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GENTE

Distributed Governance for green ENergy communiTiEs

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The authors bear the entire responsibility for the content of this report and for the conclusions drawn therefrom.

Zusammenfassung

Das Ziel des GENTE Projektes ist es, ein Toolkit für Energie-Gemeinschaften und deren Manager zu erstellen. Das Toolkit soll eine Optimierung der Nutzung von Energieressourcen innerhalb der Gemeinschaft ermöglichen und das Erstellen von neuen Energie-Gemeinschafften durch verschiedene neue Geschäftsmodelle und Dienstleistungen fördern. GENTE untersucht die Anwendungsfälle von Energie-Ressourcen Integration innerhalb von Energie-Gemeinschaften, Prosumer Energie- und Servicemanagement - Verträge, sowie die Überwachung / Kontrolle der Energie-Ressourcen durch den Gemeinschafts-Manager. Die Innovation in GENTE umfasst Edge Intelligence, IoT-Plattformintegration, KI-Ressourcenoptimierung, Blockchain-Integration für Vertragsabschlüsse, Asset-Aggregationsmodelle und sozialwissenschaftliche Forschung.

GENTE startete am 01.Juni 2022 und befindet sich rund in der Halbzeit der geplanten Projektdauer. In diesem Zeitraum hat das Konsortium die Definition von Systemarchitektur und Datenmodellen, funktionale Anforderungen, Systemspezifikationen und technischen Spezifikationen abgeschlossen und die Definition von Testfällen und Benutzerprofilen erstellt. Zurzeit werden Arbeiten zu fortschrittlichen Last- und Erzeugungsprognosen auf Basis von KI-Techniken finalisiert.

Résumé

GENTE a pour but de créer une boîte à outils pour les communautés et les gestionnaires de communauté pour l'optimisation des ressources énergétiques et la fédération communautaire, et de promouvoir la création de nouvelles communautés grâce à de nouveaux modèles et services commerciaux. Les cas d'utilisation de GENTE sont l'intégration des ressources énergétiques communautaires, la gestion des contrats et des services énergétiques des prosommateurs et la surveillance et le contrôle des ressources énergétiques communautaires par l'intermédiaire du gestionnaire de communauté ou de fédération. L'innovation dans GENTE comprend l'intelligence en périphérie, l'intégration de plateformes IoT, l'optimisation des ressources par intelligence artificielle (IA), l'intégration de blockchain pour les contrats, les modèles de fédération communautaire / agrégation d'actifs et la recherche en sciences sociales.

GENTE a débuté le 1er juin 2022 et se trouve à peu près à mi-parcours de la durée prévue du projet. Durant cette période, le consortium a achevé la définition de l'architecture du système et des modèles de données, des exigences fonctionnelles, des spécifications du système et des spécifications techniques, et a établi la définition des cas de test et des profils d'utilisateur. Actuellement, les travaux sur les prévisions avancées de charge et de production basées sur des techniques d'intelligence artificielle sont en cours de finalisation.

Summary

GENTE will create a toolkit for communities and community managers for energy resource optimisation and community federation, and to promote the creation of new communities through new business models and services. GENTE use cases are for community energy resource integration, prosumer energy contract and service management, and monitoring / control of community energy resources through the community or federation manager. The innovation in GENTE includes edge intelligence, IoT platform integration, AI resource optimisation, blockchain integration for contracting, community federation / asset aggregation models, and social sciences research.

GENTE started on 01 June 2022 and is about halfway through the planned project duration. During this period, the consortium has completed the definition of system architecture and data models,

functional requirements, system specifications and technical specifications, and created the definition of test cases and user profiles. Work is currently being completed on advanced load and generation forecasting based on AI techniques.

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Abbreviations

ACF	Autocorrelation Function
AI	Artificial Intelligence
API	Application Programming Interface
DER	Distributed Energy Resources
DG	Distributed Generation
DLT	Distributed Ledger Technology
DMS	Distribution Management System
DSM	Demand Side Management
DSO	Distribution System Operator
EV	Electrical Vehicle
HP	Heat Pump
ICT	Information and Communications Technology
IoT	Internet of Things
LV	Low Voltage
LEC	Local Energy Community
ML	Machine Learning
MPC	Model Predictive Control
MV	Medium Voltage
NWP	Numerical Weather Predictions
PCA	Pearson Correlation Analysis
PV	Photovoltaic
RES	Renewable Energy Sources
SCADA	Supervisory Control and Data Acquisition System
SM	Smart Meter
SME	Small to Medium Enterprise
TRL	Technology Readiness Level

1 Introduction

1.1 Background information and current situation

To achieve the ambitious goals of the Paris Agreement and enable an effective green energy transition, a paradigm shift is needed. Energy is at the core of our society and a transition in how energy is sourced, shared, and traded will involve all stakeholders from all sectors. Decentralised renewable energy systems are rapidly becoming a key part of the future energy system, with new models of integration into energy networks, and facilitated by digital technologies as well as new business models. In particular, the participation of citizens as partners in energy projects will transform the energy system, with Local Energy Communities (LECs) being a core enabling structure.

The European Commission's Clean Energy Package confirms the prominent role LECs will play in the energy system; however, their economic, environmental, and social potential can only be realised through the adoption of new technology and systems that are underpinned by practical, human-centric support. Locally, the Swiss energy landscape must shift towards a higher penetration of renewables to meet the goals of the Energy Strategy 2050. An impulse towards this shift was given by a recent law reform which introduced the so-called “Zusammenschluss zum Eigenverbrauch” (ZEV) as a possible embodiment of local energy communities [1].

It is in this context that the GENTE project was conceived. GENTE will create a toolkit for communities and community managers for energy resource optimisation and community federation, and to promote the creation of new communities through new business models and services. GENTE has a strong relevance for the Swiss Energy Strategy 2050, the digitalisation strategy [2], and the SFOE energy research concept [3].

Research in decentralised approaches to LEC optimisation and control has the potential to help maintain a balance regarding supply and demand in energy networks for electricity, heating, and cooling, using socially acceptable technological paths. Further research is necessary to ensure reliable, optimised interaction of electrical, thermal and gas networks, buildings, local energy generation and feed-in, storage and distribution, in particular with regard to the load and provision flexibility of a site or its individual buildings for the electrical or thermal grid as well as the distribution of these flexibilities (over time and space), and the extent to which innovative information and communications technology (ICT) solutions can be applied in this respect.

Artificial intelligence plays a central role within GENTE. Of notable importance is the use of privacy preserving approaches to build forecasting models for consumption and production at the level of LECs and federations. This will allow the LECs and the federations to better discover and exploit flexibilities, translating into a more effective planning and optimisation for community energy goals.

The transition towards a renewable, secure and efficient energy system will be enabled by markets, policies and institutions designed to support energy efficiency and a shift towards renewables in a way that is efficient, broadly accepted, and facilitates individual well-being [3]. Research is required that can bring about a better understanding of the behaviour of the various actors, of their response to policy measures, and of the way the markets function.

In summary, GENTE provides a holistic approach to operate and promote LECs, including a governance toolkit, decision tools, algorithms, IoT platforms and approaches from social/behavioural

sciences which boost the possibilities and motivation for stakeholders to participate in LECs. GENTE adds a layer on top of the LECs to enable federations of communities, which will make it possible to coordinate several communities in a broader network, thereby optimising the grid and enabling new business models.

1.2 Purpose of the project

To address and support successful engagement of citizens in the energy transition through the LEC, GENTE creates a distributed governance toolkit for LECs comprising technology for resource optimisation and human-centric protocols for successful realisation in the community. The need owners are prosumers, community managers, aggregators, municipalities, and distribution system operators (DSOs).

GENTE use cases are for community energy resource integration, prosumer energy contract and service management, and monitoring / control of community energy resources through the community or federation manager. The innovation in GENTE includes edge intelligence, IoT platform integration, production and consumption forecasts, resource optimisation, blockchain integration for contracting, community federation / asset aggregation models, and social sciences research.

To achieve its goal, the GENTE consortium integrates emerging technology, cutting edge applied research, strong links to need owners, social science expertise and expertise on commercial exploitation of project outcomes. Partner expertise includes IoT platforms, artificial intelligence applications in energy systems, distributed ledger technology (DLT), advanced sensors, smart devices, modelling and optimisation in intelligent energy systems, and social sciences. Links to need owners are provided by partners Troya (community), CELL (municipality, energy community), and Alingsås Energi (DSO).

GENTE develops energy community-oriented optimisation solutions for the LEC, focusing on consumer demand, heat pumps, buildings, renewable energy sources (RES), electrical vehicles (EVs), and storage. The project creates cutting-edge generation and consumption forecasts based on data analytics, while implementing intelligent decentralised control schemes through advanced edge computing, without compromising data privacy and cybersecurity. Advanced data collection and analysis algorithms support solutions for optimal energy utilisation via IoT, edge and platform-based tools. GENTE scalable solutions facilitate orchestrated operation of assets within and across communities, based on a cross-functional IoT platform, identity management, edge computing and blockchain technologies, bringing intelligence to distributed physical assets.

GENTE deploys an advanced energy IoT platform for real-time monitoring and control of LECs as well as facilitating communication to grid operators' control systems (e.g., SCADA/DMS). The IoT platform acts as the backbone for developed integrated solutions, as it gathers high-quality data, incorporating forecasting algorithms, optimisation, and control strategies for LECs and associated services by LECs (e.g., peak load control by heat-pumps/buildings). The reliable bi-directional communication enhances systems' resilience, allowing users to manage all energy-related services, providing both an individual and collective view using a single account platform. Overall, end users' smart meters, the grid and smart contracts for automatic energy exchange and flexibility services are interconnected via the identity system that facilitates communications between end users and the grid.

GENTE formulates a decentralised monitoring and control system for LECs and their integration in larger scales, allowing the community manager to monitor or federate community assets, calculate the

available flexibility, determine the financial status, and to interact with community members and external actors. Then, the federation manager monitors the activity of the energy communities, interfacing with external markets as well as communities' assets. The developed algorithms will be tested in at least one of the three demonstration sites to identify the bottlenecks for a wider roll-out. Privacy and data security will be ensured through the governance models enabled by DLT.

1.3 Objectives

GENTE will create a toolkit for communities and community managers for resource optimisation and community federation, and to promote the creation of new communities through new business models and services.

To achieve these above goals, the following technical objectives (TOs) and non-technical objectives (NTOs) are defined within GENTE:

- **TO1** - Develop and demonstrate scalable technology for autonomous orchestration of electricity, heat and eMobility assets within and across communities (based on IoT, edge) bringing intelligence to distributed physical assets, considering data security, interoperability, and privacy.
- **TO2** - Develop and integrate modules for forecasting using edge-based processing, including developing/providing optimisation algorithms for distributed control as well as reduced models to inform model predictive control.
- **TO3** - Build the intelligent assets and forecasting into a DLT-based framework for identification and traceability of community energy resources, as well as digital identity management of the community members and the other stakeholders.
- **TO4** - Develop and demonstrate a community platform for decision making and resource control that will support secure and resilient energy systems.
- **NTO1** - Accelerate the economic viability of Local Energy Communities (LECs) through Community Federations and business models based on energy resource optimisation.
- **NTO2** - Accelerate the creation of LECs by proving the framework in Living Labs across Europe. Maximise energy efficiency and balance and increase the interactions with the energy market.
- **NTO3** - Promote engagement in LECs, and support the non-economic benefits of community energy, including self-governance, through innovative products and services.
- **NTO4** - Define and incorporate need owner requirements in platform design and replication toolkit.

Technical KPI's are defined in Table 1.

Table 1: GENTE Technical Key Performance Indicators (KPI)

#	KPI	Value	Measured by
1	New services to the DSO	2 new	Demonstrated in WP9
2	Community CO2 emissions reduction	Up to 30%	Calculated from measurements in WP9
3	User interaction with platform through living lab	200 users 2 communities	Measured in WP9 and shown in WP2
4	Improved community energy efficiency	Up to 30%	Demonstration in living labs/simulations

2 Description of facility

GENTE provides a good representation of LECs with six demonstrators at different scales in Sweden, Switzerland, and Turkey which can demonstrate solutions for new types of technologies and services in different technical, environmental and market contexts.

Demonstration sites include:

i) CELL Living Lab/Am Aawasser (Switzerland): A living lab with a “self-consumption community” that provides a test facility, equipped with PVs, EV charging, smart grid hardware-in-the-loop test lab, etc.; and which can be combined with the HSLU campus.

ii) Luzern Sued (Switzerland): An early-stage cross-community mixed site that comprises six urban areas around HSLU campus, which can be used to implement and evaluate co-design practices in a new energy community setting.

iii) HSB Living Lab (Sweden): A residential building on the premises of Chalmers campus equipped with PVs, batteries, heat pumps, EV chargers and other controllable resources (washing machines, dryers, etc.).

iv) Alingsås Energy grid (Sweden): A distribution network with increased installation of PVs and heat pumps with energy storage of heat.

v) Troya Cooperative (Turkey): A residential energy community equipped with large PV installations and heat pumps.

vi) Troya cooperative island energy community (Turkey): An energy community on an island that is suitable for the demonstration of federations of communities, which is under development and expected to be formally established in early 2023.

3 Procedures and methodology

GENTE’s consortium consists of a well-balanced composition of academic partners, SMEs (technology providers/developers) and large industrial partners (DSOs) with complementary competences and capabilities to deliver the project ambitions.

GENTE adopts a mission-based approach (Figure 1).

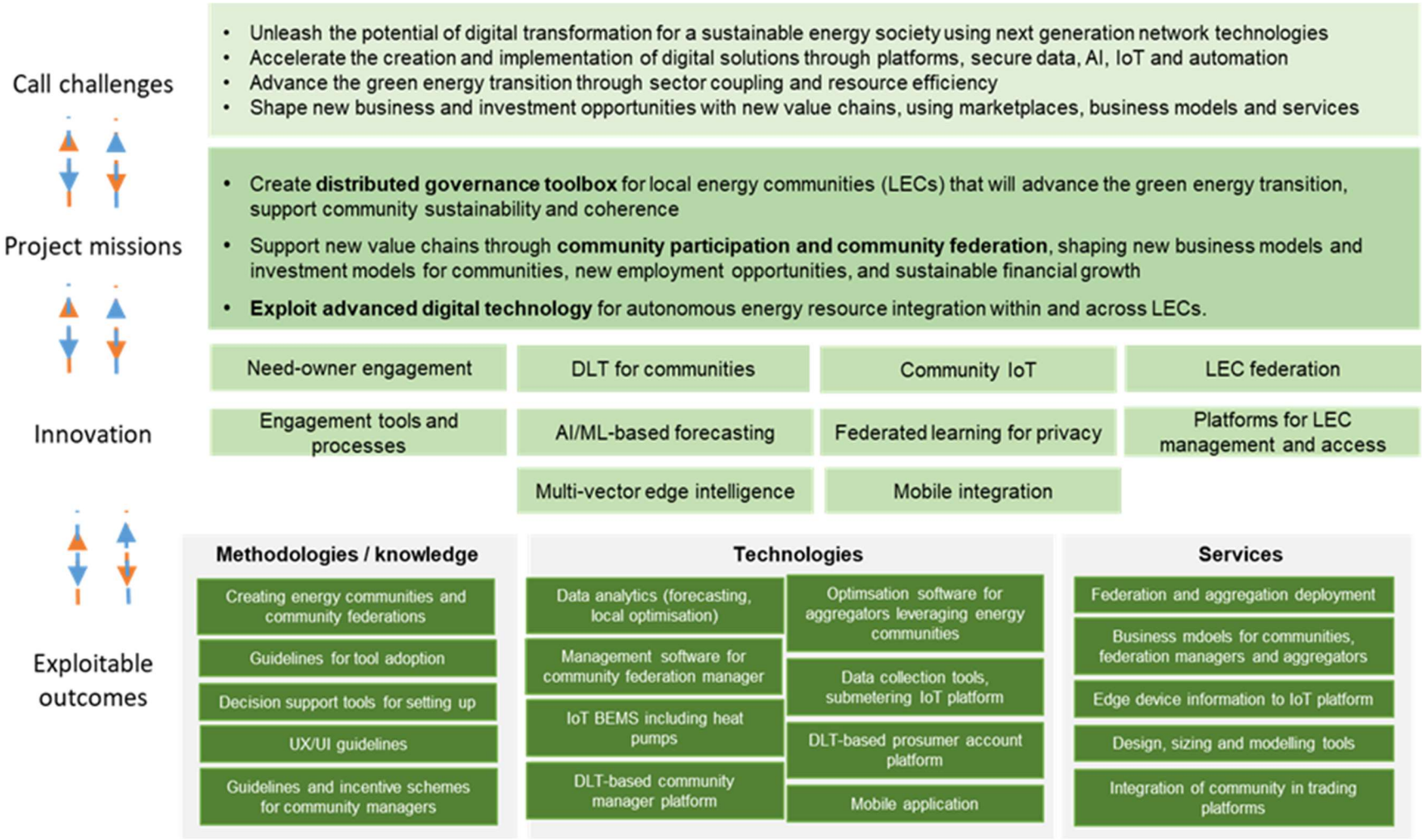


Figure 1: Mission-based approach (challenges, missions, innovation, and exploitable outcomes)

GENTE is organised along nine work packages, belonging to four broad categories: WPs 1-2 include project management and knowledge community building; WPs 3-4 deal with the specification of need owners and related use cases, as well as the behavioural studies to develop tailored business models targeting market uptake and scalability of the exploitable results of the project. WPs 5-8 will develop the technical framework, which is the backbone of the GENTE platform. This will include edge intelligence and data analytics (WP5), optimisation algorithms and services for LECs (WP6), aspects of cybersecurity and identity management and their bundling into a governance framework (WP7) and the coordination of all these parts within an IoT platform (WP8), which will then be deployed. The last, crucial work package focuses on the deployment of the developed system within living labs in different countries (WP9). The work package structure is shown in Figure 2. At a high level, partners are responsible for scope as follows:

- Lucerne University of Applied Sciences (HSLU) provides competences in LEC, IoT, AI, edge, resource optimisation, and federated analytics. In addition, the Institute of Sociocultural Development brings expertise in evaluation of community development processes, engagement and adoption in energy and social science data analysis. CELL, Luzern Sued and Am Aawasser are demonstrators.
- Chalmers University of Technology (Chalmers) develops a building energy management system from previous projects within communities for energy optimisation and provision of flexibility to DSOs. HSB Living Lab is a demonstrator.
- ES Systems AB, part of Energy Save Group (ES) contributes with development and control of heat pumps, enabling integration into LEC and smart buildings. ES will demonstrate the functionality of heat-pump systems connected in the local energy community in Alingsås distribution network.
- Alingsås Energi Nät AB (AE) provides a demonstrator in Alingsås in Sweden to show how to develop a sustainable energy society through cooperation between the LEC and suppliers of heat pumps, energy storage and equipment for measurement, analysis, and control to achieve increased flexibilities, energy efficiency, and reduced CO_2.
- Prosume Solutions SL (PRO) provides solutions for DLT applications in the energy sector, develops cybersecurity and identity management modules and distributed governance tools, designs mobile-first apps for user-engagement and data monitoring, coordination, and deployment of data licensing methods, and integrates the solutions into demonstrators.
- R2M Solution Spain SL (R2M) contributes with development of AI algorithms for energy optimisation in the LEC, individual controls based on reduced models, digital twins for buildings and energy models to support predictive controls; definition of business models, commercial exploitation, and scalability for the market uptake of the GENTE solutions.
- SmartHelio (SH) provides IoT-based sensors for DER and conducts AI-enabled data analysis which can predict losses to optimise resources and improve energy forecasts.
- REENGEN (REE) develops a cloud-based Energy IoT Platform with Platform-as-a-Service data analytics solution for integration of distributed assets, data sources and stakeholders.
- Troya Renewable Energy Cooperative (Troya) is a member of Rescoop.eu and leader of Turkey's Energy Cooperative network. Troya provides a demonstrator which will test GENTE's solutions in communities.

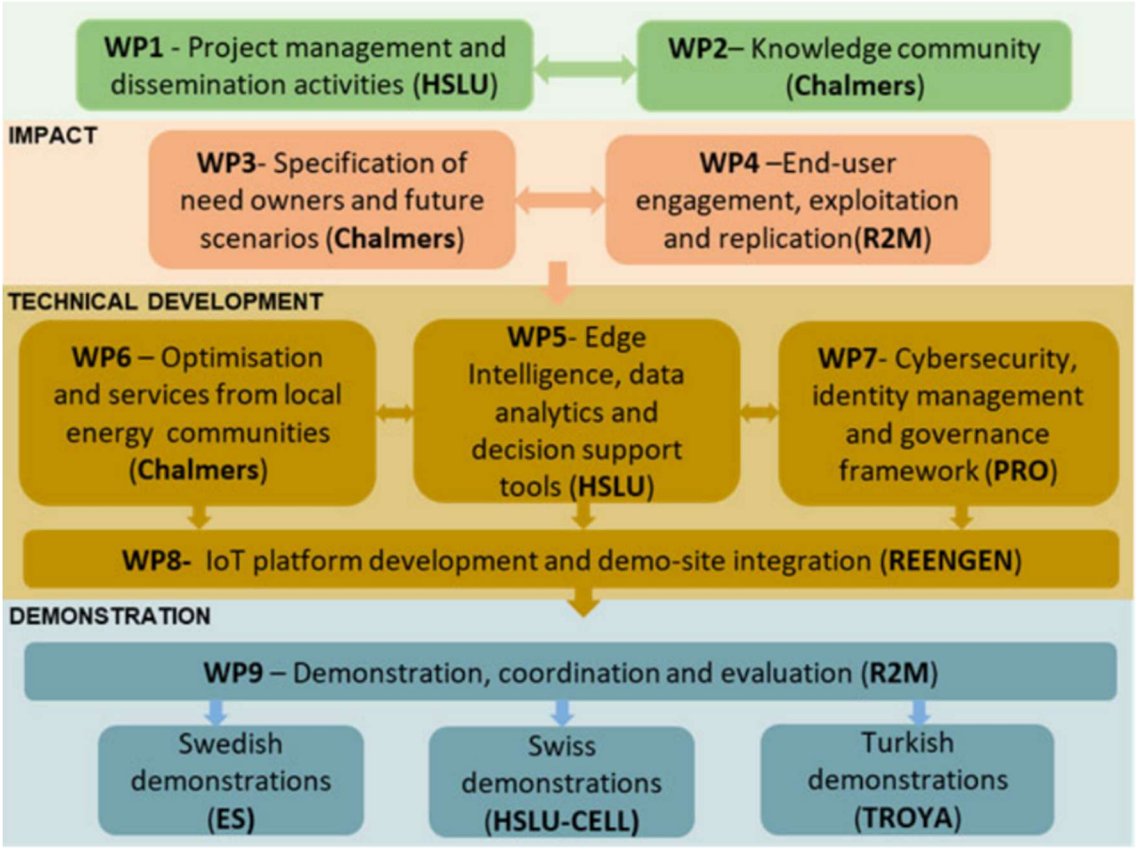


Figure 2: GENTE work package structure

GENTE uses a multi-disciplinary approach for collaborative innovation, integrating research domains in several fields:

i) social sciences to map the needs and values of need-owners and to develop new business models.
ii) in smart grid technologies to develop energy optimisation in energy communities and development of IoT based energy community governance toolkit, including energy resource management and distributed ledger technologies; and
iii) in data sciences, AI methods for advanced forecasting, edge intelligence as an enabler for energy management and optimisation)

to push forward the practical implementation of energy communities.

GENTE solutions are first being developed by the academic partners and technology developers in the project. For co-creation and involvement, needs and preferences of end-users and other stakeholders will be identified using a combination of survey, interview, and experimental methods. The solutions will be validated first at the living lab levels, then at real full-scale environments to increase TRL levels of solutions. Once solutions have been validated, business models can be developed, and replicability and scale-up plans can be made to bring the solutions to the market.

4 Activities and results

4.1 Overview of finished deliverables

GENTE started on 01 June 2022 and is about halfway through the planned project duration. During this period, the consortium has completed several deliverables. A summary of work completed to date or just being finalized after review is provided in Table 2.

Table 2: Overview of completed deliverables or just being finalized after review.

Deliverable	Task
1.1	Project Handbook
1.2	Communication, dissemination, and exploitation strategy
2.1	Annual reporting
2.3	Annual project event
3.3	Definition of highly applicable use cases
4.1	Identification of user types and organizational models
4.3	Market and stakeholder analysis with evaluation and exploitation roadmap
6.1	Advanced load and generation forecast
7.1	Guidelines and requirements, initial set of smart rules and related ontology
9.1	Test cases, assessment framework and KPIs

4.2 Project Management (WP1)

During the reporting period the Project Handbook (D1.1 & D1.2) was finished. This document contains the project quality management approach, the risk management plan, the data management plan, and the communication and dissemination plan for GENTE project. The Project Handbook was drafted and finalised by HSLU and approved by Chalmers.

4.3 Knowledge community (WP2)

The annual report (D2.1), in this case reporting period 2022, for ERA-NET has been submitted. The purpose of this report is to show project progress. Further, the report will allow for support to the project by giving feedback and to derive content for the knowledge community. Additionally, the information will be used to assess the impact of the ERA-Net SES initiative as a whole.

Additionally, for this reporting period, two annual internal project events (D2.3) were organised: one hybrid consortium meeting in Switzerland in February 2023 where participants could join online or visit in person, and another meeting was held online in June 2023. The GENTE team also ran a public workshop at the Sustainable Places 2023 conference in June 2023. A recording of the workshop is available.[1]

[1] https://www.sustainableplaces.eu/previous/sp2023/sp2023-workshops-events/energy-communities-for-the-energy-transition-era-net-gente-special-session/

4.4 Specification of future regional scenarios for local systems with high renewables (WP3)

The Deliverable “Definition of highly applicable use cases” (D3.3) was finished in this report period. The document presents seven different use cases as the main outcome. The use cases are crucial to the development of an effective and useful toolkit during the project. The main use cases to be validated are:

- grid flexibility provision through self-consumption optimization or peak load management,
- community CO_2 emissions reduction,
- energy efficiency improvement based on energy cost reduction and autarky increase,
- community federation,
- and the co-design process for energy communities.

The use cases are characterized by their connections and involvement to technical and non-technical main objectives in the project and by the need owners in charge of developing, promoting and, at the same time, affected by the application of the use cases. Additionally, the use cases are further divided into exploitable results that derive from or are achieved through the fulfilment of the set objectives. Finally, future paths carved through necessities, legislation or main objectives are condensed into six different future scenarios and four different archetypes that fully encompass the development environment for energy communities.

The document also presents the interactions between use cases and the characterization of the elements and context required to implement them, as well as their importance in the environment of energy communities’ development and future paths.

4.5 End user engagement, exploitation, and replication (WP4)

For WP4, the report “Identification of user types and organizational models” (D4.1) has been written and is under review. It includes a definition of energy communities, and a set of dimensions for describing energy communities. For the purposes of GENTE, the relevant meanings of “community” are identified as community by technology, community of place and community of interest. The energy communities GENTE targets and wants to promote will generally fit simultaneously in all three categories.

The report also lays down mandatory characteristics which an energy community within the scope of GENTE will fulfil. For GENTE, an energy community which fulfils these characteristics is an energy project (1) involving energy consumers and/or prosumers who share renewable energy generation units, (2) who live in a shared place or have a shared interest, and (3) have some level of control over or participation in the project. Energy communities will also be connected to the public grid, organized as a legal entity and have only “smaller actors” as members.

The report also defines four archetypes (and four sub-variants). These are intended to provide an illustrative set of types of energy community to facilitate discussion within the project and help align technology development. The main archetypes are: (1) Community-led local optimization communities, focused on local optimization and with a single connection to the grid (2) Virtual community-led local optimization communities, with a virtual connection type, (3) Business-led service-focused communities, with a single connection to the grid, and (4) Virtual business-led service-focused communities.

The report further summarizes insights on organisational models adopted by energy communities, end user engagement and roles, motivations of end users and their socio-economic profiles.

A second deliverable “Market and stakeholder analysis with evaluation and exploitation roadmap” (D4.3) has been written and is under review. The aim of this report is to give a first overview of the results that can potentially be achieved and consequently exploited during the duration of the project. It mainly includes technical know-how and technological products and services, therefore Intellectual Property Rights have to be carefully considered in subsequent phases of the analysis. 17 exploitable results have been identified, analysed with the help of the responsible partners and categorised on a dedicated exploration board, helpful for understanding the current level of development of each result and its possible exploitation strategy. This was done thanks to a dedicated methodology and a questionnaire sent to the partners to assess the wanted results from GENTE. This initial analysis serves as a first contact point between R2M and the results owners, and for understanding the project interest for exploitation and potential exploitation strategies to apply in the future.

4.6 Optimization and services from local energy communities (WP6)

The document “Advanced load and generation forecast” (D6.1) was finished by Chalmers. In this report, advanced forecasting algorithms for both the Electricity Load, PV generation and Heat demand of the local energy communities (LECs) are described. The expected building energy management system for the LECs resources optimization would leverage this short term forecast for the management of all energy-related services. Accordingly, advanced AI based forecast algorithms with two different time steps of 1-hour ahead with 10-minutes resolution and 24-hours ahead with 15-minutes resolution are provided for the prediction of the PV generation, building loads and heat demands of the LEC demonstrated using HSB Living Lab (HSBLL) at Chalmers University of Technology Sweden. In principle, observed weather conditions and historical data (outputs of PV, electricity, and heat loads), from previous hours were used to forecast for an hour and 24-hours ahead.

Developing the machine learning models for the prediction of stochastic entities such as load demand and PV production requires historical data for a period to provide trends and patterns. The measurement data for this project is collected from Chalmers HSBLL building, while weather related data are retrieved from a Numerical Weather Prediction (NWP) model. For each forecasting algorithm tested based on the stated data, an individual forecasting method and performance optimization concept applied for the prediction is presented. The forecast for short term and very short term (1-hour ahead with 10 minutes resolution) are based on Long Short-Term Memory (LSTM) architecture, while the 24-hours ahead with 15 minutes resolution is on Gated Recurrent Unit (GRU) and ConvLSTM – a combination of convolutional neural networks and LSTM.

4.7 Cybersecurity, identity management and governance framework (WP7)

The deliverable “Guidelines and requirements, initial set of smart rules and related ontology” (D7.1) was finished by PROSUME and gives guidelines and requirements about Distributed Ledger Technology, guarantee of determinism and modularity and interoperability of privacy-aware software modules developed within GENTE. Further, privacy-by-design system architecture, GENTE related ontology and smart rules for personal data sharing are discussed in the report.

4.8 Demonstration, coordination, and evaluation (WP9)

WP9 includes the report “Test cases, assessment framework and KPIs” (D9.1). This report develops a detailed description of the test cases in the GENTE pilot projects and presents the assessment framework and key performance indicators for the validation of the GENTE tools.

The solutions developed within GENTE for the governance of LECs are first validated at the lab levels, and then in real full-scale environments to increase the technology readiness level (TRL) levels of solutions. For that, GENTE project elements are tested in several pilots with diverse characteristics. This variety of pilots, from labs to real environments, provides a good representation of LECs. In total, GENTE has 6 demonstrators at different scales in Sweden, Switzerland, and Turkey which can demonstrate solutions for new types of technologies and services in different technical, environmental and market contexts.

The main use cases to be validated are grid flexibility provision through the self-consumption optimisation or peak load management, community CO_2 emissions reduction, energy efficiency improvement based on the energy cost reduction and autarky increase, community federation, and the co-design process for energy communities.

Within the deliverable, for each site, the functional performance tests to verify the communication and operation of GENTE components are described. Tests for the evaluation of the accuracy of forecasting algorithms are also included. Then, all the test cases are described in detail, including the KPIs that will be calculated in each, the baseline that will be used to estimate the savings in the cases is required, and the prerequisites for each test. In addition to the test cases at each pilot, some test cases for energy federation assessment are included.

Finally, a detailed list of all the Key Performance Indicators (KPIs) that are used for project validation and assessment is defined, and the calculation methodology that will be applied is explained.

5 Evaluation of results to date

This section shows the provisional status of the work carried out during this reporting period. This status is shown by the completeness of project milestones, finished and published deliverables on the project website and a more detailed list with a short description of the deliverables contributed by HSLU.

5.1 GENTE Milestones

GENTE has made progress in delivering its scope during the reporting period in relation to the project milestones. The table below show milestones to be completed during this reporting period. However, due to numerous difficulties at the start of the project (see Chapter 6), these milestones have not yet been fully achieved as planned.

Table 3: Milestones to be achieved during this reporting period

Milestone # and Name		M	Completeness
5.1	Research complete - clear solution proposed for sub-metering device	10	90%
3.1	Identification of relevant need owners completed	12	50%
5.2	Device hardware and software functional prototype available for field testing	15	75%
6.1	Advanced BEMS operational	15	80%
5.3	Digital twin integration of data from functional prototype edge device	18	20%
8.1	IoT-platform operational and integrated in all demonstration sites	18	40%
9.1	GENTE solutions deployed in all living labs	19	30%

5.2 Resources on Website

All completed deliverables are listed in Table 2. These deliverables have different levels of confidentiality. Deliverables with confidentiality level “public” are available on the GENTE website under: https://genteproject.com/resources/

These are:

Table 4: Resources published on the GENTE website

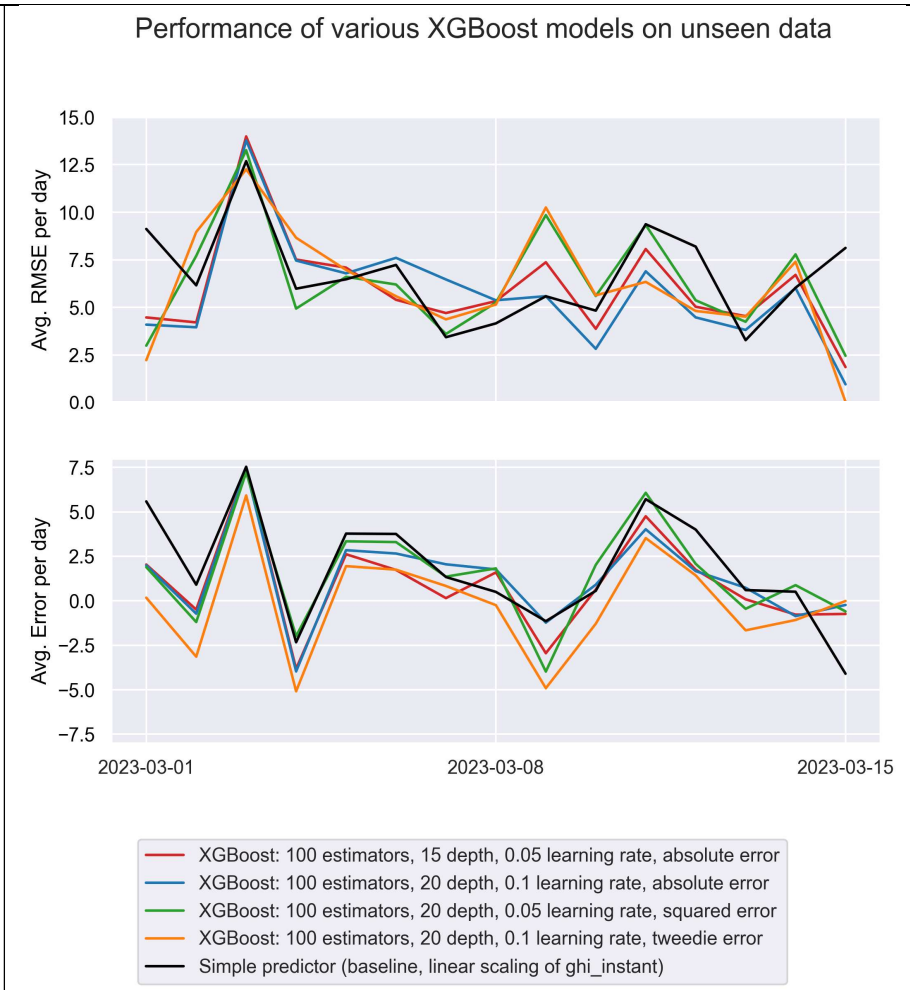
Resources	Published
D9.1 - Test Cases Assessment Framework and KPIs	March 2023
D7.1 - Guidelines and requirements, initial set of smart rules and related ontology	November 2022
GENTE Interim Report (Swiss Federal Office of Energy)	November 2022
D1.2 Project Handbook	September 2022
GENTE Project Factsheet	August 2022

5.3 HSLU Work

This section shows the work that HSLU has contributed during this reporting period. For each deliverable, a brief description of the main tasks, the amount HSLU contributed and the completeness of each deliverable is provided.

Del.	Description Part HSLU	Part HSLU	Complete - ness
D3.1	In depth review and analysis of scientific literature for future scenarios of LECs. - The report will present the results of a qualitative literature-based review of the historical developments of energy communities and projections of energy community (EC) growth in Europe. - Through a narrative of EC growth, decline, and the enabling of the next growth phase, EC’s evolution into the future is discussed. - Six future energy community scenarios are developed and presented based on the enabling factors identified in the research. - A comment on which scenarios are most likely for each of the GENTE partner countries will be made. - A mapping of the scenarios to the energy community archetypes identified in D4.1 will be made.	100%	75%
D4.1	Writing, Distribution and Analysis of Surveys for End User Engagement at am Aawasser. In-depth literature review and analysis of scientific literature on the definitions and characteristics of LEC focusing on organizational models, motivations, engagement and the socio-economic profile of end users, resulting in a comprehensive definition including a set of dimensions for describing energy communities tailored to the project's context scope of this project.	100%	95%

D4.2	Development, Implementation and Assessment of a Co-Design Process in a potential Energy Community to develop 1-3 Energy Community Models which could be pursued further. - Research on Co-Design Processes - Preparation and Implementation of Participatory Workshops in close Interaction with Site Owners, DSOs, End Users and Municipalities - Assessment of the Process	100%	25%
D5.2	Research into development of short-term solar forecasting models leveraging edge intelligence. Using meteorological forecasts and past solar panel output data to predict future outputs as accurately as possible. - Research shows that a simple model (Gradient descent based) with limited input variables performs as well as more complex models (such as XGBoost). - Model accuracy is heavily correlated to accuracy of meteorological forecast. - Past solar panel output data is heavily correlated to global horizontal irradiation forecast data, as such using past data is not beneficial to the model. - More complex models are prone to perform worse or be severely overfit. - As one of the best-performing models is a simple scaling of data pulled from online with no local data, running it on an edge-device is neither necessary nor has any advantages. - Nevertheless, a proof-of-concept showing that meteorological forecast data pulled from the internet could be processed and output in some way on an edge device has been implemented. - Complex models could also theoretically be ported to run on edge (XGBoost -> treelite/tl2cgen), would require compression and quantization, limiting the depth of the model. - A report describing the steps taken and the findings of the research has been written. - Shown below is the performance of various models on unseen data, illustrating that more complex models do not achieve better predictions due to the predictions being based on meteorological data, which itself is a very complex model.	100%	80%

	 Figure 3: Performance of various XGBoost models on unseen data		
D6.1	Development and Implementation of Production and Consumption Forecasting Models: - Research of forecasting architectures for both production and consumption forecasts - Implementation of forecasting methods - Optimisation of forecasting methods - Comparison of model training methods - Testing of training methods on Swiss testing site data	33%	100%
D6.2	Interfacing with existing BEMS on Swiss testing site: - Implement data logging - Implement site controlling tool	100%	85%
D6.3	Development of Energy Optimization tool for Swiss testing site: - Implement energy optimisation tool - Adjust tool for Swiss testing site	33%	35%

	- Testing of energy optimisation in simulation		
D8.1	Specification of IoT Platform: - In the context of the GENTE platform services and functions, the Local Energy Community (LEC) optimisation and control is described, specifically the workflow between the data sources, the forecaster, the optimiser and the setpoints of the controllers. The functions are defined according to the asset types considered: grid, producers (generation), storage, consumers and heat nodes. - A description of grid services is provided, these are: grid capacity management and congestion management. - The Swiss demonstration site is described, including the regulatory context, legal framework, and requirements. - The conceptual data model of the LEC optimization and control is provided. This model is an abstract overview of the optimisation platform that show how the historic data, forecasted data and smart contracts interact with the LEC optimisation platform. - The logical data model of the LEC optimisation and control includes more details of the parameters and inequalities that describe and limit the system, and a description of the optimisation objective. - The variations of the logical data model for the Swiss demonstration sites is described. The main two differences are that the Reengen Gateway cannot be used as there is a pre-existing solution for data acquisition at the demonstration site; the other difference is that the smart contracting module cannot be applied, as there is no DSO at this site.	33%	90%
D9.1	Definition of criteria to measure site performance: - Specific tests cases for Swiss demo site Am Aawasser - Assessment framework - Definition of site specific KPIs	33%	100%
D9.2	Implementation for Swiss Testing Site: - Database on Azure Server - Automated Loging of BEMS Values to Database - Demand Forecasting Algorithms - Production Forecasting Algorithms - Energy Optimisation Algorithm - Communication Protocol with on Site Hardware	33%	35%

6 Next steps

As the previous two chapters show, important progress has been made on the deliverables. Unfortunately, there were also obstacles which lead to delay in delivering project work, namely:

- 11 months delay to Turkish funding.
- Reduction in Turkish funding volume due to inflation.
- 9 months delay in recruitment of the researcher at Chalmers.
- 1 month delay to Spanish funding.

Moreover, there were also obstacles which were previously identified as project risks:

- Delay in demo/pilot site development in Turkey and Sweden.
- Platform integration causes difficulties and delays in gaining data and applying algorithms.
- Quality of data from demo/pilot sites.
- There was a change of research associates in the project team. It was necessary to recruit new team members.

Those difficulties had effect on various tasks. Since tasks are highly interconnected and depend on each other, various tasks were affected too by these obstacles. Therefore, a project extension will be requested for all partners.

Spain and Turkey will progress a 6-month cost-neutral extension, concluding in 2024. Switzerland and Sweden will progress a 9-month cost-neutral extension, concluding in 2025. This will lead to the following new due dates:

Table 5: New due dates for deliverables

Deliverable and Description		Owner	due date	new due date
D1.3	Replication packaging kit	HSLU	15/04/2024	15/01/2025
D2.2	Final reporting	CHALMERS	30/05/2024	28/02/2025
D2.4	Final joint call event	CHALMERS	30/05/2024	28/02/2025
D2.5	Abstract of the main results	CHALMERS	30/05/2024	28/02/2025
D3.1	Future scenarios of local energy systems with increased renewable share	HSLU	23/12/2022	23/09/2023
D3.2	Specification of relevant need owners	CHALMERS	15/06/2023	15/03/2024
D4.2	End-user engagement and community benefits based on survey and interview data	HSLU	01/09/2023	01/06/2024
D4.4	GENTE's One-Stop-Shop as a Mobile-First app	PROSUME	15/12/2023	15/06/2024
D4.5	Business models for GENTE solutions with replicability and scalability evaluation	R2M	30/05/2024	30/11/2024
D5.1	Adaptable sub-metering device for intelligent community energy resources	SmartHelio	15/09/2023	15/03/2024
D5.2	Edge-based DER forecasting and diagnostic algorithm, incl. privacy-preserving learning	HSLU	15/09/2023	15/06/2024
D5.3	Community digital twin	R2M	15/02/2024	15/08/2024
D6.2	Advanced BEMS for "Building control as a service"	CHALMERS	15/09/2023	15/06/2024
D6.3	Optimal LEC operation based on smart BEMS	CHALMERS	15/02/2024	15/11/2024

D6.4	Grid support services from LEC to system operators	CHALMERS	30/05/2024	28/02/2025
D7.2	Validation of DLT and GDPR compliance legal rules	PROSUME	15/05/2023	15/11/2023
D7.3	Data privacy and Smart Language ABC. Helpdesk & Support Toolkit	PROSUME	30/05/2024	30/11/2024
D8.1	Definition of system architecture and specification of functional requirements	REENGEN	15/03/2023	15/09/2023
D8.2	Development of GENTE cross functional platform	REENGEN	15/09/2023	15/03/2024
D8.3	IoT platform design, test, and integration in the demonstration sites	REENGEN	15/02/2024	15/08/2024
D9.2	Summary of demo-case requirements, scenarios, solutions and evaluation for each site	HSLU	15/02/2024	15/11/2024
D9.3	Assessment of demonstration, identification and lessons learned/best practices for replication	R2M	30/05/2024	30/11/2024

7 National and international cooperation

During the reporting period, partners met face to face for an international meeting hosted in Switzerland (01.02.2023), had a consortium-wide plenary session online (13.06.2023), and continue to meet at least monthly during regular, planned work package leader meetings. Bi-lateral discussions take place regularly between partners to progress individual tasks.

ERA-Net mandates participation in EXPERA (Knowledge Exchange) activities and the completion of project communication and dissemination tasks. An update on the communication and dissemination KPIs as relating to this reporting period are given in Table 6 with specific task updates given below.

Table 6: Communication & Dissemination KPIs

KPI as defined in proposal	**Metric to be measured**	**Status**
KPI 1 - Website and social media.	Website visits in year 1: 1'000 50% annual increase in visits/year	Year 1 (01.06.2022 – 31.05.2023): 1'212 page views Year 2 (partial. 01.06.2023 – 14.11.2023): 479 page views
	Social media accounts will be active with at least 400 followers, 100 retweets, and 50 comments by the end of the project	LinkedIn (to date): 9 Posts 56 Followers 11 Reposts 65 Reactions 2 Comments
KPI 2 - Conferences and publications.	The project will successfully submit at least 6 publications in peer-reviewed journals and will organise 1 public conference per year.	1 publication to date. (see *Section 9: Publications*) GENTE organized and ran a workshop at the Sustainable Places 2023 conference[2]. A recording is available[3].
KPI 3 - Newsletters, technical factsheets, press releases, leaflets, and brochures.	Technical factsheets will be produced for each demonstration and available on the website, updated every 6 months. 4 issues of the newsletter will be released, with 500 subscribers by the end of the project, and 3 articles per year in third party newsletters. Dedicated press releases will be provided every 6 months. Digital media will comprise at least 1 Leaflet, 2 project brochures, 1 project video and further content on a project YouTube channel, with at least 12 presentations spanning the project lifetime.	Factsheets in progress. 17 newsletter subscribers. No newsletters released to date. 1 project video released[4].

[2] https://www.sustainableplaces.eu/previous/sp2023/

[3] https://www.sustainableplaces.eu/previous/sp2023/sp2023-workshops-events/energy-communities-for-the-energy-transition-era-net-gente-special-session/

[4] https://youtu.be/Z7AHU_ysRpA?si=_UNuzWlyvUtM0EJi

KPI 4 - Equality, diversity, and inclusivity.	2 special features per year, targeting equality and diversity. 1 targeted speaking slot per year promoting the achievements of under-represented groups within the GENTE consortium.	No updates.

Regarding Phase 2 (M4 - M12) of the communication and dissemination plan, the following tasks were undertaken:

- The website[5] was updated with completed deliverables (public access) and project news.
- Project news and updates were shared on LinkedIn in nine separate posts throughout 2023, leading to 11 reposts and 36 new followers.
- The GENTE team ran a workshop at the Sustainable Places 2023[6] conference in June 2023. A recording of the workshop is available[7].
- Chalmers published a paper in the IEEE on their work in GENTE. See *Section 9: Publications* for details.
- Two videos were created during the reporting period: (1) an introduction to the GENTE project which can be viewed on the GENTE YouTube channel[8], and (2) a video about the GENTE demo site Am Aawasser (Buochs, CH) which was shown at the *Abend der Wirtschaft 2023* event held at Hochschule Luzern[9].

The following communication and dissemination task for Phase 2 was not completed in this reporting period due to priority deliverable tasks taking precedence.

- Newsletter: Distribute updates to registered parties and partners and social media

8 Communication

This section only applies to flagship projects and so has not been completed.

9 Publications

During the reporting period Chalmers published the following paper “A novel energy management system for optimal energy and flexibility scheduling of residential buildings: a case study in HSB Living Lab” at the 2023 IEEE Asia Meeting on Environment and Electrical Engineering (EEE-AM). The publication can be accessed under the following link: https://research.chalmers.se/publication/538024

[5] https://genteproject.com/
[6] https://www.sustainableplaces.eu/previous/sp2023/
[7] https://www.sustainableplaces.eu/previous/sp2023/sp2023-workshops-events/energy-communities-for-the-energy-transition-era-net-gente-special-session/
[8] https://www.youtube.com/watch?v=Z7AHU_ysRpA
[9] https://www.hslu.ch/de-ch/technik-architektur/forschung/veranstaltungen/abend-der-wirtschaft/abend-der-wirtschaft-2023/

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[3] ‘Energy research Masterplan of the Federal Government 2021–2024’, Federal Energy Research Commission CORE, Bern, Sep. 2020. [Online]. Available: https://www.bfe.admin.ch/bfe/en/home/forschung-und-cleantech/forschung-und-cleantech1.exturl.html/aHR0cHM6Ly9wdWJkYi5iZmUuYWRtaW4uY2gvZW4vcHVibGljYX/Rpb24vZG93bmxvYWQvMTAzMjg=.html

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[6] G. G. Kim *et al.*, ‘Prediction Model for PV Performance With Correlation Analysis of Environmental Variables’, *IEEE J. Photovolt.*, vol. 9, no. 3, pp. 832–841, May 2019, doi: 10.1109/JPHOTOV.2019.2898521.