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International Journal of Sustainable Energy Planning and Management

New Developments in 4th generation district heating and smart energy systems

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ABSTRACT

This editorial introduces the 27th volume of the International Journal of Sustainable Energy Planning and Management, which reports some of the latest developments in energy systems analyses of smart energy systems as well as district heating. The issue looks into district heating in Estonia and Norway – as part in a renewable energy transition and flexibility-providing measure. Other analyses look into future prices of renewable energy-based power production systems and optimal design of carbon-neutral energy systems combining EnergyPLAN and EPLANOpt.

Keywords:

District heating;
Energy systems analyses;
EnergyPLAN;
EPLANOpt;

URL: <http://doi.org/10.5278/ijsepm.3664>

1. Introduction

This editorial introduces the 27th volume of the International Journal of Sustainable Energy Planning and Management. This volume is a special issue from the 5th International Conference on Smart Energy Systems 4th Generation District Heating, Electrification, Electrofuels and Energy Efficiency, held in Copenhagen, Denmark in September 2019.

Papers from previous conferences have been published in previous special issues in this journal [1–5] as well as in *Energy* [6–8].

Previously published work has centred on five core topics – transformation and planning [9–12], the operation of grids [13–17], building systems [18], heat and resources [19], and balancing energy systems with a high proportion of renewables [20–22].

2. District heating-based systems

Volkova et al. [23] take a starting point in district heating remaining an important part of the Estonian energy system in the future, however, district heating should evolve

towards 4th generation district heating [24,25]. In the analyses, 146 Estonian district heating systems are considered with regard to development potentials in consumption, distribution and generation. With energy savings, improved pipes, and a switch to biomass, carbon-neutral heating may be increased from one third up to 72%. The analyses furthermore link up to the development of a mobile app previously reported in this journal [9].

Askeland et al. [26] investigate the role of district heating in energy systems with a high proportion of hydropower, taking Norway as an example. While Norway by many is foreseen having an important role as a “balancing country” for fluctuating renewable energy integration elsewhere in Europe [27], Norway is also a country with a high present degree of electrification and an ongoing further electrification. One option, which is investigated by Askeland and co-authors is the effect of an introduction of 4th generation district heating on the potential surplus of electricity from Norway. Using EnergyPLAN [28–30], the authors find that there are limited effects and that employing heat storage does not generate much additional flexibility in the energy system.

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3. Energy systems analyses

Prina et al. [31] also employ the energy systems analysis model EnergyPLAN in their analyses; here it is coupled with EPLANOpt [32] to provide a multi-objective evolutionary algorithm-based environment for determining optimal scenario configurations. By applying the setup to the Austrian region Niederösterreich the authors find that “in order to decarbonize the energy system the increase of the installed power of renewables is not enough to reach the CO₂ reduction objective. Integration methods like the already mentioned storage systems, power to gas, power to heat or power to mobility become relevant.”

Siddiqui et al. [33] investigate electricity-price forecasting in a traditional carbon-based energy system with integration of fluctuating renewable energy sources. While fluctuating renewable energy sources may have low marginal costs, the authors’ analyses demonstrate that if fluctuating renewables are to be coupled with storage, then the resulting price will not be competitive against fossil-based alternatives.

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The work presented in this special issue stems from the 5th International Conference on Smart Energy Systems 4th Generation District Heating, Electrification, Electrofuels and Energy Efficiency. As editors of the journal and/or as organisers of the conference, we acknowledge and appreciate the contributions from the reviewers that have assisted in improving the articles to the standard they have today.

References

- [1] Østergaard PA, Lund H, Mathiesen BV. Smart energy systems and 4th generation district heating. *Int J Sustain Energy Plan Manag* 2016;10:1–2. <https://doi.org/10.5278/ijsepm.2016.10.1>.
- [2] Østergaard PA, Lund H. Smart district heating and electrification. *Int J Sustain Energy Plan Manag* 2017;12. <https://doi.org/10.5278/ijsepm.2017.12.1>.
- [3] Østergaard PA, Lund H. Editorial - Smart district heating and energy system analyses. *Int J Sustain Energy Plan Manag* 2017;13. <https://doi.org/10.5278/ijsepm.2017.13.1>.
- [4] Østergaard PA, Lund H, Mathiesen BV. Editorial – Smart energy systems and 4th generation district heating systems. *Int J Sustain Energy Plan Manag* 2018;16:1–2. <https://doi.org/10.5278/ijsepm.2018.16.1>.
- [5] Østergaard PA, Lund H, Mathiesen BV. Developments in 4th generation district heating. *Int J Sustain Energy Plan Manag* 2019;20. <https://doi.org/10.5278/ijsepm.2019.20.1>.
- [6] Lund H, Duic N, Østergaard PA, Mathiesen BV. Smart energy systems and 4th generation district heating. *Energy* 2016;110. <https://doi.org/10.1016/j.energy.2016.07.105>.
- [7] Lund H, Duic N, Østergaard PA, Mathiesen BV. Smart Energy and District Heating: Special Issue dedicated to the 2016 Conference on Smart Energy Systems and 4th Generation District heating. *Energy* 2018;160:1220–3. <https://doi.org/10.1016/J.ENERGY.2018.07.012>.
- [8] Lund H, Duic N, Østergaard PA, Mathiesen BV. Perspectives on Smart Energy Systems from the SES4DH 2018 conference. *Energy* 2020;190:116318. <https://doi.org/10.1016/J.ENERGY.2019.116318>.
- [9] Volkova A, Latõšov E, Mašatin V, Siirde A. Development of a user-friendly mobile app for the national level promotion of the 4th generation district heating. *Int J Sustain Energy Plan Manag* 2019;20. <https://doi.org/10.5278/ijsepm.2019.20.3>.
- [10] Leeuwen RP van, Wit JB de, Smit GJM. Energy scheduling model to optimize transition routes towards 100% renewable urban districts. *Int J Sustain Energy Plan Manag* 2017;13. <https://doi.org/10.5278/ijsepm.2017.13.3>.
- [11] Sernhed K, Gåverud H, Sandgren A. Costumer perspectives on district heating price models. *Int J Sustain Energy Plan Manag* 2017;13. <https://doi.org/10.5278/ijsepm.2017.13.4>.
- [12] Knies J. A spatial approach for future-oriented heat planning in urban areas. *Int J Sustain Energy Plan Manag* 2018. <https://doi.org/10.5278/ijsepm.2018.16.2>.
- [13] Lund R, Østergaard DS, Yang X, Mathiesen BV. Comparison of Low-temperature District Heating Concepts in a Long-Term Energy System Perspective. *Int J Sustain Energy Plan Manag* 2017;12:5–18. <https://doi.org/10.5278/ijsepm.2017.12.2>.
- [14] Brange L, Sernhed K, Thern M. Decision-making process for addressing bottleneck problems in district heating networks. *Int J Sustain Energy Plan Manag* 2019;20. <https://doi.org/10.5278/ijsepm.2019.20.4>.
- [15] Pellegrini M. Classification through analytic hierarchy process of the barriers in the revamping of traditional district heating networks into low temperature district heating: an Italian case study. *Int J Sustain Energy Plan Manag* 2019;20. <https://doi.org/10.5278/ijsepm.2019.20.5>.
- [16] Schuchardt GK, Kraft S, Narften M, Bagusche O. Development of an empirical method for determination of thermal conductivity and heat loss for pre-insulated plastic bonded twin pipe systems. *Int J Sustain Energy Plan Manag* 2018;16. <https://doi.org/10.5278/ijsepm.2018.16.5>.
- [17] Roberto R, Iulio R De, Somma M Di, Graditi G, Guidi G, Noussan M. A multi-objective optimization analysis to assess the potential economic and environmental benefits of distributed storage in district heating networks: a case study. *Int J Sustain Energy Plan Manag* 2019;20. <https://doi.org/10.5278/ijsepm.2019.20.2>.

- [18] Best I, Orozaliev J, Vajen K. Economic comparison of low-temperature and ultra-low-temperature district heating for new building developments with low heat demand densities in Germany. *Int J Sustain Energy Plan Manag* 2018;16. <https://doi.org/10.5278/ijsepm.2018.16.4>.
- [19] Pieper H, Mašatin V, Volkova A, Ommen TS, Elmegaard B, Markussen WB. Modelling framework for integration of large-scale heat pumps in district heating using low-temperature heat sources: A case study of Tallinn, Estonia. *Int J Sustain Energy Plan Manag* 2019;20. <https://doi.org/10.5278/ijsepm.2019.20.6>.
- [20] Trømborg E, Havskjold M, Bolkesjø TF, Kirkerud JG, Tveten ÅG. Flexible use of electricity in heat-only district heating plants. *Int J Sustain Energy Plan Manag* 2017;12:29–46. <https://doi.org/10.5278/ijsepm.2017.12.4>.
- [21] Flores JFC, Espagnet AR, Chiu JN, Martin V, Lacarrière B. Techno-Economic Assessment of Active Latent Heat Thermal Energy Storage Systems with Low-Temperature District Heating. *Int J Sustain Energy Plan Manag* 2017;13. <https://doi.org/10.5278/ijsepm.2017.13.2>.
- [22] Sneum DM, Sandberg E. Economic incentives for flexible district heating in the Nordic countries. *Int J Sustain Energy Plan Manag* 2018;16. <https://doi.org/10.5278/ijsepm.2018.16.3>.
- [23] Volkova A, Latõšov E, Lepiksaar K, Siirde A. Planning of district heating regions in Estonia. *Int J Sustain Energy Plan Manag* 2020;27. <https://doi.org/10.5278/ijsepm.3490>.
- [24] Lund H, Østergaard PA, Chang M, Werner S, Svendsen S, Sorknæs P, et al. The status of 4th generation district heating: Research and results. *Energy* 2018;164:147–59. <https://doi.org/10.1016/j.energy.2018.08.206>.
- [25] Lund H, Werner S, Wiltshire R, Svendsen S, Thorsen JE, Hvelplund F, et al. 4th Generation District Heating (4GDH). Integrating smart thermal grids into future sustainable energy systems. *Energy* 2014;68:1–11. <https://doi.org/10.1016/j.energy.2014.02.089>.
- [26] Askeland K, Rygg BJ, Sperling K. The role of 4th generation district heating (4GDH) in a highly electrified hydropower dominated energy system. *Int J Sustain Energy Plan Manag* 2020. <https://doi.org/10.5278/ijsepm.3683>.
- [27] Askeland K, Bozhkova KN, Sorknæs P. Balancing Europe: Can district heating affect the flexibility potential of Norwegian hydropower resources? *Renew Energy* 2019;141:646–56. <https://doi.org/10.1016/j.renene.2019.03.137>.
- [28] Østergaard PA. Reviewing EnergyPLAN simulations and performance indicator applications in EnergyPLAN simulations. *Appl Energy* 2015;154:921–33. <https://doi.org/10.1016/j.apenergy.2015.05.086>.
- [29] EnergyPLAN website n.d.
- [30] Lund, Henrik;Thellufsen JZ. EnergyPLAN - Advanced Energy Systems Analysis Computer Model - Documentation Version 14. 2018.
- [31] Prina MG, Moser D, Vaccaro R, Sparber W. EPLANopt optimization model based on EnergyPLAN applied at regional level: the future competition on excess electricity production from renewables. *Int J Sustain Energy Plan Manag* 2020;27. <https://doi.org/10.5278/ijsepm.3504>.
- [32] Prina MG, Cozzini M, Garegnani G, Manzolini G, Moser D, Filippi Oberegger U, et al. Multi-objective optimization algorithm coupled to EnergyPLAN software: The EPLANopt model. *Energy* 2018;149:213–21. <https://doi.org/10.1016/J.ENERGY.2018.02.050>.
- [33] Siddiqui S, Macadam J, Barrett M. A novel method for forecasting electricity prices in a system with variable renewables and grid storage. *Int J Sustain Energy Plan Manag* 2020;27. <https://doi.org/10.5278/ijsepm.3497>.

