IRENA INNOVATION WEEK 2023

Power systems of the future

Infrastructure requirements for widespread electrification

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25 September 2023 • 13:30-15:00 CEST

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Introductory remarks

Dr Huafeng YAN
Chairman
CEPRI (SGCC)

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Scene-setting presentation

Dr Asami MIKETA
Head of Energy Transition Planning and Power Sector Transformation
IRENA Innovation and Technology Centre

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Insights on electrification: innovation and smart infrastructure strategies

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The urgency of the energy transition

Energy transition is driven by:

- Low-cost renewable power
- Innovation
- Decarbonisation of energy sectors
- Security of energy supply and affordability

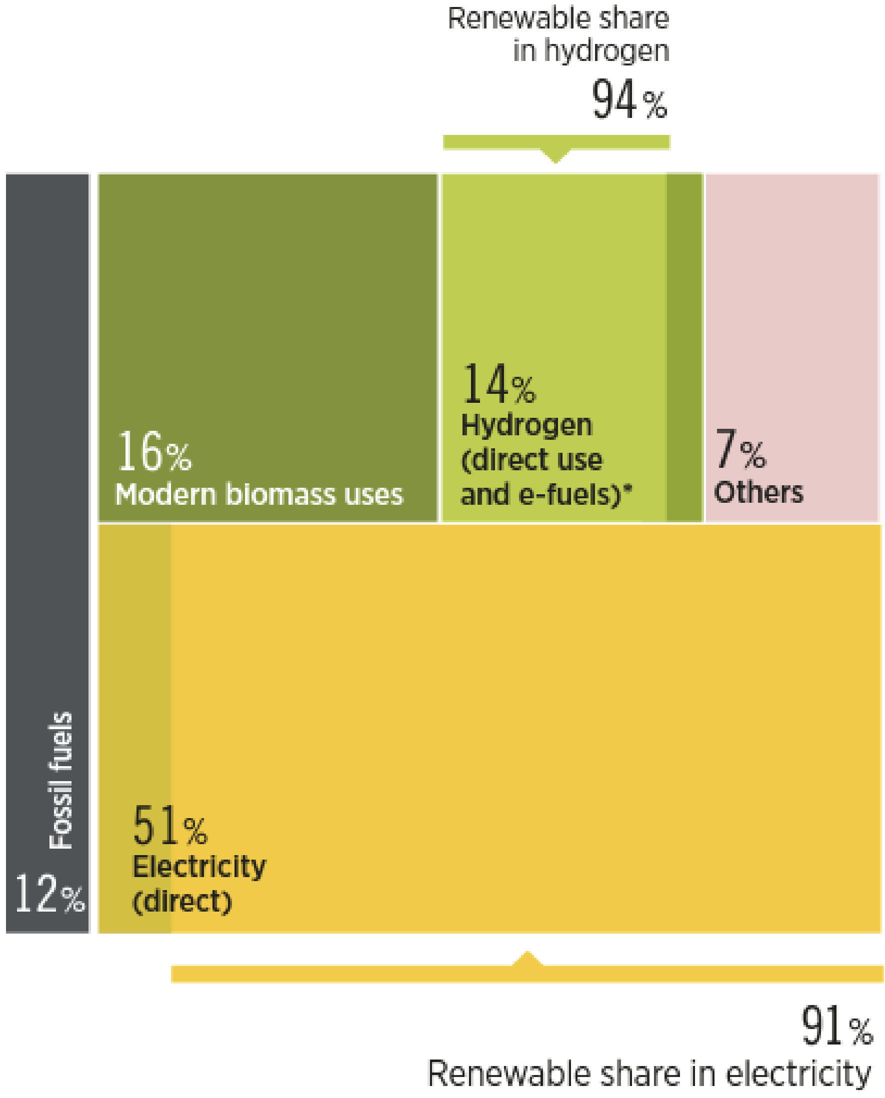
In 2050, 1.5 Scenario sees:

51% of TFEC – Direct electrification

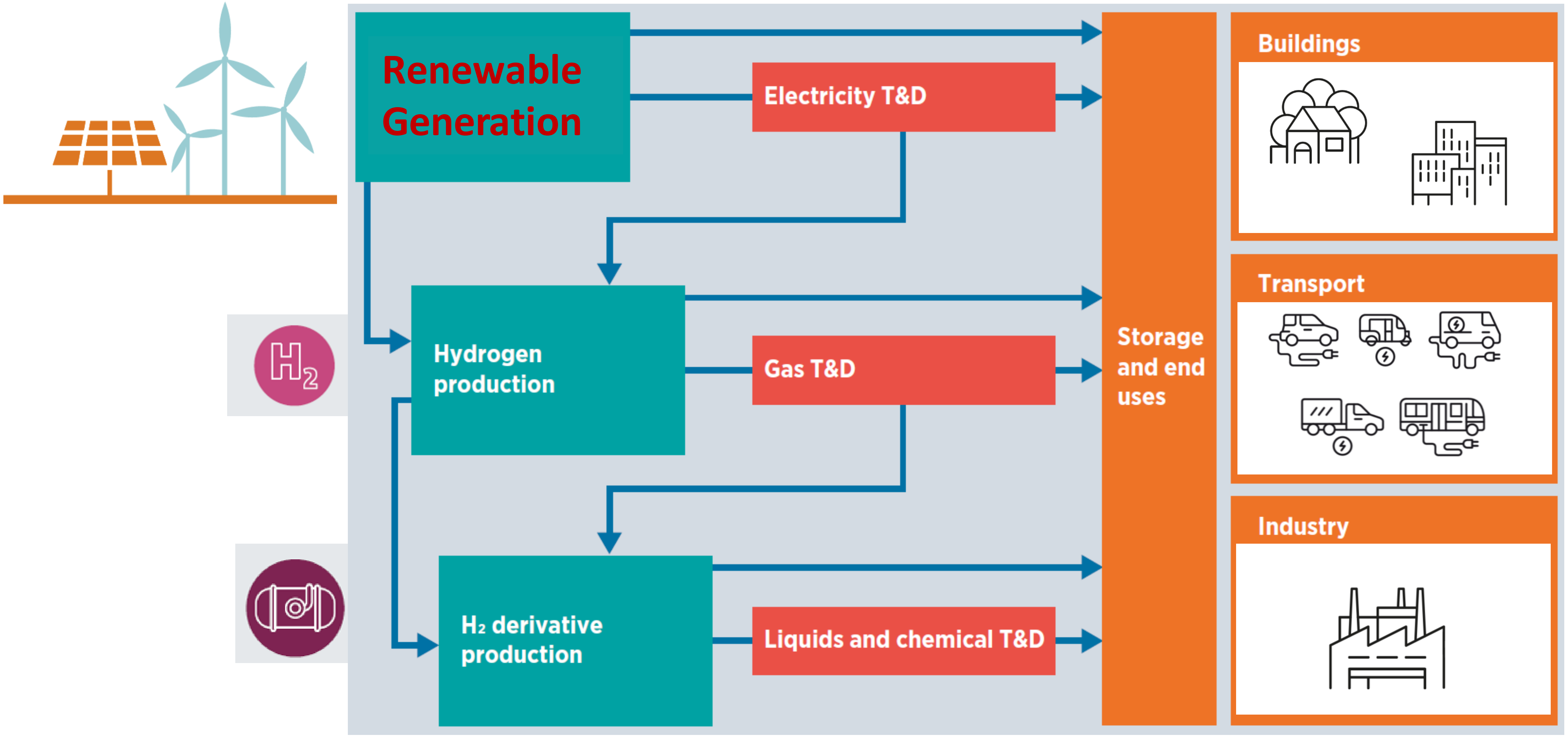
14% of TFEC – Indirect electrification

11 times RE generation compared with 2020

Total final energy consumption(TFEC)
1.5°C Scenario for 2050



What are the implications for the infrastructure?



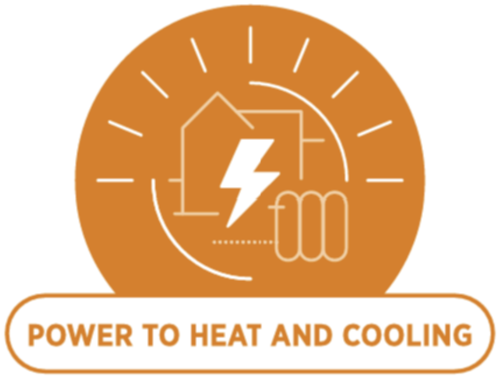
Smart Electrification – key for infrastructure planning

- **Smart management of demand**
- **Creating flexibility**
- **Strategic siting**

What enables smart electrification strategies? → Innovation!

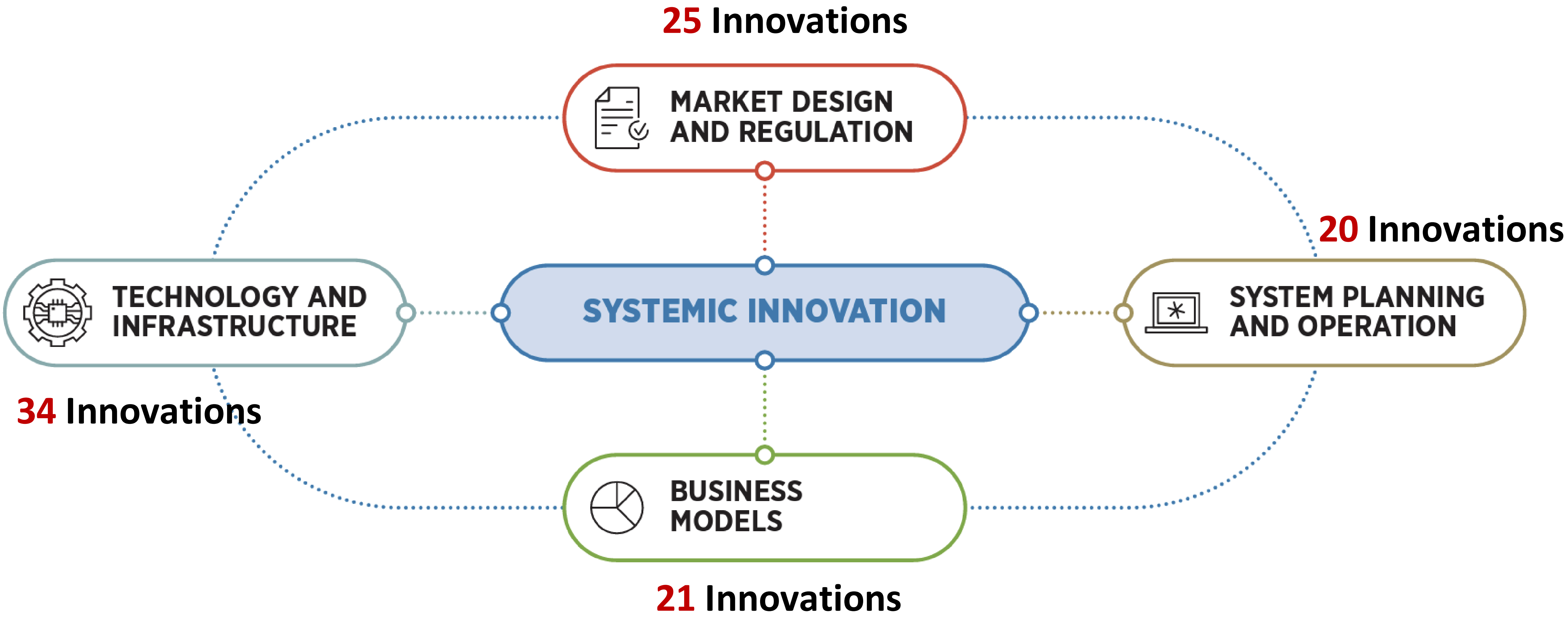
Innovation landscape for smart electrification

- The toolbox includes 100 innovations in that can play a role in transforming and decarbonising the energy use sector with smart electrification strategies



- There is no “one-size-fits-all” solution for smart electrification

Innovations go beyond technologies



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POWER TO MOBILITY

TECHNOLOGY AND INFRASTRUCTURE

Electric vehicles

- **1** EV model evolution
- **2** EV batteries
- **3** Battery recycling technology

Charging infrastructure

- **4** Diversity and ubiquity of charging points
- **5** Wireless charging
- **6** Overhead charging
- **7** Portable charging stations
- **8** V2G systems

Digitalisation

- **9** Digitalisation for energy management and smart charging
- **10** Blockchain-enabled transactions

Power system enablers

- **11** Smart distribution transformers

MARKET DESIGN AND REGULATION

Electricity market design

- **13** Dynamic tariffs
- **14** Smart charging for local flexibility
- **15** Smart charging for system flexibility

Regulation for charging infrastructure

- **16** "Right to plug" regulation
- **17** Streamlining permitting procedures for charging infrastructure
- **18** Standardisation and interoperability
- **19** V2G grid connection code

SYSTEM PLANNING AND OPERATION

Strategic planning

- **20** Cross-sectoral co-operation and integrated planning
- **21** Including EV load in power system planning
- **22** Grid data transparency
- **23** Clean highway corridors

Smart operation

- **24** Operational flexibility in power systems to integrate EVs
- **25** Management of flexible EV load to integrate VRE

BUSINESS MODELS

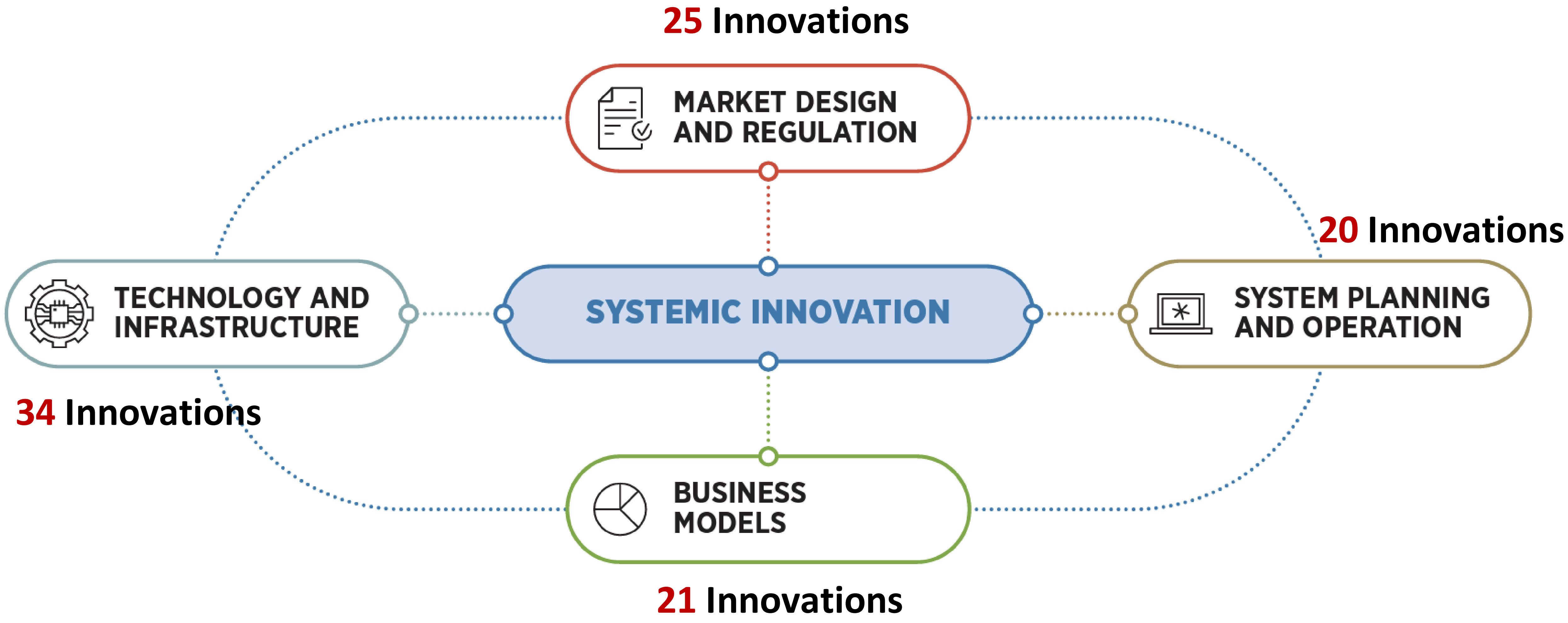
Services for the power system

- **28** EV aggregators
- **29** Shaving of EV peak loads using DERs
- **30** Battery second life and end-of-life reuse

Models to enable EV deployment

- **31** EV charging as a service
- **32** Electric mobility as a service
- **33** Ownership and operation of publicly available charging stations
- **34** A single bill for EV charging at home and on the go
- **35** Battery swapping

A smart electrification strategy requires systemic innovation



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Thank you!

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Scene-setting presentation

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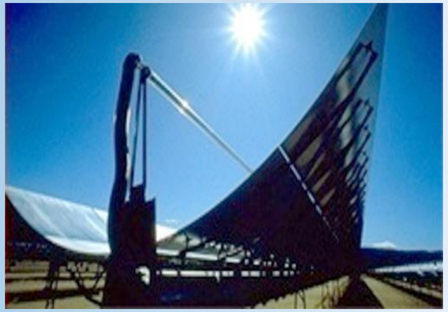
Challenges & Key Technologies of New Type of Power System (NTPS)



Li Bo IEC TC 122 Chair

China Electric Power Research Institute

25 September, 2023

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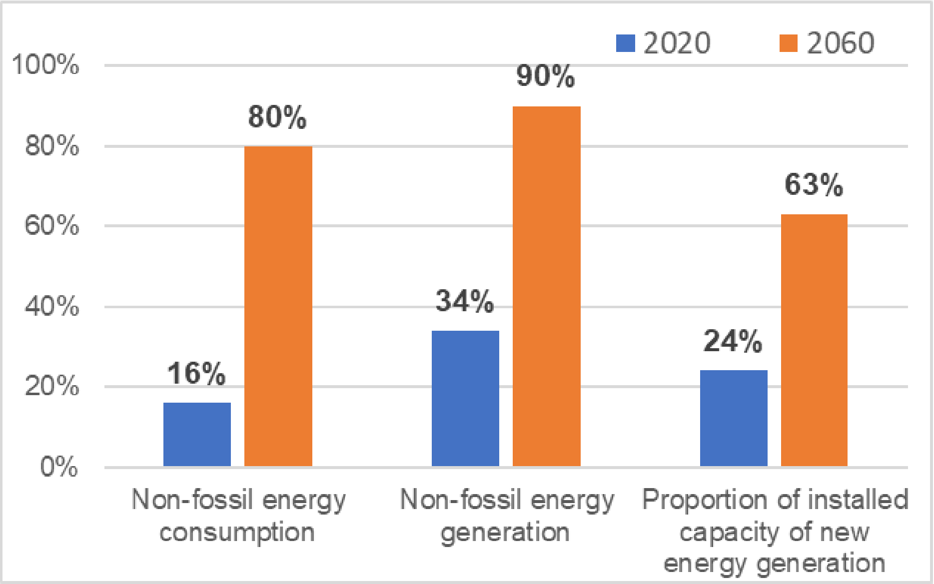
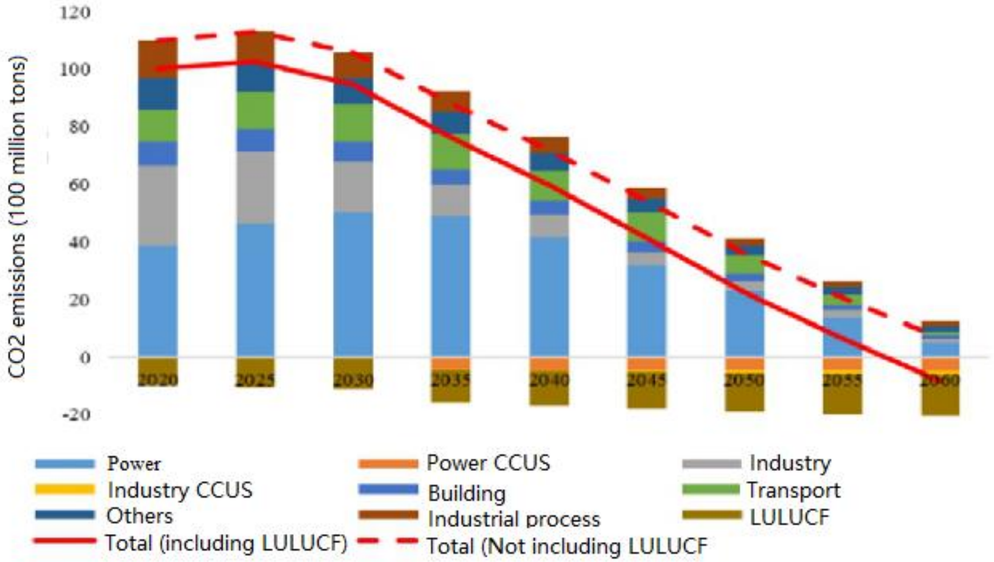
Proposal of New Type of Power System

- It is proposed to build a **New Type of Power System (NTPS)** based on renewable energy (RE) in 2021.
- Aiming to secure energy security, NTPS takes the construction of a high proportion of renewable energy supply and consumption system as the core task. Building NTPS is a vital way to develop non-fossil energy and replace fossil fuels for RE.



Projected non-fossil energy consumption and power production in China

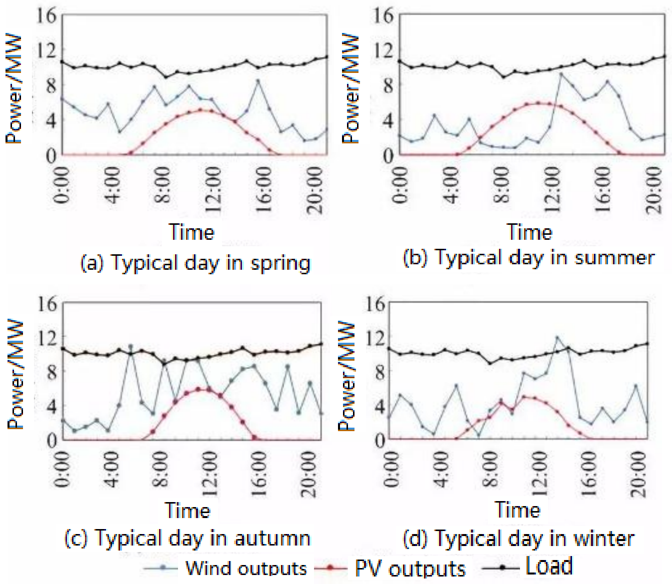


Forecast of CO_2 emissions in China

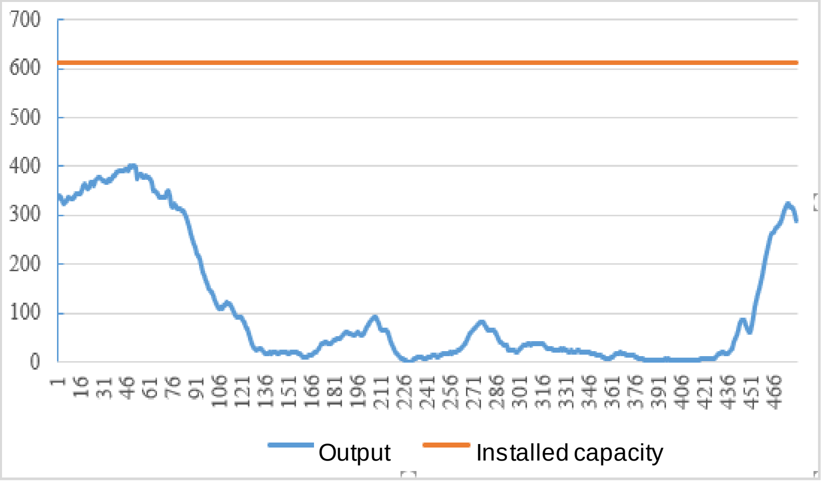
Challenge I – Balancing power and production

Strong randomness and fluctuation of wind and PV outputs and increasing peak loads challenge the real-time balancing of source and load.

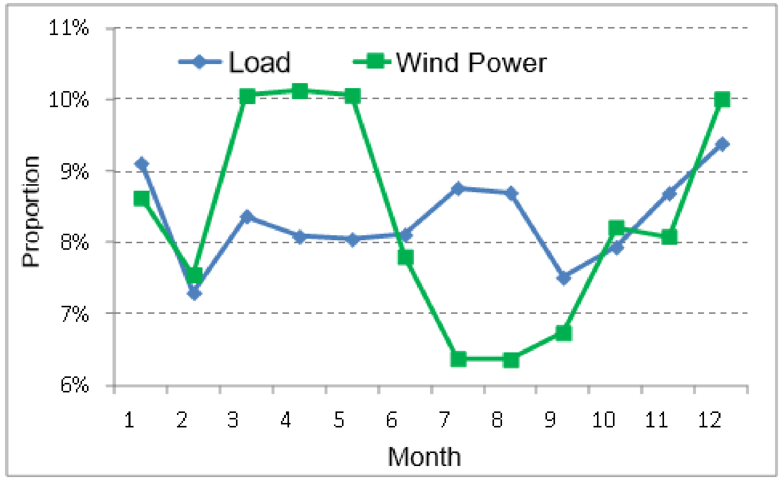
- Prominent contradiction between supply and demand in extreme weather.
- Seasonal mismatch between RE generation and power consumption.



RE output fluctuates randomly with increasing fluctuation range



Provincial wind power output for a week

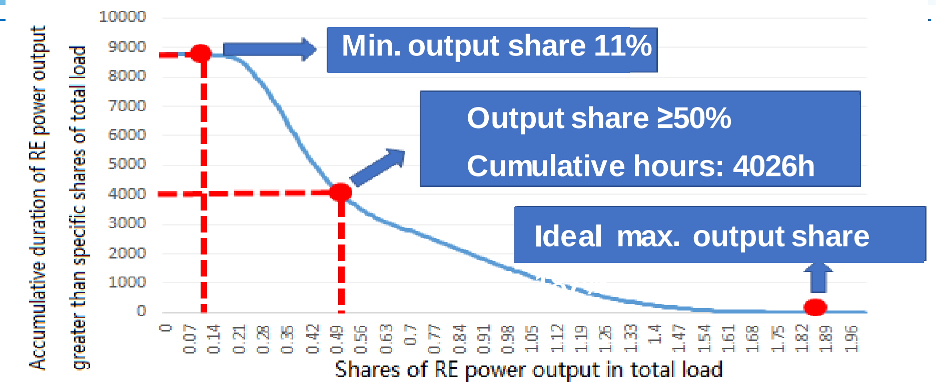


Comparison between wind power production and load consumption

I Challenges of New Type of Power System under Energy Transition

Challenge II - System security & stability

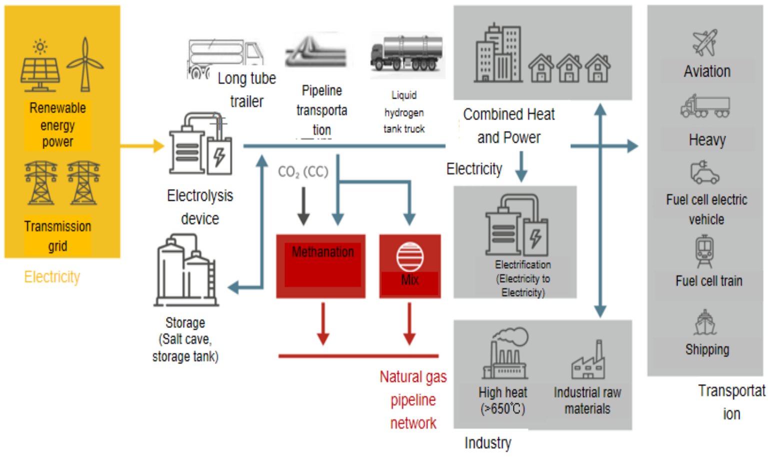
Due to weak support of RE for system frequency and voltage, **system security and stability risks will increase significantly when RE penetration reaches a certain level**.



Accumulative duration of RE power outputs greater than or equal to specific shares of total loads in 2060

Challenge III - Deep decarbonization of energy and electricity

- Other industries may transfer carbon emission pressure to power industry through electrification in future.
- **Negative carbon technologies such as CCUS** are required for carbon neutral. **RE-based hydrogen production technology** will be promoted.



Integrated utilization of electricity and hydrogen

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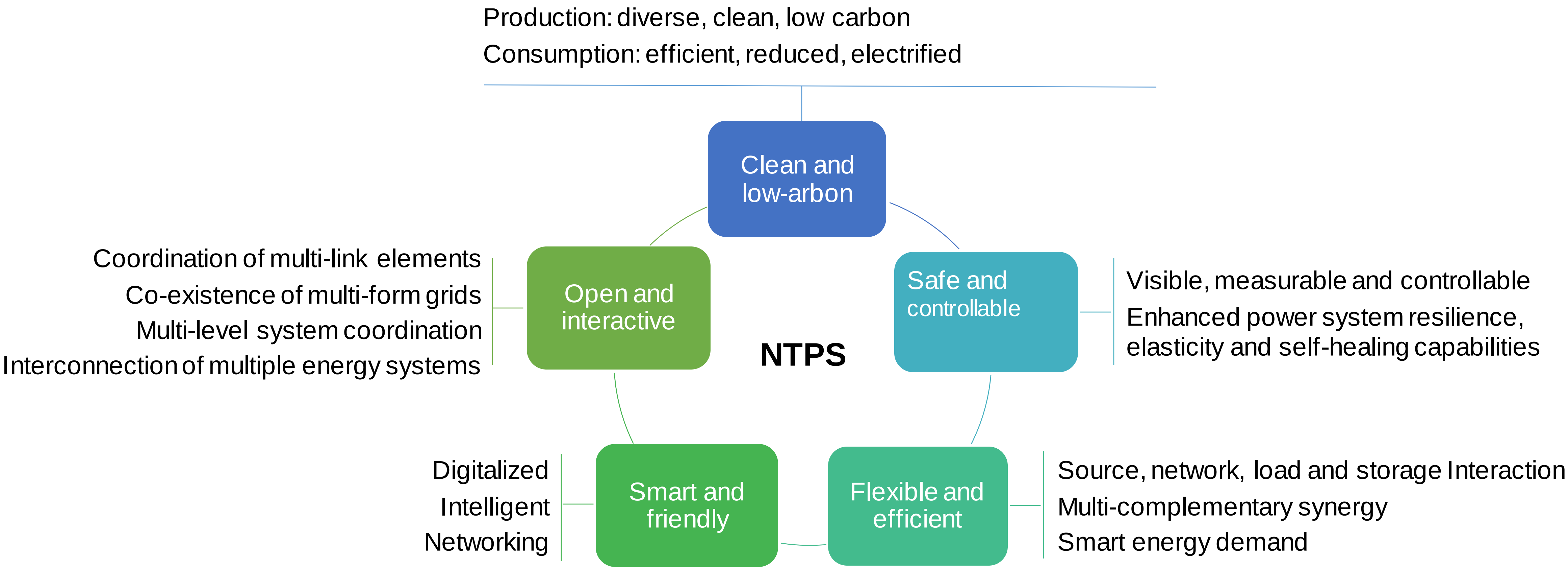
Characteristics of NTPS

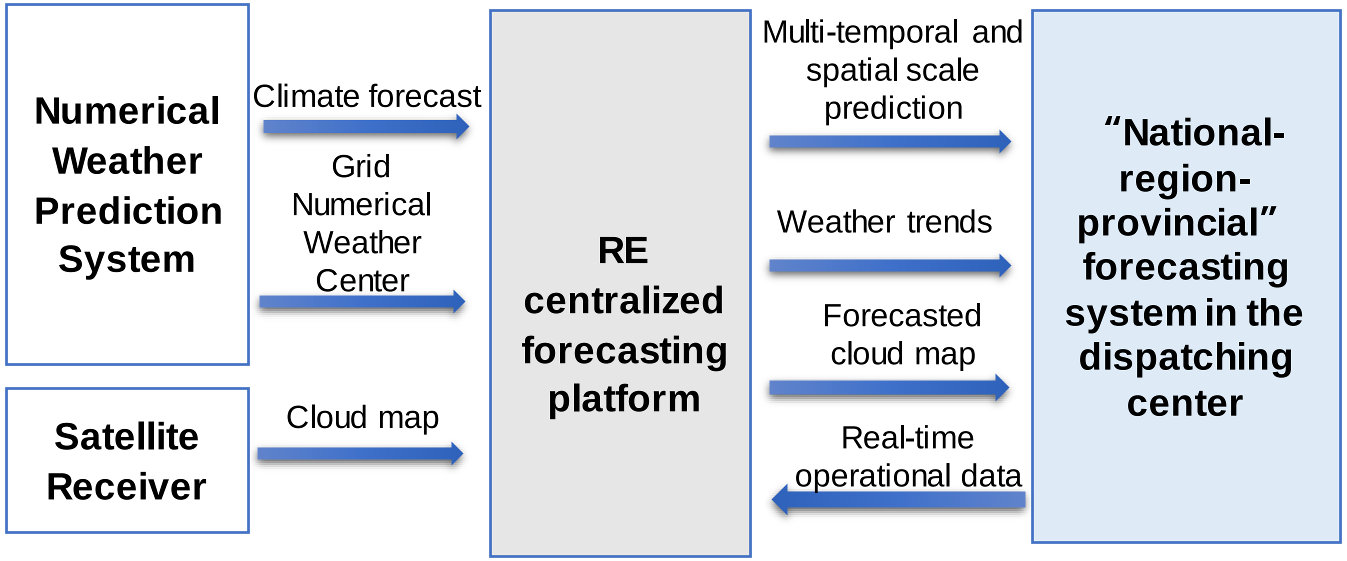
NTPS will strongly support energy transition and climate goals, with profound new changes to **generation mix, load characteristics, grid structure, technical foundation and operational features.**



RE Forecasting

- Based on the advanced meso-scale Numerical Weather Prediction (NWP) and Weather Research and Forecasting (WRF) models, with Real-time Data Assimilation and Rapid Update Cycle, CEPRI developed a **customized NWP system for electric power meteorology**.
- Established the user-oriented centralized forecasting and distribution mechanism, realized the two-way data interaction with the forecasting system at dispatching side.

Modelling-forecasting integrated platform



VSC-HVDC & flexible low-frequency transmission

- Zhangbei VSC-HVDC power grid demonstration project, the first DC project collecting and transmitting a variety of RE power, put into operation in June, 2020.
- China's first flexible low-frequency power transmission demonstration project, State Grid Zhejiang Taizhou 35kV flexible low-frequency power transmission project, put into operation in June, 2022.

Zhangbei four-terminal VSC-HVDC power grid wiring diagram

Taizhou 35kV multi-terminal flexible low-frequency power transmission demo project

Ultra High Voltage(UHV) transmission practices

- By 2022, State Grid had 250GW trans-provincial and trans-regional power transmission capacity.
- Total trans-provincial and trans-regional power transmission capacity of State Grid is expected to reach 300GW in 2025, and 370GW in 2030.

RE Bases in Gobi and other desert areas

- Deserts, gobi and sand areas, with abundant wind and PV energy, covers 2.61 million km^2, accounting for 27 percent of China's land area. China plans to build comprehensive bases for generating power with solar and wind energy with installed capacity of 455 GW by 2030.

Typical technical parameters of UHV DC projects in China

Voltage level/kV	Capacity /GW	Projects	Other Information
±800	5	Yun-Guang	LCC DC
	6.4	**Xiang - Shang**	
	7.2	**Jin-Su**	
	8	**Ha-Zheng, etc.**	
	8	Wudongde-Guangdong-Guangxi	LCC-VSC Hybrid DC
	8	**Baihetan-Jiangsu**	LCC-VSC Hybrid Cascaded DC
	10	**Zhalute-Qingzhou, etc.**	LCC DC
±1100	**12**	**Zhundong - Wannan**	LCC DC

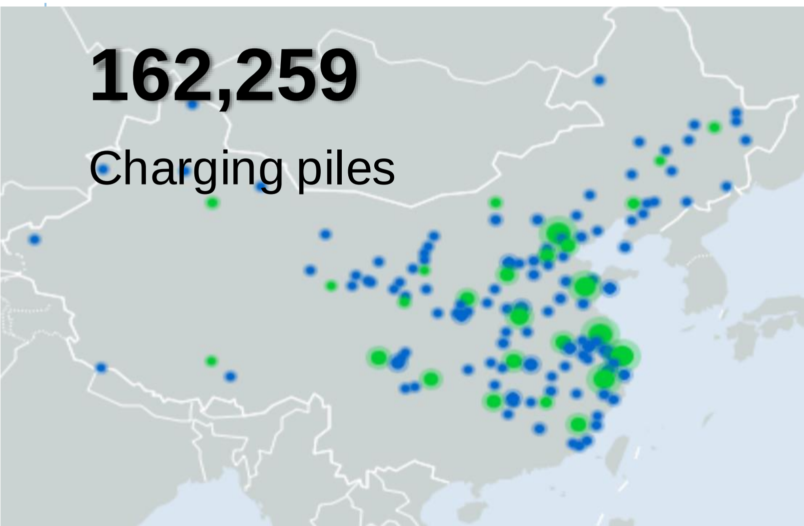
Inner Mongolia PV sand control project

Intelligent Internet of Vehicles Platform & innovation

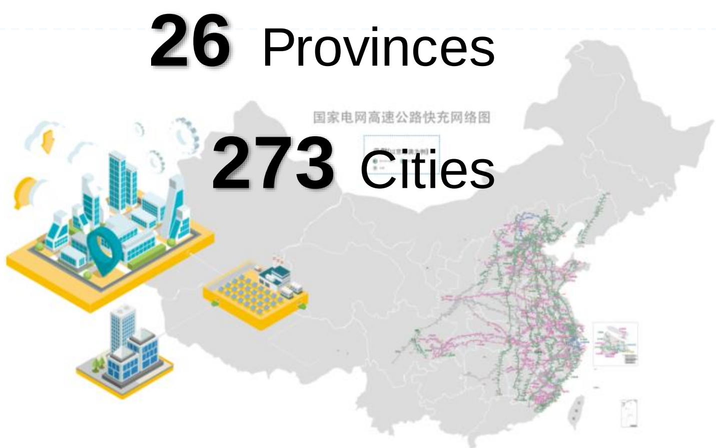
- **By 2022, a total of 13 million new energy vehicles(NEVs) were registered in China, including 10.45 million EVs.** Platform offers services to 11 million users in 26 provinces of China, with access to over 1200 operators and 1.7 million charging piles, accounting for 90% of China's public charging piles.

Energy storage

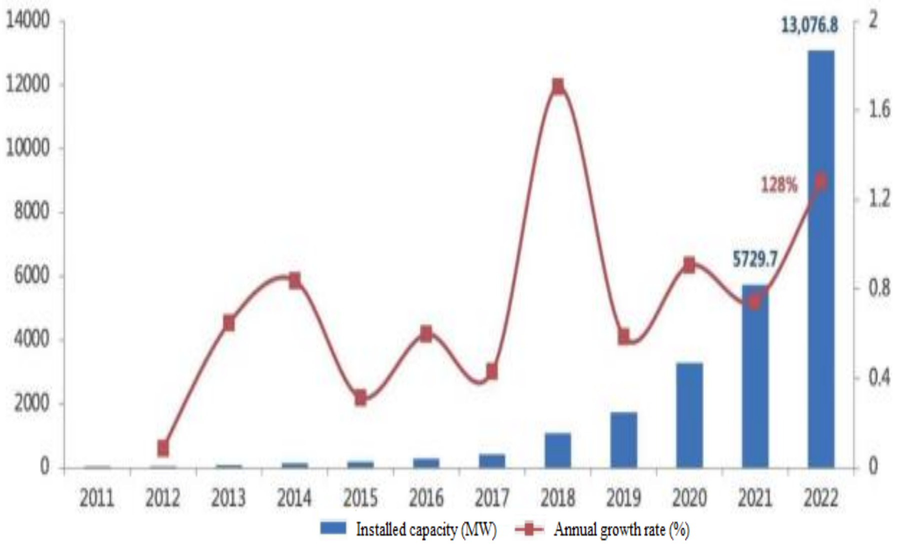
- New type of energy storage has been growing explosively. **By 2022, the cumulative installed capacity had reached 13.1GW/27.9GWh, with an annual growth rate of 128**



EV urban charging network



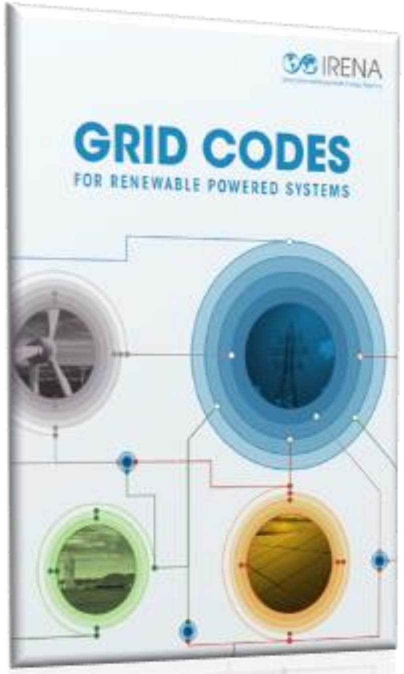
Expressway charging network



Accumulated installed capacity of China's new type of energy storage market (2000-2022)

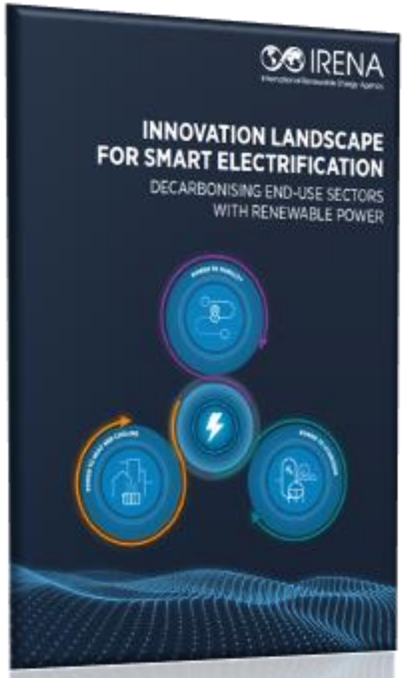
Reports launched by IRENA Innovation and Technology Centre (IITC)

- In 2022, IITC launched Report on ***Grid Codes for Renewable Powered Systems***, which contains the latest developments and good practices to develop grid connection codes for power systems with high shares of variable renewable energy – solar photovoltaic and wind.
- In 2023, IITC launched Report on ***Innovation Landscape for Smart Electrification***, which maps 100 innovative solutions for smart electrification of end-users using renewable power.



Grid Codes for Renewable Powered Systems

Informative & Instructive



Innovation Landscape for Smart Electrification

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Cooperation Proposal

- **Call on collaboration on investigation and research to jointly tackle key problems in core technological development.**

- **Share experience of successful practices, and jointly develop landscapes, roadmaps, codes, standards, etc.**

- **Encourage collaboration among different international organizations, power utilities and research institutions.**

Thank you for your attention!

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Scene-setting presentation

Norela Constantinescu
Head of Innovation
ENTSO-E

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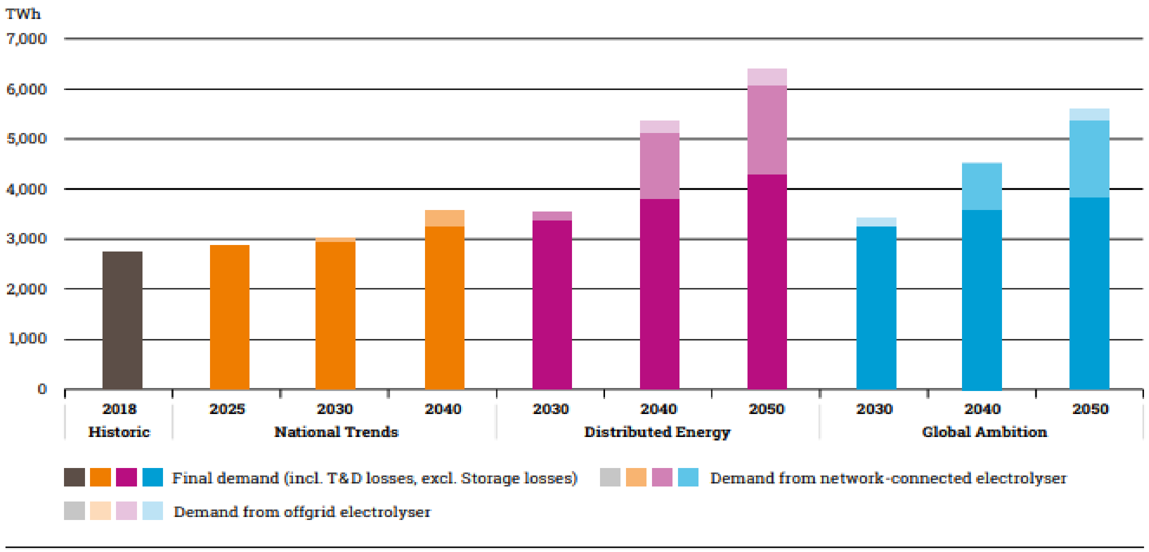
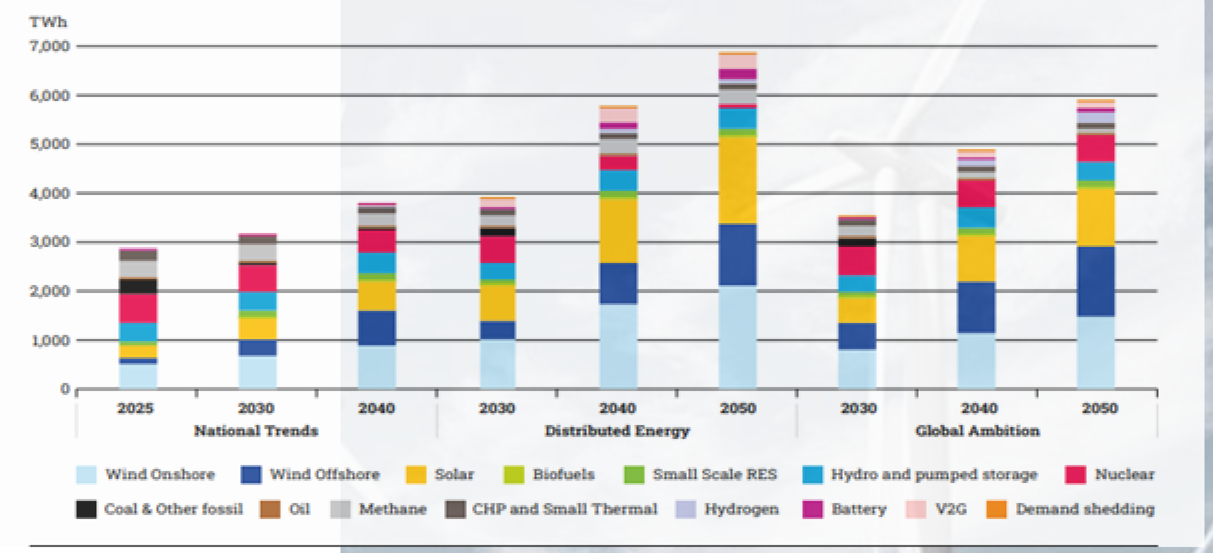
Electrification: preparing the future

Carbon neutral Europe: Electrified end uses weather dependent energy supply



TYNDP 2022 Electricity demand for final uses and electrolysers



ENTSO-E TYNDP 2022 Power generation mix

System Perspective is equally important and complements the **Technology/Solutions perspective**

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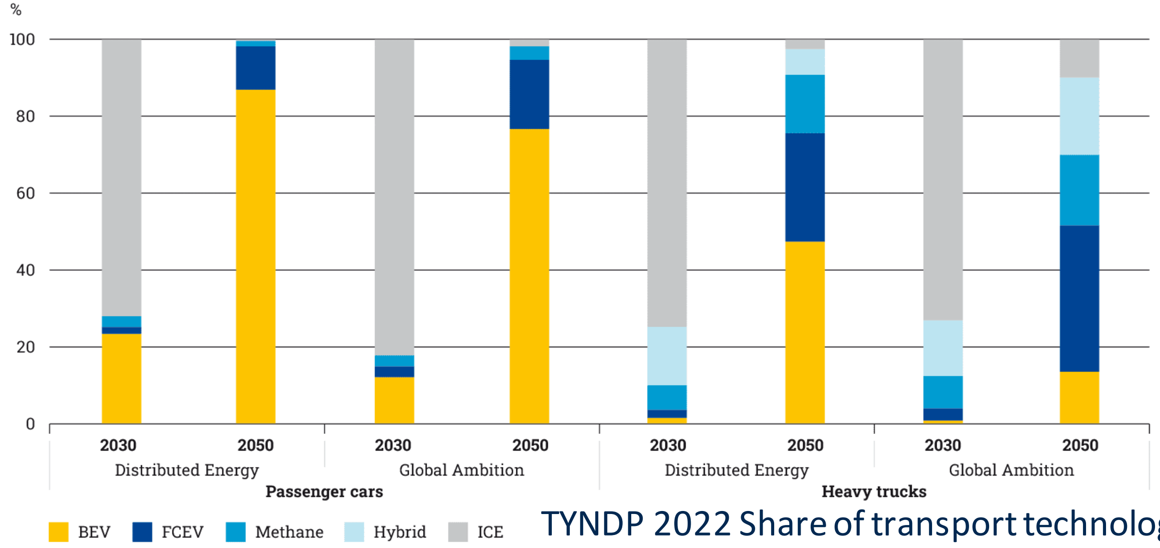
Electromobility: Fast acceleration, system needs to keep up with the pace



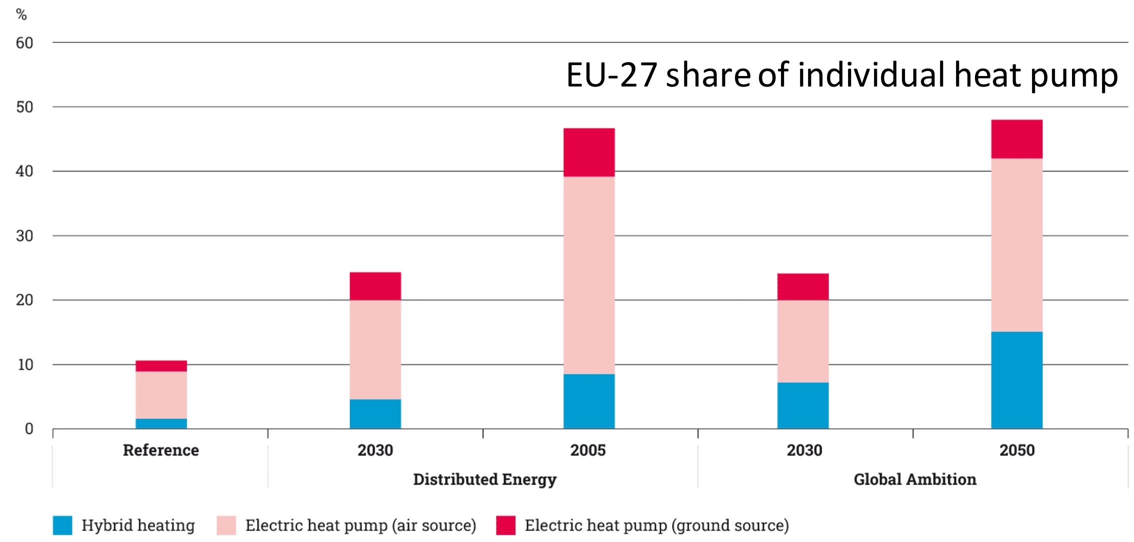
TYNDP 2022 Share of transport technologies for EU27

By 2030

- eVs: **2-4%** of **European final electricity consumption** and power peak issue if smart charging and V2G are not applied
- public, local and regional buses and trucks: **1-2% of European final electricity consumption** and **5% of peak power load** with 80% of charging in depots, the rest in opportunity charging nodes
- Long haul trucks still uncertain (BEV or FCVE): recharging stations along European roads and highways with **capacities >10MW**
- **TSOs projects** : GreenSwitch (ELES) and Speed-e (REN),

New ecosystem to be enabled, focused on consumer needs, envisage **coordinated planning** (load and its profile), **grid operation** (power peaks, high variability), **system operation** (flexibility requirements), **updated market and regulatory frameworks** combined with the use of **digital solutions**

Heating & Cooling: Flexibility potential with challenges to overcome



- **Electricity demand for heating and cooling** will increase based mainly on Heat Pumps deployment
- **Potential to provide flexibility** to the electricity system e.g. balancing services and congestion management, thermal storage …
- …. But some **challenges:**
  - **Upfront costs** and barriers hinder widespread adoption
  - **Lack of regulatory framework** for H&C technologies
  - **Retrofitting of existing units** and incentivizing the use of RES in H&C
  - Very **different starting points** across EU

Multi-sector coordination between system operators, aggregators, District Heating companies is needed

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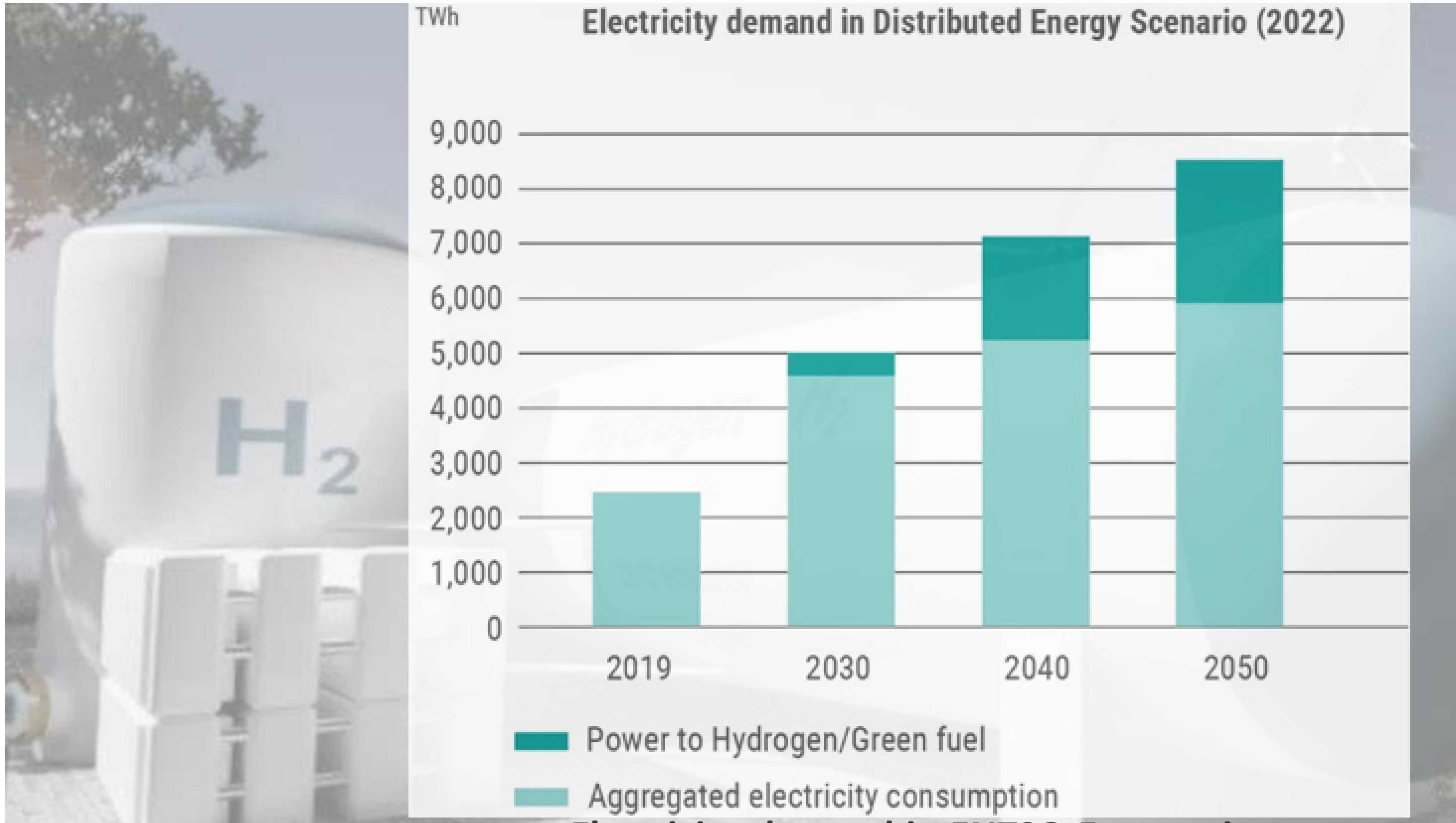
Flexibility from Power-to-H_2 - essential for carbon neutrality

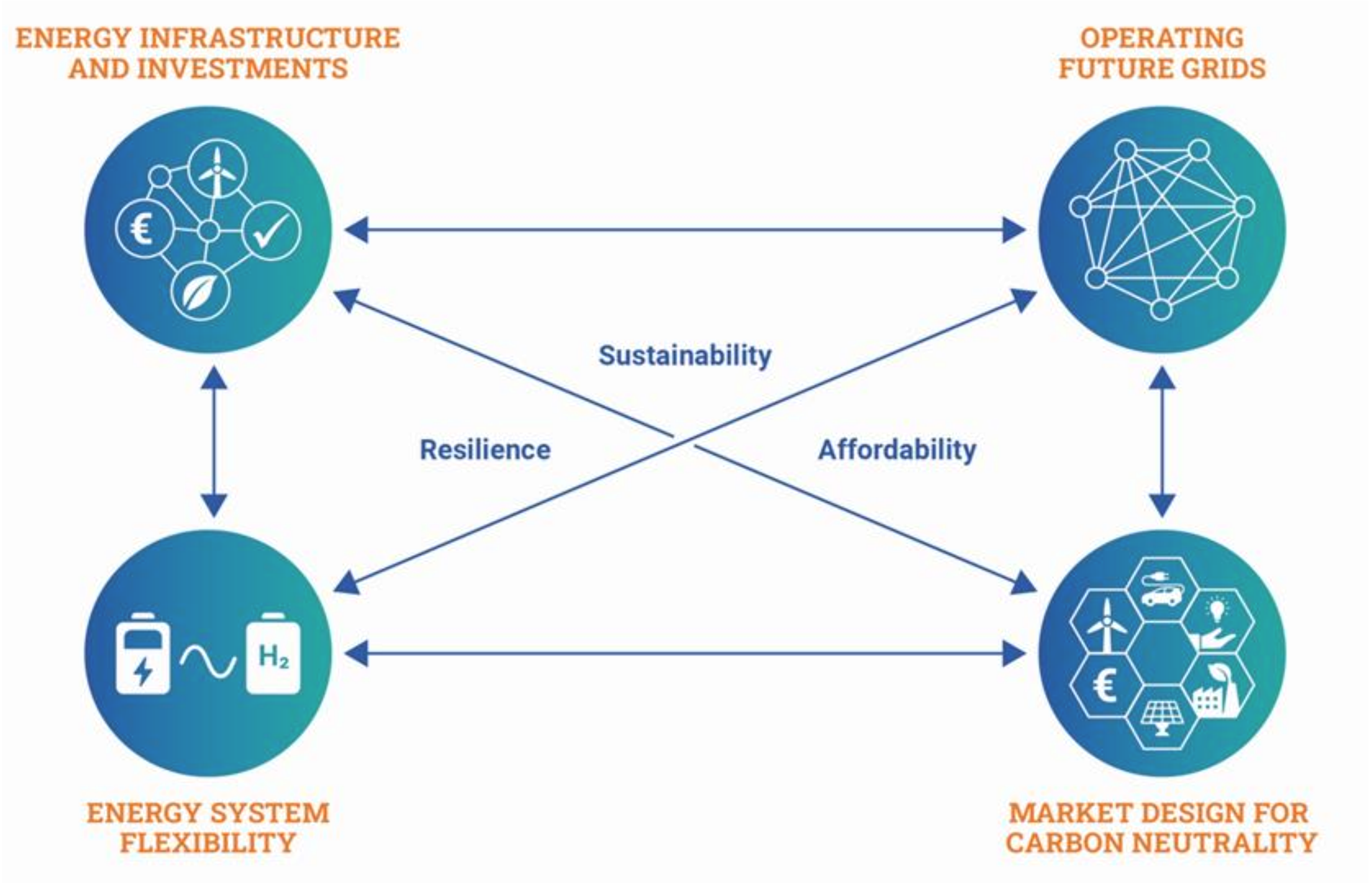
- **System services**:
  - frequency, non-frequency ancillary services, congestion management
  - Long duration flexibility to avoid RES curtailment by 2030 (20-50 TWh for a capacity of 20 GW)
- **Storage**: underground storage mainly located offshore
- **Barriers**
  - Role of P2H2 in provision of flexibility services will depend on competitiveness against other storage solutions
  - Medium to long term price signals for flexibility

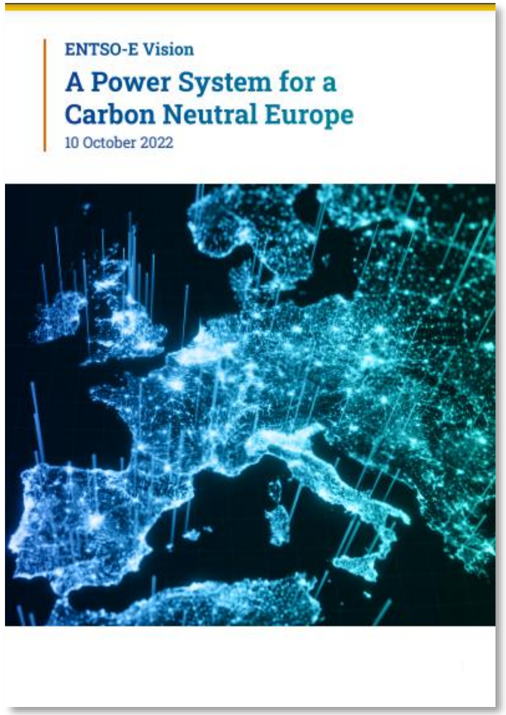


Electricity demand in ENTSO-E countries

Stacking value by 2030; a business model driven mainly by existing use cases; By 2040 to 2050 significant investments required. An integrated system view, massive RES capacity

ENTSO-E Vision for a carbon neutral Europe





Thank you!

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Panel discussion

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Sylvie TARNAI
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D.E.F.E.R by acting now

Power Systems of the Future – Infrastructure requirements for widespread electrification

Luís Vale Cunha, Board Member, EU DSO Entity and Director, EDP

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Transition through networks: two roads, one destination (?)

Reactive Investment (R_I)	Proactive Investment (P_I)
Remedial	Optimal (tends to)
Exclusive	Inclusive
Costly	Cost-efficient/effective
Delayed	On time
Ad-hoc	Planned
Biased	Balanced
?-driven	Goal-oriented
Unstructured	Structured

Anticipatory investment

$$Energy\ Transition = R_I^{*} + P_I^{**}$$

* R does not replaces P

** P tends to lower R

2030 transition through networks: D.E.F.E.R by acting now (P_I)

Challenges

45%	70%	~1.8%	30 M	60 M
RES Integration by 2030[1]	RES connected to distribution grid[2]	Electricity demand growth/year[2]	Cars replaces with ZEVs by 2030[3]	Heat pumps installed by 2030[4]

Solutions

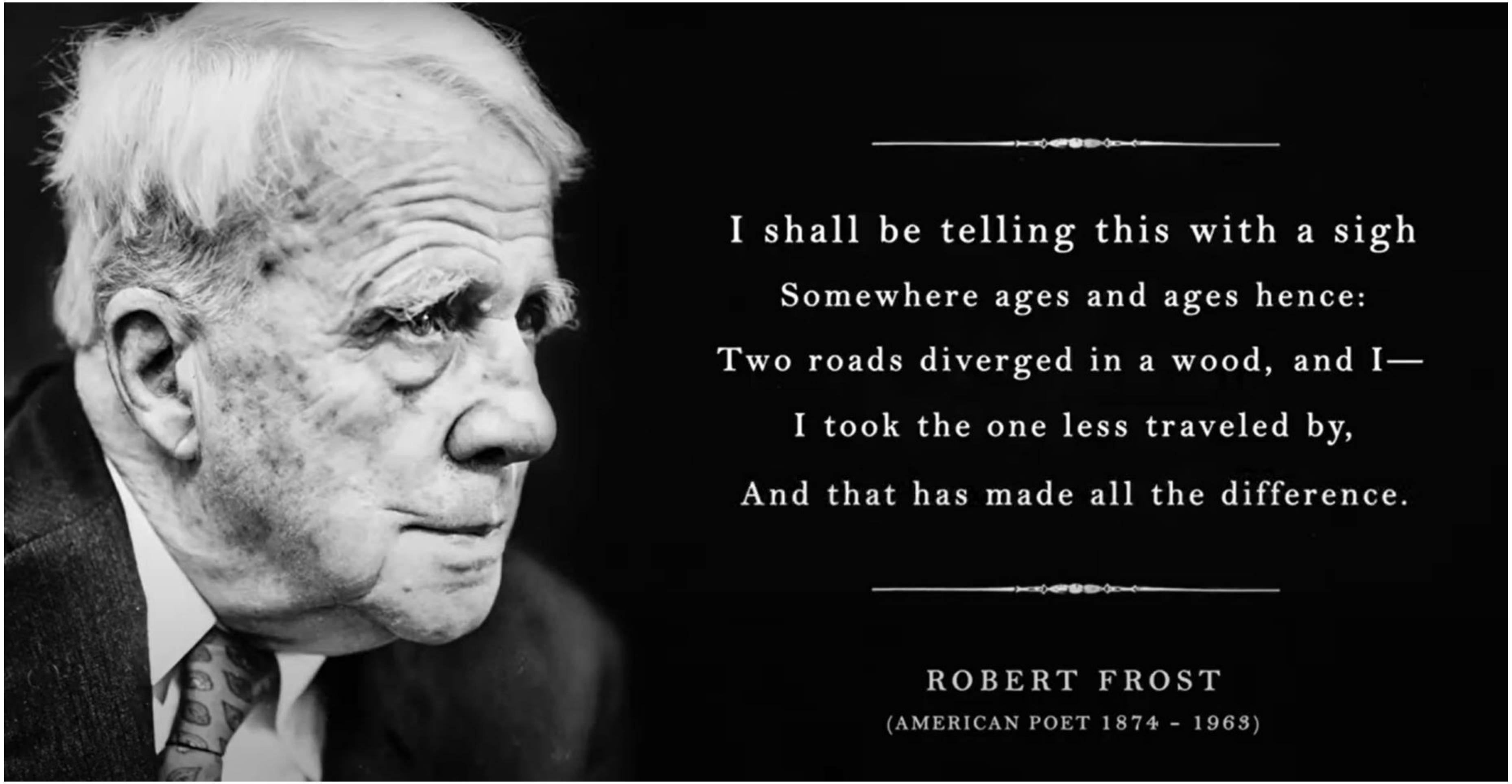
Digitalise	Enhance	Flexibilise	Expand	Renovate
170 B€ investment Supervise, Flex., Plan, Operate, Data Exchange[6]	Grid planning and operation to accommodate needs	11.1–29.1 B€ savings[8] 1-3% optimal DSF[7]	255 B€ investment Taking into account future needs[6]	50% grid assets +40y[2]

Constraints

Funds	HR	Industry	Customer	Speed
425B€ investment in distribution grid[6]	+18.1M grid-related jobs[5]	EU critical materials value/industrial supply chain	294GW flexible power[8] (164 upward, 130 downward)	2X speed of investment (average last 5 years)

1 – RED, EPBD, EED Revision; 2 – Monitor Deloitte 2022; 3 – Sustainable and Smart Mobility Strategy; 4 – REPowerEU; 5 – IEA; 6 – Digitalising the energy system – EU action plan; 7 – EUI; 8 – SmartEN

Transition through networks: the less evident road to travel by …



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IRENA INNOVATION WEEK 2023

Closing

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