Imperial College London

Future cost of energy storage and its impact on CO_2 emissions from the power sector

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International Association for Energy Economics
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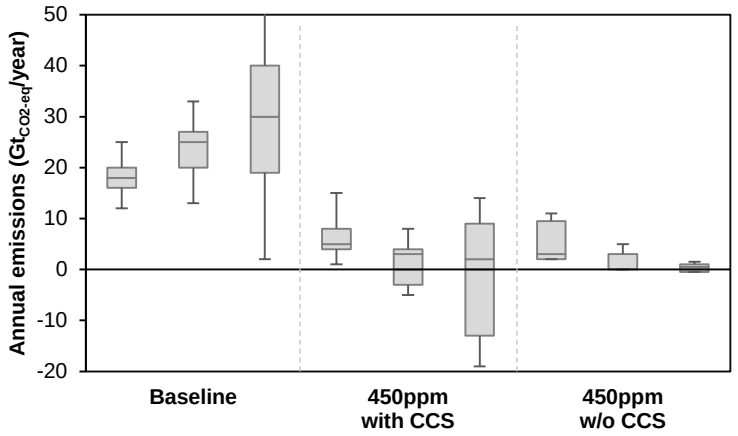
Grantham Institute

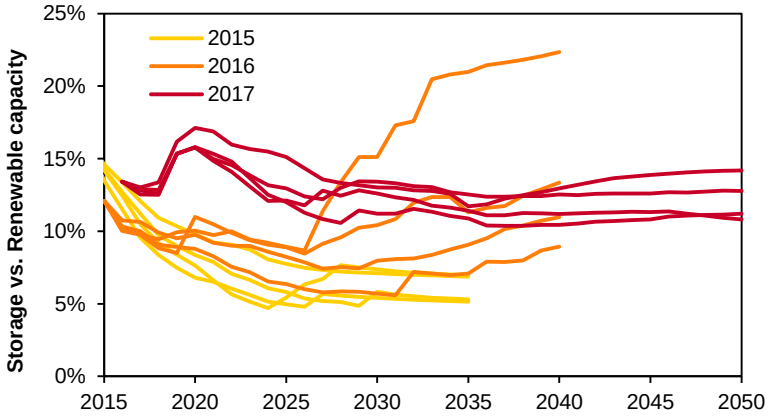
The power sector needs to be close to complete decarbonisation by 2050

Introduction



IPCC Fifth Assessment Report

- Annual emissions from power generation must reduce to max. 5 Gt_{CO2} by 2050 (glob.)
- The power sector is among the first energy sectors to completely decarbonize



National Grid – Future Energy Scenarios

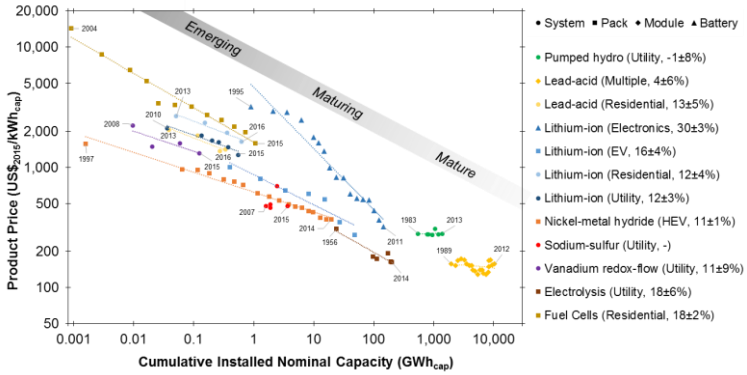
- The UK targets an 80% reduction of emissions by 2050 compared to 1990 levels
- National Grid foresees storage capacity at 5-25% of renewable capacity to succeed

Source: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)], IPCC, Geneva, 2014.); Future Energy Scenarios, National Grid, 2017.

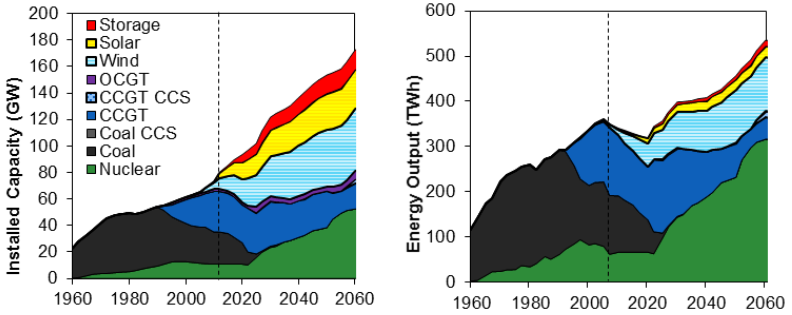
Including storage cost forecasts in power system models informs on abatement cost

Methodology

Experience Curves



Power System Model (UK)

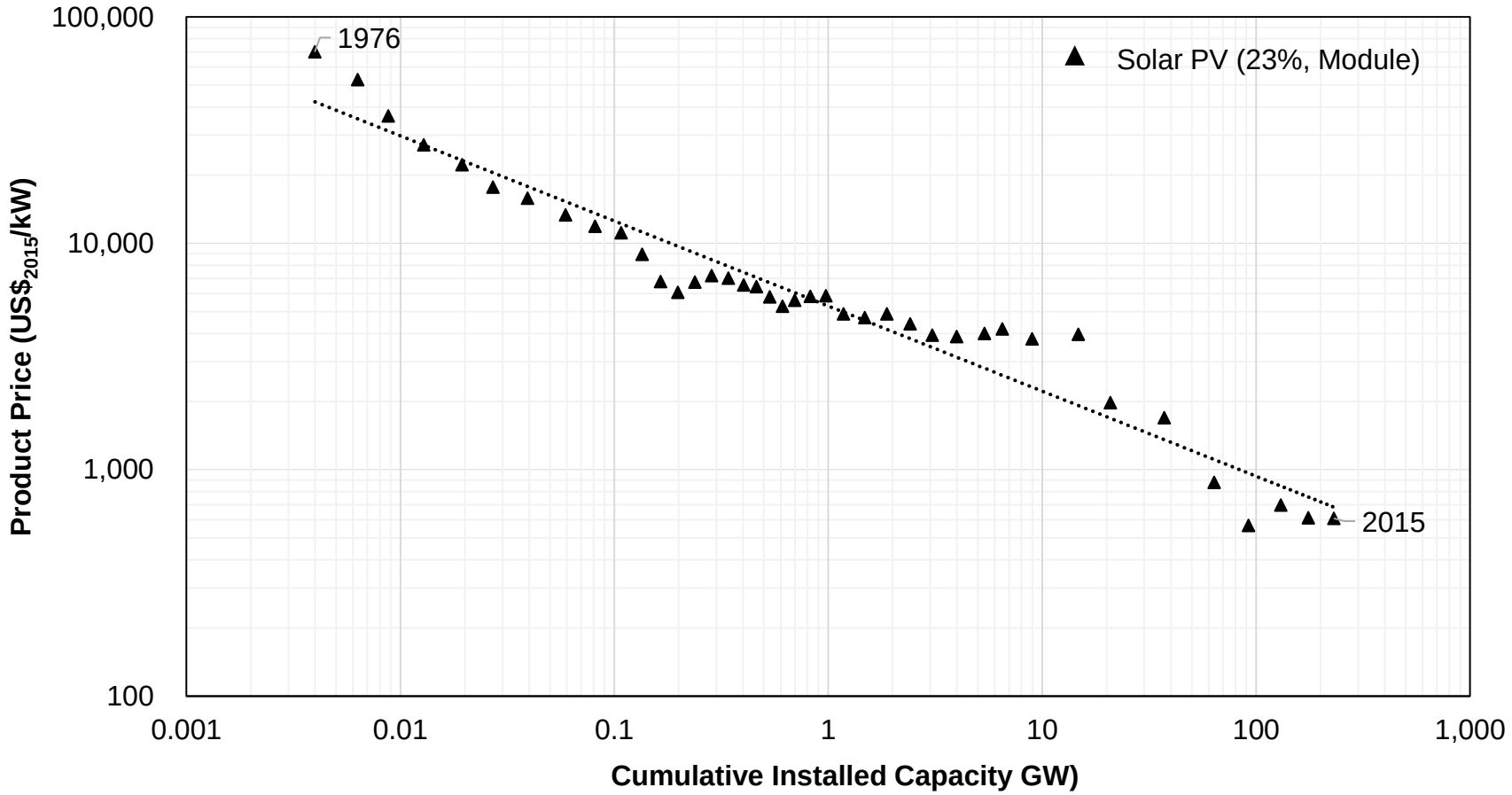


1. Determine experience rates for storage technologies
2. Combine with market forecasts to project future cost of three storage technologies
   - Lithium-ion 15y, 3h, 85%$_{AC\text{-}AC}$
   - Redox-flow 15y, 6h, 75%$_{AC\text{-}AC}$
   - Power-to-Gas 15y, 20h, 30%$_{AC\text{-}AC}$

1. Model baseline scenario for 80% emission reduction by 2050
2. Model storage scenario for three technologies at 5-30% share of Ren.
3. Determine marginal abatement cost for 80%+ emission reduction with storage

Experience curves are a scientific tool to model these cost reductions

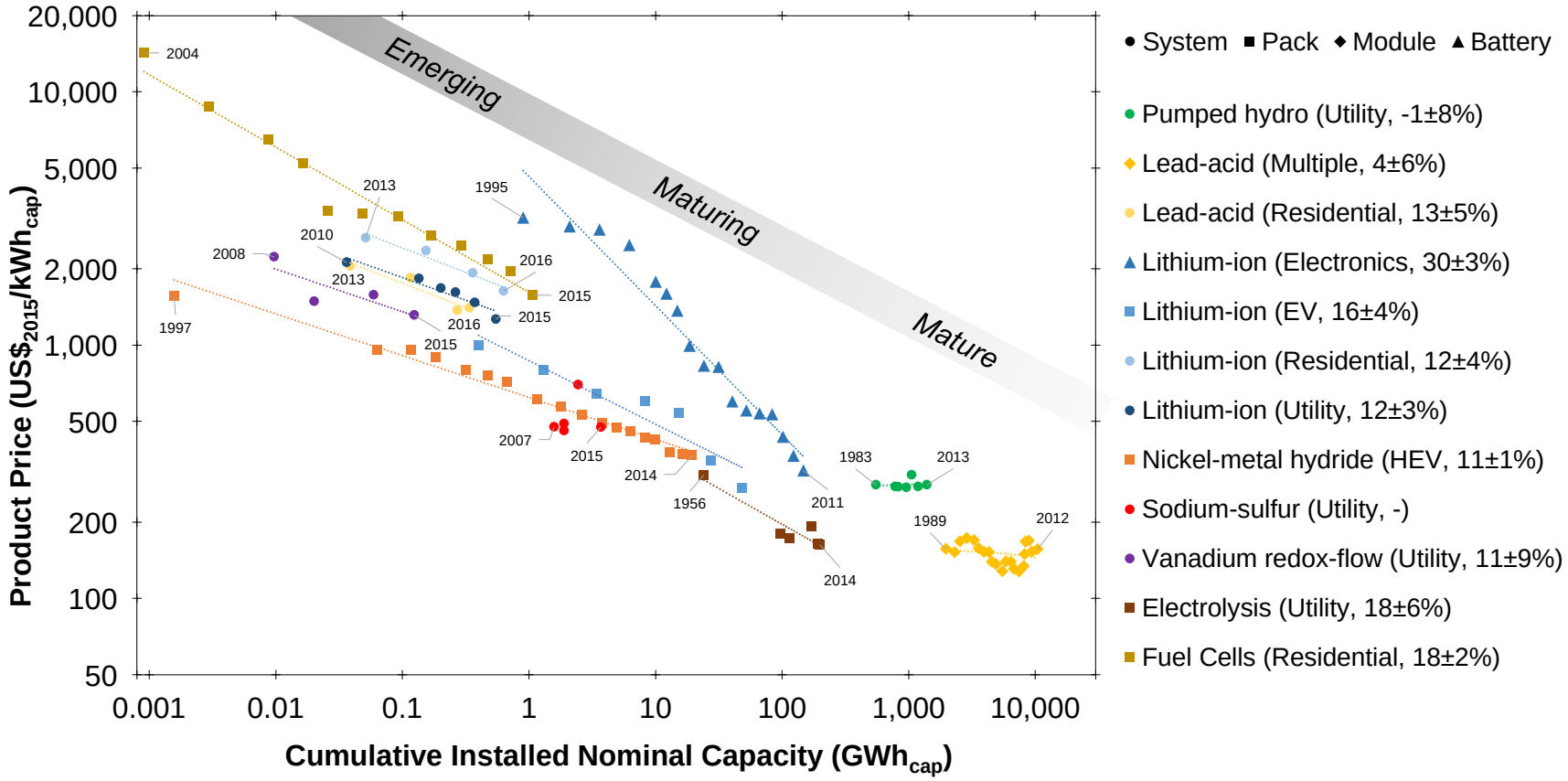
Experience curve analysis



Source: Liebreich, M. Keynote - Bloomberg New Energy Finance Summit 2016. (Bloomberg New Energy Finance, 2016).

We derive a 1st-of-its-kind experience curve dataset for storage technologies

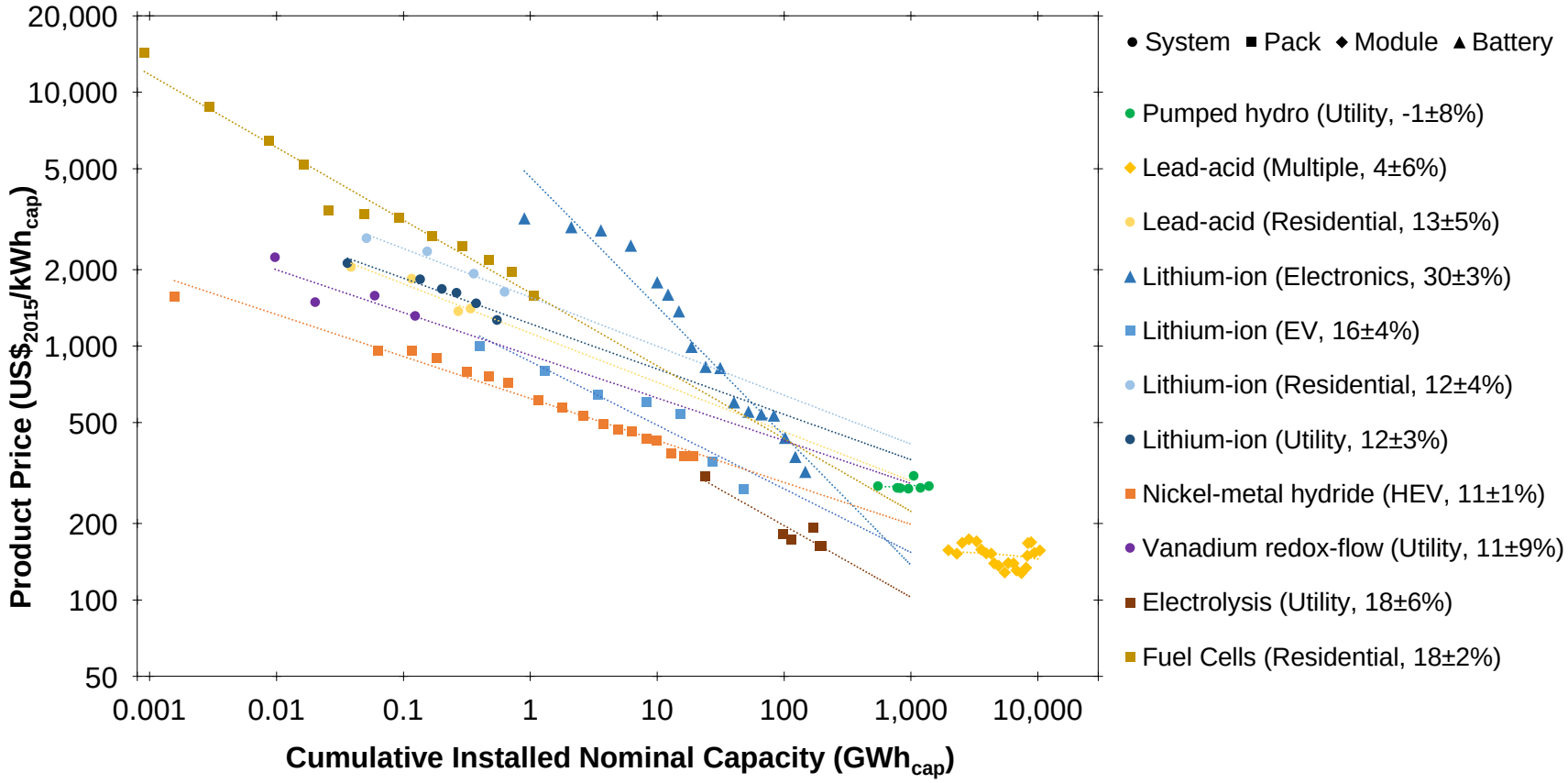
Dataset



Source: O. Schmidt, A. Hawkes, A. Gambhir & I. Staffell. The future cost of electrical energy storage based on experience rates. Nat. Energy 2, 17110 (2017)

… that enables evidence-based cost projections

Result



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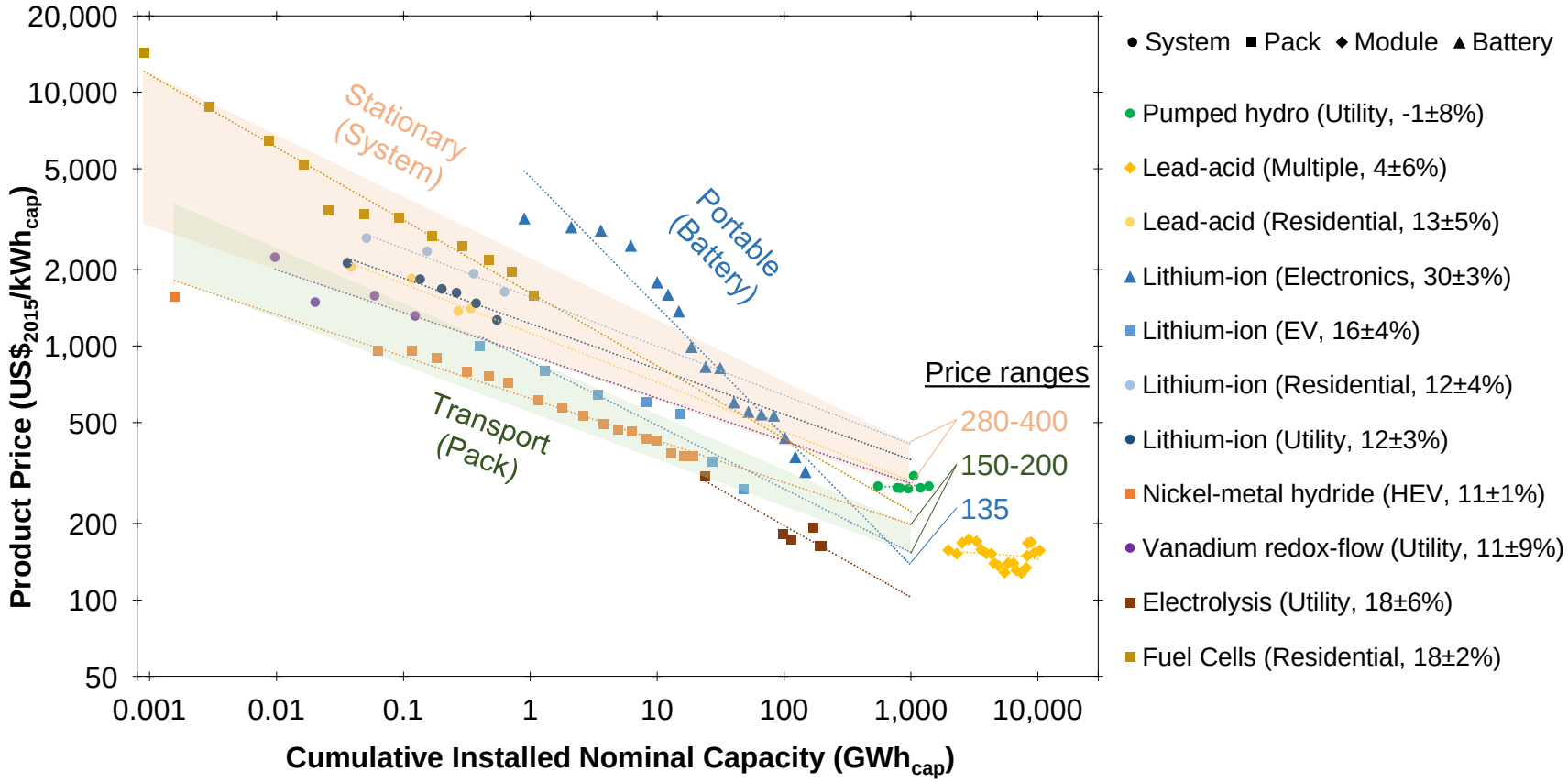
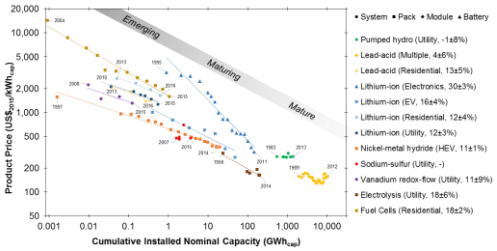
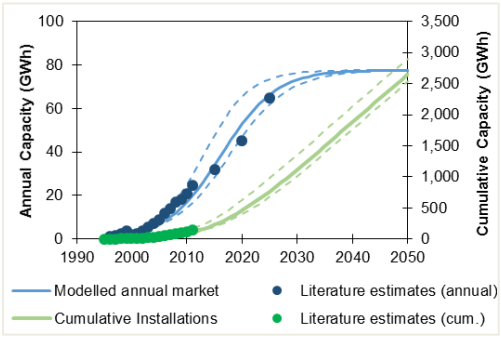


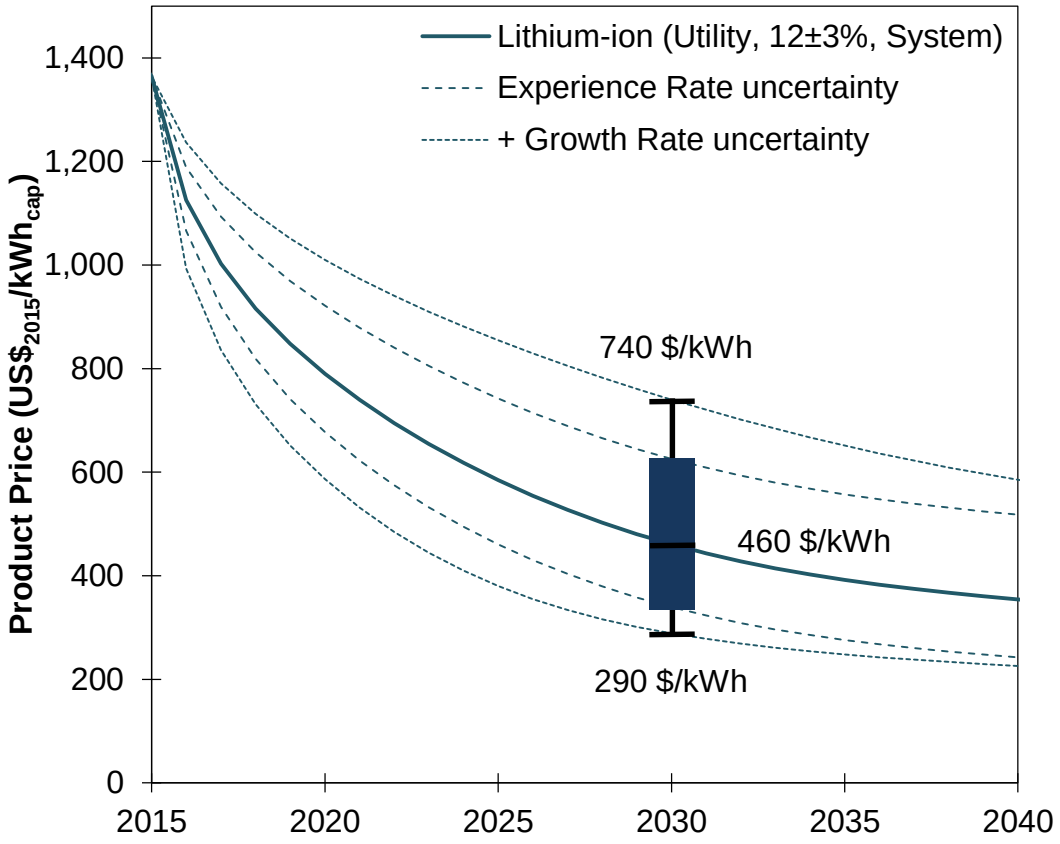
Source: O. Schmidt, A. Hawkes, A. Gambhir & I. Staffell. The future cost of electrical energy storage based on experience rates. Nat. Energy 2, 17110 (2017)

The cost of installed utility-scale lithium-ion systems fall to 290-740 $/kWh by 2030

Capital cost projection (time)







Source: O. Schmidt, A. Hawkes, A. Gambhir & I. Staffell. The future cost of electrical energy storage based on experience rates. Nat. Energy 2, 17110 (2017)

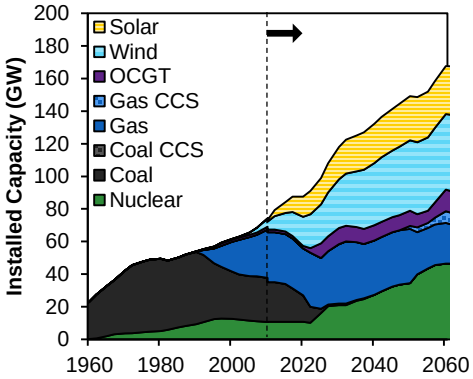
We model storage in the power system where it reduces CO_2 emissions at a cost

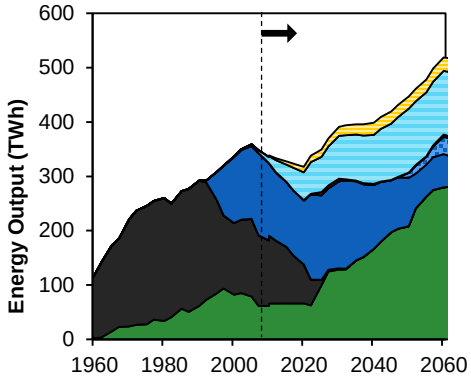
Modelling scenarios

Baseline

2050
- Carbon Price: 200 £/ton
- Strike Price: 89.5 £/MWh
- Renewables: 70 GW (50%)

2010 - 2060
- Curtailed: 159 TWh
- Emissions: 3.14 GT_{CO2}
- Net Spend: £113 bn

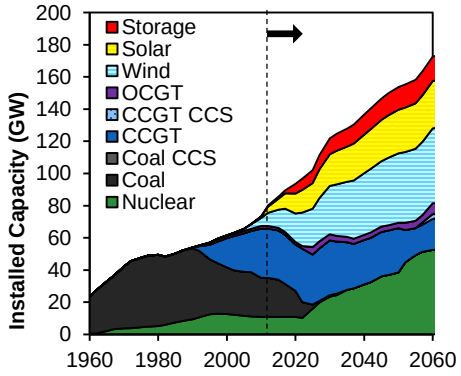


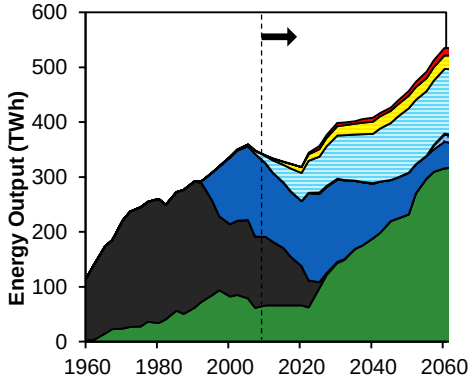


Storage

2050
- Storage capacity: 14 GW (20%)
- Storage duration: 6 hours
- Storage efficiency: 75%

2010 - 2060
- Curtailed: 117 TWh
- Emissions: 2.94 GT_{CO2}
- Net Spend: £130 bn



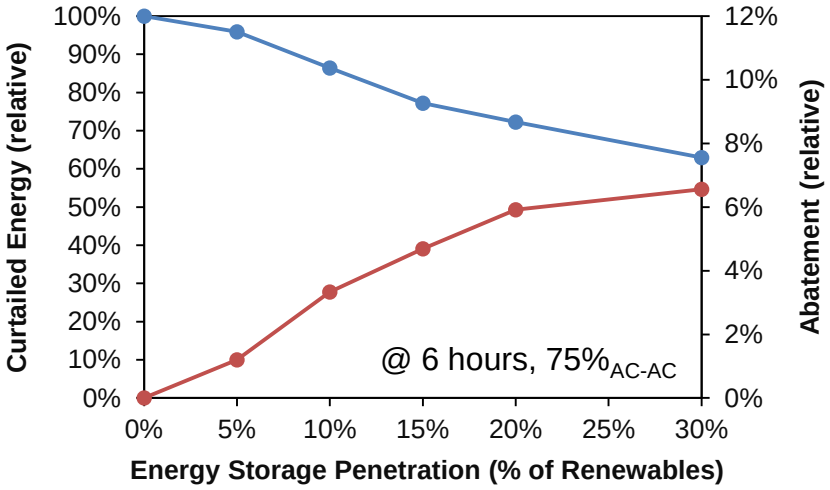


Source: Own analysis

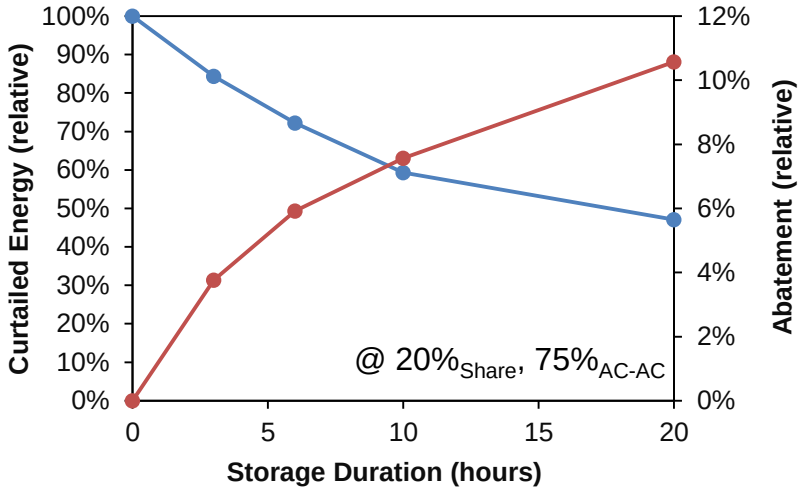
The varying impact on renewables curtailment and CO_2 emission abatement…

Impact of Energy Storage

Impact of higher penetration



Impact of longer storage duration

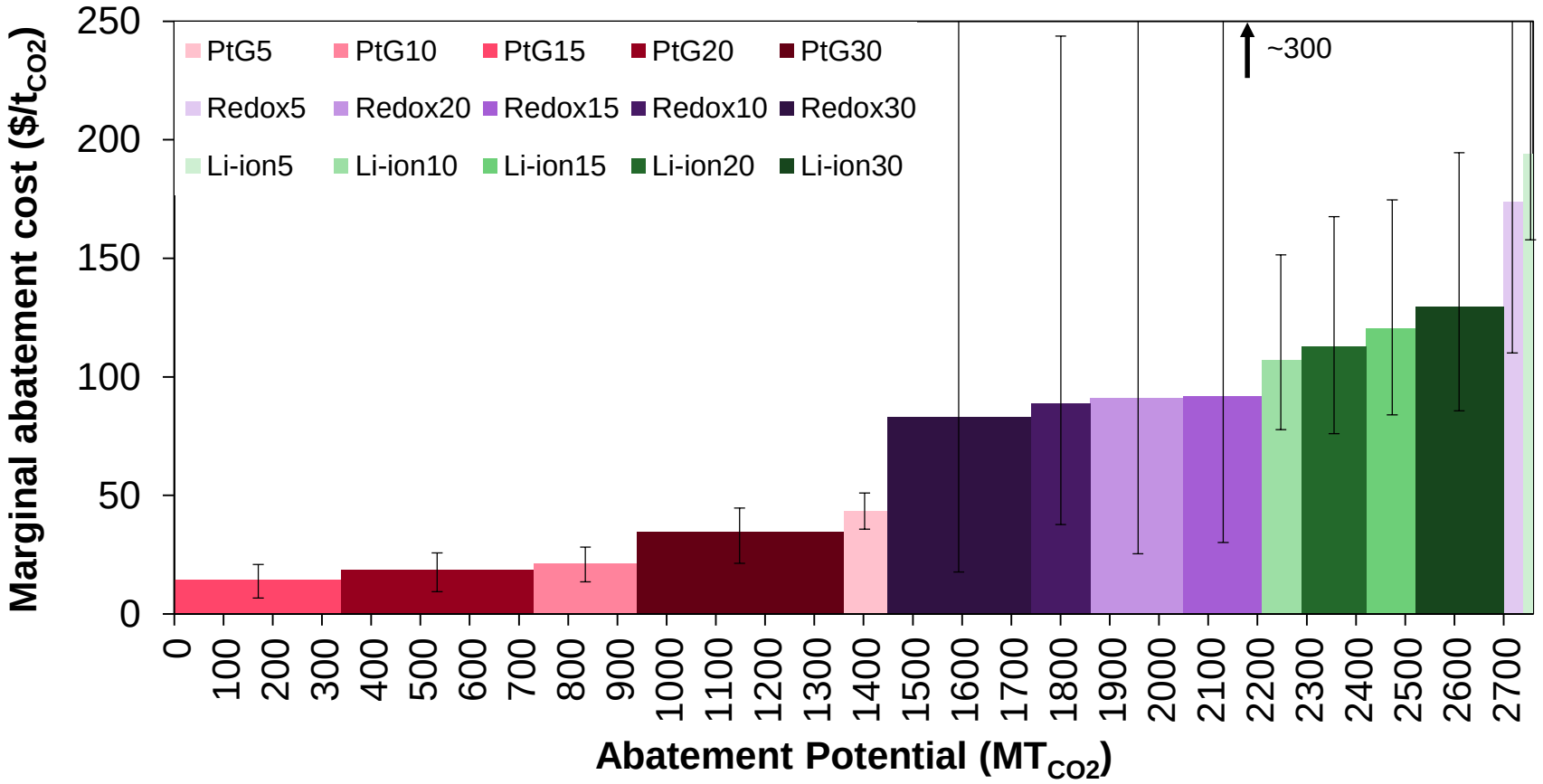


The impact of storage duration on curtailment reduction and abatement improvement appears more pronounced than that of higher storage penetration

Source: Own analysis

… is reflected in the marginal abatement cost of different storage technologies.

Marginal abatement cost curve



Source: Own analysis

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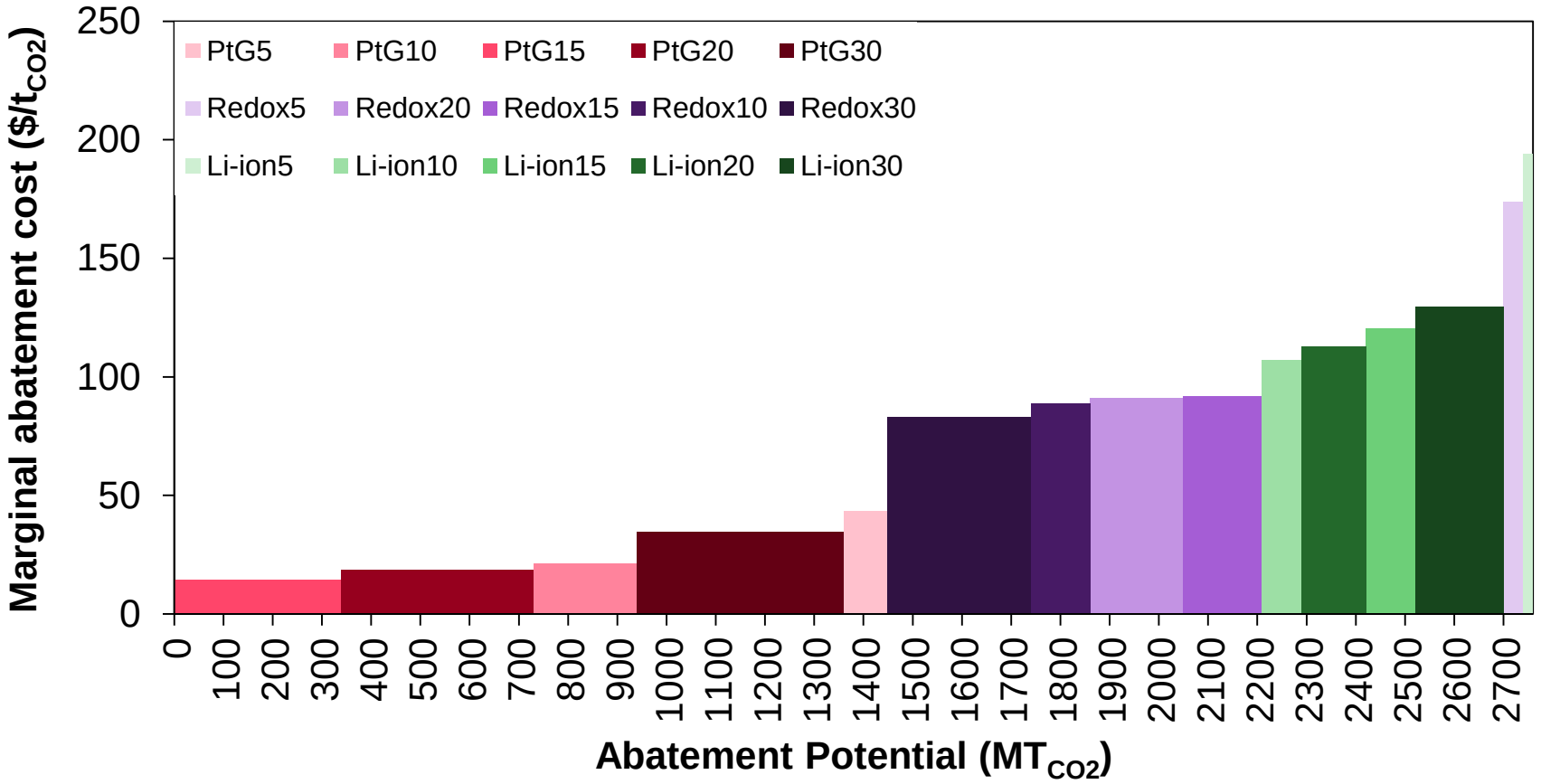
Marginal abatement cost curve



Source: Own analysis

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Questions?

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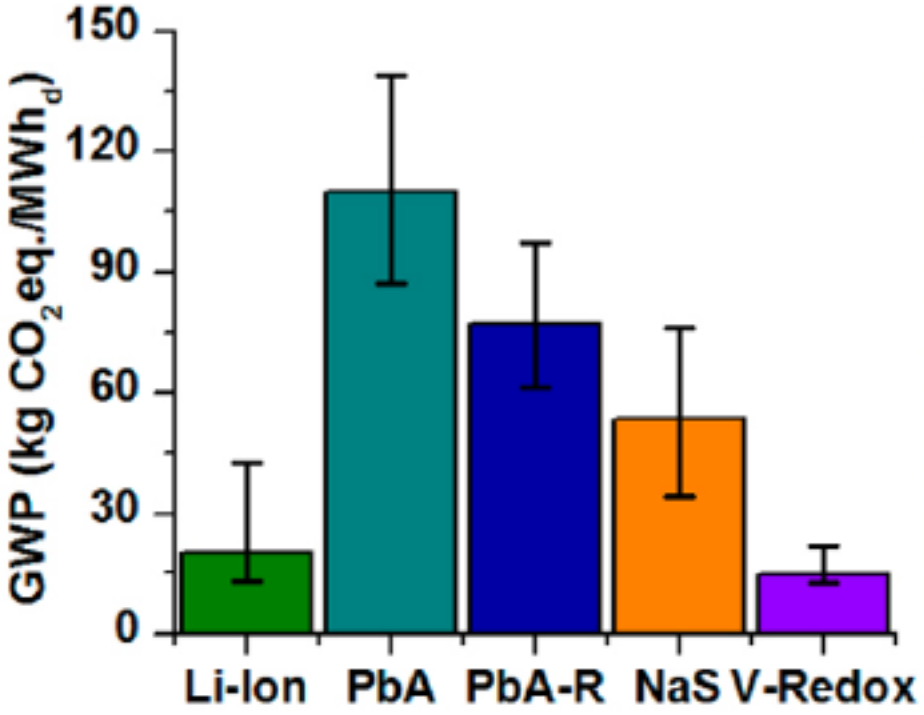
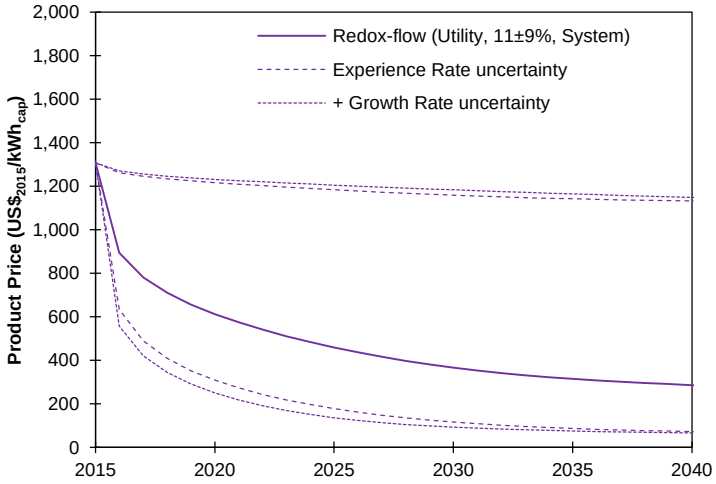
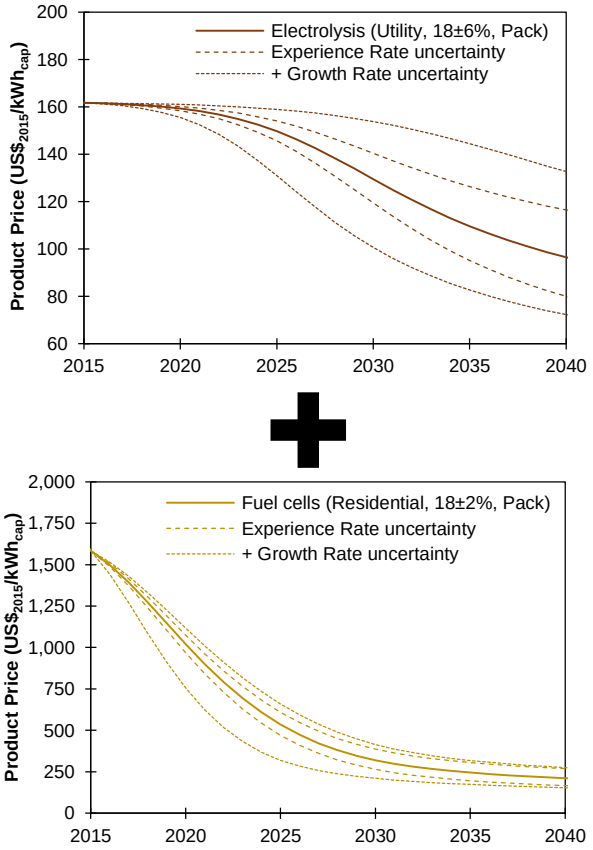
GWP of battery manufacturing



Source: M. Hiremath, K. Derendorf, T. Vogt, Comparative life cycle assessment of battery storage systems for stationary applications., Environ. Sci. Technol. 49 (2015) 4825–33. doi:10.1021/es504572q.

Vanadium redox-flow & Power-to-Gas





Raw material costs suggest that these cost projections are not infeasible

Sanity Check 1 – Raw material cost