Global Renewable Energy Trends

Progress, costs and decarbonisation

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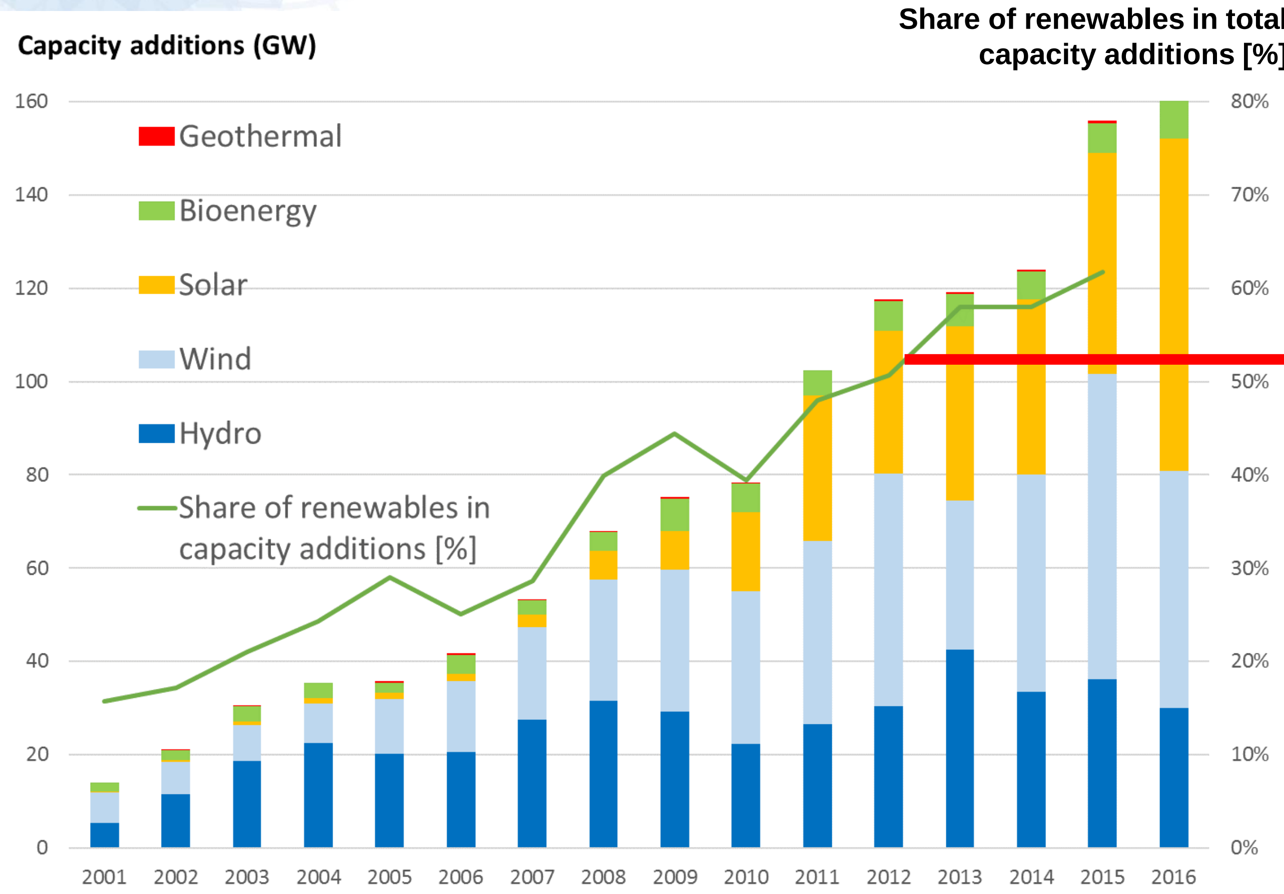
1 GLOBAL TRENDS

On-going power sector transformation



Since 2012 >50% of total capacity additions

2017 (est.)

- 95 GW solar PV
- 53 GW wind
- 3 GW biomass
- 20-30 GW hydro

Source: IRENA statistics

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

Example wind

- 540 GW cumulative installed capacity incl 19 GW offshore
- 53 GW installed 2017 incl 4.3 GW offshore wind
- Hywind 1st floating wind farm

- Projects routinely developed for UScents 3-6 per kWh
- Offshore wind cost dropped significantly in 2017 – first projects without premium
- 14% learning rate for onshore wind

- Japan wind development is lagging
- Offshore wind development is moving from Europe to other regions and countries including Japan
- Latest turbine designs 10-12 MW, up to 260 m high
- Floating offshore wind poses an important opportunity

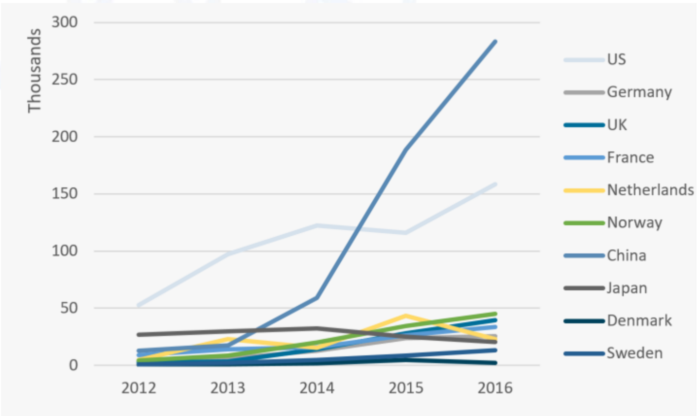
Hywind Floating Wind Farm – Oct 2017
(Source: Statoil)

Strengthening efforts in end use sectors

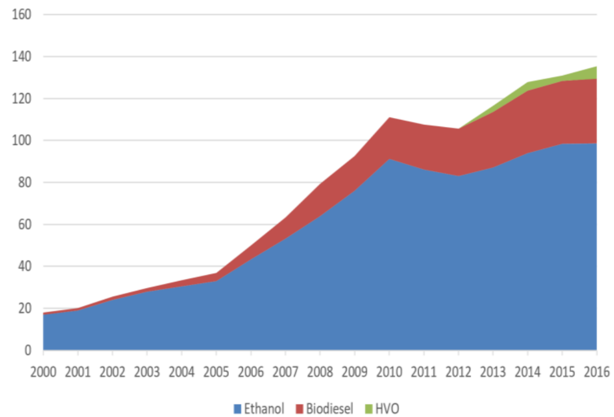
- Strong growth of electromobility
- Heat pumps in the residential sector

- New approaches to solar thermal (hybrid systems, storage)
- Corporate sourcing, maximized residential self-consumption
- Sector coupling and Power-to-X
- Continued growth biogas

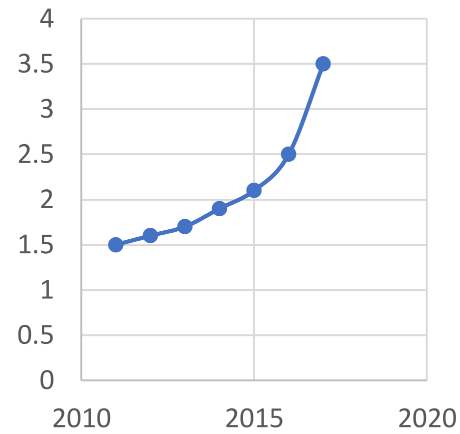
EV sales



Liquid biofuels



Heat pump sales [mln units]



Renewable Energy Prospects for the European Union: The outlook is brightening

February 2018

Aim

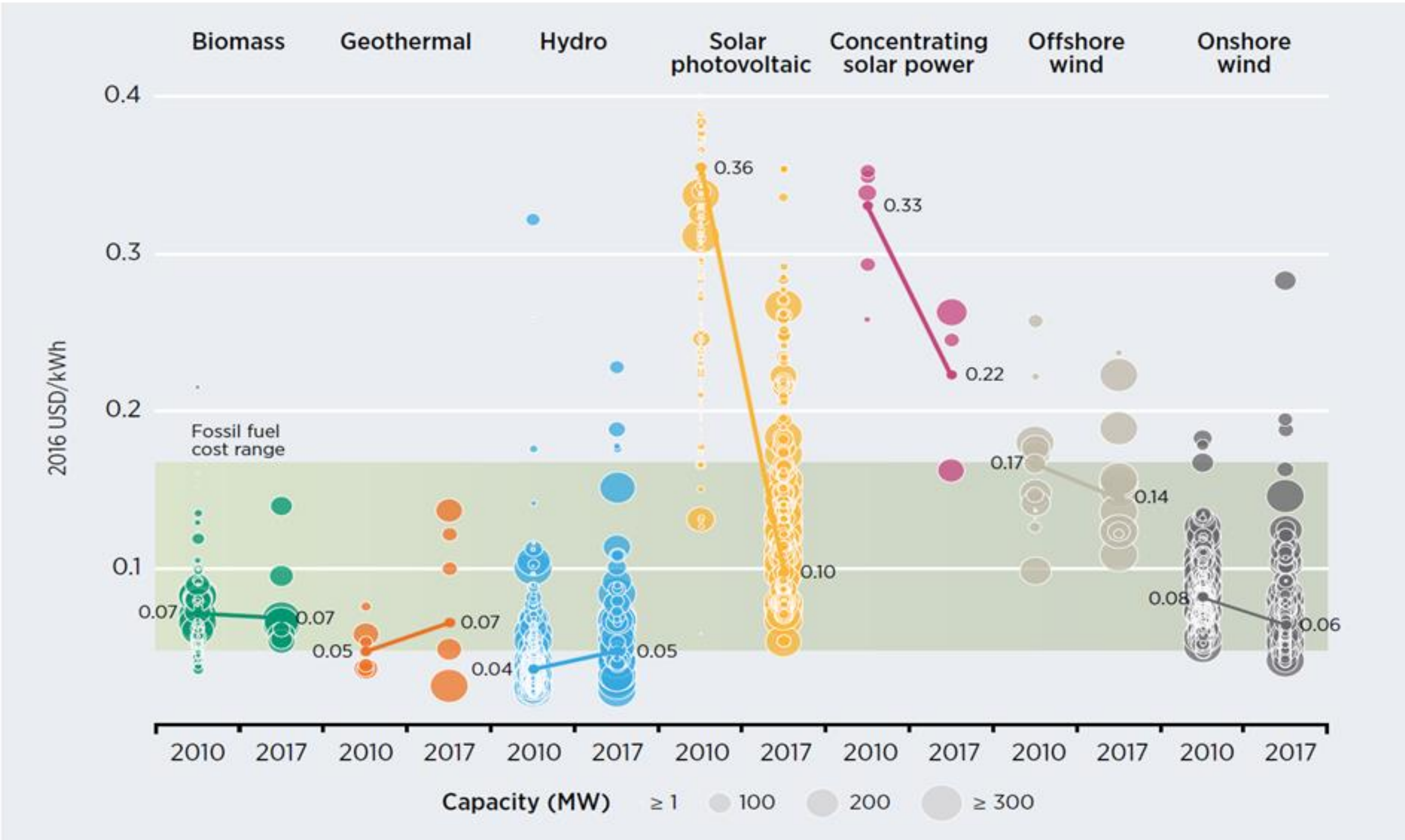
- Identify options to meet and potentially exceed the proposed 27% renewables target for 2030
- Assess the aggregated impact of national renewable energy plans
- Assess the role of renewables in long-term decarbonisation

Insights

- Doubling the RE share is feasible between now and 2030 to 34% RE share
- This is cost neutral
- RE technology improvements in recent years are the driver for greater potential
- Accelerating renewable deployment will be key for Europe to be in line with Paris Agreement
- Substantial economic and social benefits

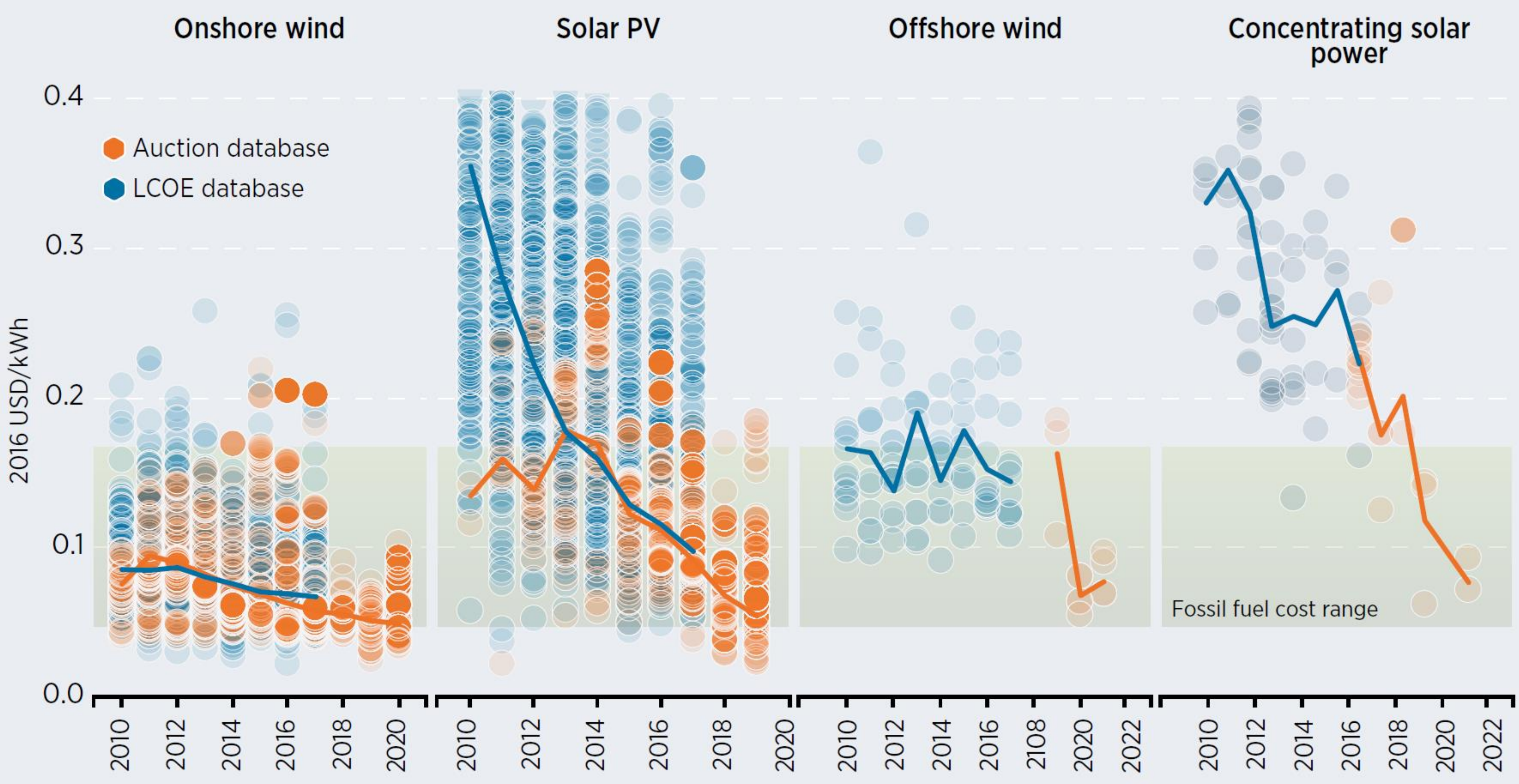
2 ECONOMICS

Cost trends – cost competitiveness

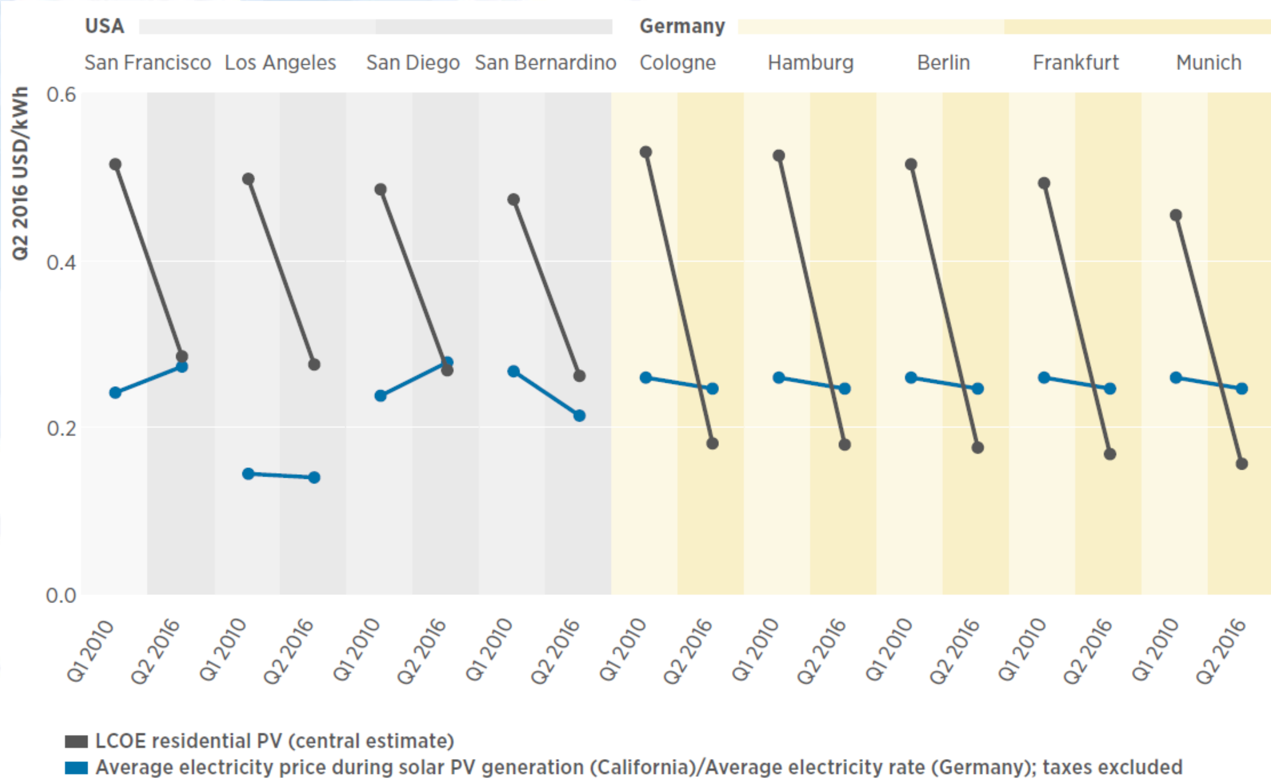


Source: IRENA Renewable Cost Database.

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



Electricity costs from residential rooftop solar PV falling rapidly



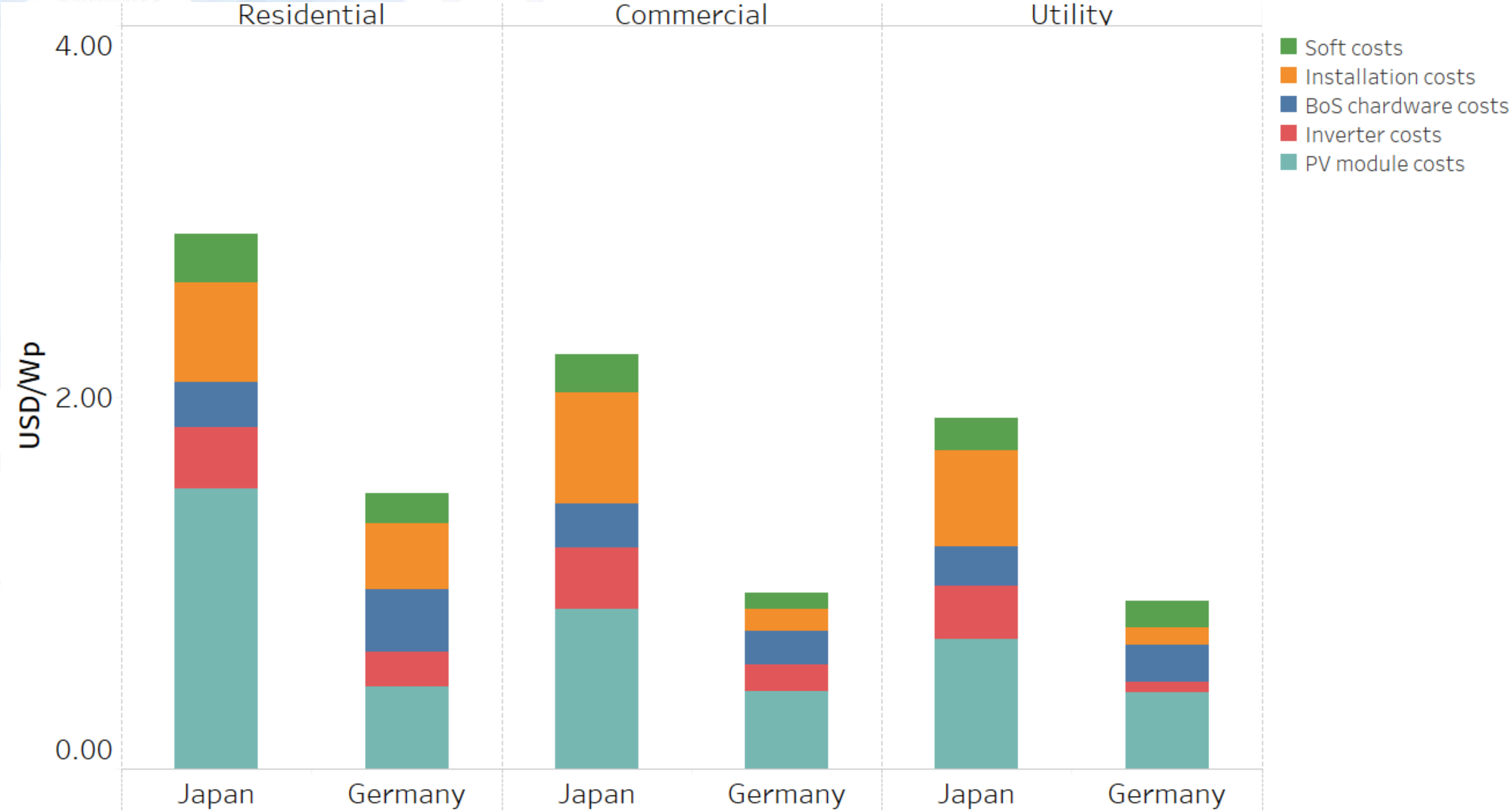
Electricity rates: San Francisco: E6; Los Angeles: TOU R-1B; San Diego: DR-SES; San Bernardino: TOU-D-T.

Source: IRENA analysis based on CEC and CPUC, 2016a; LADWP, 2016; PG&E, 2016; SDG&E, 2016; SCE, 2016; BDEW, 2016a.

In just over six years, median LCOE estimates have fallen by and average 45% for cities in California and an average 66% in German cities

The median LCOE of residential solar PV fell below the average effective electricity tariff that applies to these residential customers in six out of the nine cities analysed in this report

Cost comparison Japan and Germany



The Japanese case

- Japan has the second highest solar PV capacity per capita after Germany.
  - 43 GW installed capacity (DC based), 7 GW/yr addition
- The Japanese FIT program continues to support a high PV growth, with a good balance between large-scale, commercial, and residential systems.
  - 1st utility scale auction 20 Yen/kWh weighted average, 41 MW out of 500 proceeding – land & grid access, power offtake risk
- New solar PV installations declined since 2015 due to FIT cuts and to difficulties in securing grid connections – 4 GW/yr rooftop, 3 GW/yr ground mounted.
- 2.2 mln residential rooftop PV systems installed – 2019 first systems drop out of FiT – new zero energy houses policy from 2020
- Currently JPY 170-274/kW installation cost for utility scale PV - residential rooftop
- Expansion of foreign EPC companies into the Japanese market.

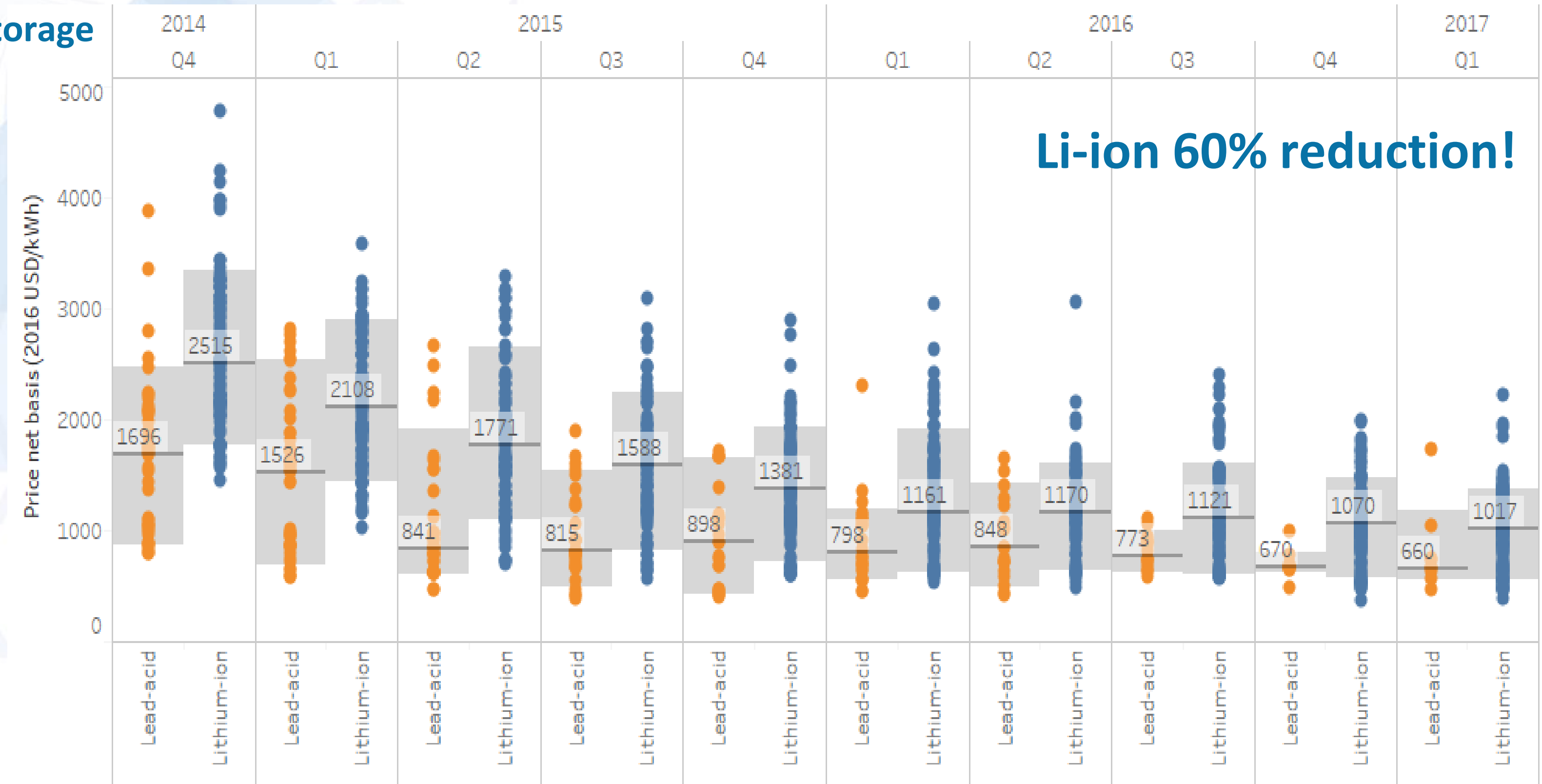
Comparing Japan and Germany solar PV

- Japan still shows significantly higher installation cost than Germany in all three analysed sectors.
- Installation times are still higher in Japan than Germany.
- Japan mainly uses earth screws, while Germany mainly uses pile driven foundations.
- Higher module cost in Japan, because a large percentage of modules are by Japanese Producers.
- According to REI the cost disparity was reduced in the last 2-3 years.
- Japan has higher solar irradiance, which gives lower LCOE despite higher CAPEX of PV systems.
- Design standards are higher in Japan than Germany due to differences in the natural environment.
- Unfavorable treatment once connected, difficult technical requirements and complicated environmental requirements create risk.
- Japan is also facing a shortage of land for new utility-scale solar installations.
- Floating PV has a high potential in Japan (to save land cost).

Small-scale storage: rapidly falling prices

An option for Japanese home owners to maximise self-consumption as FiT ends and ZEH gain importance

Home storage



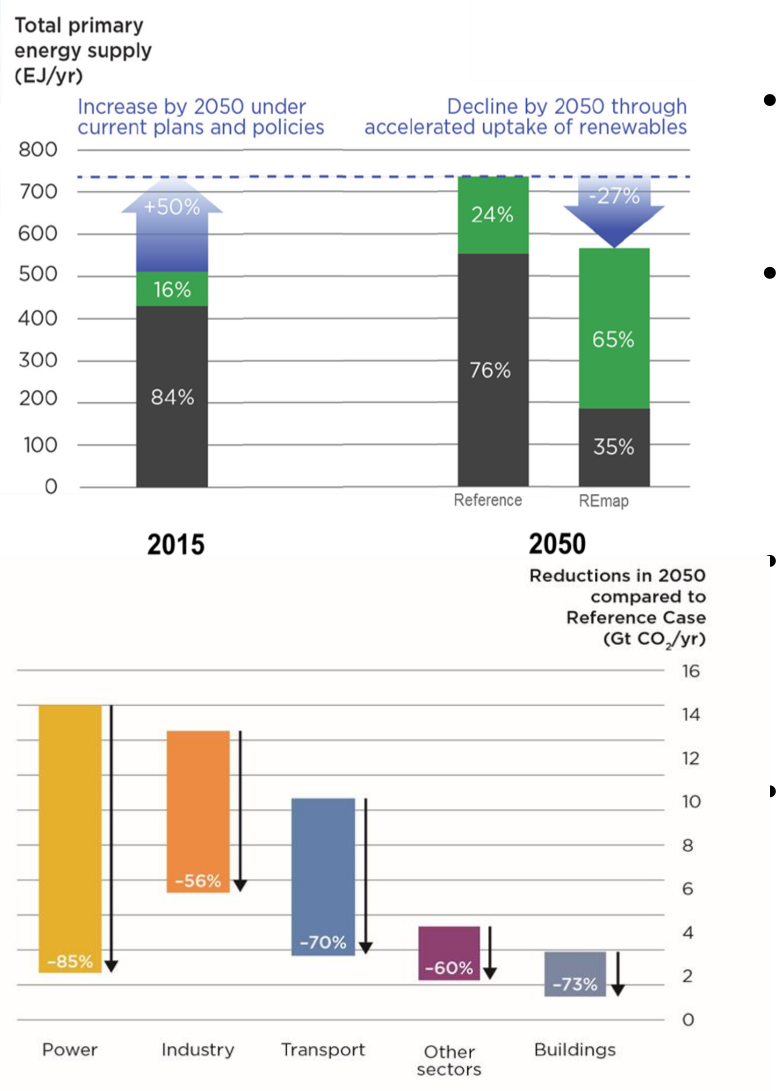
Source: IRENA, EuPD Research

Note: Horizontal bar shows median offer price, grey range 10th and 90th percentile.

Median prices for lithium-ion based residential storage system offers in Germany have declined roughly 60% Q4 2014 to Q1 2017

3 ENERGY TRANSITION NEEDS

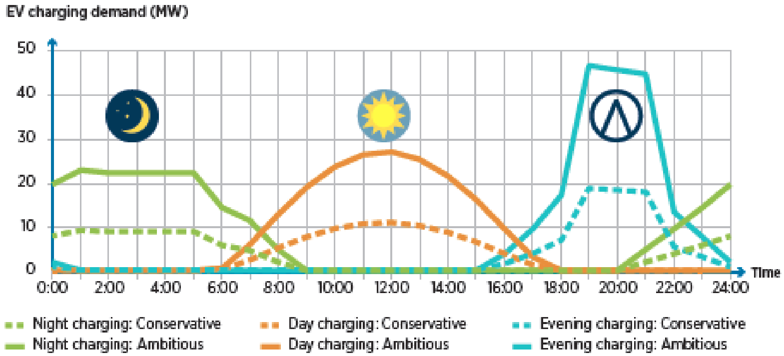
RE & EE – A need for global action



Source: IRENA, 2017

- RE and EE can deliver 90% of required CO_2 emission reduction
- Renewable energy would make up two-thirds of the energy mix by 2050 in REmap case, up from just one-quarter in Reference Case
- This requires an increase in the renewables' share of 1.4% per year, a seven-fold acceleration
- TPES would decrease from over 700 EJ to around today's level the result of both energy efficiency and RE power/electrification – intensity improvement 2.6%/yr – a doubling
- Power sector and end use sector efforts will be required

Sector coupling: Example electromobility



EVENING PEAK

- EVs charged at home as people return from work
- Likely charging pattern with no policy intervention
- Reduces system reliability by adding to existing evening peak demand
- Should be discouraged with time of use pricing and availability of public charging stations

NIGHTTIME

- Requires pricing signals and smart grid technologies to delay / prolong charging away from evening peak
- Better option for home charging
- Opportunity for vehicle-to-grid in the future, with EVs providing remunerated services to the grid

DAYTIME

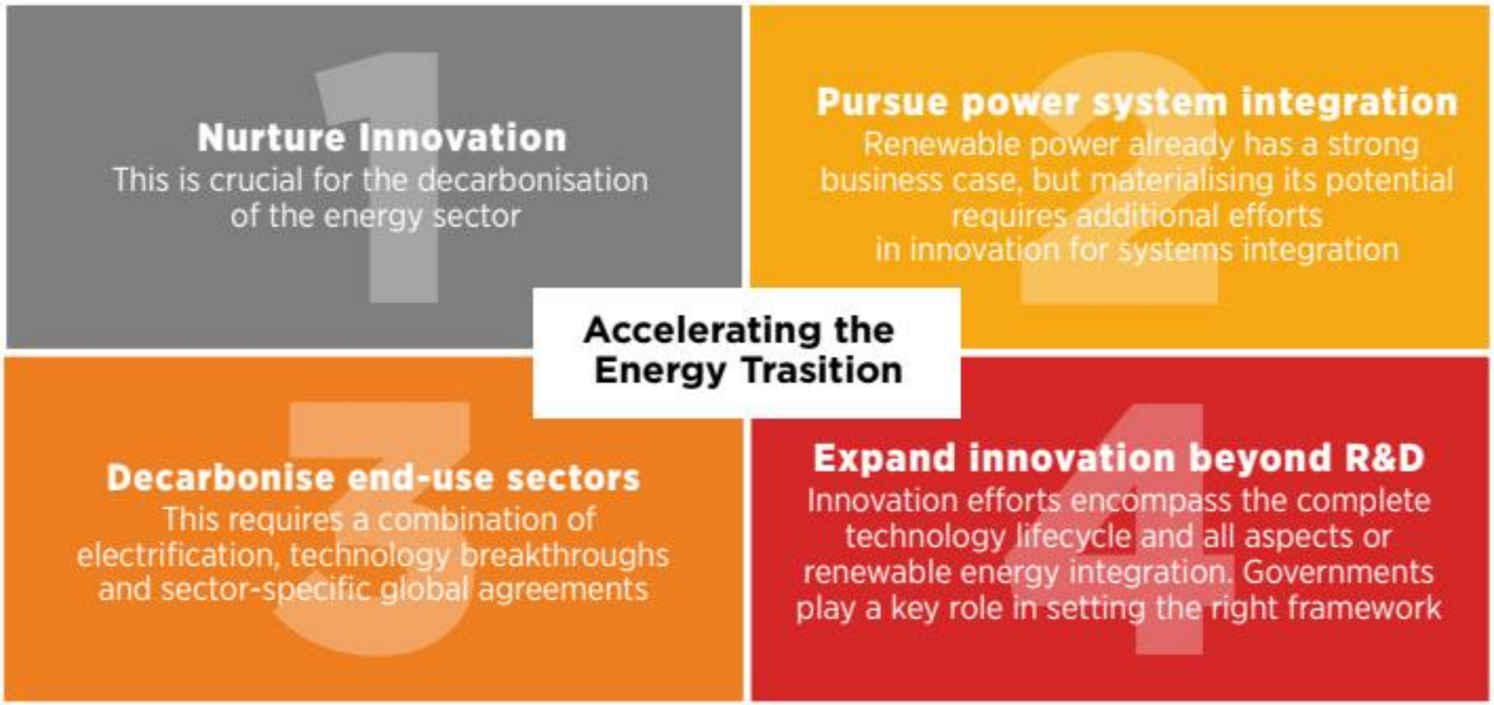
- Maximizes RE share in EV charging: 58-76%
- Significantly reduces RE curtailment from 14.5% to 9.3%
- Supports deployment of additional 12 MW of PV
- Requires investment in public charging infrastructure

- Electromobility has reached a tipping point
- Today 1-2% of car sales but much higher in some countries eg 50% of sales in Norway
- If done properly, electromobility can help to integrate larger amounts of variable renewables in the power system
- EV charging may require reinforcements in the LV grid system and smart charging is needed – Limited or no impact on HV transmission grids
- Transport sector CO_2 emissions need to reduce 70% over business as usual by 2050 with two-thirds of the reduction from electromobility

A smart charging approach is critical *(higher impact on GW than TWh)*

4 INNOVATION NEEDS

Accelerating the Energy Transition through Innovation

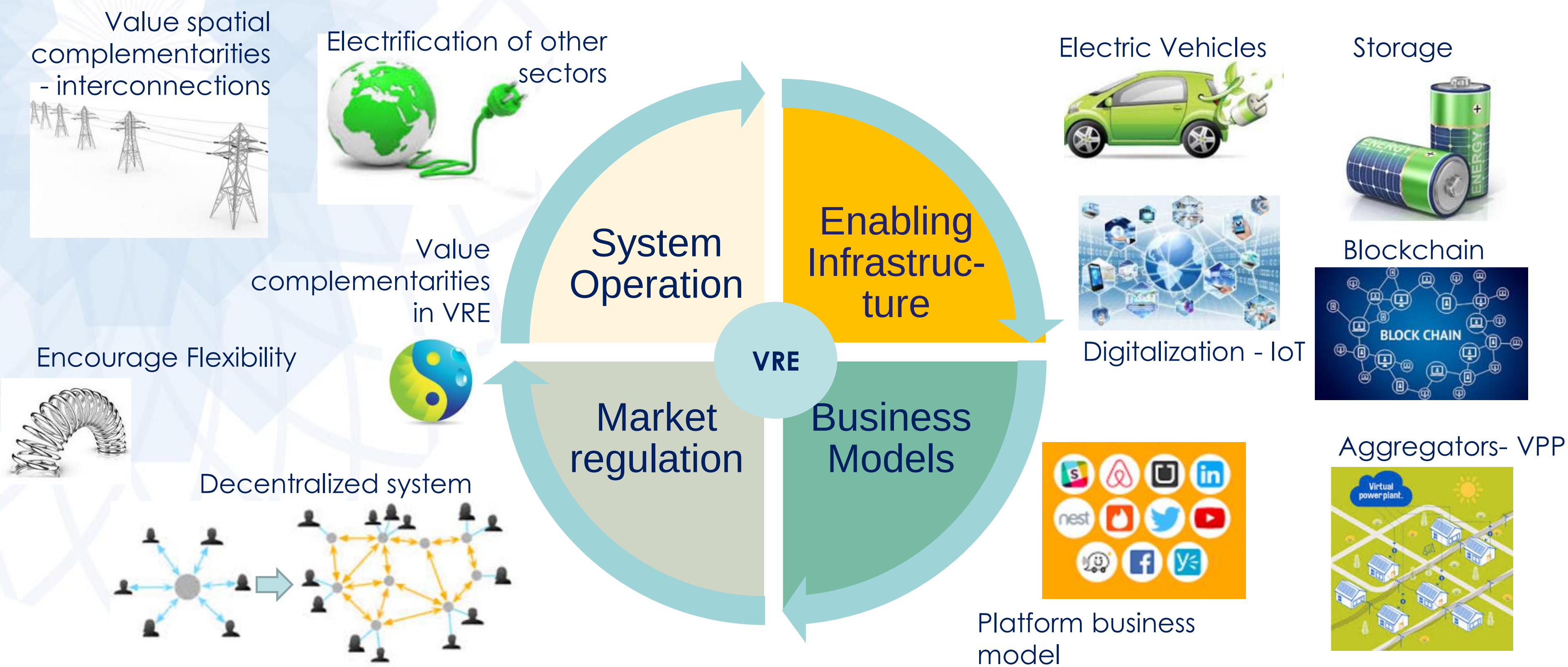


- Achieving the decarbonisation goal in the energy sector requires technology innovation in both electricity and other energy sectors and innovation to be expanded beyond R&D.

Innovation Landscape for Power Sector Transformation

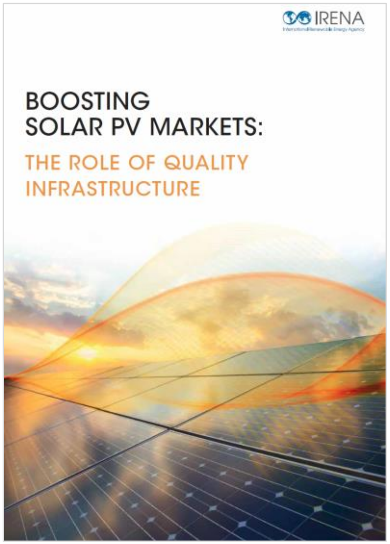
IRENA
International Renewable Energy Agency

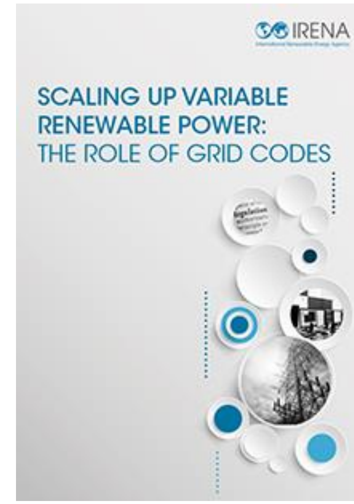
Systemic Innovation Needed for the Renewable Power Sector



- Accelerated innovation requires a combination of various policy instruments across the whole technology lifecycle, from R&D to market scale-up.
- A systematic approach is required, encompassing technical, policy, business model and regulatory considerations.
- Concentrating all efforts solely on a narrow suite of measures, such as R&D spending or market signals, will not bring the expected results.

Supporting countries to develop and implement QI for RET – innovation goes beyond R&D





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