Interoperable Concept for Energy Communities: Perspectives from FlexCHESS

Non-Scientific Article: Insights from RDIUP's Intervention in Cluster Webinar [InterSTORE – FlexCHESS – PARMENIDES].

Presented By

FlexCHESS

Funded by
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Abbreviations	
AI	Artificial Intelligence
API	Application Programming Interfaces
CHESS	Connected Hybrid Energy Storage System
DLT	Distributed Ledger Technology
DSS	Decision Support Systems
EC	Energy Community
EMS	Energy Management System
ESS	Energy Storage Systems
EU	European Union
EV	Electric Vehicle
HESS	Hybrid Energy Storage Systems
IPR	Intellectual Property Right
MQTT	Message Queuing Telemetry Transport
NFT	Non-Fungible Token
OCPP	Open Charge Point Protocol
P2P	Peer-to-Peer
SGAM	Smart Grid Architecture Model
SoC	State of Charge
VESS	Virtual Energy Storage Systems
VPP	Virtual Power Plan

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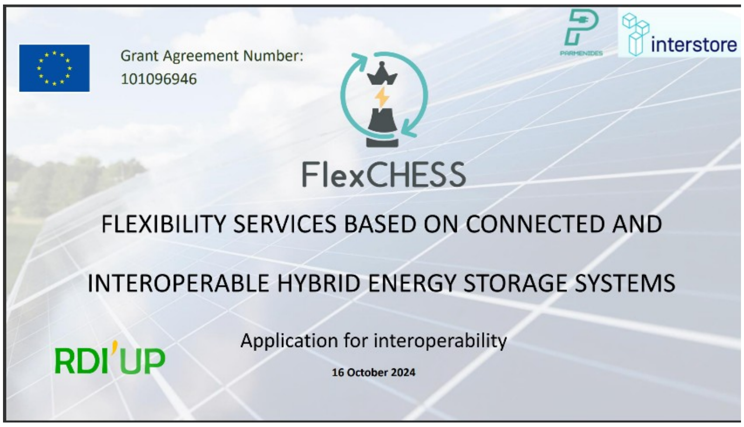
Short Description

On October 16, 2024, three European projects—FlexCHESS, InterSTORE, and PARMENIDES—came together for a cluster webinar to discuss the crucial role of flexibility and interoperability in the future of energy systems and renewable energy communities.

Among the distinguished contributors was Dr. Habib Nasser, CEO and co-founder of RDIUP, a key partner in the FlexCHESS project. Dr. Nasser shared insights into how innovative tools like Virtual Energy Storage Systems (VESS) and real-time digital twins are reshaping energy management and distribution. Dr. Nasser detailed how the Connected Hybrid Energy Storage System, CHESS Node, aggregates distributed Hybrid Energy Storage Systems (HESS) and flexible loads, optimising their collective potential to support grid resilience and stability. His insights also introduced a forward-looking vision of community-driven profitability through smart contracts, bringing incentives directly to consumers, an innovative approach that ensures transparency and trust in energy transactions, while also offering rewards for consumer-driven flexibility.

Introduction

The energy landscape in Europe is undergoing a monumental shift, driven by ambitious sustainability goals and a need for greater energy efficiency. FlexCHESS, or "Flexibility services based on Connected and Interoperable Hybrid Energy Storage Systems," is a frontrunner in developing smart energy solutions. The project leverages digital twins, VESS, and DLT to optimise energy management and support grid resilience. FlexCHESS aggregates Hybrid Energy Storage Systems (HESS) and flexible loads through the CHESS Node, allowing efficient energy storage, usage, and grid stability across Europe.



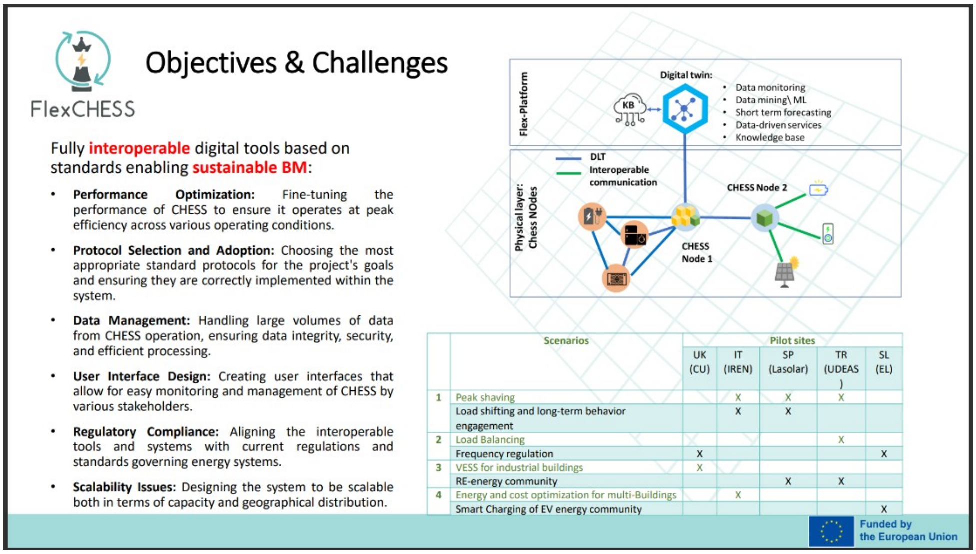
RDIUP plays a vital role in the FlexCHESS project, a consortium of 13 partners, leading quality assurance, risk management, and technical specifications. It also contributes to developing communication protocols, real-time decision-support system, and blockchain-based cybersecurity mechanisms. In the dissemination, communication and exploitation of the project's results, RDIUP defines the incentive-based business model and the exploitation strategy. Dr. Habib Nasser's presentation highlighted how FlexCHESS is a catalyst for economic profitability and environmental sustainability, positioning smart energy technology as a cornerstone for the future.

Dr. Habib NASSER holds a Ph.D. in Mechatronics and Smart systems, where his research focused on Autonomous Machines. His academic background and certifications (e.g. ISO50001) laid the foundation for the commitment to driving innovation in the realm of data science and AI. With a wealth of experience in both academia and industry, he has spearheaded numerous research and commercial projects aimed at delivering patents, disruptive concepts, and solutions. His expertise extends to AI tools development, international projects coordination and synergies elaborations. Currently, he is the co-founder and CEO at RDIUP specialised in the development of digital technologies, where he leads a dynamic team dedicated to addressing emerging challenges in rapidly changing societies. Looking ahead, Dr. Nasser is committed to pushing the boundaries of AI and Data analytics in Energy, E-Mobility and Healthcare sectors.

Key Themes from the Webinar

The Vision Behind FlexCHESS

Dr. Nasser began by explaining FLEXCHESS's core mission: to develop digital tools that aggregate small, distributed Energy Storage Systems (ESS) and flexible loads. By storing energy and releasing it when needed, these tools can significantly improve grid reliability and resilience. He emphasised the critical role of connected systems, noting, *“the future of energy systems lies in flexibility and connectivity. By linking energy storage systems together, we can optimise their performance and provide reliable flexibility services across entire regions”*. A standout part of Dr. Nasser’s presentation was the innovative use of digital twins and smart contracts. The digital twin technology allows for real-time monitoring and optimisation of the CHESS Nodes, comparing real-world data with simulations to improve efficiency and reduce costs. *“Our vision”*, he said, *“is to use Virtual Energy Storage Systems and federated real-time digital twins to provide flexibility services while de-risking the process”*. In addition, FlexCHESS has developed smart contracts to ensure transparency and trust between energy producers and consumers. These contracts are particularly useful in scenarios where flexibility services are provided, offering near real-time data on contributions. The goal is to create a system that ensures renewable energy is used efficiently across Europe, even under varying demand conditions.



The project’s approach is built on two key layers:

- **CHESS Node**: Dr. Nasser emphasised that connectivity between these systems is crucial to providing flexibility. *“The CHESS Node aggregates multiple storage systems, allowing them to act together and optimise their combined performance”* he explained.
- **FlexPlatform**: A digital counterpart creating a *"shadow"* of the CHESS Node. It assesses the node's capabilities and determines what flexibility services can be provided, all while identifying which CHESS owners should be involved. This allows the system to make data-driven decisions on how best to deploy energy resources, enhancing the system's overall efficiency.

Real-World Use Cases

Dr. Nasser's intervention moved from theory to practice as he outlined four real-world use cases where FlexCHESS technology is being tested and validated in the five pilot sites, demonstrating how these digital tools are already having a tangible impact:

1. **Increasing Grid Resilience**: By offering solutions like peak shaving - reducing energy demand during peak hours - and load shifting, the system helps grids remain resilient even under high demand.
2. **Empowering Grid Stability**: Through dynamic energy response solutions, the system provides ancillary services, such as frequency regulation via VESS and load balancing, making grids more stable.
3. **Supporting Virtual Power Plants (VPPs)**: The CHESS Node can act as a third-party service provider, offering flexibility services that help VPPs achieve their goals more efficiently.
4. **Adaptive Energy Management**: This use case includes cost optimisation and Electric Vehicle (EV) community integration, enabling more efficient energy use for EV owners.

i. FlexCHESS Pilot Sites and Use Cases

	Scenarios	Pilot Sites: Country & Partner				
		United Kingdom (CU)	Italy (Iren)	Spain (La Solar)	Turkey (UEDAS)	Slovenia (EL)
1	Peak shaving		X	X	X	
	Load shifting and long-term behaviour engagement		X	X		
2	Load Balancing				X	
	Frequency Regulation	X				X
3	VESS for industrial buildings	X				
	RE-energy community			X	X	
4	Energy and cost optimisation for multi-buildings		X			
	Smart charging of EV energy community					X

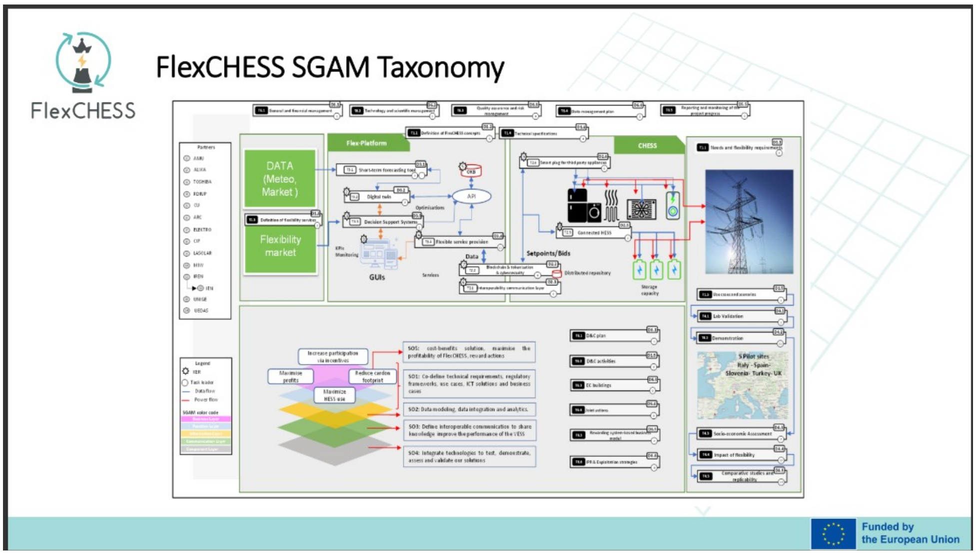
Each of these use cases demonstrates the practical impact FlexCHESS can have in diverse settings, from urban areas to remote islands.

SGAM Taxonomy: Two Workflows of FlexCHESS

At the core of FlexCHESS are two key workflows that enable flexibility provision through advanced interoperability between digital and physical systems.

The **first workflow** involves a predictive approach, where a short-term forecasting module, including the Sky-Camera developed by RDIUP, predicts energy resources, renewables' generation and consumption. This forecast is then fed into a digital twin to assess the offer capability of the VESS through simulations. Then, based on data received from physical CHESSs, the flexibility service provision engine will generate bids and return setpoints for each CHESS. The Smart energy management tool will control each asset to provide required services while continuously feeding performance data back to the cloud-based FlexPlatform monitoring information (performance, failures, state of health, SoC, ...).

The **second workflow** focuses on optimising the system itself. Based on the received feedback, digital twin will compare the real and digital behaviour to identify deviations and possible operating improvements. Using smart decision-making tools - DSS - high-level optimisation of the CHESSs are recommended, including adjustments to reduce costs, lower carbon emissions, and optimise the size and efficiency of the HESS based on real-world performance.

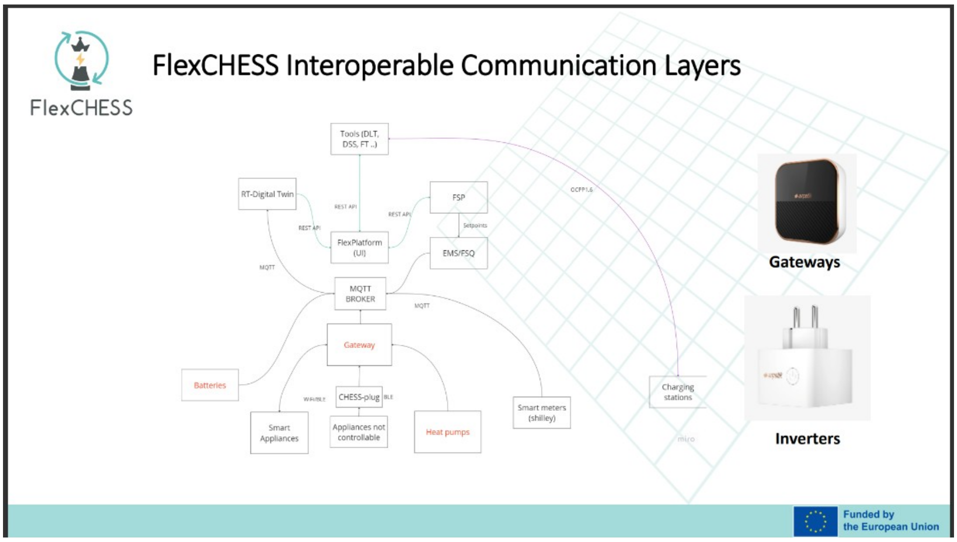


These two workflows ensure that the FlexCHESS system not only provides immediate flexibility for ECs but also continuously learns and improves, enhancing long-term efficiency and sustainability.

FlexCHESS Interoperable Communication Layers

One of the cornerstones of FlexCHESS is its advanced protocol of the communication infrastructure, which ensures that all components within the energy system—from storage units to EV charging stations—can interact seamlessly.

For real-time monitoring and data sharing between the various storage systems and the FlexCHESS platform, the project uses **MQTT** (Message Queuing Telemetry Transport), a lightweight protocol ideal for broadcasting



real-time measurements. This ensures that all energy data, including power usage and storage capacity, is continuously updated and shared with relevant modules.

To connect different cloud services, **REST APIs** (Application Programming Interfaces) are employed. These APIs enable smooth communication between the platform's digital components, facilitating interoperability and efficient data exchange.

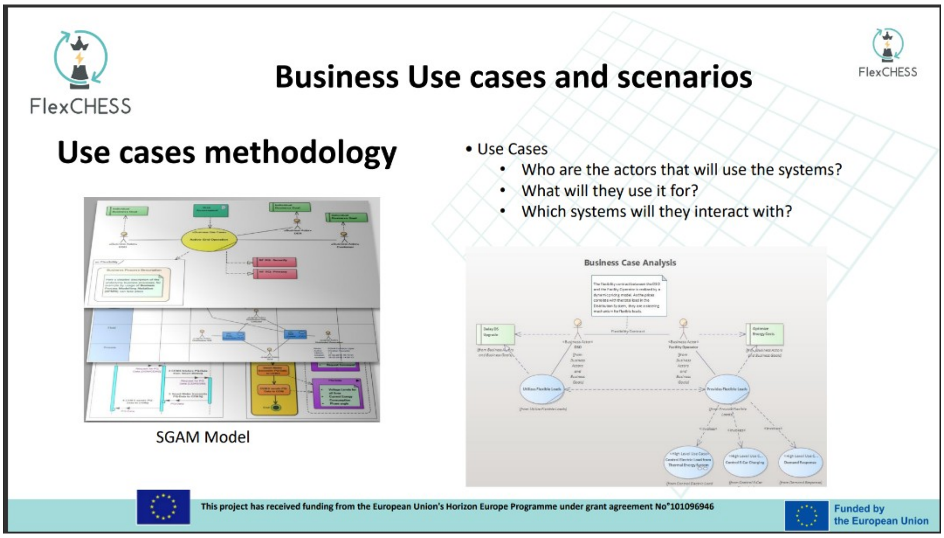
In Slovenia Pilot Site, where EV charging plays a key role, FlexCHESS integrates **OCPP 1.6** (Open Charge Point Protocol) to manage remote metering and smart charging. This allows for flexible and intelligent control of charging stations within the system.

On the physical side, FlexCHESS uses **gateways** to bridge the communication between traditional appliances and the smart grid. These gateways connect devices like inverters and smart plugs, even making older, previously disconnected appliances more responsive and controllable within the energy system.

Business Use Cases and Scenarios

In FlexCHESS, defining business use cases and scenarios is essential to ensure that its innovative energy solutions can be effectively applied in real-world situations. To achieve this, the project follows the **SGAM methodology** (Smart Grid Architecture Model), which provides a structured way to develop and evaluate use cases across different layers of the energy system.

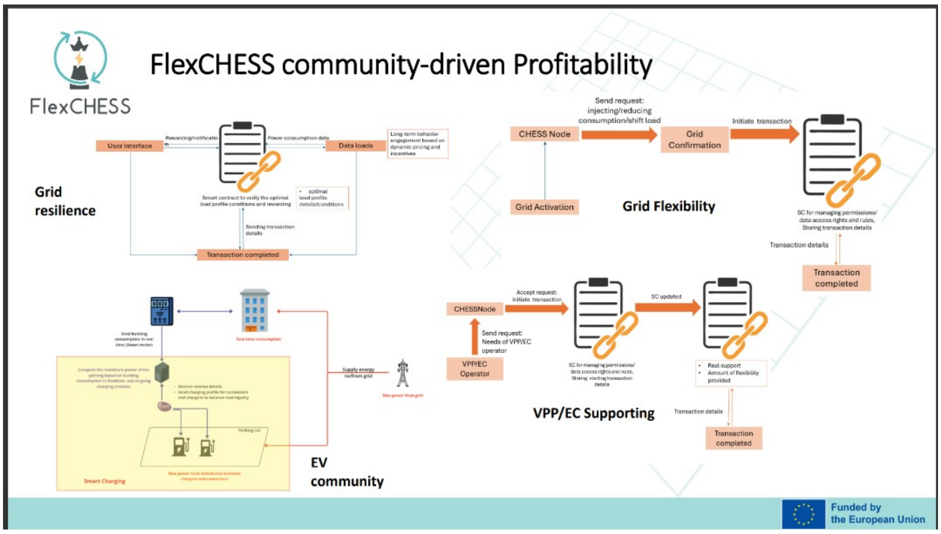
By integrating **information and communication layers** into the use cases, FlexCHESS guarantees that all components, whether physical, digital, or business-related, can work together seamlessly. This interoperability is crucial for delivering flexibility services, such as balancing energy supply and demand or optimising storage capabilities.



The SGAM framework also helps FlexCHESS map out the roles and interactions of key actors involved in each scenario. By clearly identifying the responsibilities and sequences for each actor, from energy providers to technology operators, the project can ensure smooth coordination and maximise the benefits of flexibility for all participants. These scenarios are particularly useful for the **pilot sites**, where FlexCHESS solutions will be tested and validated in real-world conditions.

FlexCHESS: Community-Driven Profitability

One of the key innovations in the FlexCHESS project is the use of **smart contracts** to enhance transparency and trust among participants while ensuring accurate reconciliation of



energy flows and flexibility services. Smart contracts are automatically executed agreements that define the rules of participation and contributions between different stakeholders, such as CHESS owners and node operators, in an **immutable** and **secure** way. Each **use case** in FlexCHESS has its own smart contract:

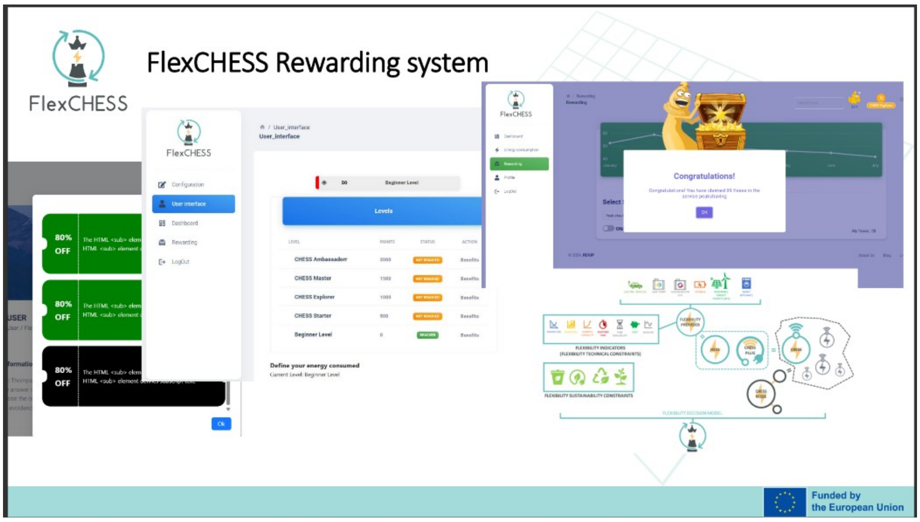
- **Use Case 1**: Smart contracts track the energy consumption behaviour of CHESS owners, analyse their contributions, and offer real-time recommendations to improve their energy usage during peak and off-peak periods.
- **Use Case 2**: The smart contract collects data from the Energy Management System (EMS) and digital twin modules to store important details such as the agreement's activation date, the type of flexibility services offered, and the final amount of flexibility provided. This ensures accurate reconciliation of energy transactions.
- **Use Case 3**: In unforeseen situations, the CHESS node can provide support to VPP or ECs, and the smart contract will recognise this as an additional revenue stream for the CHESS owners.
- **Use Case 4**: Smart contracts offer **rewards to EV owners** who reschedule their charging times or change their charging location to stations where grid flexibility is most needed. This "location-based incentive system" ensures that the grid remains balanced, particularly near substations under strain.

Through these smart contracts, FlexCHESS incentivises participants by offering **financial rewards** for consumer-driven flexibility and efficient energy management, encouraging active engagement in maintaining grid stability and efficiency.

FlexCHESS: Rewarding System for CHESS Owners

FlexCHESS introduces a groundbreaking **rewarding system**, developed by RDIUP, designed to motivate and engage CHESS owners. This incentive-based platform consists of two key components aimed at enhancing participation in flexibility provision and fostering a vibrant community.

1. **Levelling System**: This system allows CHESS owners to earn points based on their asset contributions and the value they bring to the CHESS node. As owners invest more into their systems and actively participate, they advance through different levels within the community. Each level unlocks new benefits and opportunities, encouraging continuous engagement and investment in sustainable energy solutions.
2. **Rewarding Mechanism**: The platform provides a way to reward CHESS owners for their participation and contributions to flexibility services. The CHESS node manager sets the rules for calculating these rewards, ensuring a transparent and fair process. Owners can track their contributions and see how they can maximise their rewards through an intuitive user interface.



Additionally, the FlexCHESS rewarding system incorporates **Non-Fungible Tokens (NFTs)**, their rewards can be converted into NFTs, which can be utilised in marketplaces or converted into local market discount coupons. This feature not only adds a modern twist to the rewarding system but also provides tangible benefits for CHESS owners, enhancing their overall experience within the community.

Panel Discussion

The Panel Discussion reinforced how crucial it is for all assets, whether thermal, electric, or storage, to communicate and work together. The idea that consumers won't need to directly engage with the technicalities of ontologies, but will benefit from the added value and functionalities, was a reassuring takeaway.

During the panel discussion, the moderator, Ludwig Karg (BAUM), emphasised that while **interoperability** is technically proven to facilitate the transition to a more efficient energy system, the slow pace of this transition cannot solely be attributed to technological barriers.

Dr. Habib Nasser was asked to elaborate on the benefits of increased interoperability beyond technical aspects. He highlighted several key points:

- **Implicit and Explicit Flexibility**: Long-term engagement of community members offers implicit flexibility. However, interoperability enables the provision of explicit flexibility services, enhancing revenue streams for energy communities.
- **Peer-to-Peer (P2P) Energy Trading**: Improved interoperability can facilitate P2P energy trading, empowering individuals and communities to share energy resources more effectively.
- **Market Stability**: A more interconnected and resilient grid can reduce risks associated with decentralised markets, making them more stable and reliable.

On a social level, Dr. Habib pointed out that increased connectivity among CHESS owners fosters inclusivity within communities and facilitates informative data sharing.

When the moderator inquired about the relevance of the **SGAM** to the FlexCHESS project, Dr. Habib explained that SGAM aids in defining use cases and scenarios comprehensively. It helps in structuring data and knowledge representation, making it easier to understand dependencies and enhance the discoverability and observability of data gathered from CHESS nodes.

The moderator then raised the question of how projects like FlexCHESS can support the establishment and operation of ECs, which many believe are crucial for the energy transition. Dr. Habib responded by discussing **community-driven profitability** and emphasised the importance of ensuring that storage owners benefit alongside grid operators. He proposed several methods to ensure this:

- Using **smart contracts** reconciles contributions to flexibility services, while blockchain technology provides traceability and transparency in participation.
- The **DSS** recommends optimal times for energy storage and discharge, helping community members maximise savings and revenue based on local market conditions.

As the discussion progressed, the moderator highlighted the cost-effectiveness of **storage solutions** in stabilising future electricity systems but raised concerns regarding the substantial investment required. Dr. Nasser suggested that all stakeholders, energy communities, incumbent utilities, and other entities, should contribute to the investment. Initially, he recommended maintaining lower investment levels while focusing on maximising savings from existing assets and flexible loads to minimise risks. This approach would engage CHESS owners and encourage them to invest in novel technologies in the medium term to mutualise resources, reduce costs, and create new revenue streams. In FlexCHESS, CHESS owners would subscribe for participation, thereby supporting the sustainability of the project.

Dr. Habib concluded by expressing his *"wish"* for CHESS nodes to become profitable and bankable, attracting investments from banks and business angels. He also suggested that, in the long term, large polluting industries could contribute to investments by offering grants to ECs.

Conclusion

In a world grappling with climate change and the urgent need for energy security, FlexCHESS stands at the forefront of innovation, paving the way for energy communities that are not only economically viable but also environmentally sustainable. Embracing these transformative practices means investing in a future where energy is clean, accessible, and community-driven—one that inspires trust, collaboration, and a shared vision for a greener planet.

As we transition toward an era where decentralised energy solutions become the norm, initiatives like FlexCHESS exemplify how collaboration among stakeholders, advanced digital tools, and smart contracts can transform traditional energy paradigms. The recent webinar served as a vivid reminder of the groundbreaking work being done through EU-funded projects like FlexCHESS. Dr. Nasser's insights highlighted that FlexCHESS is not merely a technological innovation; it represents a comprehensive vision for a sustainable energy future. By integrating advanced digital tools, promoting interoperability, and incentivising participation, FlexCHESS seeks to unlock the full potential of renewable energy across Europe. Dr. Nasser emphasised that the future of energy lies in cooperation between systems, technologies, and communities.

> *"In FlexCHESS we believe that digitalisation transition has to go in parallel with energy transition. More the energy systems, CHESSs, are connected and smarter, more the data sharing and integration are feasible and impactful"*
>
> ***Dr. Habib Nasser (RDIUP)***

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Related Projects:

- **FlexCHESS** : flexchess.eu/
- **PARMENIDES** : parmenides-project.eu/
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