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Sustainability and Smart Cities: Linking Renewable Energy with Gender-inclusive Urban Policies

Sürdürülebilirlik ve Akıllı Şehirler: Yenilenebilir Enerjiyi Cinsiyet Ayrımcılığına Sahip Kentsel Politikalarla Bağlantılandırmak

Meltem İnce Yenilmez [a,*] & Özgür Yenilmez [b]

[a] Prof.Dr., İzmir Democracy University, Faculty of Business and Economics, Depart. of Economics, 34140, Izmir / Turkiye
ORCID: 0000-0002-4689-3196

[b] Interior Architect, NCMAS LTD., 99850, Iskele / North Cyprus
ORCID: 0009-0005-9678-3242

ANAHTAR KELİMELER

Yenilenebilir enerji
Akıllı şehirler
Karbonsuzlaştırma
Toplumsal cinsiyet eşitliği

ÖZ

Kentsel ekonomiler, sera gazı emisyonlarının büyük bir bölümünü oluşturdukları ve sürdürülebilir enerji geçişini sağlama kapasitesine sahip oldukları için küresel karbonsuzlaşmaya büyük katkı sağlamaktadır. Akıllı şehirler, yenilenebilir enerji sistemlerini benzersiz bir şekilde entegre eden dijital teknolojiler aracılığıyla yenilenebilir enerji kaynaklarının verimli şebekelere, ademi merkeziyetçiliğe ve yeşil altyapıya nasıl dayanabileceğinin farkına varacaktır. Eşitlikçi enerji erişimi ve işgücüne katılımın önünde engeller bulunmaktadır. Toplumsal cinsiyete duyarlı politikalar, kentsel enerji planlamasına eşitliğin yerleştirilmesine, çeşitli işgücü katılımına ve son olarak yetersiz hizmet alan toplulukların entegrasyonuna yönelik kapsayıcı geçişler sağlayabilir. En iyi uygulamalar Kopenhag, Amsterdam ve Fujisawa'dan alınmıştır. Odak noktası, kentsel kalkınmayı küresel iklim hedeflerine bağlayacak ve dünya çapında sürdürülebilir, kapsayıcı ve dirençli şehirler için çevresel ve ekonomik politikaları sosyal eşitliğe doğru dönüştürecektir.

KEYWORDS

Renewable energy
Smart Cities
Decarbonization
Gender Equity

ABSTRACT

Urban economies contribute greatly to global decarbonization because they account for a huge volume of greenhouse gas emissions, and they can drive sustainable energy transition. Smart cities would recognize the way renewables can rely on efficient grids, decentralization, and green infrastructure altogether through digital technologies that uniquely integrate renewable energy systems. There exist obstacles to equitable energy access and workforce inclusion. Gender-responsive policies can ensure inclusive transitions into embedding equity in urban energy planning, diverse workforce participation, and finally integrating underserved communities. Best practices are drawn from Copenhagen, Amsterdam, and Fujisawa. The focus will link urban development to global climate goals and transform environmental and economic policies toward social equity for sustainable, inclusive, and resilient cities worldwide.

1. Introduction: The Imperative for Decarbonization in Urban Economies

The urban areas are at the forefront of the global decarbonization agenda simply because they are great contributors to greenhouse gas emissions yet hold enormous potential in driving sustainable energy transitions. In that regard, smart cities—urban ecosystems harnessing digital technologies for efficiency and innovation—are uniquely positioned to lead this transformation. There is an imperative to integrate renewable energy into urban systems to reduce carbon footprints, increase energy security, and assure economic sustainability. Most urban decarbonization strategies, however, overlook this critical intersection of technology, energy, and social equity—especially how gender shapes both access to, and benefits from, energy

* *Sorumlu yazar/Corresponding author*.

e-posta: *melteminceyenilmez@gmail.com*

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innovation (Bibri et al., 2023). Gender equity in access to energy and employment is an increasingly recognized ingredient of successful comesble energy policy. Women, especially in developing and underserved communities, face disproportionate barriers to accessing clean energy solutions and are underrepresented in the renewable energy workforce. Systemic changes in policy frameworks, urban planning, and energy governance would be needed to bridge these gaps. One of the opportunities offered by smart cities is that of addressing these discrepancies by including inclusive design principles in their energy strategies.

The purpose of the research is to answer how smart cities optimize renewable energy systems concerning dealing with disparities regarding gender. This paper contributes toward an integral comprehension of how decarbonization efforts may balance economic, environmental, and social goals based on case studies, regulatory frameworks, and the exploration of new technologies by exploring policy and technological innovations necessary to ensure energy equity integration within urban planning. A very important publication because, through the book, come urban development, energy systems, and gender equity all on one single platform. Cities globally, committed to goals of net-zero emissions, ensure energy transition leaves no one behind—is no longer going to be an issue of morality but, if anything, purely economic and environmental necessities. This paper is very instrumental in calling for collaboration among policies, technologies, innovation, and gender-inclusive practices towards decarbonized urban economies.

2. Literature review

Cornerstones of urban decarbonisation strategies now include renewable energy systems: solar, wind, and geothermal. Further, research has shown that decentralized energy systems, including microgrids and rooftop solar panels, can contribute significantly toward improving energy resilience in urban areas and reducing carbon footprints. Muttaqee et al. (2023) examined microgrid installations in American communities to show how the systems might help energy equity by supplying dependable, locally produced electricity to underprivileged areas. Non-renewable energy sources can be defined as energy sources that are finite in nature and do not regenerate at a sustainable rate. These include petroleum, natural gas, and coal. The word "non-renewable" suggests that these energy sources could be depleted and that such energy resources are available only in limited amounts in the Earth's reserves. These resources are often referred to as fossil fuels, named after the processes that formed them, whereby parts of living organisms have been broken down over millions of years. Dependency on non-renewable energy always tends to throw significant questions on sustainability; for their depletion and hazardous influence on the environment shout for a transition to more renewable and sustainable energy systems (Altun & İşleyen, 2018). For instance, by implementing community solar programs and microgrid installations, Boulder, Colorado, and New York City have led the way in renewable energy transitions and provided scalable models for urban decarbonization (Benson et al., 2023).

Magnusson (2012) and Ben Amer et al. (2019) looked at district heating system adoption in Europe and found that Copenhagen, Stockholm, and Helsinki were the top cities for renewable-powered urban heat networks. While Stockholm's district heating system has used waste heat and biofuels to almost achieve zero carbon emissions, Copenhagen's achievement is credited to policy alignment between the municipal governments and the renewable energy source. The majority of cities, particularly those in Central and Eastern Europe, like Warsaw, have outdated infrastructure, which makes it difficult to replicate such models, which demand a significant initial outlay of funds (Markard & Rosenbloom, 2020).

Bahuet (2024) elucidates transforming city governance would be necessary to have resilient, equal, and sustainable urban environments. Imprinting into the minds of people that tomorrow's cities are a result of their today decisions is especially important as inclusive policies are needed for any urban settlement today economically, socially, and environmentally. The newly envisaged type of city leadership proposed in the paper would advocate transformation beyond just urban management.

The development and testing of a methodology for assessing gender equality of urban climate policies were undertaken with women's groups from India, Indonesia, Mexico and South Africa. The GAMMA [Gender Assessment and Monitoring of Mitigation and Adaptation] methodology engages in a thorough contextual and institutional examination of cities' mitigation and adaptation policies. Application of GAMMA by women's organizations in 14 pilot cities produced policy recommendations for achieving gender equality in urban mitigation and adaptation actions. Evidence from a monitoring exercise confirmed that the project has advanced significantly in raising awareness on gender issues and action at the urban level. This empowers civil society organizations for climate justice to demand local government action towards cities that are low carbon, resilient, gender-just and inclusive. It also allows local governments to self-assess (Alber, 2024).

In the Asia-Pacific, Japan has equally led in the integration of renewable energy sources. Solar power, hydrogen fuel cells, and modern large-scale energy storage have been incorporated within the urban infrastructural frameworks of cities such as Yokohama and Tokyo (Yamaguchi et al., 2022). The Fujisawa Sustainable Smart Town demonstrates how renewable energy can be integrated with optimization into the planning of urban use, through a combination of solar panels, battery storage, and energy management systems. Land-use constraints and high population densities remain, however, large barriers to the deployment of renewable energies in Japanese cities.

While these examples show success, persistent barriers,

such as regulatory inconsistencies, high up-front costs, and technological limitations, remain substantial hurdles globally. For instance, there is no national policy framework in the United States to integrate renewable energy into cities, which results in varied approaches across different states (Sovacool et al., 2022). In comparison, the European Union's Renewable Energy Directive (RED II) and Japan's Feed-in Tariff (FIT) system have more holistic frameworks in place. However, these also face challenges in aligning with urban planning goals (Daphne, 2020).

2.1. Smart Cities as Catalysts for Decarbonization

The smart city paradigm leverages digital technologies, including IoT, AI, and big data, to optimize urban energy consumption and reduce emissions. As such, a study by Sharma and Gupta (2022) stated that integration with real-time energy monitoring systems in some pilot cities reduces energy consumption in India by up to 25%. In Europe, Amsterdam and Barcelona have been among the frontrunners in embedding renewable energy technologies within city planning. Under its Smart City initiative, Amsterdam has integrated IoT technologies in the monitoring and optimization of energy use in transportation, buildings, and public spaces, which has yielded considerable carbon reductions (Hassebo and Tealab, 2023). Barcelona has mandated solar panel installations on new buildings and decentralized energy systems to enhance grid resilience (Scordato and Gulbrandsen, 2024). In Japan, under the Society 5.0 framework, many initiatives focus on the integration of digital technologies with urban planning. In Tokyo, for example, AI-driven platforms have been used for demand prediction to optimize renewable energy use, while in Yokohama, efforts have been channelled toward integrating smart grids with solar and wind energy systems (Yamaguchi et al., 2022). Still, this has not overcome the challenge of scalability. Fragmented governance, high costs, and unequal technological adoption rates complicate the widespread implementation of smart city solutions (Sovacool et al., 2020). In the United States, New York City and San Diego have shown what smart city technologies can do to drive renewable energy adoption. On the other side, New York's "Smart City, Clean Energy" initiative aims at managing the distribution of energy using AI and IoT; on its part, the Climate Action Plan of San Diego integrates renewable with urban planning for a 100% renewable electricity vision by 2035 (Furszyfer Del Rio et al., 2021).

2.2. Gender Equity in Renewable Energy and Urban Planning

One of the most critical, yet underexplored, dimensions in urban decarbonization is gender equity. Evidence has been found of wide gender gaps in energy access, employment in renewable energy, and participation in urban planning. Indeed, women, especially in poor communities, face a disproportionately higher energy burden because of the lack of access to clean and affordable energy (Sovacool and Griffiths, 2020). This situation is rather acute in countries like the United States where energy poverty hits the marginalized groups within those communities (Koffka, 2023). In Europe, gender equity initiatives have taken hold with programs such as the EU's Horizon Europe, which provides funding for gender-responsive research and innovation in renewable energy and urban planning. For instance, Poland's "Energy for Women" program trains women in clean energy technologies, providing a model for addressing workforce disparities. Globally, according to IRENA (2021), women make up only 32% of the renewable energy workforce, with even lower representation in technical and leadership positions. Similarly, Japan has taken steps to address disparities in renewable energy on grounds of gender. The Women in Energy initiative aims at training and supporting women entering the sector, in line with broader national goals to increase gender equality within STEM fields (Yamaguchi et al., 2022). However, cultural and structural barriers remain for women to participate meaningfully in decision-making processes around urban energy planning.

While previous research has investigated the role of renewable energy and smart technologies in urban decarbonization, few works exist at the intersection of these areas with gender equity. Most research tends to treat the domains of social equity, technological innovation, and urban planning in isolation, overlooking the systemic interdependencies that shape policy outcomes. For instance, while decentralized energy systems have been studied for their importance, few analyzed how such systems can help address gender disparities in both energy access and employment. This paper tries to fill these gaps by integrating gender-responsive frameworks into analyses of renewable energy adoption and smart city development. The study thus makes a contribution toward more holistic understanding of sustainable urban development by addressing the interlinkages between renewable energy, smart technologies, and gender equity.

3. Smart Cities and Renewable Energy Integration

The use of digital technologies, added to IoI, AI, and big data, makes up the optimization of energy consumption and waste reduction in achieving increased urban efficiency. At the heart of this model is renewable energy: it powers smart grids, electric vehicle infrastructure, and decentralized energy systems. Cities like Amsterdam and Copenhagen have proven it can be done: by integrating renewables into urban design through solar housing, wind farms, and highly efficient district heating systems. However, replication of such solutions in multiple cities faces financial, technological, and regulatory barriers. A very important area of integration is in the development of energy-efficient buildings and microgrids. Smart buildings with energy management systems can reduce consumption and generate renewable energy on-site, creating self-sustaining units within the urban fabric (Bibri et al., 2023). Cities like Barcelona have adopted policies that make it compulsory to include renewable energy technologies in new urban

developments. These developments give the smart city a role as a test bed for sustainable energy solutions, but this also requires intense collaboration among authorities, private businesses, and the general public (Ince Palamutoğlu, 2023).

Incorporating renewable energy into smart cities is a governance issue more than a technological one. The goals of renewable energy should be aligned with urban planning through effective collaboration between the local government and energy providers. Poland's energy policies, for instance, are increasingly centered on renewable energy sources, but they frequently do not match urban planning objectives, which restricts the possibility of developing smart cities on a big scale (De Jong et al., 2015, Seng et al., 2022). Unlocking the full potential of renewables in cities requires closing these governance gaps. Lastly, public involvement is a vital component of a successful integration of renewable energy. Incorporating a diverse range of stakeholders, such as underserved groups, into urban energy planning ensures that solutions are both efficient and fair. This is especially pertinent in Poland, where urban and rural residents have different access to energy. Smart cities must embrace strategies that give every citizen the chance to gain from the switch to renewable energy (Bibri and Krogstie, 2017, Bibri et al., 2023).

In examining different behavior in green consumerism among men and women, Zahoa et al. (2021) discussed the reasons for the differences. Generally, women have more positive intentions toward green consumption, carbon emissions are less of a concern for them, and they purchase green products more frequently. In contrast, quite a few studies show that men seem to possess greater knowledge of environmental issues than women, and in some contexts, they show greater concern for these issues. This looks at the reason for such divergences in green consumer behavior through the VBN theory, bringing in the other angle of gender. It also highlighted a few obstacles for both men and women to buy into green consumption and present some suggestions intended to inspire more public interest in green consumption.

3.1. Ensuring Gender Equity in Renewable Energy and Smart City Development

Despite being one of the most important components for genuinely sustainable urban development, gender equity has been one of the most marginalized topics in the discussion about smart cities and renewable energy. Women encounter the majority of barriers to energy access, particularly in disadvantaged and low-income regions. The good news is that by emphasizing gender-responsive policies and technologies, smart cities may alleviate this inequality. For example, to guarantee that both men and women have equal access to sustainable energy solutions, such as community-based microgrids or solar-powered cookstoves, urban energy projects might incorporate gender impact evaluations (Koumetio Tekouabou et al, 2023). The use of renewable energy is another sector where gender differences exist. The proportion of women in the renewable energy workforce worldwide is less than one-third, and the proportions are significantly lower in technical and leadership roles. By developing specialized programs, educating, and hiring women for positions in the renewable energy industry, smart cities may aid in closing this gap. Polish initiatives such as "Energy for Women" demonstrate how a nation may train women in sustainable energy technologies. Increasing the scale of programs like these could promote greater gender and employment diversity in the smart city workforce.

Inclusive urban planning needs to consider the intersectional barriers that women face in access to energy infrastructure. For instance, public lighting from renewable sources can enhance women's safety, given that many areas of cities are poorly lit. Similarly, smart city projects that include electrification of public transport will enhance mobility for women, who often are the primary caregivers and have more dependency on public transportation. These interventions show why it is so important to embed gender considerations into urban energy strategies (Kenworthy, 2006, Toli and Murtagh, 2020).

The question of gender equity in smart cities, in the final analysis, calls for a change in governance and policy priorities. Such integration of gender perspectives in energy policies and urban planning frameworks should be included in national and local levels of government, which apply to countries like Poland. International organizations and NGOs in this regard might help further by providing their resources and expertise to compile reports to accelerate the process toward renewable energies and make the city smart, resilient, and sustainable (Nesti,2019).

3.2. Policy Implications and Pathways for the Future

The combination of renewable energy with smart city technologies opens up a perspective for decarbonized urban economies, but strong policy frameworks and strategic investments are needed to make this vision a reality. The first important policy implication is regulatory harmonization, aligning urban development with national and EU-level renewable energy objectives. For instance, the European Green Deal is a broad pathway toward carbon neutrality, but its implementation needs to be very effective at the municipal level. Poland's cities, like Warsaw and Krakow, have taken steps toward adopting renewable energy solutions, but much more alignment with EU policies is necessary if this sector is to reach its potential impact. Mechanisms for targeted funding are in place to accelerate the transition towards smart, renewable-powered cities. EU programs such as the Cohesion Fund and Horizon Europe can be used to finance innovative urban energy projects, especially in regions with lower uptakes of renewable energies. For Poland, these funds would be highly valuable in modernizing infrastructure and developing sustainable urban energy systems. Mechanisms to incentivize private sector investments in renewable energy projects may, in

addition, complement public funding and drive innovation (Florkowski and Rakowska, 2022).

Another key priority area soon will be the closure of gender gaps in energy access and employment. Governments and city planners must adapt gender-responsive energy policies that address particular needs and challenges faced by women in very specific terms: promotion of participation in decision-making processes, including training targeted at women, ensuring equitable access to energy infrastructure, and supporting efforts through international cooperation in sharing good practices and funding gender-focused initiatives in urban energy transitions. Looking ahead, the success of decarbonized urban economies will depend on integrating social equity into environmental and economic policies (Darıcı et al., 2019). Sustainable and equitable urban settings will require smart cities to strike a balance between inclusive governance and technological innovation. For the shift to renewable energy to benefit all urban dwellers, governments must address gender inequality, promote public-private partnerships, and coordinate local efforts with global climate goals (Elie et al., 2021). These initiatives will position smart cities as global leaders in sustainable development, establishing the standard for inclusive, carbon-free urban economies everywhere.

4. Integration of Renewable Energy in Smart Cities

4.1. Defining Smart Cities: Technologies, Policies, and Energy Systems

The term "smart city" refers to the new phase of urban development at a time of rapid technological advancement. This vision relies heavily on the integration and use of renewable energy sources, made possible by blockchain, artificial intelligence, and the Internet of Things. Smart grids and energy-efficient technologies, for example, have been installed in American towns like Boston and San Francisco as part of larger urban sustainability initiatives (Hua et al., 2022). Alternatively, Japan's Society 5.0 framework highlighted the integration of digital technologies with energy-efficient and renewable energy-focused urban development. EU policies, such as the European Green Deal, offer standardized rules for integrating renewable energy into smart cities that guarantee carbon neutrality and sustainable urban development (Costantini et al., 2023). This is particularly true when creating and executing a smart city built on networked systems that could lower carbon emissions, like employing real-time IoT sensors that track energy usage and enable demand response management to ensure efficient energy distribution. Because AI-driven platforms anticipate energy requirements and maximize the use of renewable resources, waste is decreased and grid resilience is increased. Financial tools and public-private partnerships are used in policies like the EU's Smart Cities Marketplace to encourage their adoption. To smoothly connect renewable energy sources and urban energy demand, Japan's National Energy Strategy incorporates smart energy technologies into the city's infrastructure (De Pascale and Romagno, 2024).

Even while technology has advanced significantly, there are still obstacles in the way of the shift to smart cities. Widespread implementation is hampered by fragmented legislation, expensive upfront expenditures, and disparities in technical uptake. For instance, there is no national framework for smart cities in the United States; instead, state and local projects are frequently disorganized. On the other hand, the EU's all-encompassing strategy offers cities a more straightforward route to using smart Technologies (Peng et al., 2024). Another practical example that ensures consistency in the deployment of smart city technologies across cities is Japan's centralized energy regulations. It is crucial to combat gender discrepancies in smart city projects to provide equal access to jobs and energy. This is why gender-responsive policies, such as training programs tailored to women in the field of renewable energy technologies, are essential for smart cities (Ren et al., 2024). The inclusion of gender equity in urban development initiatives is emphasized by Horizon Europe, which is the best framework for incorporating this element into smart city design. Japan promotes women's involvement in technology-based fields, particularly in the field of renewable energy.

4.2. Renewable Energy in Urban Infrastructure: Opportunities and Challenges

There are numerous opportunities to reduce greenhouse gas emissions and enhance energy security by incorporating renewable energy into urban infrastructure. In an effort to promote localized energy generation and grid resilience, smart cities make use of technology such as energy storage systems, wind turbines, and rooftop solar panels. Boulder, Colorado's municipal energy policy, for instance, aims to reach 100% renewable electricity by 2030 via deploying renewable energy. Thus, in Europe, cities such as Copenhagen and Amsterdam have heavily invested in renewable energy infrastructures, setting good examples for the development of sustainable urban development. Similarly, it underlines the potential of hydrogen energy and the integration of solar power into urban grids by Japan's focus on these aspects of smart cities (Noori et al., 2020).

Among the barriers to the deployment of renewable energy in cities are land-use constraints, regulatory hurdles, and financial barriers. Open space for large-scale renewable energy projects is often not available in urban centers, so innovative solutions such as floating solar farms or vertical-axis wind turbines may be needed (Abbasi et al.,2024). Progress is also slowed by inconsistent regulation, such as in the United States, where energy policies at the state level are highly varied. The EU's RED II aims at removing these kinds of barriers to the harmonization of regulations and to cross-border cooperation. The FIT system of the government has elicited investment in renewable energy in Japan; however, the effect has been somewhat mitigated by

high prices and dwindling public support (Joss et al., 2019).

Urban energy transitions will also have to grapple with social and economic inequalities, particularly in energy access. In many cities, low-income households and marginalized communities are disproportionately affected by a lack of access to clean energy. The Just Transition Mechanism is one of the policies under the EU that ensures the benefits of renewable energy are fairly shared to support vulnerable populations in the transition towards a low-carbon economy. Similarly, the United States has also taken some similar programs with the main motive of making energy affordable for unserved and underserved communities by launching an Energy Justice program (Aiyar and Ebeke, 2020).

Lastly, gender-based differences in employment and energy access make the shift to renewable energy even more challenging. Due to economic disparities, the majority of women are underrepresented in the workforce for renewable energy, and their energy costs are greater. It is necessary to overcome these disparities by focused laws and initiatives, such as Japan's Women in Energy project, which educates and assists women in the renewable energy industry. For inclusive and fair urban growth, smart cities' energy strategies must take these factors into account.

4.3. Case Studies: Successful Implementations of Renewable Energy in Smart Cities

Successful renewable energy deployments in smart cities offer scalable solutions and best practices. In the United States, the "Smart City, Clean Energy" effort in New York City has demonstrated how smart technologies can maximize the usage of renewable energy. By implementing microgrids with solar and wind energy systems, the city has been able to lower greenhouse gas emissions and improve energy resiliency. By 2035, San Diego's Climate Action Plan aims to generate all of its electricity from renewable sources by incorporating renewable energy into urban development. There are several excellent examples of smart city integration of renewable energy in the EU. One of the most notable instances of urban energy efficiency is Copenhagen's district heating system, which is powered by renewable energy. By optimizing energy use in buildings, public areas, and transportation, Amsterdam's Smart City effort significantly lowers the city's carbon footprint. In addition to providing significant funds, the EU's dedication to cross-border cooperation has been crucial in enabling these programs to grow and remain sustainable (Acheampong et al., 2024).

The Fujisawa Sustainable Smart Town in Japan is another excellent example; it integrates different cutting-edge technologies with renewable energy to create an urban ecology that is almost self-sufficient. The community uses an integrated energy system that minimizes emissions and maximizes consumption. This system includes solar panels, battery storage, and energy management technology. Japan has demonstrated leadership in incorporating renewable energy into urban infrastructure with similar projects in Tokyo and Yokohama, which are fueled by robust government funding and private sector cooperation. For sustainable urban growth, these case studies emphasize how crucial it is to match technological innovation with legislative frameworks. For example, Denmark's aggressive renewable energy targets and supportive regulatory framework may have contributed to Copenhagen's success; similarly, Japan's centralized energy regulations and emphasis on innovation have made smart city development easier. Future attempts to alleviate social and gender inequalities while incorporating renewable energy into urban systems will be guided by these lessons (Wang et al., 2023).

5. Policy and Technological Innovations to Enhance Urban Energy Efficiency

Innovations in technology and policy are therefore crucial for improving urban energy efficiency and incorporating renewable energy into smart cities. One such all-encompassing policy approach is the EU's Clean Energy for All Europeans package, which encourages energy efficiency, the use of renewable energy sources, and consumer empowerment. It includes steps to assist energy communities where residents can produce and distribute renewable energy. Similar initiatives exist in the United States, including the Smart Energy program, which stresses the role of technology in reducing energy consumption and lowering emissions (Sankaran, 2019, OECD, 2020).

Technological innovations, such as AI, blockchain, and energy storage systems, are increasingly taking the place of urban energy systems. AI-powered platforms make possible the prediction of energy demand and optimization of grid operations by integrating renewable sources of energy seamlessly. Blockchain technology makes energy transactions secure and provides peer-to-peer energy trading within smart cities. For example, the blockchain-based Brooklyn Microgrid in the United States enables residents to buy and sell solar energy locally. This shows just how technological advancement could very well drive sustainable urban transitions in energy. Only gender-inclusive policies and programs will make sure that both technological and policy innovations succeed, allowing all urban dwellers to benefit from them (Xuan and Ocone,2022). The EU's Gender Equality Strategy called for inclusion of more women in energy policies for renewables. In Japan's case, focusing on STEM education for women enables their participation in sectors driven by technology, such as smart cities. Some of the indicators that point to this very need in considering gender through the process of devising urban energy strategies create smart and sustainable cities.

The key to improving urban energy efficiency lies at the confluence of policy innovation, technological advancement, and social equity. Linking the strategies for renewable energy with smart city development thus allows

policymakers to develop urban environments that are sustainable and inclusive. Successful case studies from the United States, Europe, and Japan yield important lessons on how this could be replicated globally. Integrating gender equity into such initiatives will ensure the benefits of renewable energy transitions accrue to all, creating a more just and sustainable urban future.

5.1. Addressing Gender Equity in Renewable Energy and Smart City Development

Women still face unequal access to energy globally, especially in urban centres transitioning to renewable energy. The most affected are women in low-income households, who bear higher energy costs related to income, have inadequate access to modern energy solutions, and are excluded from decision-making on energy. Single mothers and women-led households are overrepresented among the energy poor, while studies show this group pays more for utilities than any other demographic concerning income earned. EU policies, such as the Just Transition Mechanism, target disparities and promote equitable access to renewable energy resources (O'Dwyer et al., 2019). While initiatives such as the Basic Energy Plan in Japan do recognize the need for an inclusive energy strategy, it still lacks attention to the specific gender barriers. The urban areas in smart cities amplify these inequalities if renewable energy systems are engineered without consideration for socio-economic and gender dynamics. Transition to solar energy, for instance, is normally associated with up-front costs, which could be a significant barrier, particularly for women in financially constrained households. This has been the case in Europe, where targeted subsidies and financing mechanisms have been put in place to incentivize this aim—for example, Germany's energy-efficient housing incentives. In Japan, the subsidies for household solar panel installations indirectly support gender equity by improving access for households led by women. However, such programs must be expanded to account explicitly for gendered barriers to access (Oladosu et al., 2024).

The intersection of gender and energy access requires policies tailored to address cultural, economic, and systemic barriers. For instance, the EU's Gender Equality Strategy has acknowledged the requirement for gender mainstreaming in energy policies and ensures that women are involved in decision-making. Programs like the U.S.-based Energy Equity Initiative have started evening out the playing field of these disparities, but challenges persist in reaching marginalized women (. Japan has not yet fully incorporated gender considerations into its energy access policies, even with the advancement of renewable energy technologies. Addressing these disparities is central to smart city success, as access to renewable energy has direct impacts on urban sustainability and social equity. International frameworks, such as the United Nations' Sustainable Development Goal (SDG) 5, focused on gender equality, should guide policymakers in adopting gender-responsive energy policies. Bringing a gender lens to energy access strategies not only enhances equity but also boosts general adoption rates, leading to smart city success (Arévalo et al., 2024).

5.2. Job Opportunities in Renewable Energies and in Smart City Sector

The renewable energy and smart city sectors also show large gaps in employment, with underrepresentation of women in technical, managerial, and policymaking positions. According to the International Renewable Energy Agency, women make up only 32% of the workforce in renewable energy worldwide. In technical and leadership roles, which are primarily occupied by men, the disparity grows even more. Women still only make up 25% of the solar energy workforce in the United States, despite the industry's explosive growth. Initiatives like the Women in Renewable Energy—WOMEN-IN-RE program have helped the EU make some progress, but there are still systemic obstacles to overcome; Japan faces comparable difficulties. Although the government is working to increase the number of women in the workforce, women make up a very small percentage of workers in STEM fields related to energy (Raman et al.,2024). These are caused by cultural prejudices and restricted educational and training opportunities. Social norms discourage women from pursuing STEM fields, so excluding them from the potential pool for projects related to smart cities and renewable energy. The EU budget's Horizon Europe program, for example, funds training and research initiatives that target women in an effort to close this gap. Targeting young women from underrepresented groups, the U.S. Department of Energy has also provided funding for programs like STEM Rising. In the same vein, Japan's Women in Science and Technology program, which aims to boost female involvement in STEM subjects, is still lagging behind in terms of notable employment inclusion (IMF, 2023).

The gender equity gap in smart cities' development frameworks, including job possibilities, could be filled. For example, Barcelona's Smart City initiative has prioritized gender inclusion in the creation of jobs for women in the planning of cities and in renewable energy initiatives. Another example is San Diego's Climate Action Plan, which includes workforce diversity objectives that include minorities and women in training programs for renewable energy Technologies (Wang et al., 2019). Japan's Yokohama Smart City Project has recently begun incorporating gender concerns but is at the nascent stages. Such gender-sensitive approaches might include providing scholarships, mentorship programs, or targeted recruitment of women in STEM fields for workforce development within the renewable energy and smart city sectors. International bodies like IRENA and the United Nations Development Program also indicate that gender parity is one of the significant enablers of SDGs. Hence, by closing the gap in employment, smart cities would be able to maximize their potential while ensuring equitable social and economic growth (Pearl-Martinez and Stephens, 2016).

5.3. Inclusive Urban Planning: Bringing Gender Perspectives into Smart Cities

In the heart of ensuring that smart cities address the needs of all residents, especially women, lies inclusive urban planning. Gender-sensitive urban planning entails bringing in women's perspectives in areas such as transportation, housing, and access to energy. In the United States, for instance, cities such as New York and San Francisco have come up with gender-responsive urban policies, including better public transportation and access to affordable energy solutions for women-led households. The EU has been proactive with its Urban Agenda for the EU, which contains a thematic objective of gender equality. Japan's urban development policies have also started integrating gender considerations into their actions, especially in disaster-resilient infrastructure.

Energy infrastructure in smart cities has to be designed considering diverse needs: for example, women use public transportation more, and energy outages affect them more. For example, Vienna in Europe has implemented gender-sensitive transport planning, including improved lighting and safe access to energy-efficient public transport. In Tokyo, Japan, the city has approached gender-inclusive urban design under the Tokyo Smart Energy Project, although again, this hasn't made a broader impact on energy policy at large. US cities like Portland, Oregon, have brought a gender analysis into urban planning by looking at issues of affordable housing and energy efficiency among low-income women.

An integrative approach to gender in smart cities would demand participatory planning processes. That involves including women at all levels, from the highest decision-making body at the local government down to the lowest and smallest community-based organization. Under Horizon Europe, EU funding covers those projects entailing participatory planning and, as such, incorporating women's voices in urban development. Japan is trying to involve itself in citizen-led urban planning initiatives inclusively of diversity, but still, a long way is going for complete gender parity. U.S. cities have followed suit with similar participatory approaches, including Chicago's community energy planning workshops that specifically target the inclusion of women and minorities.

Inclusive urban planning not only promotes gender equality but also leads to more effective smart cities. This might lead to energy efficiency, and reduction in carbon emissions, and create safer, more just urban environments. It is, therefore, relevant that policymakers adopt gender-responsive planning frameworks so that smart cities are sustainable and inclusive for all residents.

5.4. Frameworks and policies to promote gender-equitable decarbonization.

A holistic policy framework that puts gender at the core of renewable energy and smart city initiatives is necessary to achieve gender-equitable decarbonization. One of the most influential models is, of course, the EU Gender Equality Strategy. This underlines the principle of inclusiveness across all policy fields, including energy and urban development (Farla et al., 2012, Lindberg et al., 2019). Another commitment is that the European Green Deal is highly reinforcing in terms of social equity. In the U.S., the Biden administration's Justice40 Initiative provides for 40% of federal climate investments to be made in disadvantaged communities, including women and minorities. Japan's Fifth Basic Energy Plan includes gender considerations but does not have specific mechanisms for implementation (Velut, 2024).

Financial incentives and support mechanisms are a critical enabler of gender-equitable decarbonization. The EU has its Just Transition Fund, which explicitly includes targeted funding directed at projects catering to social and gender inequalities as part of the energy transition; in the U.S., programs like the Weatherization Assistance Program target energy efficiency upgrades for low-income households—most of these are run by women—and, in Japan, some of the subsidies now being made available for renewable energy projects targeting gender equity, though it is still relatively early days for those (European Commission , 2021, Siksnelyte-Butkiene, et al., 2021).

Collaboration among governments, private sector entities, and international organizations is imperative to drive gender-equitable decarbonization. For instance, the UNDP's Gender and Climate Change program works with countries to integrate gender considerations into national climate policies. In an effort to promote gender parity in renewable energy initiatives, the United States has partnered with organizations like the Clean Energy States Alliance. Gender inclusion in urban development is the subject of cross-border collaboration funded by the EU's Horizon Europe initiative. Though more targeted efforts are required, gender issues are beginning to be taken into account in Japan's public-private partnerships in renewable energy. Social, economic, and environmental factors must all be integrated if policymakers are to take a comprehensive strategy to gender-equitable decarbonization. By coordinating renewable energy and smart city projects with gender equity objectives, governments may expedite the shift to a low-carbon economy and foster more inclusive urban settings. Future initiatives to accomplish sustainable and equitable urban development can be guided by the lessons learned from the EU, US, and Japanese effective policies.

5.5. Synergizing Renewable Energy Policies with Smart City Strategies

Integration of renewable energy in smart cities presents a transformational opportunity for decarbonizing urban economies. Smart cities use technologies to increase energy efficiency, manage resources sustainably, and achieve sustainability. In this urban framework, the adoption of renewable sources of energy—solar, wind, biomass—shall

be one of the major steps that can be considered indispensable to the attainment of sustainability objectives. For instance, U.S. cities like San Diego have shown steps towards 100% renewable energy by the year 2035 by being integrated with smart grid systems that enhance better energy management (City of San Diego, 2020). The alignment of renewable energy policies to strategies for smart cities enables the cities to reduce carbon emissions, decrease energy expenditure, and improve the quality of life among citizens. For example, in Europe, Amsterdam has ambitious renewable energy targets under its Smart City program, including energy efficiency, carbon neutrality, and smart infrastructure. Japan, always leading in innovation, incorporates renewable energy into its smart cities through technological advances in the smart grid and advanced energy storage systems—seen in the city of Fujisawa. This will not only help in reducing the GHG emissions but also contribute to the urban resilience in facing climate change.

However, the implementation of smart cities and renewable energy strategies must address the already existing gender gaps in energy access and employment. Women, especially in low-income communities, face huge barriers in accessing technologies and benefits from renewable energy. In many countries, gendered roles in energy production and consumption limit women's participation in decision-making and leadership roles within the energy sector (Kabeer, 2021). Integration of gender-sensitive policies in renewable energy planning within smart cities is going to ensure that the transition towards clean energy is inclusive and equitable. This includes fostering female participation in the green economy through targeted training programs, subsidies for women-led renewable energy enterprises, and gender-responsive energy policies.

6. Strategies for Closing Gender Gaps in Urban Energy Systems

There is a need for a set of policy interventions that will guarantee women equal access to all benefits accruing from renewable energy while empowering them within energy-related jobs. Similarly, professional development opportunities and mentorship for women, through programs such as WEN in the U.S., work to bridge the energy gender gap, while in Europe, the same kind of activities aim at increasing female participation in the energy-related decision-making process by supporting projects to this effect (IRENA, 2019). These programs are very important to address the underrepresentation of women in the energy industry, more so in technical and leadership positions. Japan has also made efforts toward improving gender equality in the energy sector through policies, which will increase the participation of women in the renewable energy workforce. For example, Japan's "Next Generation Energy Technology Innovation Strategy" contains a gender equality dimension, aimed at ensuring diverse human resources for the clean energy sector (Japan Ministry of Economy, Trade and Industry, 2020).

Besides professional development opportunities, addressing the energy access gender gaps also means women can and do participate in the design and implementation of renewable energy projects. Most women, especially in rural and marginalized communities, lack access to clean and affordable energy. In response, some countries have initiated programs to ensure that renewable energy projects are gender-inclusive. For instance, under the World Bank's "Energy Sector Management Assistance Program," several projects have been funded that empower women in rural communities with access to affordable solar energy technologies. By targeting energy access in underserved regions and creating opportunities for women to contribute to energy solutions, smart cities can reduce gender disparities in energy access while promoting sustainability (Fernandez Núnez et al, 2022).

6.1. Sustainable Urban Growth: Balancing Economic, Social, and Environmental Goals

Smart growth in cities requires balancing economic, social, and environmental objectives to achieve sustainable urban growth with renewable sources of energy. Urban growth has to be decoupled from the old model of dependence on fossil fuels and towards inclusive and sustainable development. Particularly regarding energy systems, planning and developing urban cities should take on board environmental sustainability. Assessments of urban ecological footprints, in tandem with the carrying capacity, should therefore be considered in strategic urban energy and sustainability modeling to ensure balanced growth limited by environmental considerations. Promoting green certifications and standards of social accountability for urban industries can be used as an effective policy instrument in promoting sustainable practices. Alongside launching other psychosocial aspects, increasing the provision of financial and technical support for energy efficiency and environmentally compliant businesses is an important key to operating good urban sustainability schemes, which incorporate both the transition to cleaner energy systems and the development of ecological resilience (Türkcan, 2024). In the United States, the Green New Deal is a policy to stimulate job creation in clean energy, focusing on high-quality, green jobs with benefits accruing to all segments of society, including women. In contrast, the European Green Deal maps out a path to net-zero emissions by 2050, focusing on economic recovery through clean energy innovation (Kremer et al., 2019, Demir et al., 2021). The Just Transition Mechanism of the European Union will ensure that the transition towards renewable energy is inclusive and provides financial support to the most affected regions and sectors by the shift to a green economy. In Japan, alongside the government's "Carbon Neutrality 2050" goal, policies stimulating innovation and green entrepreneurship may open more opportunities for women in the renewable energy sector (UN-Habitat, 2021). At the heart of sustainable urban growth is social equity. Therefore, as cities transition to renewable energy systems, it will be

very important for policymakers to ensure that all residents, and more so, women in marginalized communities, get to participate in the new opportunities that come with this change. It involves investment in education and training programs that will assist women in entering the renewable energy workforce and ensuring the ability of women to access affordable energy technologies in their homes. Inclusive urban planning should be a must, providing equal access to jobs, resources, and services while maintaining environmental sustainability. Some cities, such as Oslo, have already successfully integrated sustainability with social equity in their urban planning, fostering the adoption of renewable energies together with inclusive social policies (Sanchez de Madariaga and Neuman, 2020).

6.2. Recommendations for Policymakers, Urban Planners, and Stakeholders

Gender-responsive strategies must be used by stakeholders, policymakers, and urban planners when creating and deploying renewable energy and smart city initiatives. First and foremost, the laws must be formulated in a way that guarantees all citizens fair access to energy, with a particular emphasis on women in low-income and rural areas. This could involve increasing access to funding for women-led green economy enterprises, promoting digital literacy, and providing subsidies for renewable energy Technologies (Ateria et al., 2020). By providing specialized training, networking opportunities, and mentorship, governments should implement initiatives that will promote women's involvement in energy-related decision-making positions.

The special demands of women should also be taken into consideration by urban planners when creating smart cities that integrate renewable energy into all facets of urban life. It can be achieved by implementing gender-sensitive urban design, which guarantees women leadership positions in smart city initiatives, economic possibilities, and access to sustainable energy. For instance, the "Smart Cities Japan" effort in Japan is a model for other nations and places a strong emphasis on integrating renewable energy sources while also advancing gender equality. Likewise, European cities should continue to expand such initiatives where there is collaboration with the government, businesses, and local communities towards achieving goals of gender and sustainability altogether. International organizations like the United Nations can catalyze knowledge sharing and give the impetus for developing and implementing gender-sensitive renewable energy policies across national borders (Torrens et al., 2022). Cities, through global partnership, can execute localized efforts in their pursuit of gender equity, mitigation of carbon emissions, and fostering inclusive economic growth. Such a holistic approach, bringing together renewable energy, smart city strategies, and gender equity, truly will help cities around the world set a sustainable and equitable scene for the future.

7. Conclusion

The policies to be discussed in this paper bring into focus how the integration of renewable energy systems with digital technologies and inclusive urban planning can aid in sustainable urban development. Smart cities, therefore, provide an unprecedented opportunity for leading the global decarbonization agenda through IoT, AI, and big data that optimize energy systems while enhancing grid reliability and waste reduction. Successful examples from cities like Amsterdam, Copenhagen, and Tokyo prove it is possible to combine this with urban planning through smart grids, energy-efficient buildings, and decentralized systems. However, financial, regulatory, and technological barriers remain a significant hindrance to widespread implementation.

Gender parity in municipal energy planning and jobs in the renewable energy industry are also essential to the decarbonization agenda. Accessing clean energy solutions and finding employment in this sector are disproportionately difficult for women, particularly in underprivileged areas. Although initiatives like Japan's "Women in Energy" programs and the EU's Horizon Europe initiative offer valuable templates for tackling these inequities, more coordinated efforts are required on a worldwide scale. To guarantee that everyone benefits from urban transitions to renewable energy, they include policies that support the integration of gender-responsive policies into energy strategies, such as focused training initiatives, inclusive governance frameworks, and fair access to clean energy infrastructure.

Future research and policy efforts should focus on these systemic interdependencies of technology, energy, and social equity. It will need far more coordination among the local, national, and international frameworks and increased collaboration between the public and private sectors. International cooperation and funding support throughout the process would be incorporated into urban planning so as to remove the gaps already there and bring about more access in representation. Looking ahead, the success of smart cities in achieving decarbonized urban economies will depend on the balance between technological innovation and inclusive governance. Policymakers can create an urban environment that is sustainable and equitable by addressing gender disparities, fostering public-private partnerships, and aligning local initiatives with global climate goals. Such efforts will make smart cities true leaders in sustainable development and lay the groundwork for a future that combines renewable energies with gender equality and urban planning throughout the world.

References

Abbasi, K. R., Zhang, Q., Ozturk, I., Alvarado, R., & Musa, M. (2024). Energy transition, fossil fuels, and green innovations: Paving the way to achieving sustainable development goals in the United States. *Gondwana Research*, *130*, 326–341.

https://doi.org/10.1016/j.gr.2024.02.005

Acheampong, A. O., Boateng, E., & Annor, C. B. (2024). Do corruption, income inequality and redistribution hasten the transition towards (non)renewable energy economy? *Structural Change and Economic Dynamics, 68*, 329–354. https://doi.org/10.1016/j.strueco.2023.11.006

Aiyar, S., & Ebeke, C. (2020). Inequality of opportunity, inequality of income and economic growth. *World Development, 136*, 105115. https://doi.org/10.1016/j.worlddev.2020.105115

Alber, G. (2024). A novel approach to work towards gender-responsive urban climate policy. *Environment and Urbanization, 36*(1), 133–146. https://doi.org/10.1177/09562478241230037

Altun, Y., & İşleyen, Ş. (2018). Bazı OECD ülkelerinde yenilenebilir enerji kaynaklarından elektrik üretimine yönelim üzerine ampirik bir çalışma. *Atatürk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 22*(3), 1577–1590.

Arévalo, P., Ochoa-Correa, D., & Villa-Ávila, E. (2024). A systematic review on the integration of artificial intelligence into energy management systems for electric vehicles: Recent advances and future perspectives. *World Electric Vehicle Journal, 15*(8), 364. https://doi.org/10.3390/wevj15080364

Ateria, D., Kap, J. J. K., & Utari, D. (2020). A gender-responsive approach: Social innovation for the sustainable smart city in Indonesia and beyond. *Journal of International Women's Studies, 21*(6), 196–210.

Darıcı, B., Aydın, C., & Şahin Kutlu, Ş. (2019). Ekonomik büyüme çevre kirliliğini azaltır mı? *Anemon Muş Alparslan Üniversitesi Sosyal Bilimler Dergisi, 7*(2), 191–196. https://doi.org/10.18506/anemon.459157

Bahuet, C. (2024). Shaping cities of the future to be inclusive, sustainable and resilient. https://sdglocalaction.org/op-ed-shaping-cities/

Ben Amer, S., Bramstoft, R., Balyk, O., & Nielsen, P. S. (2019). Modelling the future low-carbon energy systems: A case study of Greater Copenhagen, Denmark. *International Journal of Sustainable Energy Planning and Management, 24*. https://doi.org/10.5278/ijsepm.3356

Benson, M., Boda, C., Das, R. R., King, L., & Park, C. (2023). Illuminating practitioner challenges in energy transitions. *Heliyon, 12*, e22624. https://doi.org/10.1016/j.heliyon.2023.e22624

Bibri, S. E., & Krogstie, J. (2017). Smart sustainable cities of the future: An extensive interdisciplinary literature review. *Sustainable Cities and Society, 31*, 183–212. https://doi.org/10.1016/j.scs.2017.02.016

Bibri, S. E., Krogstie, J., Kaboli, A., & Alahi, A. (2023). Smarter eco-cities and their leading-edge artificial intelligence of things solutions for environmental sustainability: A comprehensive systematic review. *Environmental Science and Ecotechnology, 19*, 100330. https://doi.org/10.1016/j.ese.2023.100330

Bibri, S. E., Alahi, A., Sharifi, A., & Krogstie, J. (2023). Environmentally sustainable smart cities and their converging AI, IoT, and big data technologies and solutions: An integrated approach to an extensive literature review. *Energy Informatics, 6*, 9. https://doi.org/10.1186/s42162-023-00259-2

Costantini, V., Delgado, F. J., & Presno, M. J. (2023). Environmental innovations in the EU: A club convergence analysis of the eco-innovation index and driving factors of the clusters. *Environmental Innovation and Societal Transitions, 46*, 100698. https://doi.org/10.1016/j.eist.2023.100698

Daphne, N. M. (2020). Conceptualising government–market dynamics in socio-technical energy transitions: A comparative case study of smart grid developments in China and Japan. *Geoforum, 108*, 102–108.

De Jong, M., Joss, S., Schraven, D., Zhan, C., & Weijnen, M. (2015). Sustainable-smart-resilient-low-carbon-eco-knowledge cities: Making sense of a multitude of concepts promoting sustainable urbanization. *Journal of Cleaner Production, 109*, 25–38. https://doi.org/10.1016/j.jclepro.2015.02.004

De Pascale, G., & Romagno, A. (2024). Globalization and ICT capital endowment: How do they impact on an inclusive green growth index? *Structural Change and Economic Dynamics*. https://doi.org/10.1016/j.strueco.2024.03.003

Demir, Y., İşleyen, Ş., & Özen, K. (2023). Determining the effect of selected energy consumptions on carbon dioxide emissions by ARDL limit test. *Van Yüzüncü Yıl University Journal of Social Sciences Institute, 59*, 80–107.

Elie, L., Granier, C., & Rigot, S. (2021). The different types of renewable energy finance: A bibliometric analysis. *Energy Economics*, *93*, 104997.

European Commission. (2021). *Tackling energy poverty through local actions – inspiring cases from across Europe*. Lisbon, Portugal.

Farla, J., Markard, J., Raven, R., & Coenen, L. (2012). Sustainability transitions in the making: A closer look at actors, strategies and resources. *Technological Forecasting and Social Change, 79*(6), 991–998. https://doi.org/10.1016/j.techfore.2012.02.001

Fernandez Núnez, M. B., Campos Suzman, L., Maneja, R., Bach, A., Marquet, O., Anguelovski, I., & Knobel, P. (2022). Gender and sex differences in urban greenness' mental health benefits: A systematic review. *Health Place, 76*, 102864.

https://doi.org/10.1016/j.healthplace.2022.102864

Florkowski, W. J., & Rakowska, J. (2022). Review of regional renewable energy investment projects: The example of EU cohesion funds dispersal. *Sustainability, 14*(24), 17007. https://doi.org/10.3390/su142417007

Furszyfer Del Rio, D. D., Sovacool, B. K., & Griffiths, S. (2021). Culture, energy and climate sustainability, and smart home technologies: A mixed methods comparison of four countries. *Energy and Climate Change, 2*, 100035.

Hassebo, A., & Tealab, M. (2023). Global models of smart cities and potential IoT applications: A review. *IoT, 4*(3), 366–411. https://doi.org/10.3390/iot4030017

Hua, W., Chen, Y., Qadrdan, M., Jiang, J., Sun, H., & Wu, J. (2022). Applications of blockchain and artificial intelligence technologies for enabling prosumers in smart grids: A review. *Renewable and Sustainable Energy Reviews, 161*, 112308. https://doi.org/10.1016/j.rser.2022.112308

Ince Palamutoğlu, M. (2023). Sürdürülebilirlikte sağlıklı ve kaliteli yaşam (pp. 108–122). In *Her yönüyle sürdürülebilirlik*. Efe Akademi Yayınevi.

International Monetary Fund, Asia and Pacific Dept. (2023). A new growth engine for Japan: Women in STEM fields (IMF Staff Country Report No. 128). https://doi.org/10.5089/9798400237409.002.A002

IRENA. (2019). *Renewable energy: A gender perspective*. IRENA.

Joss, S., Sengers, F., Schraven, D., Caprotti, F., & Dayot, Y. (2019). The smart city as global discourse: Storylines and critical junctures across 27 cities. *Journal of Urban Technology, 26*(1), 3–34.

Kenworthy, J. R. (2006). The eco-city: Ten key transport and planning dimensions for sustainable city development. *Environment and Urbanization, 18*(1), 67–85. https://doi.org/10.1177/0956247806063947

Kez, D. A., Foley, A., Lowans, C., & Del Rio, D. F. (2024). Energy poverty assessment: Indicators and implications for developing and developed countries. *Energy Conversion and Management, 307*, 118324.

Koffka, K. (2023). *Intelligent things: Exploring AIoT technologies and applications.*

Koumetio Tekouabou, S. C., Diop, E. B., Azmi, R., et al. (2023). Artificial intelligence based methods for smart and sustainable urban planning: A systematic survey. *Archives of Computational Methods in Engineering, 30*, 1421–1438. https://doi.org/10.1007/s11831-022-09844-2

Kremer, P., Haase, A., & Haase, D. (2019). The future of urban sustainability: Smart, efficient, green or just? *Sustainable Cities and Society, 51*, 101761. https://doi.org/10.1016/j.scs.2019.101761

Lindberg, M. B., Markard, J., & Andersen, A. D. (2019). Policies, actors and sustainability transition pathways: A study of the EU's energy policy mix. *Research Policy, 48*(10), 103668. https://doi.org/10.1016/j.respol.2018.09.003

Magnusson, D. (2012). Swedish district heating—A system in stagnation: Current and future trends in the district heating sector. *Energy Policy, 48*(C), 449–459.

Markard, J., & Rosenbloom, D. (2020). Political conflict and climate policy: The European emissions trading system as a Trojan Horse for the low-carbon transition? *Climate Policy, 20*(9), 1092–1111.

Muttaqee, M., Furqan, M., & Boudet, H. (2023). Community response to microgrid development: Case studies from the U.S. *Energy Policy, 181*.

Nesti, G. (2019). Mainstreaming gender equality in smart cities: Theoretical, methodological and empirical challenges. *Information Polity, 24*(4), 1–16. https://doi.org/10.3233/IP-190134

Noori, N., Hoppe, T., & de Jong, M. (2020). Classifying pathways for smart city development: Comparing design, governance and implementation in Amsterdam, Barcelona, Dubai, and Abu Dhabi. *Sustainability, 12*(10), 4030.

O'Dwyer, E., Pan, I., Acha, S., & Shah, N. (2019). Smart energy systems for sustainable smart cities: Current developments, trends and future directions. *Applied Energy*.

OECD/European Commission. (2020). *Cities in the world: A new perspective on urbanisation*. OECD Publishing. https://doi.org/10.1787/d0efcbda-en

Oladosu, T. L., Pasupuleti, J., Kiong, T. S., Koh, S. P. J., & Yusaf, T. (2024). Energy management strategies, control systems, and artificial intelligence-based algorithms development for hydrogen fuel cell-powered vehicles: A review. *International Journal of Hydrogen Energy, 61*, 1380–1404.

Pearl-Martinez, R., & Stephens, J. C. (2016). Toward a gender-diverse workforce in the renewable energy transition. *Sustainability: Science, Practice and Policy, 12*(1), 8–15. https://doi.org/10.1080/15487733.2016.11908149

Peng, B., Streimikiene, D., Agnusdei, G. P., & Balezentis, T. (2024). Is sustainable energy development ensured in the EU agriculture? Structural shifts and the energy-related greenhouse gas emission intensity. *Journal of Cleaner Production, 445*, 141325. https://doi.org/10.1016/j.jclepro.2024.141325

Raman, R., Gunasekar, S., Kaliyaperumal, D., & Nedungadi, P. (2024). Navigating the nexus of artificial intelligence and renewable energy for the advancement

of sustainable development goals. *Sustainability, 16*(21), 9144. https://doi.org/10.3390/su16219144

Ren, X., Yang, W., & Jin, Y. (2024). Geopolitical risk and renewable energy consumption: Evidence from a spatial convergence perspective. *Energy Economics, 131*, 107384. https://doi.org/10.1016/j.eneco.2024.107384

Sanchez de Madariaga, I., & Neuman, M. (2020). Planning the gendered city. In *Engendering cities* (pp. 1–15). Routledge. https://doi.org/10.4324/9781351200912-1

Sankaran, K. (2019). Carbon emission and plastic pollution: How circular economy, blockchain, and artificial intelligence support energy transition? *Journal of Innovation and Management, 7*(4), 7e13.

Scordato, L., & Gulbrandsen, M. (2024). Resilience perspectives in sustainability transitions research: A systematic literature review. *Environmental Innovation and Societal Transitions, 52*, 100887.

Seng, K. P., Ang, L. M., & Ngharamike, E. (2022). Artificial intelligence Internet of Things: A new paradigm of distributed sensor networks. *International Journal of Distributed Sensor Networks, 18*(3). https://doi.org/10.1177/15501477211062835

Siksnelyte-Butkiene, I., Streimikiene, D., Lekavicius, V., & Balezentis, T. (2021). Energy poverty indicators: A systematic literature review and comprehensive analysis of integrity. *Sustainable Cities and Society, 67*, 102756. https://doi.org/10.1016/j.scs.2021.102756

Sovacool, B. K., & Griffiths, S. (2020). Culture and low-carbon energy transitions. *Nature Sustainability, 3*, 685–693.

Sovacool, B. K., Barnacle, M. L., Smith, A., & Brisbois, M. C. (2022). Towards improved solar energy justice: Exploring the complex inequities of household adoption of photovoltaic panels. *Energy Policy, 164*, 112868.

Toli, A. M., & Murtagh, N. (2020). The concept of sustainability in smart city definitions. *Frontiers of Built Environment, 6*, 77. https://doi.org/10.3389/fbuil.2020.00077

Torrens, L., Riutort, S., & Juan, M. (2022). Towards a new social model of the city. In *Future urban habitation* (pp. 25–36). Wiley. https://doi.org/10.1002/9781119734895.ch1

Türkcan, B., Huyugüzel Kışla, G. S., & Ince Yenilmez, M. (2022). Sustainable COVID-19 recovery and circular economy. *Sustainability and Climate Change, 15*(4), 1–7.

Türkcan, B. (2024). Sustainable urban tourism from the perspectives of overtourism and smart tourism: A systematic literature review. *Journal of Travel and Tourism Research, 25*(25), 112–156.

UN-Habitat. (2021). *Her city – A guide for cities to sustainable and inclusive urban planning and design together with girls.*

Velut, J. P. (2024). Whose industrial policy? Assessing the democratic credentials of Washington's new competitive strategy. *Politique Américaine, 2024/1*(42), 123–156.

Wang, L., Stanovsky, G., & Weihs, L. (2019). Gender trends in computer science authorship. Cornell University.

Wang, Q., Sun, T., & Li, R. (2023). Does artificial intelligence promote green innovation? An assessment based on direct, indirect, spillover, and heterogeneity effects. *Energy and Environment.*

Xuan, J., & Ocone, R. (2022). The equality, diversity and inclusion in energy and AI: Call for actions. *Energy and AI, 8*, 100152. https://doi.org/10.1016/j.egyai.2022.100152

Yamaguchi, H., Hsu, J. M., Yang, W. H., & Hung, M. C. (2022). Mechanisms regulating PD-L1 expression in cancers and associated opportunities for novel small-molecule therapeutics. *Nature Reviews Clinical Oncology, 19*(5), 287–305. https://doi.org/10.1038/s41571-022-00601-9

Zhao, Z., Gong, Y., Li, Y., Zhang, L., & Sun, Y. (2021). Gender-related beliefs, norms, and the link with green consumption. *Frontiers in Psychology, 12*, 710239. https://doi.org/10.3389/fpsyg.2021.710239