

Fine dust impact by wood energy of a structured oil heating replacement in Luxembourg – Possibilities, pathways and impacts

Wern, B.¹, Noll, F.¹, Zheng, Y.¹,

¹IZES gGmbH, Altenkesseler Str. 17A, 66115 Saarbrücken, Germany

*corresponding author: e-mail: wern@izes.de

Abstract

Heating and cooling needed in 2015 the half of final energy consumption in EU and is the biggest energy sector in EU 28. Often, the energy supply is provided by petroleum products and has to be transformed into low greenhouse gas supply according to the agreements of the Paris follow-up-process. This article is based on the “heating oil fade-out study” commissioned by the Luxembourg Ministry of Energy and estimates for Luxembourg the possibilities and pathways of decreasing heating oil in private heating sector and its impact on local environment. Main questions are: To what extent wood heating solutions are overtaking the place from heating oil solutions? What are alternative possibilities? And what is the environment impact regarding to the fine dust emission in the heating energy transition? A bottom-up approach using heat mapping data examines four sample communities in Luxembourg. The analysis shows that wood pellets in spite of using heat pumps as primary heat supply solution are needed in large quantities for the heat oil fade out due to the recently and also in future still existing energetically low building standards and limited prospects of further expansion of the natural gas network. By using fine dust filters, an increase of fine dust could be avoided.

Keywords: oil heating replacement, spatial planning, fine dust impact, heating transition

Introduction

Biomass has been the main contributor of renewable energy (RE) worldwide, especially in the heating sector. With a high potential in greenhouse gas emission saving the biomass energy plays a substantial role in the mitigation of climate change (Scarlat et al. 2015, Thrän et al. 2020). Shifting the energy from fossil to biomass fuels in the private households is seen as an important pathway to realize the defossilization in the energy sector (Steubling et al. 2020). In countries such as Germany, the use of wood energy which accounts for more than 80% of the RE in the household sector (summarized in Wern et al. 2020) has a long tradition and is particularly important in households. However, biomass is a limited resource and its usage for energy is associated with different sustainability impacts, such as its impact on biodiversity or land use change (e.g. Cornelissen et al. 2012, Jering et al. 2013). Furthermore, wood heating systems, especially the small ones are the major source of fine dust (Tebert et al. 2016) – a fact which

has gained increasing attention in European countries (EC 2018). Heating and cooling contributes the half of final energy consumption (in 2015) and is the biggest energy sector in EU28 (ISI 2017). In Luxembourg as well as in most other European countries the heating and cooling sector is characterized by a high percentage of fossil energy, of which more than one third (33.6% in Luxembourg in 2018) is provided by oil and petroleum products (Eurostat 2020), and in particular by heating oil. Meanwhile, the residential sector in Luxembourg has high greenhouse gas (GHG) emissions with 1.7 tons per capita in 2018 (EEA 2020). In this context, in line with the Luxembourg climate target to reduce GHG emissions by 55% by 2030 compared to 2005 (MEA 2020), the Luxembourg government intends to have an oil heating replacement (fade-out) through alternative and more climate-friendly technologies. The study is conducted as a bottom-up approach, assessing these goals and their impact to the fine dust emissions. In the one hand, it will be answered, which extent and which effort means the realization of these goals. And on the other hand the impact on local environment by fine dust will be measured. Questions to be answered are: To what extent wood heating solutions are overtaking the place from heating oil solutions? What are alternative possibilities? And what is the environment impact regarding to the fine dust emission? It focuses on the manner of a bottom-up approach on four sample communities in Luxembourg: Ettelbruck, Putscheid, Luxembourg City and Rambrouch. This article based on the “heating oil fade-out study” commissioned by My Energie G.I.E. in coordination with the Luxembourg Ministry of Energy

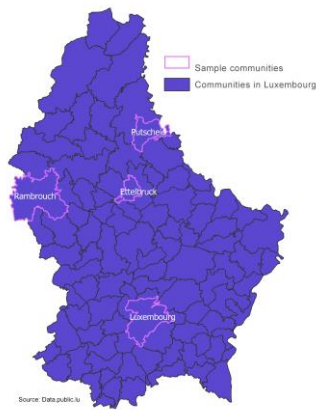


Figure 1.

Methods

Bottom-up approaches using spatial analysis based on GIS-modelling on a regional level are widely used within the transformation research, especially in the field of RE (e.g. Kueppers et al. 2020; Baur et al. 2017; Wern et al. 2016). In our work, we applied proven methods of spatial analysis to selected regions, which represent urban as well as rural settings affecting the application possibilities of RE. In the first step of the assessment, a status quo analysis of heat demand is conducted in dependence on the residential building typology throughout the four sample communities (Noll et al. 2020). The analysis of heat demand builds on own works on heat map analysis in Luxembourg having regard to additional energy suppliers' data, funding data in heating sector and further regional data on heat supply collected within the study (Noll et al. 2021). Following the status quo, an algorithm to replace oil heatings in private households by alternative low-emission heating supply technologies is developed considering the characteristic of heat technologies including efficiency, energy saving potential, heat density, costs for insulation, environmental impacts etc. and their application fields in relation to residential structures, building types and local energy supply. In total, three Scenarios are built to illustrate possible pathways of the replacement, with assumption on different degree of wood heating use and residential renovation. In the last step, based on the emission factor according to EEA report No 13/2019 (EEA 2019), the fine dust impacts are calculated. Additionally, the study examines, to what extent fine dust emissions can be reduced if appropriate filters are installed in the entire wood heating. This research is based on the experience of Berhardt et al (2016). The results are discussed with decision makers and regional experts in Luxembourg to secure theoretical data and will then be incorporated into the further policy changes in Luxembourg.

Results

The algorithm developed within the project, follows the priority of (i) energy saving, (ii) using heating grids, (iii)

using low energy heating systems and (iv) using decentralized wood pellet burners. The status quo analysis shows that especially in rural Luxemburgish areas, 80 % of the heating systems in residential buildings are based on heating oil. This corresponds to an annual heating oil consumption of 250 million liters respectively fine dust emissions of 50 tons per year. An abrupt heating oil fade-out without a comprehensive energy-focused building refurbishment leads in rural areas depending on the scenario to either an extreme increase of small wood heating systems or an increase of heating pumps. This results in locally increased fine dust emissions primarily concerning the old village centers, which requires further measures such as the use of dust filter units and leads to additional retrofitting costs. In urban area, heating grids with waste heat utilization would be more common. However, the related need for energy wood (especially wood pellets) all over Luxembourg, would grow from 14 kg today to approximately 450 kg per capita which exceeds the national availability of energy wood by far. The combination of restructuring measures and replacement of oil heating systems would enable a moderate increase of energy wood consumption and, in total, a decrease of local fine dust emissions (see Figure 2).

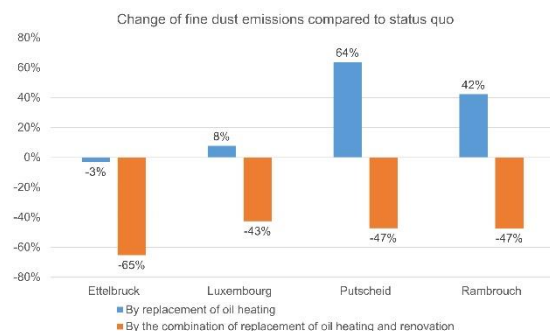


Figure 2.

Conclusion

So there is an urgent need for a structured oil heating replacement considering renovation and energy-oriented modernization, especially of the older buildings. Only the replacing of oil heating systems by wood pellet burners would overload the wood pellet supply assumed for Luxembourg extremely.

Additionally, without a comprehensive energy-focused building refurbishment, especially in rural regions, fine dust filters which affect costs for a structured oil heating replacement were needed in over half of all residential buildings to avoid a relative increase in fine dust emissions compared to today.

References

- Baur, Frank; Bur, Anna; Noll, Florian; Rau, Irina; Tomerius, Stephan (2017): Kommunen als Impulsgeber, Gestalter und Moderator der Energiewende - Elemente energienachhaltiger Governance. Kurztitel EnGovernance. Abschlussbericht. Gefördert durch das BMWi, DOI: 10.13140/RG.2.2.10255.53924
- Berhardt, Alexander; Lezsovits, Ferenc; Groß, Bodo (2016): Integrated Electrostatic Precipitator for Small Scaled Biomass Boilers. In: Chemical Engineering & Technology 40(2). DOI: 10.1002/ceat.201600200.
- Cornelissen, Stijn; Koper, Michèle; Deng, Yvonne Y. (2012): The role of bioenergy in a fully sustainable global energy system. In: Biomass and Bioenergy 41, S. 21–33. DOI: 10.1016/j.biombioe.2011.12.049.
- EEA (2019): EMEP/EEA air pollutant emission inventory guidebook 2019. Technical guidance to prepare national emission inventories. EEA Report No 13/2019. DOI: 10.2800/293657.
- EEA (2020): EEA greenhouse gas – data viewer. Available online at <https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer>, last accessed: 08.09.2020.
- EC (2018): Case C-635/18 Action brought on 11 October 2018 — European Commission v Federal Republic of Germany
- Eurostat (2020): Questionnaire for statistics on final energy consumption in households.
- ISI (2017): Heating and Cooling. Facts and Figures. The transformation towards a low-carbon Heating & Cooling sector. Fraunhofer Institute for Systems and Innovation Research.
- Jering, Almut; Klatt, Anne; Seven, Jan; Ehlers, Knut; Günther, Jens; Ostermeier, Andreas; Mönch, Lars (2013): Globale Landflächen und Biomasse nachhaltig und ressourcenschonend nutzen. Hg. v. Umweltbundesamt (UBA).
- Kueppers, Martin; Perau, Christian; Franken, Marco; Heger, Hans Joerg; Huber, Matthias; Metzger, Michael; Niessen, Stefan (2020): Data-Driven Regionalization of Decarbonized Energy Systems for Reflecting Their Changing Topologies in Planning and Optimization. In: Energies 13 (16), S. 4076. DOI: 10.3390/en13164076.
- MEA (2020): Luxembourg's Integrated National Energy and Climate Plan for 2021-2030. Ministère de l'Énergie et de l'Aménagement du territoire.
- Noll, Florian; Becker, Daniela; Ludwig, Dorothea; Schröder, Indra (2020): Development and testing of an approach for demand-oriented dynamization of heat maps on municipal level. In: GIS-Zeitschrift für Informatik 4/2019: 141-151.
- Noll, Florian; Kauten, Ralf; Martin, Olivier; Köhler, Ralf (2021): Voruntersuchungen zur Erstellung eines nationalen Wärmekatasters für Luxemburg anhand von vier Pilotgemeinden. Abschlussbericht zur Vorstudie, unveröffentlicht Saarbrücken: IZES gGmbH.
- Scarlat, Nicolae; Dallemand, Jean-François; Monforti-Ferrario, Fabio; Nita, Viorel (2015): The role of biomass and bioenergy in a future bioeconomy: Policies and facts. In: Environmental Development 15, S. 3–34. DOI: 10.1016/j.envdev.2015.03.006.
- Steubing, M.; Dotzauer, M.; Zakaluk M.; Wern, B.; Thraen, D. (2020): Bioenergy plants' potential for contributing to heat generation in Germany. In: Energy, Sustainability and Society 10 (1). DOI: 10.1186/s13705-020-00246-5.
- Tebert, Christian; Volz, Susanne; Töfge, Kevin (2016): Ermittlung und Aktualisierung von Emissionsfaktoren für das nationale Emissionsinventar bezüglich kleiner und mittlerer Feuerungsanlagen der Haushalte und Kleinverbraucher. Endbericht - Hauptteil. Hg. v. Umweltbundesamt.
- Thrän, Daniela; Cowie, Annette L.; Berndes, Göran (Hg.) (2020): Roles of bioenergy in energy system pathways towards a “well-below-2-degrees-Celsius (WB2)” world. Workshop report and synthesis of presented studies, IEA Bioenergy: ExCo.
- Wern, Bernhard; Baur, Frank; Noll, Florian; Vogler, Cornelia; Mees, Michael; Steinert, Marc et al. (2016): Wärmestudie Region Eifel und Trier. Im Auftrag des MWKEL Rheinland-Pfalz, DOI: 10.13140/RG.2.2.19140.58242
- Wern, Bernhard; Lenz, Volker; Sperber, Evelyn; Saadat, Ali; Ebert, Hans-Peter (2020): Wärmebereitstellung in Privathaushalten - Lösungen für eine CO2-freie Energiebereitstellung. In: Energy Research for Future - Forschung für die Herausforderungen der Energiewende Beiträge zur FVEE Jahrestagung 2019, S. 28–32.