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Preliminary Techno-economic assessment on small scale Methanol based-Solid Oxide Fuel Cell system for maritime application

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Keywords: methanol, hydrogen carrier, zero-emission vessels, shipping decarbonization.

Abstract: This study aims to analyse an innovative naval propulsion solution to favour the decarbonisation process of maritime transportation sector.

Introduction: *Methanol is a potential alternative fuel for maritime transport; its usage allows having meaningfully reduction in atmospheric SOx, NOx, PM and CO_2 emissions. The interest in using methanol as fuel for maritime sector is rapidly growing.*

Objectives: In this study, a small-scale methanol-based SOFC system for the propulsion of zero-CO2 vessel has been analysed through a techno-economic point of view.

Material and methods: This study is focused on the tecno-economic assessment of a methanol-based SOFC system. The SOFC stack is the ElcoStack E3000 developed by Elcogen (3kW). Figure 1 shows the system layout. The system has been modelled and the numerical results have been used for performing economic evaluations based on the definition of two economic KPIs: the Specific Capital Expenditure (S_{CAPEX}) and the Specific Operating & Maintenance Expenditure ($S_{O\&M}$):

$$KPI_1 = \mathrm{S_{CAPEX}} = \frac{C_{Stack}(€) + C_{BoP}(€)}{Installed\ Power\ (kW)} \left[\frac{€}{kW}\right] \quad (1)$$

$$KPI_2 = \mathrm{S_{O\&M}} = \frac{C_{operating}(\frac{€}{h}) + C_{maintenance}(\frac{€}{h})}{Installed\ Power\ (kW)} \left[\frac{€}{kWh}\right] \quad (2)$$

Table 1 summarizes the investment costs as well as the operating and maintenance costs for the SOFC stack and the BoP of the system.

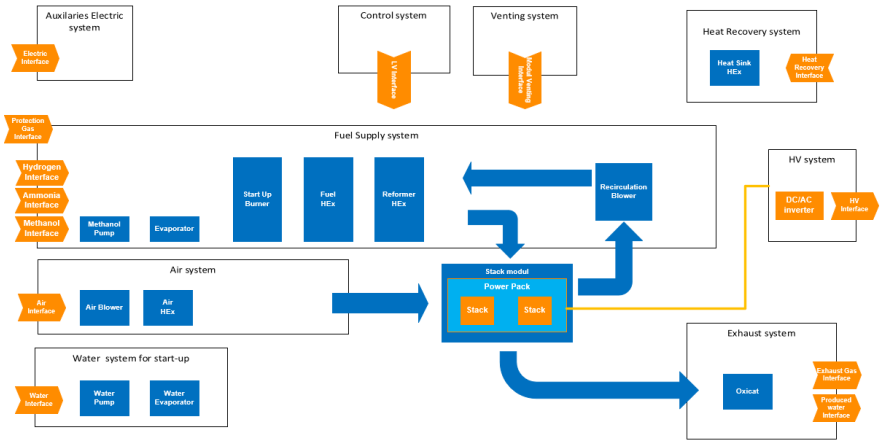

Fig.1. Methanol-based SOFC system schematic layout

Table 1. Cost items for the Methanol-based SOFC system

Components	**Investment Cost**[1]	**Annual Maintenance Cost*** [2]	**Operating Cost** [3]
3 kW SOFC stack module	14,271 €	713.5 €/year	
3 kW SOFC BoP	28,791 €	1,439.5 €/year	
Methanol	-	-	0.5 €/kg (av. value)

* The operating hours for the considered system are assumed equal to 8000 h/year.

Results: From technical point of view**,** the main operating conditions are listed in Table 2. From the economic perspective, the defined KPIs are equal to 14,354 €/kW and 0.37 €/kWh for KPI_1 and KPI_2, respectively.

Table 2. Operating conditions of the Methanol-based SOFC system

Stream	**Temperature (°C)**	**Pressure (bar)**	**Mass flow (kg/h)**
Air blower	20	1.079	31.02
Methanol Pump	30	1.128	1.69
Recirculation Blower	283	1.124	4.86
Reformer HEx	480	1.112	6.56
Air HEx	558	1.045	31.02
Exhaust	677	1.039	8.67

Conclusions: The proposed energy system for the maritime application is still quite expensive but the possibility of using renewable methanol allows achieving environmental advantages.

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