Exploring alternative power solutions in Offgrid-Offshore fish farms under long term uncertainty

Dejene A Hagos
Juli 2, 2020
OUTLINE

• GIFT Project

• TIMES-HINNØYA

• Offgrid-Offshore Fish Farms Use Case

• Application of TIMES-HINNØYA for Offgrid-Offshore Fish Farms decarbonisation
GIFT Project

- Flexibility & VREs integration are at the core of the project
- Short-term & long-term energy system decarbonisation of European Islands
- Hinnøya (Norway) & Procedia (Italy) Island as lighthouses

Figure: Geographical location of Hinnøya and Grytøya

Source: GIFT Deliverable 3.9
TIMES-HINNØYA (1)

- 3 REGIONS
  NO4-IMP/EXP

- 12 SEASONAL
  2 WEEKLY
  24 DAYNITE

- Evolving between 2015 and 2050

Figure: Geographical location of Hinnøya and Grytøya

Source: GIFT Deliverable 3.9
TIMES-HINNØYA (2)

- Residential
- Primary Sector (agriculture and forestry, fishing, and fish farming)
- Secondary Sector (industry and mining)
- Tertiary (Service)
- Transport

Exogenous Fuel & Electricity Demand

Diurnal Electricity Demand Profile

Vehicle Class/Vehicle size/Trip distance/traffic volume/Fuel economy
ETTs’ charging/filling infrastructure utilisation development - ‘S’ curve

#fleets/filling station – could be model input or output
Fish farms use case (1)

- Nearly 50% of offshore fish farms are off grid
- Fish farms are prolific near coastline
- Electricity used for feeding and appliances on the barge
- Run on standalone diesel Genset

Source: Bellona & ABB AS
Fish farms use case (2)

• Peak power demand mainly for feeding purpose

• Fish farms’ peak power demand in phase with grid peak demand periods

• Demand is too low on the island to upgrade the grid and the local grid is too weak to support additional load during peak demand periods
Modelled alternative power solutions

- Discrete small size wind turbines 50 kW, 100 kW & 150 kW

- Demand represents 3-4 clustered fish farms around the coast of the Island as energy community

- Modular Li-ion storage battery on the feed barge

- Model solutions are assumed to be upscalable due to limited alternative solutions
Long term uncertainty & scenarios

- Access to strong grid and storage system cost as long-term uncertain parameters
- Equal event occurrence
- Access to strong grid translated in to zero cumulative installed capacity in storage

- 6 stochastic & 6 equivalent deterministic scenarios

<table>
<thead>
<tr>
<th>Year</th>
<th>Low (€2018/kWh)</th>
<th>Medium (€2018/kWh)</th>
<th>High (€2018/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2025</td>
<td>704</td>
<td>896</td>
<td>1463</td>
</tr>
<tr>
<td>2030</td>
<td>528</td>
<td>672</td>
<td>1097</td>
</tr>
<tr>
<td>2035</td>
<td>431</td>
<td>548</td>
<td>894</td>
</tr>
<tr>
<td>2040</td>
<td>333</td>
<td>424</td>
<td>691</td>
</tr>
<tr>
<td>2045</td>
<td>275</td>
<td>352</td>
<td>570</td>
</tr>
<tr>
<td>2050</td>
<td>217</td>
<td>280</td>
<td>449</td>
</tr>
</tbody>
</table>
Results (1)

- High disparity between wind power availability and diurnal load profile
- On average 11-18% of wind energy is curtailed
- Wind energy curtailment increased further when access to strong grid is realised from 2030
- No wrong investment decision in hedging stage. Expected value of perfect information (EVPI) is zero.
Results (2)

- Grid integrated storage from 2045

- Storage contributes 55% of total grid electricity supply

- Direct grid supply capped to 25% during peak load hours

- No new investment in wind after 2040
Results (3)

- More than 83% CO₂ emissions reduction is achieved by 2030 compared to 2015 level.

- Assumed low battery cost is not low enough to investment as early as before 2025.

- Wind turbine investment during hedging stage shows that the operational costs of diesel Genset is very high.
Conclusions

• On the basis of the assumptions, hybrid diesel & wind is a least cost and robust solution that appeared in all scenarios

• In the absence of strong grid, grid integrated storage would not be a least-cost solution until after 2045

• In the presence of strong grid, the merit order showed that grid electricity is a least cost solution as early as its availability

• It should be noted that significant change in assumed costs as well as the assumed load profiles will have a significant impact on the results.
Thank you!