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RESEARCH ARTICLE

Long-term urban microgrid design: Socio-spatial resilience to promote energy democracy

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Abstract · This research article argues that long-term considerations for sociotechnical resilience in urban microgrid design should include socio-spatial dimensions and energy democracy as key concepts. Referring to Otto Neurath and 'Red Vienna' of the 1920s this article uses historical analogy as a heuristic tool to open up alternatives and self-reflective perspectives for policy considerations. It points to potential negative effects of 'energy gerrymandering' on urban energy democracy, i.e. the setting of spatial microgrid boundaries with a bias merely on grounds of economic, or technological efficiency.

***Langfristiges urbanes Microgrid-Design**: Sozialräumliche Resilienz zur Förderung von Energiedemokratie*

Zusammenfassung · *Dieser Forschungsartikel argumentiert, dass langfristige Erwägungen für soziotechnische Resilienz im urbanen Microgrid-Design sozialräumliche Dimensionen und Energiedemokratie als Schlüsselkonzepte einbeziehen sollten. Mit Bezug auf Otto Neurath und das ‚Rote Wien' der 1920er-Jahre nutzt der Artikel das heuristische Mittel der historischen Analogie, um Alternativen und selbstreflexive Perspektiven für strategische Überlegungen zu eröffnen. Er weist auf mögliche negative Auswirkungen auf die Entwicklung einer Energiedemokratie in Städten durch ‚Energie-Gerrymandering' hin, d. h. durch die Festlegung räumlicher Microgrid-Grenzen mit Ausrichtung auf rein wirtschaftliche oder technologische Effizienz.*

Keywords · *socio-spatial resilience, energy democracy, urban design, microgrids, Otto Neurath*

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Introduction

In this research article we discuss the long-term sociotechnical consequences of urban microgrid design. Compared to today's large urban energy grids, microgrids can organize renewable energy distribution and production on a much smaller scale down to the neighborhood level (von Wirth et al. 2018). While it is widely agreed that microgrids can provide solutions for technical resilience of future urban energy systems, it is still an ongoing research issue as to how far their implementation can also contribute to urban social innovation, like enhancing urban democracy. We argue that the socio-spatial design of microgrid boundaries is crucial in this regard. It should avoid 'energy gerrymandering', i.e. the biased definition of spatial boundaries merely on the grounds of technical, or economic efficiency. Instead, socio-spatial microgrid design can enhance innovative forms of energy democracy by considering the social composition within a microgrid. We employ a historical analogy between the 1920s Vienna legacy of urban design and present-day microgrid design as a heuristic tool to open up a narrative of change as well as a self-reflexive perspective on, and alternatives to, future microgrid design.

The longevity of urban energy infrastructures, the need for continuous urban adaptation to climate change over the next decades and centuries, as well as the permanent struggle of urban dwellers for democracy emphasize that microgrid design

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can be at the heart of long-term urban governance. But how can socio-spatial and democracy-oriented microgrid design impact the long-term well-being in cities? And how can policy considerations include this expanded temporal horizon and overcome short-term technical solutionism? In answering these questions, we seek to contribute to an expanding body of research on the urban transition towards renewable energies in the fields of technical engineering and science and technology studies (STS) (for overviews see Nik et al. 2021; Rudek 2022). In our own previous work (Ottenburger et al. 2024; Ottenburger and Ufer 2023) as well as in this article, we join the endeavors of technology assessment (TA) to close the gap between these two fields' core interests in, on the one hand, implementing technical solutions and, on the other hand, the critical deconstruction of urban sociotechnical innovation (Lösch and Schneider 2016).

In the following sections, we first discuss historical analogy as a heuristic tool and the Vienna legacy of urban design as a case for thinking with history in order to grasp the expanded temporalities of urban long-term resilience. Secondly, we link microgrid design to socio-spatial dimensions and energy democracy as two key concepts for long-term resilience. Thirdly, we demonstrate the potentially negative effects of energy gerrymandering on energy democracy. Before concluding, we discuss policy considerations in light of the previous sections.

Thinking with history for the long-term: the Vienna legacy

Thinking with history for the long-term

Recent trends in STS and TA scholarship have underscored the importance of long-term temporalities for both revisiting the past and envisioning the future in order to conceive of alternatives for change (Flyverbom and Garsten 2021; Shanley 2021; Hausstein and Lösch 2020). And with a focus on cities, urban ethnography has shown how local historical consciousness can become a driving force for empowerment and bottom-up urban transformation (Ufer 2018). Thinking with history relativizes the present status quo and opens a perspective on alternatives. It becomes particularly relevant for urban design when it aims at enhancing well-being, considers the long-term, and seeks relevance with regard to pertinent human values (Inam 2002).

Historical analogy is an established heuristic tool to this end. It operates with "indirect evidence" (Flick 1991, p. 64), i.e. it does not compare quantitatively measurable clear-cut criteria and variables, nor does it seek to infer generalizable cause-effect relations. Analogies relate diachronic or synchronic cases whose specific situatedness in space and time naturally escapes such attempts at any deeper level of analysis. How to deal with potentials and limitations of analogical inference appropriately in scientific enquiry has therefore been discussed over decades in view of the obvious dilemma between methodological rigor and broadening the horizon of the investigation, and pros and cons have been pointed out at either end (Wylie 1985; Møller 2016). For the purposes of this study and in line with Ghilani et al.'s (2017, pp. 278) categorization, our use of historical analogy serves to relate the sociotechnical constellation of future urban microgrids with socio-spatial and democracy oriented urban design and to contribute to a narrative of change for decision takers.

The Vienna legacy

Vienna after World War I presents a paradigmatic case for both top-down urban planning and bottom-up urban design (Novy et al. 2001). On the one hand, faced with massive post-war urban immigration, the Social Democratic Worker's Party of 'Red Vienna' invested hugely in social resilience and infrastructure. Social and health services were improved and housing for more than 60,000 households built within ten years with particular attention to social stratification and representation of vulnerable groups within the large public housing blocks (Gruber 1991, pp. 45). On the other hand, the Austrian Association for Settlements and Small Gardens, headed by Otto Neurath, sought to reconcile the growth of well over 100,000 informal settlements by impoverished citizens and migrants with formal urban planning. The urban settlers resorted to self-organized housing construction, food autonomy and other shared resources by building on and cultivating Vienna's urban wastes.

Urban ethnography has shown how local historical consciousness can become a driving force for empowerment and bottom-up urban transformation.

Neurath, amongst other qualifications, was an urban designer and political economist, who was passionate about democratizing the city and supported the settlers' strive for autonomy and self-administration. Complementary to top-down urban planning and industrially replicable mass-architecture, he pursued bottom-up urban design by integrating local materials and citizens' knowledge, thus basing urban design "on the needs of the man in the street" (Hochhäusl 2011, p. 77). As a curator of numerous exhibitions and inventor of the international picture language ISOTYPE, which, still to this day facilitates visualized access to statistical data, he sought to make scientific knowledge accessible to the masses and applicable to their everyday problems.

Over the same period, electricity providers expanded into Vienna's streets and private households (Krausmann 2013), which

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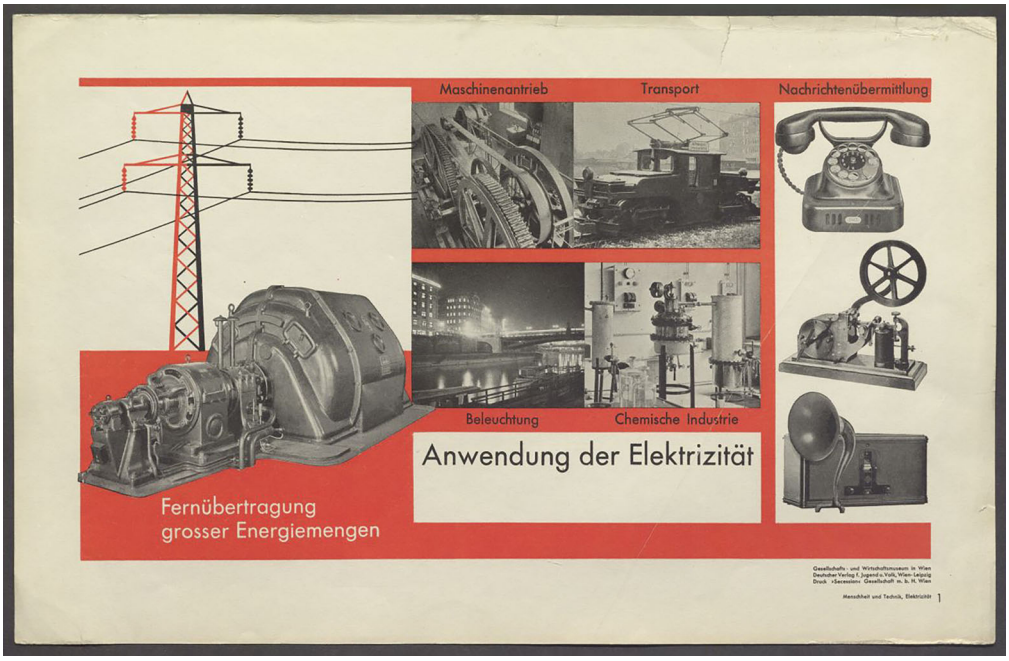

Fig. 1 Use of electricity. *Source: ÖGWM 1932, p. 1*

Fig. 2 Increase of electricity vs. gas powered street lighting in Vienna, visualized in ISOTYPE international picture language. *Source: ÖGWM 1932, p. 4*

makes the Vienna legacy even more pertinent for our argument. With the help of museum exhibitions and ISOTYPE Neurath and his followers made early efforts to promote energy literacy by enhancing citizens' understanding of how the energy transition to electricity impacted their everyday lives, e.g. by informing them about the uses of electricity (Fig. 1) and about the replacement of Vienna's gas-lit street lanterns (Fig. 2). With a prescient concern for what today would be called the resilience of urban energy systems, they pointed to the risk of blackouts, warning specifically of the latent danger in centralized energy systems "that a disturbance will cast whole districts into the dark and will cause a standstill of all machinery." (ÖGWM 1932, p. 9, authors' translation)

Long-term socio-spatial and democracy-oriented microgrid resilience

Over the past years, microgrid technology has received growing attention as a potential solution to the challenges posed

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by the transition of urban energy systems to renewable energy. Microgrids, i.e. decentralized, local, small-scale power networks that can rely largely or even exclusively on renewable energy, are capable of generating, storing, and distributing electricity in conjunction with the larger main grid during regular service, but can also operate independently during energy crises by drawing on their own renewable energy supplies, or on community energy storage systems (Ottenburger and Ufer 2019). From a purely technical perspective, urban microgrids are considered a redundancy and short-term resilience measure on the basis of stable equilibria that mitigates the risk of failures, such as blackouts and cascading effects (Little 2002), by quickly restoring the system to its status quo ante after a shock event.

With a view to the long-term, resilience understanding must go further and include the temporalities of sociotechnical dynamics, i.e. cycles of adaptations and improvements, but also of repair and maintenance (Denis and Pontille 2023). Both will affect the duration of independent operation (island mode) of a microgrid in the event of larger energy grid failures during periods of extreme weather, or in the aftermath of disasters – both ever more likely to occur as climate change unfolds. The complexity of a constantly evolving entanglement of society and technology is further influenced by variations in short-term and long-term social resilience capacities at both individual and community levels, relating to factors such as socio-economic status, access to public services and knowledge, and community embeddedness. Resilience policies must therefore consider the epistemic evolution of sociotechnical resilience as concept and practice (Amir and Kant 2018, pp. 11), which also includes integration of socio-spatial resilience and urban democracy.

Socio-spatial resilience

Debizet et al. (2016) have called for integration of spatial dimensions for the urban energy transition, and more recently the debate has focused on the social geography of urban microgrid resilience (Rutherford and Marvin 2023). Studying the case of Puerto Rico, Jeffers et al. (2018) have advocated microgrids for protection of critical resilience facilities against energy crises, which highlights the need to be sensitive to their location and accessibility. But beyond technological issues, the notion of local autonomy in times of energy crises raises the social issue of local communities' capacities for self-administration. Local energy communities on the model of representative urban democracy can be conceived within the spatial bounds of microgrids (Ottenburger et al. 2024; Palm et al. 2025). An energy-related 'right to the city' (Becker et al. 2020) and fair representation is therefore highly desirable for socially vulnerable groups that are more exposed to the negative effects of energy supply failures (Markhvida et al. 2020). The use of socio-spatial criteria in urban microgrid design could have a lasting impact in this regard by addressing multiple goals, such as balancing economic, environmental and social objectives, and can help avoid sectorized solutions and selective goal prioritization (Reinar and Lundberg 2024).

In the long run urban democracy and democratized energy literacy can play a crucial role in strengthening resilience capacities in communities.

Energy democracy

While technological soundness and affordability of microgrids are imperative, their design should simultaneously aim at social innovation far beyond mere technology acceptance (Kerscher et al. 2024). The concept of energy democracy (Szulecki 2018) brings particular attention to long-term issues like social resilience capacities within microgrids. Energy democracy has been criticized for decelerating transition, e.g. due to reiterative deliberative procedures in municipal regulation (Welton 2018). However, it is also recognized that in the long run urban democracy and democratized energy literacy can play a crucial role in strengthening resilience capacities in communities (Adil and Ko 2016). Energy democracy also addresses recent concerns over controversial aspects of urban resilience policies, e.g. regarding a relegation of responsibility for resilience capacities from state to community level (Meerow and Newell 2019). Instead, urban energy democracy can empower local energy communities in the larger context of urban society to engage in critical decisions, such as who designs microgrids, where, and with what goals in mind. Such questions need to be asked in order to raise public awareness and aid public participation in technological innovation.

Discussion: energy gerrymandering vs. energy democracy

In the U.S. electoral system, the term 'gerrymandering' refers to the biased drawing of boundaries to include or exclude specific voter groups. In our terms, "energy gerrymandering" (Ottenburger et al. 2024, p. 1068) points to the fact that, similar to electoral constituencies, spatial boundaries of microgrids are not natural, or without alternative, but should be designed with an understanding of who and what is included or excluded; even more so, if microgrids are to be considered a sociotechnical innovation that can support the formation of democratically organized urban energy communities. A scientifically grounded and equitable microgrid design could result from data-based analyses orientated

towards long-term energy transition policy based on geographic, socio-cultural, and census data (Ottenburger et al. 2024).

The choice between energy gerrymandering and energy democracy thus concerns the issue of democratic and demographic misrepresentation and the equitable distribution of resilience facilities across microgrids. If left to the biases of economic and technological efficiency, boundaries are likely to be drawn in ways that create socio-economic minorities and accumulate critical resilience in certain microgrids at the expense of others. Energy communities could be involved in decisions that concern their members' immediate local environment. They could decide on the rate of transition from fossil fuels to renewables, the energy mix balance, or the implementation and location of sociotechnical innovations that combine critical technical infrastructures and resilience facilities, like community storage systems in combination with community centers that offer cooling, warmth, information, water, or food during periods of extended energy crises. Energy communities within microgrids should also decide democratically on the ownership of energy infrastructure – whether public, private, or cooperative. Democratic and transparent decision taking becomes crucial when prioritizing energy distribution in times of scarcity, or when determining the use of profits from local surplus energy sales.

Democratic and transparent decision taking becomes crucial when prioritizing energy distribution in times of scarcity.

Historical analogy for policy considerations

Present-day high levels of urban well-being in Vienna, as documented in global ratings (Economist Intelligence 2024), are in part considered long-term outcomes of socio-spatial and democracy-oriented urban design of the period around the 1920s (Pérez del Pulgar 2021). What lessons, then, are suggested by analogical inference? The Vienna legacy and urban microgrid design clearly differ in that the former presents a concrete historical case while the latter is future orientated and therefore abstract. And both have been, or will be, embedded in their specific local contexts. However, as stated above, it is not the aim of historical analogy as a heuristic tool to seek objective evidence, or identify direct causal relations. Instead, with a view to long-term policy considerations for urban well-being in terms of socio-spatially sensitive design and urban democracy the Vienna legacy can enable historical thinking thereby unveiling the non-naturalness of the status quo. As Roberts and Nemet (2022, p. 1) have recently stated, historical analogies can play a crucial role for the sociotechnical approach, since they "present decision makers with memorable narratives and actionable examples".

Over the past decades, neoliberal regimes in urban administration and business have shifted the policy focus away from community and solidarity-oriented solutions, while fiscal challenges have created dependencies of municipalities on large tech companies for infrastructure modernization. Microgrid design thus runs the risk of being shaped by economic or technological efficiency constraints. The framing of Otto Neurath's 'Red Vienna' thus creates a self-reflexive field for policy considerations about the present status quo, stimulating questions about how we got here, and how things should move forward in the future implementation of microgrids.

In a first necessary step, local government, utility providers, and urban planners would define microgrid areas, while keeping socio-spatial resilience dimensions and energy democracy in mind. Complementary to and as a consequence of this top-down approach, certain decisions on microgrid development could then be entrusted in a bottom-up approach to local energy communities in order to continuously transform and develop their own microgrid infrastructure. Again, drawing on the same historical analogy, this would be similar to Vienna's public housing policy insofar as it would aim at fair representation and give a voice to socially vulnerable groups when building sociotechnical resilience capacities. This would involve decisions on how and where to set up local renewable energy infrastructure and local resilience services, like cooling and warming centers, or community kitchens. These services are of particular benefit to socially vulnerable households who cannot afford private solutions. Therefore, socio-spatial and democracy-oriented urban microgrid design would systematically highlight the needs of these groups and

- allow fair access to urban resilience facilities and other urban commons, similar to the Vienna settlers' self-organization. This includes the equitable distribution of such facilities, which become relevant, for example, during extreme weather events or distribution failures;
- empower residents to participate actively in and have access to decisions that concern their energy futures and urban well-being. In the same way that the settlements fostered a strong sense of community involvement through cooperation between citizens and municipal administration, a socio-spatially sensitive microgrid design could foster energy communities on the model of corporations that organize energy harvesting, storage, and distribution as a commons;
- draw regulators' attention to the long-term benefits of urban democracy and local empowerment, not only by providing residents with tools and fostering knowledge about the energy

transition to build and maintain their environments, but also, like Otto Neurath, by respecting and drawing on their own local and embedded knowledge of their city;
- view citizens not as economically defined entities, such as energy recipients or prosumers, but as active members of energy communities who own a right to the city. When designed in this way, microgrids could become more than just technical components of the energy transition. They could enhance urban socio-spatial resilience and democracy by ensuring fair representation within respective grid districts.

Conclusion

Today's urban design decisions create the foundation for future citizens' well-being. They are one step in a long historical continuum, reaching from past into future, of both active urban planning and slowly evolving urban social evolution shaped by larger historical conjunctures and socio-cultural dynamics. Climate change creates a constant need for foresighted adaptation and resilience policies in cities for decades on end. If designed with attentiveness to the hazards of selective goal prioritization, microgrids can enhance urban sociotechnical resilience by addressing energy failures and their impact on critical services, especially for socially vulnerable groups.

A design of microgrids, considered as purposefully created local energy communities, that pays attention to the composition of socially vulnerable groups from the outset and mitigates energy gerrymandering, should contribute over the long-term to more citizens involvement, to reduced vulnerability due to their embeddedness in an active and participatory community, and to general improvement of their well-being and urban resilience.

However, the long-term perspective also raises awareness of the fact that urban societies change over time. Thus, availability and good coverage of socio-economic data of respective microgrids are crucial starting points for socio-spatial and democracy-oriented microgrid design, but will need to be kept up to date. When microgrids are developed as described, they become integral parts of the urban energy system, acting as the nucleus of urban energy communities. Although these structures are difficult to alter once established, the operationalization of social vulnerability data allows for the integration of socially vulnerable groups effectively from the outset. As the urban landscape and neighborhood demographics evolve, updated data then enables city planners and local authorities to intervene with targeted measures, prioritize infrastructure improvements, and ensure that socially vulnerable groups are integrated into the decision-making process.

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References

Adil, Ali; Ko, Yekang (2016): Socio-technical evolution of decentralized energy systems. A critical review and implications for urban planning and policy. In: Renewable and Sustainable Energy Reviews 57, pp. 1025–1037. https://doi.org/10.1016/j.rser.2015.12.079

Amir, Sulfikar; Kant, Vivek (2018): Sociotechnical resilience. A preliminary concept. In: Risk Analysis 38 (1), pp. 8–16. https://doi.org/10.1111/risa.12816

Becker, Sören; Angel, James; Naumann, Matthias (2020): Energy democracy as the right to the city. Urban energy struggles in Berlin and London. In: Environment and Planning A: Economy and Space 52 (6), pp. 1093–1111. https://doi.org/10.1177/0308518X19881164

Debizet, Gilles; Tabourdeau, Antoine; Gauthier, Caroline; Menanteau, Philippe (2016): Spatial processes in urban energy transitions. Considering an assemblage of socio-energetic nodes. In: Journal of Cleaner Production 134, pp. 330–341. https://doi.org/10.1016/j.jclepro.2016.02.140

Denis, Jérôme; Pontille, David (2023): Before breakdown, after repair. In: Adriana Mica, Anna Horolets, Mikołaj Pawlak and Paweł Kubicki (eds.): Routledge International Handbook of Failure. London: Routledge, pp. 209–222. https://doi.org/10.4324/9780429355950-19

Economist Intelligence (2024): The global liveability index 2024. The world's most liveable cities. London: Economist Intelligence Unit. Available online at https://www.eiu.com/n/campaigns/global-liveability-index-2024/, last accessed on 15.04.2025.

Flick, Larry (1991): Analogy and metaphor. Tools for understanding inquiry science methods. In: Journal of Science Teacher Education 2 (3), pp. 61–66. https://doi.org/10.1007/BF02629748

Flyverbom, Mikkel; Garsten, Christina (2021): Anticipation and organization. Seeing, knowing and governing futures. In: Organization Theory 2 (3), p. 26317877211020325. https://doi.org/10.1177/26317877211020325

Ghilani, Djouaria et al. (2017): Looking forward to the past. An interdisciplinary discussion on the use of historical analogies and their effects. In: Memory Studies 10 (3), pp. 274–285. https://doi.org/10.1177/1750698017701609

Gruber, Helmut (1991): Red Vienna. Experiment in working-class culture, 1919-1934. New York, NY: Oxford University Press.

Hausstein, Alexandra; Lösch, Andreas (2020): Clash of visions. Analysing practices of politicizing the future. In: BEHEMOTH A Journal on Civilisation 13 (1), pp. 83–97. https://doi.org/10.6094/behemoth.2020.13.1.1038

Hochhäusl, Sophie (2011): Otto Neurath – city planning. Proposing a socio-political map for modern urbanism. Innsbruck: Innsbruck University Press.

Inam, Aseem (2002): Meaningful urban design. Teleological/catalytic/relevant. In: Journal of Urban Design 7 (1), pp. 35–58. https://doi.org/10.1080/13574800220129222

Jeffers, Robert et al. (2018): Analysis of microgrid locations benefitting community resilience for Puerto Rico. Albuquerque, NM: Sandia National Laboratories. https://doi.org/10.2172/1481633

Kerscher, Selina; Koirala, Arpan; Arboleya, Pablo (2024): Grid-optimal energy community planning from a systems perspective. In: Renewable and Sustainable Energy Reviews 199, p. 114485. https://doi.org/10.1016/j.rser.2024.114485

Krausmann, Fridolin (2013): A city and its hinterland. Vienna's energy metabolism 1800–2006. In: Simron Jit Singh, Helmut Haberl, Marian Chertow, Michael Mirtl and Martin Schmid (eds.): Long term socio-ecological research. Dordrecht: Springer Netherlands, pp. 247–268. https://doi.org/10.1007/978-94-007-1177-8_11

Little, Richard (2002): Controlling cascading failure. Understanding the vulnerabilities of interconnected infrastructures. In: Journal of Urban Technology 9 (1), pp. 109-123. https://doi.org/10.1080/106307302317379855

Lösch, Andreas; Schneider, Christoph (2016): Transforming power/knowledge apparatuses. The smart grid in the German energy transition. In: Innovation: The European Journal of Social Science Research 29 (3), pp. 262–284. https://doi.org/10.1080/13511610.2016.1154783

Markhvida, Maryia; Walsh, Brian; Hallegatte, Stephane; Baker, Jack (2020): Quantification of disaster impacts through household well-being losses. In: Nature Sustainability 3 (7), pp. 538–547. https://doi.org/10.1038/s41893-020-0508-7

Meerow, Sara; Newell, Joshua (2019): Urban resilience for whom, what, when, where, and why? In: Urban Geography 40 (3), pp. 309–329. https://doi.org/10.1080/02723638.2016.1206395

Møller, Jørgen (2016): Composite and loose concepts, historical analogies, and the logic of control in comparative historical analysis. In: Sociological Methods & Research 45 (4), pp. 651–677. https://doi.org/10.1177/0049124115578031

Nik, Vahid; Perera, Amarasinghage; Chen, Deliang (2021): Towards climate resilient urban energy systems. A review. In: National Science Review 8 (3), p. nwaa134. https://doi.org/10.1093/nsr/nwaa134

Novy, Andreas; Redak, Vanessa; Jäger, Johannes; Hamedinger, Alexander (2001): The end of red Vienna. Recent ruptures and continuities in urban governance. In: European Urban and Regional Studies 8 (2), pp. 131–144. https://doi.org/10.1177/096977640100800204

ÖGWM – Österreichisches Gesellschafts- und Wirtschaftsmuseum (1932): Technik und Menschheit, Heft 2. Vienna: Deutscher Verlag f. Jugend u. Volk. Available online at https://sammlung.gwm.museum/jart/prj3/guw-neurath/main.jart?rel=de&reserve-mode=active&content-id=1700425968638&item_id=10350, last accessed on 15.04.2025.

Ottenburger, Sadeeb et al. (2024): Sustainable urban transformations based on integrated microgrid designs. In: Nature Sustainability 7 (8), pp. 1067–1079. https://doi.org/10.1038/s41893-024-01395-7

Ottenburger, Sadeeb; Ufer, Ulrich (2019): Quartierspeicher für mehr urbane Resilienz. Ein Blick über den Tellerrand technischer Risiken bei der Energiewende. In: Transforming Cities 2/2019, pp. 66–69.

Ottenburger, Sadeeb; Ufer, Ulrich (2023): Smart cities at risk. Systemic risk drivers in the blind spot of long-term governance. In: Risk Analysis 43 (11), pp. 2158-2168. https://doi.org/10.1111/risa.14102

Palm, Jenny; Kojonsaari, Anna-Riikka; Magnusson, Dick (2025): Toward energy democracy. Municipal energy actions in local renewable energy projects. In: Energy Research & Social Science 120, p. 103921. https://doi.org/10.1016/j.erss.2025.103921

Pérez del Pulgar, Carmen (2021): Prioritizing green and social goals. The progressive Vienna model in jeopardy. In: Isabelle Anguelovski and James Connolly (eds.): The green city and social injustice. 21 tales from North America and Europe. London: Routledge, pp. 267–282. https://doi.org/10.4324/9781003183273-26

Reinar, Mathias; Lundberg, Aase (2024): Goals à la carte. Selective translation of the sustainable development goals in strategic municipal planning in Norway. In: Journal of Environmental Planning and Management 67 (11), pp. 2442–2458. https://doi.org/10.1080/09640568.2023.2191816

Roberts, Cameron; Nemet, Gregory (2022): Systematic historical analogue research for decision-making (SHARD). Introducing a new methodology for using historical case studies to inform low-carbon transitions. In: Energy Research & Social Science 93, p. 102768. https://doi.org/10.1016/j.erss.2022.102768

Rudek, Tadeusz (2022): Capturing the invisible. Sociotechnical imaginaries of energy. The critical overview. In: Science and Public Policy 49 (2), pp. 219–245. https://doi.org/10.1093/scipol/scab076

Rutherford, Jonathan; Marvin, Simon (2023): Urban smart microgrids. A political technology of emergency-normalcy. In: Urban Geography 44 (8), pp. 1794–1815. https://doi.org/10.1080/02723638.2022.2126609

Shanley, Danielle (2021): Imagining the future through revisiting the past. The value of history in thinking about R(R)I's possible future(s). In: Journal of Responsible Innovation 8 (2), pp. 234–253. https://doi.org/10.1080/23299460.2021.1882748

Szulecki, Kacper (2018): Conceptualizing energy democracy. In: Environmental Politics 27 (1), pp. 21–41. https://doi.org/10.1080/09644016.2017.1387294

Ufer, Ulrich (2018): Practicing urban transformation. Places of solidarity and creative traditionalism in transatlantic comparison. In: City & Society 30 (3), pp. 318–340. https://doi.org/10.1111/ciso.12179

Welton, Shelley (2018): Grasping for energy democracy. In: Michigan Law Review 116 (4), pp. 581–644. Available online at https://repository.law.umich.edu/mlr/vol116/iss4/2/, last accessed on 15.04.2025.

von Wirth, Timo; Gislason, Linda; Seidl, Roman (2018): Distributed energy systems on a neighborhood scale. Reviewing drivers of and barriers to social acceptance. In: Renewable and Sustainable Energy Reviews 82, pp. 2618–2628. https://doi.org/10.1016/j.rser.2017.09.086

Wylie, Alison (1985): The reaction against analogy. In: Advances in Archaeological Method and Theory 8, pp. 63–111. https://doi.org/10.1016/B978-0-12-003108-5.50008-7

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