Electrolytic hydrogen production from tidal energy:

A technical and economic perspective

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OBJECTIVES

➢ The study addresses both the technical and economic aspects of coupling a tidal energy plant with a local electrical grid for hydrogen production.

➢ The possible hydrogen production cost variation based on different tidal profiles and hydrogen production target is analysed.
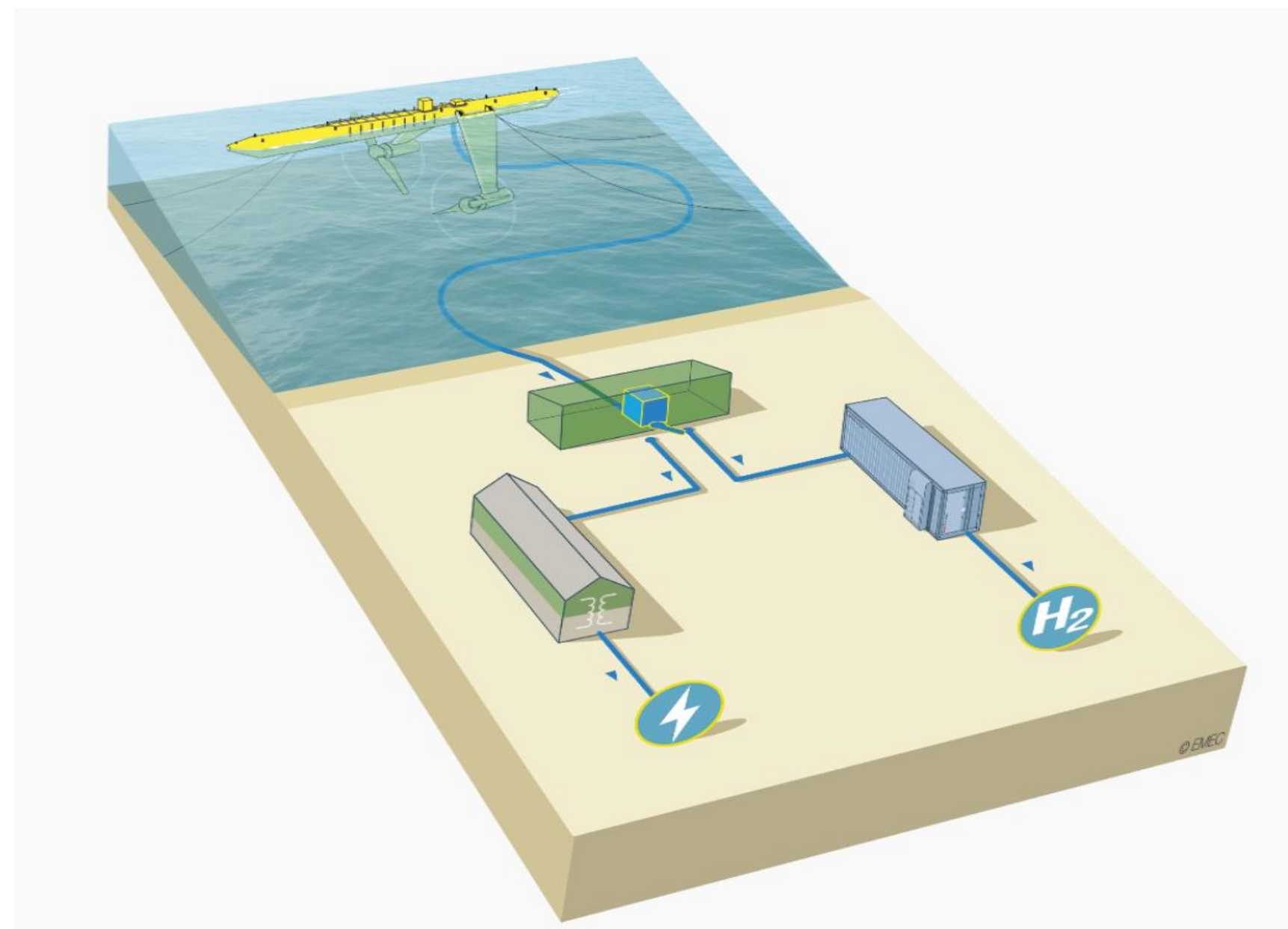

FIG 1: GRAPHICAL REPRESENTATION OF THE PROPOSED SYSTEM.
Picture courtesy – European Marine Energy Centre
(www.nweurope.eu/ITEG)

HIGHLIGHTS

➢ Annual tidal current data are treated to deduce reference daily profiles, representing for each season the highest, the average, and the lowest cases, respectively.

➢ The corresponding hydrogen production is evaluated for both tidal plant alone and tidal-grid-connected configurations.

APPLICATIONS

➢ The model can be used as a generic tool for both: system optimization, and hydrogen production and associated costs estimation.

➢ Applicable in places with abundant renewable energy sources (RES) and constrained distribution network.
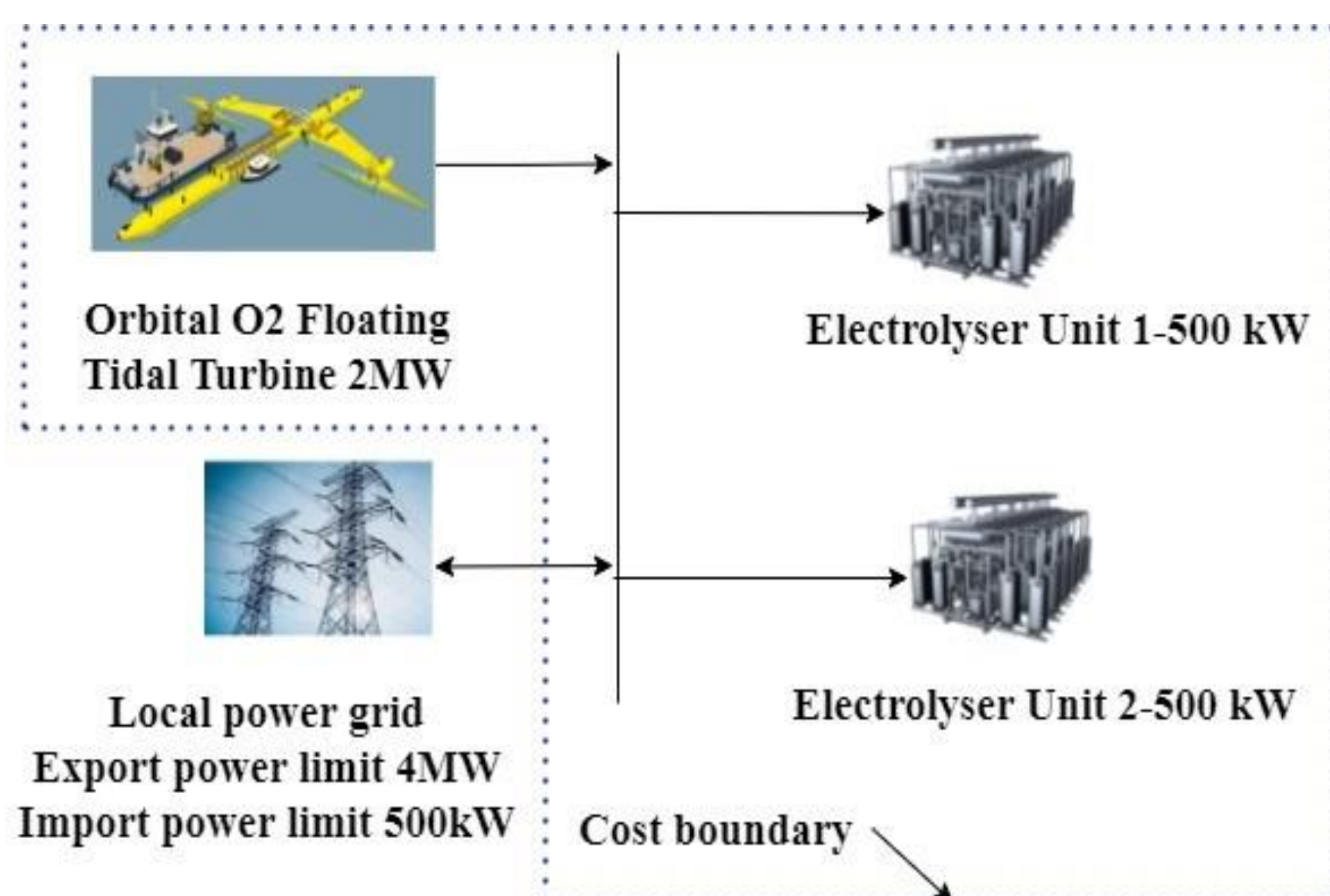
SYSTEM MODELLING

FIG 2: GENERAL SYSTEM CONFIGURATION

Each system component is considered as a single-scalable sub-model.
Power flows and sub-models interactions are considered.
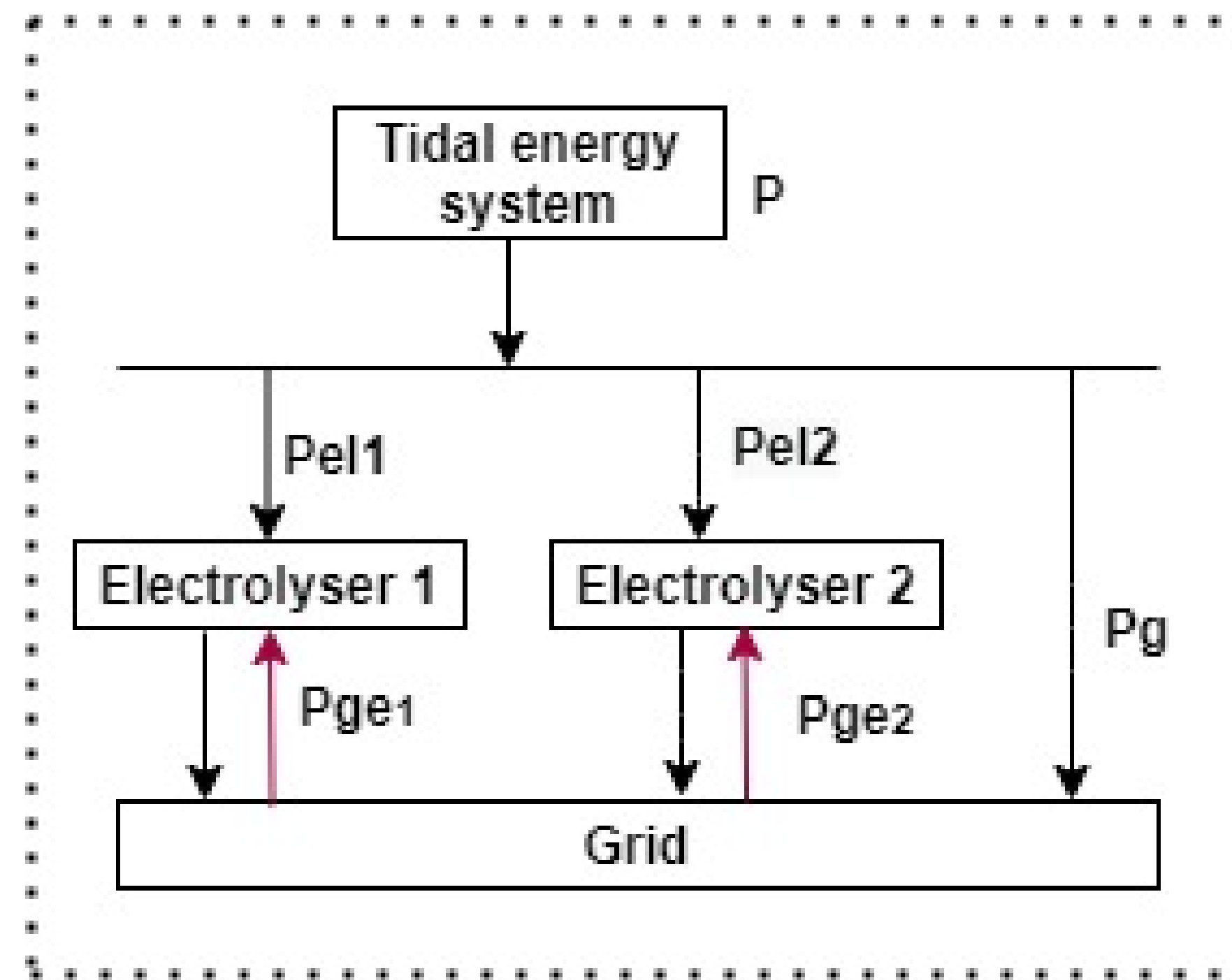Power transmission losses are also accounted.

FIG 3: POWER DISPATCHING ALGORITHM.

COST FUNCTION

The simplified daily system operating revenue (SOR) is estimated using the equation (1)

$$SOR = (-GTEC + HSR \pm GEC) \quad (1)$$

where,
GTEC – Generated tidal energy cost (€)
HSR – Hydrogen selling revenue (€)
GEC – Grid energy cost/ revenue based on import/export (€)

The sensitivity analysis on the hydrogen cost, an individual cost component factor of selling revenue is estimated using equation (1).
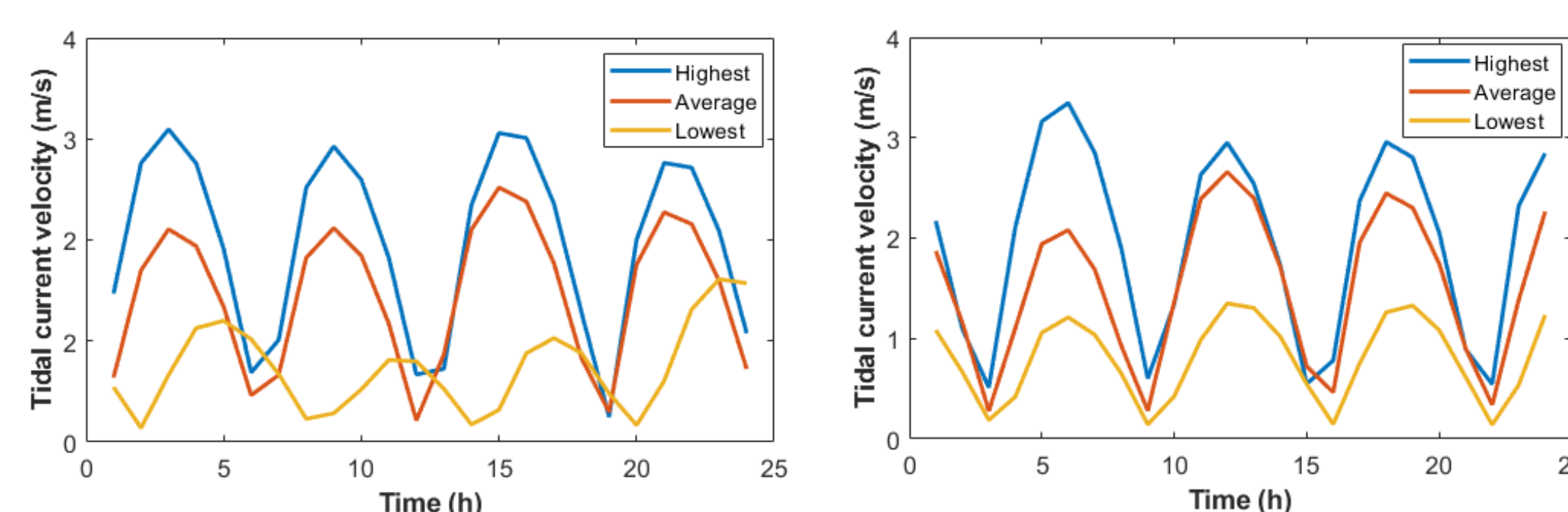
RESULTS

FIG 4: SEASONAL HIGHEST, AVERAGE, AND LOWEST DAILY TIDAL CURRENT VELOCITY PROFILES (WINTER, b. SUMMER).
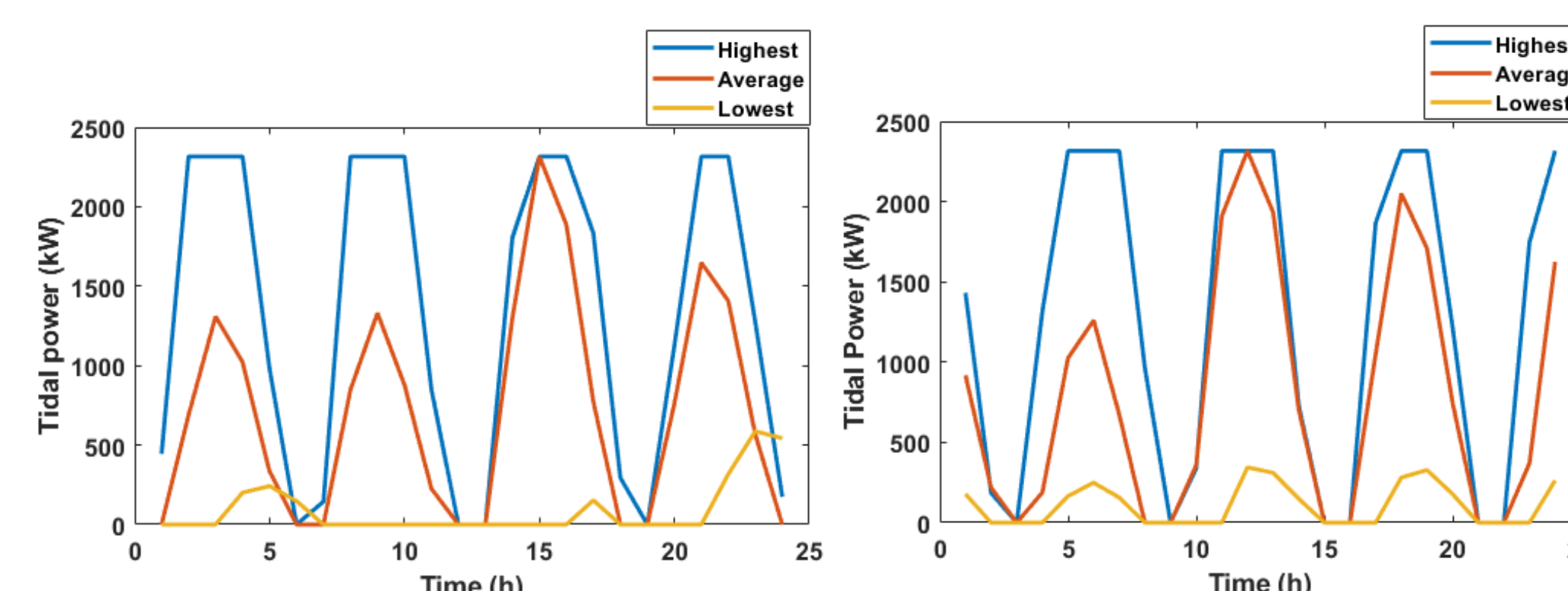

FIG 5: SEASONAL HIGHEST, AVERAGE, AND LOWEST DAILY TIDAL POWER PROFILES (a. WINTER, b. SUMMER).
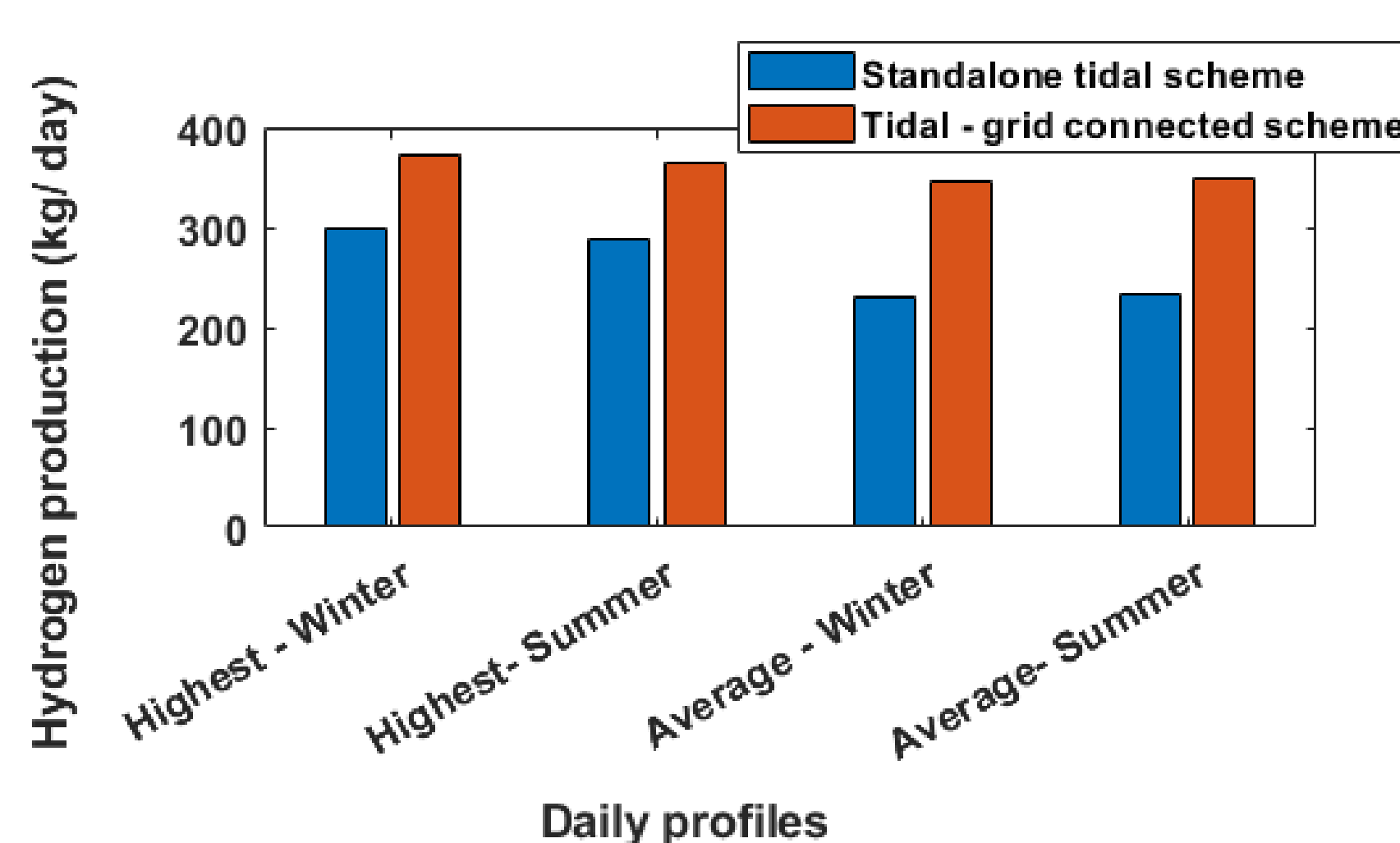

FIG 6: DAILY HYDROGEN PRODUCTION CAPABILITIES AT DIFFERENT SEASONAL DAILY PROFILES
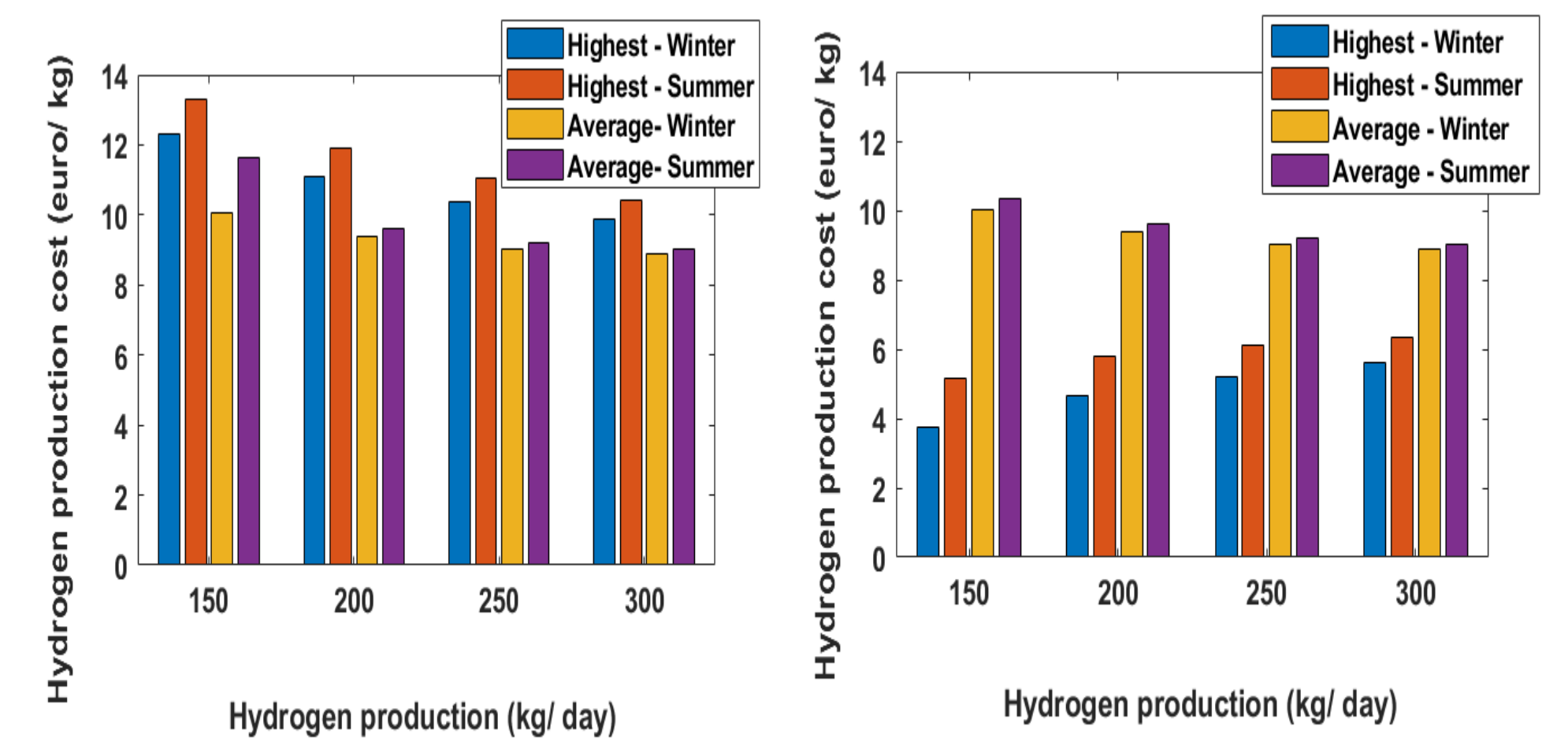

FIG 7: HYDROGEN COSTS FOR DIFFERENT DAILY HYDROGEN TARGETS WITH:
a. FIXED TIDAL ENERGY COST
b. VARIABLE TIDAL ENERGY COST

CONCLUSIONS AND PERSPECTIVES

➢ Hydrogen production capability of 230-300 kg/day in the stand-alone tidal configuration and about 340-370 kg/day considering power import from the grid.

➢ The hydrogen production cost is reduced as production is increased. The hydrogen cost is particularly reduced from 250 kg/day, underlining the advantages given by grid integration in hydrogen production and system optimization.

➢ The presented results are the object of a preliminary study based on an indicative tidal LCOE target value adapted to the given system under different scenarios.

➢ The best results are obtained considering the variable tidal energy cost scenario. In the case of highest conditions, a constant tidal electricity cost value referred to the LCOE (levelized cost of energy) calibrated on the average tidal capacity factor of about 37% can generate an overestimation of the tidal energy costs and hence, the hydrogen cost.

➢ A complete cost analysis including the system capital costs, hydrogen storage and logistics costs, electrolyser degradation costs, and other associated costs is being carried out to effectively assess the system economics.

➢ Benefits of tidal plant scaling-up and integration with other RES and grid-connected configurations will be also analysed.

ACKNOWLEDGEMENTS

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