Final report

1. Project details

Project title	Flexible Citizen Energy Communities for increased (FLEX-CEC)
File no.	64021-1090
Name of the funding scheme	EUDP
Project managing company / institution	Enyday ApS
CVR number (central business register)	38675044
Project partners	DTU Elektro/ DTU WIND, Ewii, By&Havn, Energi Danmark, PowerlabDK, KBH kommune
Submission date	7th January 2025

2. Summary

Describe the objectives of the project, the obtained results and how they will be utilized in the future, both in English and in Danish. The summary will be published on www.eudp.dk and www.energiforskning.dk.

Project summary:

ENGELSK VERSION:

As Energy Communities are a new very broad reaching concept engaging stakeholders from citizens, municipalities, and electricity companies it made sense to organize a partner group consisting of partners from municipality, electricity companies, startup and university partners. All motivated in pushing forward the green transition locally.

The FLEX-CEC project has investigated and developed IT technologies to operate “Energy Communities” (ECs). The project had 2 work packages with technology development with respectively focus on; (1) energy sharing (only electricity) and (2) flexibility. The technologies have been tested out in 2 pilots in Copenhagen NV (Northwest) and Fredericia. As the DSO Radius, in Q1-2024, presented a new proposal for a collective tariff model with focus on behind-the-transformer sharing discounts it was also simulated in the Fredericia pilot. The project had a PhD researcher who have worked on models for adding and harnessing flexibility in Energy Communities.

The project aimed at a collaborative operational model between a technology startup, Energy Communities and two Danish Utilities. The project managed to find a prototype model on how to do settlement and handled power procurement. However, as the Danish regulatory announced a change from 2026, in the end of the

project, some of the key data take-aways and findings relates to how much local power is actually shared and consumed locally.

Other important findings in the project were that organization and governance are important elements to understand and consider from the beginning. Also with project found that Energy Communities need a caretake assistant to make sure that RE installations works and operates as they should. It was clear that too many installations simply don't work as intended.

This project has been a great foundation to build up of energy community knowledge and technical solutions for partners with the intention of supporting and servicing energy communities.

- **The purpose of the project**

The societal challenge was centered around helping citizens, municipalities and SMEs in engaging in collectively owning local RE assets and implementing the new EC role in the electricity market. The scope was to build a technology tool for easy EC adaptation; data visualization, community management, electricity sharing, and create value streams.

- **Results, conclusions and perspective**

From building the FLEX-CEC platform to operate distributed energy communities and tested it out in prototype in 2 project pilots, the following project results was concluded:

- That members in energy communities currently have a limited savings potential and this limits motivation. There is a need for changes in regulations to improve the monetary incentive.
- Members in ECs need to be educated and get a knowledge transfer of Energy Communities to understand the potential and opportunities to start and operate ECs successfully.
- Utilities are still in the waiting position in regard to the future regulations and role of TSO/DSO to support ECs.

How will the results be used in the future?

- The developed energy community platform is intended to be implemented around Denmark with small aspiring energy communities with the eagerness and motivation to get started now. Its the intention to partner up with utilities which want to support energy communities with the FLEX-CEC platform.
- The PhD research and university knowledge generation will be applied in the future work on energy communities and flexibility in DTU.

What effects are expected to derive from the technology?

In Enyday the technology will be applied to support the adaptation of Energy Communities which will derive effects on both faster Energy Community adaptation which can lead to more local RE projects and small flexible assets to be controlled. It's the intention to bring this technology to export markets at some point.

Projektresumé:

Energifællesskaber er en bred ny rolle og koncept i elmarkedet som engagerer interessenter lige fra borgere, kommuner og elselskaber, hvorfor det gav mening at organisere en bred partner kreds som alle har en interesse i at skubbe til den grønne omstilling lokalt.

FLEX-CEC har undersøgt og udviklet IT teknologier til at drifte Borgerenergifællesskaber (BEF) og Vedvarende Energifællesskaber (VEF) i det danske elmarked. Projektet havde 2 arbejdspakker med teknologiudvikling med henholdsvis (1) El-deling og (2) Fleksibilitet. Disse teknologier blev testet i 2 piloter I

København NV og Fredericia. Da netselskabet Radius i 2024 præsenterede udkastet til en ny nettarifmodel, for kollektive sammenslutninger af elkunder som er placeret bag den samme 10/0,4 kV transformerstation, blev dette også simuleret i Fredericia piloten. Der var en PhD studerende i projektet som arbejdede med at undersøge og udvikle modeller for fleksibilitet i Energifællesskaber.

Projektet har arbejdet på samarbejdsmodel mellem en teknologi-opstartsvirksomhed, energifællesskaber og 2 energiselskaber. Projektet lykkedes med at udvikle en prototype model til at håndterer elafregning/eldeling og el-indkøb. Da Energistyrelsen, mod slutningen af projektet, annoncerede en eldelings platform hos Energinet med forventet idriftsættelse fra 2026 vil nogle af hovedresultaterne bestå i hvor meget lokal strøm der bliver delt og forbrugt lokalt af medlemmerne. Det er intentionen og planen at FLEX-CEC platformen vil blive implementeret rundt om i Danmark hos spirende nye energifællesskaber med interesse og motivation til at komme i gang. Udover denne direkte anvendelse af platformen er det også intentionen at lave partnerskaber med energiselskaber som ønsker at understøtte og supporte energifællesskaber.

Andre vigtige læringer i projektet var at organisering og governance er vigtige element at forstå og overveje fra start af. Projektet gjorde derudover den observation at der vil være et behov i energifællesskab for en teknisk ”vicevært” rolle som sikre at VE installationerne fungerer og drifter som de skal. Det var klart at rigtige mange eksisterende installationer af solceller og batterier slet ikke virkede som forventet.

Projektet har været en rigtig god arena til at opbygge viden om energifællesskaber og tekniske løsninger til partnere med intentionen om at støtte og servicerer energifællesskaber.

- **Formålet med projektet**

De samfundsmæssige udfordringer som der er centreret omkring at hjælpe borgere, kommuner og SMV’er i at engagere sig i kollektivt ejerskab af VE anlæg og implementering af den nye energifællesskabsrolle i elmarkedet. Formålet var at bygge teknologiske værktøjer til at kunne etablerer og drive energifællesskaber; data visualisering, community styring, el-deling og skabe økonomiske fordele.

- Resultater, konklusioner og perspektiv

Hvad var de vigtigste resultater fra projektet? (i datid og gerne i punktform)

- At medlemmer i energifællesskaber i dag har et begrænset besparepotentiale og det begrænser motivationen. Der er behov for ændringer i reglerne, ellers er det monetære incitament være for lavt.

- Medlemmer i EC'er skal uddannes og have vidensdeling ift. energifællesskaber for at forstå potentialet og mulighederne til at starte og drive EC'er med succes.

- Forsyningsselskaber er stadig i venteposition med hensyn til fremtidige regler og TSO'ers/DSO'ers rolle til at støtte EC'er.

Hvordan vil resultaterne blive udnyttet i fremtiden?

- Den udviklede energifællesskabsplatform vil forhåbentligt blive implementeret rundt omkring i Danmark med små spirende energifællesskaber med iveren og motivationen til at komme i gang. Det er hensigten at opstarte samarbejde med forsyningsselskaber, der ønsker at støtte energisamfund med FLEX-CEC-platformen.

- Ph.d.-forskningen og universitets videns genereringen skal anvendes i det fremtidige arbejde med energifællesskaber og fleksibilitet på DTU.

Hvilke effekter forventes teknologien at indfri?

I Enyday vil teknologien blive anvendt til at understøtte udrulningen af energifællesskaber, hvilket vil aflede effekter på både hurtigere energifællesskabstilpasning, hvilket kan føre til flere lokale VE-projekter og små fleksible aktiver, der skal kontrolleres. Det er også hensigten at bringe denne teknologi til eksportmarkeder på et tidspunkt.

3. Project objectives

- *What was the objective of the project?*

The project aimed to develop Flexible (FLEX) Citizen Energy Communities (CEC), which could help increase the share of renewable energy in local energy systems by enabling citizens to participate actively in decentralized energy production, consumption, and sharing. Specifically, the objectives were:

1. Increase renewable energy integration:
   By creating local energy-sharing networks within communities, the project sought to facilitate more efficient use of renewable energy sources such as solar panels and batteries, thus increasing the share of locally produced renewable energy.

2. Enhance energy flexibility:
   The project aimed to develop technologies and systems that would allow communities to manage energy flexibility, particularly through demand-response solutions and battery management systems, to better align consumption with production, reducing grid stress and optimizing energy use.

3. Develop and demonstrate a scalable platform:
   A key goal was to create the FLEX-CEC platform, a technological solution to manage energy communities. The platform would integrate tools for energy sharing, consumption monitoring, and flexibility management, enabling users to participate in energy markets.

4. Pilot projects for practical application:
   The project initially planned to implement three pilot projects in different areas of Denmark (Nordvest, Fredericia, and Nordhavn) to test how citizen involvement, combined with technological solutions, could accelerate the green transition in urban communities. These pilots were intended to provide data and insights for scaling up energy communities across Denmark and beyond.

5. Legal and regulatory alignment:
   A focus on navigating the regulatory landscape and engaging with national bodies, such as Energinet and GreenPowerDenmark (Former Danish Energy Agency), was included to ensure that the developed technologies and business models aligned with future regulations regarding energy tariffs, grid services, and community-based energy sharing.

The ultimate objective of the project was to create a viable, decentralized energy-sharing model that could contribute to Denmark's broader energy policy goals, including reducing carbon emissions, decentralizing energy production, and increasing energy efficiency through local solutions

- *Which energy technology has been developed and demonstrated?*

The project developed and demonstrated the FLEX-CEC platform, a comprehensive digital solution designed to manage and facilitate citizen energy communities. The platform integrates various technological capabilities, such as:

- Energy-sharing processes: The platform supports energy sharing within local energy communities by enabling the distribution of locally produced renewable energy (e.g., from solar panels) between community members.
- Data collection and visualization: Integrated with Denmark's national data hubs (e.g., DataHub, Eloverblik), the platform collects and visualizes real-time energy consumption and production data. The user-friendly dashboard provides members of the community with insights into their energy use, pricing, and live energy data.
- Pricing and settlement algorithms: The platform incorporates customizable pricing and settlement systems for internally shared energy. These systems allow community members to define and manage pricing for the energy produced and shared within the community. It also handles the financial settlement for energy consumed and produced in real-time.
- Battery management and flexibility: The platform includes advanced battery control systems to store renewable energy and optimize its use. The system supports energy flexibility by enabling smart consumption patterns, like charging batteries when energy prices are low and discharging during peak periods, contributing to grid stability.

Technology developed, tested and applied in 2 pilots:
To make use and test the platform, 2 pilots were established representing real-world scenarios:

- Prototypes of the platform's interface were designed and developed, showing how users could manage their energy consumption and track savings. This included both an administrator dashboard for community managers (e.g., to onboard members, set prices, manage tariffs) and a consumer app for individual users (e.g., showing consumption patterns and pricing updates in real time).
- Pilots: The 2 pilots included different community setups to test the platform's flexibility. For example, one use case involved a residential energy community sharing solar energy from rooftop panels, while another focused on a mixed-use community combining residential and commercial buildings with shared battery storage systems. These pilots demonstrated how the technology could manage dynamic pricing, battery control, and grid flexibility across diverse settings.

The platform was demonstrated in pilot projects in Nordvest and Fredericia, where it facilitated energy sharing between residential and commercial participants. Additionally, simulations were run to test how the platform could handle DSO's evolving regulatory frameworks, such as reduced tariffs for energy shared behind transformer stations.

4. Project implementation

- *How did the project evolve?*

The project faced initial delays, especially in the first 12 months, due to challenges in engaging participants and the legal and technical complexities of setting up energy communities. These challenges included difficulties in obtaining data, securing participants for pilot projects, and navigating regulatory barriers. However, by 2023, the project gained significant momentum after a bigger staff change in the people in the project group, and pilot projects were successfully established in Nordvest and Fredericia, focusing on the roll-out of the technical development from WP 3+4 such as battery control, energy sharing, while aligning with evolving regulatory frameworks.

Energy Community clarification and focus of the FLEX-CEC project.

It's important underline that the FLEX- CEC project has solely focused on distributed energy communities. And FLEX-CEC has considered both Citizen Energy Communities (CEC) and Renewable Energy Communities (REC) in the Danish electricity market. All electricity meters at Community Members in the project pilots are DSO metering points with data from Eloverblik (3rd party access to datahub at Energinet). The FLEX-CEC

project has nothing about behind the meter energy communities, which is more accurately known as “collective self-consumption”.

The regulatory distinction between REC and CECs has been limited to WP 2 and WP8, while the technology Development and pilotes (WP3-7) has viewed Ecs and the technology development has one whole. In other words, the project group has assumed the technology platform needs are the same for REC’s and CEC’s in the pilots.

The project group has written clear definitions and background for the term ”energy community” in the “project handbook” (Erfaringsopsamling). As well BechBruun has in the external ”legal paper” lawyers provided regulatory definitions.

Bech Bruun did accordingly in their legal paper suggest a legal CEC governance model for pilot 2 while legal REC governance model for pilot 3 in Fredericia. This was due to the different EC members types (private, businesses, municipality). This proves that the technology can help operate both CECs and RECs.

Regulatory outline and project approach

The regulatory landscape and assumptions which the FLEX-CEC project has been divided between: (1) what is possible in today’s market conditions and regulations and (2) anticipated, EU directives and new emerging regulatory announced during the project by Energistyrelsen, DSO’s, TSO and Forsyningstilsynet.

(1) What is possible today:

Both pilot 2 (Nordvest) and pilot 3 (Fredericia) have both been developed and executed within the current regulatory frameworks of what a utility/electricity supplier could develop and bring to the market as a new innovative service. This has been described in detail in the Handbook at page 28-30. The findings are clearly that the potential member benefits in joining ECs are bigger on the societal, collective and co-owning RE assets than from the economic gains in sharing power from each other. Sharing findings and results from the pilot simulations can be found in the

(2) Anticipated, EU directives and new emerging regulatory

As the project progressed, the project group tried to adapt to emerging national energy regulations, including new tariff models proposed by DSOs in Q1-24. This adaptability allowed the project to simulate how future regulatory changes, such as reduced tariffs for shared energy behind transformer stations, could impact energy communities.

The project group have travelled to other countries like Spain to get inspiration on how the that market allowed to share solar within 500 meters given conditions like being located in the same local grid. All in all to predict how the regulatory would work out. Luckily it seems like the predictions are going to happen as we are writing this report in Jan-2025.

In pilot 3 (Fredericia) the energy sharing was simulated behind a transformer station and it was clear that economics benefits suddenly arise as new regulations with savings potential. The intelligent battery control and local energy sharing (matching consumption and production) will bring great opportunities to save money by joining a group of energy consumers and producers and coordinate.

One important point to mention is that the project was granted Jun-21 and ran in almost 3 years, from Sep-21 to Jun-24, meanwhile the Danish regulatory framework was maturing significantly. This has been a big challenge to navigate in and also a very joy full part of the project.

Positive pilot outcomes and key findings:
Despite the early challenges, the project concluded on a strong note, with the pilots yielding valuable insights and technological advances. Key findings from the pilots include:

Energy sharing and cost savings:
In Nordvest, the platform enabled local energy sharing among residential and commercial participants, with potential significant cost savings from local tariffs observed through collective use of locally produced solar energy. The pilot demonstrated that energy communities could benefit from dynamic pricing and internal energy sharing, and concluding a high percentage of local produced and shared solar power between nabours. Simulations in the Fredericia Pilot showed that reduced tariffs for collective energy use behind transformer stations could lead to substantial savings for community members, reinforcing the viability of decentralized energy models in a future electricity market.

An economic analysis from the 2 pilots for the EC members can be found in detail in the handbook (find link in appendixes) on page 28-31. A few highlights key findings on economic findings are written in the next paragraph “project results” &“commercial results”.

- Battery control and energy flexibility:
  In the Fredericia pilot, the platform successfully demonstrated how home-battery systems could be integrated into energy communities to optimize the use of renewable energy. The batteries were charged when energy prices were low and discharged during peak periods, allowing participants to save on energy costs while reducing grid strain. This flexibility showcased the potential for energy communities to play an active role in grid stability and demand-response initiatives as MFFr was simulated in small scale in the Fredericia pilot. Please see economic savings in project results.

- Scalability and future potential:
  The findings from the pilots highlighted the need for scalability of the FLEX-CEC platform. With its ability to handle energy sharing, pricing, and battery management efficiently, the platform is well-positioned to expand beyond the pilot phase. The project’s results indicate that with further refinement, the platform could be deployed widely to support energy communities across Denmark and Europe.

By the end of the project, these pilot successes validated the developed core technology and demonstrated the platform’s potential to contribute to the future adaptation and changes in the electricity market structure for Energy Communities. The practical findings offer a strong foundation for future implementation, as well as the potential to influence national energy policies and community-based energy solutions

- *Describe the risks associated with conducting the project.*

The primary risks included delays due to the novelty of energy communities, legal complexities and changing market structure at DSO and TSO level driven from EU directives.

But also technical issues with battery installation (e.g., non-functional batteries at AB Storgården), and challenges in engaging pilot participants. The market conditions were also uncertain due to regulatory changes along the project.

The legal changes which the FLEX-CEC projected faced can pose a significant risk to the green technology deployment, as regulatory uncertainty can slow down investment and development as Energy Communities hold back due to uncertain market conditions and incentives. For green technology like the FLEX-CEC platform, which often requires long-term planning and infrastructure, these uncertainties can undermine the scalability and economic viability of projects. More information can be found in the handbook which can be downloaded at flex-cec.dk.

- *Did the project implementation develop as foreseen and according to milestones agreed upon?*

Although some initial milestones were delayed, both technical and commercial milestones were eventually achieved. A significant adjustment occurred with the approved project extension with a larger degree of focus on behind-the-transformer station simulations.

The technical M1 & M2 milestones were achieved while the CM1 & CM2 milestones was achieved. In general both the technical and commercial milestones (M3+M4 + CM3-5) on flexibility was not meet as the projected was very challenged on getting started with pilots sites due to delays.

However there were also other reasons why the aggregators service milestones were not reached as planned. One reason is that the WP 4 work package lead was EnergiDanmark and during the project it was clear that they focused on the market bidding part (TSO level) and was interesting in explore how small flexibility units from ECs could be added to their existing flexibility operations.

Therefore it ended up with a scenario where Enyday had to do everything else to control batteries; hardware, IOT and software development to do forecasting and bidding control from a single battery in order to get started at all. An API was build to Energi Danmark and simple battery control milestones were met.

Another blocker was that the 3 pilots did not have easy access to the battery capacity, as assumed in the early days of the project proposal (Nordhavn battery was problematic). So the project ended up having a few operating batteries in Fredericia.

Based on the above cirucumstances it became clear the project had to focus on the just controlling and bidding MFFr services before moving on to adding a lot of complexities with more batteries and other services for TSOs and DSOs. And DSO's in the project period, never showed interest in collaborating around peak saving as they opted for new tariffs instead.

And also the focus ended more on the energy sharing part in energy communities and M2+CM2 were accomplished. Energy sharing is also the core competence in Enyday and it was the conclusion along the way to focus deeper into this as regulations for ECs also evolved during the project. To sum up it was technical, pilot and project group barriers blocking for on-boarding more flexibility assets to the flex-cec platform.

As well the the flexibility market and competive aggregator services in Denamark also developed solutions for aggregator services during the project which gave reflections around potential partnerships for Energy Communties. Now in 2025 the market for TSO flexibility is very competitive and Enyday believe that it's better to focus on being good at a few things and then support ECs in partnering up with the best aggregators to help get the economic gains/savings from flexibility. Other findings/needs uncovered on just making solar pv and batteries work shows how a supplier like Enyday can facility aggregators services. But not doing it all by it self.

When the project proposal was submitted the market situation and landscape was more unclear for aggregators, however the project has been too complex and challenged along the way with access to batteries, to develop and deliver the expected aggregators services.

- *Did the project experience problems not expected?*

Yes, surprisingly problems such as non-functional solar and batteries at demo sites, delays in securing pilot participants, and legal complexities emerged, causing delays in milestones like energy flexibility delivery and battery integration. Also in the start, on-boarding of pilot participants took more time than expected. In general it's fair to argue it was both a very ambitious (especially on the flexibility milestones) and a very complex topic in general. Therefor it was necessary to narrow focus along the way and the project group were happy with the final result.

5. Project results

- *Was the original objective of the project obtained? If not, explain which obstacles that caused it and which changes that were made to project plan to mitigate the obstacles.*

The original objective was partially obtained. Se previous section which outlines details. While progress was made in developing and testing the platform for energy communities, delays affected the full implementation of some pilot features, particularly the flexibility extension.

Technological results:
The platform developed for energy-sharing and flexibility demonstrated a significant untapped potential. Key technological outputs included the ability to simulate energy-sharing models behind transformer stations. However, technical challenges (like battery issues) caused some delays in deliverables.

Commercial results:
Commercially, the project showcased the potential for energy communities to reduce electricity costs and improve energy efficiency through flexible use of renewable energy. This included reduced tariffs and energy-sharing models. However, the full commercial scalability of the platform is expected after further refinement.

Findings on economy gains and potentials in the EC pilots:

Regarding the monetary savings and generation of economic value in Energy Communities, the project did some quantitative findings and results from the Fredericia pilots which are described below:

- **Energy sharing results in Pilot 3 A (Fredericia) – a case within existing regulatory framework**

Metering points: 29 (25 consumption + 4 production)

Data: Consumption: 2.3 million kWh & Production: 0.4 million kWh

Results

- 13% of the electricity was covered by the energy community's local production.
- A total of 339,164 kWh was available for sharing in the EC, of which 306,814 kWh was consumed in the energy community (90% own consumption).
- A further 32,351 kWh could be shared.

Conclusions

Savings assuming all shared electricity was free solar power in the period January 1, 2022 - June 15, 2024 amounted to DKK 795,764.03 for 815,919.73 kWh.

So in pilot A we tried out a scenario where the solar pv's on the municipality buildings was given the excess solar for free to the other members in the energy community. Results show that there is good potential with this big amount of solar, if its not sold anyway.

- **Energy sharing results in Pilot 3 B (Fredericia) – a case extended with expected future regulations, simulating new tariffs.**

Metering points: 15 (11 consumption + 1 production)

Data: Consumption: 1.6 million kWh & Production: 0.3 million kWh

Results

(1) Energy sharing:
- 16% of the electricity was covered by the energy community's local production.

- A total of 309,606 kWh was sent for sharing, of which 261,118 kWh was consumed in the energy community (84% self-consumption).
- A further 48,489 kWh could be shared.

(2) Simulation with collective tariffing behind the transformer station

- Grid tariff savings: Summer day grid tariff (14 øre/kWh): 36,500 kr
- Purchased: Winter day tariff (29 øre/kWh): 390,466 kr / 2.9 = 134,643 kr

Pilot 3B showed a whole new paradigm for energy communities being behind-the-transformer station. The results show that 84% of the power consumed was locally produced and with a new tariff reduction it creates a needed saving potential for future energy communities. We have listed some of the savings in kr.

Similar for pilot 2; results and details (Nordvest) can be found the Handbook)

- **Battery control results in Pilot 3 (Fredericia)**

In pilot 3 at Fredericia School of Engineering, Raspberry Pi (Rpi) was connected to inverters via Modbus TCP to obtain information about consumption, PV and battery status. The Rpi received spot prices and tariffs from the Enyday API and sent commands to the battery based on the total price and battery status. The battery was charged when the price was low and discharged when the price was high. From September 2023 to May 2024, the following savings were achieved:

Total savings: 2,102 DKK (Battery 1: 717.6 DKK, Battery 2: 429.2 DKK, Battery 3: 955.2 DKK)

There are gaps in the data due to power outages that required manual restarts. mFRR bids and machine learning were used to produce consumption forecasts that were 50% accurate, but with potential for improvement using annual data and better models.

Results:

Based on the pilot findings above the project have generated and concluded a proof of a future economic sustainable baseline for energy communities in energy sharing, if new tariffs are implemented and intelligent battery control is roled out together other synergies are harnessed.

With the results and complexities in ECs it's fair to conclude that a technology platform like FLEX-CEC is necessary to orchestrate the activities associated in running an energy community.

A market demand will arise with the new regulations and Enyday will as a supplier of services help energy communities to seize the saving potential explained above.

Target group and added value:
The primary target groups are housing associations, municipalities, and small energy producers (e.g., households with solar panels) interested in forming energy communities. The platform provides added value by enabling energy community management and flexible use of renewable energy resources.

Pilot projects established:
Successful deployment of pilot projects in Nordvest and Fredericia, where the platform was tested in environments with real data from Eloverblik (3rd party datahub access at Energinet). These pilots demonstrated the viability of energy sharing and battery management within local energy communities.

- Battery control and energy-sharing system:
  The development and implementation of the battery control system were critical milestones. The system allowed for smart energy storage and consumption, optimizing energy use during price peak and off-peak periods.

- Energy-sharing models behind transformer stations:
  One of the major objectives, simulating energy-sharing models behind transformer stations, was achieved. This was particularly significant for validating how energy communities could benefit from new tariff structures and decentralized energy models.

- *Describe the obtained technological results. Did the project produce results not expected?*

The project produced significant technological results, including the development of the FLEX-CEC platform for energy sharing and battery control. One unexpected result was the discovery of greater potential in optimizing energy sharing behind transformer stations, particularly with the new reduced tariffs, which provided additional cost savings beyond initial projections. Technical challenges, like battery issues in some pilots, were also unanticipated and delayed certain features.

- *Target group and added value for users: Who should the solutions/technologies be sold to (target group)? Describe for each solutions/technology if several.*

The FLEX-CEC platform and related technologies are targeted at several key groups:

1. Energy Communities
2. Energy Companies
3. Housing associations and residential communities:
4. Municipalities and local governments
5. Small energy producers (households with renewable installations)
6. Etc. Many stakeholders can participate in Energy Communities.

For each group, the platform provides added value by enabling more efficient energy use, reducing costs, and fostering community-based participation in the decentralized renewable energy market.

- *Where and how have the project results been disseminated? Specify which conferences, journals, etc. where the project has been disseminated.*

The project results have been disseminated through multiple channels, including the website, presentations at industry workshops (e.g., KL's Energy Communities Workshop in January 2024, Energy Cluster Danmark annual meeting), and a handbook. The project findings were also shared with Energifællesskaber Danmark and relevant authorities like Energitilsynet. Also at ÆRØ borgerenergifællesskab the project has been presented in the Autumn 24.

The project hosted a final seminar and the project group presented in a 4 hour workshop with around 30-35 guests (incl. external) from energy communities, energy companies, DSO (radius) etc.
The project website, flex-cec.dk, serves as a key platform for sharing updates, reports, and findings. It includes technical details, pilot outcomes, and access to the project's handbook.

Key findings, work and energy-sharing scenarios, were presented to an EWII strategy seminar, Center for Global Rådgivning Friday meeting and other places to inform ongoing regulatory developments and energy community models in Denmark.

Handbook and academic contributions:
A comprehensive handbook documenting the project's findings and technical innovations is under development and will be made publicly available. This will serve as a resource for future energy communities, policymakers, and researchers. Additionally, contributions from the project have been shared in internal academic discussions at DTU and other affiliated research institutions.

The handbook can be downloaded at flex-cec.dk.

6. Utilisation of project results

- *Describe how the obtained technological results will be utilised in the future and by whom.*

The technological results from the FLEX-CEC platform will be utilized to support energy communities, energy companies, housing associations**,** municipalities, and other to create and manage decentralized energy communities in the future. The platform will allow for continued energy sharing, necessary integrations to utilities and energy management systems.

Hopefully some of the results will also be used as inputs to regulatory bodies and operators (eg. DSO and TSOs) to assess how energy communities can contribute to grid and future electricity market. The technology will likely be further be used in collaboration with commercial partners across Denmark.

- *Describe how the obtained commercial results will be utilised in the future and by whom the results will be commercialised.*

The commercial potential of the FLEX-CEC platform lies in offering it as a service to municipalities, housing associations, and energy companies. The platform will be licensed out or sold as a software-as-a-service (SaaS) to manage local energy systems and community energy sharing. The commercialization will likely be led by Enyday and other partners involved in the project, who will scale the technology for broader market application, potentially through partnerships with relevant stakeholders and partners supporting energy communities.

- *Did the project so far lead to increased turnover, exports, employment and additional private investments? Do the project partners expect that the project results in increased turnover, exports, employment and additional private investments?*

While the project is still in the demonstration phase, early signs indicate that the platform's commercial potential. First demonstration in real settings have been done, and more is on the way for Enyday. The project partners anticipate that the successful commercialization of the platform could lead to increased turnover**,** new employment opportunities (particularly in software development and energy consultancy), and potentially exports to other EU countries. Further private investments are expected to enhance the platform's scalability and white-label applications.

In the short run, first 6 months of 2025, Enyday is implementing several ECs in Denmark (ÆRØ Borgerenergifællesskab as an example) and with this experience next focus is scaling the platform in Denmark and later outside. Enyday believe first international pilot will be in place during second half of 2025.

Enyday have international ambitions around exporting the energy community solution to other European Countries. Commercially Enyday see various routes to market and have a go-to-market strategy to partner up with local players (utilities, municipalities and solar installers) in each of the national member states.

Partnerships with local players is crucial to make this work and Enyday have active sales dialogues around Europe at this point (Germany, Sweden, Spain, etc). On the team site Enyday see this business as Enterpeprise sales which means that the solution will be sold to B2B customers who can take the solution to the local markets.

- *Describe the competitive situation in the market you expect to enter.*

The market for energy community platforms is still emerging around Europe, similar to Enyday. However Enyday is now one of the frontrunners in the market. The primary competitors are likely to be companies specializing in supporting utilities with whitelabel solutions as a technical supplier. However, FLEX-CEC's

specific focus on citizen-driven energy communities **and** energy sharing provides a unique value proposition that sets it apart from more general energy platforms as it's direct-to consumer. Enyday can support an energy community with the services so it's free for the energy community to select which utility it like to buy power from. However that said, it's still early days for the energy communities. Another important point is that the Danish TSO Energinet is actually building a platform to support private consumers to share power with each other.

- *Are there competing solutions on the market? Specify who the main competitors are and describe their solutions.*

Yes, there are a few new startup competitors, including Exnaton (Switzerland)**,** WeSmart (Belgium) and other, which offer energy community management platforms with similar features. However, a platform like Exnation only support whitelabels to utilities and while WeSmart are similar market wise to Enyday. FLEX-CEC differentiates itself by catering specifically to energy communities, enabling collaborative energy management and internal pricing models among multiple users, making it possible to shop around utilities.

- *Describe entry or sales barriers and how these are expected to be overcome.*

Key barriers include the variety in regulatory complexity and market readiness for energy community solutions in different European countries. The legal landscape surrounding energy sharing is still evolving and getting standardized through TSOs, which can slow down adoption in the next 12-24 months until these standards are ready.

Moreover, initial costs of setting up energy-sharing systems might be seen as a barrier from the perspective of small energy communities. These barriers can be overcome through pilot projects that demonstrate the benefits of the system and future potential. Financial incentives or grants for green energy technologies could also help lower entry barriers for early adopters, which is still also being supported through energistyrelsens "pulje for energifællesskaber".

- *How does the project results contribute to realise energy policy objectives?*

The project directly contributes to Denmark's energy policy objectives of increasing the share of renewable energy and decentralizing energy production. By enabling citizens and communities to participate actively in energy sharing, FLEX-CEC supports the decarbonization of energy systems and promotes installation of new small RE plants (< 1MW)**.**

The project have not performed any quantitative calculations in regard to how Energy Communities can drive impact for a decentralized carbon-free energy system.

It has been the general project assumption that Energy Communities can drive carbon neutrality. It's estimated by other projects and research papers that ECs can enable 7-10 GW installed RES capacity and activate 2 Mio citizens throughout Europe[1].

Energy Communities are seen to become a catalysator for an increased adoption of more RE installations and engaging local societies in investing and consuming clean local power. This creates derivative effects like reduction in CO2, independence of fossil fuels and help secures local supply of clean power.

- *If Ph.D.'s have been part of the project, it must be described how the results from the project are used in teaching and other dissemination activities.*

The Ph.D. student involved in the project contributed to developing algorithms for battery control and energy flexibility. The mathematical models and algorithms that were developed to model citizen energy

[1] SET Ventures deep dive report 2024: "Energy Community startups driving decentralized energy transition".

communities and their flexibility were used as the foundation for a special course with a group of Masters students and a MSc thesis, which the PhD student supervised. The results from this coursework were then synthesized into a conference paper, which garnered much interest from other people in academia at the conference. . Additionally, indpendent research findings from the PhD student have been shared at academic conferences and are currently in the process of being published. Through these contributions the work of the FlexCEC project was further disseminated, showcasing the impact that citizen energy communities can have on the power system and the green transition.

7. Project conclusion and perspective

- *State the conclusions made in the project.*

The FLEX-CEC project successfully demonstrated the potential of operating energy communities in 2 pilotes with active citizen participation. The project developed and tested the FLEX-CEC platform, which facilitated energy sharing, energy community management, and battery control within energy communities. While some technical challenges delayed the full implementation of all features, the platform proved capable of delivering a settlement/sharing solution helping distributing local produced power behind transformer stations. The project also highlighted the importance of local energy.

- *What are the next steps for the developed technology?*

The next steps for the FLEX-CEC platform involve further refinement and scalability. Key technical improvements, particularly around battery functionality and flexibility management, will be addressed to ensure the platform's readiness for commercial deployment. Additionally, the platform will be commercialized, targeting housing associations, municipalities, and energy companies looking to establish or manage energy communities. The team will also focus on integration with regulatory changes, ensuring the platform can comply with future policies around energy tariffs. Several pilot projects on commercial basis are planned to expand the platform's adoption in other regions and market segments locally.

- *Put into perspective how the project results may influence future development*

The results of the FLEX-CEC project could have a significant influence on the future development of local energy markets and the energy-sharing economy. As energy communities become more prominent, the platform's capabilities in energy sharing and home-battery management could serve as a model for other countries and regions. The insights gained from the pilots regarding regulatory alignment and cost savings provide a strong knowledge pool for policymakers to support decentralized energy solutions. Moreover, the project may inspire the creation of new business models based on collective energy management, contributing to the acceleration of renewable energy integration at the local level and offering a blueprint for scaling similar initiatives globally.

The FLEX-CEC project not only validated the feasibility of energy communities but also demonstrated how digital platforms can empower citizens and municipalities to take control of their energy consumption and production. By focusing on local energy sharing, the project aligns with global trends toward decentralized energy systems, which are crucial for meeting ambitious climate targets set out in EU directives. The insights from the project underscore the need for flexible, scalable solutions that can adapt to different regulatory environments and energy markets. As the platform evolves and matures, it is poised to become a key tool in helping energy communities reduce their carbon footprint, optimize energy costs, and participate in the growing energy-sharing economy. The success of this project could potentially accelerate the adoption of smart grids and renewable energy technologies worldwide, serving as a model for sustainable energy systems.

8. Appendices

- Add link to relevant documents, publications, home pages etc.
- www.flex-cec.dk where project description and below documents can be downloaded:
  - Project handbook ("Erfaringsopsamling"): https://flex-cec.dk/wp-content/uploads/2024/07/FLEX-CEC-Erfaringsopsamling.pdf
  - Legal note by lawfirm BechBruun: http://flex-cec.dk/wp-content/uploads/2024/07/Notat-om-energifaellesskaber-flex-cec-projekt-22.-juni-2024.pdf
  - Final seminar presentation: https://flex-cec.dk/wp-content/uploads/2024/09/FLEX-CEC-Seminar-Presentation-PP_Handouts.pdf
- PhD publication to be provided