A case study on the behaviour of residential battery energy storage systems during network demand peaks

Never Stand Still | Faculty of Engineering | School of Photovoltaics & Renewable Energy Engineering

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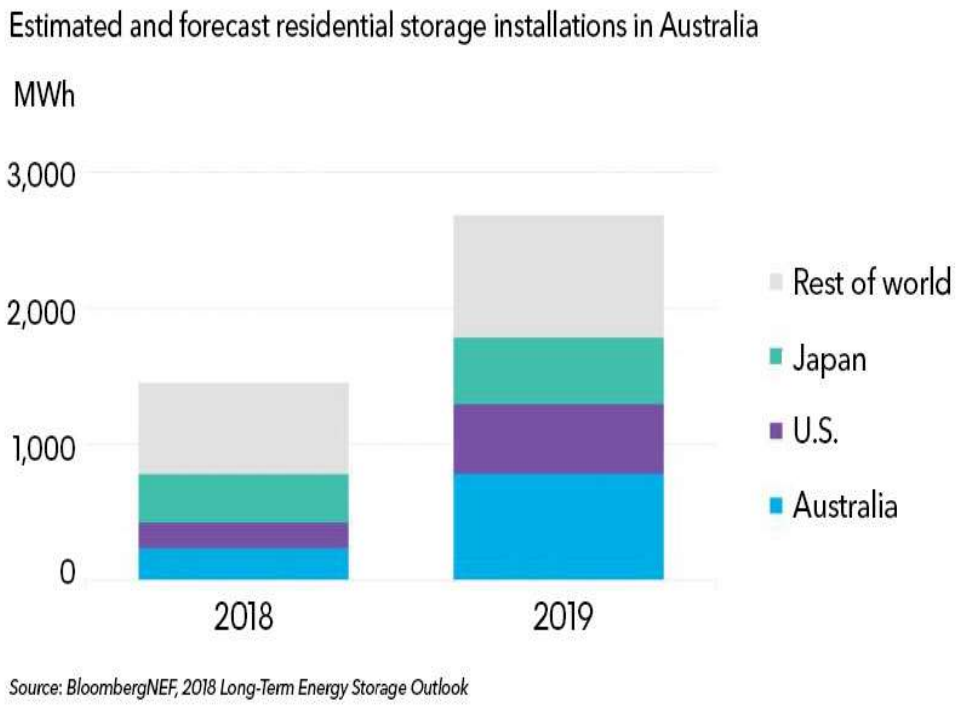
Introduction

Large market in residential battery energy storage systems (BESS)

Annual residential storage deployments by country



(Bloomberg New Energy Finance 2019)

-Many studies have reported the potential of using BESS in providing grid services (Uddin, Romlie et al. 2018)(Shaw, Sturmberg et al. 2019)(AEMO 2018)

-Growing interest in aggregating and orchestrating distributed BESS to amplify their value (Franklin, Gordon et al. 2016)(Asmus 2010)

-Fewer reports on how residential BESS behave without orchestration

Research objective

- To characterise the behaviour and analyse the performance of residential BESS during times of peak demand on the electricity network without orchestration

- To assess the potential difference in the BESS' impact on the household demand during times of peak demand on the electricity network with and without orchestration

Data source

- 1 minute resolution BESS data collected from 15 systems deployed in Queensland
- All BESS are in the sizes of 5 to 10kWh, lithium-ion batteries from supplies like LG Chem, Panasonic, BYD
- All BESS are operating in load-following mode
- Data consists of PV output, BESS charging and discharging power, grid import and export, some systems have the combined output of PV + BESS together

(Energex 2017)

Demand peaks investigated

Analysis was done on the BESS behaviour during a 30-minute interval and a 2-hour interval on several instances of network demand peaks.

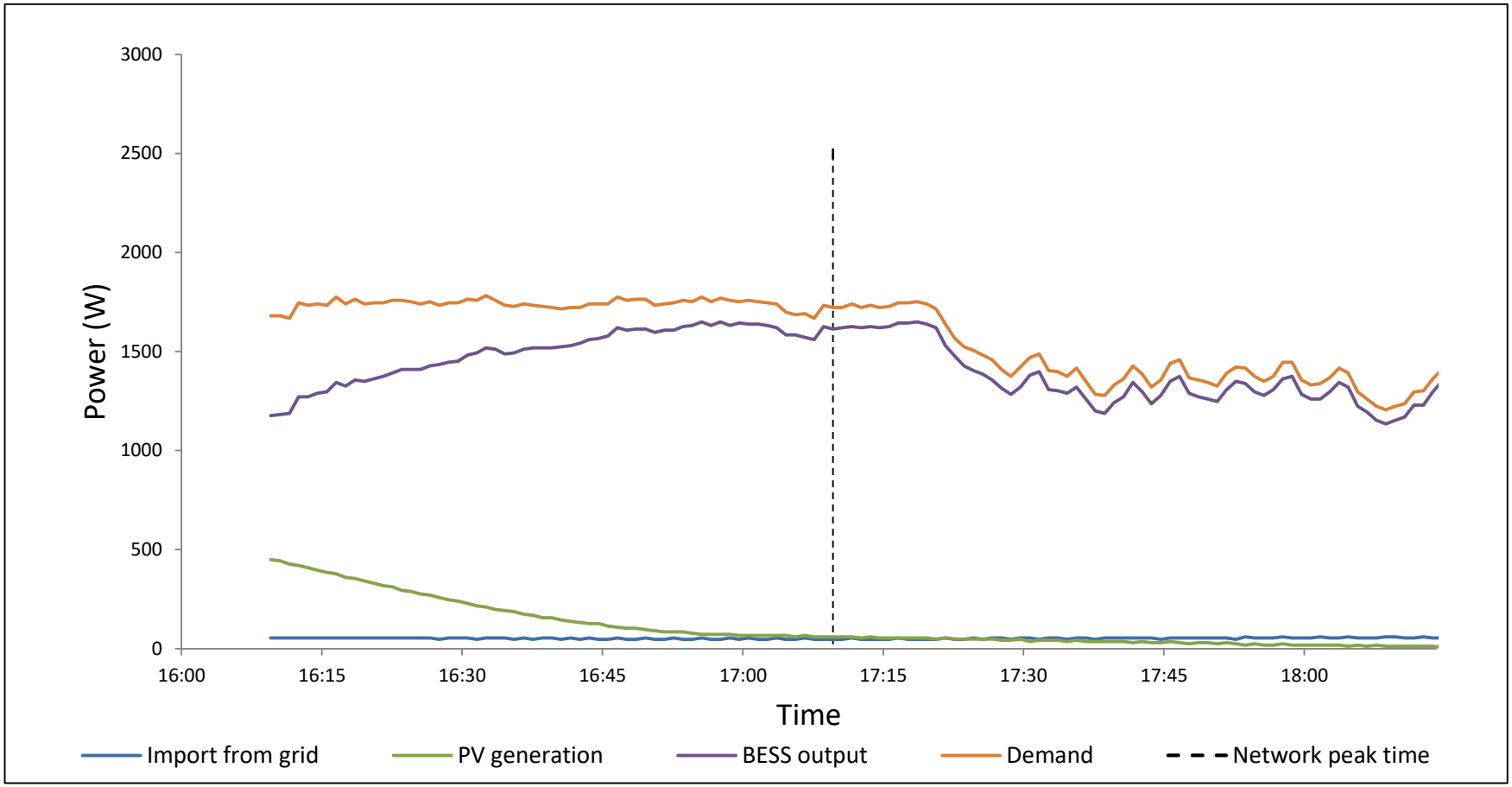
2 Network demand peaks across the entire Energex network:

-17:10 on 18th of January 2017
-17:10 on 12th of February 2017

4 Zone substation demand peaks for the feeders that the BESS is connected to:

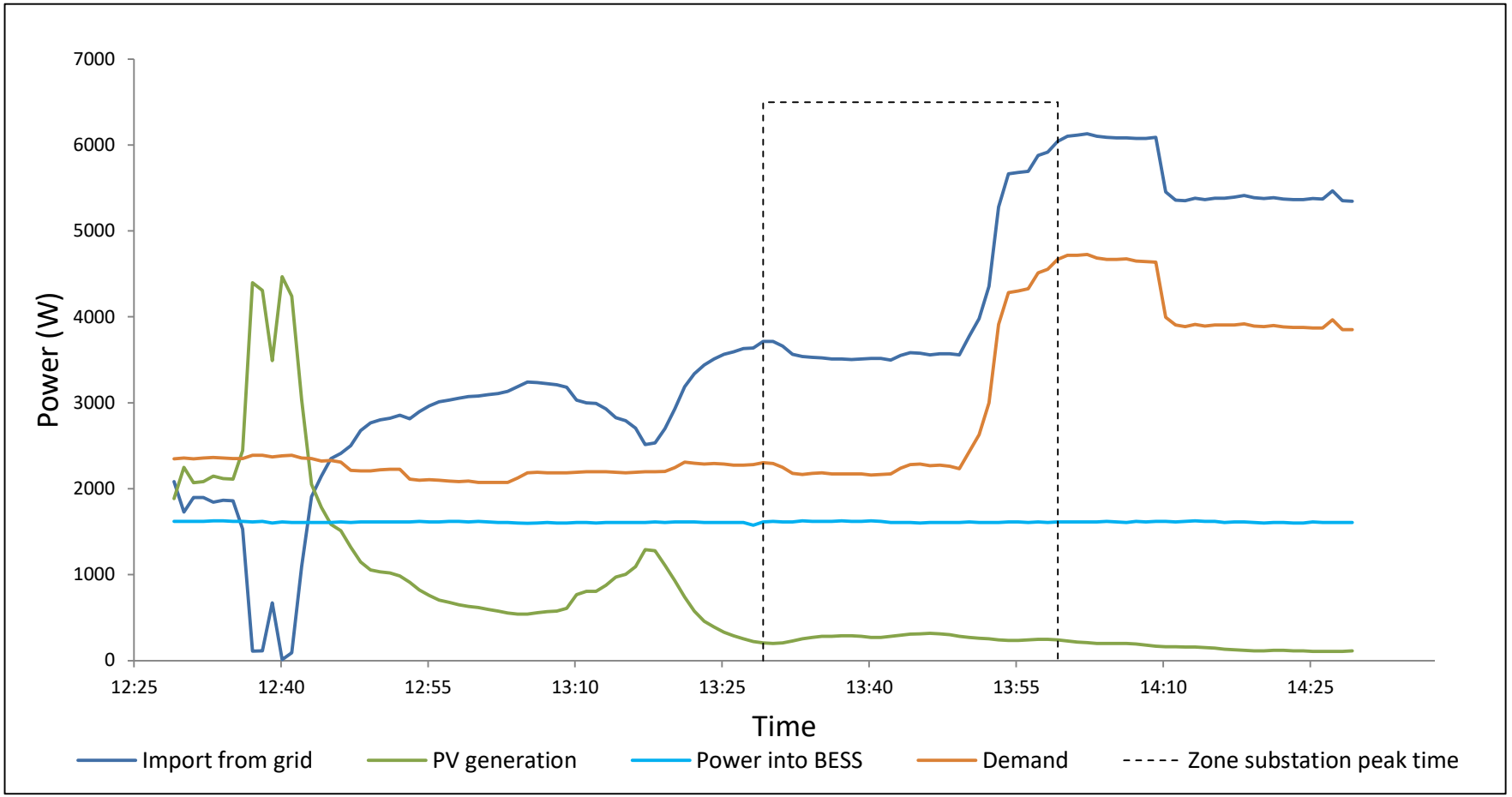
-often different for each BESS
-some coincided with the network peak period

Example of BESS load-following and reducing demand



Load-following behaviour of BESS I during the network peak on 12th of February 2017
-there were errors in the BESS' load-following accuracy and hence leaving a small trace of grid import (96% of the net demand was covered by the BESS)

Unorthodox behaviour example



Behaviour of BESS C charging at approximately 1.6kW during time of net demand during zone substation peak on 31st of December 2017

-behaviour was consistent for BESS C during charging but the charging power was not

Summary of results found

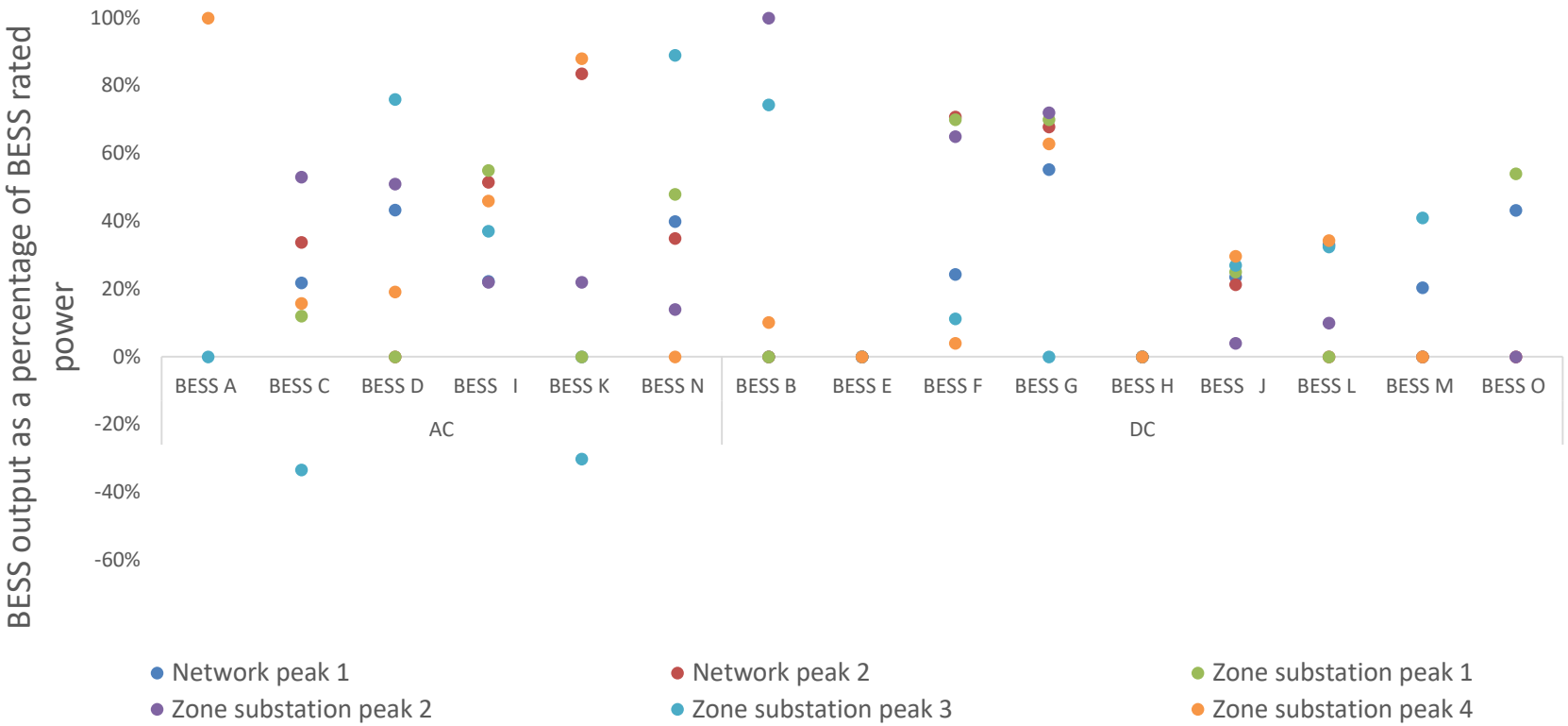
Summary of BESS behaviour during the 2 network peaks

Number of cases	Case description
6	BESS depleted before the network peak
5	Unorthodox behaviours such as: discharging at a constant rate lower than demand, spikes of high discharge that caused large amounts of grid export, and cycles of charging and discharging that did not follow demand
4	No activity from the battery
2	No data were available for the time period
13	BESS was load-following: reducing demand at the time of the network peak

Summary of BESS behaviour during the 4 zone substation peaks

Number of cases	Case description
17	BESS appeared to be depleted before the zone substation peak
2	Unorthodox behaviour such as BESS charging when the net load is positive
6	BESS with no activity during the zone substation peak
2	No data available for the BESS
2	BESS data invalid
31	BESS was load-following: reducing demand at the time of the zone substation peak

Aggregated impact on demand peaks



Distribution of the BESS output as a percentage of BESS rated power for the network and zone substation peaks,

-on average the BESS that did load-follow discharged at 42% of their rated power during network peaks and 47.5% of their rated power during zone substation peaks

Conclusions

-Unorthodox behaviours and errors in load-following indicate that more monitoring of residential BESS is needed to improve their operation

-Models of residential BESS impact on networks provides an optimised result that may not represent the outcomes caused by BESS deployed in the field

-Residential BESS operating on the interest of the customer (load-following) were providing around half of their rated power during demand peaks

-Orchestrating the BESS will provide an increase in network peak demand reduction, but it may not warrant the additional costs in control & monitoring systems

-In contrast, it may be more impactful to commit aggregation and orchestration of residential BESS to price arbitrages on the wholesale and FCAS markets

References

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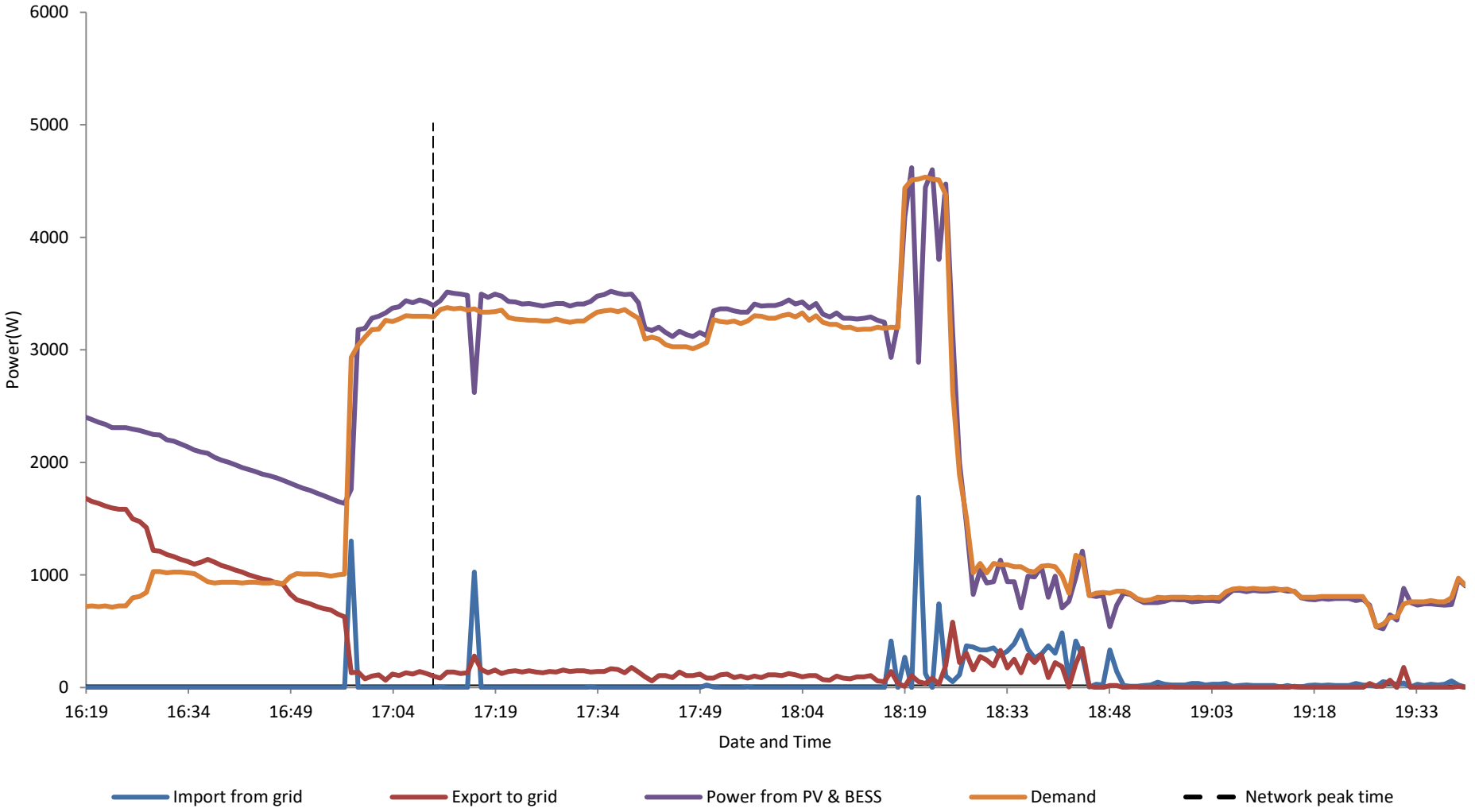
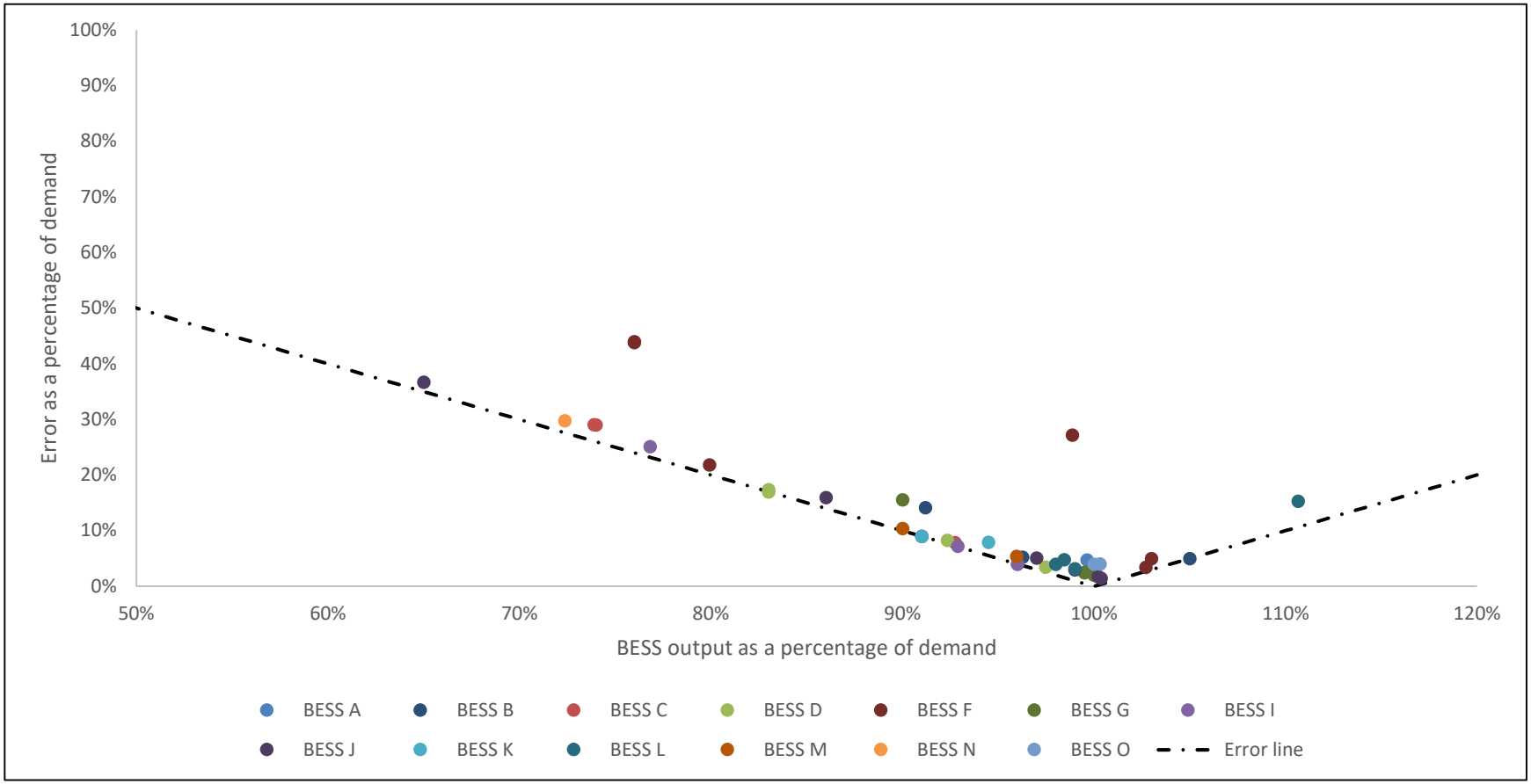
Questions?

Poor load following example

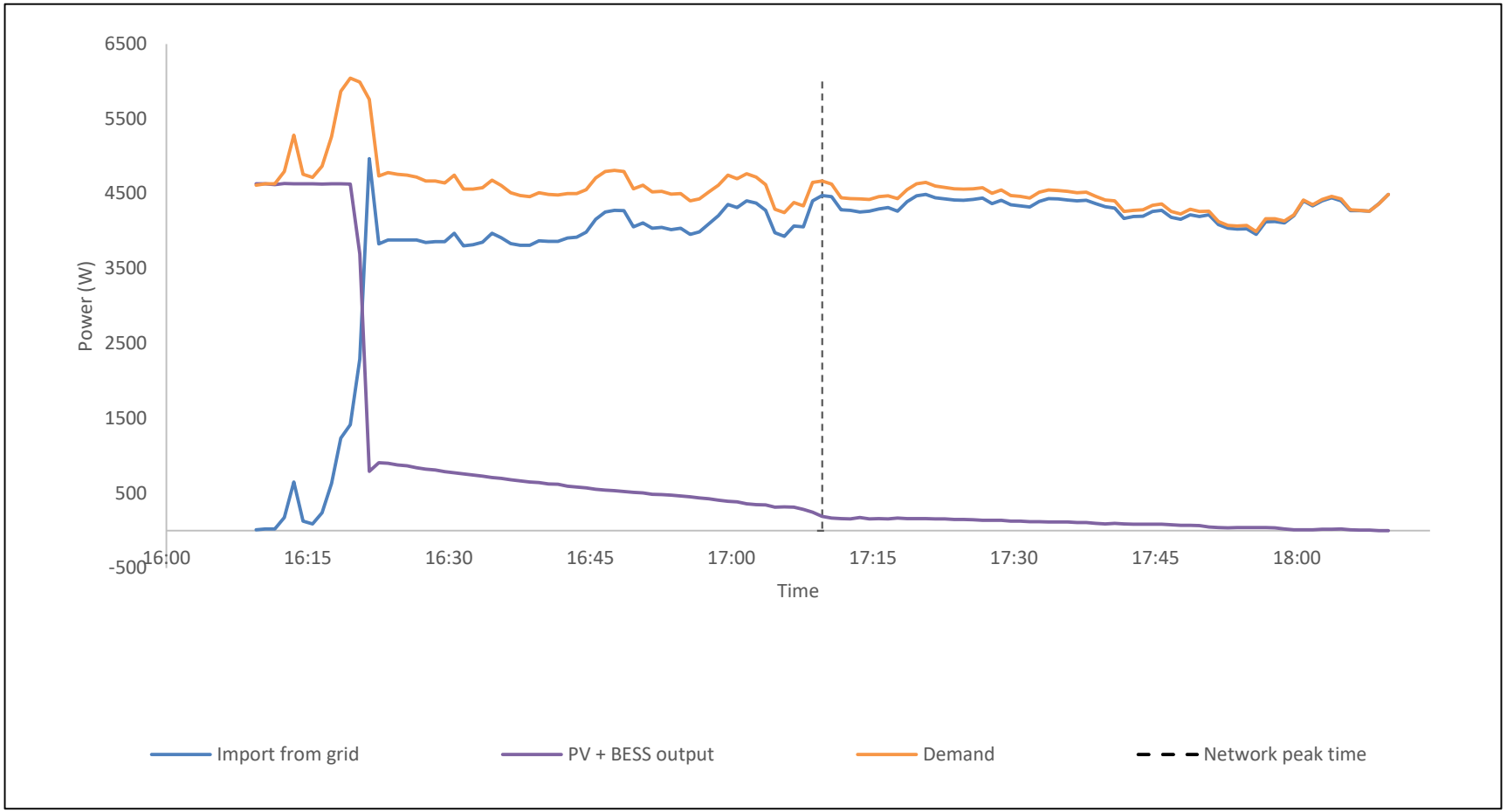


Errors in load-following



Summary of the load-following performance of the BESS in the analysed time period for network peaks and zone substation peaks, only BESS F and BESS J were load-following and reducing demand during all 6 peak events, the load-following accuracy of BESS were not consistent across the demand peaks

Example of BESS depleted before demand peak



Another unorthodox behaviour example