DATA ACCESS AND EFFECTIVE SOCIAL ENGAGEMENT: A PATHWAY TO RESILIENT AND CONSUMER-ACTIVATED COMMUNITIES

Mário Couto[1], Mariana Jimenez[1], Peter Richardson [1], Alessio Coccia[1], Alexandra Revez[2], Julia Blanke[2], Deirdre de Bhailís[3], Jonathan Sandham[4], John Walsh[5]*

[1]EPRI Europe, Dublin, Ireland
[2]University College Cork, MaREI, Cork, Ireland
[3]Dingle Hub, Dingle, Ireland
[4]DCSix, Cork, Ireland
[5]ESB Innovation, Dublin, Ireland
**mcouto@epri.com*

Keywords: ENERGY COMMUNITIES, SOCIAL ENGAGEMENT, SMART METERING, DATA ANALYTICS

Abstract

Social engagement and data sharing have a critical role in transitioning to sustainable energy systems. Leveraging the work developed in the ENPOWER and Crete Valley projects, this research focuses on the Dingle Peninsula, where smart meter data is used to characterize energy behaviour and identify opportunities for load shifting and optimizing renewable energy use. Firstly, two interlinked Data-Sharing Workshops were conducted with local representatives and community members. Participants highlighted the importance of financial benefits, community independence from major energy providers, and contributions to the local sustainability. Concerns about data handling and privacy were also raised. Secondly, towards the energy behaviour characterization of the local community, historical active power measurements from 49 household smart meters, covering various periods between 2019 and 2022, were analysed. Households were categorized based on their behind-the-meter assets. Also, Monte Carlo simulations were applied to model electric vehicle (EV) charging patterns, accounting for variability and uncertainty, by using the data collected through the EV infrastructure available in Dingle.

1. Introduction

The transition to decentralized and sustainable energy systems requires active participation from local communities driven by effective social engagement and innovative data-sharing practices [1]. This idea is at the core of the two Horizon Europe-funded projects, ENPOWER [2] and Crete Valley [3], guiding this research. ENPOWER aims at integrating social science insights with information and communication technologies (ICT) to build a consumer-centric energy system. Similarly, the Crete Valley project seeks to transform the Crete Island in Greece into a self-sustaining energy ecosystem by utilizing a range of renewable energy sources and storage technologies. In both initiatives, the energy community in the Irish Dingle peninsula operates as a pilot, but with different roles; in ENPOWER, the Dingle community acts as a front-runner in the integration of social innovation and data sharing technologies, while, in Crete Valley, it operates as a follower incorporating the lessons learned from the four Community Energy Labs (CELs) of the Renewable Energy Valley (REV) in Crete.

This paper outlines a pathway for energy communities to achieve their goals through data-driven strategies developed by ENPOWER and Crete Valley. By utilizing smart meter data, the study aims to characterise the energy behaviour of customers and prosumers in the Dingle community, focusing on developing control strategies for load shifting and optimising renewable energy use. Additionally, the paper explores the role of social innovation and data sharing in enhancing community engagement during the energy transition, reflecting an evolving paradigm of decentralised, collaborative energy systems. The Dingle case illustrates the integration of smart meter data analytics with social innovation tools to promote sustainable energy practices, supporting broader European efforts to create resilient and consumer-driven energy communities. This approach not only optimises energy use but also empowers individuals and communities to contribute to the energy transition, aligning with the objectives of ENPOWER and Crete Valley projects.

2. Dingle Community Characterisation

The Dingle Peninsula located in the southwestern part of Ireland is 583 square kilometres geographically and has a small resident population, yet it receives over one million tourists annually. The economy largely relies on these visitors as 26 percent of the houses serve the purpose of being vacation homes. With the purpose of supporting low-carbon development for the community, the Dingle

Peninsula Sustainable Energy Community (SEC) was set up in April 2018. Initial actions consist of understanding the energy balance of the region and developing a 'Register of Opportunities'. The reduction of energy consumption and the transition to renewable sources of energy are the objectives of these plans.

Local initiatives have been essential in tackling these challenges. In January 2020, West Kerry Dairy Farmers SEC was established, and the Energy Masterplan was created, which highlighted significant energy use and CO_2 emissions in the community. This initiative involves installing Solar PV systems on farms, with ongoing efforts to boost adoption rates. Likewise, the Corca Dhuibhne Tourism and Hospitality SEC, launched in March 2023, focuses on encouraging sustainable practices in the tourism industry. Their goal is to cut energy consumption by 75% and reduce the carbon footprint by 85%. Programs like the Solar PV Meitheal and the Citizen Renewable Platform assist local businesses in collectively embracing renewable energy solutions, showcasing the community's commitment to sustainability.

3. Social Engagement

It is increasingly acknowledged that energy data sharing can create new opportunities to deliver sustainable energy systems. The integration of new technologies and products—such as sensors, communication tools, data processing, and automation controls—is transforming how people engage with energy. This shift can reconnect energy end-users with discussions about collective energy generation, renewable energy and the efficiency of local assets, thereby reducing the phenomenon of "energy invisibility". As new technologies and products emerge, public support for improved data sharing is crucial. Without the community's engagement, data-sharing initiatives may encounter significant challenges and may not achieve the positive outcomes hoped for. New sets of values for energy data sharing around connectedness, security and resilience may evolve, but there are also associated risks to privacy, data valuation and processing.

3.1. Engagement Strategies

In ENPOWER, we used participatory and deliberative engagement methods to explore energy data sharing. Our goal was to create approaches that align with community expectations in Dingle while addressing common concerns. Two interlinked Data-Sharing Workshops were held with local community representatives and community members using the Dingle pilot as a case study. The first workshop fostered brainstorming and dialogue to uncover the possibilities, challenges, and benefits of energy data sharing, establishing a foundation for the second workshop. This follow-up session delved deeper, using scenarios to contextualize data sharing within community-specific needs and envision its integration into future activities.

The first workshop in Dingle, held in February 2024, was an interactive brainstorming session designed to explore the concept of "energy data sharing" with 11 participants, including representatives from farming and tourism sectors. The session was structured around four key questions to spark discussion and capture diverse insights into the value, concerns, and future opportunities related to energy data sharing. Several main themes emerged from the discussions. Financial benefits were a primary focus, with participants questioning how data sharing could reduce costs for individuals and the community. Non-financial benefits were also highlighted, including greater community independence from major energy providers, enhanced energy sharing, and contributions to sustainability. However, significant concerns about data handling and privacy were raised, particularly regarding data ownership, misuse for marketing, and potential penalties for non-compliance with usage norms.

A recurring theme was the importance of education and engagement in building a well-informed community. Participants suggested creating "community champions" to inspire others through their investments in energy-efficient technologies and offering practical tools like energy bill guides, outreach programs, and accessible platforms for learning. The introduction of the DCSix Citizen Renewable Platform and a presentation on energy data monitoring provided practical insights, while a local farmer's testimonial showcased the tangible financial and environmental benefits of energy-efficient investments, inspiring attendees.

The second workshop in Dingle, held in April 2024, was a structured session designed to deepen participants' understanding of "energy data sharing," with 13 attendees, including farmers, people from the hospitality sector, experts, and organizers from the Dingle Hub. It featured a "three-dimensional questionnaire" to introduce participants to stakeholders, purposes for data collection, and types of data that might be shared, followed by three practical scenarios: grid flexibility, asset optimization, and vehicle-to-grid integration. Feedback sheets and an interactive ballot were used to explore key themes and rank participant priorities (Figure 1 and Figure 2). Main themes included the following:

- **Financial/Economic Considerations:** Participants emphasised financial incentives for both individuals and the community, cost-benefit analysis, and clear return on investment.

- **Communication/Education:** There was a strong call for community education and outreach, with suggestions for workshops, storytelling, peer learning, and leveraging role models to demonstrate the benefits of data sharing and energy-efficient technologies.

- **Sustainability/Environment:** Attendees highlighted the environmental benefits of data sharing, its role in sustainable tourism, and the need for renewable energy expansion
- **Technical/Operational Concerns:** Focus areas included user-friendly AI tools, accessible monitoring devices, standardisation of data tools, and privacy concerns. Digital literacy and the fear of new technology were identified as barriers.
- **Regulatory Needs:** Flexible regulations, trust in service companies, clear guidelines for grants, and easily accessible asset installation and maintenance were critical points.

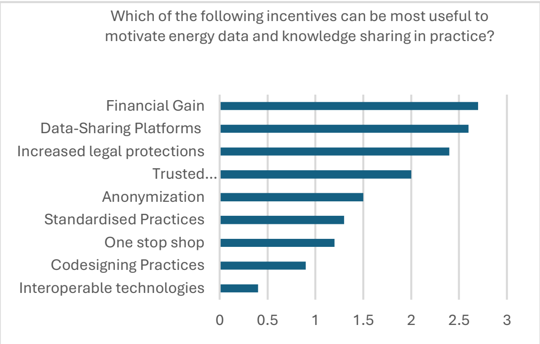

Figure 1 Ballot results from Question 1 with the Dingle Pilot

The interactive ballot revealed financial incentives and tools for secure, anonymised data sharing as top motivators. Education and communication were identified as key challenges to supporting participation. At the same time, collaboration between commercial entities and public governance (70% of the respondents) was favoured as the best approach for managing energy data sharing initiatives. The workshop outcomes aligned closely with broader themes discussed at other community events, underscoring their significance to Dingle's energy transition efforts.

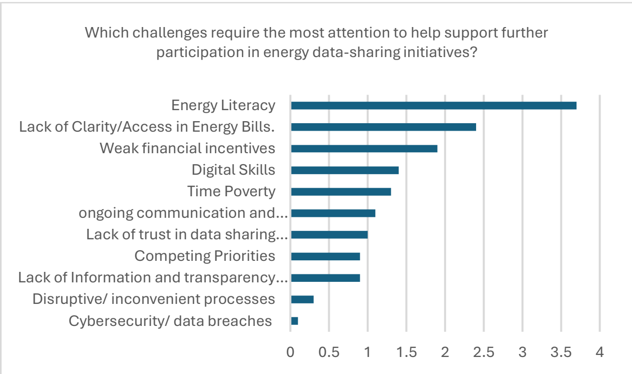

Figure 2 Ballot results from Question 2 with the Dingle Pilot

4. Data Access

Within the ENPOWER project, historical active power measurements (net load) from 49 household smart meters in the Dingle peninsula are provided. The datasets cover different periods between 2019 and 2022 for each household with 15-minutes granularity. The sampled households can be divided into five categories depending on the reported Behind-the-Meter (BTM) assets they own: Ambassadors (4), Regular EV owners (4), V2G EV owners (5), Solar prosumers (17) and Regulars (19).

4.1. Historical Data Sets

Ambassador homes have different BTM assets from which individual data is collected using additional metering devices as shown in Figure 3. These homes are part of a program promoted by ESB Networks Dingle Project to facilitate active engagement and learnings from the adoption of low-carbon technologies. They also have heat pumps installed and have undergone a building retrofitting [4]. Regular customers are those for which no information regarding the BTM assets they own is available. The rest of households own EV and/or solar as indicated by their given label.

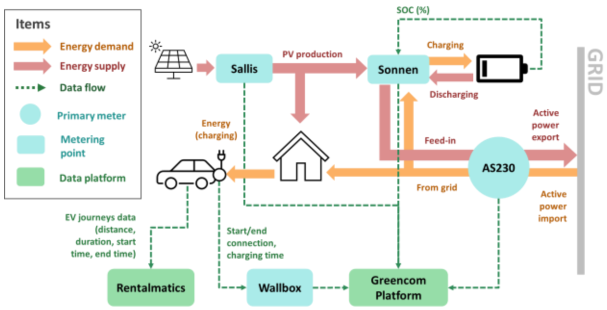

Figure 3 Simplified energy and dataflows in Ambassador homes (based on the set-up reported in [4])

4.2. Data Sets Analysis

A first analysis of the Regular household active power consumption and injection suggests that they most likely have PV solar and some form of BTM storage installed (Battery/V2G). Figure 4 shows the aggregated average net consumption for all households. It resembles the shape of a low-voltage feeder with high penetration of heat pumps and EVs [5], which is consistent with the reported BTM installed assets. Given that the community's Energy Master Plan envisions a significantly higher usage of solar PV, EVs, and heat pumps by 2030 [6], the sampled profiles are useful to model and simulate future scenarios in which this type of customers take a relevant role in the community's grid management.

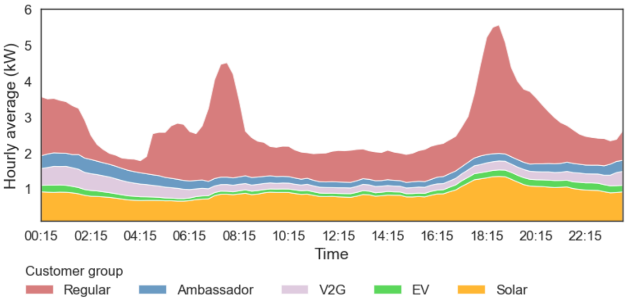

Figure 4 Aggregated load shape per customer group

4.3. *Load Profile Generation*

Using available data, we built a set of representative load shapes based on their peak grid consumption, using 5 categories defined after time slots typically used for residential consumer classification [7]: Peak early morning (5:00-10:00), Peak morning-noon (10:00-17:00), Peak evening (17:00-21:00), Peak night (21:00-00:00) and Peak late night (00:00-5:00). The final proposed slots are customised based on our sampled customer behaviour. Finally, the representative daily load shapes are built using the average net hourly consumption reported in Winter and Summer by each peak demand group, differentiating between weekend and weekday loads. Example results are shown in Figure 5.

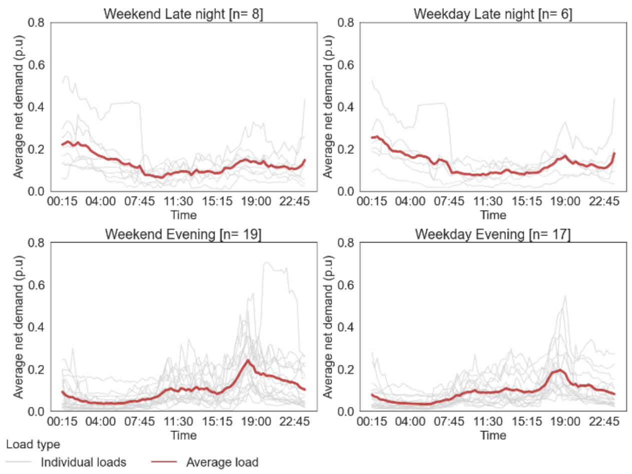

Figure 5 Late night and evening peak load shapes for weekends and weekdays in winter

4.4. *Electro Mobility Model*

As part of the Dingle Project, significant advancements in Electric Vehicle (EV) charging infrastructure were made through the procurement and installation of chargers at 15 properties. Each charging session's history was saved with information on the start hour, charging time and charging energy. Data sets from these charging sessions are utilized to model the EV charging patterns in Dingle through a Monte Carlo simulation approach [8]. This statistical method accounts for the variability and uncertainty in EV charging behaviour, leading to more accurate predictions and better-informed decisions for future energy management and infrastructure planning. For example, Figure 6 depicts the start and end hours of EV charging based on historical charging session data for the Dingle community.

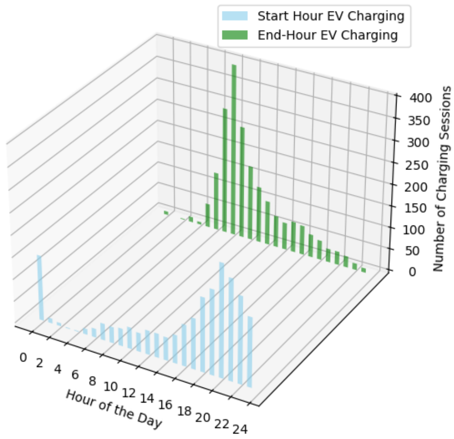

Figure 6 Start and end hours of EV charging based on historical charging session data

In the context of EV load curve modelling, the Monte Carlo process was implemented in Python to model EV behaviour in Dingle as follows:

1) **Define variables:** Number of EVs (*N*), Total Time period for simulation (*T*), time interval (*t*), Power demand of the *i-th* EV at time t ($P_i(t)$), Charging start time for the *i-th* EV (C_i), Duration of charging for the *i-th* EV (D_i), and maximum power demand of a single EV (P_{max})
2) **Generate Random Samples:** Create random scenarios of EV charging based on historical data and usage patterns. This includes generating random charging start times, C_i and charging duration D_i for each EV using predefined probability distributions,
3) **Simulate Charging Behaviour:** For each scenario, simulate the charging behaviour of all EVs over the specified time period (*T*), calculating the power demand at each time interval *t*. The power demand $P_i(t)$ for the *i-th* EV at time *t* is given by:
$$P_i(t) = \begin{cases} P_{max}, if\ C_i \le t < C_i + D_i \\ 0, otherwise \end{cases}$$
4) **Aggregate Results:** Collect the power demands from all EVs at each time interval t to compute the total load curve: $P_{total}(t) = \sum_{i=1}^{N} P_i(t)$
5) **Iterate and Average:** Repeat the simulation for a large number of iterations (10,000 times) to account for the variability and uncertainty in the input variables. Finally, the average load curve is obtained.

Figure 7 represents the aggregated load EV diagram for 30 electric vehicles in the Dingle community. This was obtained by using historical data sets for charging sessions and running the Monte Carlo process as described above.

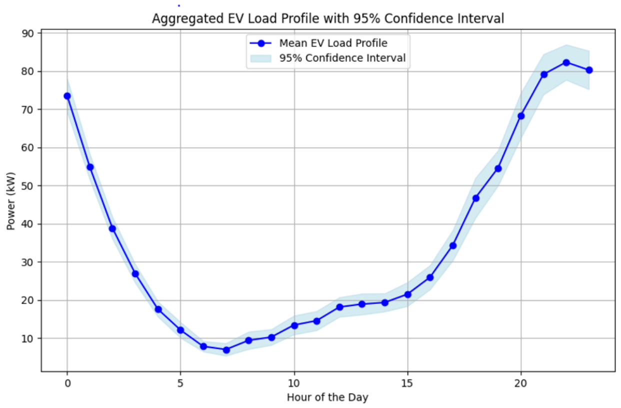

Figure 7 Aggregated EV residential load curve for Dingle community (simulation for 30 EVs)

5. Conclusions and Further Research

Decentralised and renewable energy systems rely on active participation from local communities, which is driven by effective social engagement with innovative data-sharing practices. This research, informed by the Horizon Europe-funded projects ENPOWER and Crete Valley, demonstrates how critical data-driven strategies are to accomplishing energy objectives. The integration of smart meter data analytics with social innovation tools, as shown by the Dingle community case, underlines the potential for optimising energy use and fostering sustainable practices. Participatory engagement methods and continuous community involvement have been crucial in overcoming challenges and achieving substantial reductions in energy consumption and carbon footprints.

Historical active power measurements from households, categorized according to their BTM assets, provide valuable data for modelling future energy scenarios. Utilising smart meter data has allowed the development of representative load shapes based on peak grid consumption and customised time slots. These representative daily load shapes offer a comprehensive understanding and facilitate the simulation of future energy usage patterns. The advancements in the EV charging infrastructure are reflected in the installation of chargers in various properties and Monte Carlo simulations is used to model EV charging patterns, taking advantage of the data collect via EV infrastructure.

The designing of control strategies for energy management in the local community is vital for increasing self-sufficiency and implementing demand response strategies. Characterising, effectively modelling, and developing control strategies for distributed energy resources requires accurate data sharing for the right determination of energy behaviour. Further work must consider various aspects that encompass the community as a whole toward ensuring a considerable level of uptake and participation. Leveraging the insights and real data shared by the community and stakeholders, it is now crucial to develop effective control strategies and deploy them to integrate renewable energy sources, manage peak demand periods and ensuring the reliability of the local energy grid.

6. Acknowledgements

This research was conducted in the scope of Horizon Europe-funded projects ENPOWER and Crete Valley. ENPOWER has received funding from the European Union’s Horizon Europe research and innovation programme under grant agreement no. 101096354, while CRETE Valley is co-funded by the European Union under grant agreement no. 101136139.

7. References

[1] Gjorgievski, Vladimir & Cundeva, Snezana & Georghiou, George. (2021). Social arrangements, technical designs and impacts of energy communities: A review. Renewable Energy. 169. 1138-1156.

[2] EMPOWER Project, https://www.enpower-project.eu/, accessed 20 January 2025

[3] Crete Valley Project, https://cretevalley.eu/, accessed 20 January 2025

[4] Boyle, E., McGookin, C., Watson, C., et al., 'ESBN Networks’ Dingle Project Ambassador Programme' (MaREI Centre, 2021), p. 2.

[5] Scottish & Southern Electricity Networks, 'SSEN Distribution RIIO-ED2. Load-Related Plan Build and Strategy' (SSEN, 2021), p. 38.

[6] Dingle Creativity and Innovation Hub & MaREI Centre, 'Dingle Sustainable Community Energy Master Plan' (Dingle Creativity and Innovation Hub, 2020), pp. 7-9.

[7] Michalakopoulos, V., Sarmas, E., Papias, I., et al.: 'A machine learning-based framework for clustering residential electricity load profiles to enhance demand response programs', Applied Energy, 2024, 361, p. 9.

[8] J. A. P. Lopes, F. J. Soares and P. M. R. Almeida, "Integration of Electric Vehicles in the Electric Power System," in *Proceedings of the IEEE*, vol. 99, no. 1, pp. 168-183, Jan. 2011.