OptiREC project successfully concludes, delivering advanced solutions for the future of energy communities

The OptiREC project has officially concluded, marking a milestone in the advancement of energy communities and their integration into modern energy systems and markets. Led by a consortium of multidisciplinary partners including IREC, University of Girona (UdG), Comillas Pontifical University – IIT, and Universitat Politècnica de Catalunya (UPC). The project developed innovative methods, tools, and models that enhance the design, operation, flexibility management, and market participation of local energy communities in Spain and across Europe.

Energy communities are increasingly recognized as key actors in the ecological and digital transitions, yet face barriers in operational coordination, system integration, and economic viability. OptiREC was designed to address these challenges holistically. Across four coordinated subprojects, the consortium delivered advances spanning flexibility management, network integration, local energy market design, and wholesale market participation.

OptiREC pursued a comprehensive approach to develop smarter and more integrated energy communities and tackled four high-impact challenge areas:

1. **Flexibility management at community/hub level**, including interaction with distribution grids.
2. **Integration and aggregation** of energy communities into distribution networks.
3. **Design of local energy markets** and the mechanisms that link them to national systems.
4. **Optimal participation of energy communities in wholesale markets**, including day-ahead, intraday, and reserve markets.

Through innovative models, tools and advanced forecasting and optimization methods, the project provided actionable frameworks for real-world implementation. The collaboration across engineering, economics, market design, and data science was essential to its success. Scientific and Technical Highlights from each subproject (SP) are presented below:

SP1 – AI-Enabled Distribution Networks and Community Integration (IREC)

IREC addressed key challenges emerging from the ecological and digital transition, focusing on Distribution System Operators (DSOs), individual consumers, and energy communities leading to:

- Statistical models of user behavior to support DSO operational planning.

- Peer-to-peer energy trading frameworks incorporating uncertainty in flexibility forecasts.
- Consensus-based distributed optimization using ADMM and communication-graph strategies.
- Learning-based voltage estimation tools using LASSO regressions where network data is limited.
- Advanced planning tools with discrete investment decisions and multi-scenario constraints.
- Operational optimization for DSO line-switching strategies to reduce energy costs and improve network reliability.

SP2 – Flexibility Forecasting, Modeling, and Control in Real Communities (UdG)

UdG delivered a complete, end-to-end methodology for residential flexibility management, including:

- Identification and modeling of household energy assets.
- Precise flexibility estimation using decentralized, privacy-preserving algorithms.
- Edge-based forecasting and optimization deployed inside users' homes.
- Secure communication protocols with aggregators and open-source integration via Home Assistant.
- Validation across multiple pilots, including EV charging in Amsterdam and the Port of Borg.

SP3 – Local Energy Market Design and Regulatory Integration (COMILLAS)

COMILLAS advanced the state of the art in local electricity market design by:

- Analyzing regulatory frameworks and defining requirements for integrating energy communities into national systems.
- Designing market architectures incorporating peer-to-peer trading, dynamic tariffs, and flexibility mechanisms.
- Proposing performance indicators for transparency, efficiency, and neutrality of local markets.
- Developing generalized models and integration parameters tailored to different community contexts.

SP4 – Optimal Market Participation for Energy Communities (UPC)

UPC developed an innovative multistage stochastic programming model enabling optimal bidding strategies across all major electricity markets. Key innovations include:

- Co-optimization of buy and sell bids, including simultaneous offers.

- Detailed modeling of aggregated flexible demand within complex stochastic frameworks.
- Enhanced scenario-generation methodology including solar generation uncertainty.
- Insights showing that strategic over-purchasing in day-ahead markets can increase reserve-market earnings.

A Major Step Toward the Energy Communities of the Future

OptiREC has delivered actionable tools and knowledge that empower DSOs, policy makers, aggregators, and community managers to plan and operate energy communities with higher efficiency, lower costs, and greater resilience. The project's integrated vision—spanning data analytics, optimization, regulation, and real-world pilots—positions energy communities as central actors in Europe's clean energy transition.

In total, the project generated 19 journal publications (16 published and 3 in review), 3 conference articles and 10 presentations, and 2 book chapters, reflecting a substantial scientific and technical contribution and demonstrating the project's broad impact across research, innovation, and knowledge dissemination.

The consortium partners are now preparing for follow-up initiatives focused on scaling deployment, supporting regulatory evolution, and accelerating community-level digitalization.

For more information, please contact: Josh Eichman (jeichman@irec.cat), Joan Colomer (joan.colomer@udg.edu), José Pablo Chaves (jose.chaves@comillas.edu) or F. Javier Heredia (f.javier.heredia@upc.edu).

Acknowledgements (in Spanish): OptiREC (TED2021-131365B-C41) es un proyecto financiado por MCIN/AEI/10.13039/ 501100011033 y por la Unión Europea "NextGenerationEU"/PRTR.