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'Valuing Dedicated Storage in Electricity Grids'

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The Value of Energy Storage for Grid Applications

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Background

- Aim to produce EASAC report for **EU policy makers, investors, and other stakeholders** (system operators, generators, electricity users) engaged in **policy debates** on the future of EU electricity grids.
- Working Group nominated by **11 of the National Science Academies in Europe** – 16 members with a broad range of expertise (power systems, technology, economics, social science).
- **Experts** from stakeholder groups (**Europe and US**) and from the European Commission were invited to provide inputs to the work.
- Focus is on **dedicated storage** i.e. “electricity in – electricity out” of storage systems connected to electricity grids

Dedicated storage deployment (49 GW in 2016)

(Pumped Hydro, Compressed air, Flywheels, Batteries)

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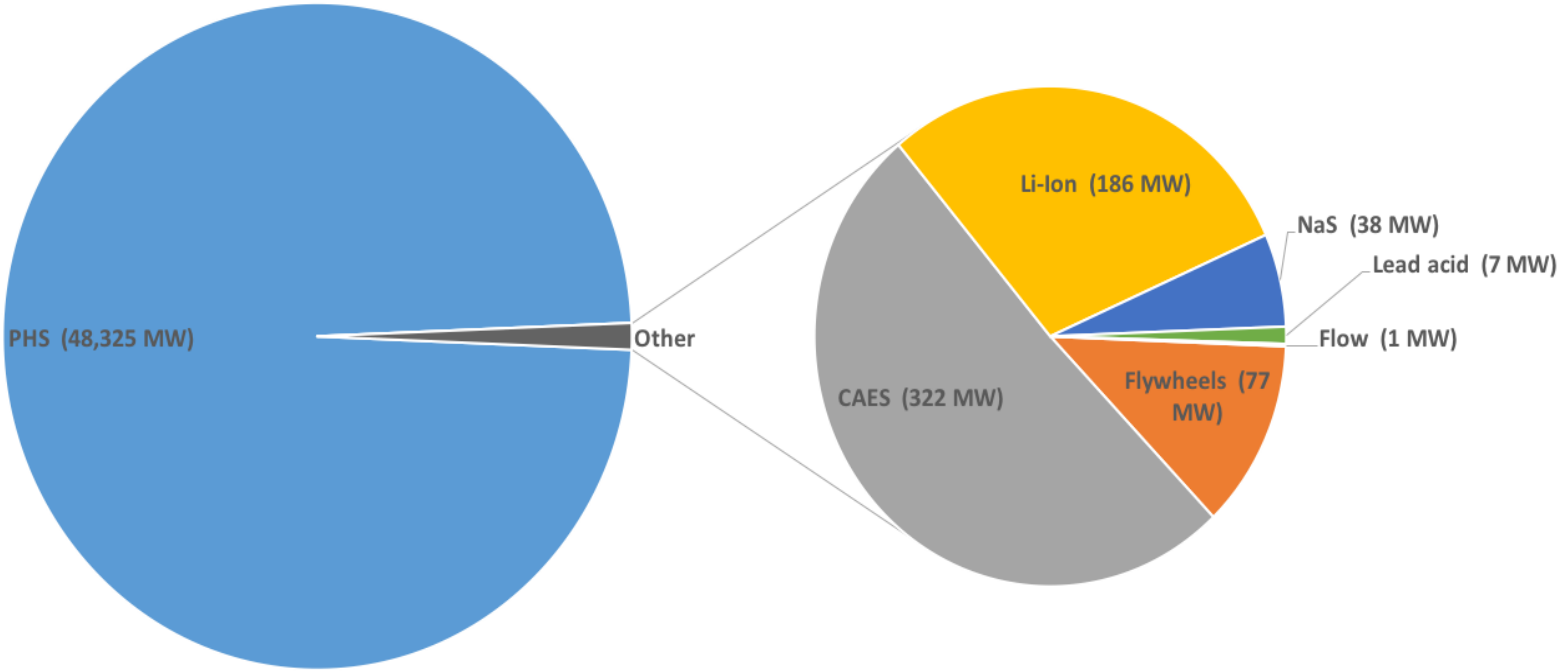

Current deployment of grid connected electricity storage in EU28+NO+CH

Note: Data were exported from DOE database in September 2016. Specialised applications of high power flywheels in UK and German fusion research labs and the RWE Adele Compressed Air Energy Storage (CAES) plant (which is not operational) were excluded.

Non-dedicated storage options

- **Power to heat** – a low cost alternative to curtailment, but not usually possible to revert to electricity. Typically the heat is used in buildings where its value may be low because of competition with other low cost options.

- **Power to gas** – already technically feasible and being studied in demonstration projects for transport and industry applications.

- **Battery electric vehicles** – an application of growing interest where owners of electric vehicles can use their batteries also to contribute to self consumption at home or at work.

Why should policy makers consider storage?

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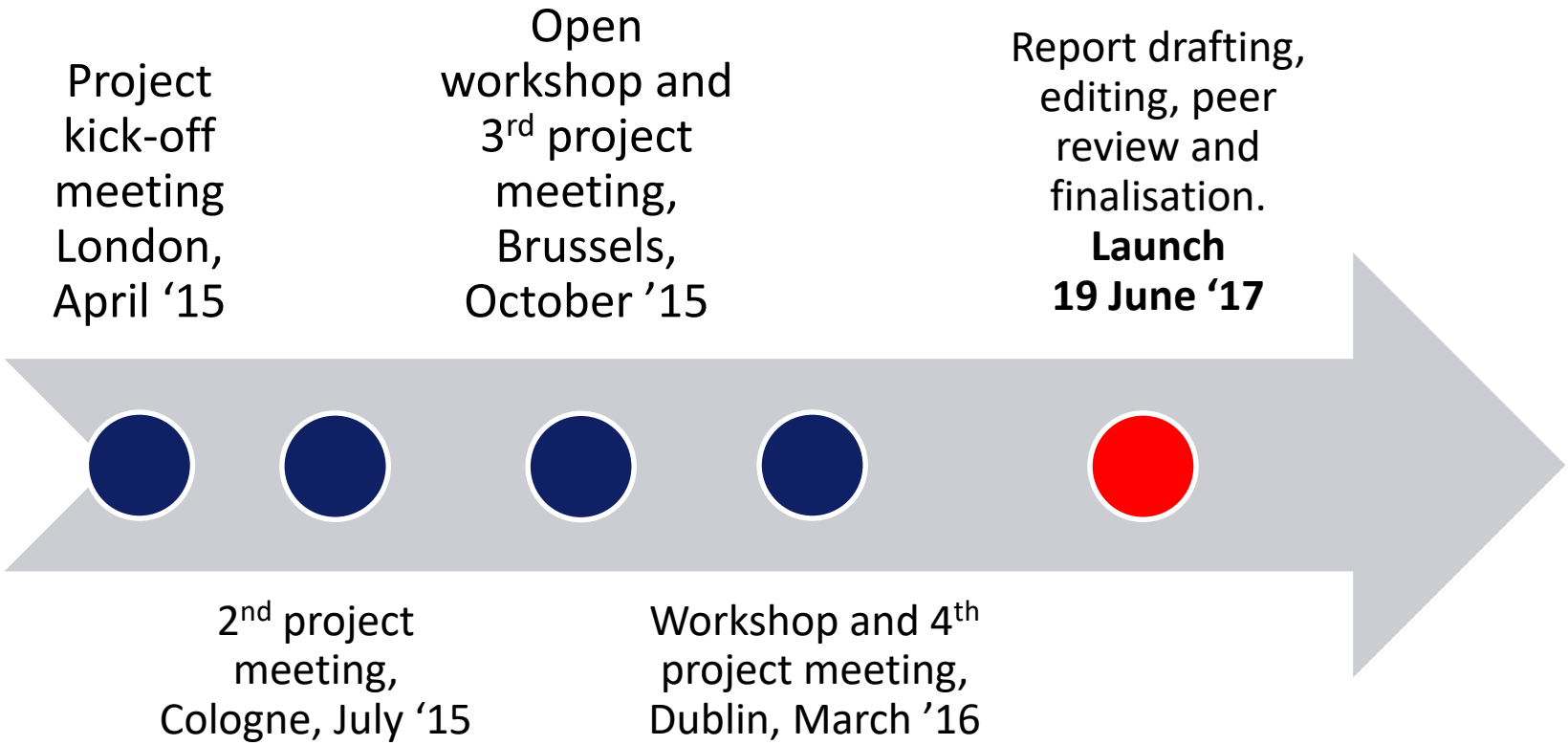
(i) As the penetration of **variable renewable generation** (wind and PV) increases, transmission and distribution grids will require more **flexibility**.

(ii) Small storage systems are being installed on distribution grids as battery prices fall and "prosumers" invest in "PV + battery systems" for increased self consumption.

EASAC storage project timeline



Potential for cost reductions in dedicated storage technologies

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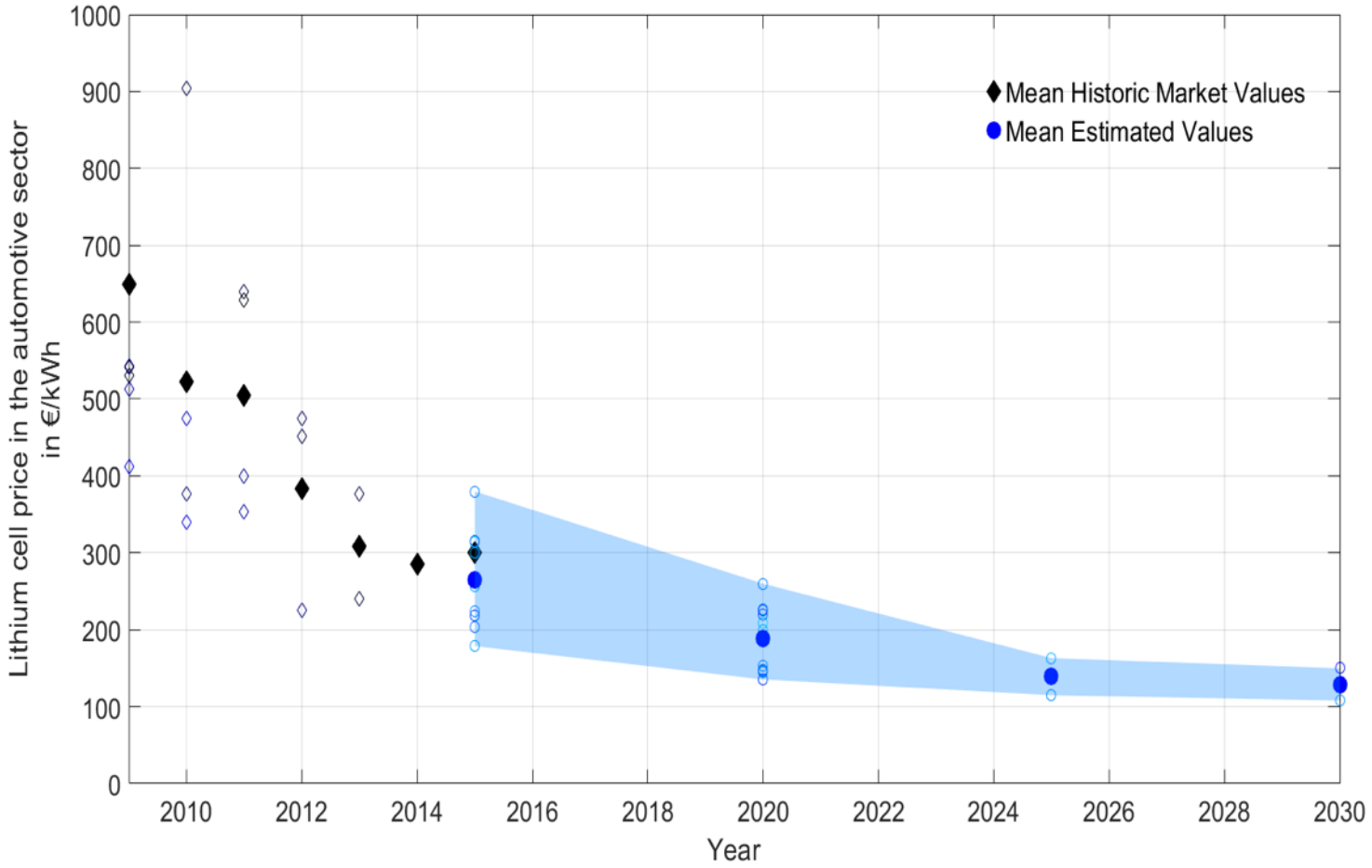
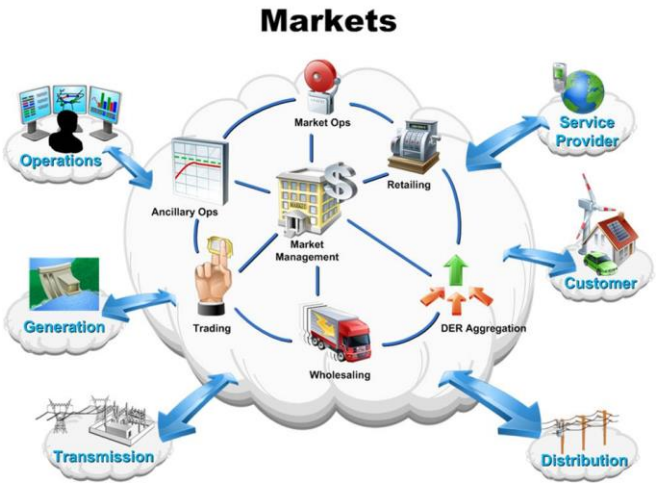
Technology	Potential for future cost reductions
Pumped Hydroelectric storage (PHS)	Low
Compressed air energy storage (CAES)	Medium
Flywheels	Medium
Lead acid batteries	Low
Li-ion batteries	High
Sodium ion batteries	High
Redox flow batteries	Medium / High
Sodium sulphur batteries	Medium
Super capacitors	Medium
Power to gas to power (P2G2P)	Medium
Cryogenic energy storage (CES)	Medium

Projected cost reductions for Lithium ion batteries (cell price)



Services offered by storage to electricity markets

- **Energy arbitrage**
- **Ancillary services**
  - Reserves (frequency control and balancing).
  - Voltage control
  - Black start
- **Grid adequacy** (for congestion control and up-grade deferral)
- **Generation adequacy**
- **End user and consumer needs**
  - Power control / local back-up
  - Self consumption (PV + battery)
- **Operation in multiple roles and markets**



Modelling and assessing values of storage

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- **Modelling methodologies reviewed**
  - **System models**
  - **Storage-centric models**
- **Findings from peer reviewed modelling assessments**
  - Storage to reduce variable renewable electricity curtailment
  - Storage for multiple uses
  - Marginal value of additional storage
  - Value of storage depends on services provided
  - Value for isolated systems and weak interconnected areas
  - Competitiveness of storage
  - Expected deployment
- **Gaps and priorities for further research**

"Yes, the planet got destroyed, but for a beautiful moment in time we created a lot of value for shareholders."

Conclusions

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- The value of dedicated storage is **system dependent** and it has **many competitors**
- Electricity market design should
  - deliver price signals (locational and temporal) which **encourage investments** in cost-efficient flexibility options (including storage) on both transmission and distribution grids.
  - **not create barriers** to the deployment of potentially valuable systems and technologies (including storage).
  - address **PV plus battery systems** on distribution grids.
- Storage will **not greatly reduce** EU needs for **back-up generating** capacity
- **Seasonal storage** technologies are being developed – **the opportunity**

Acknowledgements

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Annex 3 Working group composition and timetable

The report was prepared in consultation with a working group of experts nominated by member academies of EASAC, and with valuable inputs from invited experts who gave presentations at project meetings and workshops (see details below).

Chairperson

Mark O'Malley, University College Dublin, Ireland

Working group members

Michael Ornetzeder, Institute of Technology Assessment, Austria
Jan Desmet, Gent University, Belgium
William D'haeseleer, University of Leuven, Belgium
Hannele Holttinen, VTT, Finland
Angelika Heinzel, Duisberg Essen, Germany
Marc Oliver Bettzüge, University Köln, Germany
Raphael Moissis, National Energy Strategy Council, Greece
Ciara O'Dwyer, University College Dublin, Ireland
Richard van de Sanden, Eindhoven University and DIFFER, Netherlands
David Rios, Rey Juan Carlos University, Spain
Göran Andersson, ETH Zurich, Sweden
Thomas Schmidt, ETH Zurich, Switzerland
Peter Bruce, University of Oxford, UK
Göran Strbac, Imperial College London, UK
Juha Kiviluoma, VTT, Finland
Christoph Ritz, Swiss Academy of Sciences, Switzerland

The first working group meeting was hosted by Imperial College in London on 1 April 2015, with invited guests Paul Denholm (NREL) and Göran Strbac (Imperial College).

The second meeting was hosted on 25 June 2015 by the University of Cologne with invited guests Craig Carter (MIT), Andreas Zucker (European Commission JRC), Joachim Birtsch (EWI), Andreas Lemke (Trianel) and Jochen Schwill (Next Kraftwerke).

The third meeting was preceded by an open workshop hosted by the Royal Academies for Science and the Arts of Belgium on 14 October 2015 in Brussels with the following invited speakers: Manuel Sanchez Jimenez (European Commission DG Energy), Norela Constantinescu (ENTSOe), Patrick Clerens (EASE), Daniel Fraile (EWEA), Andreas Zucker (European Commission JRC), Pavla Mandatova (Eurelectric), and Michael Flynn (investor). Informal preparatory meetings for this workshop were held with EC officials working on electricity sector policies and with Frauke Thies (SEDC). The working group meeting on 15 October 2015 in Brussels was hosted by the EC's Joint Research Centre (JRC) and attended by invited guests Ulla Engelmann, Efstathios Peteves, Andreas Zucker and Dora Dudas from the JRC. EASAC energy steering panel members were also invited.

The fourth meeting was hosted by the Royal Irish Academy on 23/24 March 2016 in Dublin, preceded by an open workshop with invited speakers Jonathan O'Sullivan (EirGrid), Gerard Finneran (Glen Dimplex), John McCann (SEAI), Mark Byrne (Gaelectric), Orla Nic Suibhne (Údarás Na Gaeltachta), John Ward (REDT), Peter Duffy (Schwungrad), Julia Badeda (RWTH Aachen) and Gerard Vowles (Gaelectric).

Annex 4 Acknowledgements

EASAC thanks Professor Mark O'Malley and Dr Ciara O'Dwyer from University College Dublin for their extensive contributions to the drafting of this report, Imperial College London, the University of Cologne, the Royal Academies for Science and the Arts of Belgium, and the Royal Irish Academy for hosting workshops and working meetings, the European Commission Joint Research Centre for its scientific inputs and for hosting a working meeting, Julia Badeda from RWTH Aachen University for sharing her expertise on batteries, the EASAC working group members for their contributions, insights and commitment, and members of the EASAC Energy Steering Panel for their advice and guidance.

Dr William Gillett