Power to the People: A People-Centred Approach to Accelerate the Transition Towards Net Zero Emissions Energy Systems

BY SARA ZAIDAN AND MUTASEM EL FADEL

Abstract

This article introduces a framework linking the concept of "energy communities" to the Net Zero Emissions (NZE) agenda for envisioning the Paris Agreement. It presents the potential benefits of energy communities and examples of selected case studies showcasing global developments in community-driven projects and initiatives. The challenges are discussed, followed by people-centred policy recommendations to accelerate the transition towards democratized NZE energy systems.

In line with the directions of the Paris Agreement, the current global agenda is moving towards net zero emissions (NZE) energy systems given across different timelines but mostly centred around 2050, to limit global warming temperature levels to between 1.5°C to 2°C by 2100. The NZE agenda necessitates clean energy transitions, which involve shifting from traditional, fossil fuel-based energy systems to more sustainable and environmentally friendly alternatives. Since the enactment of the Paris Rulebook in 2016, much efforts ([1]–[5] targeted various types of energy-driven technologies that are deemed promising in attaining and accelerating the clean energy transition. Examples include (a) renewables such as solar photovoltaics, wind turbines (onshore and offshore), hydropower, biomass, and geothermal energy, (b) energy storage such as battery storage (lithium-ion, solid-state, flow batteries), pumped hydro storage, compressed air energy storage, thermal energy storage, (c) energy efficiency technologies such as high-efficiency HVAC (heating, ventilation, and air conditioning) systems, lighting and appliances, (d) advanced nuclear technologies, (e) advanced materials and manufacturing, (f) electrification such as electric vehicles, charging infrastructure and battery technologies, (g) smarts grids and grid management, and (h) carbon capture and utilization (CCU) and storage (CCS), and (i) hydrogen-based technologies considering green hydrogen production, hydrogen fuel cells and hydrogen storage and transportation. In fact, the existing spectrum of feasible technologies for attaining the long-desired goal of NZE energy systems is wide, with over 550 individual technology designs and components related to the energy system [6] reported by the International Energy Agency (IEA) towards envisioning a global trajectory to keep the ideal 1.5°C goal in reach [7]. These technologies have different readiness levels, which are identified within several phases of either concept, small to large prototype, demonstration, market uptake, or mature.

Nonetheless, the fundamental question remains: is technological change "enough" or "just enough"?

In attempting to answer this question, recent efforts ([8]–[10]) examined the role of societal behaviour and lifestyle change in pursuit of the NZE agenda. It is invariably argued that technological change alone is not sufficient without the consent and active support of people. From here emerges the concept of "energy communities" which hands the power to people towards achieving people-centred clean energy transitions. A people-centred approach means the active involvement of the general public in decision-making and the delivery of NZE energy systems [11]. While there is no standard definition of it, energy communities refer to collective entities or groups of individuals, businesses, or organizations that voluntarily accept to participate in energy generation, distribution, and consumption for the management of the energy system [12]. Irrespective of the actual "structural form", the role of people, or what we can refer to hereafter as local citizens, lies at the heart of energy communities that are founded on the principles of social cohesion and unity to promote sustainability for regional development. Members of these communities adopt measures that foster development mainly in the areas of renewable energy and energy efficiency to share common objectives of supply security, accessibility and affordability, as well as environment protection. The concept of energy communities is closely linked to the broader goals of the energy trilemma pillars in the context of the NZE agenda as demonstrated by Figure 1.

As demonstrated, policy interventions are the vehicle to implement technological changes that go hand-in-hand with complementary social changes that emphasise a people-centred approach. This is exemplified by concepts like energy communities, contributing towards attaining just and inclusive clean energy transitions. The proposed framework emphasizes sustainable policy planning and formulation integrating both technical and social solutions to accelerate the transition towards NZE energy systems. Zooming into the social dimension, the concept of energy communities is becoming increasingly prevalent worldwide for realizing the Paris Agreement goals. Energy community projects are entirely or partially owned, managed, and democratically controlled by local citizens. Members of these communities can have different levels of involvement in the project from production to storage to management of energy. Figure 2 depicts a fictional schematic conceptualizing "energy communities" as part of the NZE transition.

Certain countries have long adopted energy communities as an energy management model, while others have recently discovered their potential, and many have yet to do so. The history and culture of a country determine its driving policy levers and implementation

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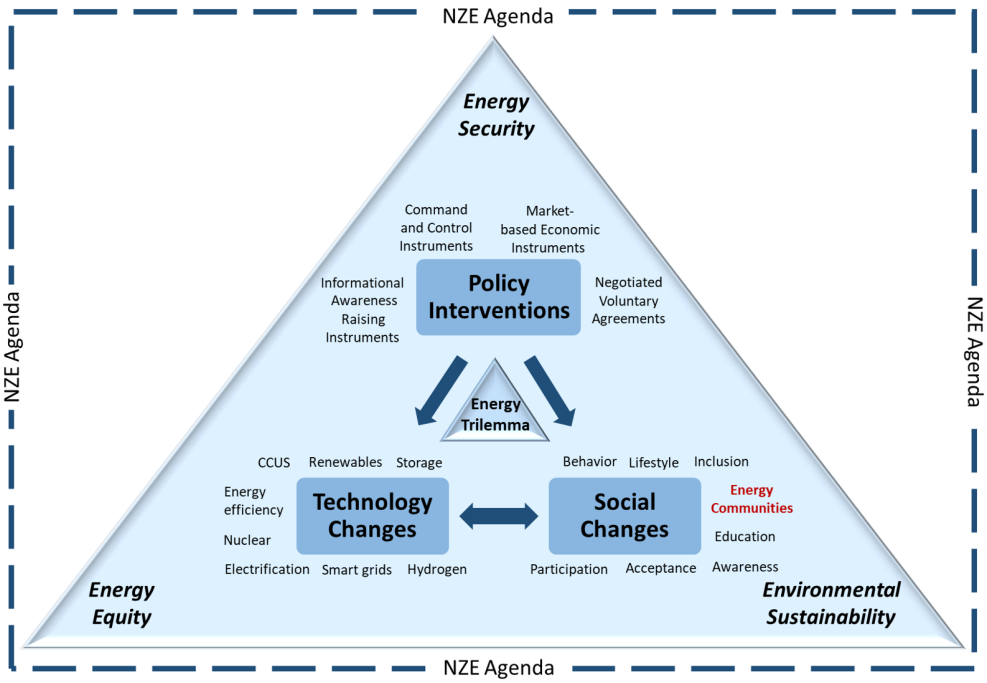

Figure 1: Proposed framework linking policy, technology, and social dimensions with the energy trilemma pillars within the context of the NZE agenda.

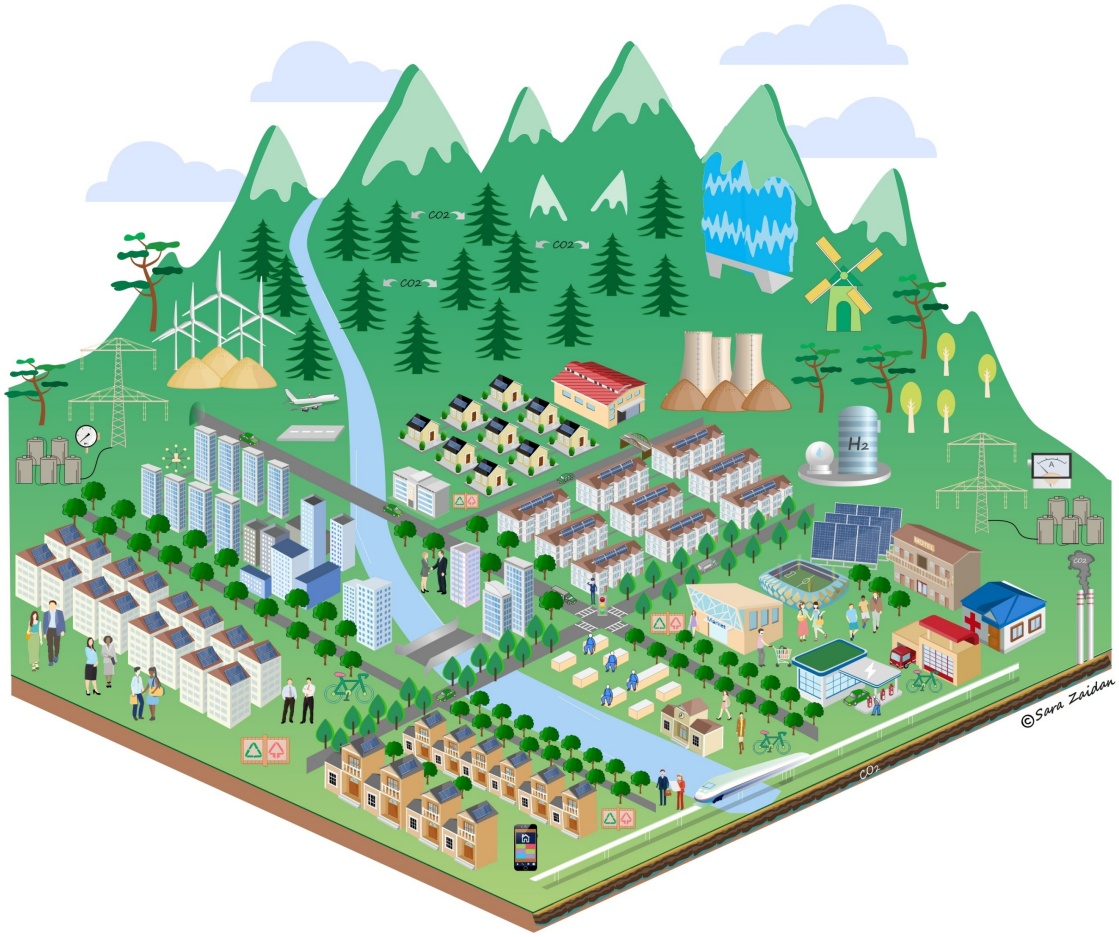

Figure 2: Schematic illustration envisioning the concept of "energy communities" within NZE energy systems.

Table 1: Selected case studies demonstrating the status of energy communities from a global perspective.

Region	Country	Projects/Initiatives
Europe	Italy	—The Italian National Recovery and Resilience Plan provided a fund of EUR 2.2 billion to aid energy communities and self-consumption initiatives.
	Spain	—Crevillent village, a local energy community using solar photovoltaic technology allowing residents to consume self-generated electricity from collectively owned photovoltaic panels.
	Greece	—Allocated a fund of EUR 42 million to support local energy communities operating via net metering and fulfill the electricity requirements of public facilities and households experiencing energy poverty.
	United Kingdom	—Introduced a GBP 10 million Community Energy Fund in 2023 to support the growth of energy communities considering a variety of projects including wind farms, rooftop solar systems, battery storage, heat networks, and electric vehicle charging stations for rural and urban areas.
	Germany	—The Renewable Energy Act was passed guaranteeing fixed feed-in tariffs for local citizens generating renewable power, which encouraged households to install rooftop photovoltaic panels and feed the produced electricity into the grid or consume it themselves.
	Denmark	—Karise Permatopia eco-village established a shared geothermal heating system powered by locally produced renewables, along with Avedøre which is an energy community that supports projects related to the production and storage of renewable energy.
	Scotland	—Barr River Hydropower Scheme has an installed capacity of 1.6MW and delivers 100% community-owned hydropower to 1000 homes.
North America	United States	—The Inflation Reduction Act provides 10% additional financial incentives for community-based clean energy projects.
Oceania	Australia	—Collective utilization of battery resources by 119 households led to savings exceeding AUD 81,000 within five years, reducing 85% of electricity consumption from the grid at peak times.
Asia	India	—Aga Khan Foundation developed a project to help 100 villages in remote areas escape energy poverty using a community-led model that increases the adoption of efficient, renewable energy products.
South America	Brazil	—RevoluSolar photovoltaic community project enabled renewable energy access for 30 families, where the profits from the projects were used for job training to reduce local unemployment rates and protect the citizens from rising energy prices.
Africa	Zambia	—Mwembeshi Solar Mini-Grid provides electricity to a rural community with over 600 households, schools and health clinics.

models. Nevertheless, differences disappear when we consider the common goal of clean energy transitions towards NZE community-driven energy systems. Table 1 presents a brief overview of global developments in the field of energy communities considering various case studies.

These global energy community projects have demonstrated clear benefits which include [13]:

—Adopting energy efficiency measures and renewable energy resources such as individual homes solar panels and larger-scale community wind farms or biomass plants
—Reducing energy bills, enhancing local resilience, alleviating energy poverty, and minimizing regional disparities and vulnerability through the supply of affordable energy
—Minimizing grid stress and costly infrastructure upgrades during peak demand periods
—Creating jobs, investment opportunities for local businesses, and generating income/profit which supports the local economy
—Improving energy security and independence by supporting access to local sustainable resources and improving the quality and reliability of power supply
—Developing stronger social bonds through people's active involvement including management of citizen-owned production units and the use of local resources. Citizens can become prosumers and participate in local energy system decisions, fostering a sense of ownership and obligation
—Improving local air quality and decreasing air pollution levels by substituting fossil fuel-based energy generation with sustainable energy production and consumption
—Deploying new technologies to restructure the energy system, offering a testing ground for emerging innovations such as smart grids, energy storage, and demand-response systems
—Decarbonizing the energy system to attain the NZE target for the overall mitigation of climate change

However, despite their benefits, community-led energy projects can face their share of persistent challenges in terms of their establishment and operation. These challenges commonly span the technical, economic, social, and institutional domains. In particular, there are regulations to navigate, funding to secure, and public support to gain. Further illustrative examples include [13]–[16]:

—*Technical:* grid connection, infrastructure (generation, transmission, and distribution networks), smart meter operation, information and communication technology (ICT) installations
—*Economic:* financing and funding issues (cost of new technological components and equipment), unequal distribution of costs and benefits, instability of energy market conditions
—*Social:* public acceptance (motivation and positive attitude), community participation, capacity building (reskilling and training), ownership, customers unwill-

Table 2: Policy instruments for clean energy transitions considering a people-centred approach.

	Policy Instrument	Type of Instrument
1.	Command and Control Instruments	—Codes (building codes, land and other resource management codes) —Standards (appliance, vehicle, building, technology, renewable portfolio) —Energy auditing and assessment programmes —Obligation/compulsory schemes —Regulations / directives / acts / ordinances / laws —Bans / prohibitions / limits / thresholds
2.	Market-based Economic Instruments	—Taxes / charges / penalty —Subsidies / grants / rebates / funds / loans —Feed-in tariffs / premiums —Tax deductions / relief / exemptions —Credits (energy saving loans) —Licenses —Tradable permits / quotas (emissions trading system or cap and trade) —Direct/public investments (infrastructure, procurements, research and development spending) —Environmental offset and banking —Competitive auctions / bidding —Net metering —Time of use pricing
3.	Informational Awareness Raising Instruments	—Labels (energy efficiency labels, performance labels) —Smart meters and billing information —Subsidized consultation / advisory services —Education/communication campaigns and promotions —Training and professional qualification / capacity building —Research, development and deployment programs —Demonstration project / pilot trials / prototypes —Environmental reporting, monitoring and verification —Access to information and justice rights —Opinion and feedback surveys —Third-party certification programs (green and white certificates)
4.	Negotiated Voluntary Agreements	—Agreed commitments / target setting —Consensus-based negotiations / networks —Recognition and innovation awards / prizes —Technical support / technology transfer / capital exchange —Internationalism / public-private partnerships / joint venture —Institutional creation / organizational structures —Strategic planning / action plans / initiatives

ingness to alter consumption habits, inclusivity and equity across diverse community members

—*Institutional:* regulatory and legal barriers, political obstacles, effective business models, supportive governance schemes, administrative and authorization processes bottlenecks, monitoring and controlling the newly structured energy system, environmental considerations of potential new projects

The highlighted challenges related to energy communities pave the route for identifying opportunities in achieving democratized, community-driven energy systems. Policy governance emerges as a pivotal force for driving change in this context, considering that energy communities are shaped by policies at several levels ranging from regional to national and local. Consequently, the role of the government and policymakers is vital in enabling regimes that establish and nurture energy communities. This necessitates identifying how to engage people in the clean energy transition towards NZE, understanding how people's lives will be disrupted, and integrating co-benefits into the policy-making process [11]. Table 2 outlines examples of the policy instruments that can be adopted to drive change towards just and inclusive clean energy transitions considering a people-centred approach.

Evidently, policy governance structures within energy communities can range from informal grassroots initiatives to formalized legislation. Future prospects can be guided by the broad arena of potential policy techniques to advance developments of energy communities [13]–[16]. For example, a specialized legal framework can be established to overcome the complexity of operating these communities. A legal entity can be formed to allow for open and voluntary participation among members and to increase the coordination between national and regional governments, following a democratic format for internal decision-making. Periodic meetings and public consultations can be conducted to address rising community concerns. Legislation on collective self-consumption can also provide energy communities with a strong legal foundation, while clear guidelines and streamlined administrative processes facilitate community-led activities. On a similar note, collaboration is required among academia and industry with energy communities through joint transdisciplinary projects and knowledge transfer. This may include conducting pilot trials and designing real

system prototypes to demonstrate potential benefits and thus increase public acceptance at the community level. With relevant stakeholders, governments can facilitate for energy communities knowledge exchange platforms and networks such as campaigns, workshops, and online forums to promote sustainable cultural awareness and education. Other supportive policy levers that governments can introduce include net metering, feed-in tariffs, community-based renewable targets, updated grid codes, as well as tax incentives, grants, subsidies, low-interest loans, grants, or venture capital for community-led energy projects, among many others. Additional technical support mechanisms involve increasing grid capacities, providing easy-to-use tools to show energy generation and consumption profiles, and securing reliable information and communication technology (ICT) structures and load management logistics. To top that, joint purchase, remuneration and smart contracts for shared flexibility, along with Pay for Performance (P4P) contracting and Energy Performance Contracting (EPC), represent innovative mechanisms to further streamline the adoption of community energy projects. Other potential opportunities include leveraging artificial intelligence and machine learning techniques to effectively manage the energy system and optimize its operation, along with maintaining and controlling community assets.

To close, a people-centred approach is paramount for the successful implementation of climate policies required to achieve the Paris goals. Without putting people at the heart of future energy systems, the NZE ambition is most certainly out of reach.

References

[1] T. Otsuki, Y. Shibata, Y. Matsuo, H. Obane, and S. Morimoto, "Role of carbon dioxide capture and storage in energy systems for net-zero emissions in Japan," *Int. J. Greenh. Gas Control*, vol. 132, p. 104065, Feb. 2024, doi: 10.1016/J.IJGGC.2024.104065.

[2] K. Akimoto, "Assessment of road transportation measures for global net-zero emissions considering comprehensive energy systems," *IATSS Res.*, vol. 47, no. 2, pp. 196–203, Jul. 2023, doi: 10.1016/j.iatssr.2023.02.005.

[3] J. Price, I. Keppo, and P. E. Dodds, "The role of new nuclear power in the UK's net-zero emissions energy system," *Energy*, vol. 262, p. 125450, Jan. 2023, doi: 10.1016/J.ENERGY.2022.125450.

[4] G. Vats and R. Mathur, "A net-zero emissions energy system in India by 2050: An exploration," *J. Clean. Prod.*, vol. 352, no. March, p. 131417, 2022, doi: 10.1016/j.jclepro.2022.131417.

[5] S. Afrane *et al.*, "Role of negative emission technologies in South Africa's pathway to net zero emissions by 2050," *Energy Sustain. Dev.*, vol. 79, p. 101401, Apr. 2024, doi: 10.1016/J.ESD.2024.101401.

[6] International Energy Agency, "Energy Technology Perspectives Clean Energy Technology Guide." https://www.iea.org/data-and-statistics/data-tools/etp-clean-energy-technology-guide (accessed Feb. 16, 2024).

[7] International Energy Agency, "Net Zero Roadmap: A Global Pathway to Keep the 1.5°C Goal in Reach," 2023. Available: https://www.iea.org/reports/net-zero-roadmap-a-global-pathway-to-keep-the-15-0c-goal-in-reach.

[8] T. M. Marteau, N. Chater, and E. E. Garnett, "Changing behaviour for net zero 2050," *BMJ*, vol. 375, no. October, p. n2293, 2021, doi: 10.1136/bmj.n2293.

[9] G. Perlaviciute, L. Steg, and B. K. Sovacool, "A perspective on the human dimensions of a transition to net-zero energy systems," *Energy Clim. Chang.*, vol. 2, p. 100042, Dec. 2021, doi: 10.1016/j.egycc.2021.100042.

[10] S. Nelson and J. M. Allwood, "Technology or behaviour? Balanced disruption in the race to net zero emissions," *Energy Res. Soc. Sci.*, vol. 78, no. January, p. 102124, 2021, doi: 10.1016/j.erss.2021.102124.

[11] C. Verfuerth, C. Demski, S. Capstick, L. Whitmarsh, and W. Poortinga, "A people-centred approach is needed to meet net zero goals," *J. Br. Acad.*, vol. 11, no. S4, pp. 97–124, 2023, doi: 10.5871/jba/011s4.097.

[12] S. Moroni, V. Alberti, V. Antoniucci, and A. Bisello, "Energy communities in the transition to a low-carbon future: A taxonomical approach and some policy dilemmas," *J. Environ. Manage.*, vol. 236, no. January, pp. 45–53, 2019, doi: 10.1016/j.jenvman.2019.01.095.

[13] S. ; Ahmed *et al.*, "A Review of Renewable Energy Communities: Concepts, Scope, Progress, Challenges, and Recommendations," *Sustainability*, vol. 16, no. 5, p. 1749, Feb. 2024, doi: 10.3390/SU16051749.

[14] G. Di Lorenzo, E. Stracqualursi, L. Micheli, L. Martirano, and R. Araneo, "Challenges in Energy Communities: State of the Art and Future Perspectives," *Energies*, vol. 15, no. 19. Multidisciplinary Digital Publishing Institute, p. 7384, Oct. 08, 2022, doi: 10.3390/en15197384.

[15] G. Yiasoumas *et al.*, "Key Aspects and Challenges in the Implementation of Energy Communities," *Energies*, vol. 16, no. 12. Multidisciplinary Digital Publishing Institute, p. 4703, Jun. 14, 2023, doi: 10.3390/en16124703.

[16] M. L. Lode, G. te Boveldt, T. Coosemans, and L. Ramirez Camargo, "A transition perspective on Energy Communities: A systematic literature review and research agenda," *Renewable and Sustainable Energy Reviews*, vol. 163. Pergamon, p. 112479, Jul. 01, 2022, doi: 10.1016/j.rser.2022.112479.