

Multi-vector Demand Response for Residential Flexibility

ABSTRACT

The Greek pilot of DEDALUS shows how **multi-vector demand response** can optimise both electricity and heating flexibility in residential environments. Deployed across **more than 130 households**, the pilot combines smart heating control, advanced appliance-level disaggregation and digital twins with user-friendly nudging applications. It highlights how sophisticated forecasting with personalised, continuous app-based interaction is crucial for sustaining user participation and balancing grid efficiency with occupant comfort.



KEY POINTS

- Interoperable multi-vector platforms to seamlessly manage both electricity and heating flexibility within a unified residential DR environment.
- Combining smart heating control and appliance-level disaggregation with personalised nudging apps to drive active and sustained resident engagement.
- Validating day-ahead optimisation across highly diverse household configurations and a broad portfolio of flexible assets.
- Useful lessons and practical behavioural insights for the deployment of user-centred residential demand response.

The Greek pilot is a **residential multi-vector DR demonstration**, deployed across the wider Athens area and other cities. It combines electricity and heating flexibility through two complementary streams: the **HERON electricity-focused pilot** and the **DOM-X heating-focused pilot**. Together, they provide a real-world testbed for evaluating the interaction between flexible household assets, forecasting tools and user-facing services within the same residential DR environment.

INTEGRATED TECHNOLOGIES AND SERVICES

The pilot combines a set of interoperable technologies supporting both heating- and electricity-based flexibility:

- **Forecasting and optimisation components**, including dynamic tariffs and day-ahead RES-share signals calculated from the Greek TSO's data to generate optimal DR recommendations for clusters of buildings.
- **HERON energy control platform and EnergiQ Lab app**, upgraded with a unified "Home" concept to coordinate 204 flexible assets (including ACs, smart plugs, and white goods) across 91 households, providing appliance-level energy breakdowns and an intuitive "RES wheel" to align consumption with green energy.
- **DOM-X smart heating control infrastructure**, a network of 55 heating controllers for gas boilers, 25 controllers for heat pumps, 50 energy meters and IAQ sensors successfully converting legacy systems into DR-ready assets.
- **Two nudging applications**, enhanced to provide near real-time, personalised and context-aware notifications that guide users to shift loads toward high-RES and low-carbon periods.
- **Advanced digital twin**, delivering interactive dashboards and clustering analytics to visualise real-time consumption behaviours and evaluate flexibility planning for building managers.

ENGAGEMENT

- **9 engagement activities** were implemented across the pilot, including co-creation workshops and technical training sessions, using clear real-life examples and dynamic visual signals to build users' confidence in the new digital services.
- Leveraged application usage tracking and nudging activities to identify critical behavioural barriers, revealing that grid-driven midday optimization often conflicts with users' actual availability at home.
- Successfully onboarded **133 consumers** through targeted nudging applications, combining continuous app-based interaction with **localised 1-on-1 support**.



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KEY RESULTS

- Achieved **37.88% gas savings** through smart, automated heating control.
- Reached **34.6% electricity efficiency** by successfully shifting flexible appliance usage to renewable-rich midday periods.
- Successfully mobilised **2.03% of aggregated flexibility** and achieved a **77.6% exploitation ratio** of planned flexibility by using daily optimisation algorithms that maximised DR opportunities.
- Delivered tangible well-being and financial benefits, including a **66.67% reduction in temperature-related complaints** and a **29.87% reduction in gas energy costs**.

REPLICATION RELEVANCE

- The Greek pilot shows the value of **deploying modular multi-vector architectures** to seamlessly manage both electricity and heating flexibility within a unified, interoperable residential DR environment.
- Replication should build on **interoperable systems** that connect flexible assets, forecasting tools and user-facing applications rather than treating them as separate layers.
- User engagement should rely on **clear real-life examples, transparent communication and practical familiarisation**, especially when services require behavioural participation

RECOMMENDATIONS

- Multi-vector DR services should be designed as **integrated systems** combining flexibility activation, forecasting and user interaction across both electricity and heating.
- **Comfort and user control** should remain core design parameters, ensuring that smart heating deployments respect individual household preferences and daily routines.
- **Interoperable control systems, flexible household assets and accessible user applications** are all necessary to support effective residential DR deployment.
- **Engagement should not be treated as secondary**: preparatory materials, familiarisation actions and clear in-app feedback can strengthen participation and acceptance.

REFERENCES

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