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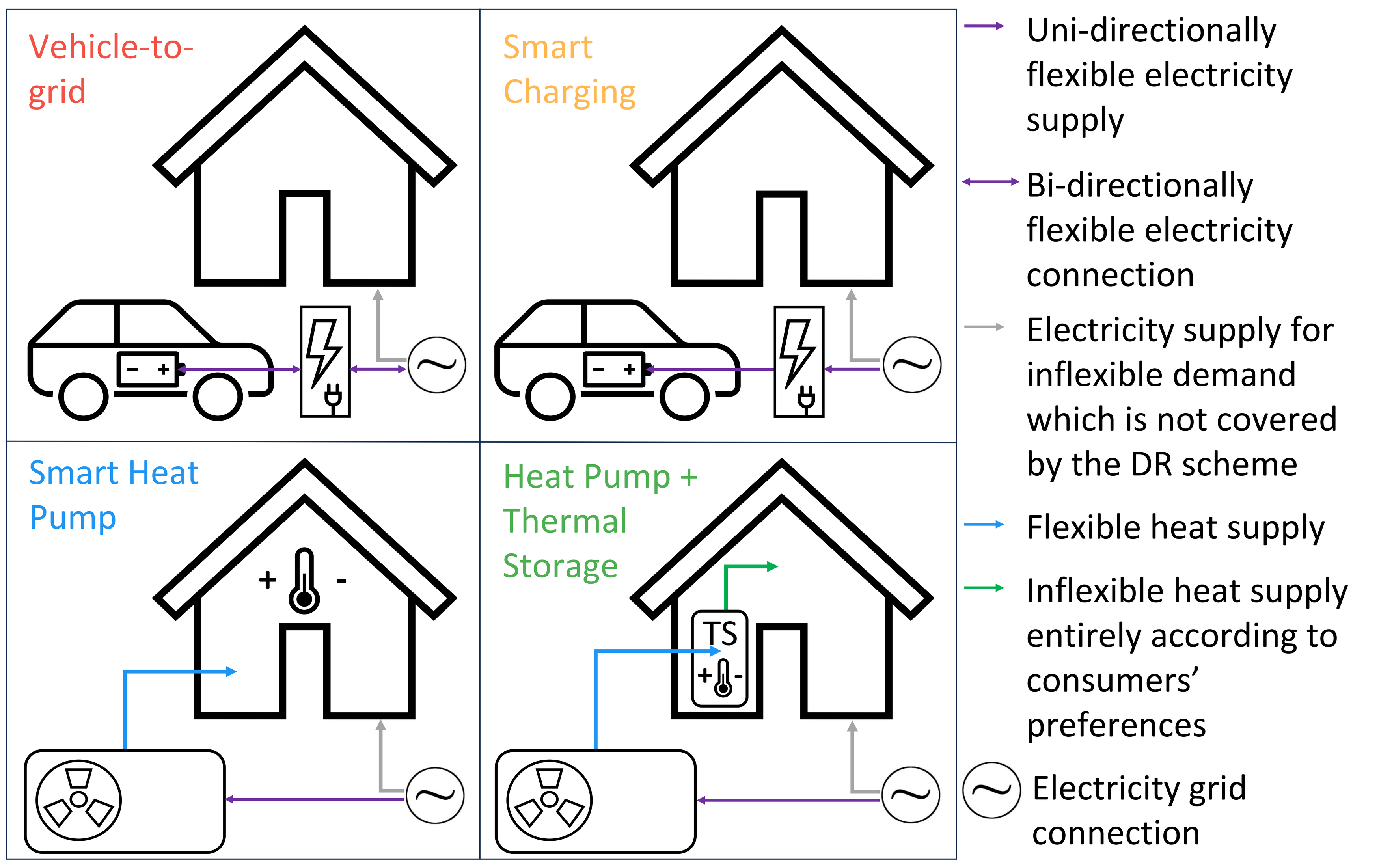
Levelised Cost of Demand Response

COMPARISON OF ENERGY STORAGE AND DEMAND RESPONSE USING THE LEVELISED COST FRAMEWORK

Introduction

Demand response has received growing attention over the last decade as a supposedly lower-cost alternative to energy storage for the integration of renewable energy. Direct load control (DLC) schemes are especially gaining traction, thanks to the ongoing electrification of transport and heating. Four common DLC schemes are shown on the right. While DR schemes undoubtedly offer lower investment costs than storage technologies, they also require consumer reward payments which makes their operational costs exceed those of common storage technologies. The levelised cost of storage (LCOS) annuitises investment and operational costs and thereby permits the comparison of storage technologies' lifetime costs. The levelised cost of demand response (LCODR) expands this framework to DR schemes, providing a realistic assessment of whether DR offers lower lifetime costs than energy storage.



Methodology

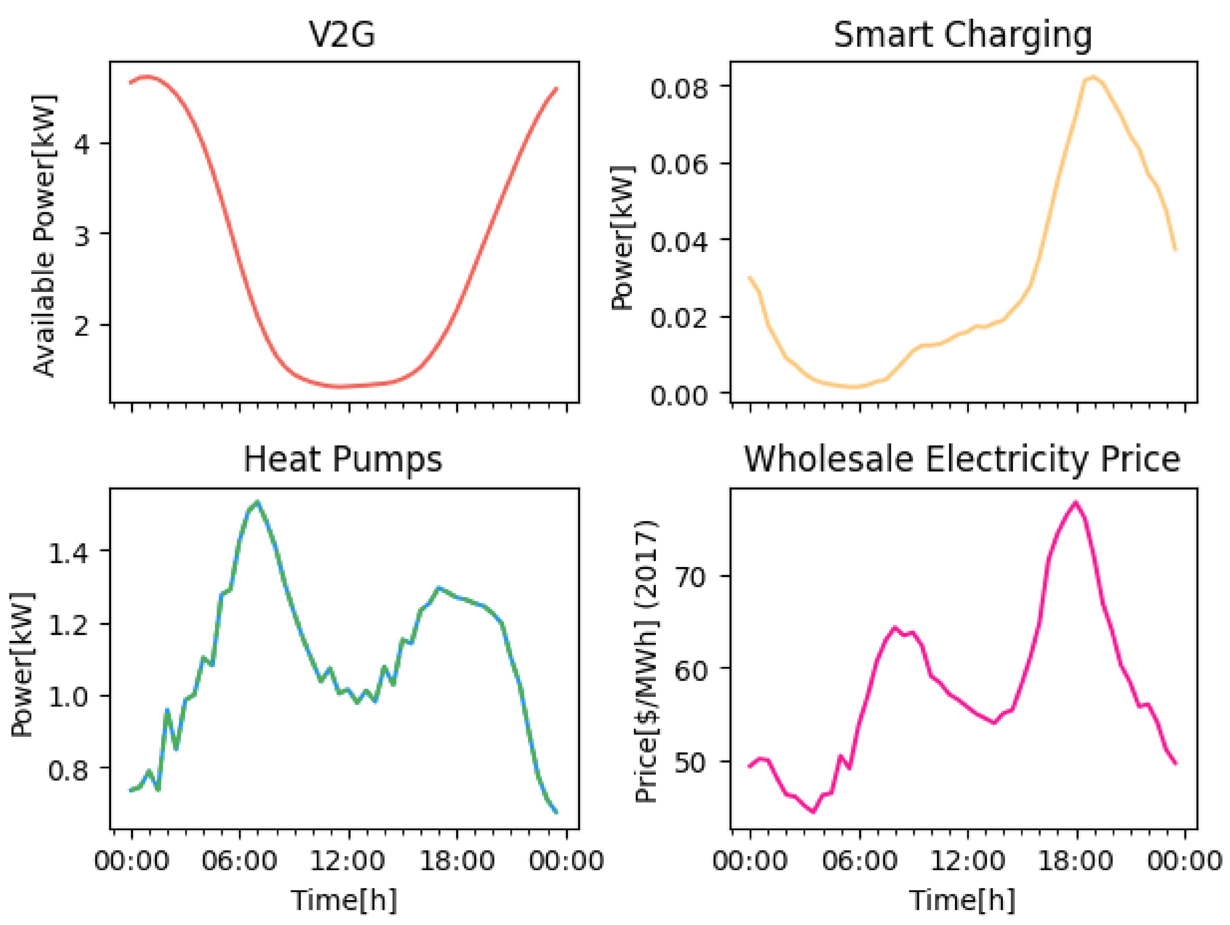
The estimation of the LCODR mostly follows that of the LCOS [1] with three differences (highlighted in blue):

$$LCODR_{VF}\left[\frac{\$}{MWh}\right] = \frac{Investment + \sum_t^T \frac{O\&M}{(1+r)^t} + \sum_t^T \frac{Rebound}{(1+r)^T} + \sum_t^T \frac{Rewards}{(1+r)^t} + \frac{End-of-life}{(1+r)^{T+1}}}{\sum_t^T \frac{E_{app}}{(1+r)^t} \times Value\ factor}$$

Rebound costs are the costs that the shifted electricity consumption causes (analogous to charging costs in the LCOS). Reward payments are issued to consumers to incentivise them to enrol in DR schemes.

Value Factor

The value factor methodology was taken from electricity generation cost assessments where it adjusts the cost of variable renewable energy for the value of their generation profiles [2]. For the LCODR the value factor is the ratio of a DR asset's revenue to the revenue from an equivalent storage asset (with a flat availability profile).

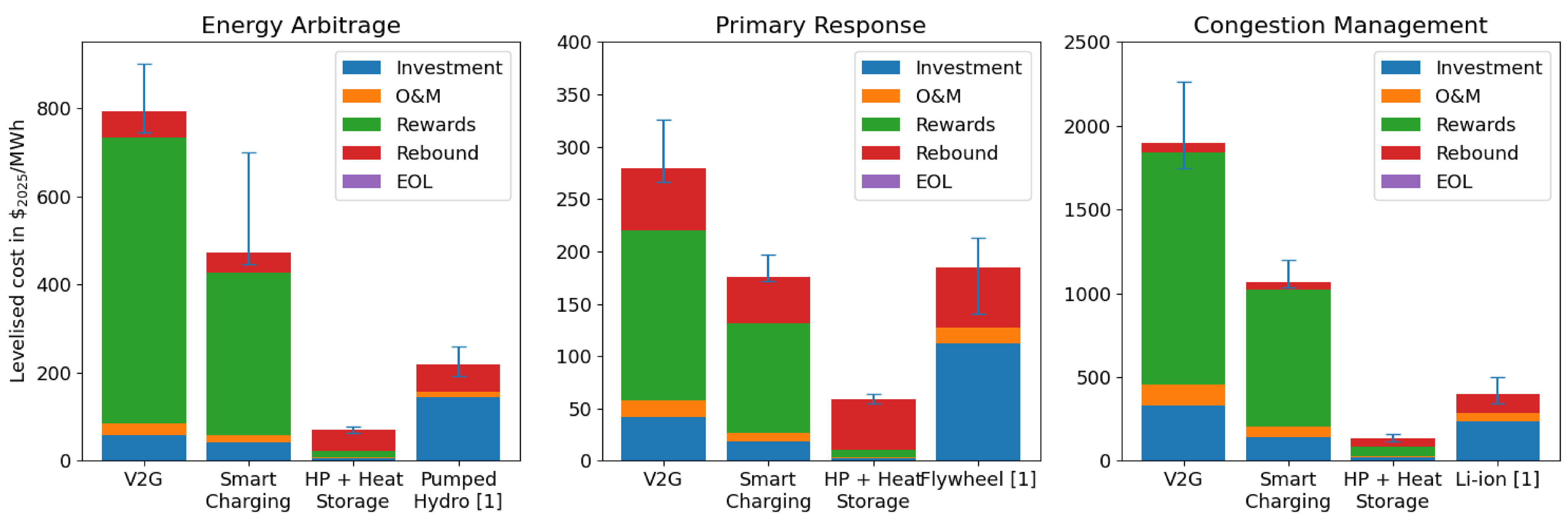


The availability and price profiles in the figure above can be overlayed to roughly infer the value factor.

	V2G	Smart charging	Heat pumps
Value Factor	0.98	1.12	1.05

Results

The LCOS is estimated individually for a specific pairing of technology and application, and the same applies to the LCODR. Results are displayed for the three applications: energy arbitrage, primary response and congestion management. The cheapest energy storage technology from Schmidt & Staffell [1] is also included for each application. Primary response requires the most shifted/discharged energy, meaning the cost per unit of shifted/discharged energy is lowest. The high amount of energy also favours EV-based schemes, meaning primary response is the only application in which they can compete with energy storage. Heat pumps with thermal storage consistently outperform energy storage, suggesting that these should be the focus of DR investment. The LCODR of smart heat pumps without thermal storage exceeds that of any other technology by at least a factor of 10 and is therefore not displayed.



References

[1] Schmidt, O., & Staffell, I. (2023). *Monetizing energy storage: A toolkit to assess future cost and value*. Oxford University Press.
[2] Hirth, L. (2013). The market value of variable renewables: The effect of solar wind power variability on their relative price. *Energy economics, 38*, 218-236.

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