WORLD ENERGY COUNCIL

World Energy Resources

E-storage: Shifting from cost to value

Wind and solar applications
2016

Zulandi van der Westhuizen

Deputy Director, Scenarios & Resources

“Within a year, I hope, we shall begin the manufacture of an electric automobile. I don't like to talk about things which are a year ahead, but I am willing to tell you something of my plans.

The fact is that we have been working for some years on an electric automobile which would be cheap and practicable. Cars have been built for experimental purposes, and we are satisfied now that the way is clear to success.

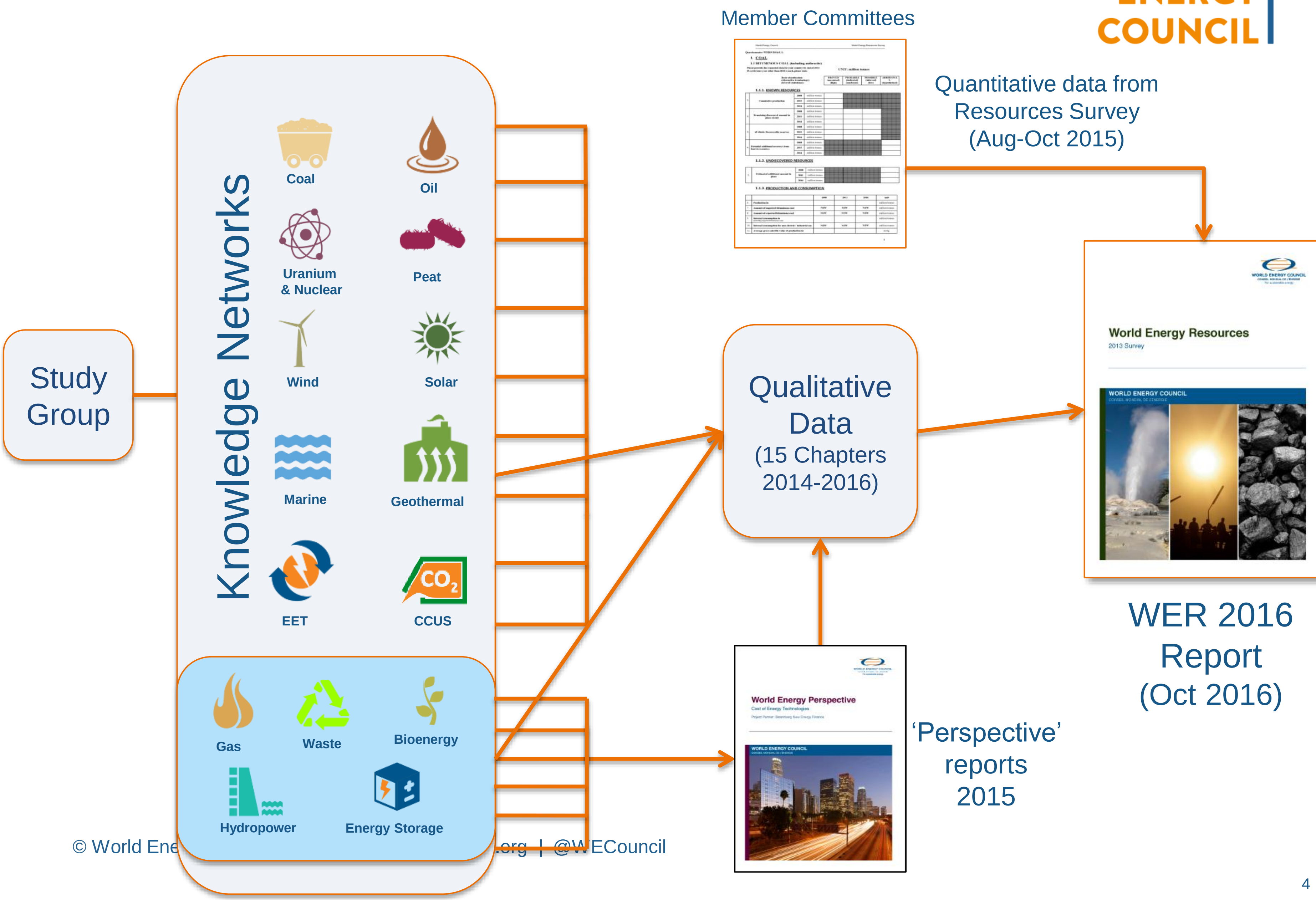
The problem so far has been to build a storage battery of light weight which would operate for long distances without recharging. We have been experimenting with such a battery for some time.”

Henry Ford, New York Times, 11 January 1914

Table of contents

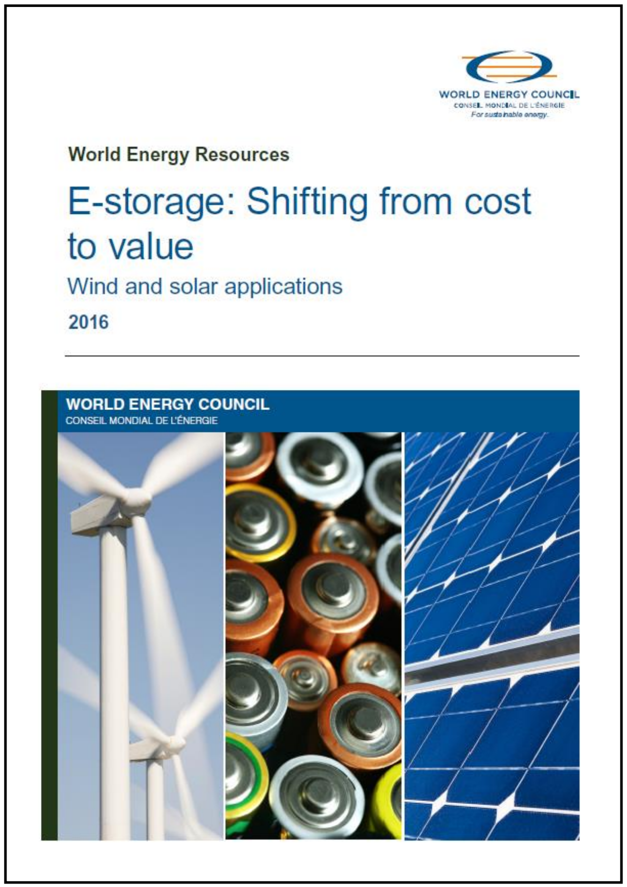
Output of Resources Study Group

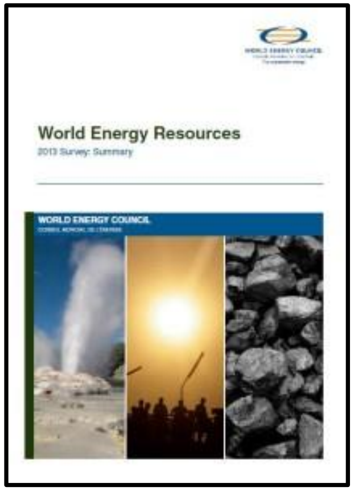
WORLD ENERGY COUNCIL

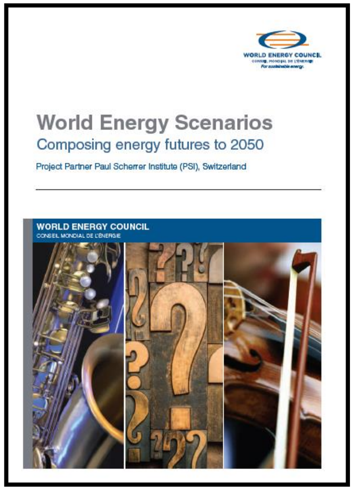


WORLD ENERGY COUNCIL

This report will form part of the E-storage Chapter in the World Energy Resources Report 2016







Purpose

- This work has been prompted by the combination of:
  - Falling costs of renewables, especially PV
  - Falling costs of storage, especially batteries
  - Increasing penetration levels of volatile renewables (wind and solar), prompting concerns about electricity system stability, and effect on system costs

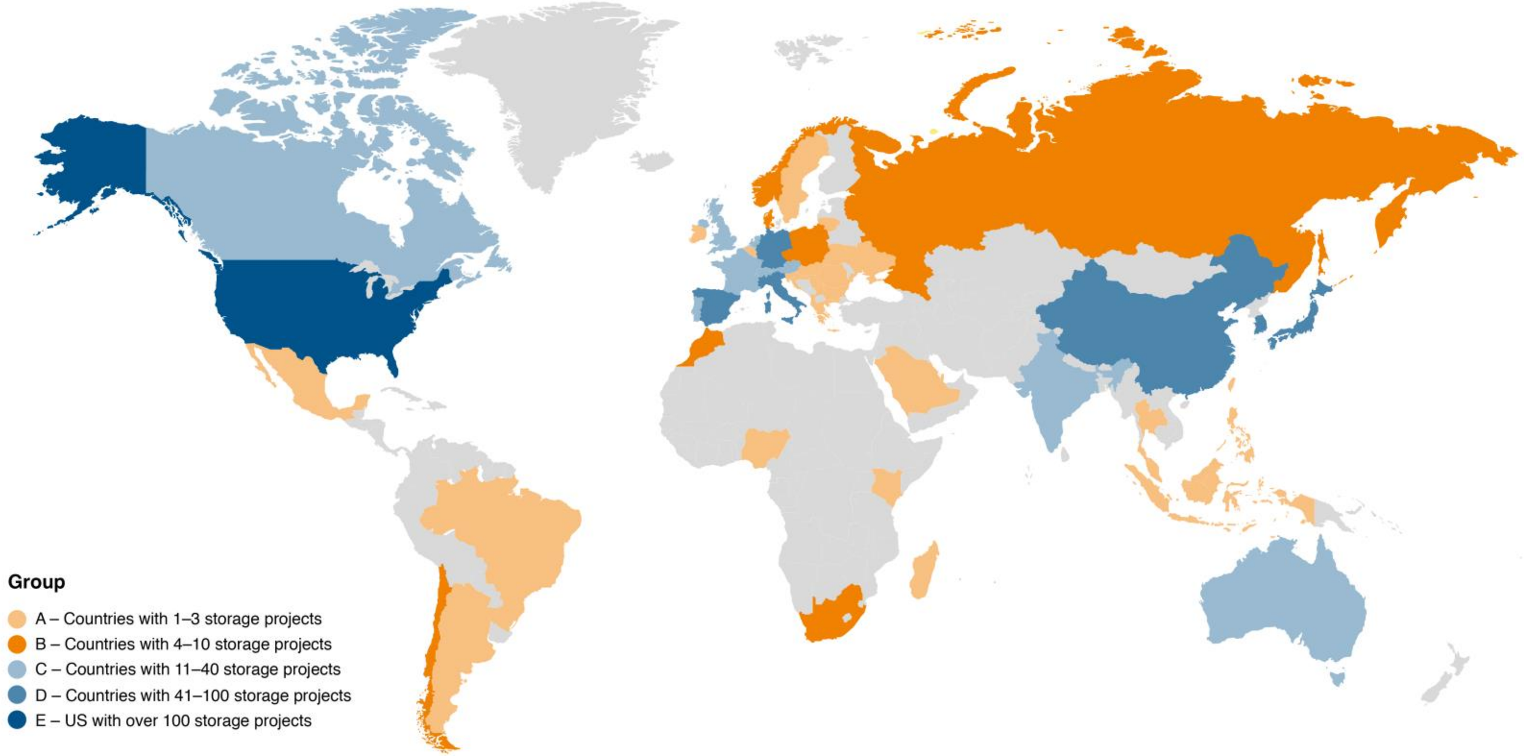
- How can we understand the ***costs*** of storage with PV and wind?
- How can we establish the ***value*** of storage with PV and wind?

Key messages

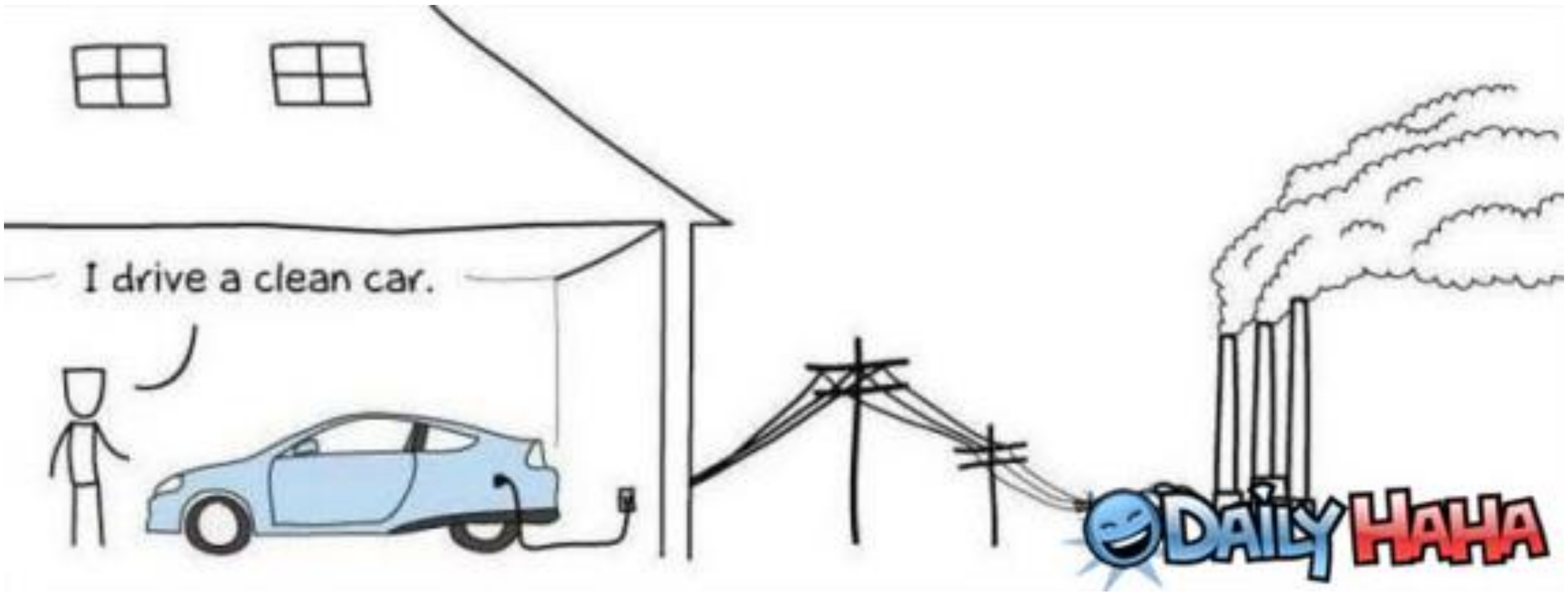
WORLD ENERGY COUNCIL

- Pumped hydropower storage plants constitute over 90% of all installed storage capacity

- Lithium-ion batteries constitute about one third of all installations in the world

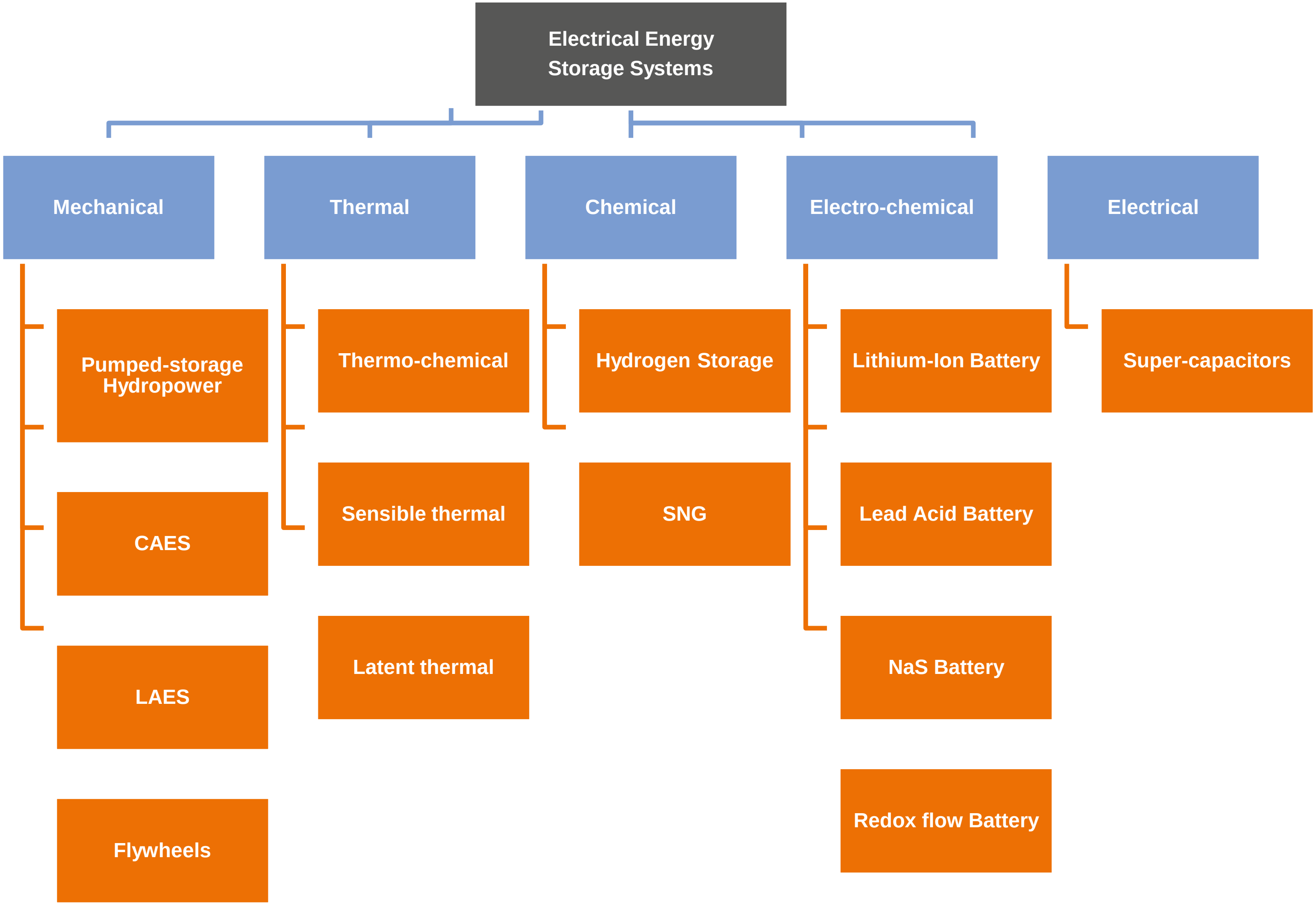


The value chain should also be kept in mind when talking about E-storage

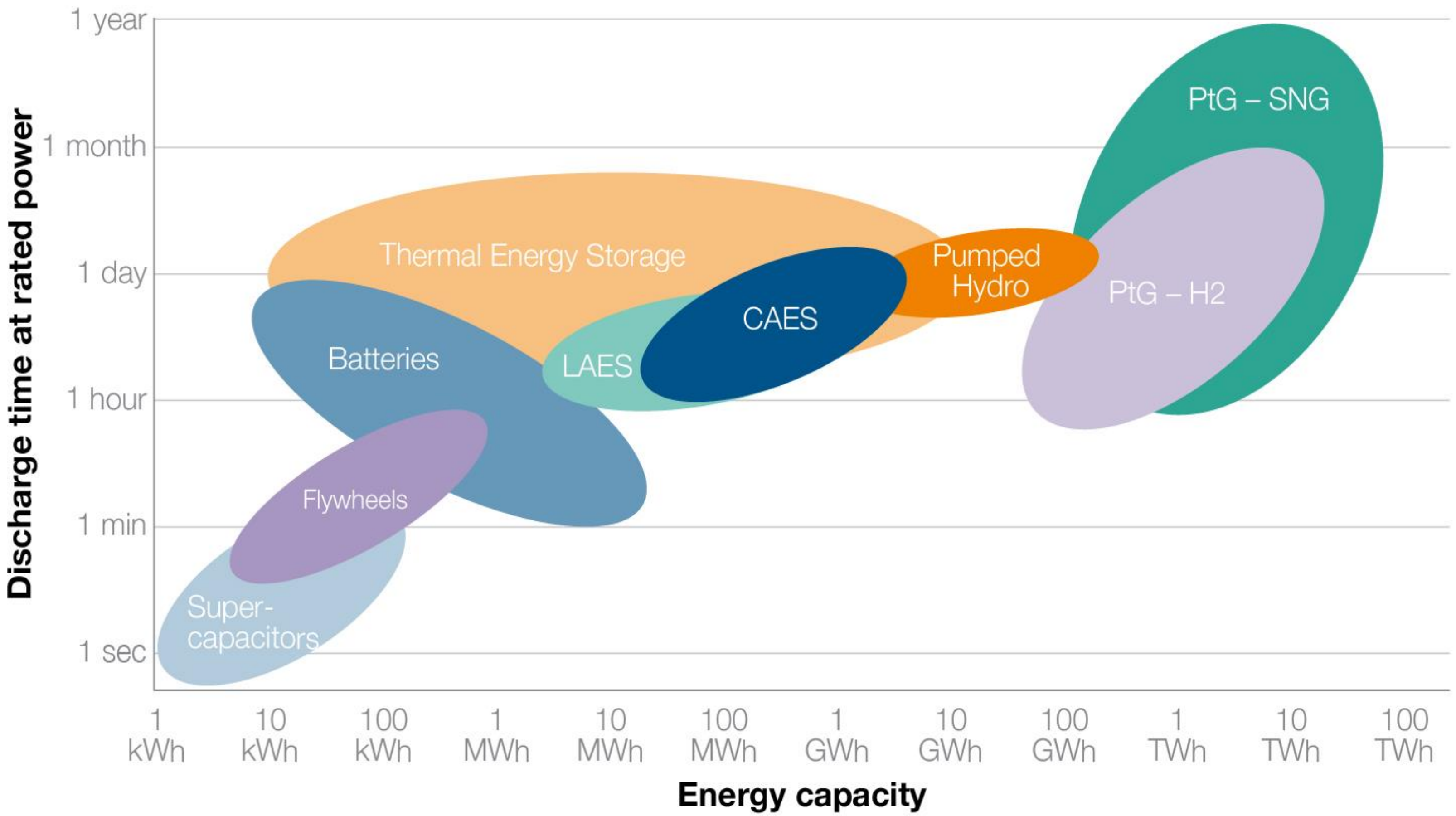


Scientific categorisation of storage

WORLD ENERGY COUNCIL



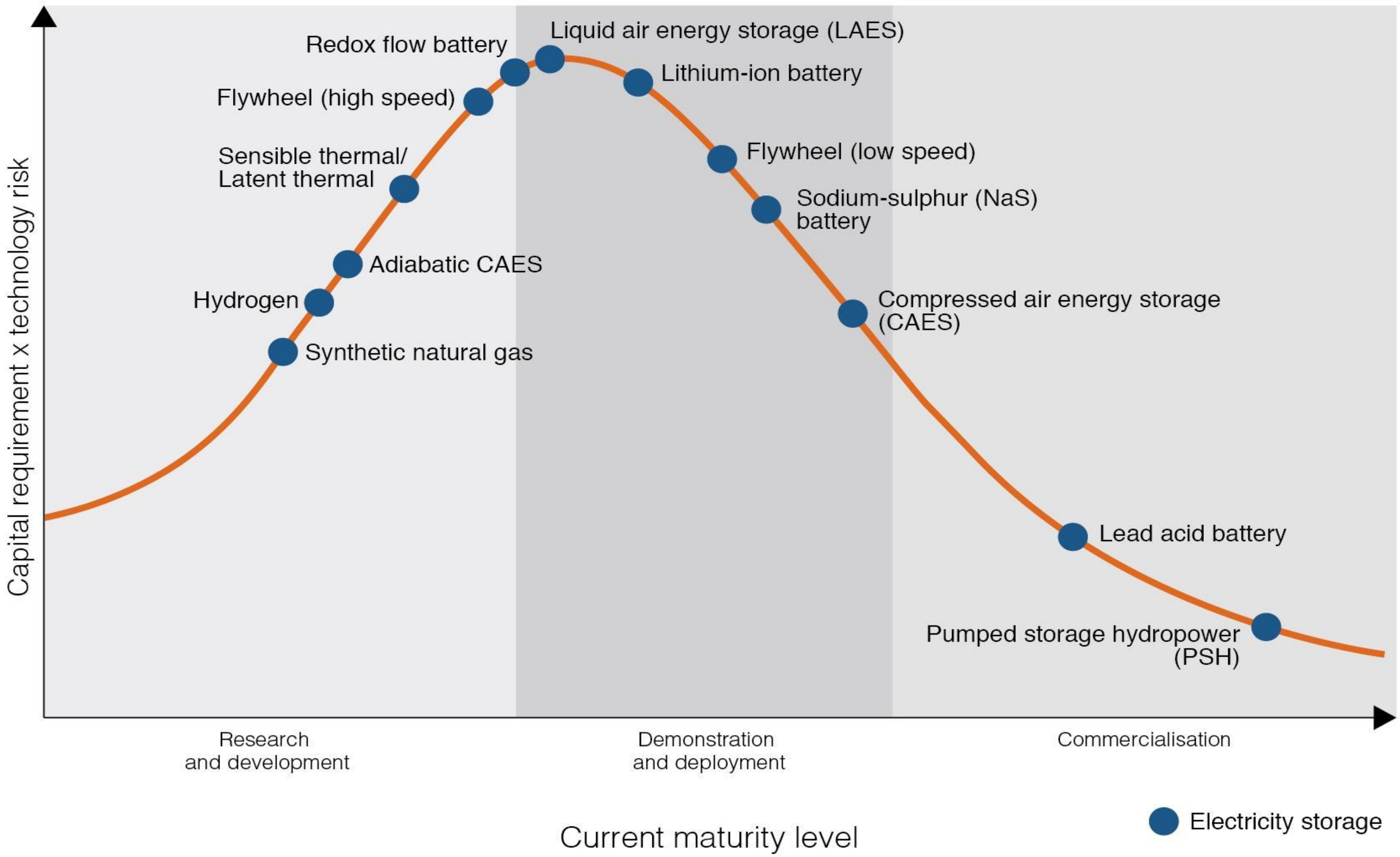
E-storage has a wide range of technologies and applications



Source: PwC, 2015, following Sterner et al. 2014

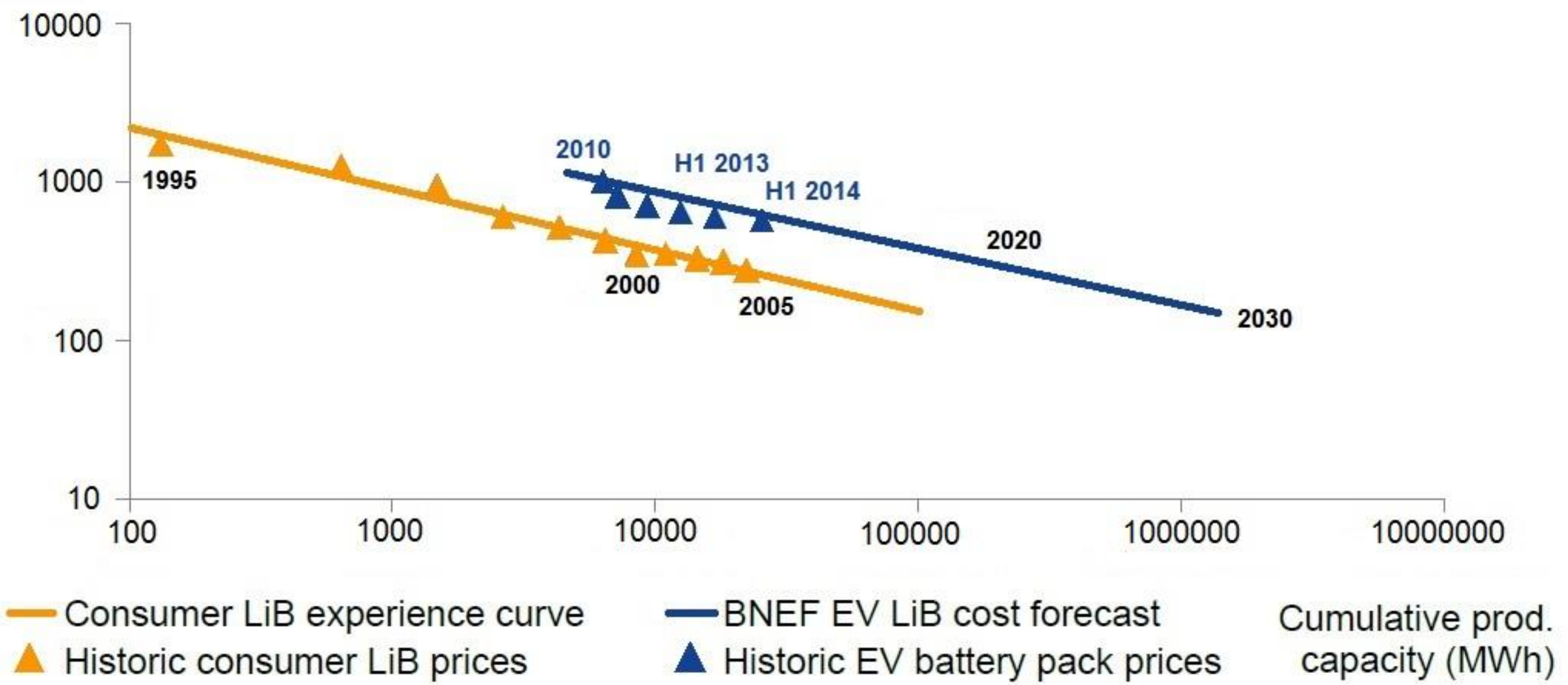
E-storage technologies improving their maturity level

WORLD ENERGY COUNCIL



Technologies are maturing, but still have some way to go

Cost reduction is forecasted

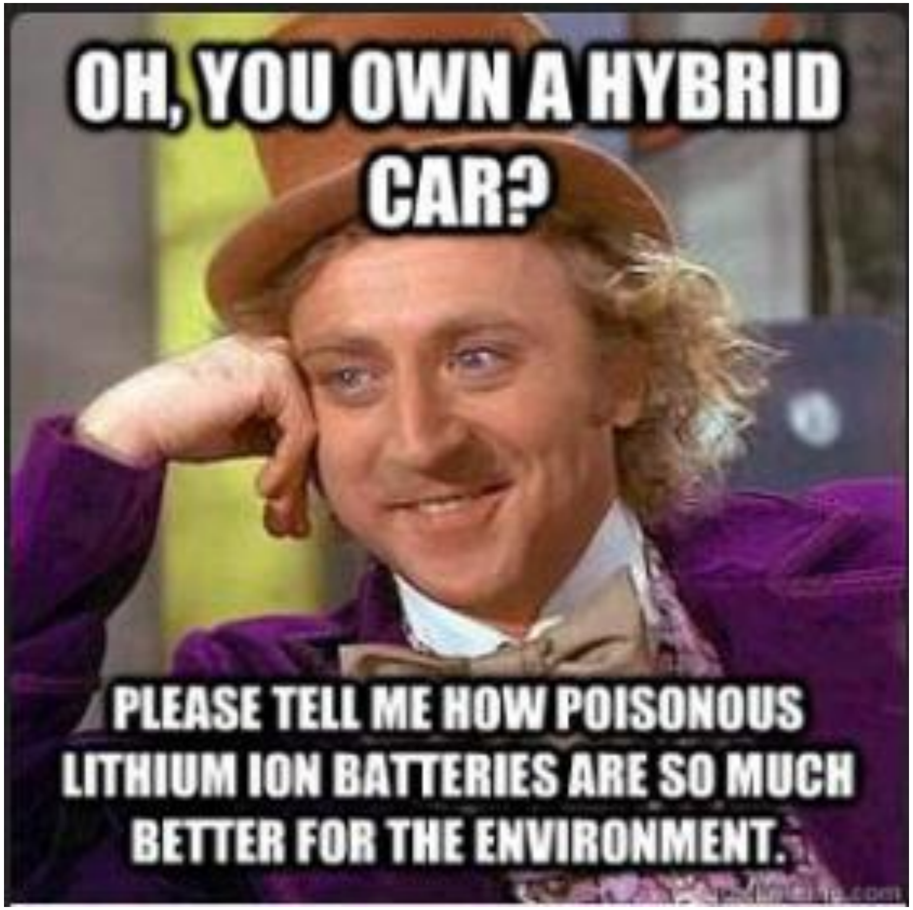


Source: Bloomberg New Energy Finance, Maycock, Battery University, MIIT

Cost are important to consider, but even more important is to take in account the application for each technology

Cost calculations do not currently consider Costs for waste disposal or recycling

WORLD ENERGY COUNCIL



Cost modelling

WORLD ENERGY COUNCIL

- The cost analysis is based on a literature review, cost modelling and review by World Energy Council Knowledge Network Energy Storage
- The two key metrics considered in the analysis are:
  - Specific investment cost **(SIC)** and
  - Levelised cost of storage **(LCOS)**
- Results are estimated for both current 2015 and 2030 conditions
- LCOS in particular raises methodological difficulties: see later

Levelised Cost of Storage (LCOS)

- LCOE is typically used to assess the cost of electricity from different power plant types. In this analysis it has been transferred to storage technologies and therefore the term LCOS is used.
- It enables comparison between different types of storage technologies in terms of average cost per produced / stored kWh.

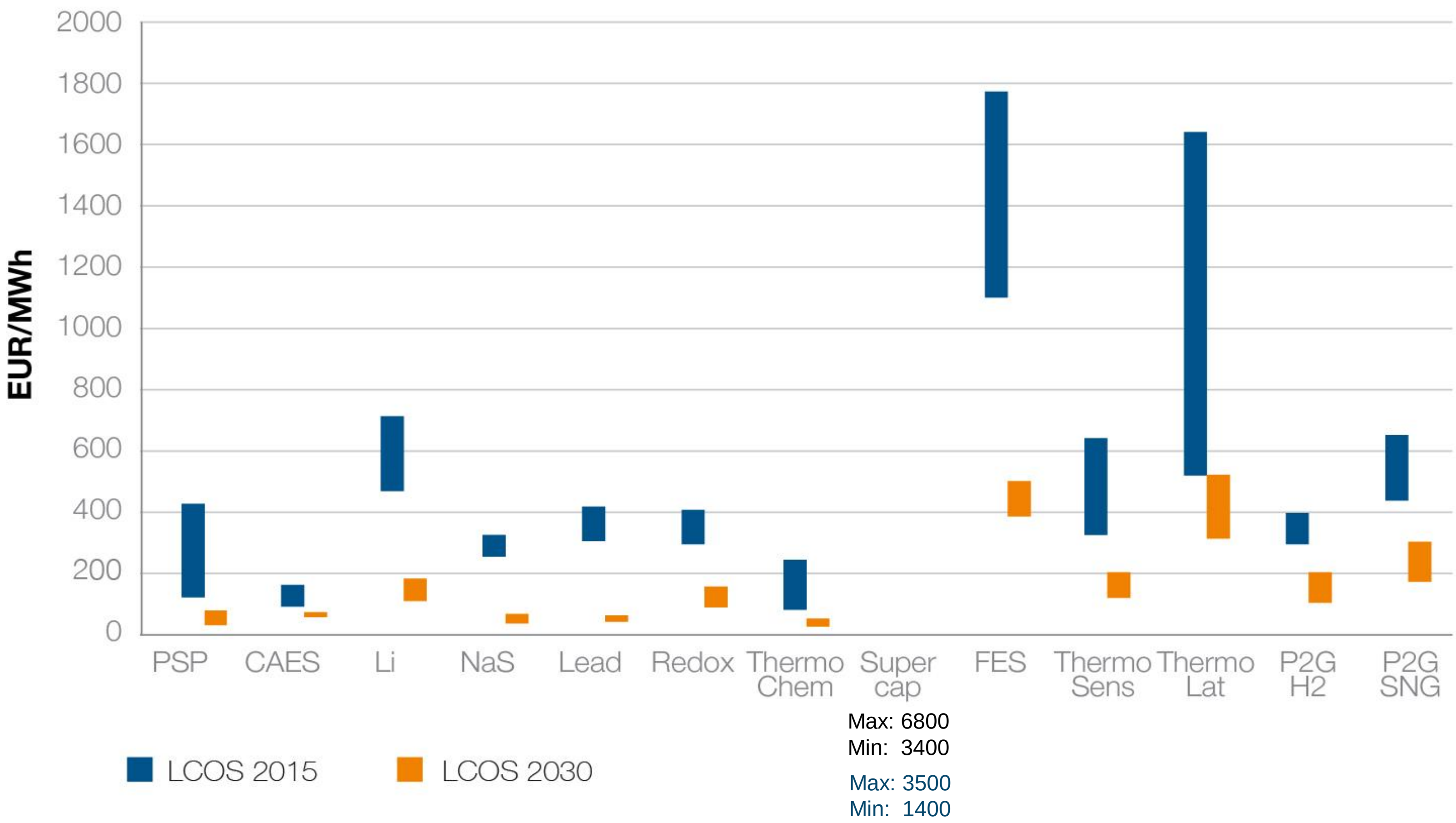
$$LCOS = \frac{I_0 + \sum_{t=1}^{n} \frac{A_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{M_{el}}{(1+i)^t}}$$

LCOS	Levelized cost of energy [€/kWh]
I_o	Investment costs [€]
A_t	Annual total costs in year t [€]
M_{el}	Produced electricity in each year* [kWh]
n	Technical lifetime [years]
t	Year of technical lifetime (1, ..., n)
i	Interest rate (WACC) [%]

Input Variables	Elements	Example values
Investment costs [€]	Specific cumulative investment cost * rated power	700 - 1500 €/kW * rated power
Annual total costs in year t [€]	Operational costs (in %) * Investment costs	2% * Investment costs
Produced electricity in each year [kWh]	Rated power * Equivalent full-load hours * Efficiency	Rated power *1,460 h/a * 80%
Technical lifetime [years]	Technical lifetime	50 years
Interest rate (WACC)	Interest rate	8%

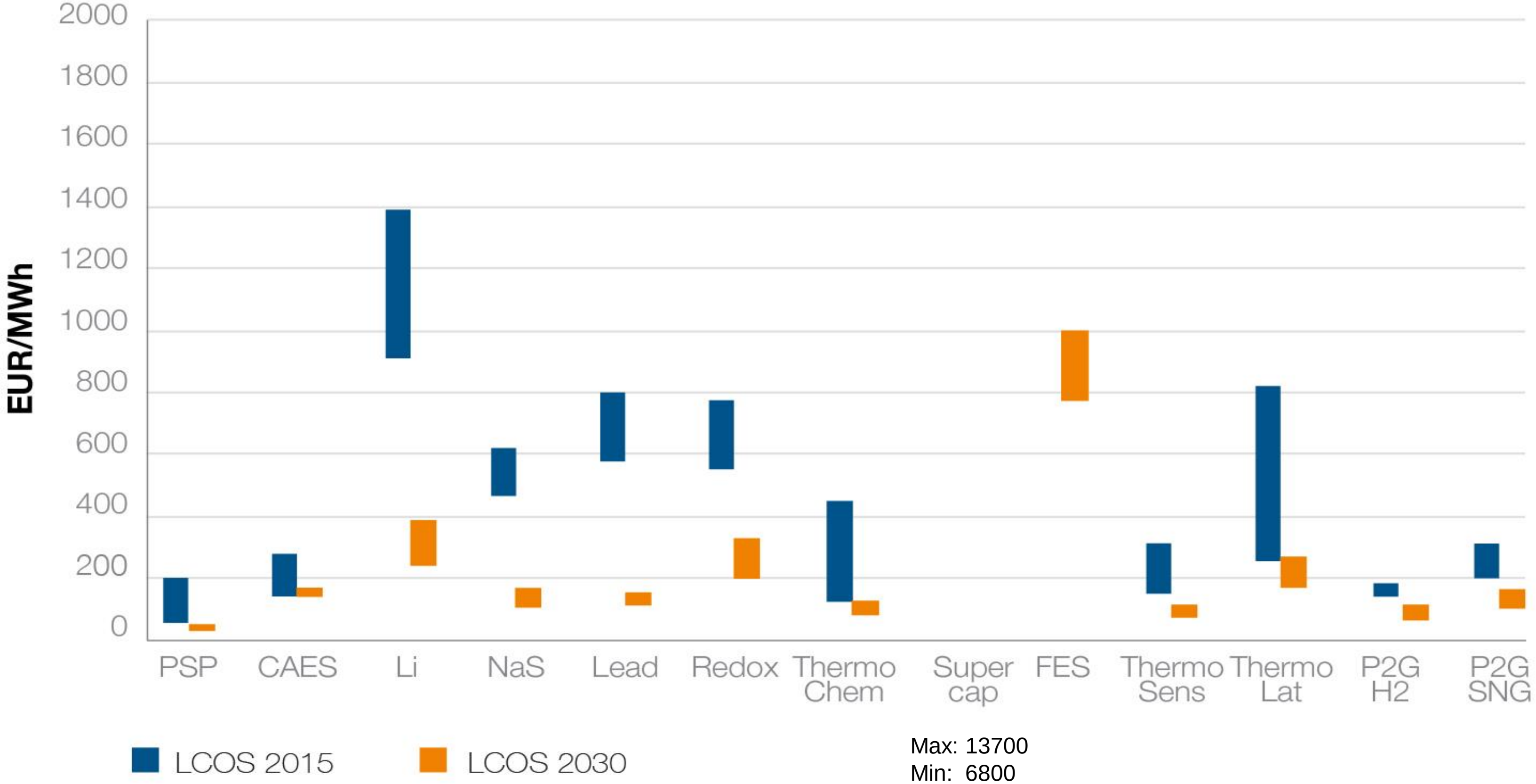
Comparing levelised cost of storage co-located with Solar for 2015 and 2030 (€ 2014)

WORLD ENERGY COUNCIL



Comparing levelised cost of storage co-located with Wind plant for 2015 and 2030 (€ 2014)

WORLD ENERGY COUNCIL



Max: 13700
Min: 6800

Max: 6900
Min: 2900

Max: 135000
Min: 2200

Key messages

- The costs of energy storage technologies are forecasted to reduce by as much as 70% by 2030

- Levelised Cost of Storage (LCOS) is useful as a metric
  but its limitations need to be clearly understood
  - Depends on technology
  - Depends on location
  - Depends on ***application***

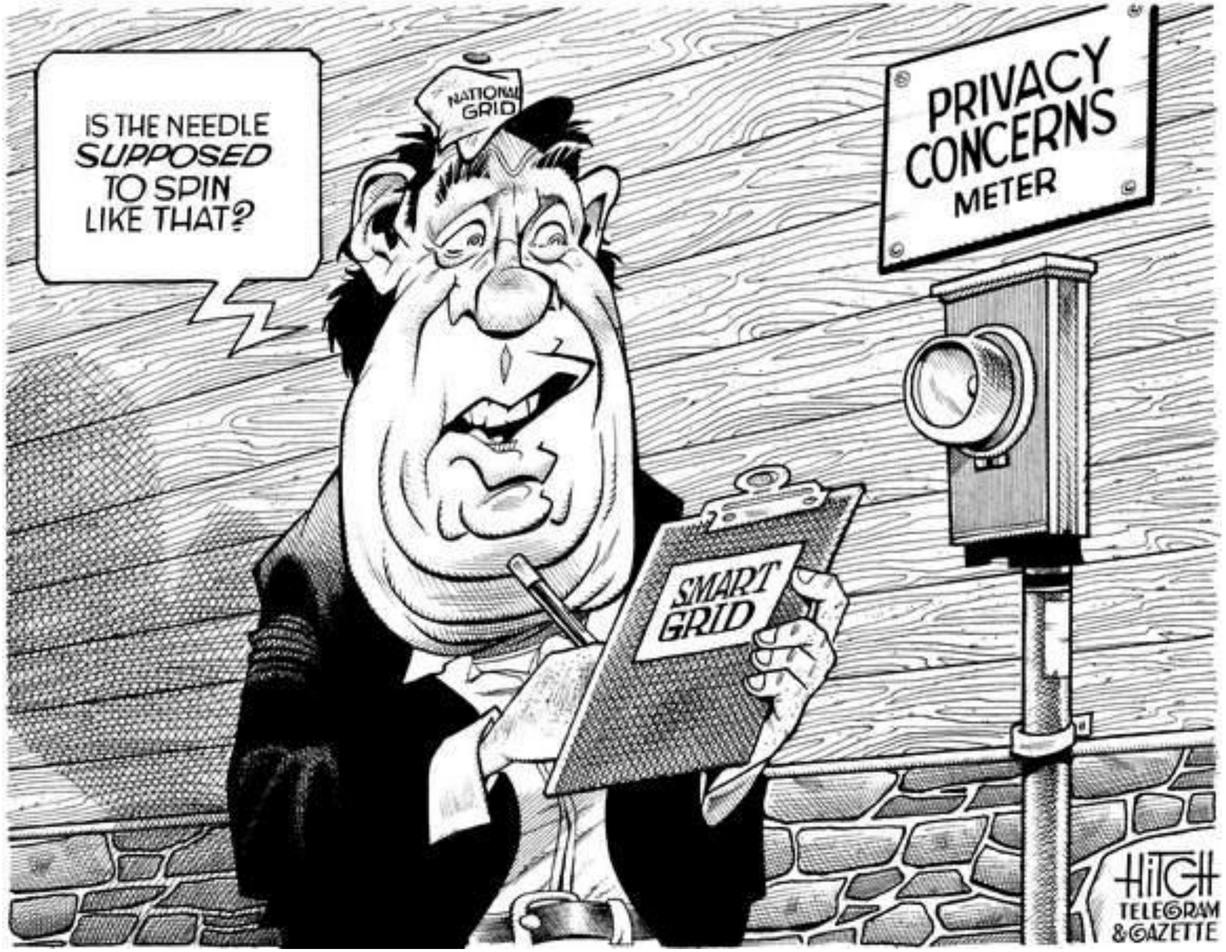
- LCOS is not the only issue: storage creates additional value through its function to:
  - Improve power quality, reliability, and security of supply;
  - Provide reserve capacity or ability to restart after a blackout;
  - Level the load, create possibility of price arbitrage;
  - Enable deferral of grid investment.

Implications

The key implication of these challenges is that **context matters**

- Wide variation in energy storage costs
- The important metric is *value*, where value is a function of both *cost* and *revenue*:
  - LCOS is only part of the story.
  - Understanding the *application* is critical.
- The renewable industry's focus on LCOS seems to stem from particular circumstances where, often, revenue is fixed.
- Understanding the revenue side of storage has urgency due to its complexity
- From a country and societal perspective, the value of storage is the ability to provide power quality and reliability, and security of supply
- Storage creates additional value through its function to level the load

Consumer behaviour towards E-storage is still uncertain



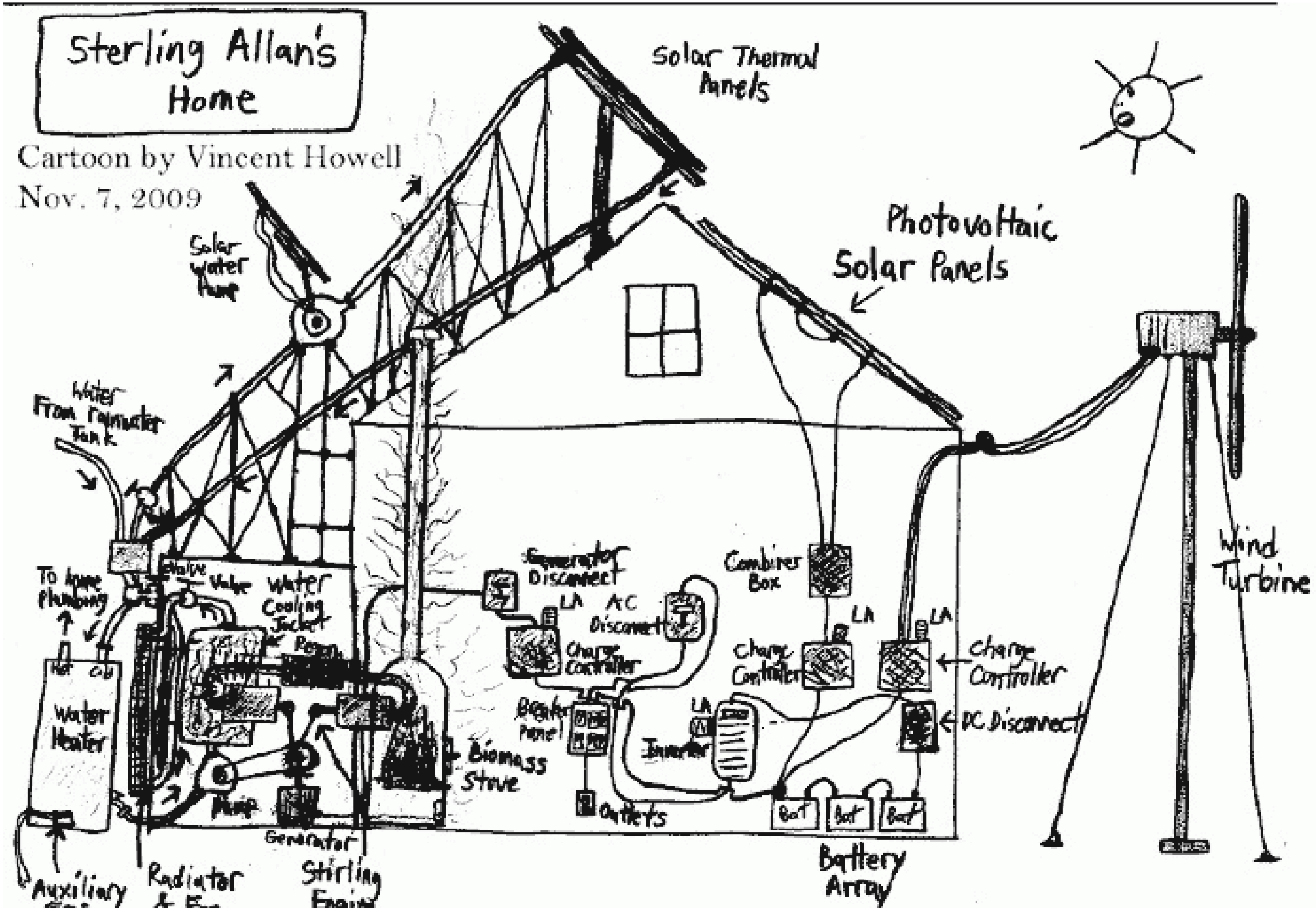
Recommendations

WORLD ENERGY COUNCIL

- Go beyond a narrow levelised cost approach to storage technology assessment
  - The lowest LCOS is not always the best option
- Examine storage technologies through holistic case studies in context
- Accelerate the development of flexible markets
  - working with transmission and distribution system operators and regulators
- Storage provides value in its ability to provide power quality and reliability, security of supply, and flexibility
- Storage is a key component when planning for grid expansion or extension

E-storage should be an integral part of planning

WORLD ENERGY COUNCIL



Thank you

Zulandi van der Westhuizen
westhuizen@worldenergy.org

Discussion of results: PV application case

- Solar-storage results: Assuming daily cycles and six hours discharge time at rated power, the most competitive technologies have LCOS of 50-200 €/MWh, though these are technologies which are not necessarily suited to all PV projects. Battery technologies are next, around 200-400 €/MWh. By 2030, a much wider range of technologies offer LCOS below 100 €/MWh. Looking to 2030, it is particularly striking that battery technology becomes especially more competitive, with sodium sulfur (NaS), lead acid and lithium-ion technologies leading the way
- It is important to stress that the cost ranges are specific to the application cases and assumptions defined in this report.

Discussion of results: wind application case

WORLD ENERGY COUNCIL

- Wind storage results: This application assumes two-day cycle structure, and 24 hours discharge time at rated power. Levelised costs are much higher for the wind-storage case than the solar-storage case because of the high sensitivity of the LCOS to the number of discharge cycles, and the suboptimal energy-to-power ratios required for the wind-storage case as defined.
- It is important to stress that the cost ranges are specific to the application cases and assumptions defined in this report.