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Editorial: Advanced Hybrid Polygeneration Technologies

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Editorial on the Research Topic

Advanced Hybrid Polygeneration Technologies

To achieve global energy and environmental targets, future energy policies have to encourage a clean-energy development based on both renewable energy sources and advanced high efficiency systems. The European Commission has already launched the "Fit for 55" package on 17 July 2021 that contains legislative plans to edit the European Union (EU) 2030 climate and energy objectives. More precisely, two of the main pillars of this package concern the increase of the current EU target by at least 32% of renewable energy sources penetration in the overall energy mix to at least 40% by 2030 and, moreover, the growth of the current EU objective for energy efficiency from 32.5 to 39% for primary energy request. In this context, the combination of high efficiency polygeneration systems and renewable energy sources, representing hybrid polygeneration systems, seems to fit both the previously mentioned pillars: the greater efficiency of primary energy conversion and the lower environmental impact than traditional single-output fossil-based technologies.

In this Research Topic five original papers have been collected about polygeneration systems within the domain of hybrid systems, combined cooling and heating systems, national applications and fossil fuels production optimization.

As regards to hybrid polygeneration systems, Kim et al. have modelled and simulated a hybrid solar-geothermal heat pump polygeneration system in TRNSYS software. The model has been validated through experimental data recorded at the experimental facility installed in a factory building located in Republic of Korea. The demonstration apparatus is composed of 10 photovoltaic thermal collectors (PVTs) and two ground heat exchangers (GHXs) coupled with a water to water heat pump with a cooling capacity of 50 kW and a heating capacity of 90 kW. The plant is equipped with two storage tanks with a volume of 500 L each. One storage tank is linked to the PVTs and GHXs and the second one is coupled to the heat pump in order to limit its partial load operation. The results of this study have demonstrated that, at the design conditions (outside temperature of 32.3°C in the cooling season), TRNSYS model overestimates the primary energy consumption of the experimental plant by 12% confirming the need of field performance data. With reference to hybrid polygeneration systems performance evaluation, Picallo-Perez et al. have analysed a hybrid polygeneration system that meets the space heating, domestic hot water and electric demand of three buildings located in Basque Country by means of an energy and exergy analysis to assess the irreversibilities along the system. The plant consists of a natural gas-fuelled cogenerator based on an internal combustion engine (12.5 kW of thermal power and 5.5 kW of electric power), an air to water electric heat pump with a nominal thermal capacity of 12.9 kW powered by photovoltaic panels (with 22.4 kW of peak power) and a condensing boiler with 102 kW of rated thermal power. The boiler works as an auxiliary device when the cogenerator and the heat pump cannot cover the space heating

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and domestic hot water needs. The facility has been modelled in TRNSYS software and its performance is compared to a separate production system based on the external power grid and a natural gas boiler. The results show a positive primary energy saving equal to 27% and a primary exergy savings of 30%.

On the other hand, Liu et al. have evaluated the performance of a combined cooling, heating and power (CCHP) system meeting the electric, space heating and cooling demands of an eco-campus in Japan by using the genetic alghotim method. The CCHP is composed of a power generation unit fuelled by natural gas, an absorption chiller and two back up devices (boiler and chiller used in heating and cooling operation, respectively). The performance of the CCHP system has been compared to that of a separate production system in which the electricity demand is balanced taking electric energy from power grid, the cooling requests are supplied by an electric chiller and the space heating needs are met by a boiler. The outcomes have demonstrated that the economic performance of the CCHP system is better than that of the separate system and, by performing a sensitivity analysis, it has been found that the variation of electricity price mostly affects the economic performance of the CCHP rather than the change in the natural gas price. More precisely, when the electricity price decreases, the payback period goes from 3.6 to 12.6 years, while an increase in the natural gas price results in a change of the payback period in the range of 4–6.3 years. The CCHP system ensures a primary energy saving with respect to separate system, whereas the CO_2 emission reduction is recorded only in the regions of Japan in which the electricity production mix is mainly based on fossil fuels.

As regards to fossil fuels employed in polygeneration systems, it is important to analyse their production process from the "cradle to grave". Thus, Zhao et al. have developed a data-driven model optimization of the fossil fuels shearer-scraper conveyor.

The remaining contribution in this Research Topic focuses on hybrid polygeneration systems at national level. In this regards, Züttel et al. have defined the technical and economic implications associated to the replacement of the fossil fuels with renewable energy in Swiss energy sectors. They have investigated three solutions: one based on electricity from photovoltaic panels coupled with batteries, another one in which photovoltaic electricity is used to produce hydrogen and the last one in which photovoltaic electricity is employed to produce synthetic hydrocarbons. The first solution is the most efficient from an energy point of view, but it requires a greater infrastructure investment cost, while the production of synthetic hydrocarbons has a lower cost since the infrastructure and the applications already exist.

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All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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