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1st MISSION ARENA
14-16 November 2023 | Gothenburg, SE

WIND and WAVE energy combined – EU-SCORES

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THEME: **MULTI-USE TECHNOLOGY ROADSHOW**

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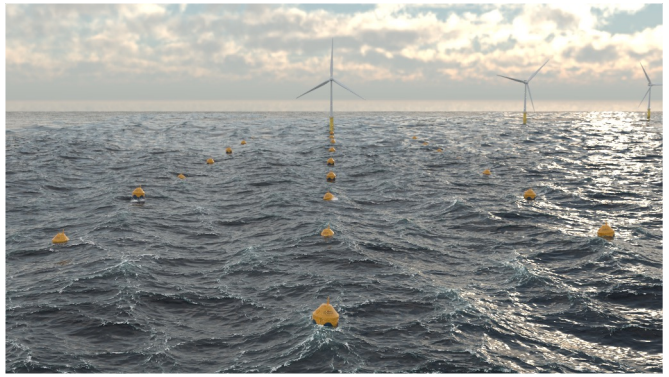
Content

- EU-SCORES project
- Correlation and complementarity
- Need for energy storage as a measure of variability
- Grid value of hybrid power plant (wave-wind-solar)
- Conclusions

EU-SCORES project

- Large offshore wind park installations
- Efficient marine spatial planning
- Reliable and low-cost energy systems



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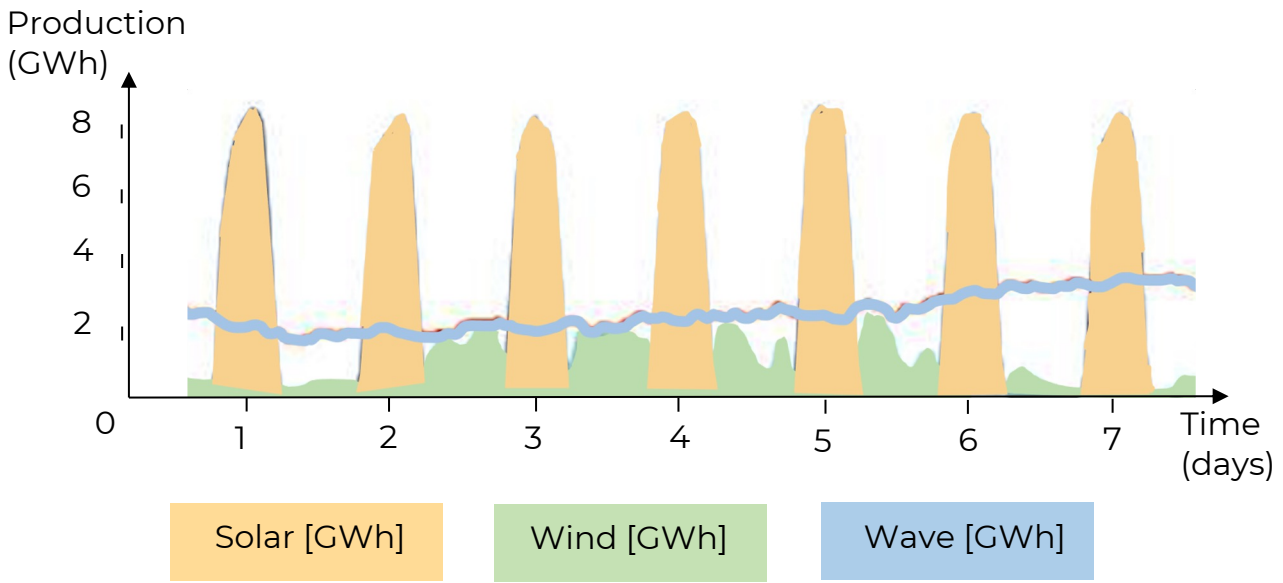
EU-SCORES project

- Reliable and low-cost energy systems



Grid balancing

Lowest cost zero-carbon system

Increased revenues

Continuous electricity sales

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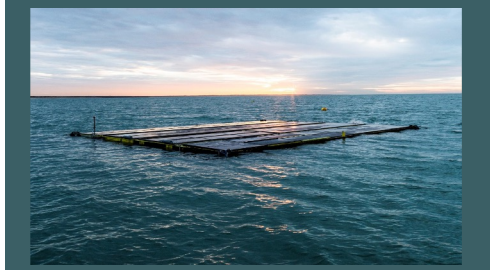
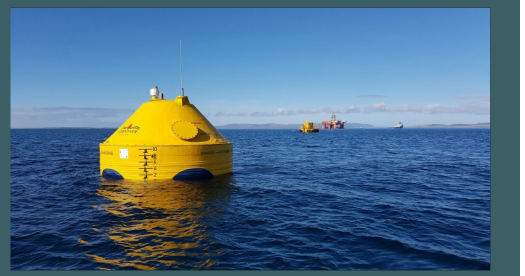
EU-SCORES project

- Two demonstrations:
  - Offshore floating PV park (Oceans of Energy) in Belgium
  - Wave power park (CorPower) in Portugal
- Large-scale park design: mooring, O&M, electrical infrastructure, etc.

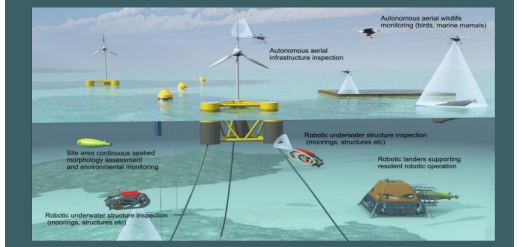
Offshore solar PV



Wave power park



Large-scale park design



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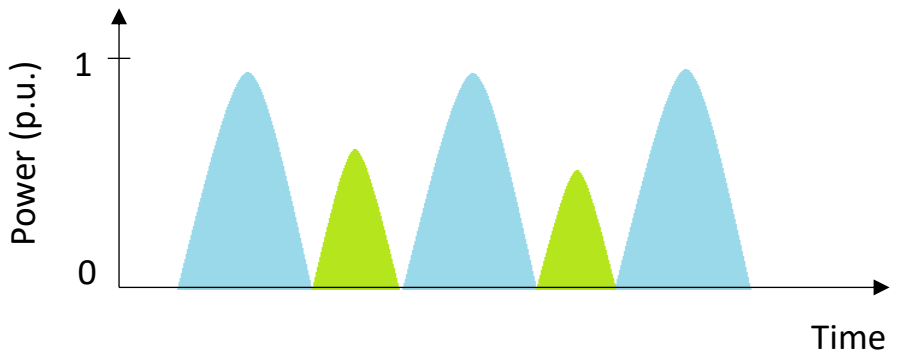
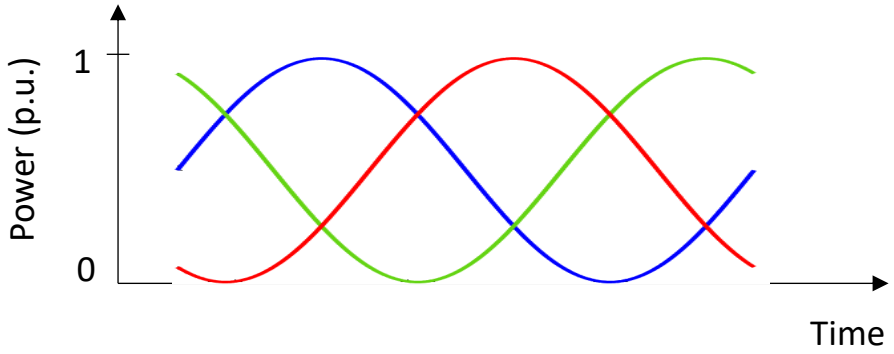
Hybrid power parks

- Hydrid power park planning: capacity, resources, complementarity
- How to assess complementarity?
  - Correlation coefficient for 2 sources: $r_{xy} = -1$
  - Similar concept for 3 and more resources





E Jonasson, J Jurasz, FA Canales, I Temiz, (2023). Energy 269, 126762

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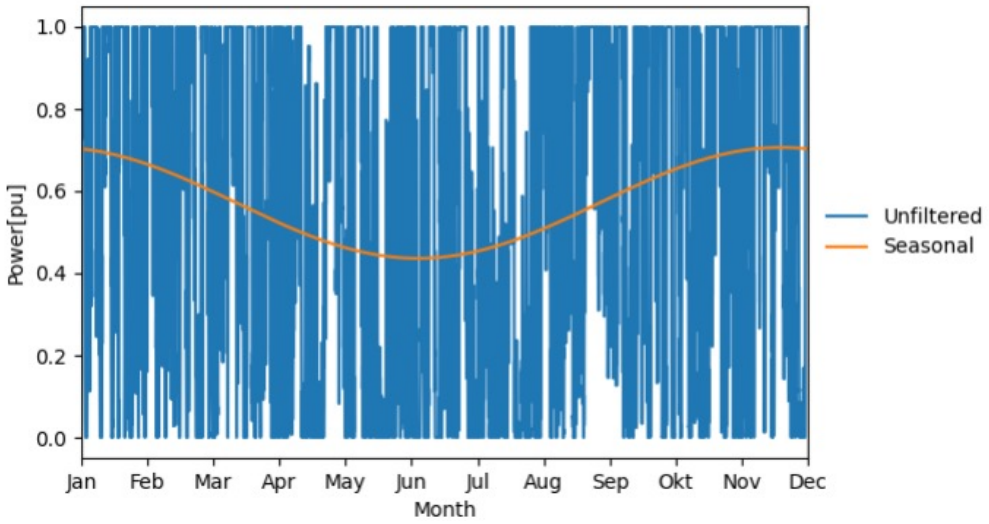
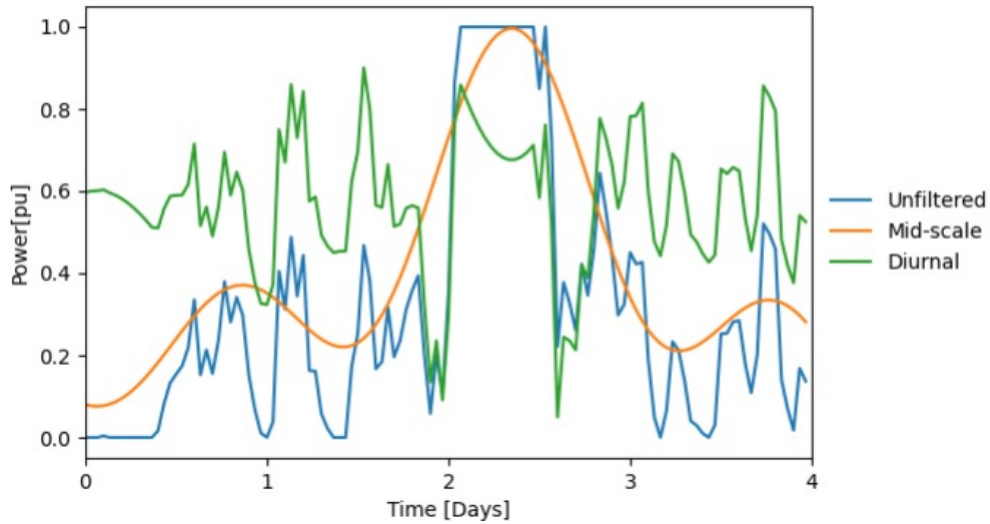
Need for energy storage

- Power smoothing and continuous power supply
- Variability at different time scales: seasonal, middle, diurnal





An example of one sample year (2004) of wind turbine power production detrended to show seasonal and unfiltered power profiles (left) and mid-term and diurnal profiles (right).

Jonasson, E., Lindberg, O., Lingfors, D., & Temiz, I. (2023). at the 7th Hybrid Power Plants & Systems Workshop, Faroe Islands, 23-24 May.

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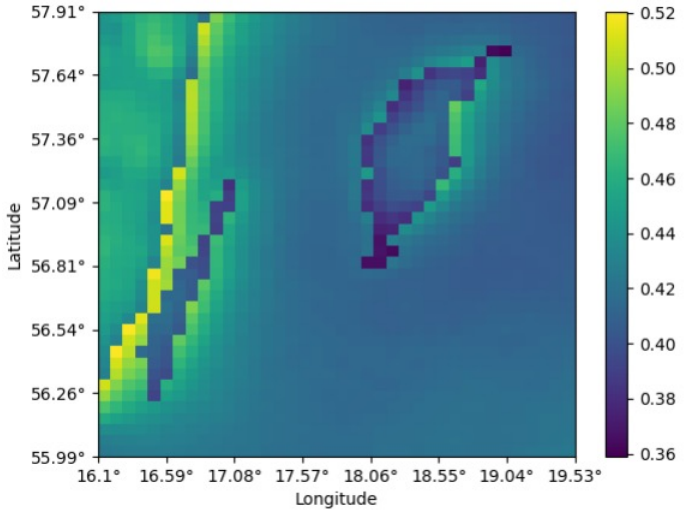
Need for energy storage (NFES)

- The metric **NFES** represents the **fraction** of the generated energy that needs to be **stored** and **discharged** from energy storage in order to deliver **constant output power**.

Case study: Gotland



Share of wind power in the hybrid power plant (wind + PV).

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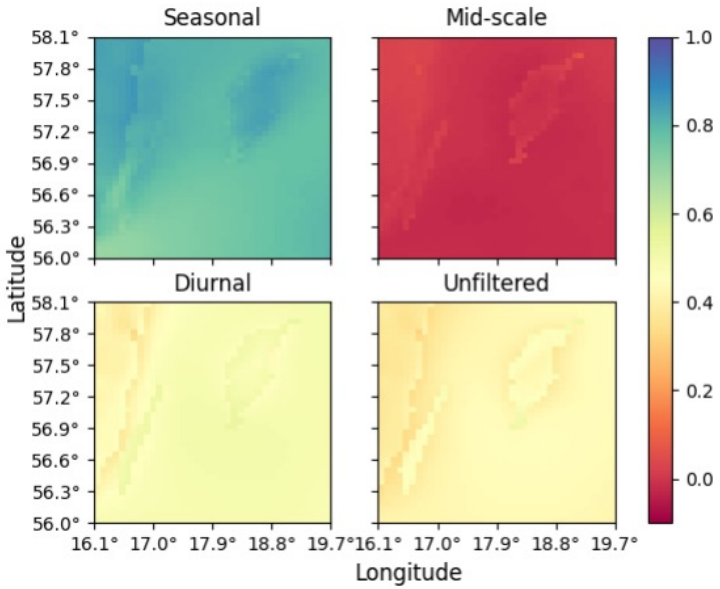
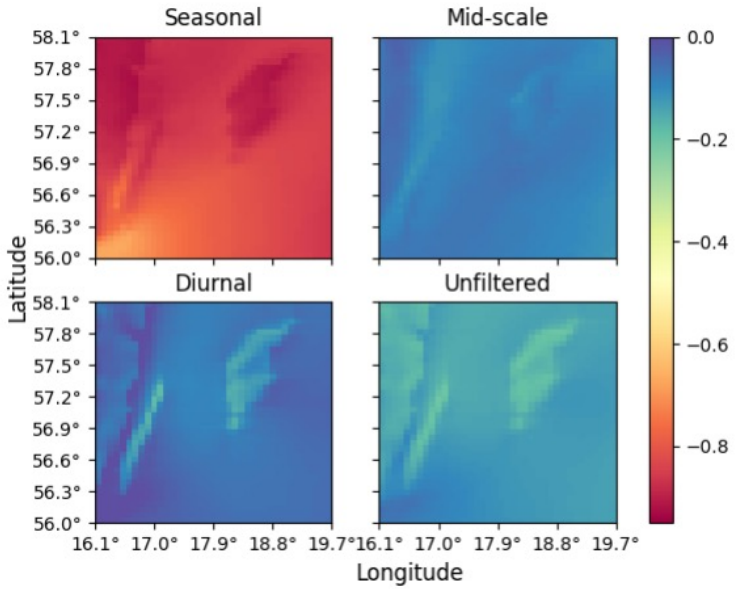
Need for energy storage

- The correlation coefficient does not fully represent the variability of a source.



Decrease of metric NFES in the hybrid power parks.



Correlation coefficient of filtered profiles.

Jonasson, E., Lindberg, O., Lingfors, D., & Temiz, I. (2023). at the 7th Hybrid Power Plants & Systems Workshop, Faroe Islands, 23-24 May.

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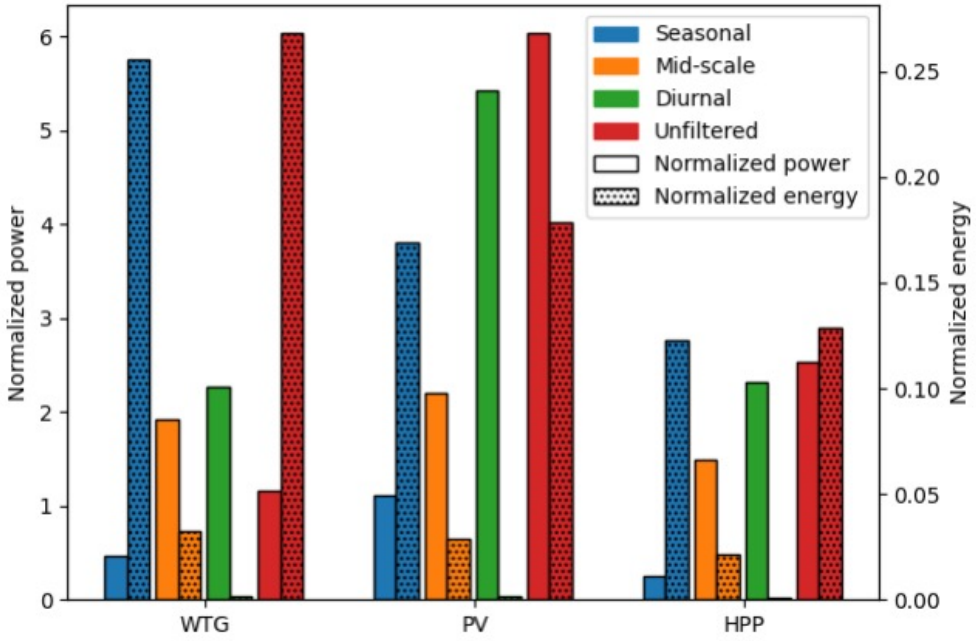
Need for energy storage

- Different energy storage systems to compensate for variability at different time scales.
- Detrending prior to optimization could help for bidding strategies in the intra-day and day-ahead financial markets.



Normalized power and energy ratings of energy storage.

Jonasson, E., Lindberg, O., Lingfors, D., & Temiz, I. (2023). at the 7th Hybrid Power Plants & Systems Workshop, Faroe Islands, 23-24 May.

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Grid-value of co-location

- Frequency regulation, flexible demand, local energy communities, energy storage, etc.
- Co-location in hybrid power parks
- Composition derived from economics and/or reliability

Jonasson, E., & Temiz, I. (2023). at the 15th European Wave and Tidal Energy Conference, Bilbao, 3-7 September.

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What is the grid value?

Several approaches in the literature:

- the provision of defined grid services, avoided system costs, measurable contributions to desired grid qualities such as low carbon intensity
- anti-correlation of generation profiles
- integrated renewable energy portfolios to improve system reliability and resilience

Jonasson, E., & Temiz, I. (2023). at the 15th European Wave and Tidal Energy Conference, Bilbao, 3-7 September.

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Grid-value of co-location

- The added value derived from the ability to deliver a reliable, stable supply of energy and the efficient usage of the electrical transmission system.

Jonasson, E., & Temiz, I. (2023). at the 15th European Wave and Tidal Energy Conference, Bilbao, 3-7 September.

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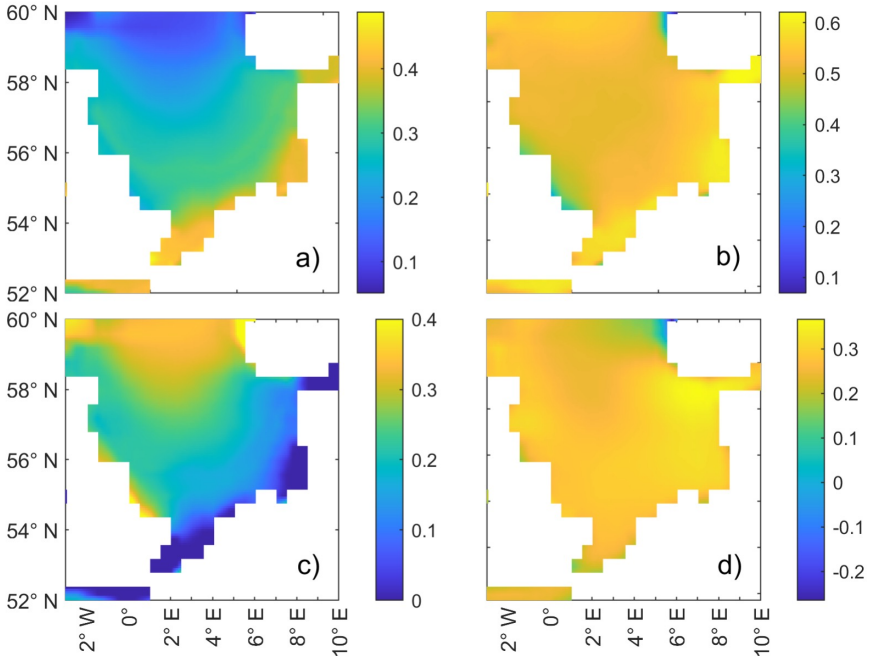
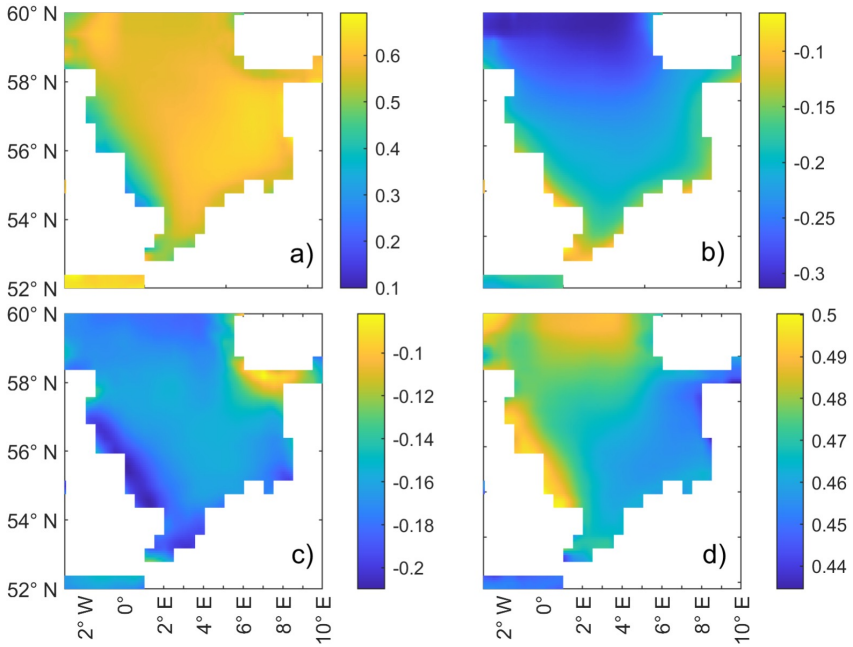
Grid-value of co-location



Weight of (a) wind, (b) OFPV, (c) wave power, and (d) decrease of NFES.



Correlation of (a) wave-wind, (b) wave-solar, (c) wind-solar, and (d) complementarity wave-wind-solar.

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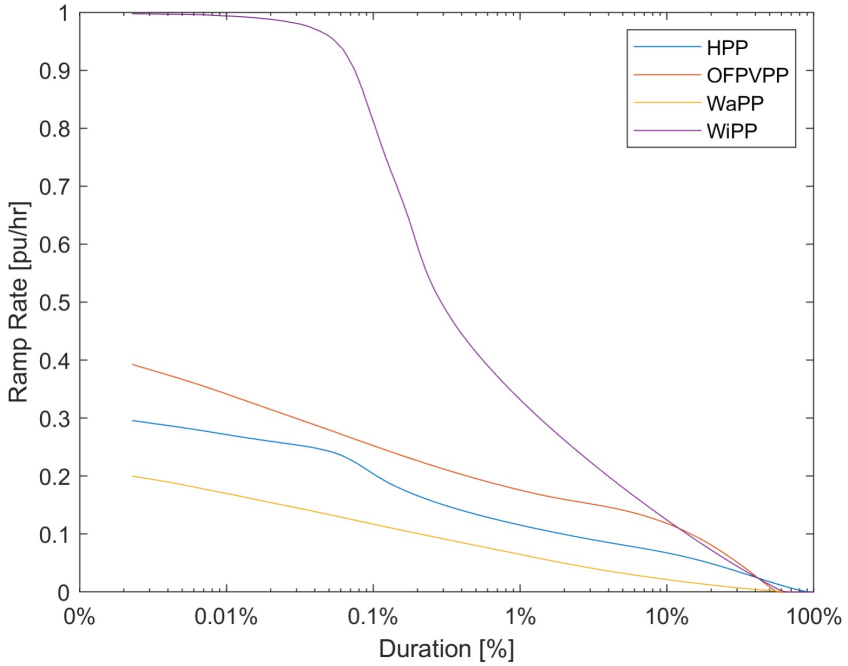
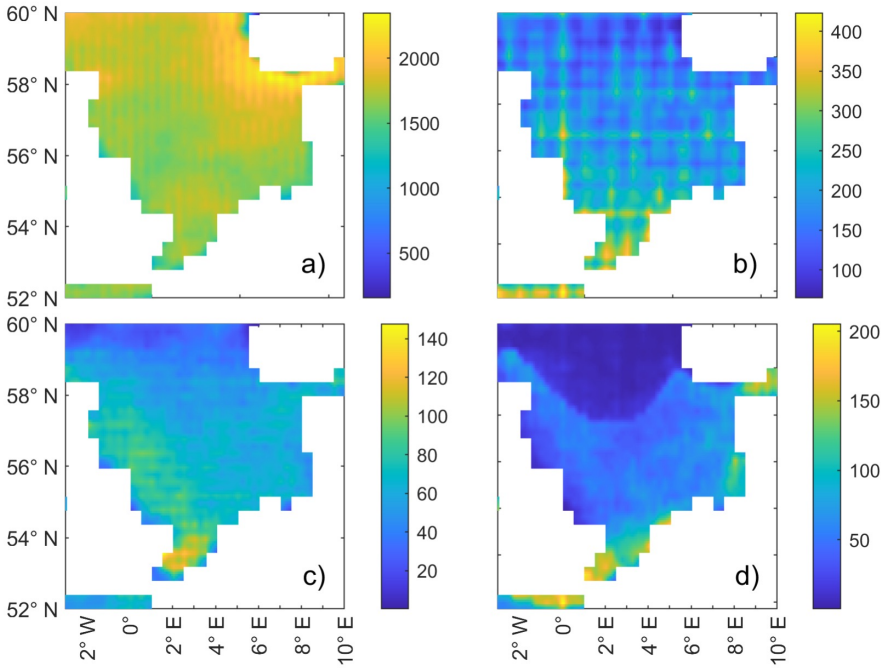
Grid-value of co-location



Ramp rates duration.



Occurrences of ramp rates exceeding 0.2 pu/hr for a) WiPP, b) OFPVPP, c) WaPP and d) hybrid power plant.

Jonasson, E., & Temiz, I. (2023). at the 15th European Wave and Tidal Energy Conference, Bilbao, 3-7 September.

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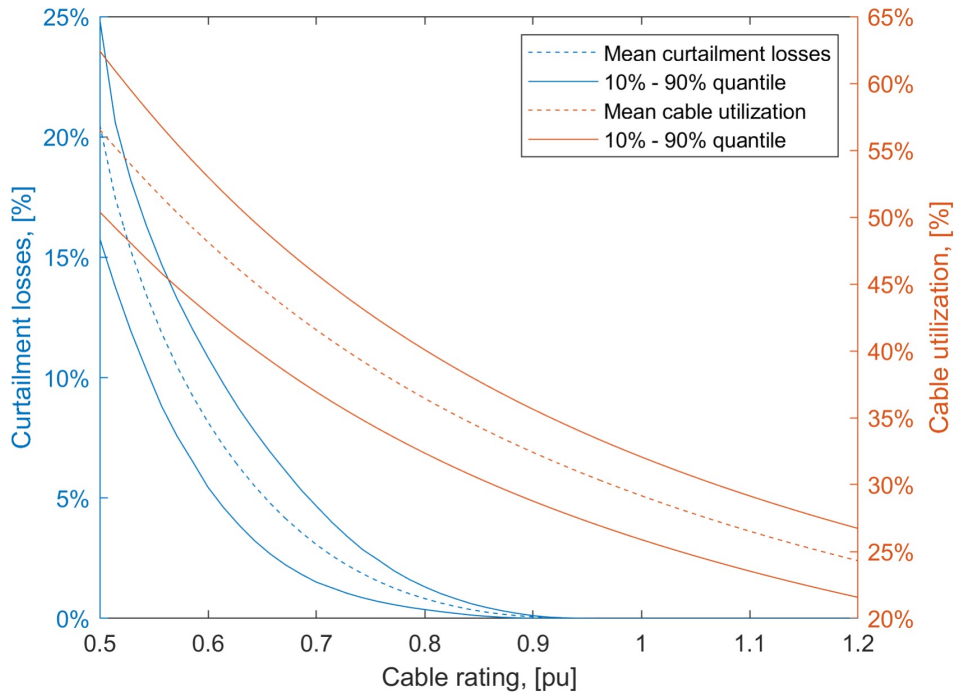
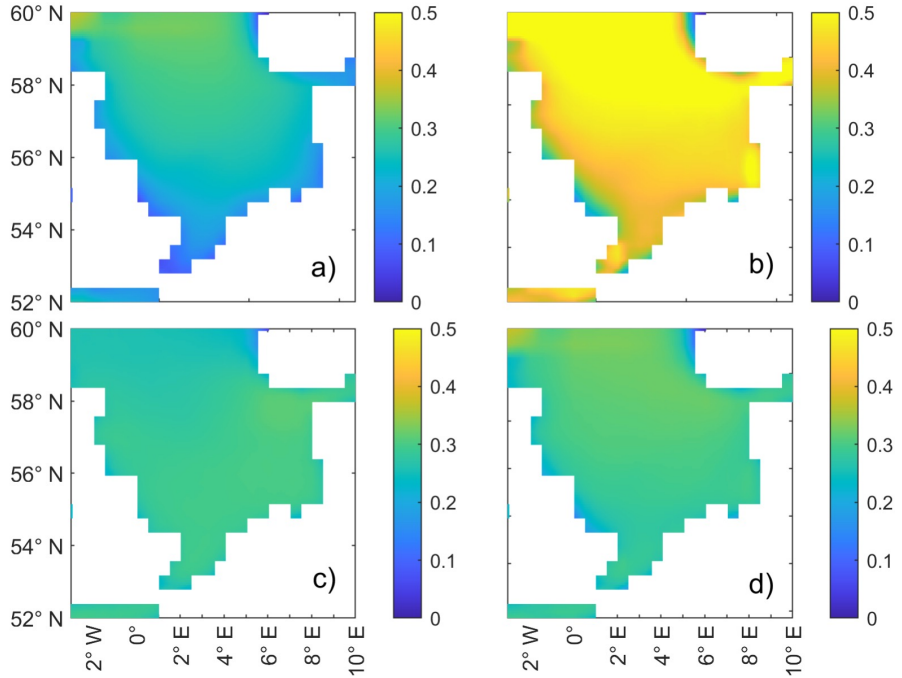
Grid-value of co-location



Curtailment losses and cable utilization with varying cable rating for hybrid power plant.



The capacity factor of combined a) wave-OFPV, b) wave-wind, c) wind-OFPV and d) wave-wind-OFPV.

Jonasson, E., & Temiz, I. (2023). at the 15th European Wave and Tidal Energy Conference, Bilbao, 3-7 September.

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Conclusions

- Variability of renewable energy sources
- Grid balance: production=demand
- Energy storage optimization
- Co-location (hybridization) may help reduce variability, ramp rates, increase transmission cable utilization

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