Gaining scale, climbing the learning curve and lowering flow battery costs

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Introduction

The advantages of redox flow batteries (RFB) are obvious: a long cycle life, low levelized costs of storage (LCOS), non-flammability and easy scalability. Nevertheless, this storage technology is still less widespread than other storage technologies.

A major obstacle to the broad market entry is the higher initial investment compared to other technologies: While Li-Ion batteries benefit from learning curve and interlinking effects, as they are used in large quantities for electric cars, RFB are at the beginning of their commercial use. In order to meaningfully assess the market opportunities of RFB, it is necessary to estimate future economies of scale, learning curve and interlinking effects and the resulting unit costs. In other words: How far down the cost curve can we run?

Obstacles for accelerated market penetration

There is a major obstacle in sales pitches: LCOS seem to be difficult to understand for many potential customers, decisions are often made on the basis of CAPEX in EUR/kWh.

1 MW/4MWh	Cycle life	LCOS (Cycle costs)	CAPEX [€/kWh]
Li-Ion	4,000	0.05 €	100-250
Redox-Flow	15,000	0.02 €	250-400

Figure 1: Comparison of CAPEX and LCOS[1]

While LCOS consider factors such as longevity, lack of degradation of the electrolyte and other costs over the entire life cycle of the system, the initial investment in EUR/kWh only reflects a small part of the total costs. Nevertheless, it is clear that based on sales experience, customers focus on only these very tangible initial investments and find it difficult to include less tangible factors. The reasons for this are manifold and should be the subject of further investigation. In any case, these factors should be taken into account in the actual sales approach of redox flow batteries.

Against this background, we draw the following conclusion for the commercialization of the technology: The industry must realize that CAPEX/kWh must be significantly reduced; arguing solely on LCoS will not open the market.

Cost curves – concept and application to RFB

To forecast future CAPEX, we can draw analogies to technologies such as solar systems and semiconductors, which have already passed through the cost curve with proven massive cost reductions. The basic idea of the cost curve concept shows the relationship between the quantity produced and the unit costs. The more units are produced, the lower the unit costs.

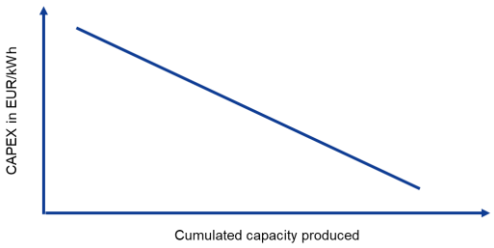


Figure 2: Schematic cost curve concept

An obvious comparison for the cost-cutting potential of RFB is the solar industry, that was also initially characterized by high investment costs in EUR/Wp. For this technology, too, there were long doubts about the extent to which these high initial investment costs could be reduced in order to offer marketable solutions. The following figure from a study by Fraunhofer Institute showed the correlation between market penetration and necessary unit costs as early as 2015[2].

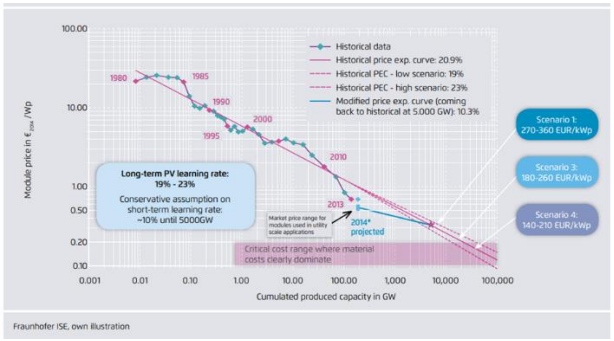


Figure 3: Cost curve development solar industry in EUR/installed capacity

In the course of anti-dumping discussions, European manufacturers like Meyer Burger published current figures on investment costs in EUR/Wp on LinkedIn underlining that these forecasts have been achieved and exceeded.

As a manufacturer of components for RFB, we see clear analogies for stack and module production. Standardization of components and serial production will help to achieve the necessary economies of scale to further develop the RFB market. Initial discussions with suppliers have shown that discount scales with significant cost-cutting potential are being offered as purchase volumes increase. We emphasize the need of standardisation and cost reductions: a mass market for RFB will be possible when the initial investment costs in EUR/kWh can be reduced in a similar way to those of the solar industry in EUR/Wp.

Bottom up verification using core cost analysis

In our view, the future cost structure of RFB will benefit significantly from the above-described top-down scaling effects. To further prove the cost-cutting potential, we challenged the findings bottom up by using core cost analyses of the components to evaluate the lower bound of cost reductions set by the materials used. We would like to highlight the outcome of this analysis with two examples.

First example are the tanks used for RFB. Today tanks with a capacity of 1,000 litres are purchased for several hundreds of EUR. In fact, these tanks consist of approx. 56 kg HD-PE granulate. According to market places like plasticker.de this granulate costs are at 0.85 EUR/kg. Leaving aside manufacturing costs, we consider material costs lower than 50 EUR/tank as the lower bound of the costs. This underpins the potential of running down the cost-curve.

Core cost analysis for more complex parts might be more difficult, but nevertheless analogies from similar products are reasonable. Pumps are purchased for several hundreds of EUR. Considering the technical requirements, the pumps can - to a certain extent - be compared with pumps for other applications. These are available for EUR 100 or less. Technical requirements of RFB justify higher costs. Nevertheless, the cost reduction potential is obvious.

Conclusion

It is of high importance for the development of the RFB market to draw a clear picture concerning the development of CAPEX based on learning curves. For this, raw material suppliers and manufacturers are encouraged to jointly describe and publish potential costs paths for RFB. To our believe, this is necessary to convince customers, investors and other stakeholders that RFB are a competitive storage technology.

Our concept is based on an estimation of achievable cost structures using the cost curve concept and validation of the findings using core cost analyses. VANEVO implemented a concept of standardising stacks and modules, which achieves significant economies of scale. Running down the cost-curve will be crucial for all market participants to harvest the full potential of RFB. Indicators like LCoS are relevant, but should not obscure the fact that the initial CAPEX are key for purchasing decisions.

References

[1] Source: own calculations.

[2] https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/AgoraEnergiewende_Current_and_Future_Cost_of_PV_Feb2015_web.pdf