# Influence of electric vehicle uptake on competitive dynamics of storage technologies in electricity sector applications

Martin Beuse, ETH Zurich, e-mail: mbeuse@ethz.ch
Bjarne Steffen, ETH Zurich, e-mail: bjarne.steffen@gess.ethz.ch
Tobias S. Schmidt, ETH Zurich, e-mail: tobiasschmidt@ethz.ch

## Overview

Mitigating anthropogenic climate change requires a rapid decarbonization of the electricity sector (Rockström et al., 2017). To this end, intermittent renewable electricity sources, such as wind and solar irradiation, are likely to play a major role (Edenhofer et al., 2011). In turn, electricity storage technologies (ESTs) can enable higher shares of intermittent renewable energy sources to be used and thereby support the transition towards a low-carbon electricity sector (Steffen and Weber, 2013). Already today, electricity systems with high shares of renewable energy are increasingly relying on ESTs to provide flexibility across different applications (Malhotra et al., 2016). While a variety of technologies is available, further cost and performance improvements are necessary to allow a rapid transition towards low-carbon electricity systems at a reasonable cost.

To project potential cost reductions and support strategic planning by policy makers and industrial players alike, researchers apply technology and innovation forecasting methods. Among energy economists, experience curve-based projections have emerged as prominent approach to project the future cost and performance of low-carbon energy technologies (Kittner et al., 2017; Nykvist and Nilsson, 2015; Rubin et al., 2015; Schmidt et al., 2017; Steffen et al., 2018). While the use of experience curves is well established for power generation technologies (Rubin et al., 2015), it may lead to misleading results for ESTs. The first reason for this is the multi-purpose character of ESTs (Battke and Schmidt, 2015; Schmidt et al., 2019), meaning that they may be used in multiple applications and sectors. The second reason is that in the current early stage of deployment, various competing ESTs still exist, and not all technologies will be able to drive down their experience curve as they might be outcompeted before (Schmidt et al., 2016; Sivaram et al., 2018). Most prominently, Lithium-ion (Li-ion) batteries are used to power electric vehicles (EVs), an application that has been experiencing particularly strong growth in recent years. The resulting cost and performance improvements of battery packs bolstered the market share of Li-ion batteries across electricity sector applications, limiting the deployment and learning of other ESTs. By extension, it is likely that future uptake of EVs will affect the cost and competitiveness of ESTs in the electricity sector. However the likelihood and size of this effect remain unknown.

## Methods

To model the influence of EVs (and other storage-using sectors in general) on ESTs' cost and competition, the paper makes two contributions. First, we construct component-based experience curves (Ferioli et al., 2009) for electrochemical storage technologies, based on new data. We do so by considering the electricity storage systems as comprised of a battery pack (which can be considered the same across sectors and applications) and a balance-of-system component (which is differentiated between sectors or applications). Second, to reflect competition amongst the various available technologies, we present a system-dynamic modelling approach. This model uses the component-based experience curves to estimate the cost development of ESTs based on their deployment, which in turn is determined by a technology's competitiveness. In other words, if a specific EST is chosen to be deployed at scale, this technology can realize cost improvements, while the not-chosen ETSs fall further behind. We derive deployment probabilistically by calculating each technology's market share based on its cost-competitiveness relative to others in every period. As a result, projections until 2030 for cost and market shares of the individual EST in key applications are derived, and their sensitivity is assessed.

## Results

We find that by 2030, Li-ion batteries are likely to dominate across applications and EV uptake scenarios, even in longer-duration applications. The timing of this change depends on the extent of EV uptake. Since the dominance of Li-ion batteries (e.g. over flow batteries and pumped-hydro storage) might lead to long-term inefficiencies and reduced technological resilience, we also assess potential policy interventions that foster alternative technologies. We find that policy interventions (e.g. subsidies for early flow battery deployment) can result in increased technology diversity but need to be adjusted to EV uptake. This highlights the importance of continuously monitoring developments across sectors when assessing multi-purpose technologies and using respective modelling approaches.

## Conclusions

Technology forecasting plays an important role in informing decision makers in the transition towards low-carbon energy systems, and energy economists contribute to that end with model-based projections. The paper highlights that the common experience curve approach needs to be adapted for multi-purpose technologies such as EST. By analyising EST competition under various electric vehicle uptake scenarios, our paper goes beyond past EST cost projections and contributes to the policy debate on how to actively manage technology deployment to ensure efficient pathways for the decarbonisation of electricity systems.

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