

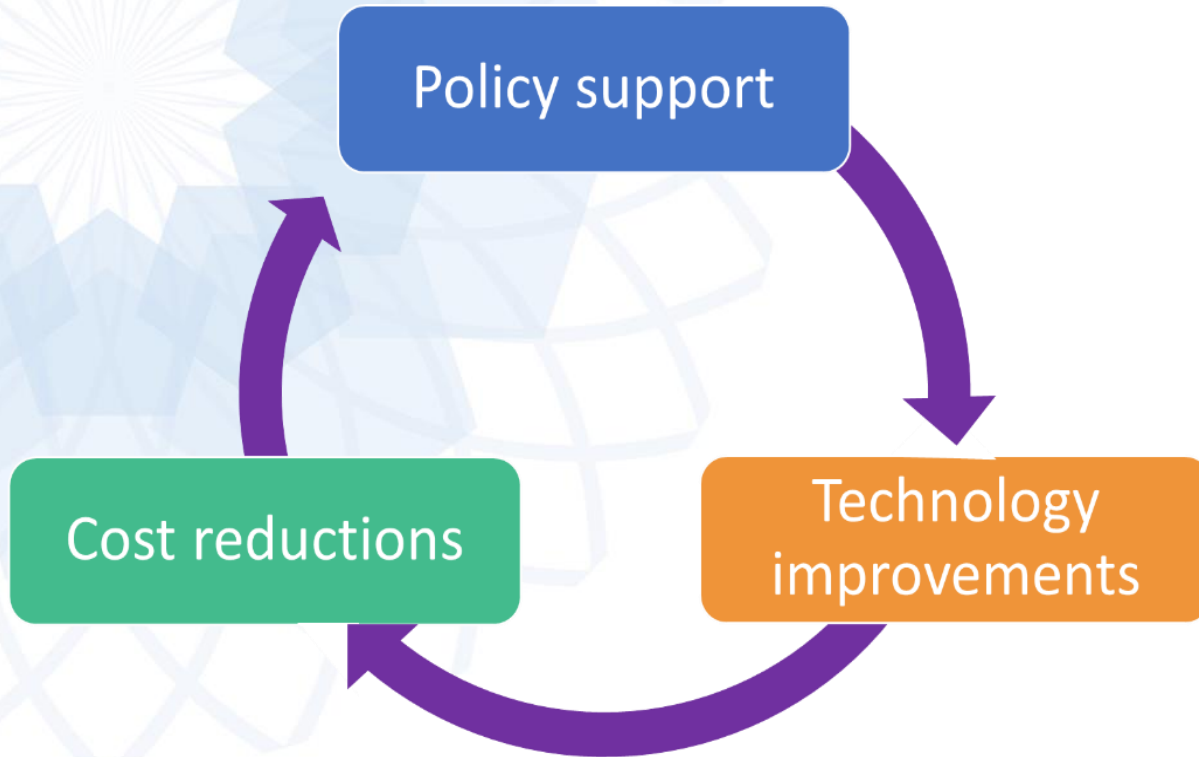
ELECTRICITY STORAGE: AT THE HEART OF THE ENERGY SECTOR TRANSFORMATION

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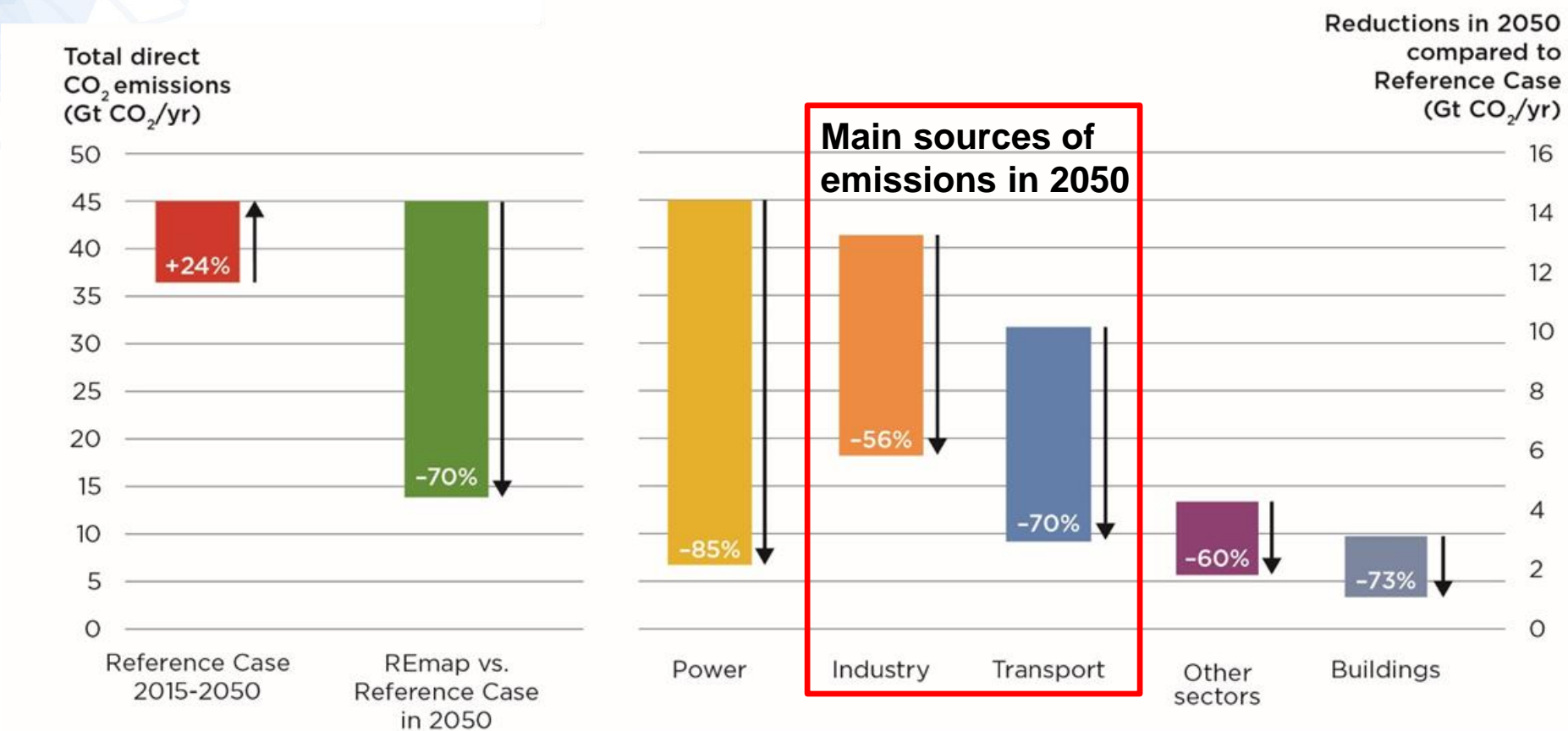
The Energy Sector is Being Transformed



A *virtuous cycle* is unlocking the *economic*, *social* and *environmental* benefits of renewables



Development in CO₂ emissions by sector



By 2050, total energy-related CO₂ emissions will need to decrease to below 10 Gt/yr
 CO₂ emissions from the power and buildings sectors will be almost eliminated

ELECTRICITY STORAGE: COSTS & MARKETS TO 2030

**AT THE HEART OF THE
ENERGY SECTOR TRANSFORMATION**

Multiple drivers of electricity storage

2050

Off-grid, mini-grids & islands

1.2 billion
without
electricity

High shares of VRE

4800 GW
Wind

6350 GW
Solar PV

Electromobility

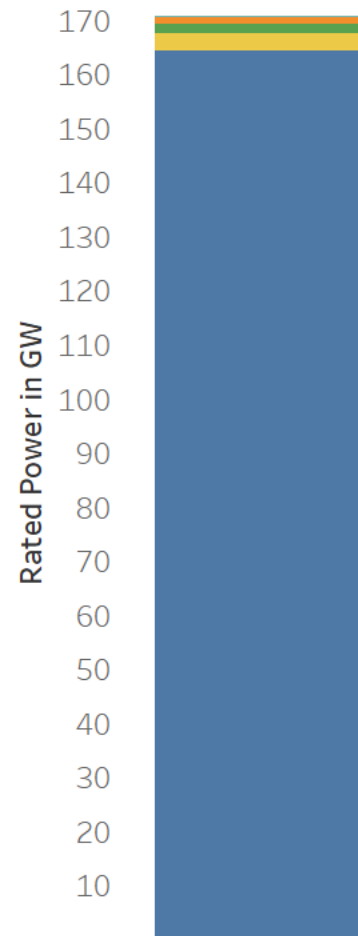
830 million
Electric
vehicles

22 million
Electric
Buses

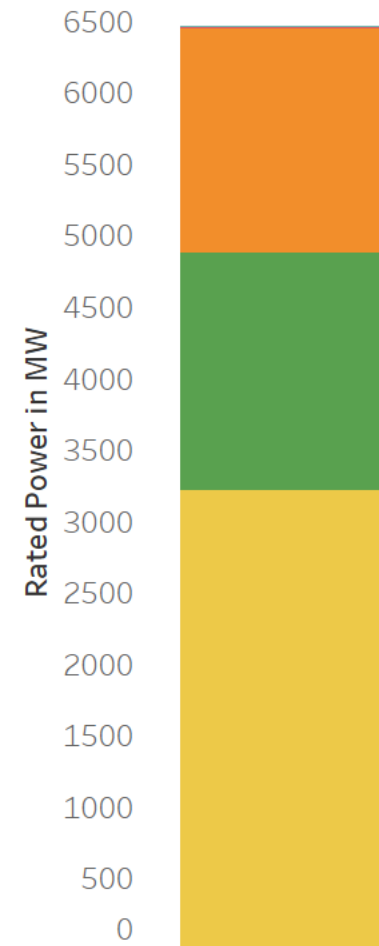
1940 million
electric 2/3
wheelers

Stationary storage today

Total



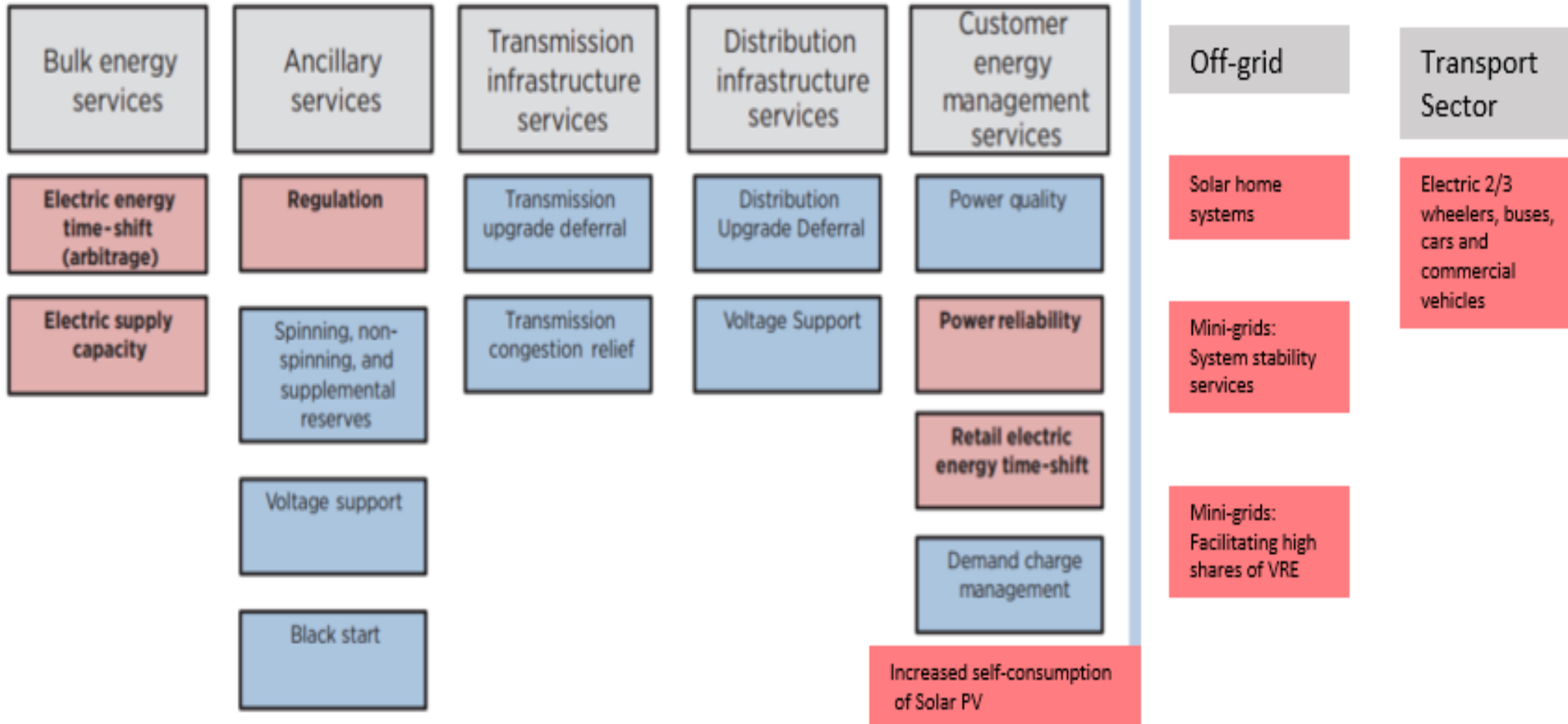
excl. Pumped hydro



- Liquid Air Energy Storage
- Hydrogen Storage
- Electro-mechanical
- Electro-chemical
- Thermal Storage
- Pumped Hydro Storage

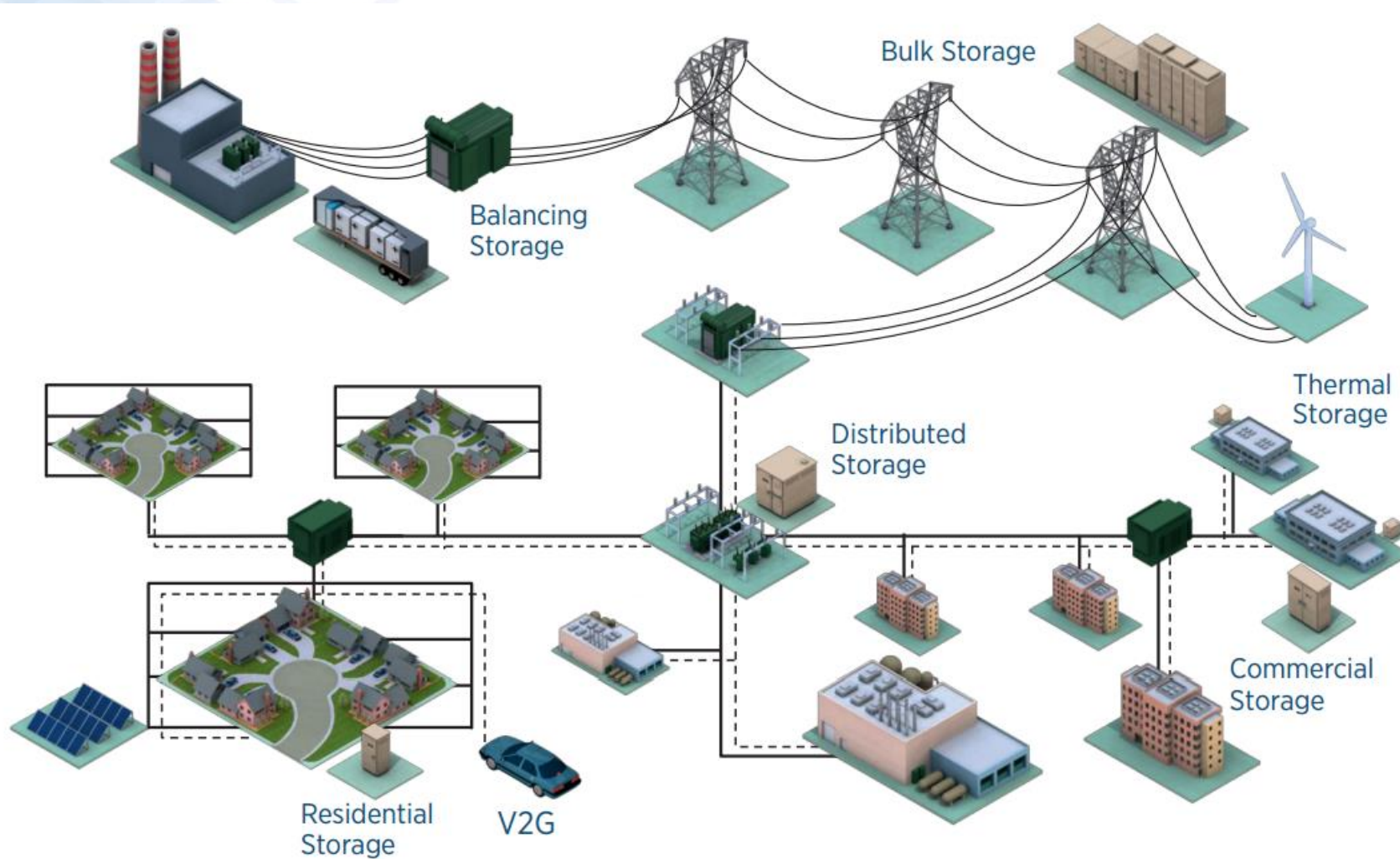
• Source: DOE

Electricity storage can deliver multiple services and benefits



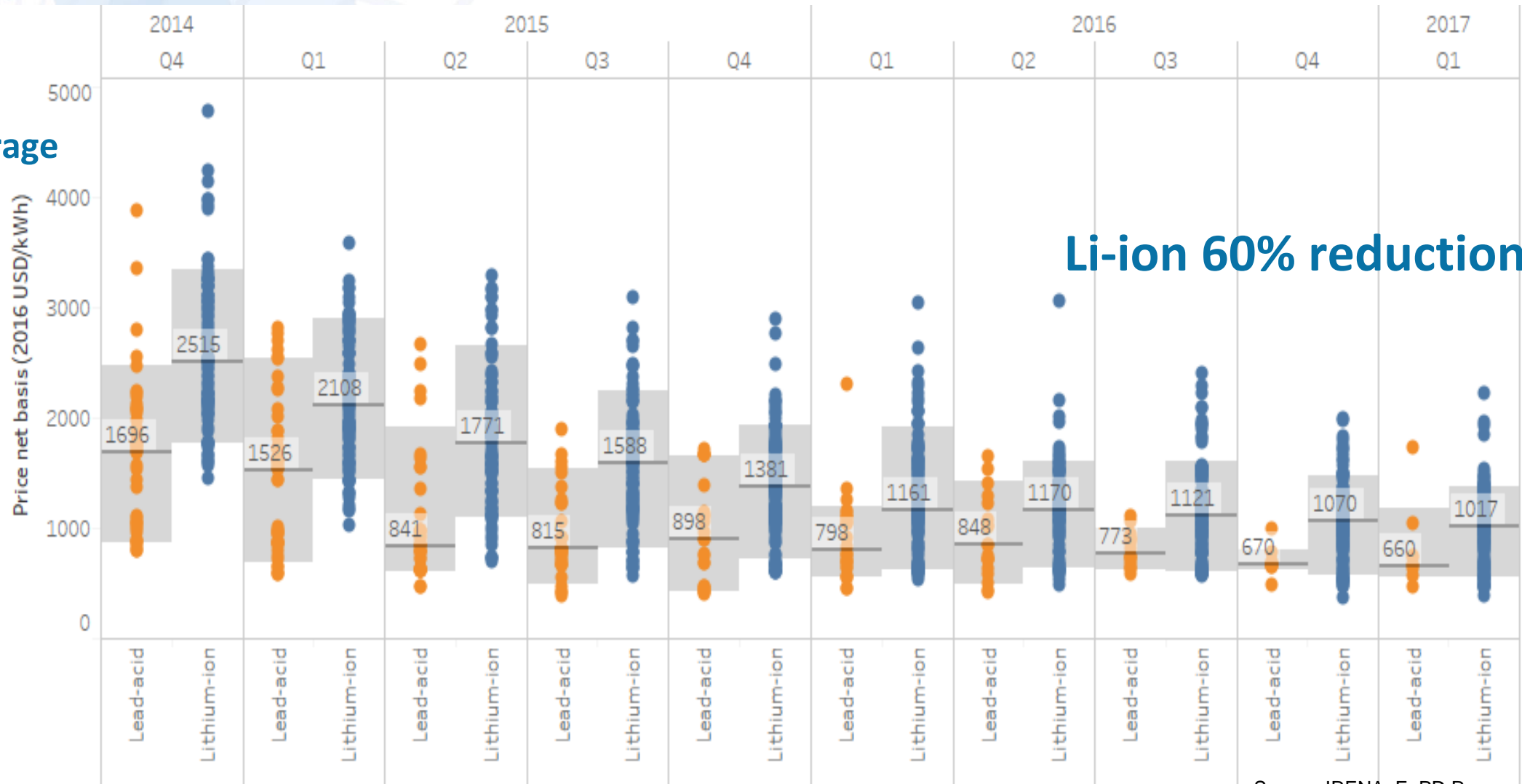
Boxes in red: Energy storage services directly supporting the integration of variable renewable energy

Potential locations and applications of electricity storage



Small-scale: rapidly falling prices

Home storage



Source: IRENA, EuPD Research

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

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

ELECTRICITY STORAGE FOR STATIONARY APPLICATIONS

KEY FINDINGS

Costs of storage are falling and performance improving to 2030



Installed energy costs to fall 50-66% by 2030

Performance improvements

Market to support range of technologies

Overall market for electricity storage to grow 2-3X
Battery storage by 17-38X

Report coverage

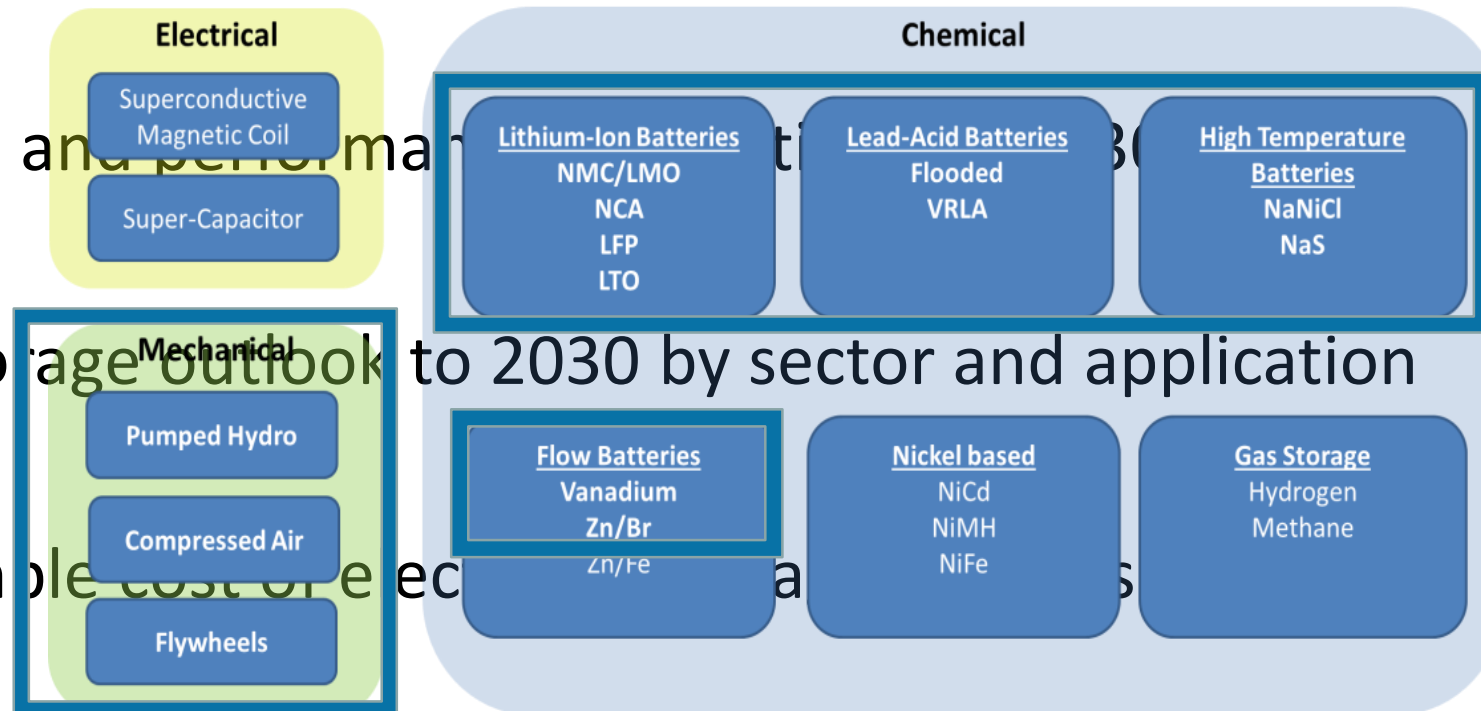
Stationary applications of electricity storage (12 in detail)

13 electricity storage technologies, from five groups

Current costs and performance

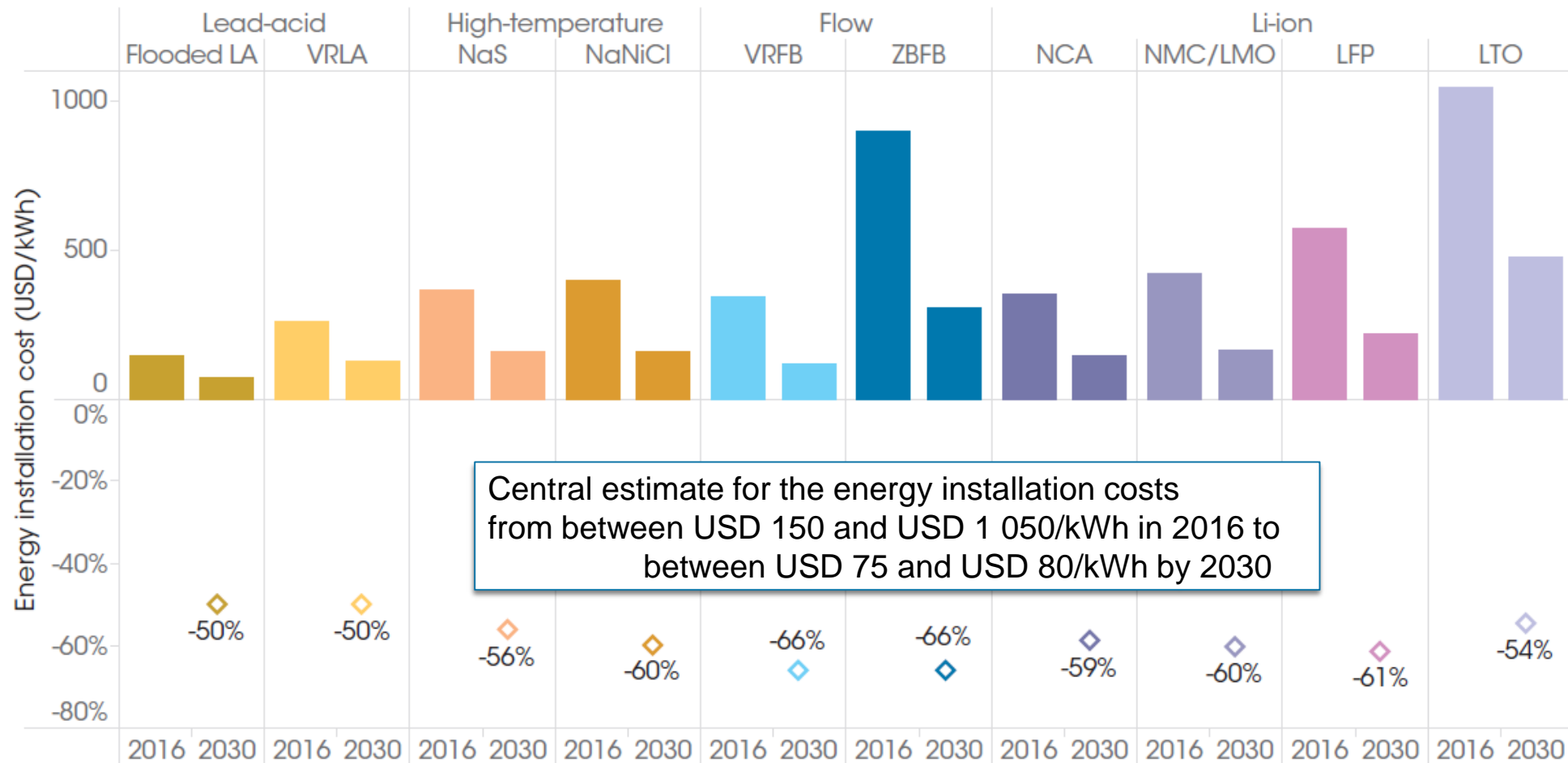
Electricity storage outlook to 2030 by sector and application

Online: A simple cost of electricity calculator



Current prices of different storage technologies

Current energy installations costs (USD/kWh of storage) Reference case 2016



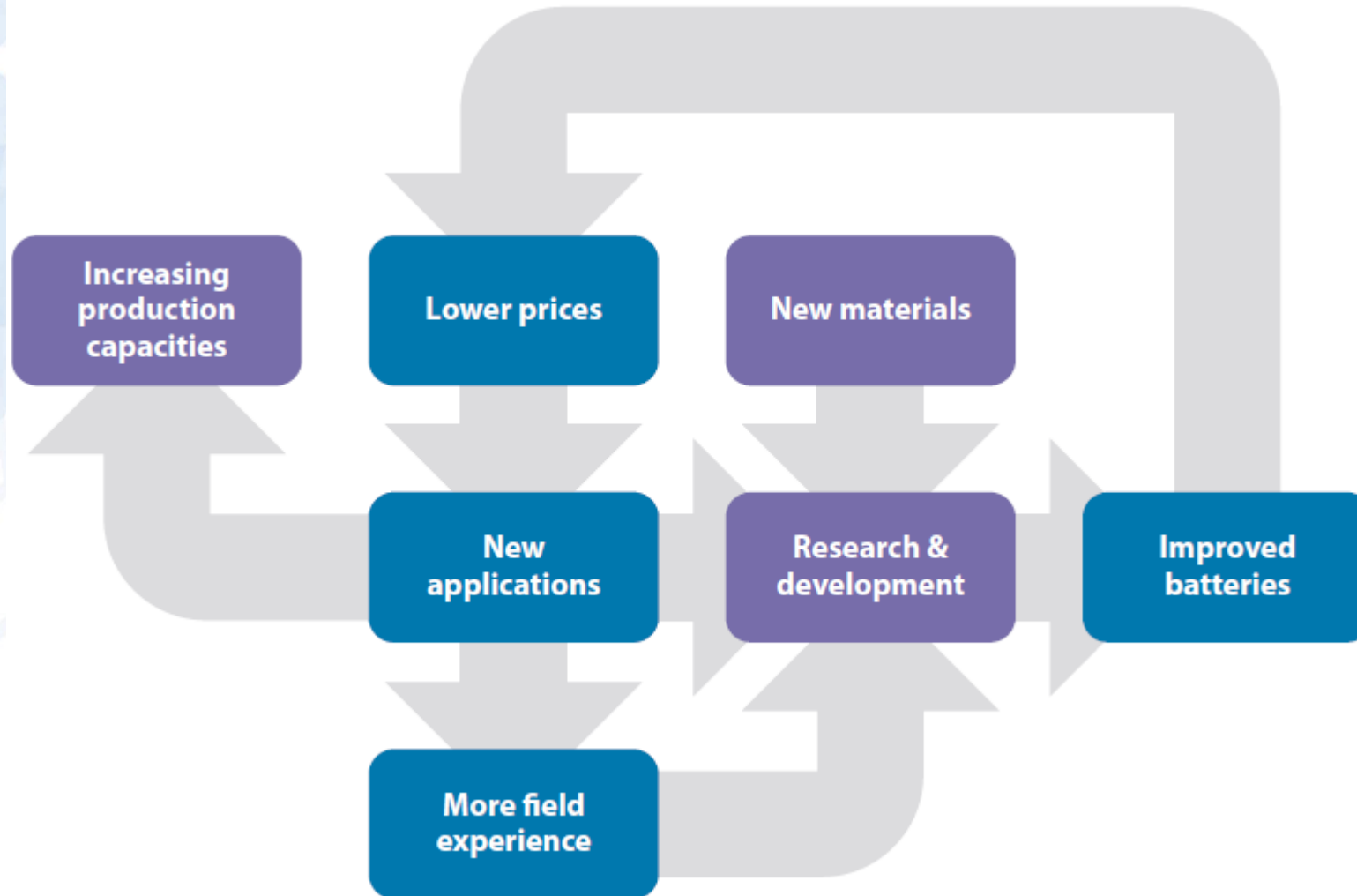
Central estimate for the energy installation costs from between USD 150 and USD 1 050/kWh in 2016 to between USD 75 and USD 80/kWh by 2030

The total installed cost of a Li-ion battery could fall by an additional 54-61% by 2030 in stationary applications

A drop for Li-ion batteries for stationary applications to between USD 145 /kWh and USD 80/kWh

Note: LA = lead-acid; VRLA = valve-regulated lead-acid; NaS = sodium sulphur; NaNiCl = sodium nickel chloride; VRFB = vanadium redox flow battery; ZBFB = zinc bromine flow battery; NCA = nickel cobalt aluminium; NMC/LMO = nickel manganese cobalt oxide/lithium manganese oxide; LFP = lithium iron phosphate; LTO = lithium titanate.

Cost reduction drivers of battery electricity storage systems



- Drivers are not exclusive to Li-ion, as other storage technologies are likely to experience a similar dynamic as their deployment grows.
- However, with the dominance of Li-ion batteries in the EV market and the synergies in the development of Li-ion batteries for EVs and stationary applications the scale of deployment that Li-ion batteries likely to be of magnitude higher than for other battery technologies.

Main drivers: Lithium-ion

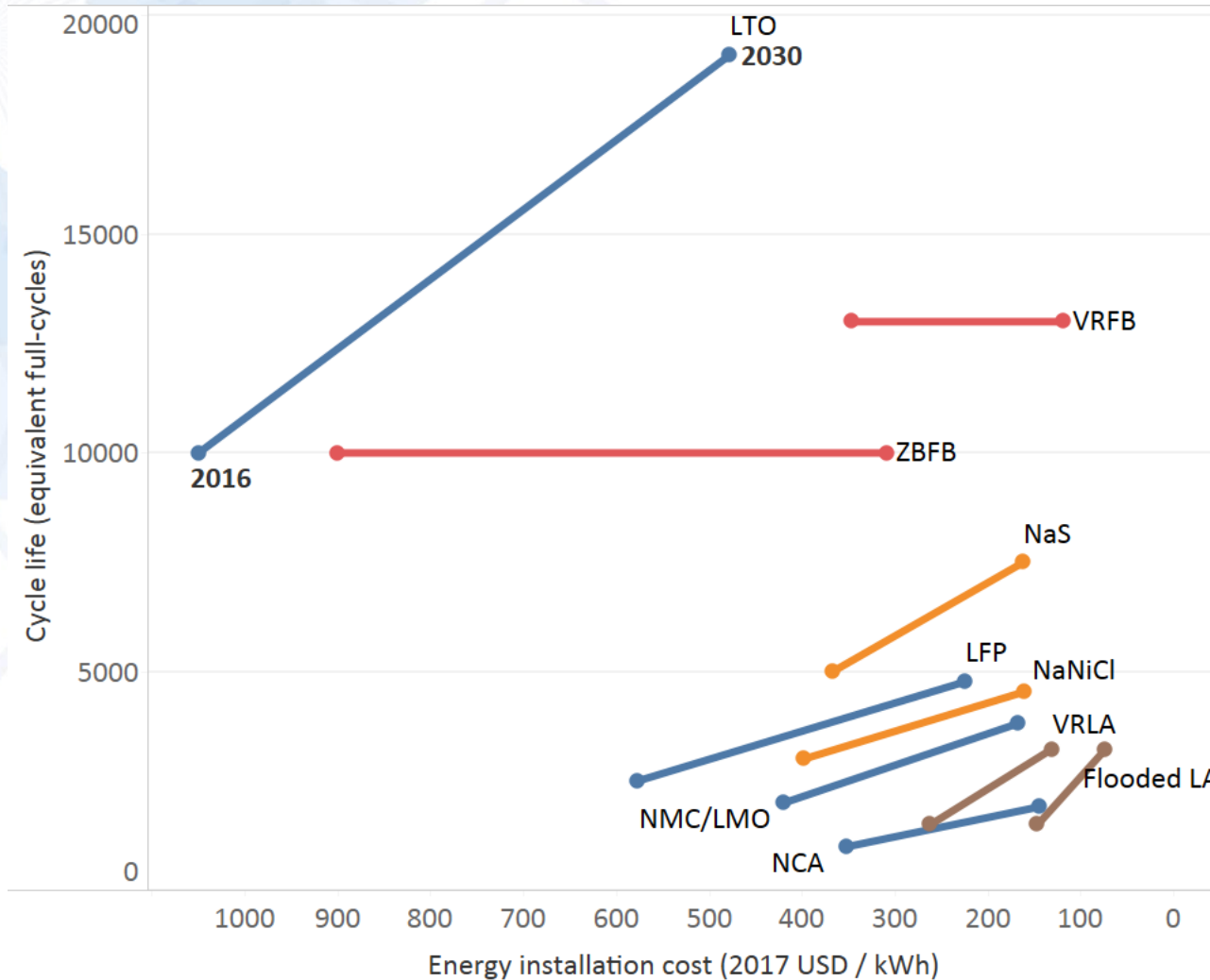
- Differentiation between 4 different technologies
 - NMC/LMO, NCA, LFePO₄ and Titanate
- International transition towards electro mobility leads to substantial scale effects (NCA NMC/LMO)
 - 70% price reduction since 2012
- > 170 GWh / year production capacities projected for 2020
 - Tesla Gigafactory / BYD / CALB / ...
 - LG Chem / Foxconn / CATL / ...



- Innovative developments
 - Mass production
 - Utilize silicon in anode
 - Durable LMO cathodes
 - 5 V electrolytes
 - Lithium-Sulphur
 - Lithium-Air

Cost declines and performance increases for batteries

Note: prices shown are for utility-scale stationary applications (EV or small-scale residential applications could have different values)

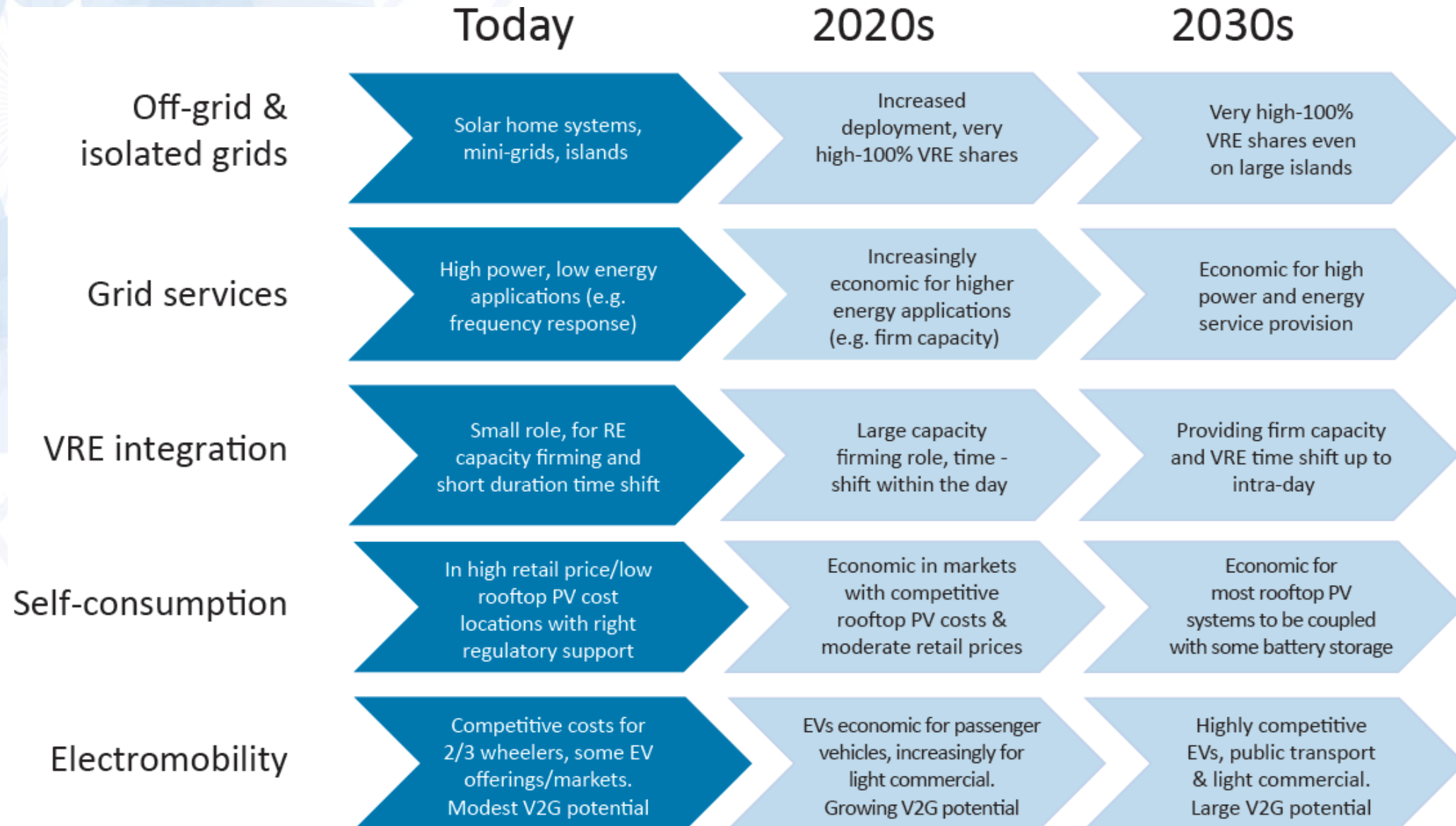


- Flooded LA
- VRLA
- NaNiCl
- NaS
- ZBFB
- VRFB
- NCA
- NMC/LMO
- LFP
- LTO



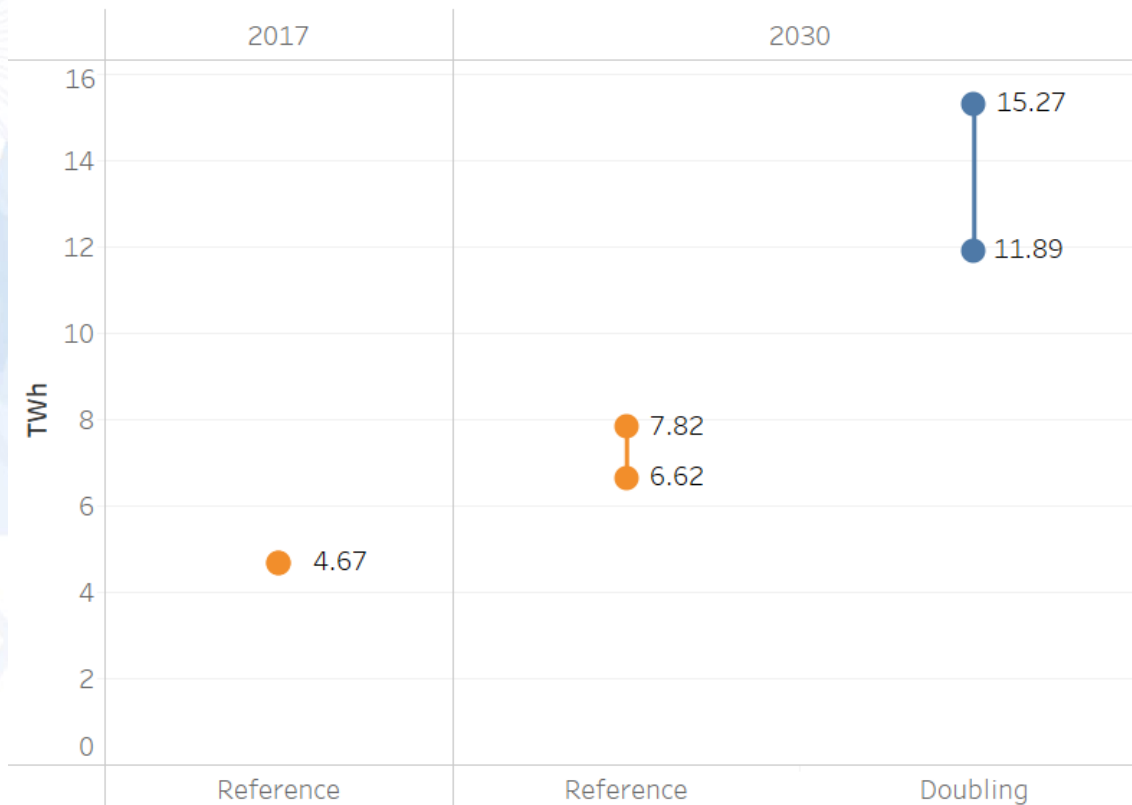
MARKET OUTLOOK 2030

Electricity storage needs in the energy transition

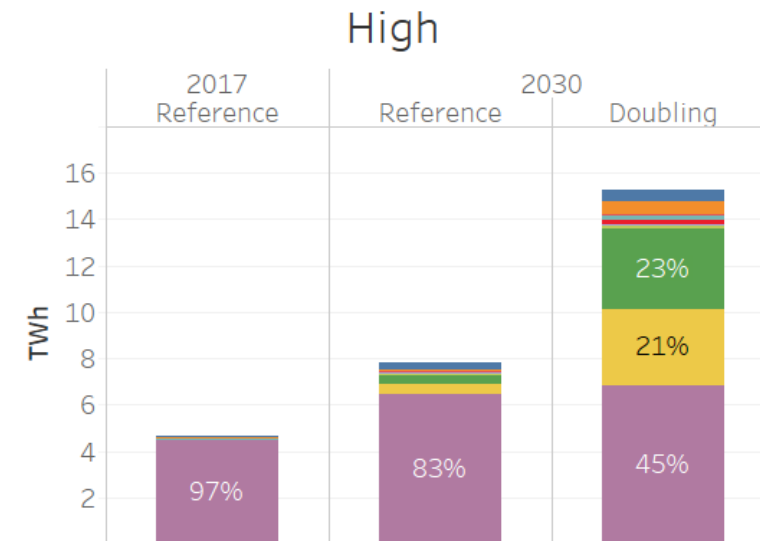
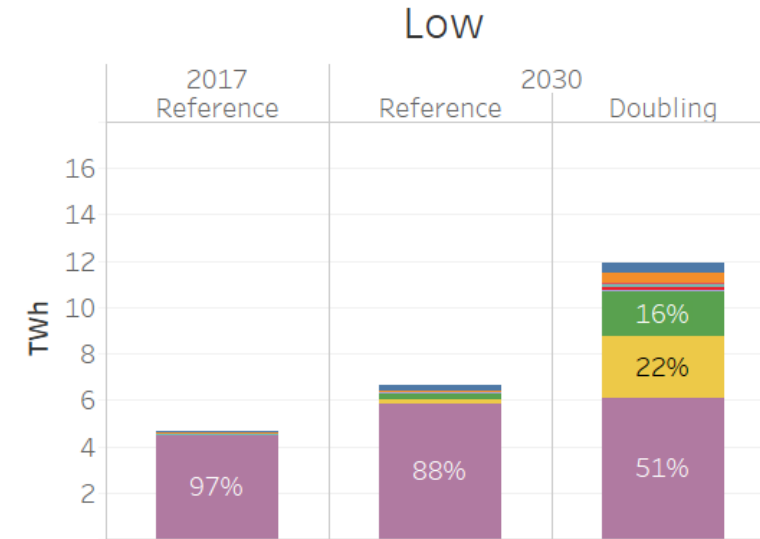


Growth in the electricity storage market to 2030

Storage growth by scenario

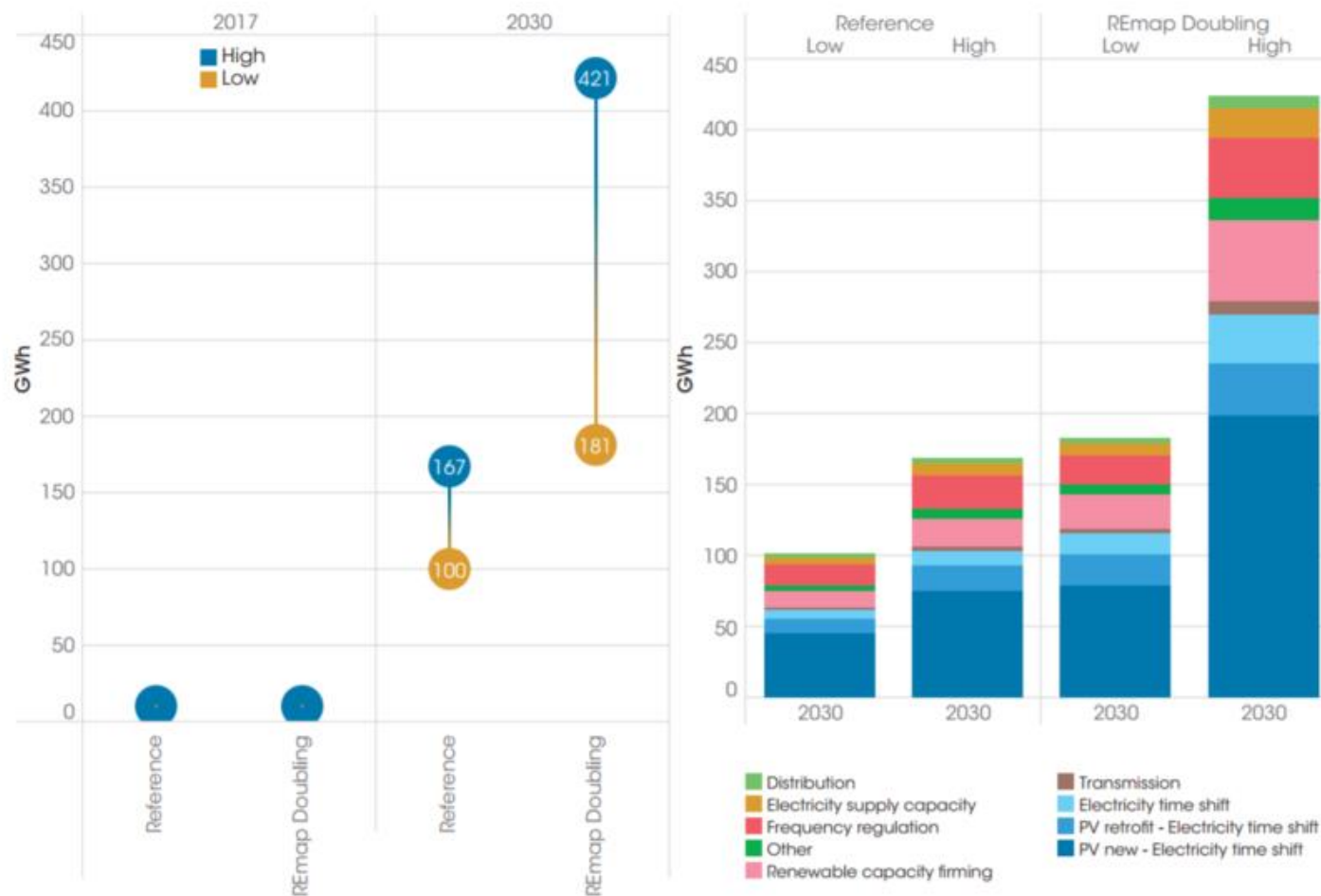


- Technology**
- 2/3 wheelers - electric
 - Buses - electric
 - CAES/flywheels/other thermal
 - Commercial LDVs - electric
 - Rooftop PV
 - Rooftop PV retrofit
 - Utility-scale batteries
 - CSP
 - Passenger EVs
 - PHS



Growth of battery market

Total battery capacity in stationary applications could increase from a current estimate of 11 GWh to between 100 GWh and 167 GWh in 2030 in the Reference case



In Doubling case, battery capacity can grow to 181-421 GWh by 2030 (at least 17-fold growth from current market)

Electricity storage to 2030

At the heart of the next phase of energy transition

Needed, today tomorrow and in long-term

Cost reductions and performance improvements drive competitiveness

EVs likely to dominate, so V2G potentially very important

Different applications, will support different storage technologies

Electricity storage: Facilitating the next phase of the energy transition



**The winners are customers, the environment
and our future**

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Generation technologies

- Solar PV
- (bio-)Diesel backup

Storage technologies

- OPzS Lead-acid batt.

