Carbon Footprint Analysis of Floating PV systems

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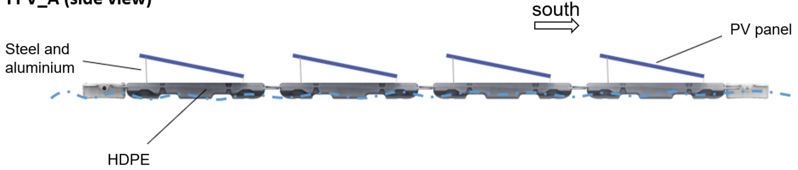
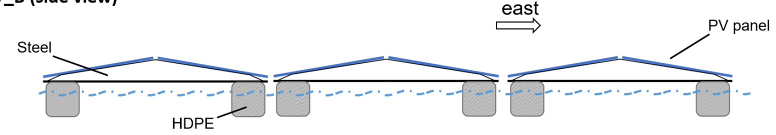
Methods

- Goal and Scope
  - Assess life cycle carbon footprint of two different floating PV (FPV) systems on small inland water bodies in Western Europe with very low wave height.
  - Lifetime, performance ratio and degradation rate of PV modules in floating PV systems are assumed to be identical as in ground-mounted PV systems, since empirical data is not available.
- Technology and its modelling
  - 2 operational floating PV systems are assessed,
    FPV_A: framing structure made predominantly of HDPE
    FPV_B: steel/HDPE
  - Foreground data on floating support structure from suppliers
  - Background data on PV modules, electrical installation from UVEK DQRv2:2022 and other sources

FPV_A (side view)



FPV_B (side view)



- Yield simulation for Cologne (Germany) - GHI: 1062 kWh/(m^2yr)
  - Bifaciality factor: 0, albedo: 0, degradation rate: 0.7%/year, performance ratio (PR): 0.80, lifetime: 30 year

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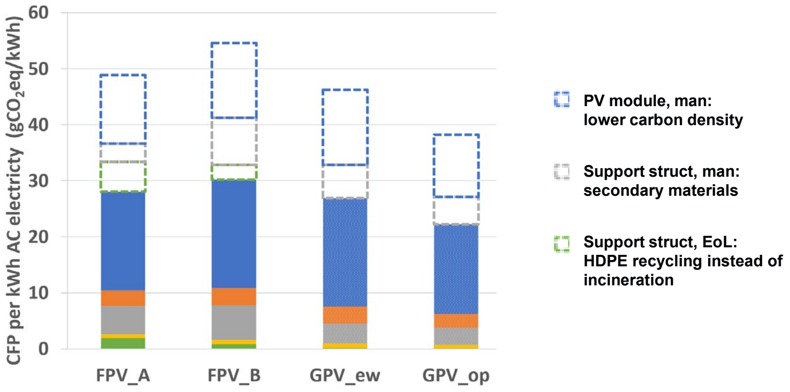
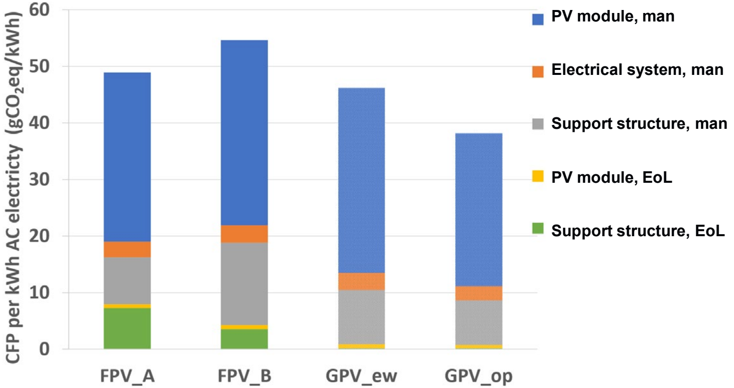
Results

Component	Unit	FPV_A	FPV_B	GPV_ew[1]	GPV_op[1]
Main material of support structure	-	HDPE	Steel, HDPE	Steel, aluminium	Steel, aluminium
Orientation	°	180	90+270	90+270	180
Tilt angle	°	11	12	12	38
Ground coverage ratio (GCR)	%	60	87	87	60
Power density	[kWp/ha]	1.23	1.78	1.78	1.23
Location	-	Cologne (DE)	Cologne (DE)	Cologne (DE)	Cologne (DE)
Specific energy yield	kWhac/ (kWp yr)	889	795	962	962
Rated power	kWp	1'479	29'770	n.a.[2]	n.a. [2]

1. ew: east-west orientation and low tilt; op: optimum orientation and optimum tilt.
2. This is a reference system from a background database. Rated power is not available.



Graph below:
Carbon footprint per kWh_{AC} of floating PV systems A and B, and ground-mounted reference systems



Graph above:
Three major ways to decrease carbon footprint

- sourcing of PV modules: lower grid carbon intensity (e.g., Europe instead of China)
- sourcing of materials for support structure: secondary materials
- end-of-life treatment of support structure: HDPE recycling instead of incineration

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Main messages

- The estimated carbon footprint of the two example floating PV installations is ~50 g CO_2eq/kWh$_{AC}$, which is comparable to that for ground-mounted PV in the same location
  - This is a factor 7 lower than that of the grid mix both in Germany and in the Netherlands in 2018 (~380 gCO_2eq/kWh$_{AC}$), and 3-4 times lower than the EU grid mix target for 2030 (176 gCO_2eq/kWh$_{AC}$).
- The carbon footprint can be further reduced by over 40% with three measures:
  - Manufacturing PV modules with lower carbon electricity sources. Here we compared manufacturing in the EU instead of China (country-average) (~25%)
  - using recycled raw (secondary) materials for the support structure (~7-15%)
  - recycling the HDPE at end of life instead of incinerating it (~5-11%)
- Lifetime, performance ratio and degradation rate of the PV modules in FPV systems are the main unknowns that will determine the system performance.
- Key degradation patterns of PV modules in FPV systems should be identified, as well as the long-term benefits, if any, of dedicated PV modules for FPV systems (e.g., lower degradation rate).

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