

1. PUBLISHABLE SUMMARY

Summary of the context and overall objectives of the project (For the final period, include the conclusions of the action)

The European energy system will experience important changes, in particular due to the targets set for renewable energy integration, reduction of greenhouse gas emissions and energy efficiency. The electricity system is expected to be exposed to new or increased risks, for instance in terms of security of electricity supply, congestion, system stability, curtailments, difficulty to meet the demand at some periods of time. To face this evolution, there is a growing need for more flexibility and more active involvement of all the stakeholders at all levels (from distribution to pan-European) to ensure an efficient and reliable operation of the electricity system.

Enhanced synergies between different energy carriers appear now as one means to provide flexibility to the electricity system but also to drive efficiency and business innovation in the energy sector.

The MAGNITUDE project has developed a whole chain of optimization and coordination tools, as well as business and market mechanisms, to provide flexibility to the European electricity system, by optimizing the synergies between electricity, gas, heating and cooling systems.

More specifically, MAGNITUDE's main goals were to:

- enable the provision of services by Multi-Energy Systems (MES) to support the cost-effective integration of Renewable Energy Sources (RES), and enhance security of supply,
- bring under a common framework, technical solutions, market designs and business models,
- contribute to the ongoing policy discussions in the energy field.

The methods and tools were assessed on seven real-life case studies of multi-energy systems of different sizes and technological features located in seven European countries (Austria, Denmark, France, Italy, Spain, Sweden, UK) and covering different regulatory frameworks, sector-coupling technologies, stakeholders and business models.

The project results confirmed that MESs can definitely provide flexibility to support the integration of RES in the electricity system and to contribute to decarbonization of energy system. They have potential to participate in energy markets, frequency ancillary service procurement, congestion management and capacity requirement mechanisms. But this strongly depends on the technologies involved in the MES, the process and operation strategies. The simulations carried out for the seven case studies showed that a significant amount of flexibility can be available but only a small part is actually activated (i.e. in terms of energy delivered). The main reasons for this situation are of different natures: (i) technical, for instance linked to the capabilities of the technologies, (ii) economic, for instance linked to competitiveness of the bids proposed on the markets with respect to other resources, or the economic viability of the business models, (iii) regulatory, for instance linked to limitations to access some markets.

Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far (For the final period please include an overview of the results and their exploitation and dissemination)

The project results can be summarized as follows:

- Identification of the most relevant flexibility services to be provided by Multi-Energy Systems (MES) to the electricity system (which allow to increase the share of RES and enhance security

of supply); characterisation and comparison of their procurement mechanisms in the 7 case study countries.

- Characterisation of the technologies and MES involved in the 7 case studies in terms of their flexibility capabilities and their ability to provide the selected services.
- Definition of the project high-level business use cases and formalisation of the MAGNITUDE functional technical and commercial architectures for the 4 energy sectors (electricity, gas, heating, and cooling), integrating the proposed interactions between the MES and the aggregation platform.
- Development of models and tools for the simulation and optimization of control strategies of the technologies and MES in the 7 case studies to improve their operation and maximize the flexibility provision.
- Development of a multi-energy aggregation platform to quantify the benefits of pooling the flexibilities of decentralized MES for trading on the identified energy and ancillary service markets.
- Elaboration and comparison of innovative multi-carrier market designs for the enhancement of the synergies at the level of the electricity, gas, and heat markets. Development of a market simulator implementing these innovative market designs.
- Assessment of the integrated system (namely MES optimisation, pooling through the aggregation platform, and market simulation) for the selected business use cases in the 7 case studies.
- Analysis of the replicability and transferability of the MAGNITUDE's business cases.
- Evaluation of the business models for the MES operator and for the aggregator in the 7 case studies.
- Definition of the specifications and development of a light implementation of a multi-energy data hub and interoperability layers.
- Capitalization of the project main findings and lessons learnt and proposition of policy strategy and recommendations in a pan-European perspective – including technology, market, business models, and regulation aspects.

All the partners are committed to exploit the project outcomes and findings through activities such as:

- Development of commercial products and provision of consulting services.
- Further research, development and field testing in internal, national or European projects.
- Dissemination and use in (pre-)standardization bodies, working groups and associations, as well as in regulatory and policy discussions.

Progress beyond the state of the art, expected results until the end of the project and potential impacts (including the socio-economic impact and the wider societal implications of the project so far)

MAGNITUDE demonstrated that MES have potential for the provision of flexibility to the electricity systems. The project brought major advances in the following fields.

1. The design and operation of MES by developing technological factsheets, which can inform the wider community of the flexibility capabilities to be expected from multi energy technologies and their combinations. MAGNITUDE also provided tools for the optimized operation of MES and the maximisation of flexibility provision.
2. The market design and business models as the project studied market and regulatory options, based on a transnational perspective, to enable MES participation in the markets. Through its results, MAGNITUDE provides insights to the ongoing discussions to shape the European energy markets. The project contributes to the creation of business opportunities and business models for MES operators, aggregators or energy suppliers. It identified barriers to the participation of flexibility providers in the market and proposed solutions and recommendations.

In particular, MAGNITUDE addressed the specific role of the aggregator in different national markets and provided adapted software solutions.

3. The societal and environmental aspects as the project both contributed to meeting climate and energy targets at a European level, and to stimulating new economic and social benefits at different levels. The project results will contribute to increase the share of RES while ensuring the quality and security of supply in the electricity system. Increased flexibility and multi energy carrier integration will allow to smooth energy consumption, reduce peak load and offset the need for additional power generation. Therefore, it will contribute to reducing the environmental footprint and the greenhouse gas emissions

Address (URL) of the project's public website

<https://www.magnitude-project.eu/>

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