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The Threefold Role of the University in Fostering the Energy Transition: The Case of Bologna and Its Cesena Campus

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Abstract: As acceleration toward the transition to a carbon-neutral energy production becomes an urgent imperative, universities are called to play a multifaceted role: to produce knowledge and cutting-edge research for the pursuit of energy transition; to transform infrastructures to promote circular economy practices and a more sustainable use of their building stock; and to promote energy citizenship through formal and informal education. The authors aim to move from these considerations to critically present some actions and programs in education, research, and campus operations in which the University of Bologna is engaged. The first part presents an overview of the role of universities in this transition, with a focus on the UI GreenMetric international standard for assessing the different dimensions of sustainability. In the core section, an empirical focus is provided on Bologna and its Cesena campus through three directions: the University's multicampus sustainable strategy (campus operations), the relevant research–action projects on energy justice and the energy transition (research), and the EN-ACTION project to foster energy citizenship and behavioral change in students and citizens (education). This study concludes that the comprehensive approach of the University of Bologna in integrating sustainability into its operations, education, and research while fostering student engagement in energy citizenship, provides a replicable model for other institutions. It highlights the need for consistent and ongoing support to ensure the long-term impact and effectiveness of sustainability initiatives. The integration of social components and engagement with civil society is crucial for fostering a collective behavioral shift toward low-carbon systems, which can be further supported by interdisciplinary and transdisciplinary research approaches.

Keywords: energy transition; sustainable campuses; energy citizenship; Bologna; Cesena



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1. Introduction

In the face of contemporary environmental challenges and the urgent need for sustainable solutions, universities are increasingly seen as prominent agents of change. A significant body of literature has grown in recent decades, especially concerning the embeddedness of sustainability and transition-related topics in university curricula [1], with ever-increasing importance attributed to the contribution that universities can play in manifold dimensions which, beyond education and research [2], include the so-called third mission, which is the set of scientific, technological, and cultural transfer activities and productive transformation of knowledge through processes of the direct interaction of the university with civil society and entrepreneurial actors [3].

Another underlying core dimension is that of campus operations concerning the management of the university's building infrastructure, which has achieved paramount significance due to the widely acknowledged impact of the built environment on carbon emissions. This dimension of university impact has been particularly emphasized by the

emergence of international standards and rating systems such as UI GreenMetric [4], which publishes a yearly report on how universities have performed in multiple dimensions including the management of their facilities and infrastructures.

Therefore, a new conceptualization seems to emerge that goes beyond the third mission and sees three pillars (campus operations, education, and research) being encompassed and sustained by a third-mission approach to the transition, penetrating all domains and influencing the way universities approach their relations to the external environment [5]. This is particularly true for the ecological transition and specifically the energy transition: partnerships with public, private, and social actors are key to mainstreaming the transition, promoting the role of universities as living labs and enablers of energy citizenship behaviors.

This paper's aim is to explore these pillars and their relations through the case of the University of Bologna, with a specific focus on the Cesena campus. The multicampus sustainable strategy (campus operations), the more relevant studies on energy justice and energy transition (research), and the EN-ACTION project to foster energy citizenship in students and citizens (education and third mission) will be the focal lenses to understand the potential of universities to embed sustainability policies, measures, and initiatives on and off campus. The role of international standards such as the UI GreenMetric is used as a benchmark and a lens through which to evaluate the University of Bologna's actions.

In the first part, the state of the art of the threefold role of universities will be provided, with particular attention to the role of promoting energy citizenship. After that, an overview of the UI GreenMetric standard and metrics for sustainable campuses is given, with attention to the University of Bologna's ranking. The role of universities is also presented through the University of Bologna and its Cesena campus, with attention to the multicampus sustainable strategy, relevant research–action projects about energy transition, and the EN-ACTION project.

2. The Threefold Role of Universities in Energy Transition

As the low-carbon transition becomes more and more urgent due to the critical effects of climate change across the globe, actors at different levels are moving to accelerate this transition. Universities are one of them through education, research, campus operations, and partnerships within the quadruple helix model (public, private, knowledge, and social actors) [6].

2.1. Education

By including sustainability in their programs, universities can train students about the pitfalls of mainstream models, their impact on well-being, the opportunities to change these trends, and their individual and collective roles in implementing them [7].

Even though there is consensus on sustainability as the core of new university curricula, the debate is still open on how to integrate it within the different branches of knowledge [8,9]. The lack of clear guidelines results in a lack of homogeneity among pioneering initiatives [10]. Recent surveys outline that the integration of sustainability matters into curricula is often implemented ad hoc, making comparison and replication more difficult [7].

In the specific case of energy transition, multiple issues have to be considered to incorporate the sustainability pillars throughout the energy chain: extraction of minerals, production, conversion, transport, and consumption. In that sense, the transformation of the current energy model requires a joint effort from a wide range of technical disciplines and trades. Table 1 presents the proposal of the key topics, contents, and skills to be considered based on the work of Ruiz-Rivas et al. [11]. Even if this proposal was made for energy-related curricula, it can be extended to other technical ones. The objective is to train students to deal with current and future problems of energy systems.

Table 1. Proposal of energy topics and contents to be included in university curricula based on [6].

Topics	Contents and Skills
Basic and applied sciences	<ul style="list-style-type: none"> - Energy-related: thermal engineering, fluid mechanics, and electricity - Energy-oriented: applied mechanics, materials science and structures, electronics and automation, and engineering graphics
Renewable energy production	<ul style="list-style-type: none"> - Fundamentals of each renewable source and principles of its conversion - Characteristics of the competing technologies - Environmental assessment - Economic assessment
Energy management	<ul style="list-style-type: none"> - Services related to energy end uses - Energy efficiency strategies - Conventional and alternative tools of renewable energy integration - Policy, regulation, and economic aspects
Sustainability of the whole energy model	<ul style="list-style-type: none"> - Fundamentals of environmental sciences - Environmental impact - Fundamentals of sustainability and sustainable development - Ethics of technology - Suitability with local conditions - Interdisciplinary concepts related to energy patterns, energy conservation, and local politics

2.2. Research

As knowledge producers, universities continuously adjust their research focus to societal requirements, aiming to enhance human well-being [12]. In the framework of energy transition, challenges encompass several levels simultaneously and are often complex, multifaceted, and open-ended [13]. Therefore, an overcoming of the traditional research fields is requested. Three main approaches can be considered to implement this overcoming: multidisciplinary, interdisciplinary, and transdisciplinarity.

Some misunderstandings persist in the use of these concepts [14]. If multidisciplinary refers to approaching a complex issue from different disciplines at the same time, interdisciplinary consists of integrating those insights from different disciplines to enhance a general understanding [15]. Transdisciplinarity aims at bringing together and confronting knowledge from science and practice in order to build integrated visions connected to real-world conditions [10]. In that sense, a transdisciplinary process will also involve nonacademic actors such as municipalities, companies, or other societal organizations [14].

According to Prades et al. [16], these approaches are particularly relevant to building new research teams and dynamics capable of unveiling and addressing the complexity of energy challenges. First, they facilitate the understanding and integration of past, present, and projected future conditions that may affect energy production, management, and supply [17]. Then, this perspective is critical to building a common narrative and a shared vision of energy transition that facilitates collaborations and actions [18]. Finally, opening research to nonacademic actors also allows for aligning global policies with major challenges, reducing the time to market groundbreaking solutions [19], and facilitating their testing and effective deployment [20].

Nevertheless, the implementation of new methods is often challenging for universities [21]. Such a paradigm shift implies a major rethinking of the academic structure and organization, which is traditionally based on research units working in parallel with

each other [21]. Furthermore, the most valued research for academic staff in terms of tenure, career, and promotion is the one conducted in small unidisciplinary teams [17]. As a consequence, multidisciplinary, interdisciplinarity, and transdisciplinarity potentially imply a substantial change in how scientific work is performed: from a siloed approach to an evolving interactive and collaborative one [22]. Universities should promote these new practices at different scales (faculties, departments, centers and institutes, and university administration), such as funding opportunities, specific training, new research structures, tenure evaluation criteria, or the development of partnerships [17,21].

2.3. Campus Operations

The purpose of a university campus is to offer facilities for research and education through buildings equipped with laboratories, classrooms, study areas, offices, and meeting spaces. Additionally, campuses are places of life for students and thus also provide amenities such as dining services and housing, as well as outdoor recreational areas and natural spaces [23]. As a consequence, their amount of greenhouse gas emissions is significant [24,25]. In their review of the literature, Ma et al. outline the weight of energy-related activities in the carbon footprint of universities and higher education institutions and the resulting necessity of including strong energy measures in the envisioned transitions of campuses towards sustainability [26]. These considerations for campus environmental impact thus confirm that “energy in higher education” goes beyond incorporating this topic into classroom curricula and research efforts.

In that context, universities can serve as laboratories for the design, testing, and validation of solutions that could be replicated and scaled within real-world environments [27]. According to Evans et al., living laboratories constitute “a form of experimental governance whereby stakeholders develop and test new technologies and ways of living to address the challenges of climate change and urban sustainability. They involve staging intentional experiments in real-world settings which are then monitored and learnt from in a rigorous way” [28]. In that sense, the implementation of a living laboratory within a campus adds an observable and practical dimension to the ways in which universities produce and transmit knowledge [29] and enables the connection of academic research and teaching with campus planning, infrastructure operations, and community development [27].

In the field of energy transition, living laboratories can help address the deployment of renewable sources, the energy retrofitting of buildings, or the integration of smart assets. Many of the innovations that have emerged to address those challenges are still in their early stages of development and need to be tested and improved in real-world settings [28]. According to Olivieri et al., campuses as living laboratories constitute the ideal environment where to research, develop, and test solutions and strategies that accelerate energy system decarbonization [30]. Indeed, university campuses are not just similar to small urban systems, they also have some unique features that reinforce their relevance as testbeds. First, their buildings and installations are often old and in urgent need of renovation [31]. Then, campuses include a high diversity of energy uses, ranging from classrooms and laboratories to student dorms, restaurants, shopping, and sports facilities [32]. Finally, they usually have restrictions in terms of budget and historic protection, which complicate the implementation of sustainability strategies [31,33]. As a result, these spaces combine most of the typical urban challenges that occur in the case of energy transition projects’ implementation. As a consequence, their testing and validation have the potential to lead to robust, efficient, and flexible solutions that pave the way for cities and communities.

2.4. The UI GreenMetric International Ranking

The UI GreenMetric international ranking was created with the aim of establishing a global ranking of the most virtuous university institutions in terms of green policies and estimating the collective commitment to environmental sustainability issues within the global academic community. In 2010, the University of Indonesia initiated and promoted a ranking project called UI GreenMetric. It was designed for universities worldwide to assess

their green actions and policies and to gauge the collective commitment to global academic environmental sustainability issues. The UI GreenMetric ranking acknowledges the key role that the academic world can play in promoting sustainability discourse by producing and disseminating knowledge on sustainability; setting an example in practice by embracing sustainable solutions, design, and policies within their campuses; and strengthening the bridge between governmental, international, and local environmental agencies for change.

Moreover, the ethos of the UI GreenMetric project is inherently linked to the Agenda 2030, and consequently, the 17 Sustainable Development Goals (SDGs) are foundational parts of its criteria and indicators. Methodologically, UI GreenMetric organizes its system based on 51 indicators grouped into six categories for a maximum score of 100 points: Setting and Infrastructure (green and blue infrastructures and built environment, accounting for 15 points), Energy and Climate Change (emissions and energy consumption—21 points, the highest weight attributed), Waste (consumption and disposal of waste—18 points), Water (reduction in water consumption—10 points), Transportation (sustainable and active mobility—18 points), and Education and Research (student awareness on environmental issues—18 points). These indicators are weighted, meaning they have varying relevance in determining a university's position in the ranking. The energy theme carries the highest weight, accounting for 21% of the total [4].

The architectural characteristics of university campuses wield significant influence over energy consumption patterns and the realization of sustainability objectives. Li et al. [34], however, underscore the importance of incentivizing sustainable energy behaviors among students and adherence to campus rules [35]. Furthermore, the assessment and mitigation of carbon footprints [36] stand as critical measures for evaluating campus sustainability, alongside initiatives aimed at enhancing energy efficiency and judicious resource utilization.

These considerations on campus environmental impact confirm that “energy in higher education” goes beyond incorporating this topic into classroom curricula and research efforts. Universities must strive to be the first ones to achieve a successful energy transition, implementing strategies to switch to a renewable-based model, improving their energy efficiency, and enhancing their flexibility [21,22]. The role of research as a third pillar of this model is pivotal: universities can transfer the production of new knowledge to both educational curricula and to the way campuses' built infrastructure is built and enhanced and its uses monitored and assessed [37].

3. Energy Citizenship and Student Citizenship for a Just Transition

The role of universities in the energy transition is increasingly connected with the concept of energy citizenship, which has gained prominent importance and is now seen as unattainable without the deep transformation of sociotechnical systems as a whole [38].

Technological shifts alone cannot achieve decarbonization goals if technologies are not broadly adopted at the societal level [39]. This is particularly true in the energy transition, as contemporary lifestyles have a significant impact on highly carbon-emitting domains such as building use and operations [40]. On the other hand, rising energy costs have direct effects on people in the form of energy poverty, i.e., the inability of citizens to adequately heat and cool their households. Therefore, promoting awareness and energy literacy, as well as more active forms of participation in the energy transition, is crucial to reducing burdensome energy costs for households [41].

It is within this framework that the concept of energy citizenship has emerged. It is viewed as the multiple ways “in which citizens are becoming actively involved in the energy transition and engaging politically either as consumers and users by participating in protest and support movements and [. . .] as prosumers” [42]. The notion of energy citizenship implies both rights and responsibilities, but also awareness, positive feelings, and willingness to act as prosumers' renewed agency in the energy system. It is seen as a major contributor to mitigating energy poverty [43] and supporting the local and global transition to carbon-neutral human systems [44].

While academic research has only recently turned towards energy citizenship, the prodromes of this concept were already present in many bottom-up initiatives to promote a collective use of renewable energy sources, energy literacy, and environmental awareness [42]. These initiatives set the ground for the current legislation on (and implementation of) energy communities [45]. Cooperatives, public–private partnerships, and energy communities have been mapped in Germany, Italy, the Netherlands, Spain, France, and the UK [42], with benefits including the strengthening of political and public participation, the enhancement of social cohesion, and a decrease in energy poverty [46].

However, the literature points out the lack of clear information for citizens to make informed decisions and to be active in the transition [47]. Consequently, a twofold need emerges: to provide people with the tools that enable the visualization and sharing of information to households, businesses, and individuals (energy informatics) [48] and to ensure that cognitive actors, namely educational institutions, can contribute to training activities and the emergence of energy citizenship behaviors.

Universities are putting significant efforts into achieving these objectives [49]: the “societal domain” is not only a mission of its own requiring greater interactions with the general public, entrepreneurs, and local governance but also a shift in the pursuit of the other missions, which are being transformed by the urgency to contribute to local and global challenges [50].

The role of universities in the transition is becoming a broad topic, mostly focusing on sustainability education [51] and on innovation and transfer to foster environmental resilience and climate adaptation and mitigation [52]. A growing body of research is focusing on the interplay of the three missions to combine innovative research, education, and societal engagement [53]. This arena appears as the most promising in that it is able to leverage all the roles and functions of universities within their local ecosystems, promoting awareness, producing technological breakthroughs, and promoting their uptake and mainstreaming to address local and global challenges.

According to Gifford et al. [54], active citizenship entails robust student engagement within their communities, prompting deliberations on the nature and participatory dimensions of such engagement. Additionally, an examination has been undertaken on the contribution of university courses in instilling citizenship values among students [55]. Ariza et al. [56] point out that educational interventions, coupled with other civic engagement activities, could lead to a more sustainable relationship with the environment and to more sustainable lifestyle choices from the rest of citizens. A public consultation promoted by the States General of the Italian National Agency for Innovation, Energy, and Sustainable Development [57] revealed a specific eagerness among students to actively participate in reducing their campus’ environmental footprint. However, the report also remarks a lack of pertinent information to guide the organization of mitigation efforts.

In the multifaceted stakeholder ecosystem of universities, however, what is often overlooked is the role of students in the process towards carbon-neutral human systems, constituting a considerable research gap. This role can be fostered by environmental education programs and sustainability courses, which are able to affect their attitudes and behaviors on these matters, as demonstrated by numerous studies in several countries [58–60]. Furthermore, the relationship between students and the transition is often connected to just one of the three university missions: the educational one. Especially concerning the third mission and the interaction between the university and civil society, very limited literature has been produced on projects to foster the role of students as promoters of sustainable behaviors. These research gaps are directly addressed by the EN-ACTION project, which is focused on in the following paragraphs.

4. Materials and Methods

In this section, two themes are presented: The first is the broader contribution of the University of Bologna to the transition, specifically read through the lens of its multicampus sustainable strategy and its Sustainability Report in relation to UI GreenMetric indicators

and the position held by the University of Bologna in the ranking. The second is a detailed focus on the EN-ACTION project, aiming to combine the three pillars of the university's contribution to sustainability actions with a third-mission approach focused on eliciting energy citizenship in students.

4.1. The “Multicampus Sustainable” Strategy of the University of Bologna and the Cesena Case

The University of Bologna is located in the center-north of Italy; the area, and specifically the Po Valley, has sadly been famous for being “blighted by air pollution among the worst in Europe”—as “The Guardian” titled their article at the end of 2023, stating that “more than a third of the people living in the valley and surrounding areas breathed air four times the World Health Organization’s guideline limit for the most dangerous airborne particulates” [26].

Among the 1050 universities worldwide analyzed by UI GreenMetric in 2023, the University of Bologna ranked 12th, the first in Italy for the fifth consecutive year. Additionally, since 2017, the University of Bologna has taken on the role of Italian Coordinator of the GreenMetric World University Ranking Network (UIGWURN).

Concerning the management of buildings and infrastructures, all the campuses of this university (Bologna, Cesena, Forlì, Ravenna, and Rimini) are involved in the strategy, which is articulated into four axes: University Energy Plan, Mobility, Environment, and People [61]. A “Sustainability Report” is also published every year [62], outlining the University’s actions with respect to strategy and governance, sustainability governance, teaching and student community, research, people, society, and environment.

The “environment” part of the strategy focuses on waste management through extensive recycling programs, the development of green spaces, and the installation of green roofs on campus buildings. The “Il Nastro Verde” film showcase raises awareness about environmental issues inside and outside the academic community, while the EXTra project focuses on expanding urban green spaces and integrating them with campus life. Some pilot experiments of green roofs are also being developed. The mobility part of the strategy foresees initiatives like car sharing, AlmaBike, and subsidized public transport passes for students and staff. An annual survey informs these strategies for improving commuting options. Projects include new cycle paths, enhanced public transport rates, and innovative mobility services to foster a more sustainable campus environment. The “people” section of the strategy is focused on well-being within the university. Namely, sports facilities and special rates for students have been implemented, while the Baby PitStop project promotes spots for breastfeeding and for changing babies’ nappies.

The most relevant part of the strategy for the purposes of this study, however, is the University Energy Plan, with which the University of Bologna aims to achieve significant milestones by 2030, including cutting greenhouse gas emissions by 50% by 2030. Following the indications of the European Green Deal and the “Fit for 55%” program, the Energy Plan identifies interventions to be carried out in the immediate future. These include the installation of new photovoltaic systems to achieve self-production by 2030 of about 17% of the electricity consumed; a relamping plan to increase the efficiency of the lighting systems in the University’s buildings; the implementation of a remote-control system for the entire thermal plant fleet; and the elimination of the last thermal power plants powered by diesel and fuel oil [62]. The 2024 Sustainability Report of the University of Bologna illustrates the steps made: the reporting of energy consumption and expenditure data is now available on the University Data Warehouse integrated by the Archibus information system with the aim of making it possible to cross-reference energy and property data and other university data that may influence its consumption.

According to the Sustainability Report, the analysis of the consumption time series shows a marked improvement over the three-year period, with energy consumption in 2023 falling by 13.6% compared with 2021. This significant drop has a concrete effect not only in reducing costs associated with resource supplies (even in the face of an increase in electricity and gas tariffs) but also in CO₂ emissions, which in 2023 decreased by 11.7%

compared with 2021. The University of Bologna is additionally below the national average concerning the emission index (the ratio between total emissions and total consumption), with 2.27 tons of CO₂ emissions against the national average of 2.53 tons.

Despite its commitment and overall score, in 2023, the University of Bologna still ranked 105th in the UI GreenMetric list. This is mostly due to the historical building stock, characterized by severe conservation norms and obsolescence problems (especially regarding energy retrofit), confirming the challenges already outlined by the literature [31,33]. Specifically, the Sustainability Report of 2022 from the University of Bologna testifies that both electricity and water consumption increased with respect to 2021, while “the cost of electricity purchased from suppliers grew by 27% year-on-year” [62]. Improvements were made over the past two years, as the Sustainability Report of 2024 [63] indicates a decrease in energy consumption for 2023 yet counterbalanced by an increase in energy prices.

4.2. The EN-ACTION Project

The study we present is framed within the EN-ACTION project that has been funded by the University of Bologna’s AlmaDea tender. The core of the project is focused on both energy citizenship and the threefold role of the university in energy transition.

The specific scope was to export and disseminate sustainability expertise and energy citizenship practices outside the campus with a core role of students as “ambassadors”. For this purpose, the research–action–research methodology was adopted [64], a methodology with a constant feedback loop that builds on research knowledge to experiment with state-of-the-art actions and/or actionable guidelines that then result in further knowledge and open new research streams [65]. EN-ACTION is also closely related to the position of the University of Bologna in the UI GreenMetric ranking, particularly concerning the education and research indicator.

The methodology was articulated into three Work Packages (WPs):

- WP1: Mapping and cataloging best practices aimed to gather and analyze successful sustainability initiatives from universities across Europe, aimed at defining the enabling factors and processes for the creation of energy citizenship. Specific attention is paid to energy efficiency, renewable energy adoption, user engagement strategies, and energy citizenship inferences in universities.
- WP2: Development of guidelines for community involvement to enhance energy citizenship of the university community, emphasizing behavioral change and active participation in sustainability efforts. This was performed by implementing workshops, questionnaires, interviews, and information days.
- WP3: Coordination, management, and dissemination of project activities to assure fruitful knowledge exchange with project stakeholders as well as with all of the academic and local communities.

The research–action–research approach was aligned with the threefold role of the university in promoting the transition, and specifically, the energy transition, in that they involved the three core dimensions of education, research, and campus operations, underlined by an approach grounded on the university’s third mission. Specifically, the research activities that started the empirical phase of the project emphasized the need to create actionable knowledge through the involvement of professors and experts in students’ training, creating a diversified curriculum. Students were then engaged in lab activities with experts and invited to actively reflect on the dissemination of the acquired knowledge. Ultimately, the project methodology foresaw initiatives to disseminate the results beyond students, embracing the whole citizenship (especially for what concerns the Municipality of Cesena where a campus of the University of Bologna is located and where the EN-ACTION activities were mainly set).

To monitor the project and analyze results, data collection methods were used throughout the WP2 tasks: surveys, interviews, and participatory workshops with members of the university community. The aim of data collection was to assess current levels of energy awareness, identify barriers to sustainable behavior, explore opportunities to foster energy

citizenship, and evaluate the success of the project and its ability to involve students in the promotion of energy transition among civil society.

5. Results

EN-ACTION results can be presented based on the three core scopes of Italian universities: research, education, and the third mission [3,66].

(a) Research.

EN-ACTION benefited from the expertise of a multidisciplinary group that collaborated in international projects such as Horizon 2020 ROCK “Regeneration and Optimization of Cultural Heritage in Creative and Knowledge Cities” (GA no. 730280) [67], Horizon 2020 GRETA “Green Energy Transition Actions” (GA no. 101022317) [68], and EIT Climate KIC GECO “Green Energy Community” (TC_2.2.15_190736_P125-1A) [69]. In the present section, the focus is on the GRETA and GECO projects, which both focus on the energy transition and energy citizenship.

GRETA aimed at understanding the unlocking and driving factors for energy citizenship behaviors in five EU case studies: natural gas-free living in the Netherlands, a renewable energy-driven cooperative in Portugal, an energy-efficiency-driven cooperative in Spain, a virtual community for sustainable mobility in Germany, and a renewable energy district in Italy. The latter was carried out in the Pilastro-Roveri district of Bologna. Some research tools and expertise for this case have been important to inspire EN-ACTION as well: the engagement of university students in Living Labs and co-creation and the research–action steps with residents and local actors. The main projects, Energy Citizenship Manifesto, Energy Citizenship Contracts, and Community Transition Pathways, also formed the baseline for the work of EN-ACTION.

GECO was a community management project of local energy to shorten the distance between production and consumption through the involvement of residents and local enterprises to increase renewable energy generation and self-consumption. This project has also been implemented in the Pilastro and Roveri areas. Moving from the recent legislative changes approved as part of the Clean Energy Package (CEP) at the European level, GECO aimed to stimulate and support national stakeholders for the creation of the new Italian regulation of the energy sector. GECO’s initiatives in promoting behavioral changes and educating the community about sustainable energy practices were mirrored in EN-ACTION, in particular, webinars and community events to raise awareness and drive collective action toward sustainability.

(b) Education.

EN-ACTION incorporated sustainability, energy transition, and energy citizenship in the lab activities to strengthen the students’ expertise at the Cesena campus and potentially transfer it to the rest of the academic community, as well as to citizens. This mission of the project is also closely related to the ambition of improving the University of Bologna’s position in the UI GreenMetric ranking, particularly in the education and research indicator. Bologna was ranked 12th globally and first in Italy, but it is 4th in this specific category.

EN-ACTION was the first initiative at the University of Bologna to explicitly address students-as-citizens in promoting sustainability education and in enacting and eliciting sustainable behaviors through a joint effort of research experts, education activities, and campus operations.

The EN-ACTION lab has been the most important activity to consider the conditions and the enabling factors in energy citizenship processes for 17 students of the Single-Cycle Degree Programme in Architecture at the Cesena Campus. The lab was implemented through ten online seminars from 26 April to 4 July 2023. Four University credits were assigned to participants. This activity culminated in ten dossiers with reflections, topic summaries, graphs, and illustrations on the perspectives of participants and are accessible on the EN-ACTION page on the University of Bologna’s website [70]. The dossiers focused on different energy transition issues: energy citizenship (in connection to the GRETA

project), energy poverty and social issues, energy communities and ecological transition (in connection to the GECCO project), the University's energy community, ICTs and technologies enabling the energy transition, the commitment of local administrative actors (creating linkages to the Green City Accord [71] in Cesena and the Bologna Climate Mission [72]), the sustainable universities (with attention to the UI GreenMetric World University Ranking), and specifically awareness of the multicampus sustainable strategy by the University of Bologna and the participatory energy framework (from legislation to city application). Multidisciplinary experts and emblematic case studies were part of the lab contents with the intention to cover these aspects and steps of the transition.

A further output was the analysis of participants' feedback through eleven individual video interviews at the end of the program. Students were contacted beforehand with open-ended questions on energy transition topics from the lectures. The interviews were held both to promote the role of students as ambassadors of the transition and, consequently, for dissemination purposes across various local platforms: the Energy Help Desk for the City of Cesena, the Municipality of Cesena, and the Green Office of the Romagna Region.

(c) Third Mission.

EN-ACTION stemmed from an established collaboration between the University of Bologna (and specifically the Cesena Campus) and the Municipality of Cesena. In particular, two projects have emerged. The first involves the Municipality of Cesena in the Green City Accord [71], a European network focused on urban nature protection, air and water quality, nature and biodiversity, noise, waste, and the circular economy. An agreement signed in 2022 between the Municipality of Cesena and the University of Bologna facilitated a shared data collection and analysis. The second project is called "Tutti insieme tutti green" ("All together all green"), and it is a partnership between the university and part of the city's Climate Council: the aim is to take some steps and plans to establish the city's first Renewable Energy Community (REC) in Cesena.

EN-ACTION's efforts for civic engagement found further expression in some events scheduled in 2023, including the Sustainable Development Festival and the European Researchers' Night. At the end of each session, experts were invited to offer insights from disciplinary and practical standpoints, engendering a compendium that included guidelines, steps, challenges, and objectives to foster an equitable and just transition. Through a critical and collective review of the responses, a list of pivotal and overarching concepts emerged, gleaned from the speakers' presentations. This inventory informed the manifesto of the EN-ACTION project, charting a course for individual, collective, and political behavioral shifts necessary to enable the transition. In this context, energy is conceptualized as an inalienable right for all communities and individuals.

A last significant output was the convergence of results and demands generated by students into two projects: the aforementioned "Tutti insieme tutti green" ("All together all green") and "Sentinelle dello spreco" (Waste Watchmen). These initiatives entailed the drafting of the Manifesto for the forthcoming Energy Community of the Municipality of Cesena and the University of Bologna.

6. Discussion

The University of Bologna's engagement in the multicampus sustainable strategy and its participation in initiatives like EN-ACTION highlight the pivotal role of universities in societal transformation towards sustainability. The university is aligning with the need to adopt a comprehensive approach to environmental stewardship and energy justice across its threefold role: education by embedding sustainability into its curricula [11,16]; campus operations by setting goals to meet climate neutrality in domains such as energy efficiency, mobility, waste management, and societal initiatives [23,32]; and research through targeted studies which not only directly tackle different dimensions of climate neutrality and the ecological transition but also engage directly with territorial stakeholders, including citizens and public institutions, thus fulfilling its third mission [6,20,22].

EN-ACTION is not the first project to engage students on energy citizenship and sustainability issues with the ambition of enhancing their understanding and active participation in the energy transition process. Student Energy [73], for example, empowers university students across different universities worldwide to solve local energy problems using proven processes and technologies. It provides tools, coaching, and funding for projects such as solar PV installations, creating solar-heated greenhouses, and building off-grid solar charging hubs on university campuses [74]. At the University of Manitoba, for example, a donated shipping container was turned into a solar-heated greenhouse, aiming to distribute it to rural and indigenous communities in northern Manitoba [75]. EC² (Energy Citizenship and Energy Communities for a Clean-Energy Transition) [76] has been funded by the EU Horizon 2020 to empower students and other community members to actively participate in energy systems and transition to clean energy. EnergyPROSPECTS [77] is another EU-funded project to develop a broad understanding of energy citizenship focusing on engaging university students in the exploration of energy practices.

All these projects actively involve university students and stress the importance of community engagement in addressing energy challenges and the role of students in leading these efforts. EN-ACTION, however, was limited to the University of Bologna, while Student Energy and EC² have a broader international scope. Moreover, EN-ACTION's effort is to integrate research, teaching, and campus operations in one university, whereas projects like these involve diverse and dispersed projects with diverse degrees of student involvement across the globe.

In any case, EN-ACTION emerged as a beacon of how student engagement can be leveraged to foster a deeper understanding of energy issues and to cultivate a culture of active energy citizenship. The findings from the University of Bologna and Cesena campus suggest that universities are uniquely positioned to advance energy transition and nurture energy citizenship. This is achieved not only through education and research but also by modeling sustainable practices on campus and fostering a process in which students are encouraged to be active in sustainability initiatives.

In this respect, its comprehensive nature goes beyond the adhocacy characterizing most environmental initiatives observed by the literature [12]: its living lab approach, incorporating research practice, educational activities, and societal outreach, is able to collect the university's sustainability initiatives into a methodological framework that proves scalable and replicable to other contexts.

The EN-ACTION project advances the literature on sustainability education and sustainable campuses in two ways. First, it is the result of all the roles that universities are called to cover today, providing the whole of society with usable knowledge gained through research–action–research [64] and bridging the university and citizens through active student citizenship. Second, it aims not only at providing students with knowledge through educational activities but also at the transfer of such knowledge and capabilities to broader citizenship.

The limits of EN-ACTION need to be taken into account: The limited timeframe and funding available did not allow for a more comprehensive involvement of other faculties in the initiative, nor to envisage follow-up activities that would have sustained the impact of the project in the long term. Another critical point was the limited feedback of participants. Seventeen students joined the project, but only eleven filled out the final satisfaction questionnaire. This can be seen as an indicator of limited engagement, probably related to a demanding class schedule; also, lectures were held in the evening hours, making it demanding for students to add it to their study plan. A third critical point was the lack of in-person activities during the lab: the project had to face the pandemic context, as well as the scarcity of funds to cover these activities. If the majority of students declared to be satisfied with the laboratory, the initial objective was much more ambitious: transmitting interdisciplinary knowledge to students and making them “transition ambassadors”. That aim has just partially been accomplished due to the lack of a virtuous combination of elements: more time, more space availability, and more human resources to follow the process.

This study thus highlights the need for more homogeneous integration of sustainability into curricula and the ongoing pursuit of carbon neutrality in campus operations, indicating areas where further efforts are needed. Additionally, while the initiatives undertaken by the University of Bologna and its Cesena campus have shown very positive results, their scalability and applicability in other contexts require further exploration, as the different environmental, social, and cultural characteristics of campuses, their existing sustainability initiatives, and other context-specific needs require careful crafting of energy citizenship initiatives among students.

7. Conclusions

This study positions itself within the literature on the threefold role of universities in energy transition and energy citizenship. The multicampus sustainable strategy and the EN-ACTION project have been the focal points to focus on this role. If multicampus sustainability becomes more established and better connected with international initiatives like UI GreenMetric, EN-ACTION can innovate in fostering energy citizenship through student engagement and education.

Specifically, we note that the UI GreenMetric indicators do not feature a social component, which is present in the breakdown of UNIBO's multicampus sustainable initiative, as well as in its Sustainability Report. This social component is aligned with the university's growing commitment to its third mission of societal engagement and outreach toward civil society. EN-ACTION represents an interesting stance on how this happens, as the project bridges the third-mission components with sustainability education, creating further linkages with the research and infrastructure dimension. In this respect, it should be highlighted that the UI GreenMetric would benefit from another set of indicators concerning engagement and civil society to emphasize the role of universities in the collective behavioral shift required to foster a rapid transition to low-carbon human systems.

This research also highlights that there is still much to achieve on both the multicampus sustainable front and the domain of energy citizenship and student citizenship. Concerning the former, the infrastructure of the university is still facing high (and increasing) resource demands, as demonstrated by the indicators of the Sustainability Report. Despite these limits, the score of the University of Bologna in UI GreenMetric still stands; yet, it is worth noting that urgent efforts must be made to make this infrastructure more resource-efficient and less carbon-dependent. The obsolescence of its building stock and the presence of heritage buildings hinder the process, making retrofitting and energy efficiency measures hard to implement.

Conversely, a dimension that the university does not take into account is the discrepancy between the multicampus sustainable strategy articulated into four dimensions and the dimensions outlined and measured in the Sustainability Report, which do not coincide (as illustrated in Section 4). Aligning the actions with the evaluation is critical for the purposes of effectively enhancing the contribution of the university to the sustainable growth of its territory and its community.

Despite these discrepancies, results highlight the University of Bologna's achievements in embedding sustainability into its operations and curricula. Results concerning the number of courses dealing with sustainability, in particular, are significant in illustrating its educational effort, while the number of competitive projects dealing with sustainability is another indicator of the skill to produce a necessary body of knowledge to tackle climate change. The EN-ACTION project is showcased as a model for student engagement to foster a deeper understanding of energy issues and cultivate energy citizenship. The study finds that universities, through initiatives like this, are uniquely positioned to nurture energy transition and energy citizenship.

In promoting awareness of energy use and renewable energy production and consumption, EN-ACTION touches upon many aspects of the UI GreenMetric indicators, as well as the multicampus sustainable strategy. More importantly, it expands the impact of

educational initiatives beyond the student dimension, especially concerning sustainability education to reach citizens of the Cesena community.

The EN-ACTION project, however, faced severe challenges, such as limited feedback and a demanding study schedule for the participant students, which hindered the full realization of its ambitious goals. Additionally, the lack of continuity of the project represents a major constraint, highlighting that consistency would only be ensured by continuous and ongoing support. Building on the foundational work of this study, future research is encouraged to delve into several key areas to extend our understanding of sustainability within educational institutions and their broader communities. The threefold role of the university (research, education, and campus operations) seems to be very clear both from the literature review and from our case study, as well as the critical role of students in the process. Assessing the long-term effects of sustainability education on students is pivotal, as understanding how such education influences their attitudes, behaviors, and career paths over time can provide invaluable insights into the effectiveness of educational frameworks.

Acting in a small community can be highly effective for starting and testing energy citizenship projects due to the ease of engagement and quick implementation. However, these limited resources and the scale of impact must be carefully managed to ensure sustainability and broader applicability. By leveraging the strengths of small communities and addressing their challenges, these projects can serve as valuable models for larger-scale initiatives. Developing precise metrics and methodologies to accurately measure the impacts of campus sustainability initiatives could significantly enhance our grasp of their true value and effectiveness.

Lastly, the adoption of interdisciplinary and transdisciplinary research approaches to tackle sustainability challenges offers the potential to uncover innovative solutions and deepen our understanding of the energy transition's complexity.

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