IRENA Innovation Landscape for the Power Sector Transformation

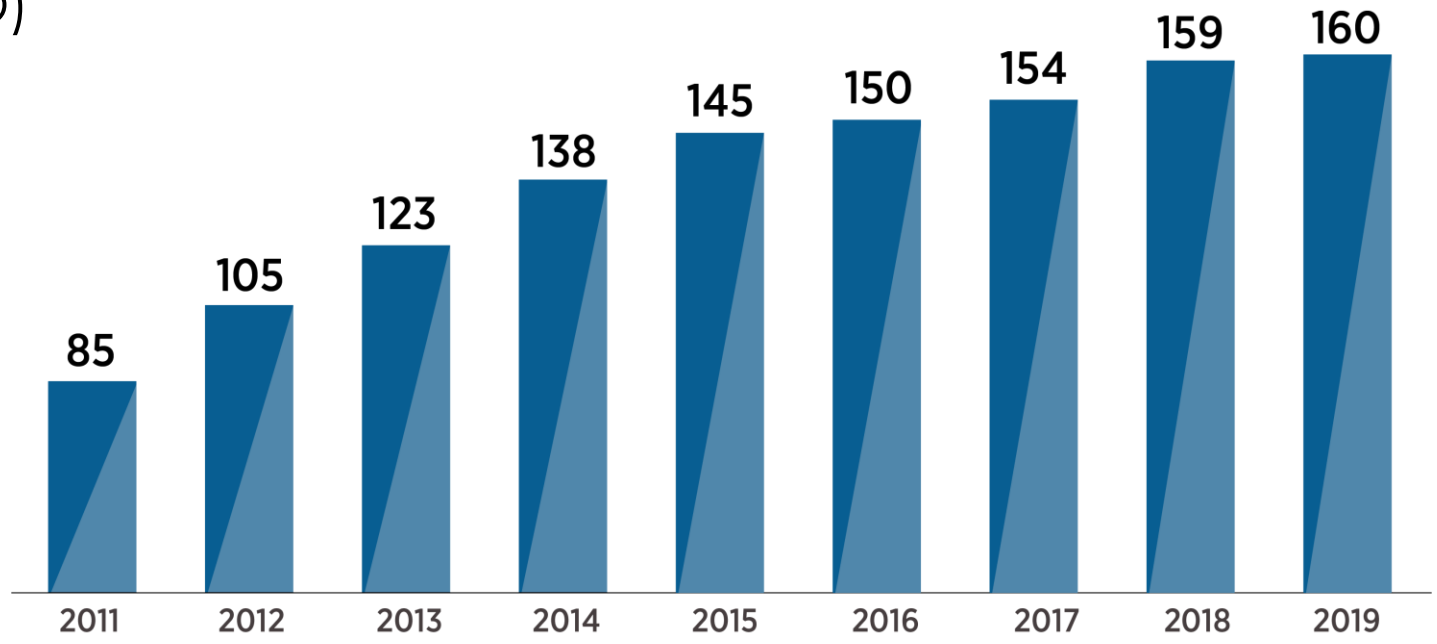
ALGERIAN-GERMAN ENERGY DAY
Second edition
Algiers, 28 November 2019

IRENA at a glance

Mandate

To promote the widespread adoption and sustainable use of **all forms of renewable energy** worldwide

- Intergovernmental Organization (IGO)
- Established in 2011
- Headquarters in Masdar City, Abu Dhabi, UAE
- Country Support & Partnerships (CSP)
- Permanent Observer to the United Nations – New York, USA
- Director-General – Francesco la Camera



Membership

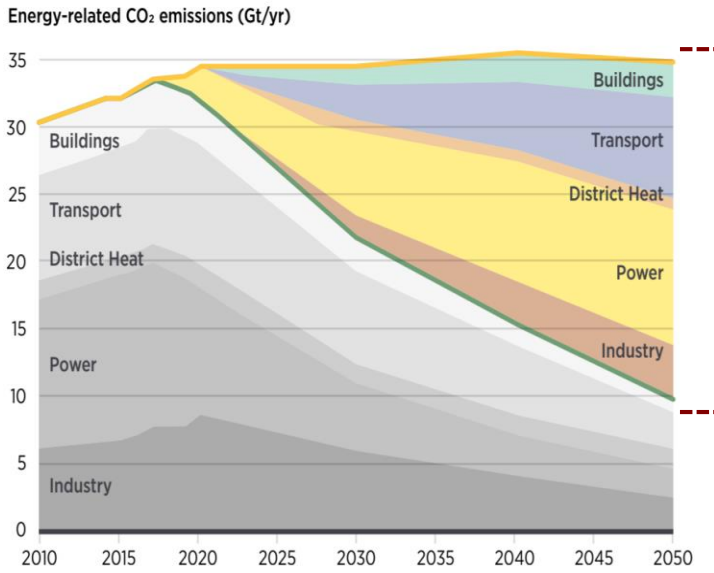
160 members + 23 in accession

IRENA's Report "Innovation Landscape for a Renewable-powered Future"

Ongoing Energy Transformation - drivers

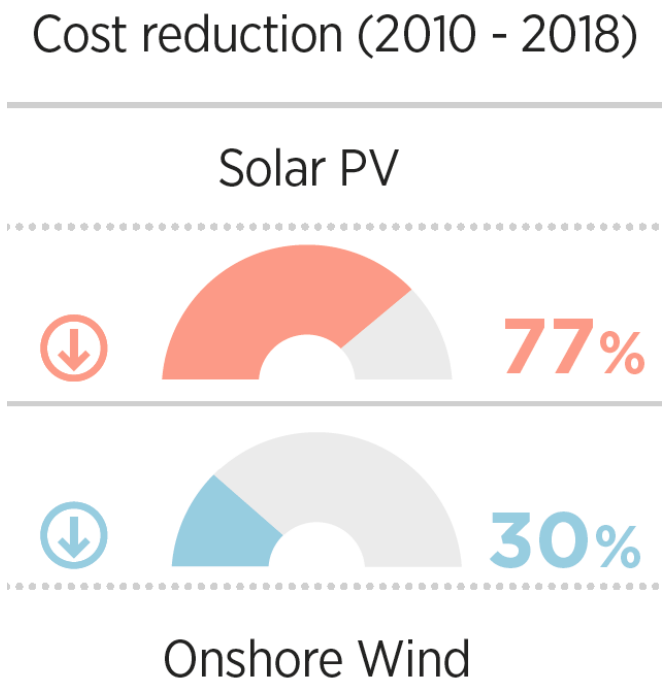
- **Policy imperatives**
  - Sustainable Development and Economic Growth (SDGs)
  - Climate and Environmental agenda (Paris Agreement)

Annual energy-related CO_2 emissions and reductions, 2015-2050 (Gt/yr)



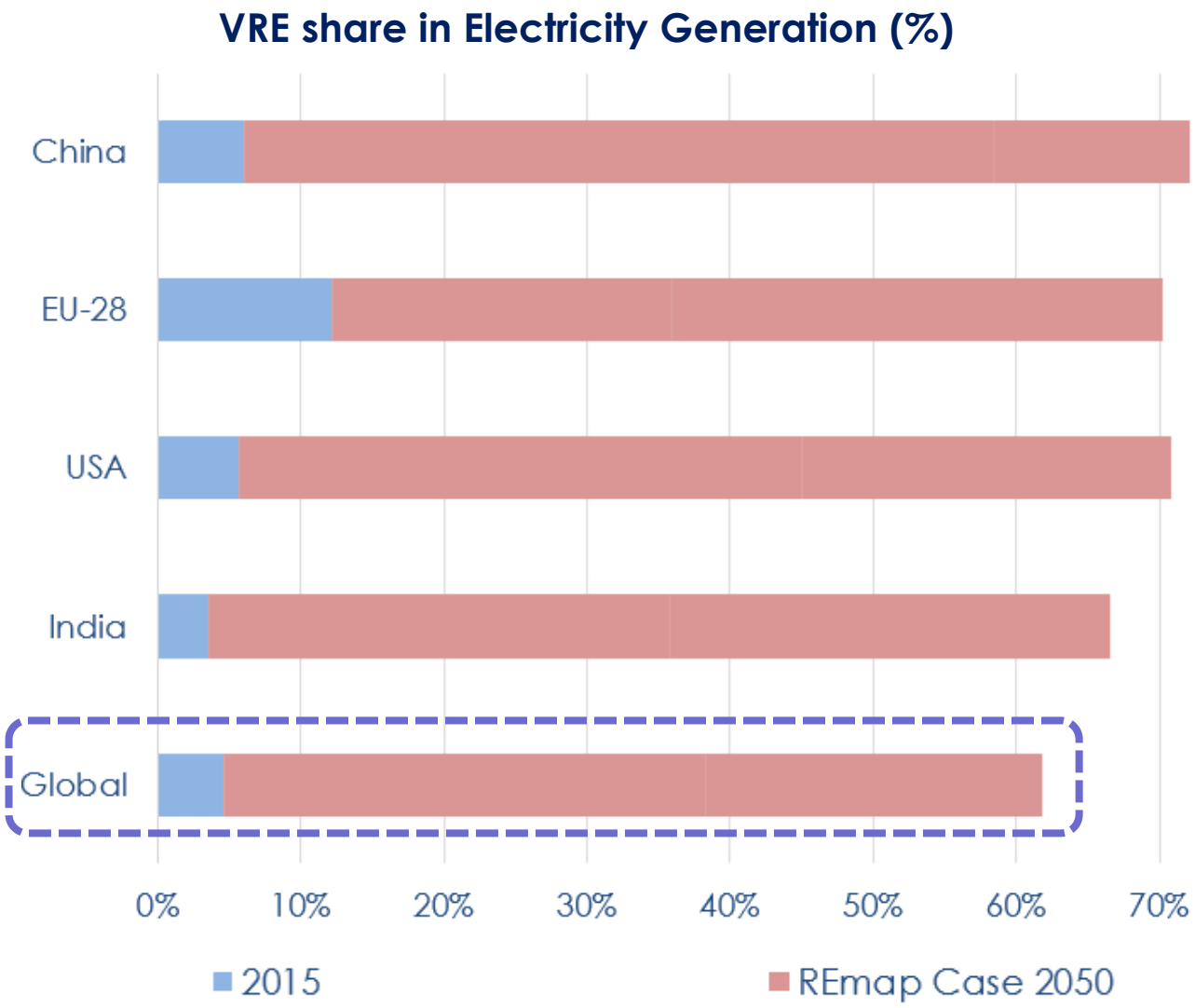
94% of needed emission reductions from RE and EE

- **RE Strong Business case**
  - Policy frameworks, business and technology innovation
  - Dramatic cost reduction



Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables

Wind and PV at the core of the energy transition



> 60% Global VRE Share by 2050 in Paris Agreement aligned case

- Wind and PV are **variable energy sources** – addressing variability is crucial for high deployment.
- Today's innovation challenge – **integrating high shares of wind and PV at lowest-cost** in power systems.
- **Power-system flexibility** is key to the cost-effective use of renewables.

Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables

Landscape of Innovation for Power Sector – 30 innovations in Four Dimensions

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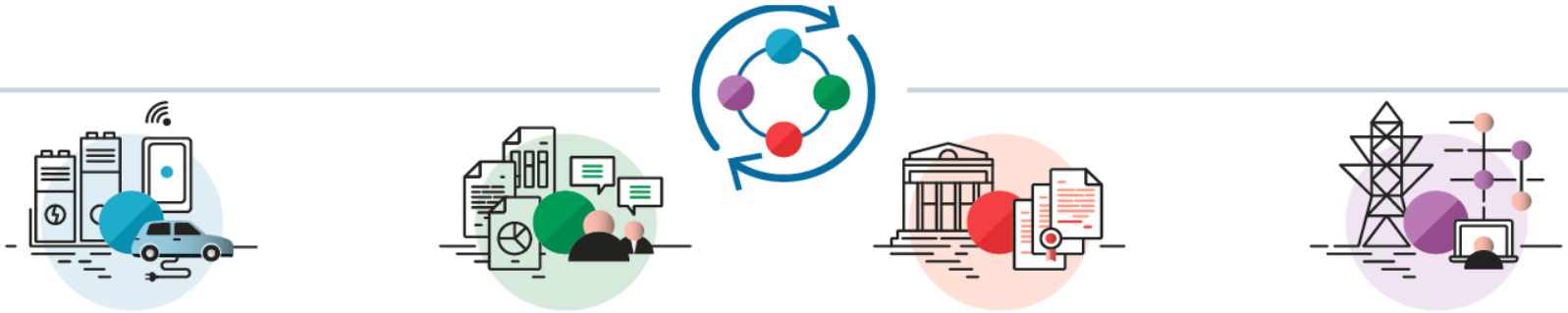


ENABLING TECHNOLOGIES

1	Utility-scale batteries
2	Behind-the-meter batteries
3	Electric-vehicle smart charging
4	Renewable power-to-heat
5	Renewable power-to-hydrogen
6	Internet of things
7	Artificial intelligence and big data
8	Blockchain
9	Renewable mini-grids
10	Supergrids
11	Flexibility in conventional power plants

BUSINESS MODELS

12	Aggregators
13	Peer-to-peer electricity trading
14	Energy-as-a-service
15	Community-ownership models
16	Pay-as-you-go models

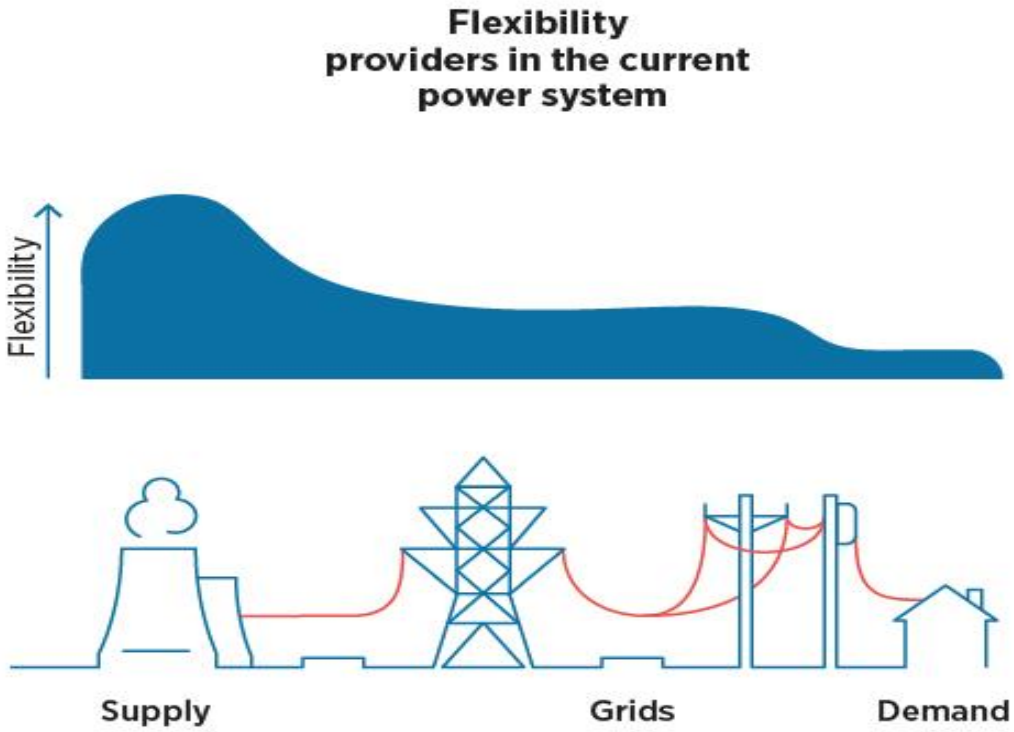
MARKET DESIGN

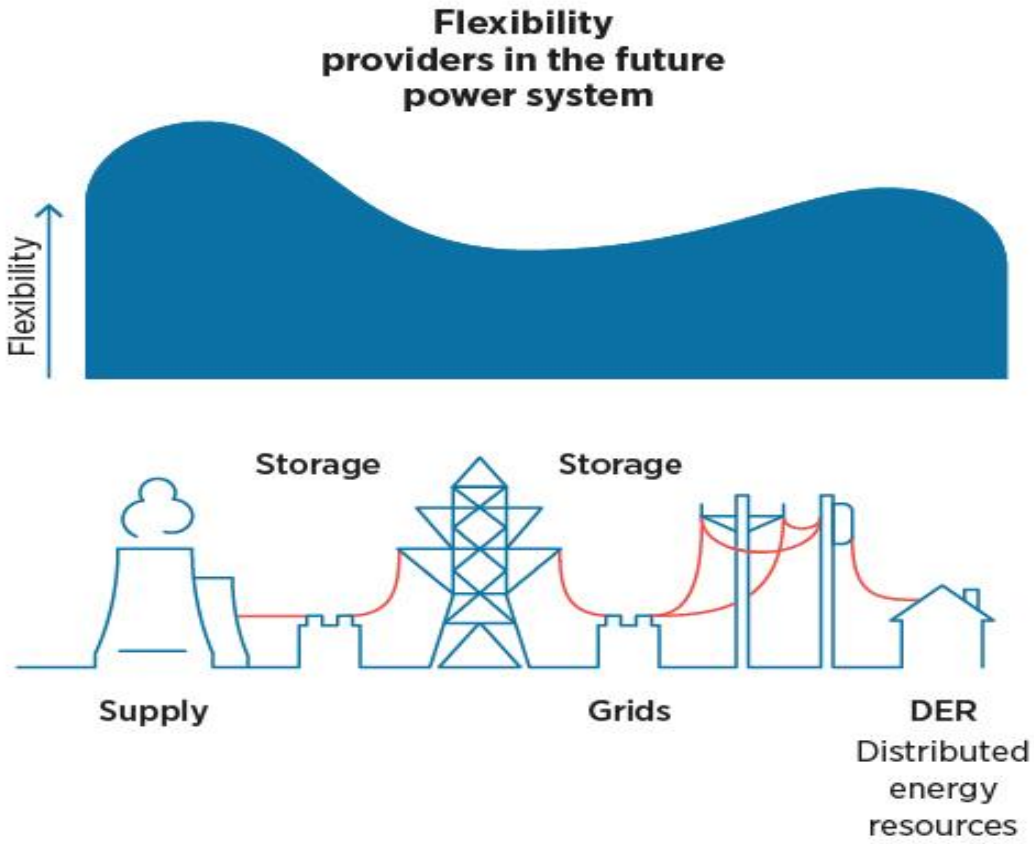
17	Increasing time granularity in electricity markets
18	Increasing space granularity in electricity markets
19	Innovative ancillary services
20	Re-designing capacity markets
21	Regional markets
22	Time-of-use tariffs
23	Market integration of distributed energy resources
24	Net billing schemes

SYSTEM OPERATION

25	Future role of distribution system operators
26	Co-operation between transmission and distribution system operators
27	Advanced forecasting of variable renewable power generation
28	Innovative operation of pumped hydropower storage
29	Virtual power lines
30	Dynamic line rating

Innovation unlocks flexibility across whole power system





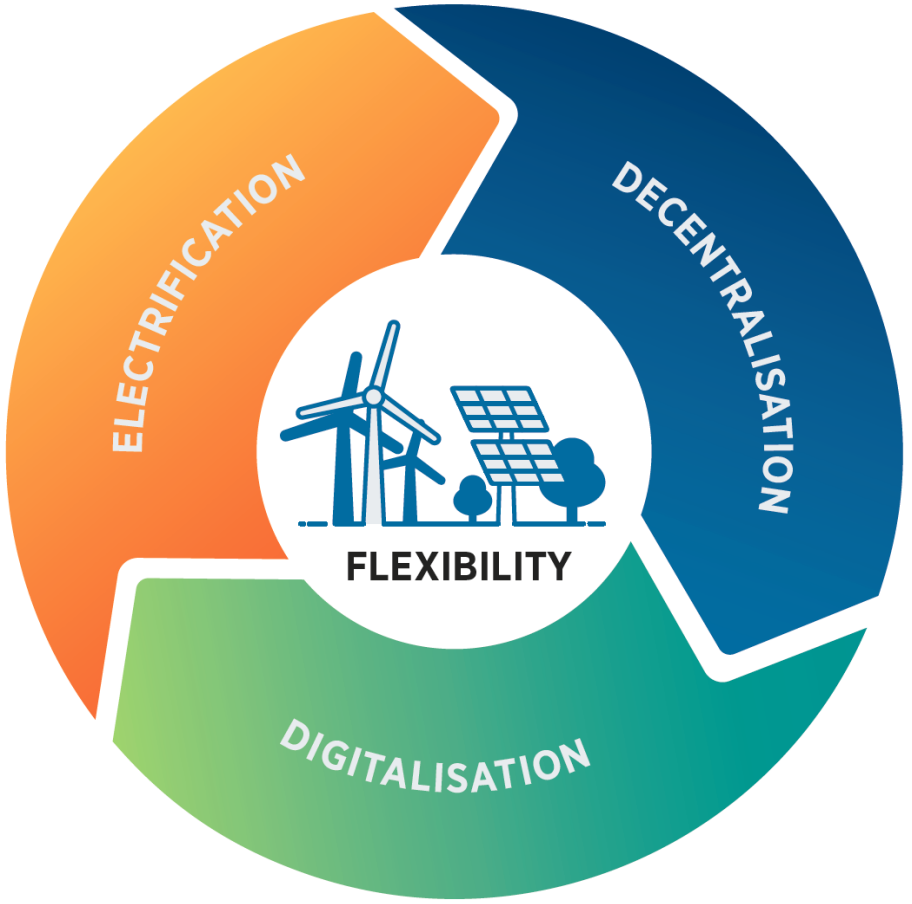
Flexibility sources: Flexible generation

Flexibility sources: Flexible generation; Regional interconnections and markets; Demand response; Storage; Power to X

Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables

Innovative solutions to increase power systems flexibility propelled by three trends

- **Decentralisation –impact on supply side-.** Wind and PV is largely centralized today but distributed generation - notably rooftop PV, ~ 1% of all electricity generation today – is growing bringing new flexibility opportunities at demand side
- **Electrification –impact on demand side-.** It plays in two ways, may decarbonize end-use sectors through renewable electricity and, if done in a smart way, become a flexibility source to integrate more renewables in power systems
- **Digitalisation –impact on system integration-.** Key enabler to amplify the energy transformation by managing large amounts of data and optimizing systems with many small generation units



Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables

Combining innovations into solutions – 11 solutions

FLEXIBILITY

SOLUTIONS

SUPPLY-SIDE FLEXIBILITY SOLUTIONS	
I	Decreasing VRE generation uncertainty with advanced generation forecasting
II	Flexible generation to accommodate variability

GRID FLEXIBILITY SOLUTIONS	
III	Interconnections and regional markets as flexibility providers
IV	Matching RE generation and demand over large distances with Supergrids
V	Large-scale storage and new grid operation to defer grid reinforcements investments

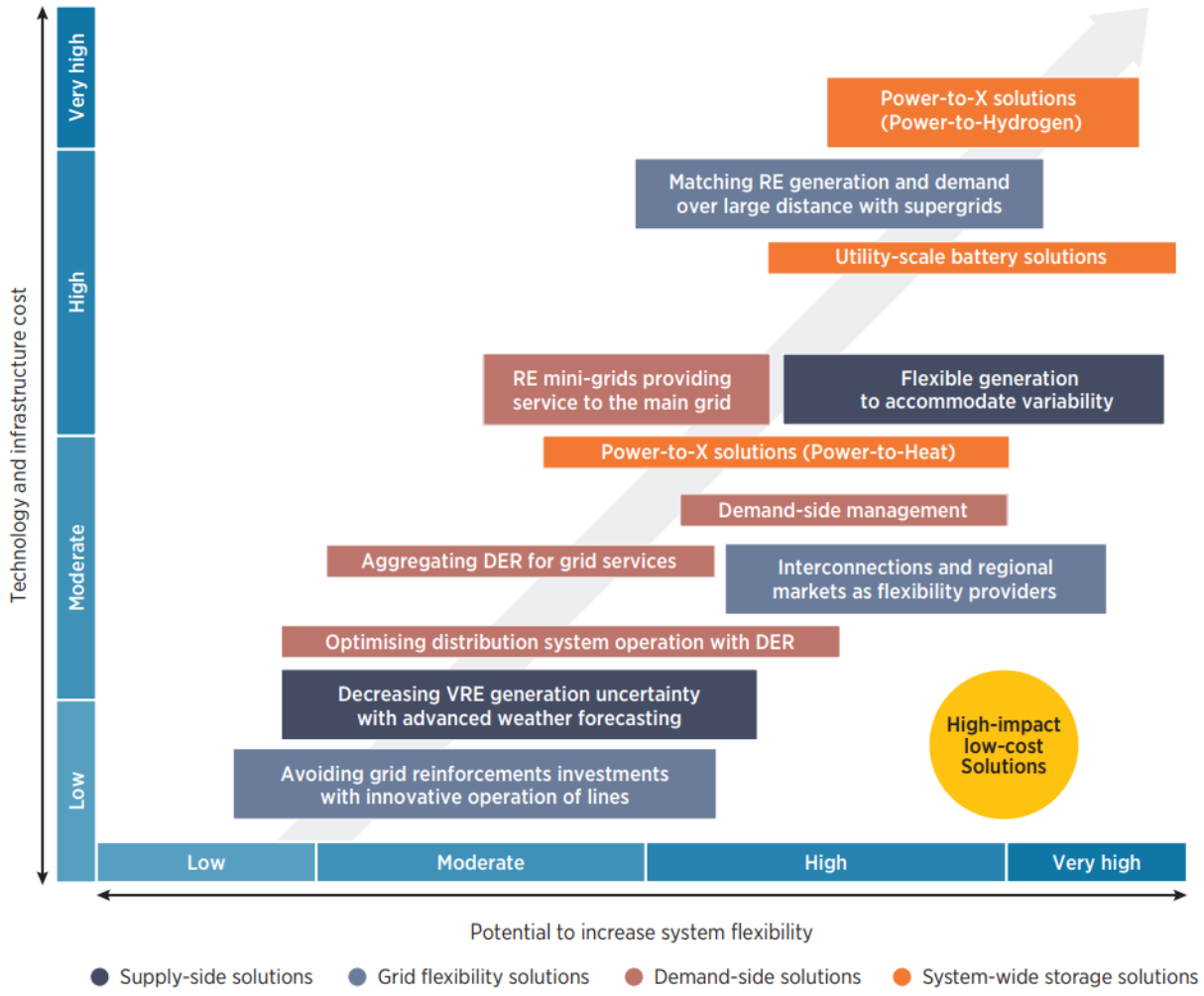
DEMAND-SIDE FLEXIBILITY SOLUTIONS	
VI	Aggregating distributed energy resources for grid services
VII	Demand-side management
VIII	RE mini-grids providing services to the main grid
IX	Optimising distribution system operation with with distributed energy resources

SYSTEM-WIDE STORAGE FLEXIBILITY SOLUTIONS	
X	Utility-scale battery solutions
XI	Power-to-X solutions

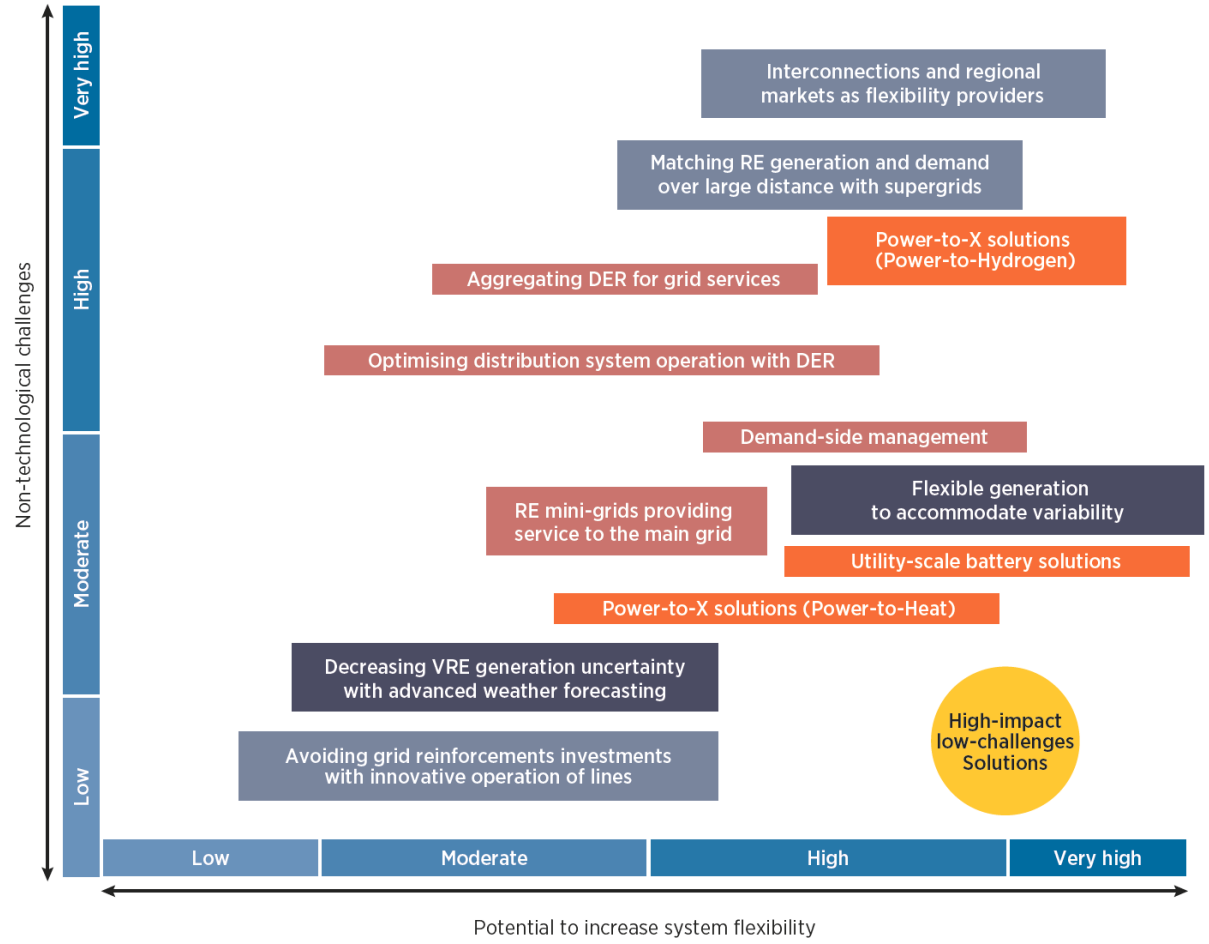
Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables

Priority solutions based on country/system context

Flexibility vs Cost



Flexibility vs Implementation Complexity



Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables

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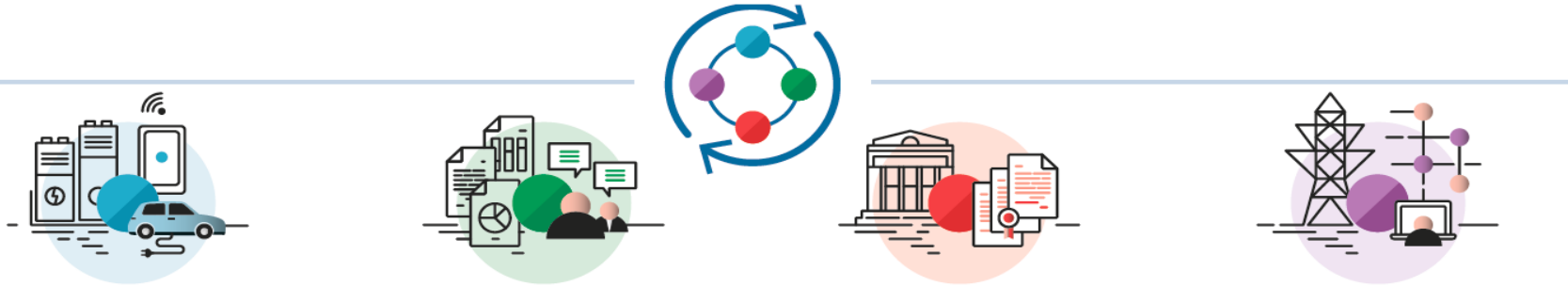
Smart Charging for Electric Vehicles

Innovations to integrate solar PV and Wind – EVs smart charging is one of those



ENABLING TECHNOLOGIES	BUSINESS MODELS	MARKET DESIGN	SYSTEM OPERATION
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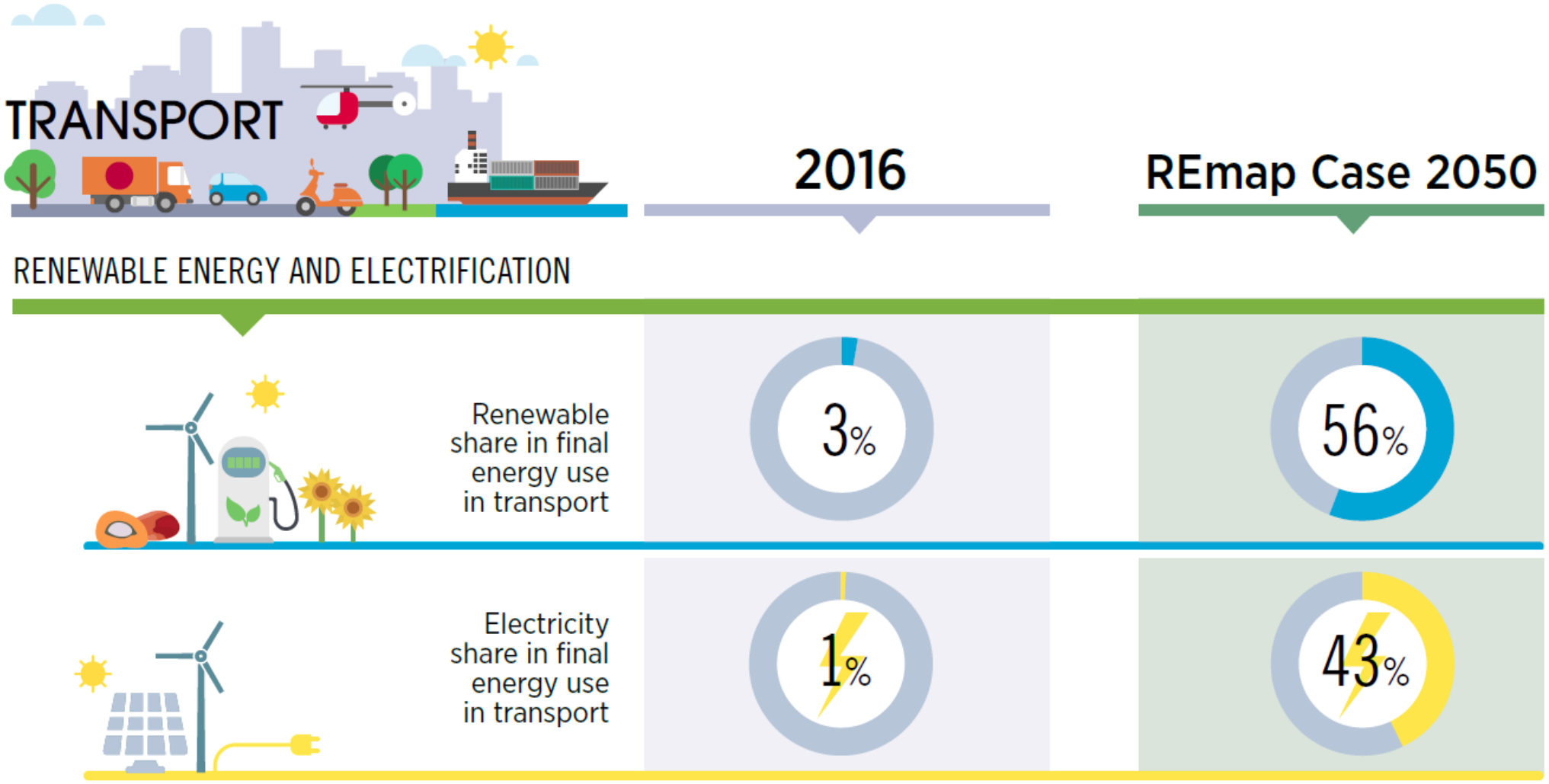
Free download of report at:
https://www.irena.org/publications/2019/Feb/Innovation-landscape-for-a-renewable-powered-future

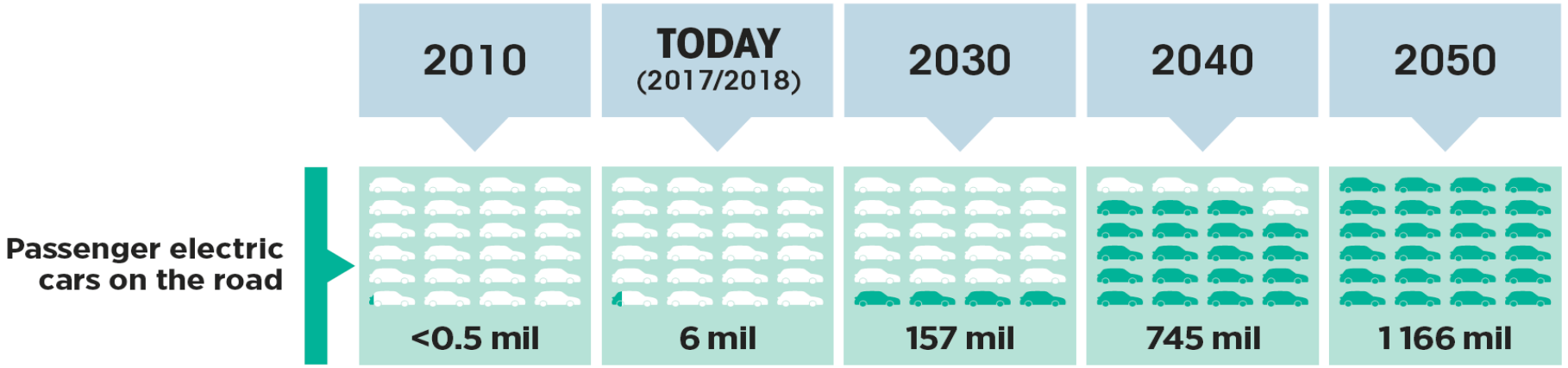
Electrification of the transport sector



Source: IRENA Global Energy Transformation: A roadmap to 2050 (2019 edition)

Uptake of EVs - the battery bank of the future

Growth in EV deployment between 2010 and 2050 in a Paris Agreement-aligned scenario



By 2050, potential storage capacity to provide grid services:

~ 14 TWh EV batteries vs ~ 9 TWh stationary batteries

Source: IRENA (2019) Innovation Outlook: Smart charging for Electric Vehicles

EV smart charging

Why smart charging?

Uncontrolled and simultaneous charging of EVs lead to…

…Increase in peak demand and frequent congestion in distribution grids…

…Requiring additional investments in grid infrastructure and limiting the integration of solar PV and wind

What is smart charging?

Smart charging means adapting the charging cycle of EVs to the needs of vehicle users as well as to the conditions of the power system

Source: IRENA (2019) Innovation Outlook: Smart charging for Electric Vehicles

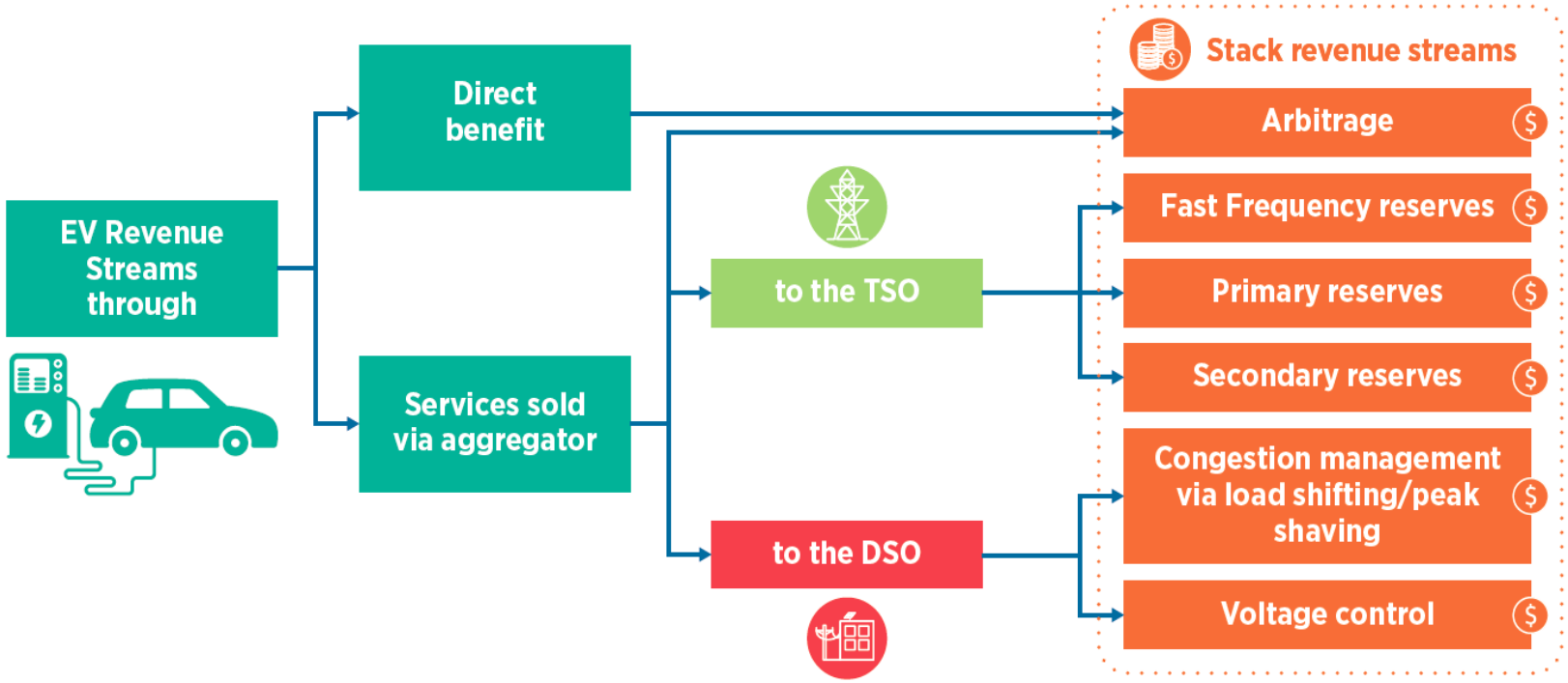
Flexibility services to be provided by EVs – innovation in business models and regulation

Regulation:

- Time-of-use tariffs
- Need for flexibility markets at low-voltage level (e.g. congestion)
- EVs bidding multiple services in ancillary markets
- Reward performance and capacity
- Avoid double levies and fees (charging and discharging)

Business models:

- Aggregator business models crucial to reach trade capacity
- Consider car owner priorities - type of grid services with high revenue but also preserve car/battery ('on-call' service)



Source: IRENA (2019) Innovation Outlook: Smart charging for Electric Vehicles

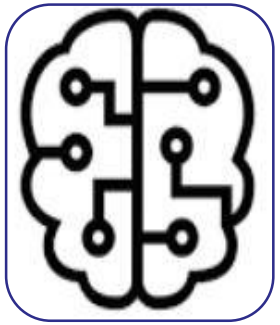
Impact of smart charging on grid infrastructure

Case study: EVs impact on Hamburg's distribution grid

Stromnetz Hamburg assessment: 9% EV share (60.000 EVs) would cause bottlenecks in 15% of the feeders in city's distribution network

Option A: Grid reinforcement solution

- Reinforcing ~ 10 000 km of 0.4 kV cable lines, replacing trasformers
- Construction works for many months, closing of roads
- Estimated investment: **20 million EUR**



Option B: Smart digital solution

- Decrease the simultaneity. All charging points need to be visible by the DSO
- A real-time communication system enables DSO to reduce charging points loads.
- Estimated Investment: **2 million EUR**

90% grid investment savings with smart solution

Source: IRENA (2019) Innovation Outlook: Smart charging for Electric Vehicles

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Blockchain

Innovations to integrate solar PV and Wind – Blockchain

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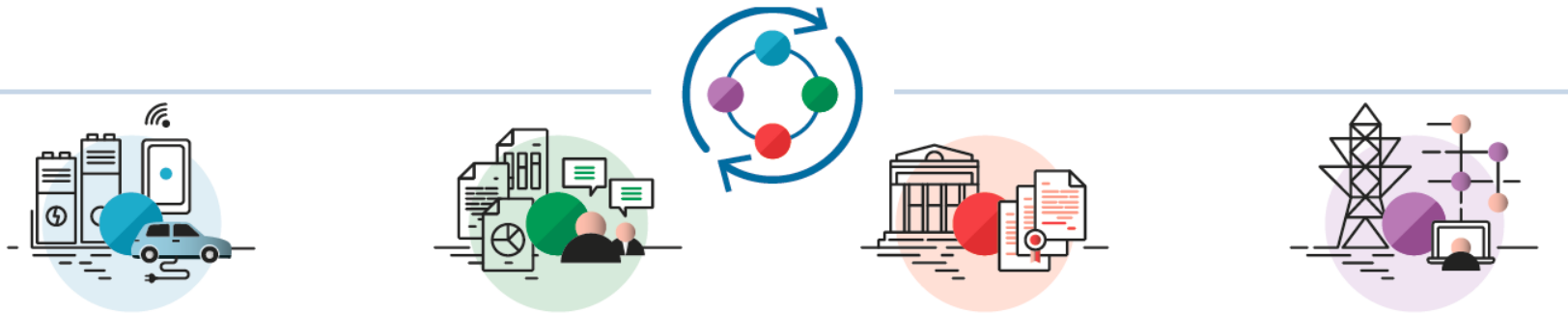

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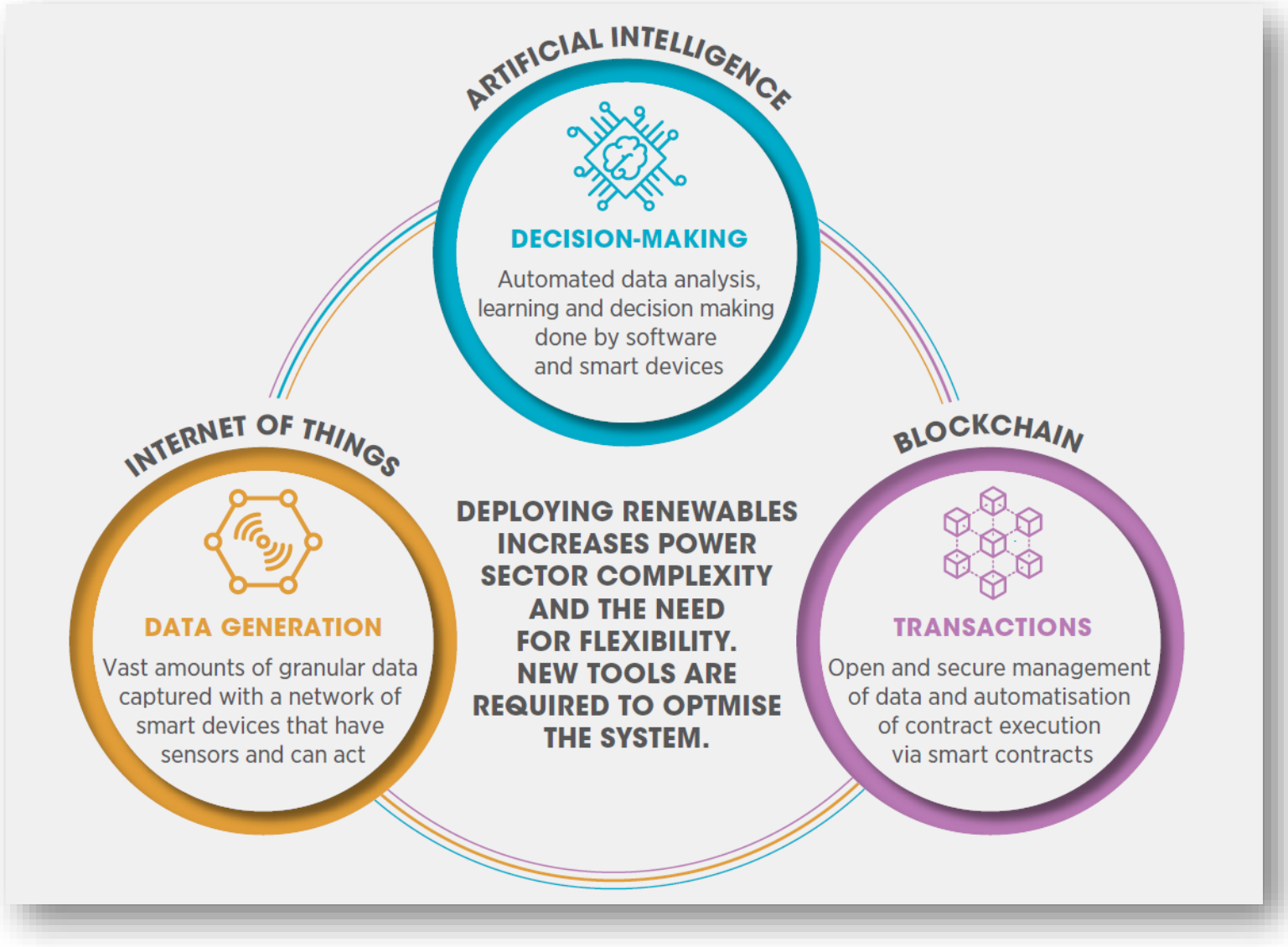
Role of digitalisation in integrating a high-share of variable renewable electricity



Source: IIRENA (2019), Innovation landscape brief: Artificial intelligence and big data, International Renewable Energy Agency, Abu Dhabi.

Blockchain – Innovation Brief and Innovation Week 2018

- Blockchain is a tool that can be used to accelerate the energy transition and is not a goal in itself. Increasing complexity requires newer, smarter tools.
- Blockchain has a strong business case in decentralised systems, not suitable for all applications. When does it make sense to use blockchain (?)
- Blockchain has the potential to create new markets/value based on 'Data Economy' [value from data-based services instead of kWh]
- Challenges remain in asset registration and integration, interoperability and scalability.

https://innovationweek.irena.org/

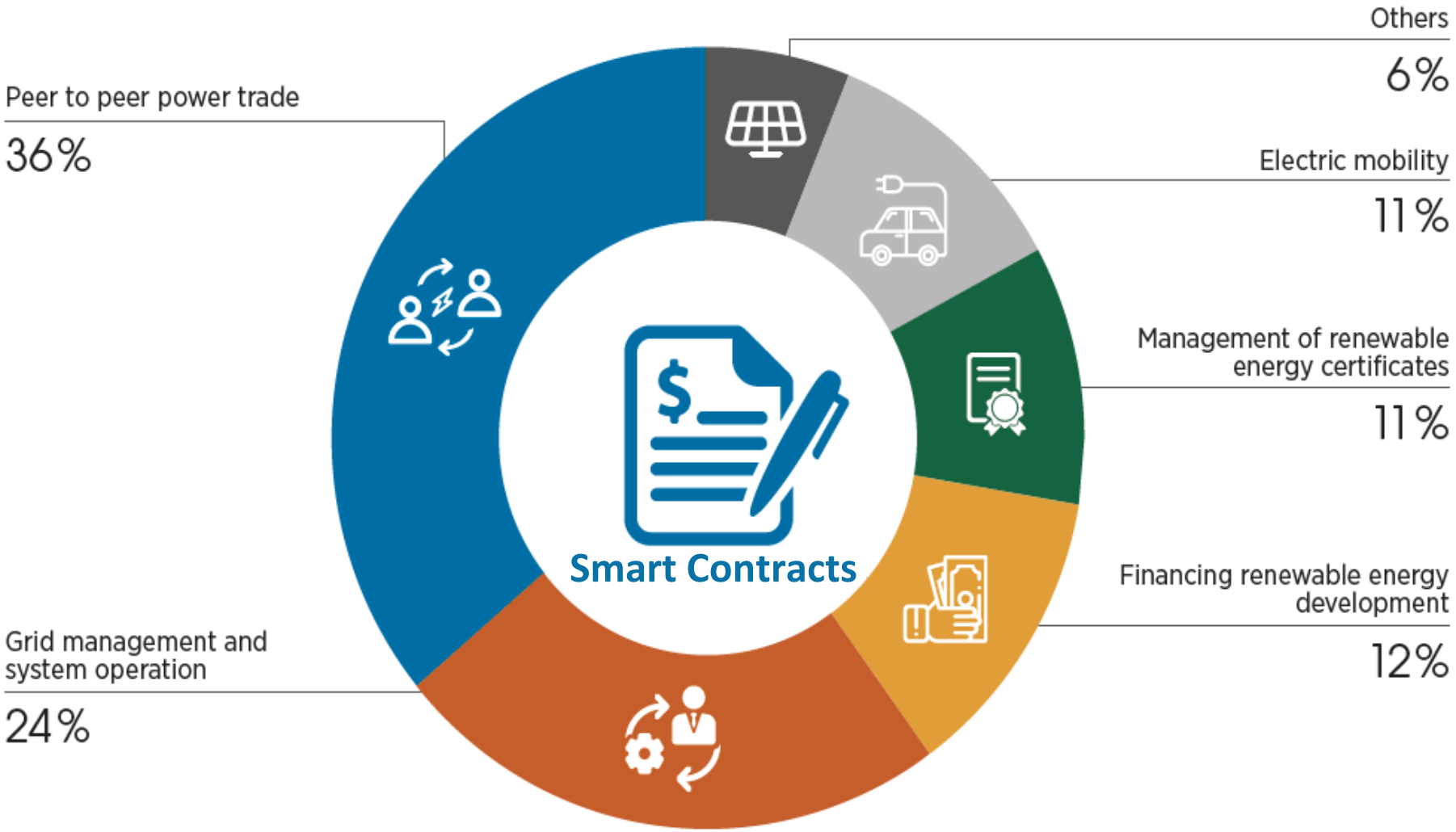
INNOVATION WEEK 2018
solutions for a renewable-powered future

Blockchain Investment (EU vs ROW)

- **1bn invested** in Energy (71 companies), Logistics (34), IoT (24), Mobility (19), and Agriculture & Food (10) between 2017 and mid-2018
- **723m in funding is centered in Europe**
- Blockchain investment in energy sector expected to cross **$5.8 billion by 2025**

Source: Cleantech Group

Current uses of blockchain in the power sector



Note: Data as of July 2018.
Based on: Livingston et al. (2018), Applying Blockchain Technology to Electric Power Systems.

When does it make sense to use blockchain or other DLT?

Source: IRENA (2019) Blockchain: Innovation Landscape Brief

Regulations in the EU

Regulation is essential in enabling and steering large-scale blockchain applications

- As set out in its "Digital Single Market" policy strategy, the European Commission aims to develop a common approach to the development of blockchain for the EU

- EU Blockchain Observatory and Forum launched Feb 2018
  - EU Observatory seeks to highlight key blockchain related developments, promote European blockchain-related activity, and improve European engagement with stakeholders that are involved in blockchain-related activities

- April 10, 2018, 22 European countries signed a "Declaration on the establishment of a European Blockchain Partnership.
  - Intended to encourage member states to exchange technical and regulatory experience with blockchain technologies and to prepare for the launch of EU-wide blockchain applications.

- In total, the European Commission has provided €83 million in funding for blockchain-related projects and could commit up to an additional €340 million from 2018 to 2020.

Source: IRENA (2019) Blockchain: Innovation Landscape Brief

Regulations and government buy-in Singapore & ROK

Singapore

- Singapore Power Group launched a blockchain-powered marketplace for RECs in October 2018. Claimed as world's first blockchain-powered marketplace in REC
- Onboarding consumers from Nov. 2018, the Open Electricity Market (started by the Energy Market Authority) allows consumers to buy electricity from any provider. Electrify is building a decentralized marketplace for energy using blockchain.
- In Dec 2018, Enterprise Singapore (a government agency set up to develop the startup ecosystem) announced they are supporting a new blockchain accelerator program called Tribe Accelerator.

Republic of Korea

- South Korea's government will spend $3.5 million) to set up a blockchain-enabled virtual power plant (VPP) in the city of Busan (Korea's second-largest city 3.5M).
- In Nov. 2018, KEPCO, Korea's largest power provider announced it will use blockchain and other innovative energy solutions to develop its next-generation micro grid (MG), also for H2 production.
- In June 2018, a South Korean governmental agency — the Industry-SW ICT Convergence Association (WICA) — also revealed plans to establish a blockchain center in Busan modeled on Switzerland's Crypto Valley.

Source: IRENA (2019) Blockchain: Innovation Landscape Brief

Open questions on blockchain for a low-carbon electricity sector

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?

Questions to experts (you)

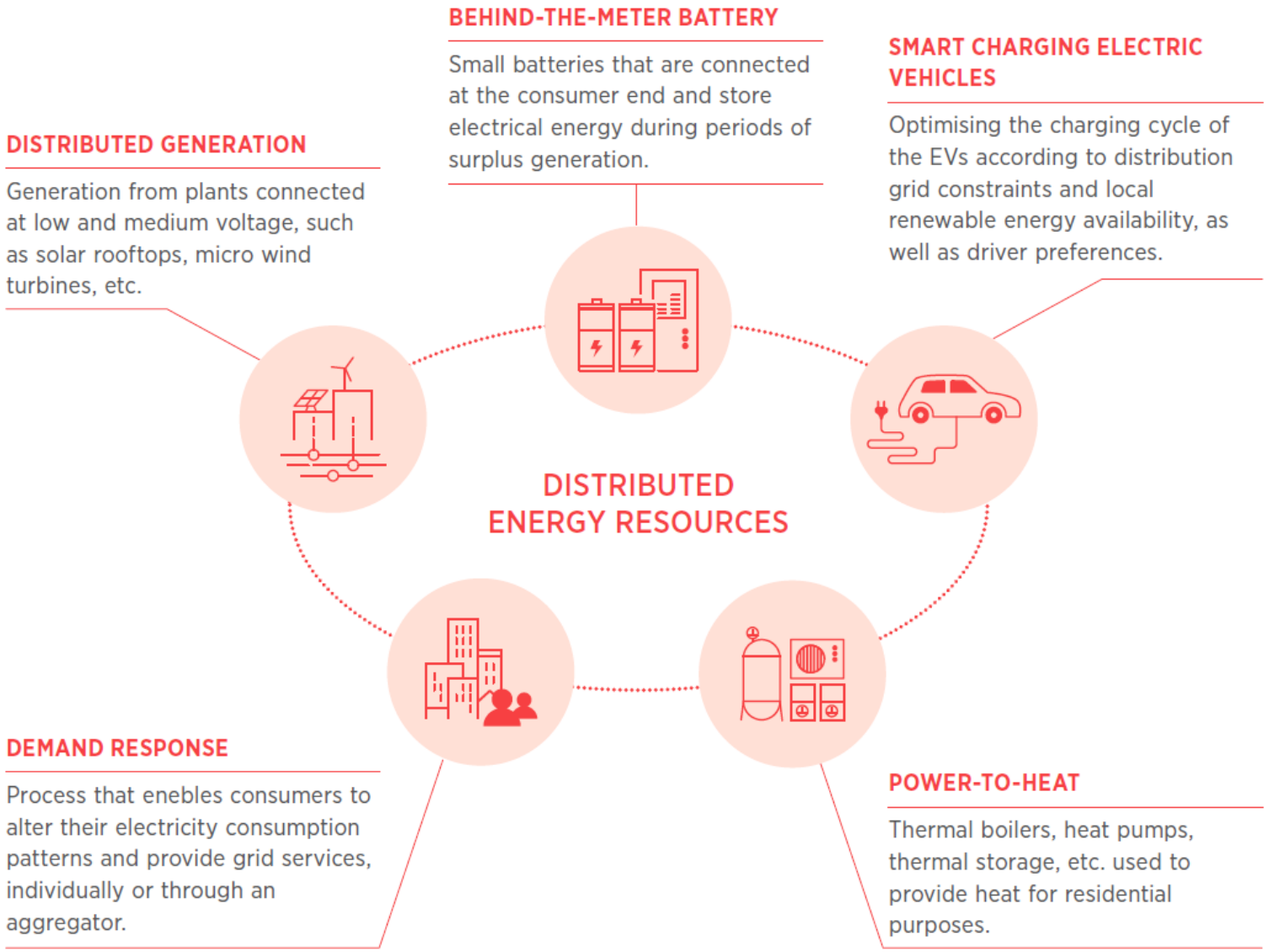
GOVERNANCE: How to coordinate all actors involved (ICT, retailers, DSO/TSO, regulator, consumer), who has authority, how to ensure transparency and compliance with other related electricity regulations. Should we look and learn from other sectors beyond energy

Data privacy: comply with GDPR (EU) but foster sharing data (?). No data sharing, no open energy market

Interoperability: what is needed in terms of standards

Distributed Energy Resources

Types of distributed energy resources



Source: IRENA (2019), Innovation landscape brief: Market integration of distributed energy resources, International Renewable Energy Agency, Abu Dhabi.

Enabling DER participation

REQUIREMENTS REGULATORY

Electricity wholesale market:

- Allow aggregation of DERs to enable their participation in the markets or reduce the minimum bid sizes to allow DERs to participate.
- Reduce the time before trading gate closure to better capture the short-term forecast of DERs.

Ancillary service market:

- Make ancillary service product requirements and local system service product requirements technology neutral.
- Introduce shorter procurement times that facilitate DERs' participation.

Transmission and distribution system:

- Define geographic markets, *i.e.*, geographic segmentation into local zones, where DERs can provide balancing and flexibility services to meet local needs.
- Incentivise network operators to upgrade their network infrastructure to facilitate wider DER adoption, or to use DERs to manage grid congestion.

Source: IRENA (2019), Innovation landscape brief: Market integration of distributed energy resources, International Renewable Energy Agency, Abu Dhabi.

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