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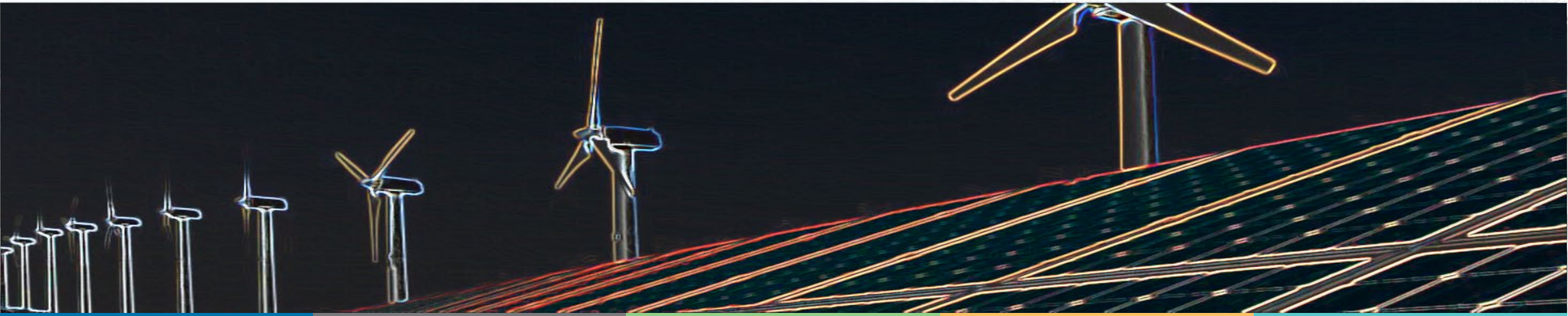

Innovation Outlook and Trends in Renewable Energy

Dr. Roland Roesch – Deputy Director IRENA Innovation and Technology Center

III Semana de la Energía
10. December 2018
Montevideo, Uruguay

About IRENA

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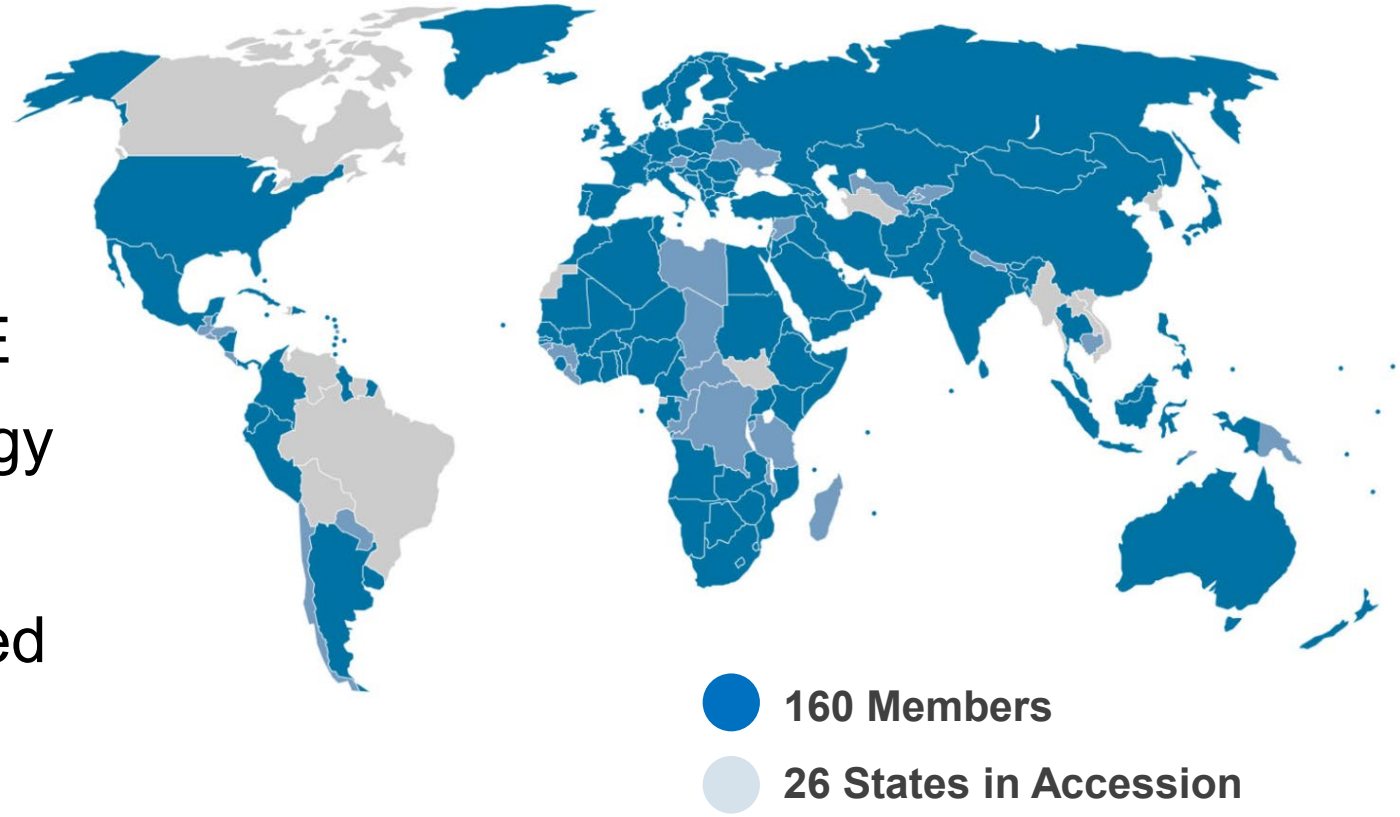
International Renewable Energy Agency

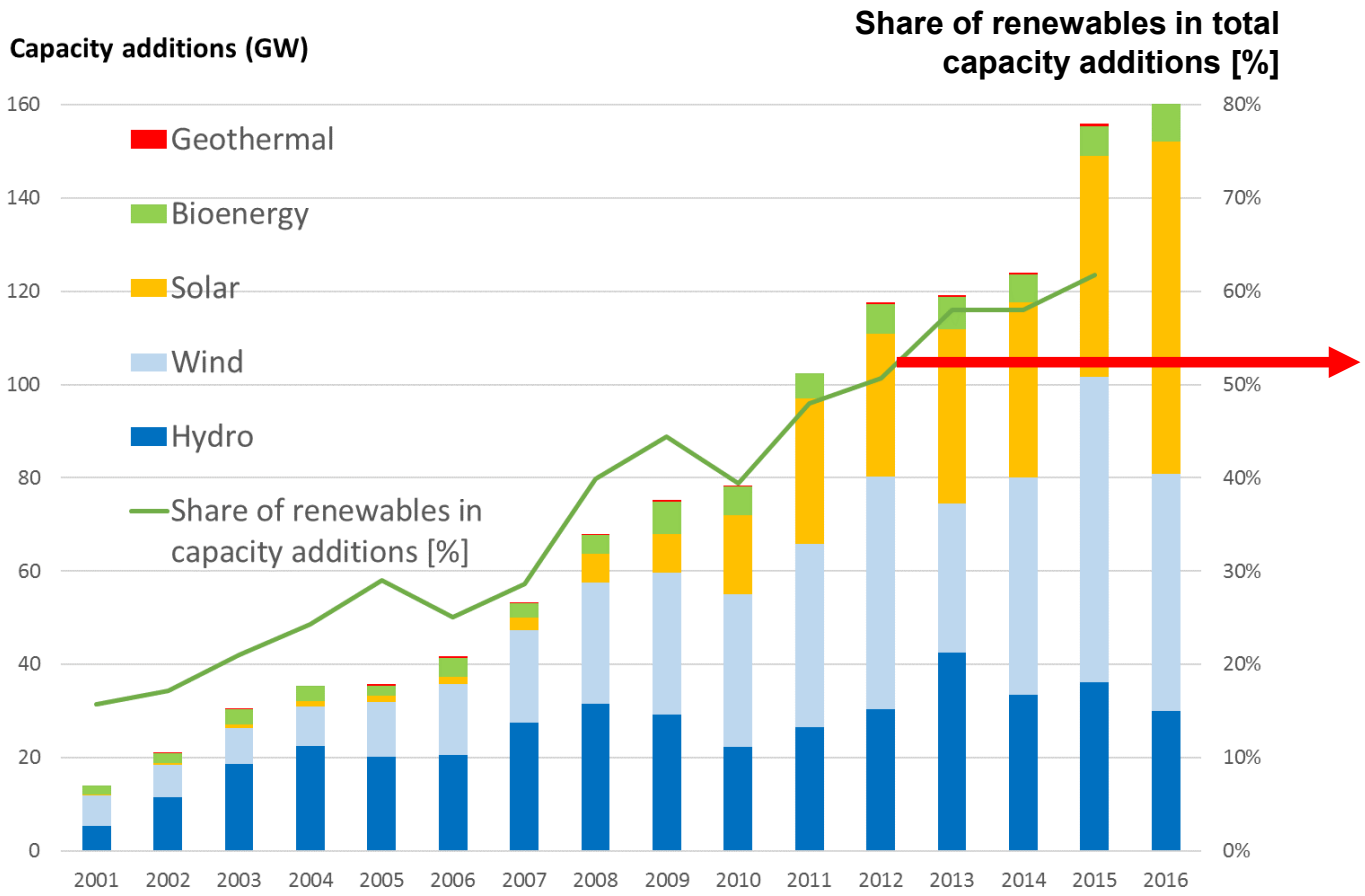
- Inter-governmental agency established in 2011
- Headquarters in Abu Dhabi, UAE
- IRENA Innovation and Technology Centre – Bonn, Germany
- Permanent Observer to the United Nations – New York



Mandate: Assist countries to accelerate renewable energy deployment

1 GLOBAL TRENDS

On-going power sector transformation



Source: IRENA statistics

Since 2012 >50% of total capacity additions

2017

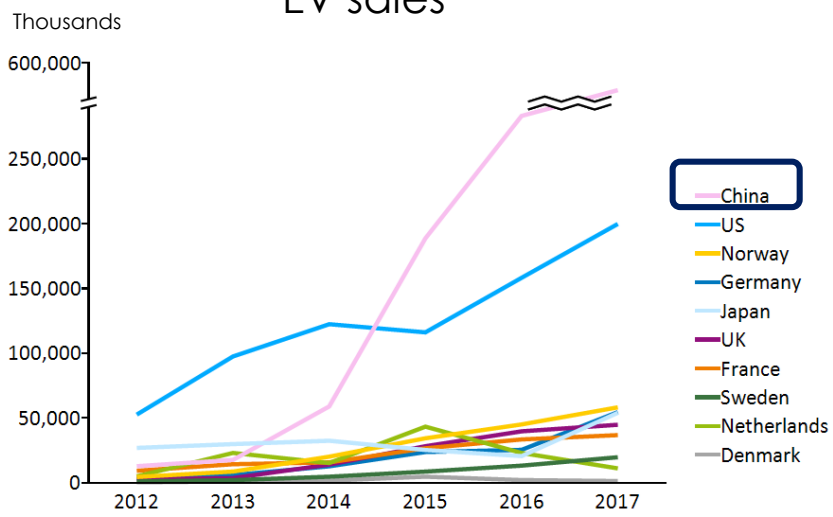
- 95 GW solar PV
- 53 GW wind
- 3 GW biomass

- Around 25% renewable power generation share worldwide
- Growing by 0.7 percentage points per year

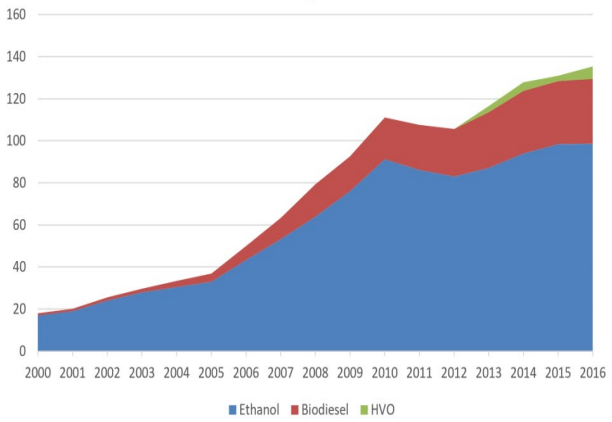
Energy transition in the end use sectors

- Strong growth of electromobility – 1.2 million EVs sold in 2017
- Heat pump sales in the residential sector have been increasing
- New approaches to solar thermal (hybrid systems, storage)
- Corporate sourcing, maximized residential self-consumption
- Sector coupling and Power-to-X
- Continued growth for biogas

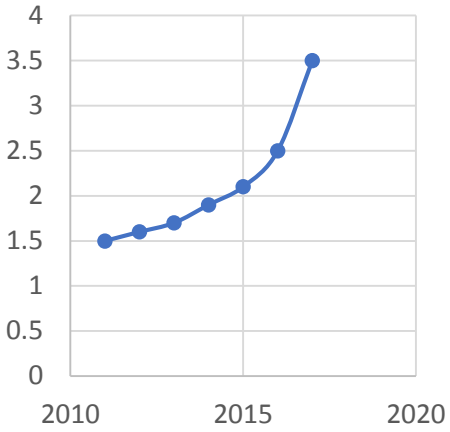
EV sales



Liquid biofuels



Heat pump sales [mln units]



Positive indicators in the end-use sector

2 ECONOMICS

Renewable power rapidly becoming competitive

Cost reduction in the period 2010 - 2017

73% Solar PV

23% Onshore Wind

Expected cost reduction in the period 2015 - 2025

54% Solar PV

37% CSP

15% Offshore Wind

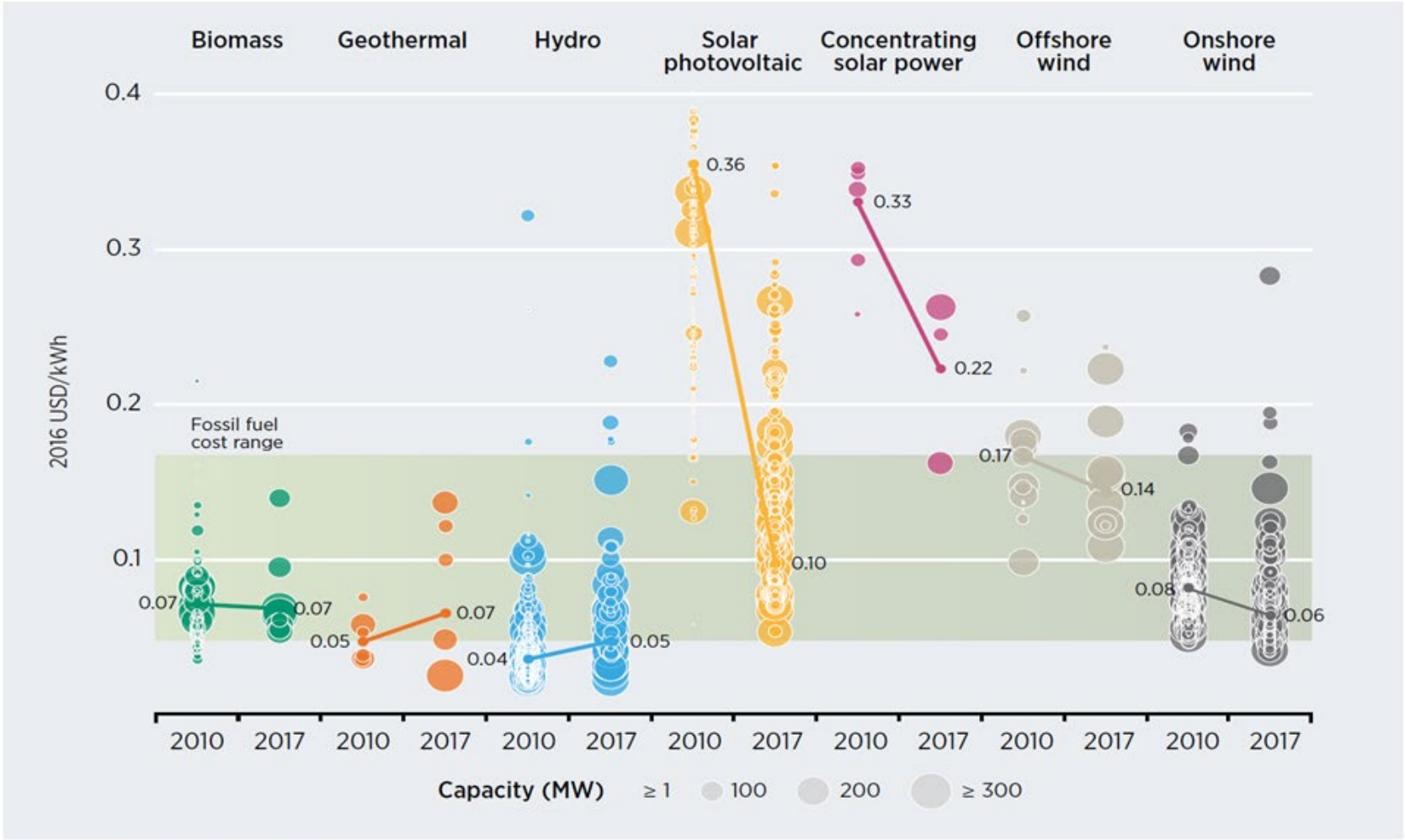
12% Onshore Wind

- All renewable power options will compete with fossil fuels on price by 2020
- Wind and PV are abundant and available in most countries

Source: IRENA (2018), Renewable Power Generation Costs in 2017, International Renewable Energy Agency

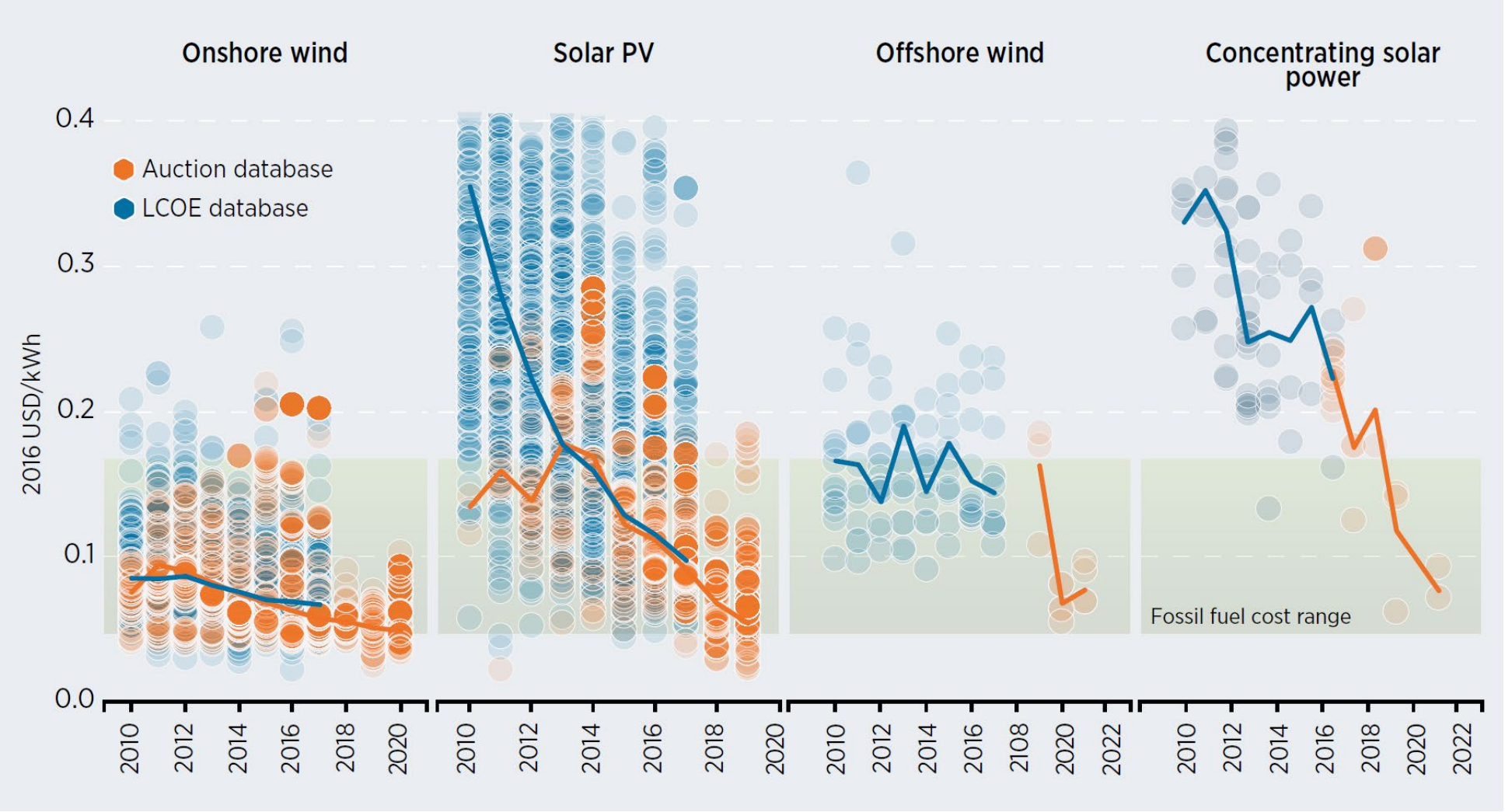
Today's strong business case for renewable power

Levelised cost of electricity (LCOE) for renewable power between 2010 and 2016



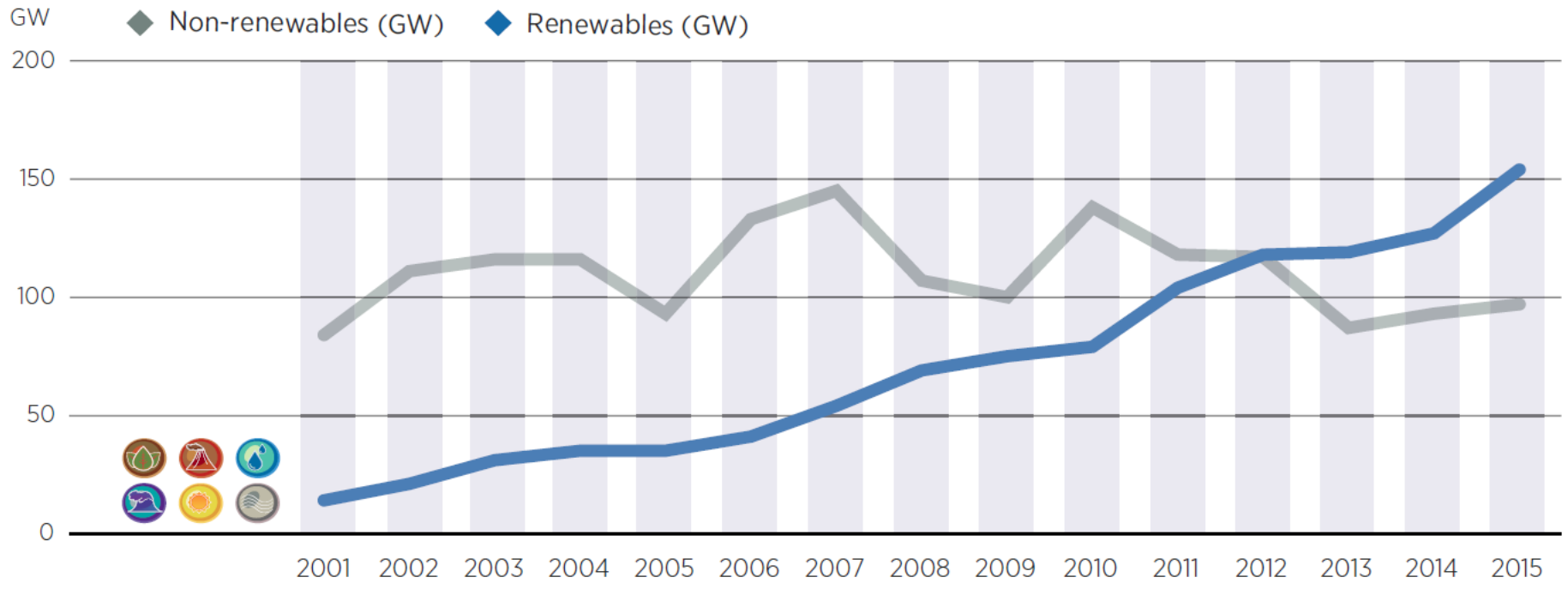
Rapid cost reduction – *PV: 80% reduction in the last 6 years*

Solar & Wind: LCOE/Auction Price Evolution Overview
Continued rapid cost reduction in the coming years



Investments in renewable power have surpassed the ones in fossil fuels

RE represents 60% of the total new capacity investments in the last two years



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Renewables (GW)	14	21	31	35	35	41	54	69	75	79	104	118	119	127	154
Non-renewables (GW)	84	111	116	116	93	133	145	107	100	138	118	117	87	93	97

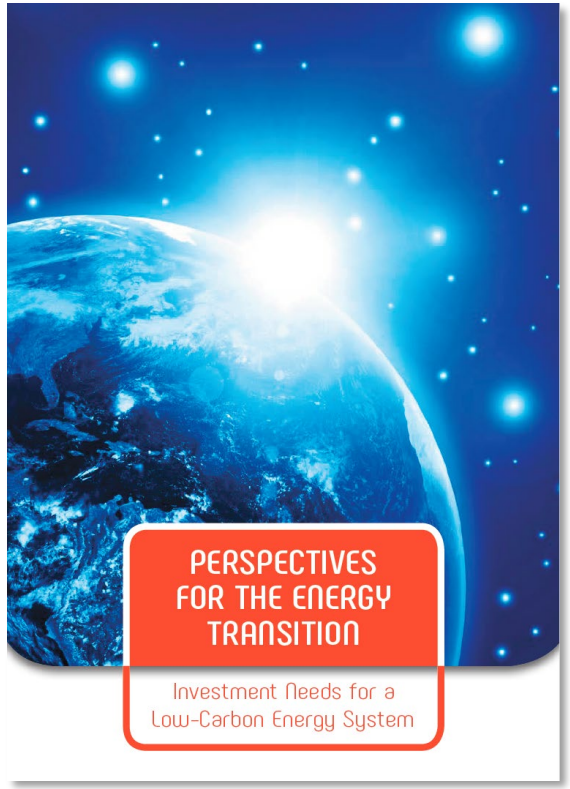
Source: IRENA (2017) Rethinking Energy

2016: **242 USD billion.** Solar PV and wind leading

3 ENERGY TRANSITION NEEDS

Context

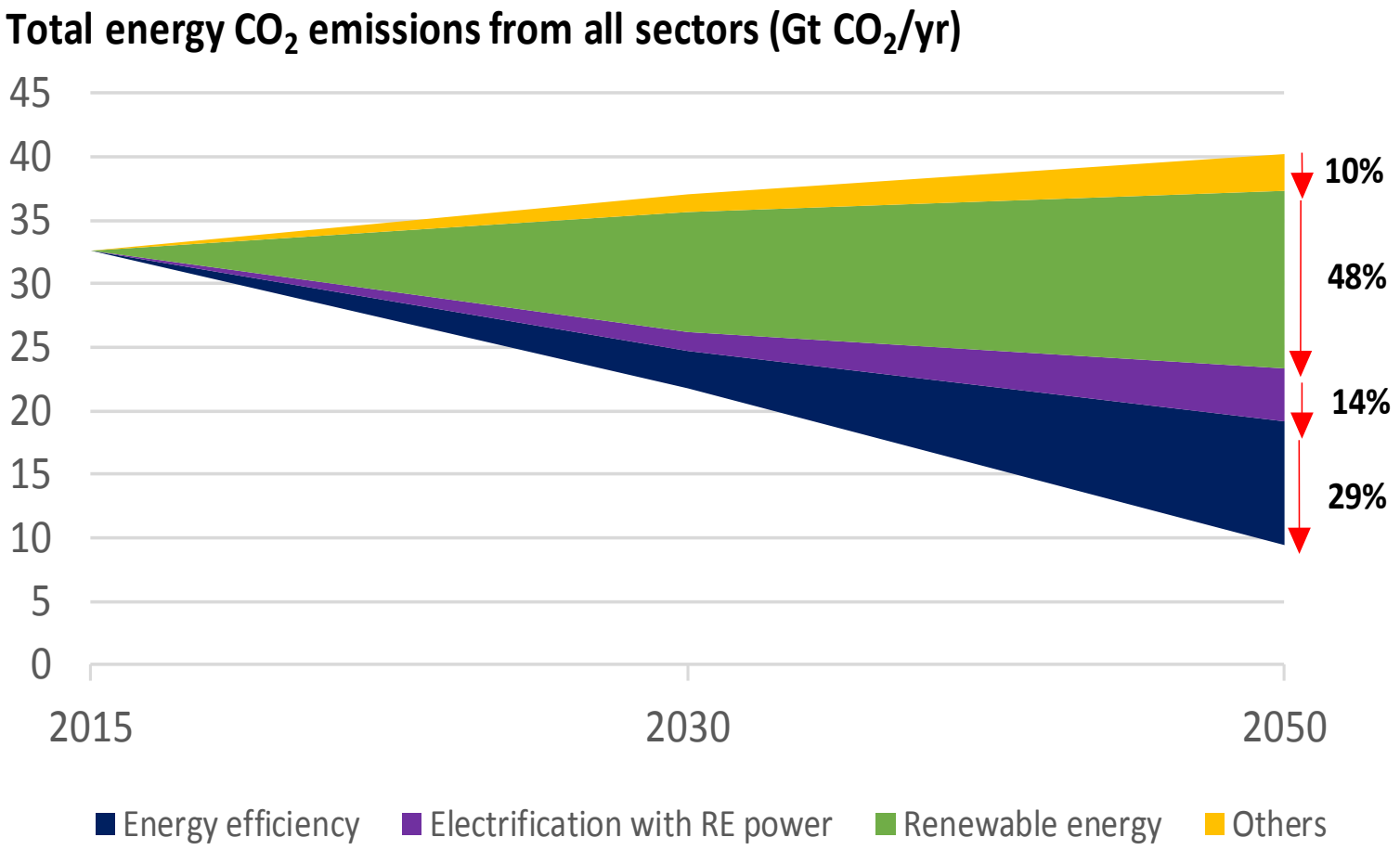
- At the request of the German G20 Presidency
- To inform decarbonization Action Plan discussion in G20
- Study prepared by IRENA in cooperation with IEA
- Publication released March 2017 during Berlin Energy Transition Dialogue



March 2017

Energy accounts for two-thirds of total greenhouse gas emissions

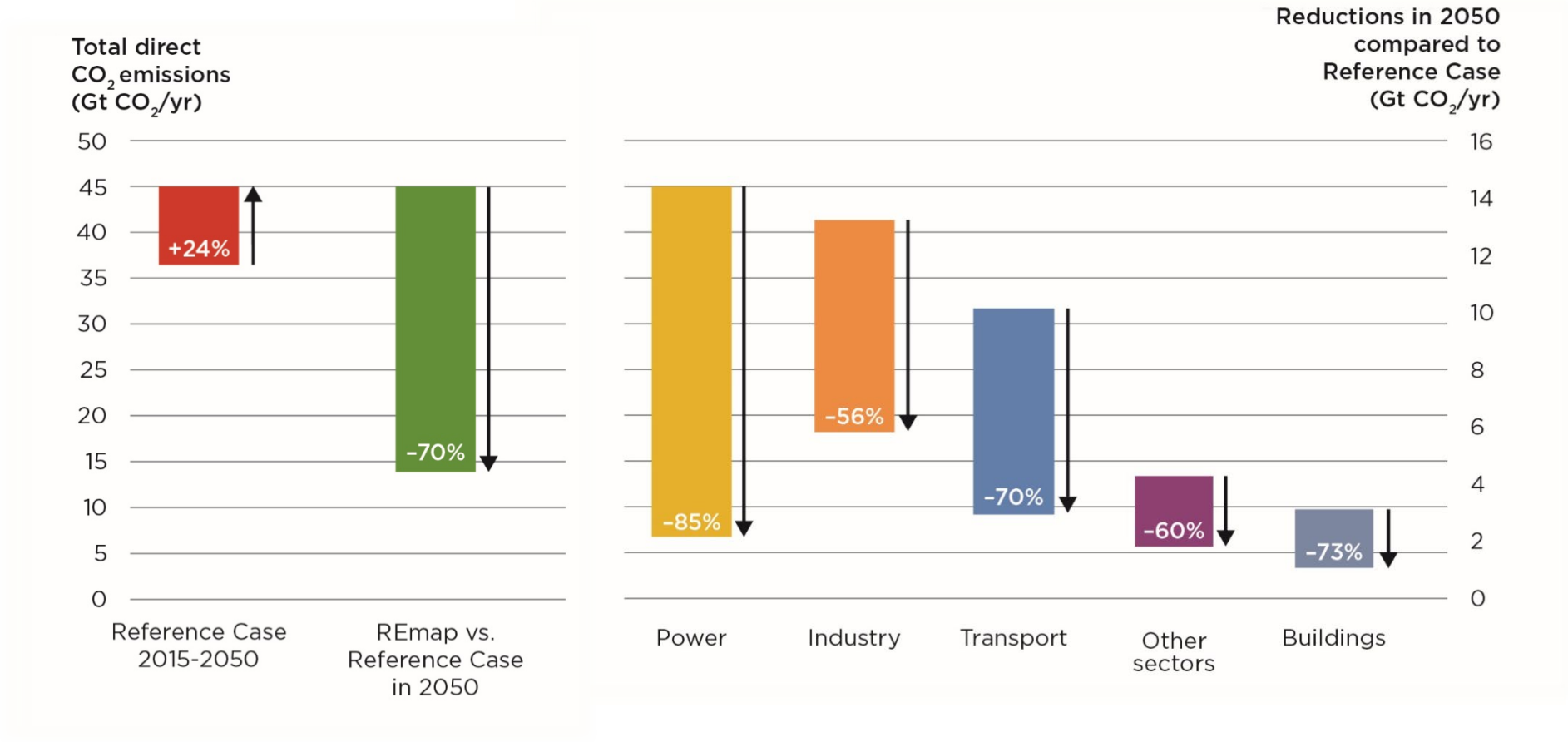
To meet 2°C climate target set at COP 21 in Paris 2015



- Carbon Emissions of energy:
  - needs to fall by 85% in 2015-2050
- Energy-emission budget:
  - 790 Gt CO_2 from 2015 till 2100
  - *At current emissions rate, carbon budget would be consumed by 2040*
  - RE and EE can achieve 90% of emission reductions needed by 2050
  - The growth rate in terms of **renewable share per year will need to increase seven-fold** over past rates

Source: IEA/IRENA (2017) Perspectives for the Energy Transition

CO_2 emissions by sector: REmap relative to the Reference Case

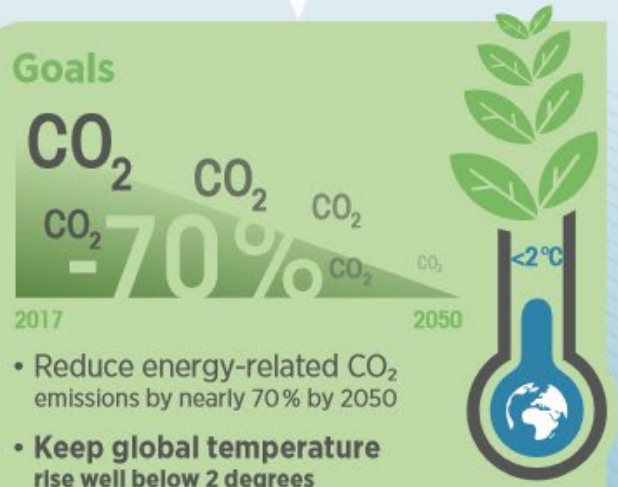


By 2050, total energy-related CO_2 emissions will need to decrease to below 10 Gt. CO_2 emissions from the power and buildings sectors will be almost eliminated.

Industry and transport would be the main sources of emissions in 2050.

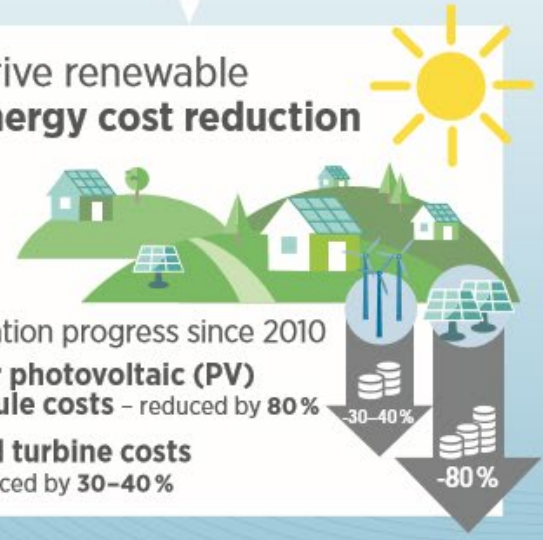
Innovation to Decarbonise the Energy Sector

Goals



- Reduce energy-related CO_2 emissions by nearly 70% by 2050
- **Keep global temperature rise well below 2 degrees**

1 Drive renewable **energy cost reduction**



- Innovation progress since 2010
  - **Solar photovoltaic (PV) module costs** – reduced by **80%**
  - **Wind turbine costs** – reduced by **30–40%**

2 Enhance **technology performance**

- **Today's renewable energy technologies:**
  - Need to grow renewable energy share 1.2% yearly to reach 2050 climate goals
  - Could provide 2/3 of the world's primary energy supply
- **What about the remaining 1/3?**

3 Integrate high shares **of renewable energy in power systems**

- **Enabling** technologies
- New ways to **operate** systems
- Innovative **business** models + **market** designs

4 Create new **breakthroughs** for end-use sectors

- **Find affordable, scalable solutions**
  - **Develop low-carbon technologies for:**
    - aviation
    - heavy industry
    - road transport
    - shipping

Action **needed now:**

- **Governments** – encourage private sector innovation
- **Developing new technologies** – requires decades
  - **R&D → demonstration → market**
- **Innovation goes beyond technology**
  - creating new businesses; system integration; wealth creation

Accelerating Energy Transition

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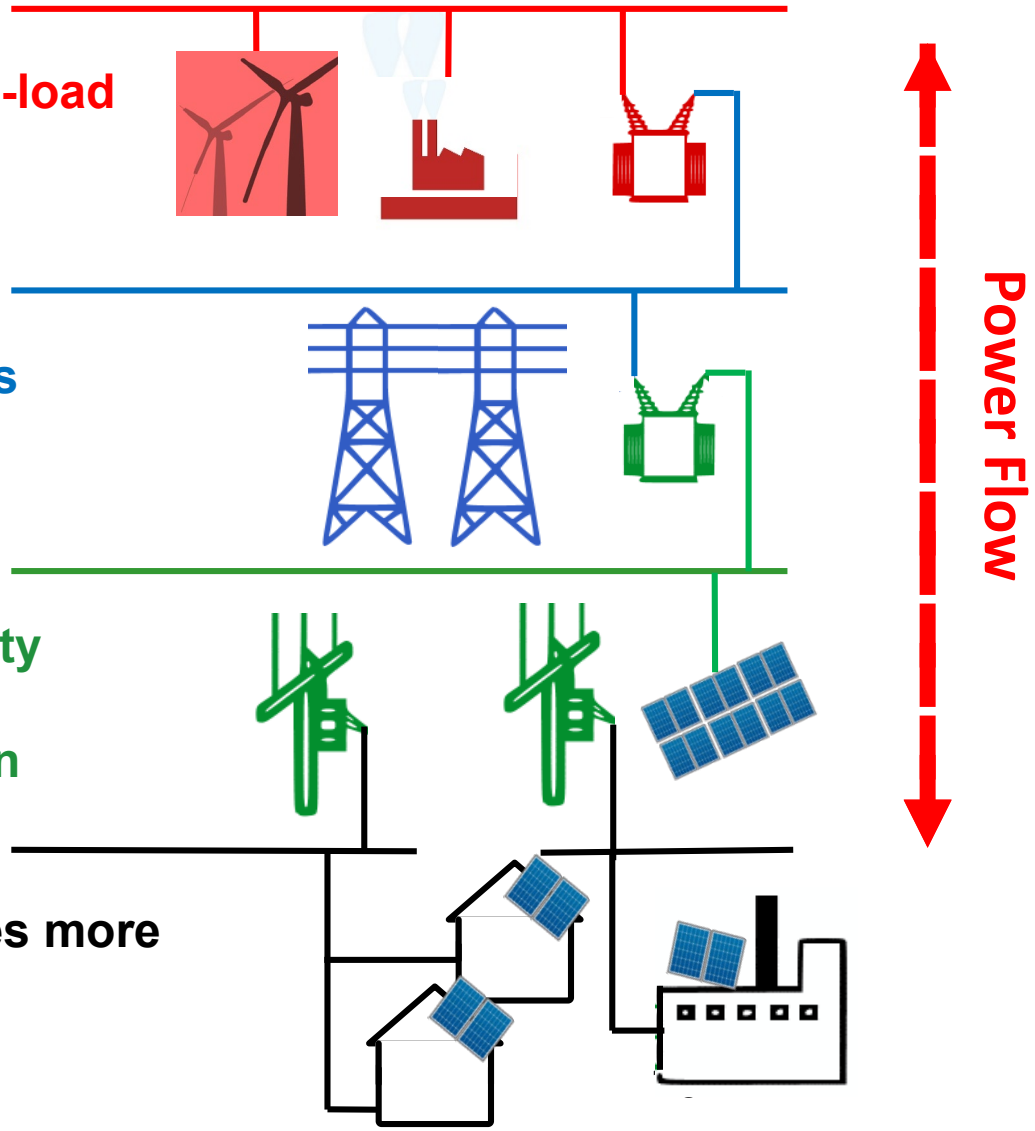
…but materialising its potential require additional efforts in system integration

The power sector paradigm changes, creating challenges to integrate high share of variable renewable energy in the system

System operation regime is changing



4 THE ENERGY INNOVATION PANORAMA

Vision for the Power Sector Transformation

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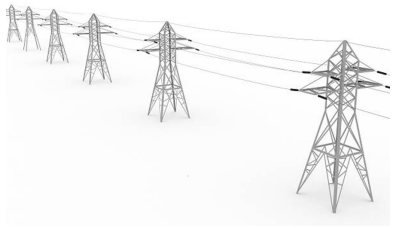
We need to map and understand the implications of these innovations for the power sector

Electrification of other sectors

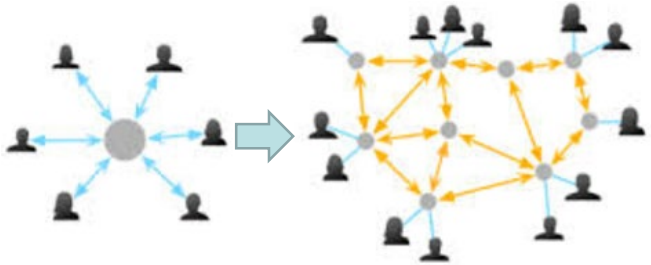
Value spatial complementarities - interconnections

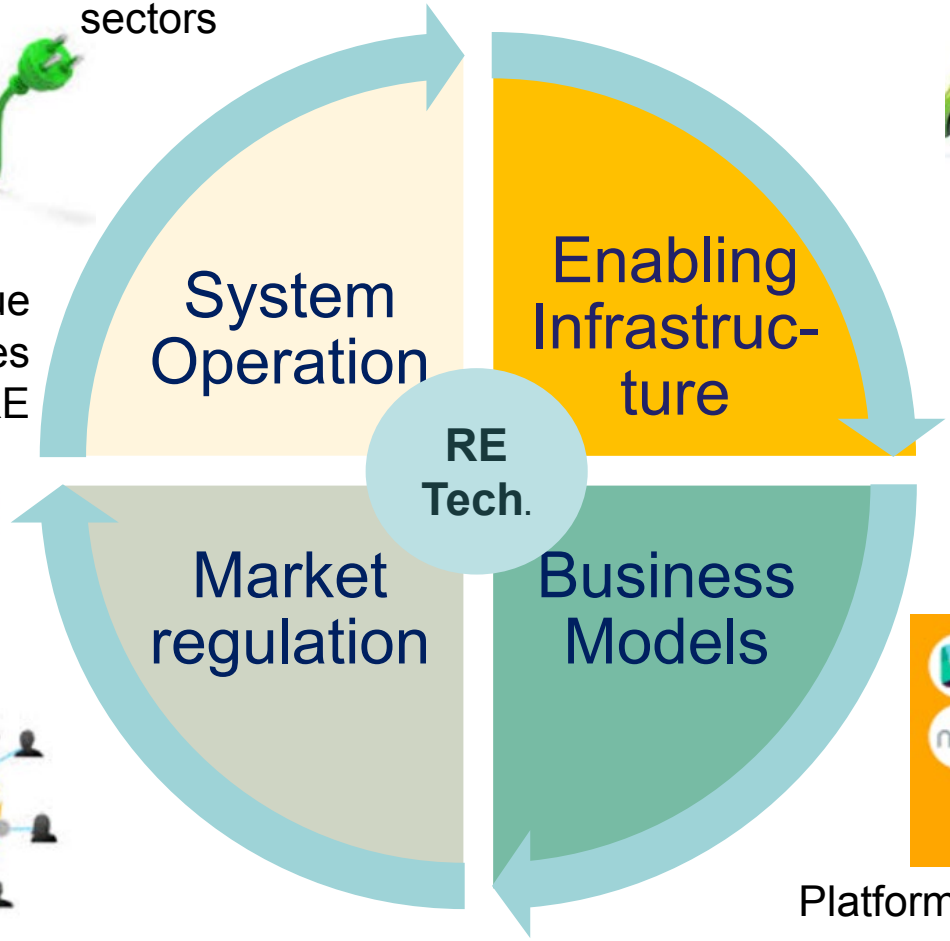


Value complementarities in VRE

Encourage Flexibility

Decentralized system





Electric Vehicles

Digitalization - IoT

Platform business model

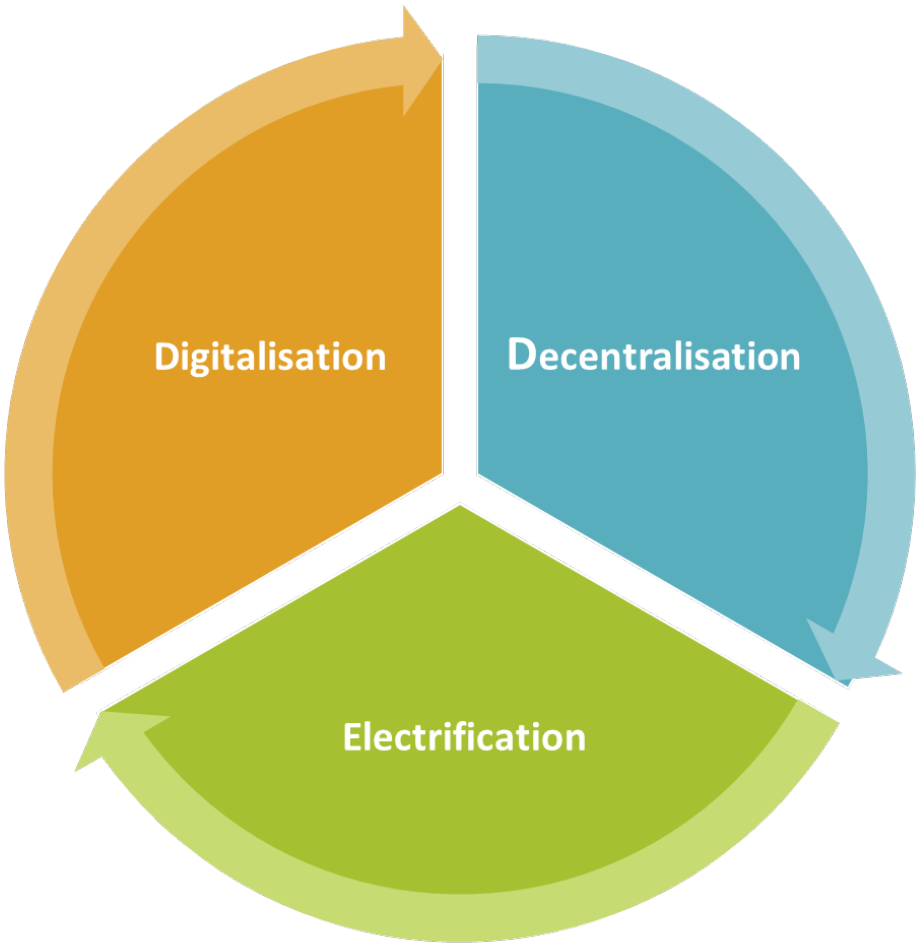
Storage

Blockchain

Aggregators- VPP

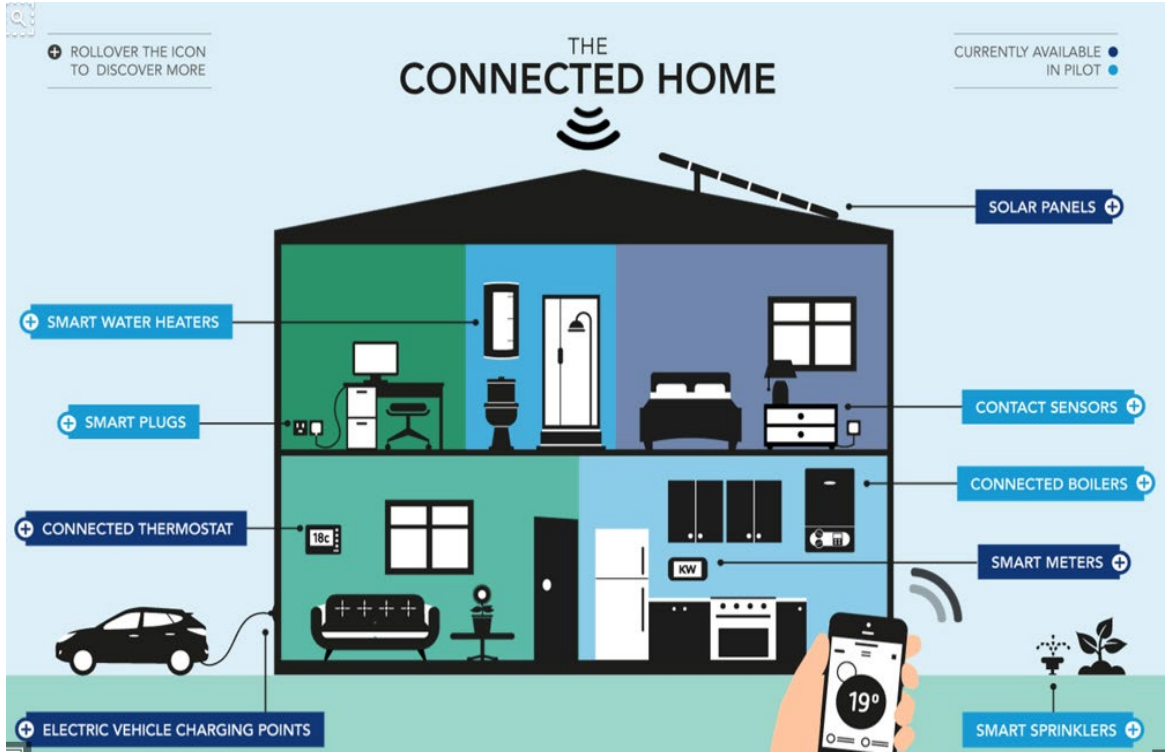
Innovative solutions to increase power systems flexibility propelled by three trends

- **Decentralisation.** 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
- **Digitalisation.** Key enabler to amplify the energy transformation by managing large amounts of data and optimizing systems with many small generation units
- **Electrification.** 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



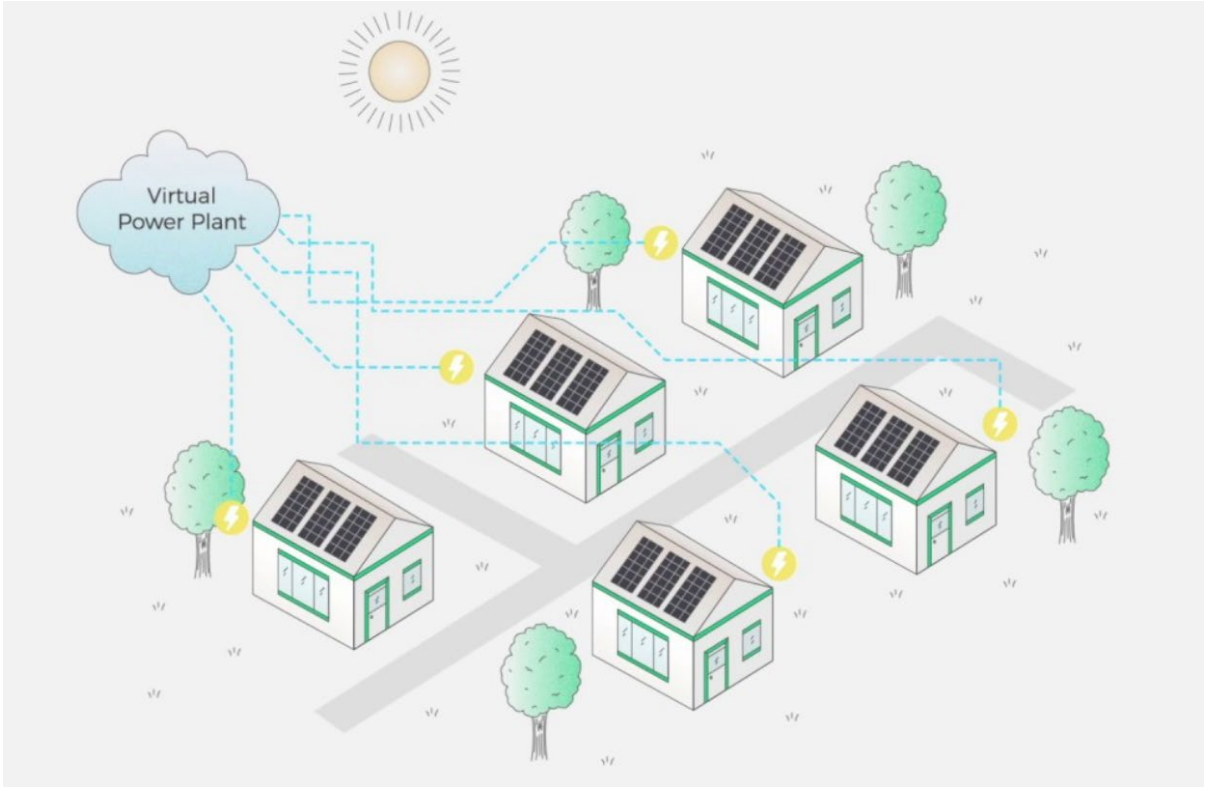
New technologies and business models empower the consumer

Smart Houses : IoT and Artificial Intelligence



IoT and AI enable demand side management, decreasing consumers' costs by improving energy efficiency and preventing energy waste

RE aggregator: Virtual Power Plant (VPP)

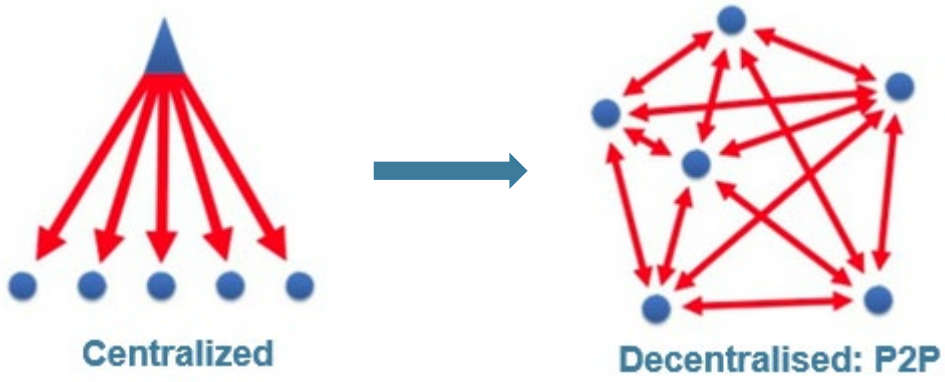


Aggregators enable distributed technologies (RE plants, storage) to participate in the energy market

Photo source: https://www.centrica.com/

New technologies and business models empower the consumer

Peer to peer trading



Platform based model promote Peer to Peer trading, offering a market place for distributed generation

Blockchain

Prosumers generate power beyond their needs and feed it into the grid through a blockchain-enabled e meter

The flow of electricity is automatically encoded in the blockchain

Algorithms match buyers and sellers in real time based on preferences and encode smart contracts into blockchain

Smart contracts execute when electricity is delivered, transferring payment in cryptocurrency from buyer to seller

Other nodes in the network verify the transactions

By promoting P2P trading and though emerging cryptocurrencies, blockchain incentivizes growth in decentralized generation

IRENA INNOVATION WEEK 2018

An Overview of IRENA Innovation Week 2018

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Bonn, Germany, 4 to 7 Sept. 2018.

Aim was to: **inspire & inform** decision makers; **showcasing solutions** from around the world

Sessions were informed by past and ongoing IRENA analysis.

Discussed latest developments in **enabling technologies**, **business models**, **system operation** and **market design** that are:

- Enabling the much higher deployment of variable renewable energy sources, such as solar and wind;
- Increasing the flexibility of power systems to integrate variable renewable generation at lower costs than present options;
- Supporting the increased electrification of the end-use sectors of transport, industry and buildings, powered by renewable electricity.

IRENA: Innovation Week 2018: Session Topics

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Digitalisation and Decentralisation

- Digital applications for energy transitions: Blockchain
- Digital applications for energy transitions: AI & big data
- The new consumer in the digital world
- Broadening energy access through innovation

Electrification

- Electrification of heat
- Electrification of transport
- Electricity storage
- Electrification of fuels: hydrogen

Markets & Citizens

- Market design for an integrated RE based energy system
- Empowering Citizens: value, challenges and implications

Plenary Discussion

- Future grids: getting bigger and smaller
- Perspectives on the transformative impacts of innovation

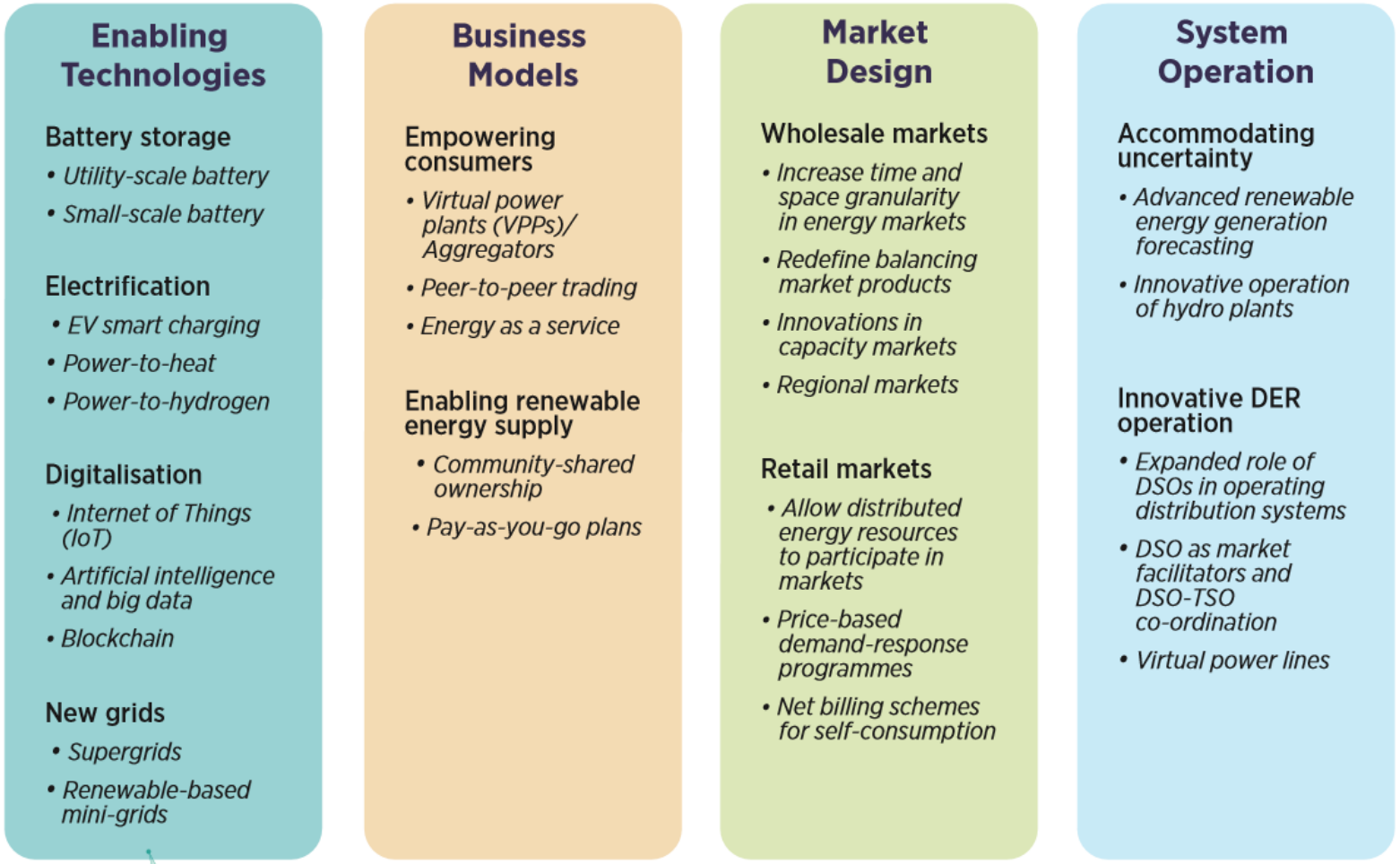
A short and longer form overview of the event, together with summaries and video of each session plus the slides used can be found at http://innovationweek.irena.org.

Navigating the Innovation Landscape for Renewable-Power Integration

Coming in 2019: The *"Landscape Report"* - **Solutions for a Renewable Powered Future: The innovation landscape for the integration of variable renewable power.**

The report and online resources will.

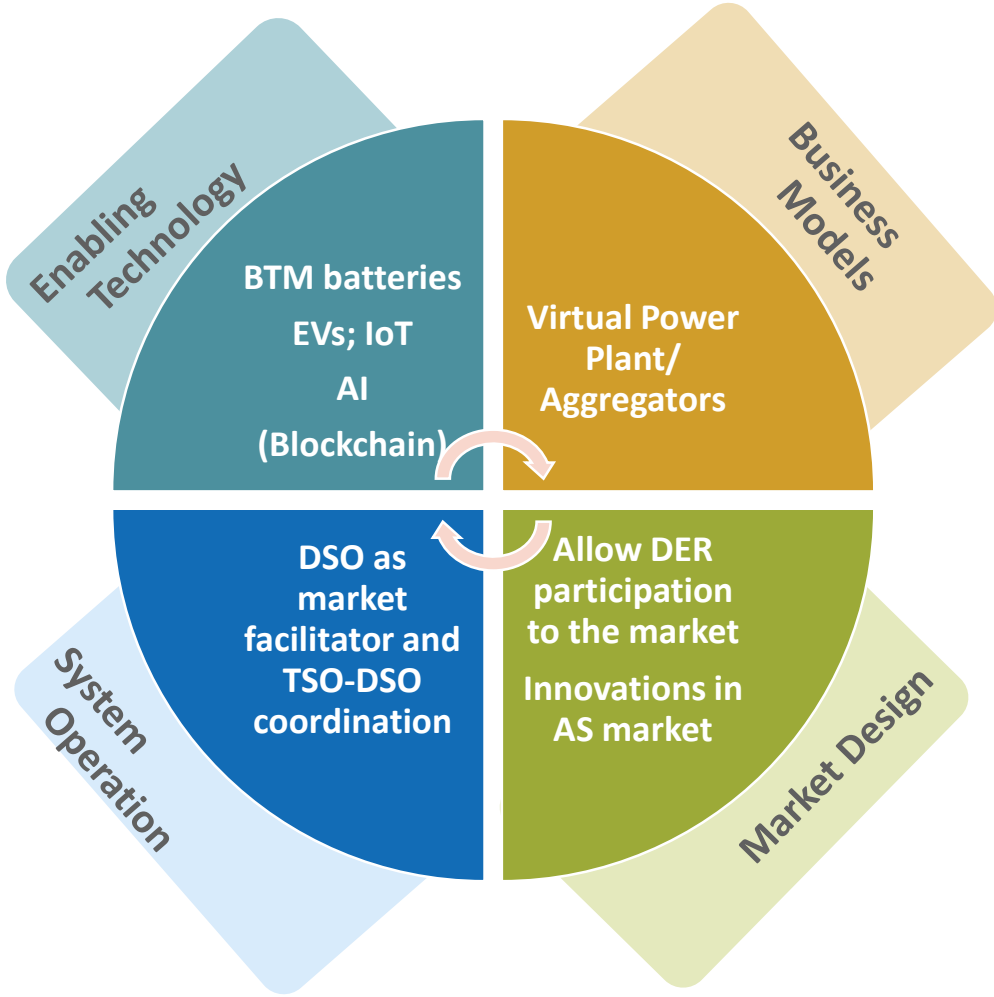
- provide decision makers with an **accessible** but comprehensive **overview** of the diversity of innovations in use or development
- explain how those innovations are being **combined to create solutions** suitable for wide range of power-systems
- provide guidance to help decision makers make judgments on **what to explore further** for their energy systems.



Solutions come from interactions between different innovations

Innovations do not emerge in isolation.

Synergies between innovations create combined solutions that have real-world impact.



An example of a solution requiring multiple innovations:

Distributed energy resources (DERs) providing services to the grid

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Thank you

We invite you to engage!

Roland Roesch: rroesch@irena.org

Francisco Boshell: fboshell@irena.org

Arina Anisie: aanisie@irena.org

www.irena.org

One more innovation
Blockchain: No middleman

By promoting P2P trading and though emerging cryptocurrencies, blockchain incentivizes growth in decentralized generation

Through smart contracts, blockchain makes distributed grid management easier

Prosumers generate power beyond their needs and feed it into the grid through a blockchain-enabled e meter

The flow of electricity is automatically encoded in the blockchain

Algorithms match buyers and sellers in real time based on preferences and encode smart contracts into blockchain

Smart contracts execute when electricity is delivered, transferring payment in cryptocurrency from buyer to seller

Other nodes in the network verify the transactions

Applied to larger interconnected grids, might lead to:

- No need for retailers
- No need for system operators - If smart contracts secure frequency and voltage control as well as balancing the grid system as a whole

Multiple drivers of electricity storage 2050

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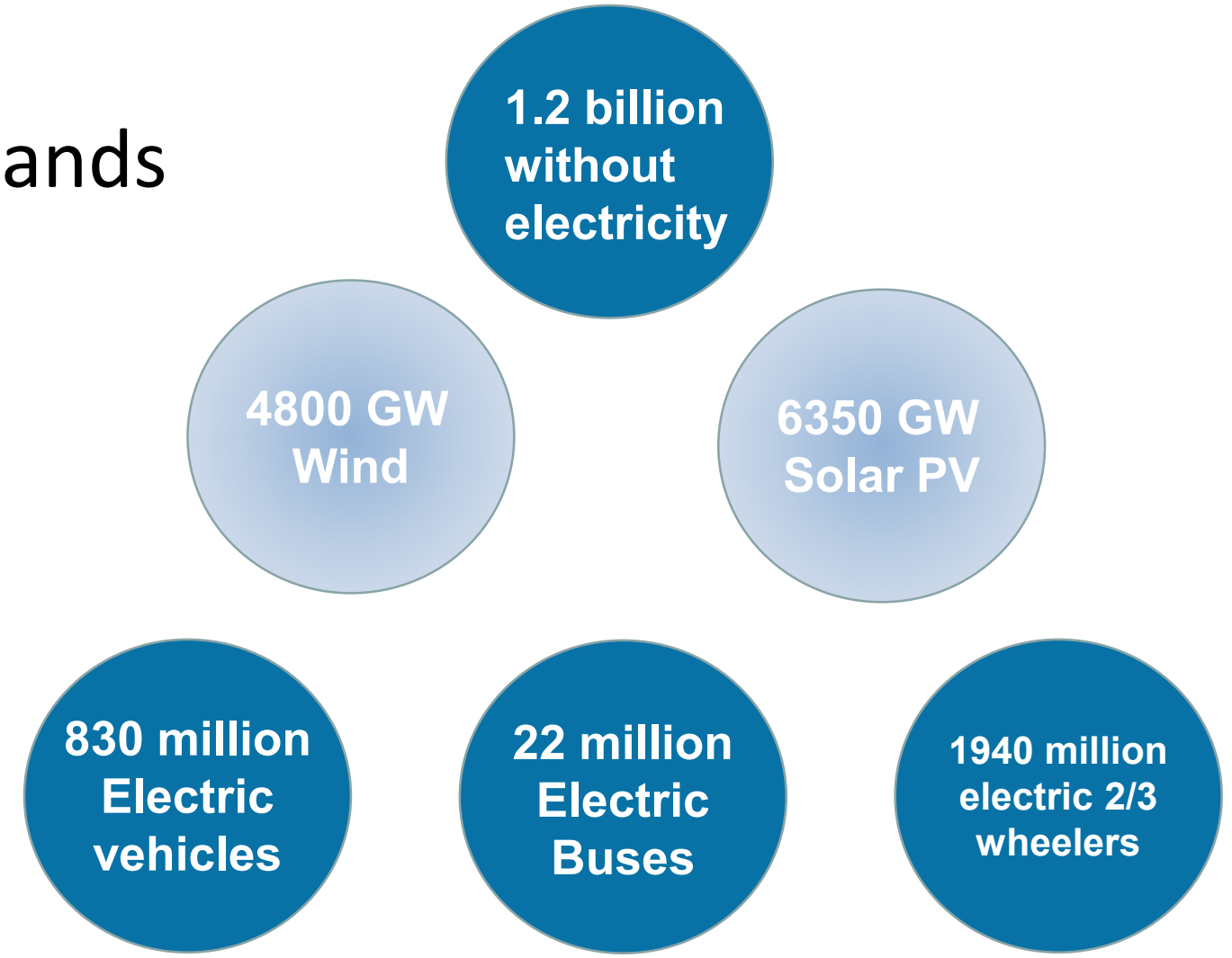
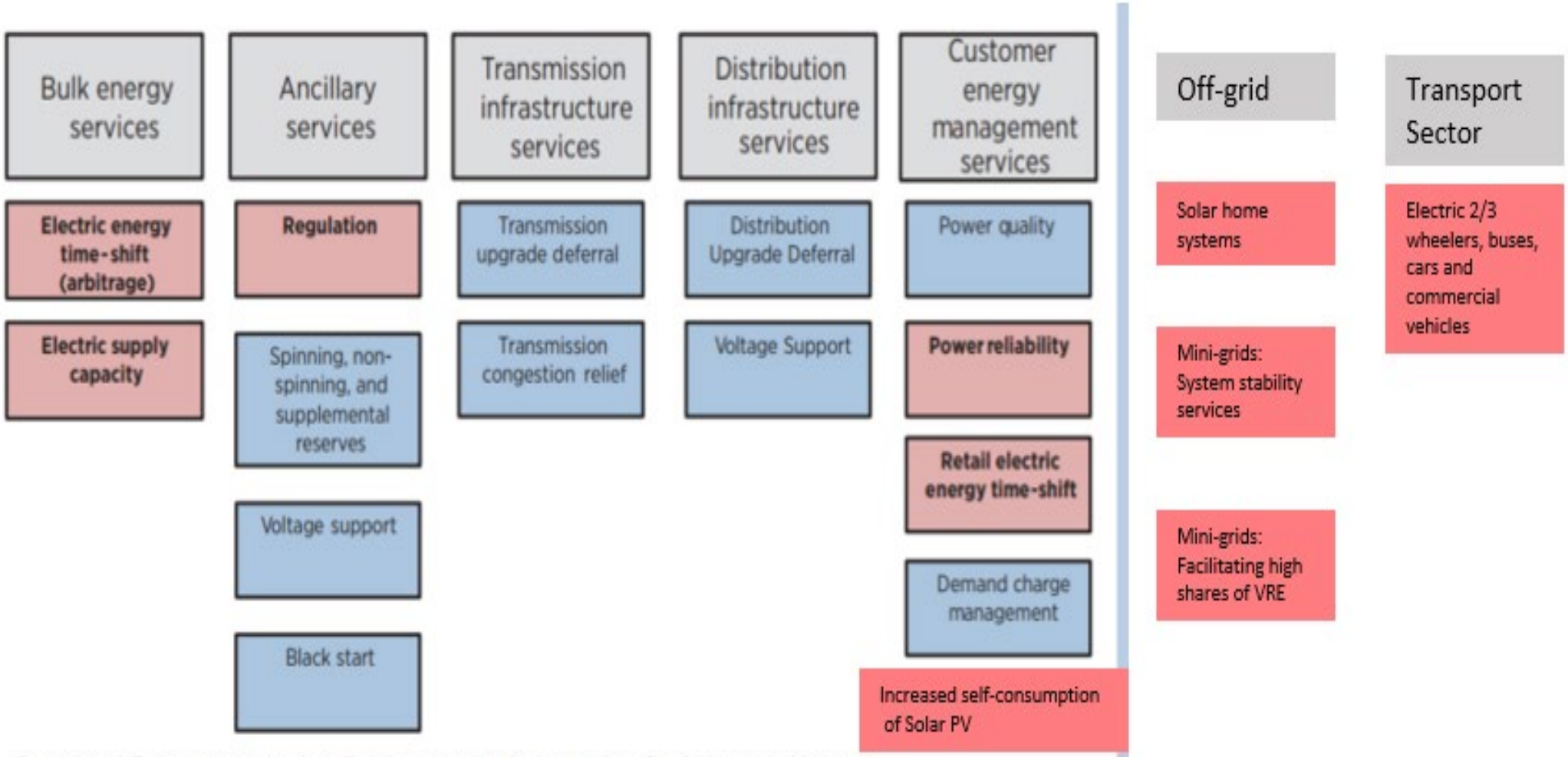
Off-grid, mini-grids & islands

High shares of VRE

Electromobility



Electricity storage can deliver multiple services and benefits



New technologies empower the consumer

Smart houses – how to implement?

Hardware

- Smart meters
- Sensors
- Supercomputers
- Other digital technology to convert the electricity grid from servo mechanical to digital connectivity to manage multiple sources of energy flowing to the grid from local generators

Software

- Optimization tools

Communication protocol:

- Agree and develop common interoperable standards (both at physical and ICT layers)

Regulation is key for demand-side management

Retail market

- Efficient, real-time price signals that reflect the cost of the participation of each agent to the electricity market

Distribution

- Incentivise distribution system operators to invest in smart grids and other digital solutions

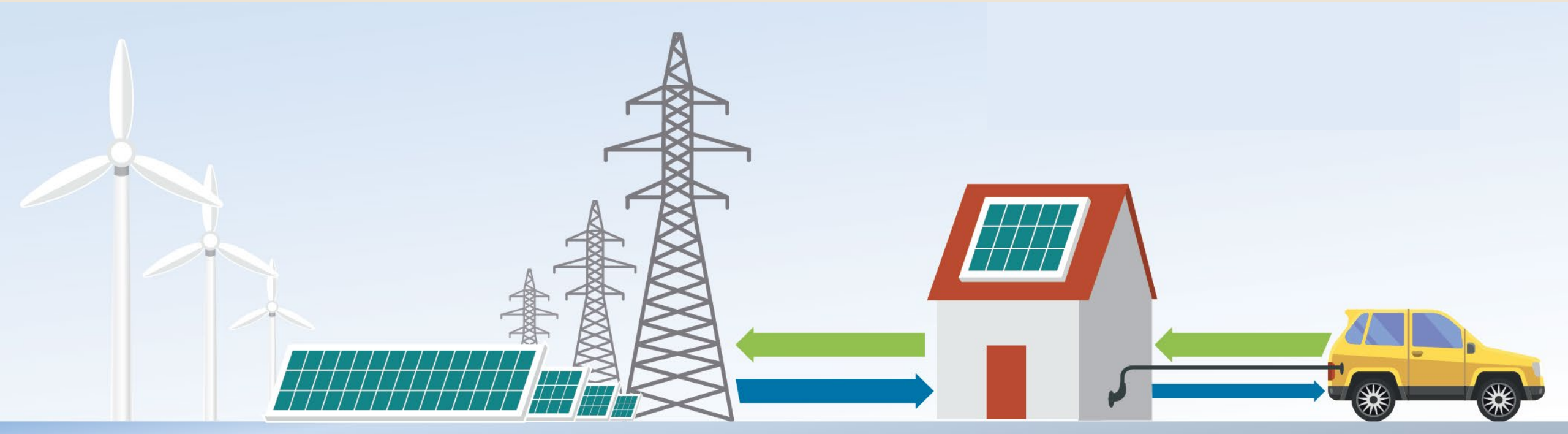
Other policies

- To ensure cybersecurity, data security, avoid misuse of data

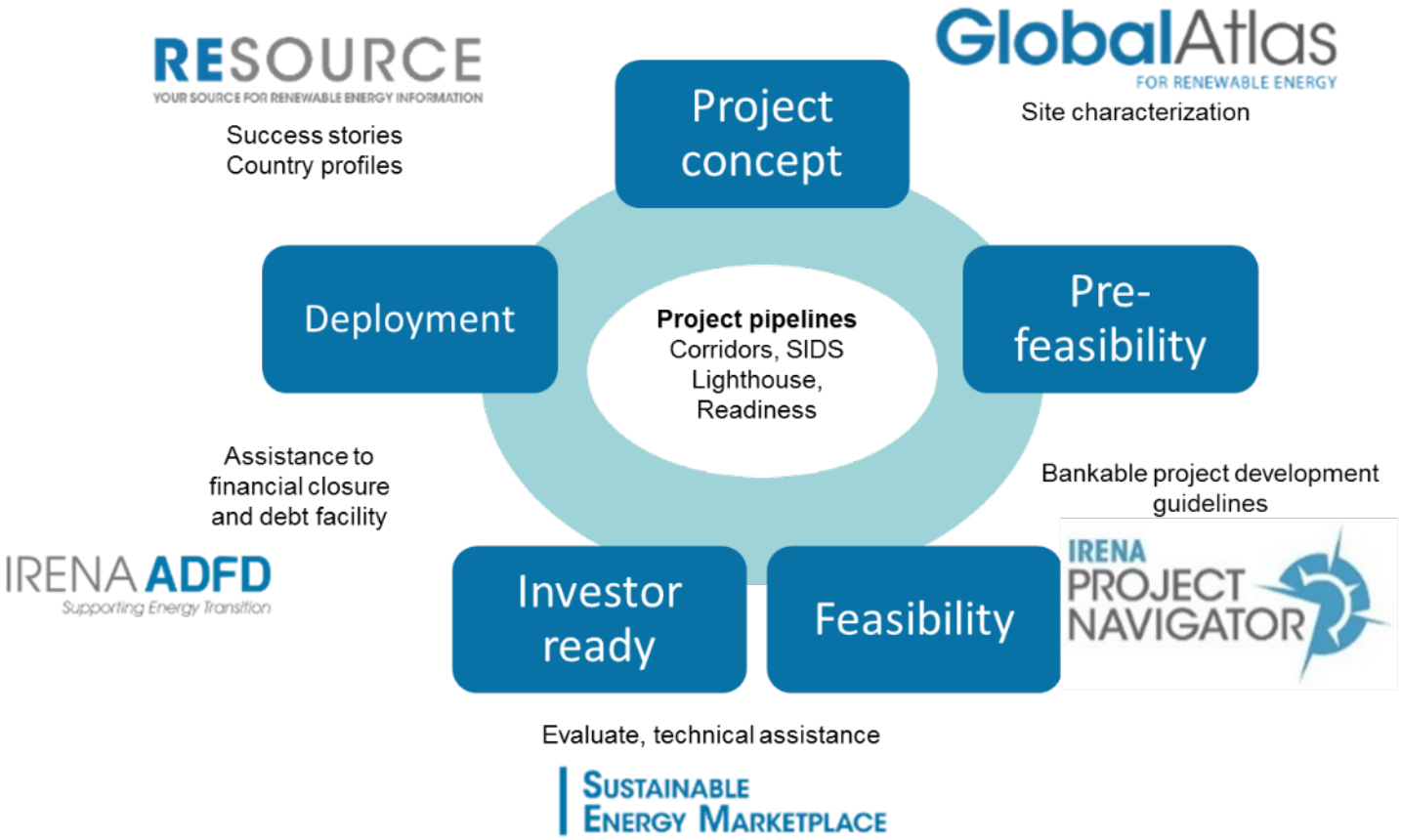
Some take aways

Technological innovations push towards a decentralisation and democratisation of energy, while market designs need to adapt and enable innovative business models emerge

Consumers' role is increasing: their behaviour is key!



IRENA Project facilitation platforms



Access the Project Navigator!

www.irena.org/navigator

The increasing role of consumer

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The new consumer is also producing, storing, trading energy and managing own load

Distributed generation

Behind the meter storage

Electric vehicles

Smart meters

Digitalisation - Internet of things

Artificial intelligence

Electricity becomes more Decentralised and Democratised