

## Abstract

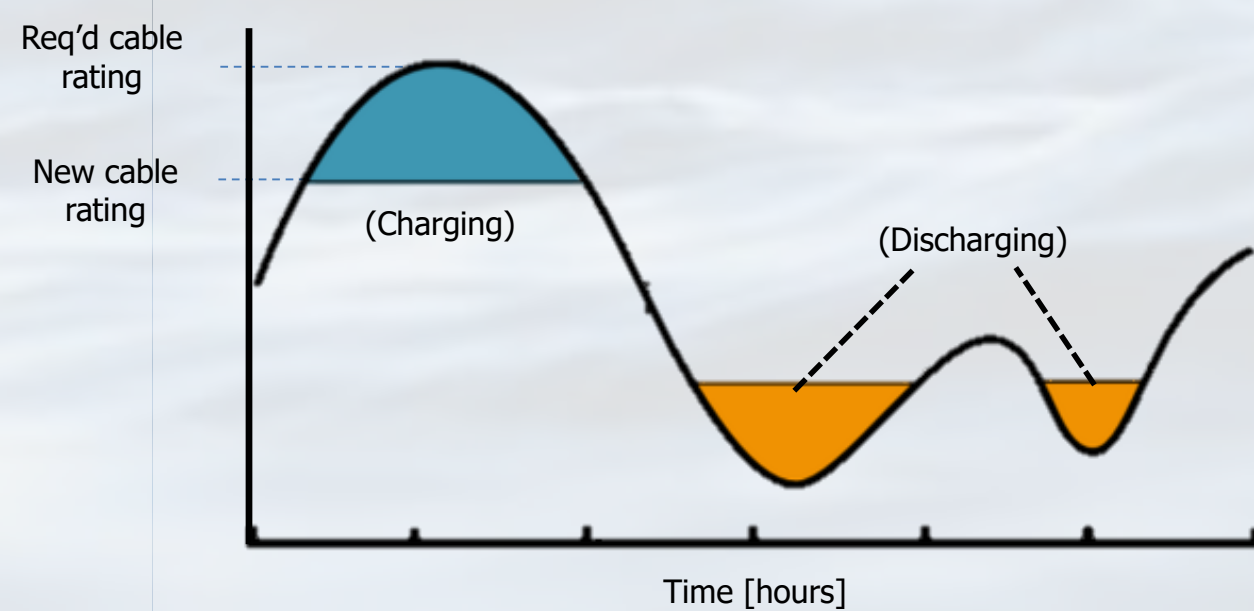
Offshore collector networks contribute a significant cost to the capital expenditure (CAPEX) of an offshore wind farm (2-8%)<sup>1</sup>. This project investigates the benefits of adopting energy storage systems (ESS) within the wind farm as an additional variable in the cable layout optimisation design phase. Utilising the ESS for 'peak shaving', improved cable layouts can be found using lower-rated cables, reducing the CAPEX of the electrical infrastructure.

Electrical losses, physical obstructions and branching penalties are included. Additionally, given the discrete cable types available, sizing of the ESS is optimised to achieve the desired de-rating of the cable at minimal lifetime cost.

<sup>1</sup> - González, J. S., Payán, M. B., Santos, J. M. R., & González-Longatt, F. (2014). A review and recent developments in the optimal wind-turbine micro-siting problem. Renewable and Sustainable Energy Reviews, 30, 133-144.

## Energy Storage

- Introducing energy storage allows the output power of a turbine to be improved through 'peak shaving'

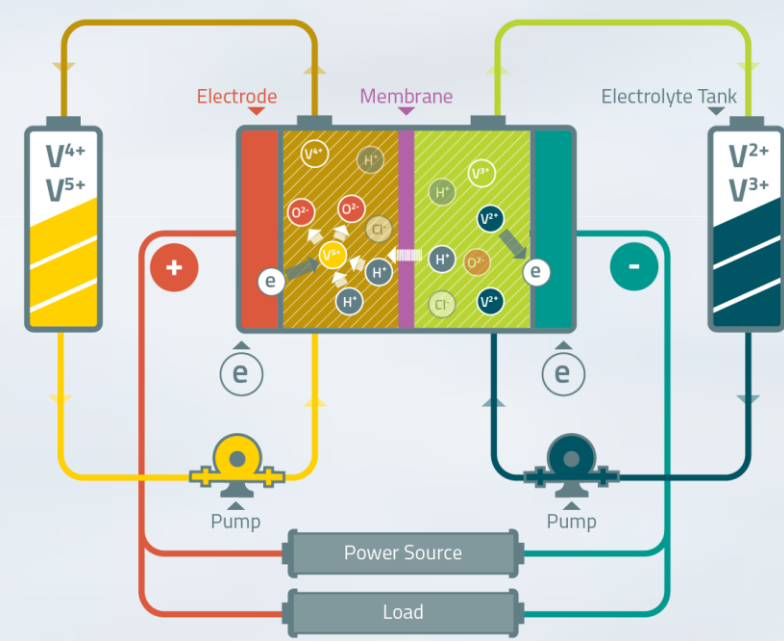


- A reduced peak power output lowers the power rating required of array cables – reducing CAPEX
- This can be included in a cable routing optimisation process



### Energy Storage System (ESS) Types

- Huge variety of ESS types and benefits/limitations
- ESS's with decoupled energy and power capacity may be able to provide more services (e.g. generator torque provision)



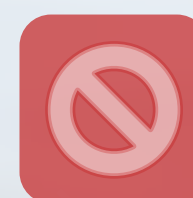
Vanadium Redox Flow Batteries have a decoupled power and energy capacity

## Cable Optimisation – How is it Done?

$$\sum c_{i,j}^t$$

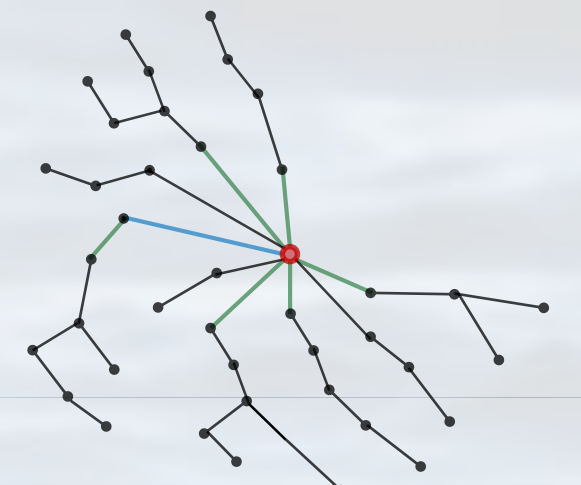
### Current optimisation process

- Minimise the total lifetime cost of the electrical infrastructure
- Considerations include: cable losses, branching penalties and physical obstructions



### Problems with this approach

- Cables are still required to handle turbine rated power
- Resulting optimal CAPEX is still very high



Example cable layout showing different cable types for supporting a higher power transfer

What is the potential economic impact of using energy storage at offshore wind farm level to reduce the cable rating and mechanical fatigue in the offshore wind turbines?

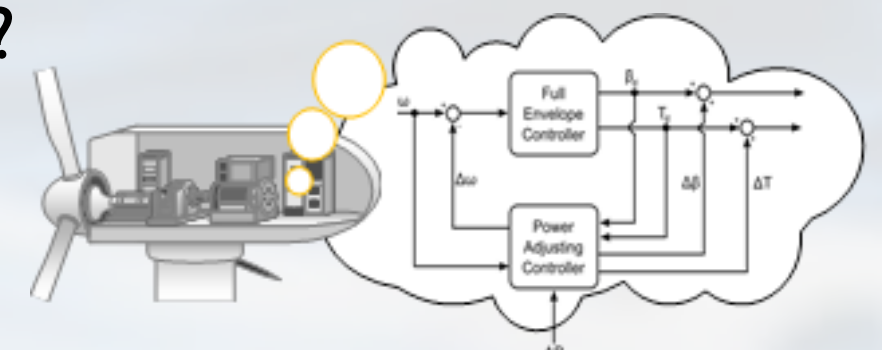
How can energy storage and wind turbine assets be controlled effectively to maximise benefits in terms of electrical collector cost and wind farm performance?

## Future Work



### Mechanical fatigue load reduction

- Use energy storage capacity to extend range of generator torque provision/alleviation
- Reduce transient turbine speeding
- Possible OPEX reduction?



### Holistic Control

- Development of holistic controller to manipulate power output of individual turbines
- Extend range of power adjustment from turbines

## Electrical Infrastructure Research Hub

This project is part of a collaboration between the Offshore Renewable Energy Catapult and the Universities of Strathclyde and Manchester.

**CATAPULT**  
Offshore Renewable Energy