Data for AI training in the field of energy: ownership, ethics and the role of EU regulations

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***Summary*—Artificial intelligence (AI) is revolutionizing the energy sector by increasing efficiency, integrating renewables, and enabling smart grid management. However, the introduction of artificial intelligence in this domain raises key questions about data ownership and the impact of European Union (EU) regulations on the rights of citizens participating in energy communities. This article explores the types of data used to train AI in the energy sector, examines the ownership of AI-generated outputs, and analyses the implications of EU regulations for data protection and citizens' rights in the context of the concept of citizen energy.**

Keywords — trainang data; data ownership; data monetization; EU legislative

I. Introduction

The integration of data ownership and artificial intelligence (AI) into citizens' energy sector represents a transformative shift in the way energy is produced, consumed and managed. As the global energy landscape transitions from centralized power structures to more democratized systems, citizens are evolving from passive consumers to active prosumers, participating in energy production and consumption through initiatives such as Citizen Energy Communities (CECs) and Renewable Energy Communities (REC) [1].

This empowerment is key to fostering sustainable energy practices, enabling collective actions that support the transition to cleaner energy sources, improving community resilience, while maximizing individual benefits through energy generation and storage capabilities.

AI technologies play a key role in this development, increasing operational efficiency and sustainability in energy management. They enable smart grid management, predictive maintenance, and real-time energy optimization, significantly improving system reliability, sustainability and efficiency - inherently reducing carbon footprint [2].

However, the intersection of AI and data ownership raises important ethical considerations, in particular regarding data governance, privacy and consent. The complexity of managing and protecting data collected from citizens' energy activities poses challenges to ensuring that individuals retain the rights to their data while facilitating its ethical use in AI-driven innovations [3].

Namely, the discourse around data ownership in the energy sector of citizens is full of controversy. Restrictive data policies can stifle innovation by limiting how data is shared and used, while a lack of clear ownership rights can lead to confusion and mistrust among stakeholders.

Moreover, issues related to algorithmic bias and the potential misuse of personal data require strong governance frameworks that prioritise transparency and accountability in AI applications.

As the energy sector continues to evolve, the dual focus on data ownership and artificial intelligence within citizen energy communities highlights the critical need for ethical, secure, and compliant data management practices. Addressing these challenges is key to promoting trust among citizens and fostering wider participation in the ongoing energy transition, ultimately ensuring that technological advances serve the interests of all stakeholders involved [4].

II. Background

A. Data ownership

The intersection of data ownership and artificial intelligence in the energy sector of citizens is a key area of focus in the ongoing energy transition. Historically, the energy supply has been dominated by traditional energy structures, including large production facilities and centralised grids, leaving little room for the involvement of citizens other than passive consumers [5].

However, recent policy developments in the European Union have introduced the already mentioned concepts of CEC and REC, which empower citizens to take on more active roles, moving them from consumers to prosumers – individuals who produce and consume energy. This change is crucial because it promotes the democratization of energy production and consumption, allowing citizens to engage in collective energy actions that support a cleaner energy future. The citizens thus become more proficient in managing their energy needs. As prosumers, citizens can now benefit from their energy production, consumption and storage, increasing the flexibility of the electricity system through demand response and energy exchange. The change in the system operation paradigm is not without challenges however – the adoption of new energy services already raises concern and data security proficiency even within the early adopters [6].

The emergence of energy communities marks a transformation in the energy market, which is increasingly characterized by participatory governance structures that prioritize social engagement and active participation of citizens. With this transformation, the role of artificial intelligence in optimizing energy systems is gaining momentum.

B. *Artificial intelligence as a "disruptor"*

AI technologies are becoming essential to increase efficiency, sustainability and operational effectiveness in the energy sector, especially in the context of smart grid management and renewable energy optimisation.

The integration of AI brings new challenges, especially in terms of data ownership and management. As energy communities leverage data from their activities, the complexity of managing and protecting this data becomes paramount. Ensuring that individuals have rights to their data while facilitating its ethical use for AI-driven innovation in energy systems is key to fostering trust and wider participation in the energy transition.

Therefore, the dual focus on data ownership and artificial intelligence within citizens' energy communities represents a significant evolution in the way energy is produced, consumed and managed. It highlights the need for robust frameworks that balance the rights of data owners with the operational needs of energy systems, ensuring ethical, secure and compliant data handling practices as the energy sector continues to evolve [7].

III. The Role of Data in Energy

Artificial intelligence (AI) is revolutionizing citizens' energy sector by increasing efficiency, promoting sustainability, and empowering consumers. As the energy landscape evolves, AI technologies are being used to optimize energy management and reduce environmental impact, while also addressing the ethical and social implications associated with their use. AI-powered energy management systems are an integral part of citizens' energy sector, as they use advanced algorithms and machine learning to analyse vast data sets and steer energy consumption patterns in real time, resulting in significant energy savings and a reduction in the carbon footprint [8].

AI can also play a significant role in optimizing energy flows within the citizens' energy sector. By facilitating smart grid management, AI systems can increase the efficiency of energy flow and reduce waste. For example, AI algorithms can dynamically manage energy surges and changes, determining when energy should be saved and where it should be distributed most efficiently.

This capability is particularly important for the integration of renewables into the grid, as AI can help mitigate the disruption problems that often accompany renewable energy production.

AI systems in the energy sector rely on a variety of data sources and types to function efficiently and provide relevant and accurate analyses. One of the most important categories of information relates to energy consumption patterns. Such data mainly comes from smart meters and IoT devices and provides a detailed insight into the habits of users, from which precise estimates of future energy needs can then be performed.

In addition, it is very important to collect network performance metrics – for example, voltage level, frequency and load data – to help maintain grid stability and identify potential problems more quickly. Weather data, i.e. forecasts of meteorological conditions, are crucial for predicting the production and demand of renewable energy sources, since factors such as wind or solar radiation directly affect production. In addition, understanding the demographic characteristics of customers is particularly useful for the adaptation of energy services, which is reflected in more efficient planning and creation of offers that meet the real needs of different user groups [9].

The data that enables this level of prediction and adjustment comes from several sources. Among the most important are IoT devices and smart meters that continuously collect real-time consumption data, thus enabling a detailed analysis of consumer habits. Public datasets also play a significant role, as they contain a wide range of information on energy trends, weather conditions or socio-economic characteristics. Finally, there are energy suppliers who have proprietary information about the production and distribution itself, and such data can be of crucial importance for the assessment of grid capacity and long-term planning. By combining all these elements, AI systems can more accurately predict consumption, improve grid stability and optimise energy resource management [10].

Using this data allows AI models to optimize energy distribution, predict demand, and efficiently integrate renewable energy sources.

A. *Ownership of Results in Artificial Intelligence Training*

The integration of artificial intelligence into an organization's business processes itself involves the collection and analysis of large amounts of data. This increased data activity raises significant privacy and security issues that organizations must address to protect the privacy and security of their employees' and customers' data.

The issue of ownership of the outcomes resulting from the operation of AI models, which are trained on shared data, is extremely complex and involves different aspects of intellectual property. On the one hand, individuals and entities providing data can claim the insights generated by AI based on their information, as it is their data that is the basis for the development of these insights. On the other hand, energy companies or any other organizations that develop and maintain AI models emphasize their ownership of the models themselves and their results, especially when using proprietary algorithms and company expertise.

To better illustrate this issue, an example can be considered in which an artificial intelligence model predicts

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potential energy savings for a particular local community, relying on data provided by members of that community. In such a situation, the question arises whether the rights to the results and conclusions belong to the residents themselves, given that their data were crucial for the model, or whether they are completely retained by the energy company that created and manages the model.

To protect the interests of all parties involved, it is important to put in place clear agreements and legal frameworks that precisely define ownership rights and ensure fair remuneration for participants who have contributed data. Such agreements prevent potential disputes and maintain trust in the processes of collecting, analysing and using data for the purpose of improving energy systems and other areas [11].

Recent efforts have been devised to develop privacy-preserving schemes to handle the data while still exploiting the most utility of the data itself [12] and [13]. These schemes in general may induce significant overheads in performance and communication cost. However successful examples of collaborative privacy preserving schemes exist and are suitable even for monetizing of the data assets in business contexts [14].

Balancing these interests requires clear agreements and legal frameworks to demarcate property rights and ensure fair remuneration for those who contribute data.

B. North Adriatic Energy Community Case Study

The North Adriatic Energy Community (EZSJ) is one of three operating energy communities in the Republic of Croatia that have a license for energy activities. It has 27 members primarily from the North Adriatic region, with a total installed production capacity from photovoltaic plants of over 150 kW. The community members are of various types, from retirees, family households to non-profit associations, companies and craftsmen. The purpose of the participation of each member in the energy community of citizens is to achieve savings in relation to other sources and forms of energy supply, for example, in relation to energy from the grid [15]. Each member has obligation to supply data that are the subject of system or optimisations management (energy production and/or consumption curves). In the context of the EZSJ, this is achieved by delegating the function of collecting and processing data from each member to the energy community itself, which is regulated by contracts between the community and the member. Following the defined meaning and purpose of participation in the citizens' energy community, it follows that the effect of participation may vary in the ranges of benefits of each member of the community. Therefore, the central issue of data management comes down to optimization to achieve the best effects of each member of the community.

EZSJ members are divided into 4 categories (users – consumers (P1) or prosumers (P2) and companies – consumers (B1) or prosumers (B2)) to enable analytics and simulations that are in accordance with the valid tariff policies on the energy market of the Republic of Croatia.

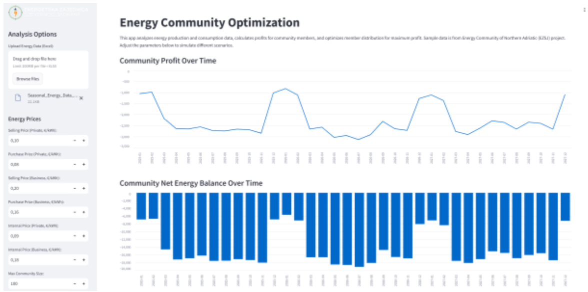

Figure 1. Energy Community Administration System ECAS

On Fig. 1 we are presenting Energy Community Administration System (ECAS) used for managing and optimizing EZSJ. As a simulation engine open-source Grid Singularity Energy Exchange provided under GPL v3. Codebase licence is used [16]. There are several parameters that govern optimization, but the most important are: (i) data on produced and consumed energy, (ii) internal prices of shared energy, and (iii) consumption (load) profiles. However, the curves of energy produced and taken from the grid are different for each billing period, and each billing period may vary by the number and type of members. Therefore, optimization should be carried out for each billing period. (Fig. 2).

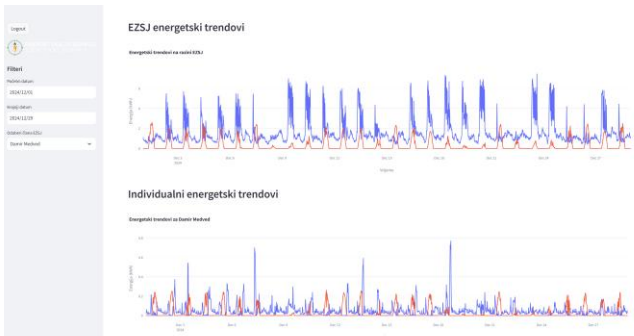

Figure 2 ECAS billing period sample

Optimization can be carried out on several levels regarding targeting precision. The first level of optimization refers to the goal of minimizing the energy distributed to the grid. In this case, suboptimal business occurs when the demand for shared energy is lower than the supply.

The second level of optimization refers to maximizing the benefits of different groups of users. Namely, members of the community can be classified into groups with regard to certain criteria such as the status of a producer or passive consumer, the purchase price of energy from the network, and the like. Suboptimal performance in this case will be if the benefits of the group are less than the maximum possible.

The third level of optimization is methodologically like the second level, except that in the third level, optimization is carried out at the level of each member of the community. Optimization is carried out by comparing the effects "outside" and "inside" the community. An illustration of the optimization method results is shown in Fig. 3:

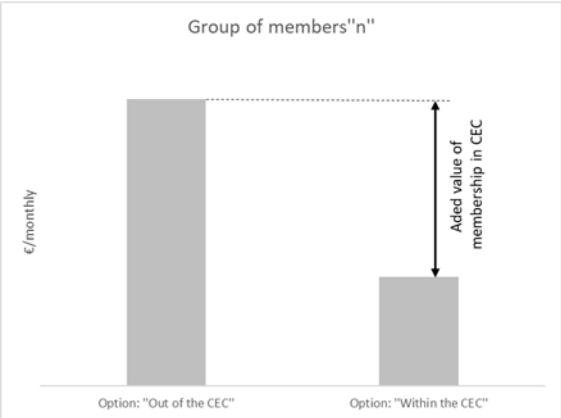

Figure 3. Illustration of the added value of participating in the optimised community

The relationship between these benefits represents an added value due to participation in the community, and the goal is to make it as high as possible for each group as presented as result of one iteration result in Fig. 4.

Figure 4. Profit distribution by member type simulation

From the previous considerations, it is quite clear that the benefits of participating in the energy community cannot be precisely determined without historical data from all members, therefore their consent to the automation of data collection as well as their profiling in the context of consumption is a prerequisite for entering the energy community. In the framework of the Northern Adriatic Energy Community, this is specifically regulated by decisions of the community assembly and is based on valid EU regulations in the context of data protection.

C. *EU rules and citizens' (consumers' rights)*

The legal bases for the right to privacy and data protection are defined in the EU Charter of Fundamental Rights [17]. Along that, the General Data Protection Regulation (GDPR) serves as a global benchmark for data protection laws, reinforcing the importance of these rights. In many EU Member States, including Croatia, constitutional laws further protect these fundamental rights.

The GDPR, which has been in force since 2018, has important role in regulating the use of personal data in the context of the AI platforms implementation. Most importantly, the GDPR explicitly prohibits decisions based solely on automated data processing (avoiding “man in the loop”), including profiling, and imposes strict guidelines on how personal data is collected, managed and kept.

The European Union has introduced extensive regulations to protect citizens' privacy and rights in the area of artificial intelligence implementation, with the General Data Protection Regulation (GDPR) playing an important role. This regulation requires that all personal data be processed lawfully, transparently and only for a clearly defined purpose. In particular, it is emphasized that individuals have the right to access, request their correction or deletion, and that they can request the restriction of processing. Furthermore, in the context of AI development, it is vital to respect the principle of minimizing the data collected and to obtain explicit consent from users before using their personal information, which often limits the amount of data available for model training.

In addition to the GDPR, the European Union has also adopted other regulatory acts, such as the Digital Services Act (DSA) [18] and the Digital Markets Act (DMA) [19]. They aim to create a safer digital environment and establish a more balanced AI implementations, which has a direct impact on the operation of AI-based platforms, including those operating in the energy sector. These acts also introduce requirements for greater transparency in the operation of algorithms, i.e. the obligation for companies to explain how their AI systems make decisions. This aims to ensure greater accountability and clarity in the use of AI, which is crucial for user trust and the sustainability of AI technologies.

D. *Artificial Intelligence Act*

The Parliament and the Council of the European Union have adopted the world's most ambitious technology regulation – the Artificial Intelligence Act [20], which aims to set clear requirements and expectations for specific uses of AI. Although the AI Act entered into force on August 1, 2024, most of its provisions will not be implemented immediately. Instead, it will be phased in and full implementation is scheduled for 1 August 2027.

The AI Act will standardise AI regulation across the EU27, with significant extraterritorial implications, covering all AI systems that affect people in the EU, regardless of their origin. As with other recent EU regulations, the fines for non-compliance are enormous.

Pending the full implementation of the AI Act, the European Commission is promoting the AI Pact [21], asking for a voluntary commitment by the industry to anticipate adaptation to the AI Act and to start implementing its requirements before the legal deadline.

The AI Act introduces a risk-based approach, according to which AI systems are classified according to the degree of potential danger to users and the wider community. The strictest requirements relate to so-called high-risk applications, where it is mandatory for their developers to establish detailed risk management systems, as well as to ensure adequate human supervision of the operation of artificial intelligence. Such an approach has a direct impact on the energy sector, as all AI systems that manage critical infrastructure – such as energy supply networks – are considered high-risk. Therefore, adherence to strict safety and ethical standards is crucial for them.

AI governance in the energy sector presupposes the establishment of comprehensive AI governance frameworks to prevent abuse and protect the rights of all users. Clear guidance should specify the permitted uses of AI for the processing of production/consumption data and consumer behaviour, ensuring that AI applications comply with ethical standards and legal requirements. This includes setting boundaries for monitoring, decision-making processes, and the use of service user data. Effective AI governance fosters accountability and ensures the responsible use of AI tools, thereby reducing the risks associated with the automation and manipulation of user data.

Such regulations together aim to better protect citizens' rights, ensure respect for the privacy of collected data and encourage the ethical and sustainable development of artificial intelligence in the field of energy. This seeks to strike a balance between promoting innovation and reducing potential risks to society and the environment.

E. Ethical and Practical Implications

Ethical implementation of AI systems is paramount for maintaining trust among employees, employers, and clients. The 2019 Ethics Guidelines for Trustworthy AI [22], developed by the independent High-Level Expert Group on Artificial Intelligence appointed by the EC, outline seven non-binding ethical principles for AI that AI systems should comply to be considered credible:

1. **Human action and oversight:** AI systems should support people, enable them to make informed decisions and nurture their fundamental rights. At the same time, adequate monitoring mechanisms need to be ensured, which can be achieved through the 'man in the loop', 'man above the loop' and 'man in command' approaches.

2. **Technical robustness and safety:** AI systems need to be resilient and proven. They must be safe, they must provide a backup plan in case something goes wrong, as well as be up-to-date, credible and repeatable.

3. **Privacy and data governance:** In addition to guaranteeing full respect for privacy and data protection, it is also necessary to ensure appropriate data governance mechanisms, taking into account their quality and integrity and ensuring legitimate access to data.

4. **Transparency:** The business models of data, systems and applications of AI should be transparent. Furthermore, AI systems and their decisions should be explained in a way that is tailored to the average user.

5. **Diversity, non-discrimination and fairness:** Unfair bias must be avoided as it can have multiple negative implications, from marginalising vulnerable groups to exacerbating prejudice and discrimination.

6. **Social and environmental well-being:** AI systems should benefit all people, including future generations. Therefore, their sustainability, energy efficiency and environmental friendliness must be ensured.

7. **Accountability:** Mechanisms should be put in place to ensure accountability of organisations using AI systems and any errors to end-users.

The application of AI in the energy sector brings a number of ethical and practical challenges, especially when it comes to balancing innovation and the responsible application of technology. One of the key aspects of this relates to fairness and equality, that is, the necessity of ensuring that AI systems do not perpetuate existing biases or put certain demographic groups at a disadvantage. Since AI models rely heavily on historical data, there is a danger that learning from this data will only cement existing inequalities and thus create additional barriers for those groups that are already marginalized.

In order to mitigate or completely eliminate bias, various techniques are being investigated, among which *federated learning,* and the use of synthetic data stand out [23]. Federated learning allows models to be trained on decentralized datasets, without exchanging sensitive data between different sources, which can reduce the possibility of bias associated with limited or uniform datasets. Synthetic data, on the other hand, is created by computer means to complement or replace real data, thus providing a wider and more diverse range of examples for model training, allowing for more accurate and fair solutions. The use of such approaches seeks to encourage the continuous development of innovation in the energy sector, while ensuring that the highest ethical standards are respected.

F. Trust of the members of the energy community

Transparency is key to building trust and ensuring a smooth process of digital transformation of companies and the adoption of AI technologies within the organization. The same principles apply, of course, to energy communities and other forms of citizens' associations (CEC and REC) Promoting a culture of transparency in data collection and processing includes clear communication about how artificial intelligence is used, about the benefits it brings, but also about the consequences it can have on various aspects of the work of organizations. This openness helps demystify AI technologies, alleviating fears and misconceptions among users. Involving members in the adoption process fosters a sense of ownership and collaboration, minimizing the risks inherent in each application of new technologies. Transparent communication also extends to stakeholders outside the organization, strengthening the organization's commitment to the ethical and responsible use of AI and the processing of large data sets. Addressing these implications requires ongoing dialogue among stakeholders, adherence to ethical guidelines, and continuous monitoring of AI systems.

IV. Recommendations and Future Directions

As organizations (including SME or NGO sector) integrate AI into their operations, prioritizing ethical standards becomes imperative to ensure fairness and accountability. Implementing strong ethical guidelines for the use of AI helps mitigate risks such as bias, discrimination, and unintended consequences. Those guidelines should cover principles such as data privacy, transparency in decision-making processes and accountability mechanisms. By incorporating ethical considerations into their AI strategies, organizations not only follow regulatory requirements but also build trust with customers, employees, and other stakeholders.

To effectively navigate the complexities surrounding the use of data and AI in the energy sector, it is essential to ensure active cooperation and a clear allocation of responsibilities between policymakers, energy companies and citizens themselves. In the first place, policymakers need to design and implement clear legal guidelines to clarify the ownership of data and results generated using AI. This can prevent potential conflicts over intellectual property and ensure that legal frameworks keep pace with rapid technological progress, thereby protecting citizens' rights while allowing innovation to flourish.

At the same time, energy companies must adopt transparent practices and communicate openly about the ways in which they collect, process and use consumer data, including AI-based decision-making processes. The introduction of ethical principles in the development of AI systems is additionally important to prevent technological progress from coming at the expense of social values and privacy protection. On the other hand, citizens should try to be as well informed as possible about their rights related to their own data and the possible impacts of AI systems on the field of energy. It is also desirable for them to actively engage in public debates and consultations, to contribute to the creation of fairer and more effective policies and practices with their opinions.

The adoption of new technologies such as collaborative learning can improve data privacy while enabling effective AI training, offering a way forward that respects citizens' rights and fosters innovation.

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