Investments in operational procedures 对运作程序的投资
  - Updating current practises (including software enhancement)
  - Use existing technology
  - Updating procedures for new technology
- Investments in policy and institutions 对政策和机构的投资
  - Incentivising uptake
  - Tracking of uptake and utilisation (including software)
  - Requirements for new investments
- Investment in hardware: *smart-ready* infrastructure 对硬件的投资:智能基础设施
  - Sensors and Meters
  - Connected appliances

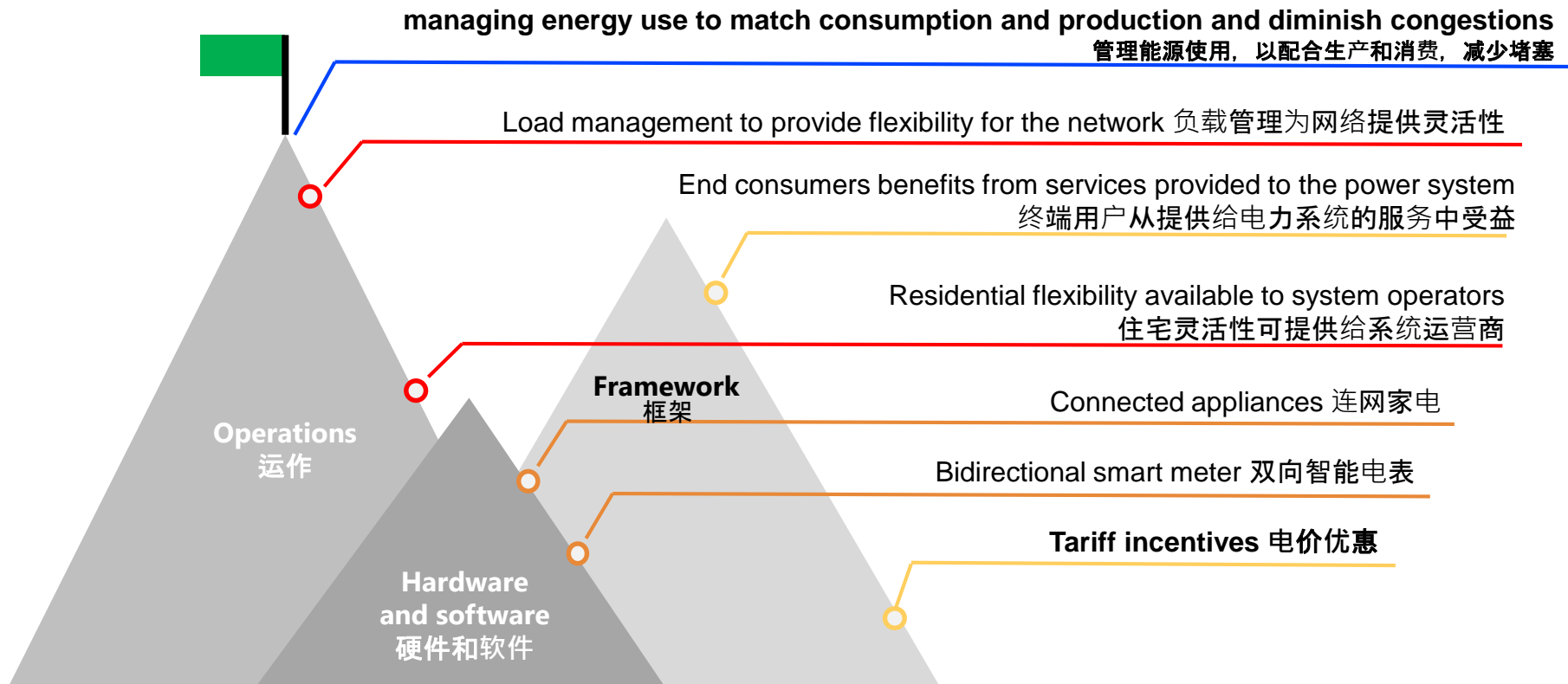


**To yield the benefits of digitalisation, procedures, policy and institutions must support hardware 为了产出数字化的好处，程序、政策和机构必须支持硬件**

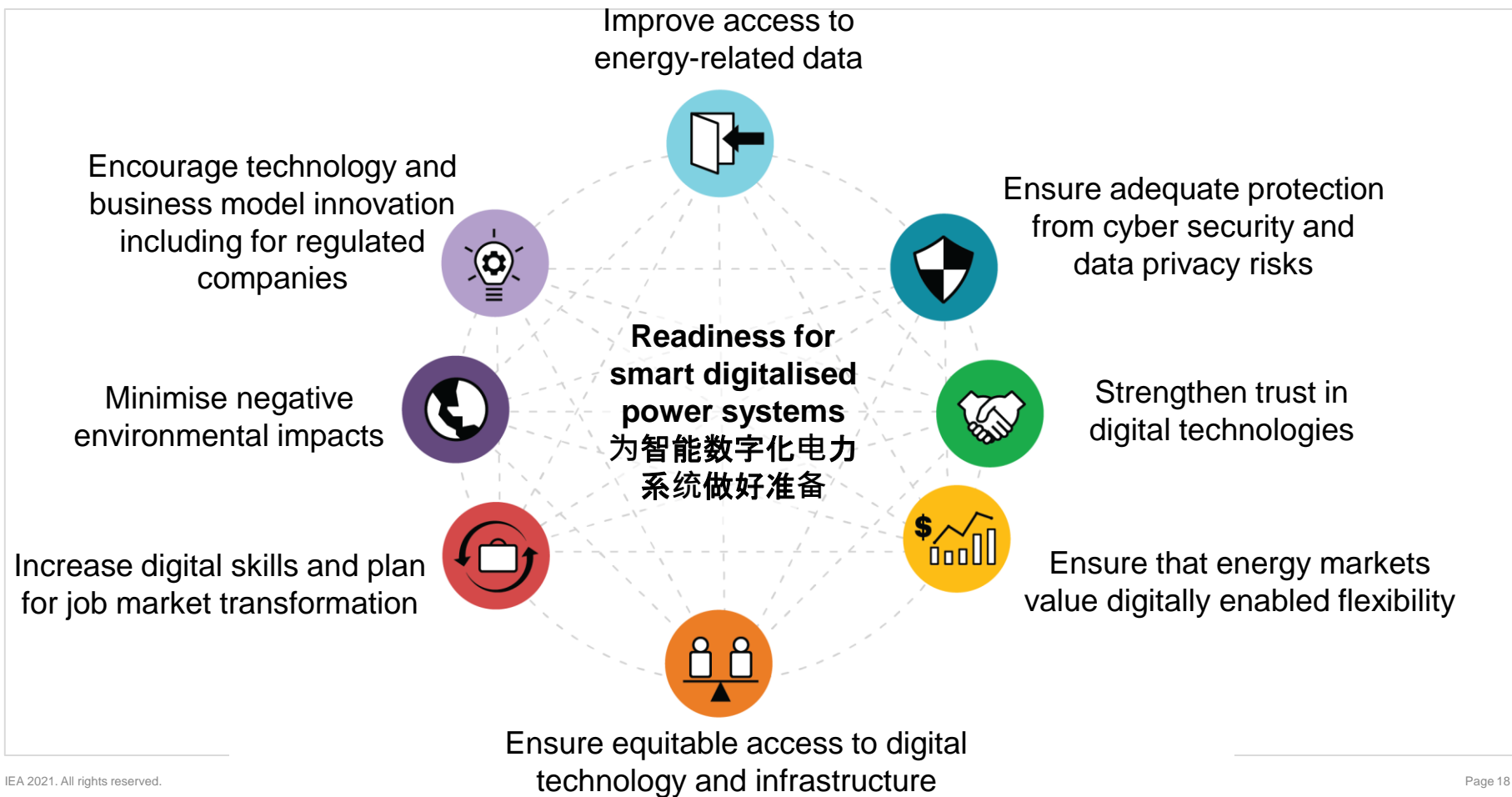


# Application : Capturing flexibility from distributed generation

## 应用:从分布式发电中获取灵活性



# A wide range of policy options are necessary 广泛的政策选择是必要的



## 数字需求驱动的电力网络倡议(3DEN)

- **Aim of the Project** – with the generous support of the Government of Italy, the IEA is providing actionable guidance to policy makers on the policy, regulatory, technology and investment context needed to accelerate progress on power system modernisation and effective utilisation of demand side resources.

项目目标——在意大利政府的慷慨支持下，国际能源署正在为政策制定者提供政策、监管、技术和投资背景方面的可操作性指导，以加快推进电力系统现代化和有效利用需求方资源。

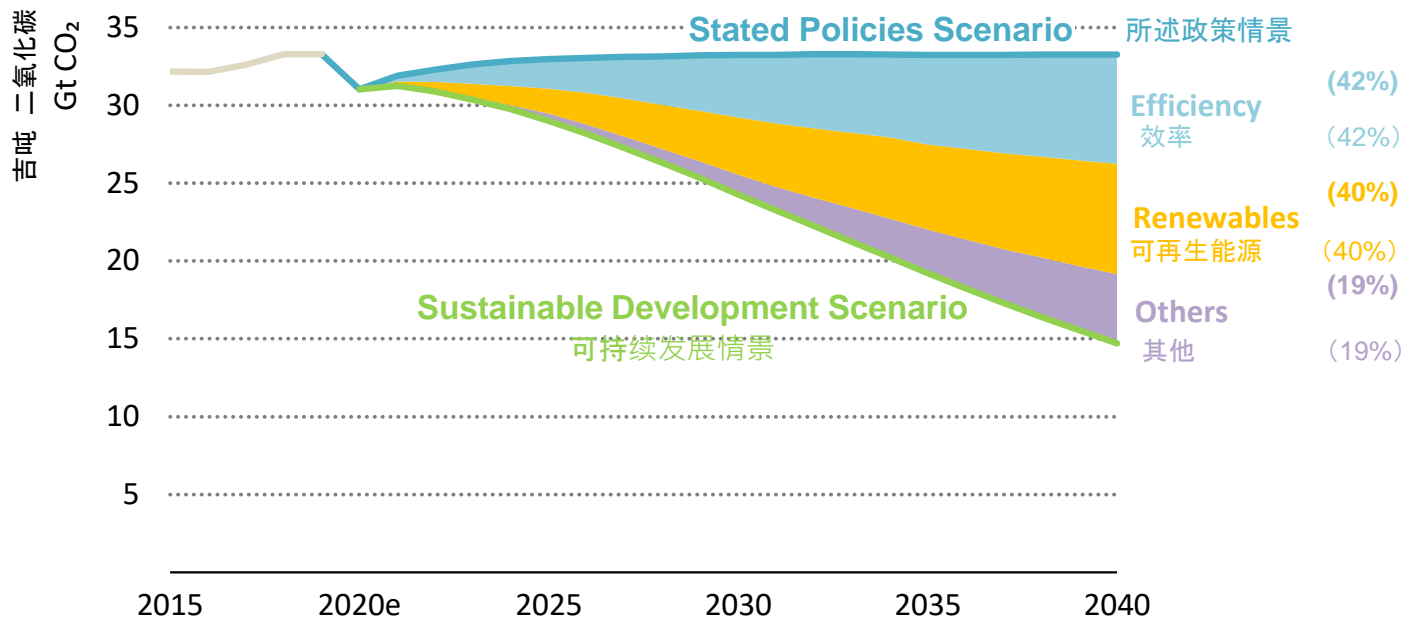
- A consultative expert group is contributing to the project, and advising in further developing project activities 一个咨询专家组正在对该项目作出贡献，并就进一步发展项目活动提供咨询意见
- **Duration:** 2020 – 2023 时长: 2020 - 2023
- **Outputs 结果产出**
  - Inputs into G20 working group 提交给G20工作组的资料
  - Tools and policy guidance documents 工具和政策指导文件
  - Pilot projects assessment guide to demonstrate the benefit digitalisation can bring for power systems 示范数字化给电力系统带来的效益的试点项目评估指南

# Energy efficiency is crucial for achieving global climate goals...

## 能源效率对于实现全球气候目标至关重要.....

CO<sub>2</sub> emissions reductions in the Sustainable Development Scenario relative to the Stated Policies Scenario

可持续发展情景中相对于所述政策情景的二氧化碳排放量减少



Energy efficiency is expected to contribute over 40% of energy sector GHG abatement up to 2040.

A slowdown in energy efficiency today lessens the chance of meeting long-term climate goals.

预计到2040年，能源效率对能源部门温室气体减排的贡献将超过40%。今天，能源效率的减速降低了实现长期气候目标的机会。

**Regulations**  
规定

**Information**  
信息

**Incentives**  
奖励

