International Journal of
Sustainable Energy Planning and Management

Sustainable development using renewable energy systems

Poul Alberg Østergaard[a1], Rasmus Magni Johannsen[a] and Neven Duic[b]

[a] *Department of Planning, Aalborg University, Rendsburggade 14, 9000 Aalborg, Denmark*

[b] *Department of Energy, Power Engineering and Environment, University of Zagreb, Lučićeva 5, 10000 Zagreb, Croatia*

ABSTRACT

This editorial introduces the main findings from the 29th Volume of the International Journal of Sustainable Energy Planning and Management. The issue includes both contributions to the 2019 *Sustainable Development of Energy Water and Environmental Systems* conference and ordinary journal submissions. In either case, the research is centred on sustainable development using renewable energy systems – with particular attention to technology assessment, pricing & regulation and systems analyses. Case studies and model development from Austria, Cape Verde, Columbia, and Iran are presented – with varying focal points. Different drive trains for the electrification of the transportation sector are assessed. Lastly, pricing regimes for evolving district heating systems as well as consumer involvement in 4th generation district heating and social factors for implementing building energy conservation policy are considered.

Keywords:

Energy technology assessment;
Pricing and regulation;
Systems analyses;

URL: https://doi.org/10.5278/ijsepm.4302

1. Introduction

This issue of the *International Journal of Sustainable Energy Planning and Management* combines a special issue dedicated to the SDEWES 2019 conference – *Sustainable Development of Energy Water and Environmental Systems* and a normal issue. The SDEWES 2019 Special Issue follows after previous special issues in this journal [1] covering energy security [2], the optimal geographical level of scenario making [3], acceptance of grids [4] and cost-optimal energy savings [5], as well as special issues in e.g. *Renewable Energy* [6] and *Energies* [7].

This issue also contains a wider selection of research within the sustainable energy planning and management field with a focus on the area *Sustainable development using renewable energy systems*.

2. SDEWES papers

In *Modelling, designing and operation of grid-based multi-energy systems*, Kienberger and coauthors [8] present a modelling framework – HyFlow – to analyse integrated energy systems. As an addition to other modelling frameworks of integrated energy systems – or smart energy systems [9] – like the widely applied EnergyPLAN model [10,11] – the HyFlow model includes the spatial dimension to enable more in-depth analyses of this characteristic of distributed systems. The contribution here builds on the authors' previous published work on the HyFlow model in the journal *Energies* [12].

Ferreira and co-authors follow up on previous country studies with a new study on Cape Verde in their article

*Corresponding author - e-mail: poul@plan.aau.dk

Planning for a 100% renewable energy system for the Santiago Island [13]. Using a purpose-built GAMS (General Algebraic Modelling System) model, the authors analyse Santiago Island with a particular focus on renewable energy sources (RES) in the electricity system, finding issues of costs and load balancing capability in high-RES scenarios. This work complements other work on West African nations [14,15].

3. Technology and assessment

In their article *A technology evaluation method for assessing the potential contribution of energy technologies to decarbonisation of the Italian production system* [16], the authors present a technology assessment screening methodology to assist in the energy planning process. The authors also apply the framework to a wide range of technologies relevant in the energy transition.

Buzoverov and Zhuk provide a *Comparative Economic Analysis for Different Types of Electric Vehicles* [17] where they analyse three alternative means of electrification of transportation - batteries, fuel cells, and aluminium-air electrochemical generators. They find interesting prospects for the aluminium-based solution. The work adds to previous studies of electric vehicles presented in this journal both with regards to drive-train analyses [18] and more widely the energy system impacts with focus on strategies for charging electric vehicles on the electricity market [19] and national studies of electric vehicle integration for Portugal [20], Indonesia [21], Sweden [22], and Chile [23].

In the article *Methodology to Assess the Implementation of Solar Power Projects in Rural Areas Using AHP: a Case Study of Colombia* [24], Gelves and Florez apply an *Analytic Hierarchy Process* (AHP) to assess the location for the planning of photo voltaic installations in Columbia. They find particularly good prospects along the Caribbean coast when factoring in *"techno-economic, social, and environmental-risk criteria"*. Similarly, Quiquerez et al. investigated the location and optimal choice between photo voltaics and thermal solar collectors [25] and Oloo investigated the spatial distribution of the solar energy potential in Kenya [26]. Other location studies in this journal have focused on heating demands and district heating systems [27–31], and biomass digesters [32].

Praliyev et al. [33] investigate the production and cost effects of introducing solar tracking systems rather than fixed-angle PV systems in the Jambyl region, Kazakhstan. While both single and dual-axis tracking systems perform better than fixed-angle systems, the associated cost outweighs the production benefits by a large margin.

4. Systems analyses

In the article *Policy Framework for Iran to Attain 20% Share of Non-Fossil Fuel Power Plants in Iran's Electricity Supply System by 2030* [34], Godarzi and Maleki presents a system dynamics approach to explore future high-RES scenarios for the Iranian electricity system. With low fossil fuel costs in Iran, the introduction of RES will increase costs and the authors stress that the electricity prices must be based on technology costs. Previous work on Iran in this journal has focused on the role of desalination in the energy system [35].

Paliwal investigates *"reliability and cost-based sizing of solar-wind-battery storage system for an isolated hybrid power system"* in the article *Reliability constrained planning and sensitivity analysis for Solar-Wind-Battery based Isolated Power System* [36]. Applying Monte-Carlo simulation and Particle Swarm Optimization, Paliwal investigate hybrid systems with photo voltaics, wind power and battery storage. This is in line with previous work on similar isolated systems in Kenya [37] based on assessments using HOMER, though this latter work also looked into non-technical barriers. A previous hybrid energy system study in the IJSEPM focused on the Himalayan region [38].

5. Pricing, regulation and engagement

Odgaard and Djørup present *Review and experiences of price regulation regimes for district heating* [39]. With a starting point in the favourable prospects identified for district heating as outlined in various studies [40] the authors look into how regulation can safeguard district heating consumers in a situation where they are supplied from an energy supply company which is a monopoly. As the authors state, both "*privately and publicly owned DH supplies must be guided by various efficiency-enhancing measures*" to ensure that companies are not simply exploiting their position and disregard efficiency improvement potentials. This follows up on previous work by one of the same authors on both district heating prices [41] and electricity prices in smart energy systems [42–44].

Krog and coauthors analyse *Consumer involvement in the transition to 4th generation district heating* [27] with a focus on how these can be "*meaningfully and* *strategically included in the transition towards"* 4th generation district heating (4GDH). A main focus in 4GDH research hitherto has been on the definition of the concept [45] and technical assessments of the potentials as in national cases of Denmark and Norway [46,47], while less attention has been devoted to consumer involvement. Through a literature study, Krog and coauthors investigate the current knowledge within the field – finding however limited material. They do stress the importance of adequately coordinating supply and demand initiatives. Previous work has also demonstrated the need for an integrated planning approach and ownership structures that engage consumers [48–51].

Qarnain and co-authors present an *Analysis of social inequality factors in implementation of building energy conservation policies using Fuzzy Analytical Hierarchy Process Methodology* [52] focusing on e.g. how social inequality and environmental injustice in society is linked to policy within the climate change mitigation area. Previous studies in this journal have focused on barriers and potentials for energy conservation [53] and the role of heat savings in energy system scenarios [54,55] and employment generation [56].

References

[1] Østergaard PA, Duic N. Sustainable energy, water and environmental systems. Int J Sustain Energy Plan Manag 2014;3. http://doi.org/10.5278/ijsepm.2014.3.1.

[2] Taliotis C, Howells M, Bazilian M, Rogner H, Welsch M. Energy security prospects in Cyprus and Israel: A focus on natural gas. Int J Sustain Energy Plan Manag 2014;3:5–20. http://doi.org/10.5278/ijsepm.2014.3.2.

[3] Waenn A, Connolly D, Gallachóir BÓ. Investigating 100% renewable energy supply at regional level using scenario analysis. Int J Sustain Energy Plan Manag 2014;3:21–32. http://doi.org/10.5278/ijsepm.2014.3.3.

[4] Menges R, Beyer G. Underground cables versus overhead lines: Do cables increase social acceptance of grid development? Results of a Contingent Valuation survey in Germany. Int J Sustain Energy Plan Manag 2014;3:33–48. http://doi.org/10.5278/ijsepm.2014.3.4.

[5] Tronchin L, Tommasino MC, Fabbri K. On the cost-optimal levels of energy-performance requirements for buildings: A case study with economic evaluation in Italy. Int J Sustain Energy Plan Manag 2014;3:49–62. http://doi.org/10.5278/ijsepm.2014.3.5.

[6] Østergaard PA, Duic N, Noorollahi Y, Mikulcic H, Kalogirou S. Sustainable development using renewable energy technology. Renew Energy 2020;146:2430–7. http://doi.org/10.1016/j.renene.2019.08.094.

[7] Calise F, Vicidomini M, Costa M, Wang Q, Østergaard PA, Duić N. Toward an efficient and sustainable use of energy in industries and cities. Energies 2019;12. http://doi.org/10.3390/en12163150.

[8] Kienberger T, Traupman A, Sejkora C, Kriechbaum L, Greiml M, Böckl B. Modelling, designing and operation of grid-based multi-energy systems. Int J Sustain Energy Plan Manag 2020;29. http://doi.org/10.5278/ijsepm.3598.

[9] Lund H, Østergaard PA, Connolly D, Mathiesen BV. Smart energy and smart energy systems. Energy 2017;137. http://doi.org/10.1016/j.energy.2017.05.123.

[10] Østergaard PA. Reviewing EnergyPLAN simulations and performance indicator applications in EnergyPLAN simulations. Appl Energy 2015;154:921–33. http://doi.org/10.1016/j.apenergy.2015.05.086.

[11] Lund H, Münster E. Modelling of energy systems with a high percentage of CHP and wind power. Renew Energy 2003;28:2179–93. http://doi.org/10.1016/S0960-1481(03)00125-3.

[12] Böckl B, Greiml M, Leitner L, Pichler P, Kriechbaum L, Kienberger T. HyFloW—A hybrid load flow-modelling framework to evaluate the effects of energy storage and sector coupling on the electrical load flows. Energies 2019;12. http://doi.org/10.3390/en12050956.

[13] Ferreira PV, Lopes A, Dranka GG, Cunha J. Planning for a 100% renewable energy system for the Santiago Island, Cape Verde. Int J Sustain Energy Plan Manag 2020;29. http://doi.org/10.5278/ijsepm.3603.

[14] Oyewo AS, Aghahosseini A, Ram M, Breyer C. Transition towards decarbonised power systems and its socio-economic impacts in West Africa. Renew Energy 2020;154:1092–112. http://doi.org/https://doi.org/10.1016/j.renene.2020.03.085.

[15] Momodu AS. Energy Use: Electricity System in West Africa and Climate Change Impact. Int J Sustain Energy Plan Manag 2017;14:x-y. http://doi.org/10.5278/ijsepm.2017.14.3.

[16] De Luca E, Zini A, Amerighi O, Coletta G, Oteri MG, Giuffrida LG, et al. A technology evaluation method for assessing the potential contribution of energy technologies to decarbonisation of the Italian production system. Int J Sustain Energy Plan Manag 2020;29. http://doi.org/10.5278/ijsepm.4433.

[17] Buzoverov E, Zhuk A. Comparative Economic Analysis for Different Types of Electric Vehicles. Int J Sustain Energy Plan Manag 2020;29. http://doi.org/10.5278/ijsepm.3831.

[18] Huertas JI, Quirama LF, Giraldo MD, Díaz J. Comparison of driving cycles obtained by the micro-trips, markov-chains and mwd-cp methods. Int J Sustain Energy Plan Manag 2019;22:109–20. http://doi.org/10.5278/ijsepm.2554.

[19] Juul N, Pantuso G, Iversen JEB, Boomsma TK. Strategies for Charging Electric Vehicles in the Electricity Market. Int J Sustain Energy Plan Manag 2015;7:67–74. http://doi.org/10.5278/ijsepm.2015.7.6.

[20] Carvalho E, Sousa J, Lagarto J. Assessing electric vehicle CO_2 emissions in the Portuguese power system using a marginal generation approach. Int J Sustain Energy Plan Manag 2020;26:47–66. http://doi.org/10.5278/ijsepm.3485.

[21] Setiartiti L, Al Hasabi RA. Low carbon-based energy strategy for transportation sector development. Int J Sustain Energy Plan Manag 2019;19. http://dx.doi.org/10.5278/ijsepm.2019.19.4.

[22] Bramstoft R, Skytte K. Decarbonizing the Swedish transport sector with electricity or biofuels. Int J Sustain Energy Plan Manag 2017;14:3-y. http://doi.org/10.5278/ijsepm.2017.14.2.

[23] Osorio-Aravena JC, Aghahosseini A, Bogdanov D, Caldera U, Muñoz-Cerón E, Breyer C. Transition toward a fully

renewable-based energy system in Chile by 2050 across power, heat, transport and desalination sectors. Int J Sustain Energy Plan Manag 2020;25. http://doi.org/10.5278/ijsepm.3385.

[24] Gelves JJP, Florez GAD. Methodology to Assess the Implementation of Solar Power Projects1 in Rural Areas Using AHP: a Case Study of Colombia. Int J Sustain Energy Plan Manag 2020;29. http://doi.org/10.5278/ijsepm.3592.

[25] Quiquerez L, Faessler J, Lachal B, Mermoud F, Hollmuller P. GIS methodology and case study regarding assessment of the solar potential at territorial level: PV or thermal? Int J Sustain Energy Plan Manag 2015;6:3–16. http://doi.org/10.5278/ijsepm.2015.6.2.

[26] Oloo F, Olang L, Strobl J. Spatial Modelling of Solar energy Potential in Kenya. Int J Sustain Energy Plan Manag 2015;6:17–30. http://doi.org/10.5278/ijsepm.2015.6.3.

[27] Grundahl L, Nielsen S. Heat atlas accuracy compared to metered data. Int J Sustain Energy Plan Manag 2019;23. http://doi.org/10.5278/ijsepm.3174.

[28] Urquizo J, Calderón C, James P. Modelling the spatial energy diversity in sub-city areas using remote sensors. Int J Sustain Energy Plan Manag 2019;22:61–80. http://doi.org/10.5278/ijsepm.3324.

[29] Möller B, Nielsen S. High resolution heat atlases for demand and supply mapping. Int J Sustain Energy Plan Manag 2014;1:41–58. https://doi.org/10.5278/ijsepm.2014.1.4.

[30] Kuriyan K, Shah N. A combined spatial and technological model for the planning of district energy systems. Int J Sustain Energy Plan Manag 2019;21. https://doi.org/10.5278/ijsepm.2019.21.8.

[31] Dochev I, Seller H, Peters I. Spatial aggregation and visualisation of urban heat demand using graph theory. Int J Sustain Energy Plan Manag 2019;24. http://doi.org/10.5278/ijsepm.3346.

[32] Mukherjee D, Cromley R, Shah F, Bravo-Ureta B. Optimal location of centralized biodigesters for small dairy farms: A case study from the United States. Int J Sustain Energy Plan Manag 2015;8:3–16. http://doi.org/10.5278/ijsepm.2015.8.2.

[33] Praliyev P, Zhunis K, Kalel Y, Dikhanbayeva D, Rojas-Solórzano L. Impact of both One- and Two-axis Solar Tracking on the Techno-Economic Viability of On-Grid PV Systems: The case of the Burnoye-1 Power Plant, Kazakhstan. Int J Sustain Energy Plan Manag 2020;29. http://doi.org/10.5278/ijsepm.3665.

[34] Godarzi AA, Maleki A. Policy Framework for Iran to Attain 20% Share of Non-Fossil Fuel Power Plants in Iran's Electricity Supply System by 2030. Int J Sustain Energy Plan Manag 2020;29. http://doi.org/10.5278/ijsepm.5692.

[35] Caldera U, Bogdanov D, Fasihi M, Aghahosseini A. Securing future water supply for Iran through 100% renewable energy powered desalination. Int J Sustain Energy Plan Manag 2019;23. https://doi.org/10.5278/ijsepm.3305.

[36] Paliwal P. Reliability constrained planning and sensitivity analysis for Solar-Wind-Battery based Isolated Power System. Int J Sustain Energy Plan Manag 2020;29. http://doi.org/10.5278/ijsepm.4599.

[37] Johannsen RM, Østergaard PA, Hanlin R. Hybrid photovoltaic and wind mini-grids in Kenya: Techno-economic assessment and barriers to diffusion. Energy Sustain Dev 2020;54:111–26. http://doi.org/10.1016/j.esd.2019.11.002.

[38] Malik P, Awasthi M, Sinha S. Study of grid integrated biomass-based hybrid renewable energy systems for Himalayan terrain. Int J Sustain Energy Plan Manag 2020;28. http://doi.org/10.5278/ijsepm.3674.

[39] Odgaard O, Djørup SR. Review and experiences of price regulation regimes for district heating. Int J Sustain Energy Plan Manag 2020;29. http://doi.org/10.5278/ijsepm.3824.

[40] Connolly D, Lund H, Mathiesen BV, Werner S, Möller B, Persson U, et al. Heat roadmap Europe: Combining district heating with heat savings to decarbonise the EU energy system. Energy Policy 2014;65. http://doi.org/10.1016/j.enpol.2013.10.035.

[41] Djørup S, Sperling K, Nielsen S, Østergaard PA, Thellufsen JZ, Sorknæs P, et al. District heating tariffs, economic optimisation and local strategies during radical technological change. Energies 2020;13. http://doi.org/10.3390/en13051172.

[42] Djørup S, Thellufsen JZ, Sorknæs P. The electricity market in a renewable energy system. Energy 2018;162:148–57. http://doi.org/10.1016/J.ENERGY.2018.07.100.

[43] Sorknæs P, Djørup SR, Lund H, Thellufsen JZ. Quantifying the influence of wind power and photovoltaic on future electricity market prices. Energy Convers Manag 2019;180:312–24. http://doi.org/10.1016/J.ENCONMAN.2018.11.007.

[44] Sorknæs P, Lund H, Skov IR, Djørup S, Skytte K, Morthorst PE, et al. Smart Energy Markets - Future electricity, gas and heating markets. Renew Sustain Energy Rev 2020;119. http://doi.org/10.1016/j.rser.2019.109655.

[45] 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. http://doi.org/10.1016/j.energy.2014.02.089.

[46] 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. http://doi.org/10.1016/j.energy.2018.08.206.

[47] 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. http://doi.org/10.5278/ijsepm.3683.

[48] Hvelplund F, Østergaard PA, Meyer NI. Incentives and barriers for wind power expansion and system integration in Denmark. Energy Policy 2017;107. http://doi.org/10.1016/j.enpol.2017.05.009.

[49] Hvelplund F, Möller B, Sperling K. Local ownership, smart energy systems and better wind power economy. Energy Strateg Rev 2013;1:164–70. http://doi.org/10.1016/j.esr.2013.02.001.

[50] Kooij HJ, Oteman M, Veenman S, Sperling K, Magnusson D, Palm J, et al. Between grassroots and treetops: Community power and institutional dependence in the renewable energy sector in Denmark, Sweden and the Netherlands. Energy Res Soc Sci 2018;37:52–64. http://doi.org/10.1016/j.erss.2017.09.019.

[51] Sperling K, Hvelplund F, Mathiesen BV. Centralisation and decentralisation in strategic municipal energy planning in Denmark. Energy Policy 2011;39:1338–51. http://doi.org/10.1016/j.enpol.2010.12.006.

[52] Qarnain SS, Sattanathan M, Sankaranarayanan B. Analysis of social inequality factors in implementation of building energy

conservation policies using Fuzzy Analytical Hierarchy Process Methodology. Int J Sustain Energy Plan Manag 2020;29. http://doi.org/10.5278/ijsepm.3616.

[53] Meyer NI, Mathiesen BV, Hvelplund F. Barriers and potential solutions for energy renovation of buildings in Denmark. Int J Sustain Energy Plan Manag 2014;1. http://doi.org/10.5278/ijsepm.2014.1.5.

[54] Nielsen S, Thellufsen JZ, Sorknæs P, Djørup SR, Sperling K, Østergaard PA, et al. Smart Energy Aalborg: Matching End-Use Heat Saving Measures and Heat Supply Costs to Achieve Least Cost Heat Supply. Int J Sustain Energy Plan Manag 2020;25. http://doi.org/10.5278/ijsepm.3398.

[55] Lund H, Thellufsen JZ, Aggerholm S, Wichtten KB, Nielsen S, Mathiesen BV, et al. Heat Saving Strategies in Sustainable Smart Energy Systems. Int J Sustain Energy Plan Manag 2014;04:3–16. http://doi.org/10.5278/ijsepm.2014.4.2.

[56] Oliveira C, Coelho D, da Silva PP. A prospective analysis of the employment impacts of energy efficiency retrofit investment in the Portuguese building stock by 2020. Int J Sustain Energy Plan Manag 2014;2:81–92. http://doi.org/10.5278/ijsepm.2014.2.7.