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EDITED AND REVIEWED BY  
Michael Carbajales-Dale,  
Clemson University, United States

\*CORRESPONDENCE  
Michal Holubčík,  
✉ michal.holubcik@fstroj.uniza.sk

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# Editorial: Environmental impacts from small heating systems

Michal Holubčík<sup>1\*</sup>, Dagmar Cagáňová<sup>2</sup> and Jozef Jandačka<sup>1</sup>

<sup>1</sup>Department of Power Engineering, Faculty of Mechanical Engineering, University of Žilina, Žilina, Slovakia, <sup>2</sup>Department of Marketing and Commerce, Faculty of Management, Comenius University, Bratislava, Slovakia

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## Editorial on the Research Topic

### Environmental impacts from small heating systems

Emissions from residential heat sources are a major contributor to air pollution. In particular, the burning of solid fuels in homes generates most of the particulate matter in the air that causes health problems and increases the risk of serious diseases. Therefore, it is necessary to minimize the production of emissions from small heat sources in combination with the highest possible fuel combustion efficiency. Due to the rising prices of energy (coal, electricity, and natural gas), it is not possible to expect the early termination of the use of emission-producing heat sources in households, and further research in this area is still necessary.

The European Union's (EU) national climate change policy is governed by the Kyoto Protocol to the UN Framework Convention on Climate Change (UNFCCC), the Paris Agreement, and the EU Climate Policy. The Paris Agreement (2015) recognizes that limiting the global average temperature increase would significantly reduce the risks and consequences of climate change. The constant consumption of resources exerts pressure on the environment, not only due to their exploitation but also because, once processed, resources produce waste, emissions, or effluents. The EU has set targets for all Member States to improve energy efficiency, reduce emissions, and generate more energy from renewable energy sources (RES). This is also related to the EU's key legislative proposals Fit for 55 and RepowerEU, which are part of the EU's efforts to meet its goals for reducing greenhouse gas emissions and transitioning to a cleaner and more sustainable energy future. Fit for 55 is an ambitious package of measures that aims to reduce greenhouse gas emissions in the EU by 55 percent by 2030 compared to 1990 levels, while gradually replacing and modernizing small heat sources in households to achieve a higher level of use of RES, higher energy conversion efficiency and lower the impact on the environment. RepowerEU is the EU's strategic plan for the modernization and transition of its energy system in order to achieve energy independence, reduce dependence on fossil fuels and increase the share of renewable energy sources, with residential small heat sources playing an important part in the decentralization of energy systems for heat supply. In this area, energy communities are increasingly being created, while in the area of electricity sharing, photovoltaic panels, and battery storage are increasingly being used, thanks to which electricity-based heat sources, especially heat pumps, can be used more in households, without the need for additional capacity increases in the distribution of electrical networks.

The current trend is toward the energy use of different types of materials, including waste, whose parameters must be adapted to a specific heat source. Similarly, there are innovations in the

construction of heat sources that increase the efficiency of combustion and reduce the production of emissions, especially particulate matter (PM). Research into these innovative ways of burning fuels in domestic conditions should be carried out with a view to the circular economy and environmental sustainability. In this area, smart technologies with the Internet of Things (IoT) can be helpful, which, in combination with greener fuels and proper operation of heat sources by their users, can significantly improve the quality of the environment.

The current trend in energy is for smart technologies to be increasingly applied in residential settings-smart homes. They represent the use of modern technologies and intelligent systems to improve the efficiency, security, and sustainability of energy systems. These innovations aim to optimize energy production, distribution, and consumption, contributing to better management of energy resources and reducing negative environmental impacts. Within smart homes, which could be used in households, are Smart Grids, which combine information and communication technology technologies with traditional energy networks within energy communities. These networks will enable more efficient integration of RES, management of supply and demand, optimization of energy distribution, and increased fault tolerance. Accurate and reliable measurement of individual quantities- Smart Metering-is also important in this area. Smart meters are digital devices that enable accurate and automatic data Research Topic and subsequent optimal operation of heat sources, which can be predicted according to current or forecast weather conditions. In cases of excess energy production, whether electricity or heat, energy storage is a useful tool. This helps balance fluctuations in energy production and demand and increases the reliability of energy systems. Smart energy innovations play a key role in the transition to more sustainable and efficient energy systems and are a key pillar in efforts to reduce greenhouse gas emissions and combat climate change.

These and other Research Topic related to small heat sources in the home and their impact on the environment were addressed in the Research Topic Environmental Impacts from Small Heating Systems.

Reducing the negative impact of households on the environment is also possible through the use of photovoltaic micro-installations in family houses, both in Poland and in other countries in Central and Eastern Europe. Blazy et al. attempted to estimate the scale of reduction of air pollution (in particular CO<sub>2</sub>) in the urbanized Metropolitan area of Krakow, which is one of the most polluted regions in Poland. As indicated by the results of this work, the potential of single-family houses in relation to the feasibility of photovoltaic installations makes it possible to reduce the existing CO<sub>2</sub> emissions of power plants and combined heat and power plants, which have been responsible for the electricity supply so far. This is a very positive result in terms of achievable environmental impact, but it is not sufficient to make Poland independent from fossil fuels.

At present, the energy consumption structure of rural areas is transitioning from traditional solid energy to commercial energy and clean energy, especially in China. Zhang et al. reviewed this transition trend, influencing factors, and regional differences in China's rural household energy consumption structure since the 1990s. It is clear from the analyses that many factors, especially household income level and energy availability, influence the choice

of energy source in rural areas. In order to increase the use of greener facilities, it is necessary to raise awareness and implement subsidies in rural areas.

Legislation modernization is also associated with the implementation of modern technologies. Xu et al. showed in their work that the positive legal regulation on the environmental performance of energy companies is more pronounced than that of non-R&D investment.

Hydrogen also has its place in modern energy, and in the future it may be used in smaller applications, e.g., within energy communities. However, hydrogen is a tiny, leak-prone molecule that can indirectly warm the climate. Esquivel-Elizondo et al. found that the presented hydrogen leaks are very diverse and that field measurements of hydrogen emissions throughout the value chain are critically needed to sharpen our understanding of hydrogen emissions.

An important part of reducing the negative impact of households on the environment is the minimization of waste, or its valorization and use to the maximum extent possible. According to the work of Latosińska et al., proper treatment and recycling of waste are crucial for the natural environment. For example, biowaste and ash from heat sources could be used for the production of ceramic building materials. Such a reduction in the amount of waste leads to a smaller burden on the environment and can also offer energy recovery.

There are many ways to reduce the negative impact of human activity on the environment, and since people spend most of their lives in their homes, it is necessary to start there. Every small change for the better can make a big difference.

## Author contributions

MH: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing-original draft, Writing-review and editing, DG: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing-original draft, Writing-review and editing, JJ: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing-original draft, Writing-review and editing.

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