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Project Deliverable Report

D1.3

Pilot specific demonstration scenarios

HESTIA Holistic dEmand response Services for European residenTIAl communities has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957823

Technical references

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PU Public

PP Restricted to other programme participants (including the Commission Services)

R Restricted to a group specified by the consortium (including the Commission Services)

CO Confidential, only for members of the consortium (including the Commission Services)

Version	Date	Authors	Beneficiary
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DISCLAIMER

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EXECUTIVE SUMMARY

This document is the deliverable **D1.3** "Pilot specific demonstration scenarios" of the European project HESTIA (Holistic dEmand response Services for European residenTIal communities), and results from **Task 1.3: Follow-up specification of demonstration scenarios at pilot sites (M1-M6).**

The main objective of this task is to discover suitable demonstration scenarios for each pilot site in terms of adequate Demande Reponse (DR) strategies to exploit the consumer engagement potential and underlying energy-efficiency. The aim is also to identify the specific energy loads which could be affected by the HESTIA DR solutions and the manual or automated control strategies that can be applied at the individual and community level. One strong requirement that underlies the definition of the use cases is to propose applications with enough leeway for a co-construction with the recruited participants within the participatory design strategy of WP2.

First, common goals and shared objectives were defined for the three pilot sites of the HESTIA project (Berchidda in Italy, Camille Claudel in France, Voorhout village in the Netherlands). These common goals are focused on: the creation of energy communities; improving the use of renewable energy by shifting energy use; lowering maximum energy consumption; fostering responsible consumption by means of energy consumption explanation and visualisation; achieve community-level optimisation; improved water management; optimal use of energy storage; and the use of transparent and certified data. Depending on the local constraints and goals, each pilot aims to develop a specific implementation of these applications.

Then, specific Use Cases were built based on the local constraints and opportunities of each pilot site:

- The Berchidda pilot site is focused on the optimal use of local photovoltaic energy within a local energy community, promoting self-consumption as well as energy exchange, buying or selling among citizens, supported by certified and transparent use of energy consumption and PV generation metering data. The twomain Use Cases revolve around the shifting of appliance use at favourable moments in order to maximise the use of PV energy, and the optimal use of energy storage for creating additional flexibility and improving the operation and longevity of these appliances. In both cases, this is applied within an energy community for encouraging community trading and collective maximisation of renewable consumption in case of energy excess from the PV production.
- The Camille Claudel pilot site use cases are focused on the joint improvement of heat and electricity consumptions. The specificity of this pilot site is that all consumers are connected to a biomass and gas-basedheating network for space heating and DHW. In addition, the future development of renewable electricity on the territory such as PV panels will also bring opportunities to consume locally produced electricity and to decrease the amount of electricity needed from the grid. To anticipate and accompany these changes, the Camille Claudel Use Cases propose to study the combined use of heat and electricity in order to: reduce the energy consumption from the heating network and shave off consumption peaks at the community level; shifting electricity uses to favourable moments for anticipating the development of renewable electricity.
- The Voorhout village pilot site is built around new, net positive buildings and efficient systems, associated with local PV production and electricity storage capabilities. The Voorhout village use cases are focused on the management of batteries to improve self-consumption at the individual level and within the community; the management/selling of energy production excesses inside or outside the district; and the possibility of offeringmarket flexibility through the use of individual and community batteries and other shiftable or controllable loads including electric vehicles. The Voorhout village use cases are therefore focused on the management of batteries, while being able

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to reach to all types of shiftable loads.

The described use cases are used as inputs to several tasks of the project: to guide the definition of requirements regarding the needed data points (WP1 T1.4 *HESTIA platform design, requirements and KPI specificatio*n); as inputs to the participatory approach of WP2 T2.2 *Inclusive and participatory DR solution design processes* and WP2 T2.3 *Proof-of-concept for user-centred DR initiatives*; to identify requirements for the optimisation processes studied in the WP4 *ICT enabled cooperative demand response model*; as requirements for the needed metering equipment in WP5 T5.1 *Pilot site planning and deployment activities*; and for the definition of related business models in WP7 T7.6 *Products, services and supporting business model definition*.

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1. INTRODUCTION, OBJECTIVE AND STRUCTURE OF THE DELIVERABLE

This document is the deliverable D1.3 "Pilot specific demonstration scenarios" of the European project HESTIA (Holistic dEmand response Services for European residenTIal communities), and results from Task 1.3: Follow-up specification of demonstration scenarios at pilot sites (M1-M6). The demonstration scenarios are related to the 3 pilot sites of the HESTIA project described in D1.1 "*Pilot technical characterisation and regulatory framework analysis*":

- Berchidda in Italy
- Camille Claudel in France
- Voorhout village in the Netherlands

The main objective of this task is to discover suitable demonstration scenarios for each pilot site in terms of adequate Demande Reponse (DR) strategies to exploit the consumer engagement potential and underlying energy-efficiency. Theaim is also to identify the specific energy loads which could be affected by the HESTIA DR solutions and the manual or automated control strategies that can be applied at the individual and community level.

One strong requirement that underlies the definition of the use cases is to propose applications with enough leeway for a co-construction with the recruited participants within the participatory design strategy of WP2. The Use case propositions developed in T1.3 will therefore be used to prepare the background to share with the recruited participantsfor the co-construction process, and to feed all the HESTIA tasks that will develop and implement the necessary technologies (identification of data points to be measures, requirements for HESTIA analytical services, guide the installation of equipment in the recruited households, guide the definition of KPIs and success criteria).

This deliverable is composed of 5 sections:

- Section 1 : Introduction, objectives (this section)
- Section 2 : Approach for the Use Cases development (methodology and scope)
- Section 3 : Description of the Use Cases
- Section 4 : Common and specific traits and associated requirements
- Section 5 : Conclusion

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2. APPROACH FOR THE USE CASES DEVELOPMENT

In order to build suitable demonstration scenarios for each pilot site in terms of adequate DR strategy to exploit the consumer engagement potential, a participatory approach with all involved partners was carried out throughout task T1.3. Throughout this approach, the objective of the Use Case development has been to make propositions of Use Cases by the project partners from the point of view of energy experts, while allowing for the necessary leeway that the projectwill need in the following tasks for:

- involving consumers for challenging these solutions,
- co-constructing solutions with them,
- adapting the solutions to household practices – practices that will be analysed at each pilot site through HESTIAWP2 (Participatory design and consumer engagement process) and the Digital Twin approach of HESTIA WP3 (Consumer Digital Twin and non-intrusive analytics).

The development of the Use cases was divided into 3 phases: an initial storytelling propositions from the pilot partners, followed by an asynchronous feedback phase from all HESTIA partners, and concluded with a convergence workshop and formalisation phase.

In the first phase, the pilot site leaders (Italy: GRB/AXPO, France: EDF/CPS, Netherlands: i.LECO/4YEF) generated the initial inputs to the Use Case construction, based on their knowledge of the pilots and their past experience in consumerand grid flexibility related projects. In this ideation phase, each preliminary Use Case proposition was described with the following simplified template:

General presentation	• Title • Scope • Objective • General narrative and household practices addressed
Pilot stakeholders and theirroles	• Actors roles, motivation & benefits, and inconveniences • Collectivity level • General prerequisites
Relationships between actors and workflow of exchanges	• In the form of a simplified business process diagram

Table 1: General template for use case ideation

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The first propositions were categorised into the following Propositions and benefits types:

Pilot	Main features of the pilot	Propositions and benefits
Berchidda	Older buildings, well equippedin PV generation	• Shifting the use of appliances (e.g., washing machines, dryers,DHW) to favourable times for consuming locally generated energy • Efficient use and increased longevity of appliances (always onversus on/off, battery charging strategies) • Combined water & energy management • Responsible consumption (explaining the current context and energy consumption, proposing actions to reduce consumptionand costs) • Data transparency (trusted data recording and sharing)
Camille Claudel	Connected to wood-fired heating network for heating &DHW, focused on thermal comfort at home New buildings to be built in the following years will have important impact on the current heating network	• Collective improvement of biomass consumption throughheating/DHW reduction, peak shaving and load shifting • Responsible consumption (explaining the current context and energy consumption, proposing actions to reduce consumptionand costs) • Impact of collective changes in practices for anticipating thedevelopment of local PV generation at the district scale
Voorhout village	Well equipped, new buildings,local PV generation, local batteries New buildings to be built in the following years will havePV but no batteries	• Optimal individual and collective self-consumption andassociated collective gains • Valorisation of energy excesses inside or outside the district • Mid/Long term energy storage

Table 2: Summary of Use case types

The convergence workshop aimed at delving into more detail and identifying more precisely the stakeholders and their motivators, the information and data flows, the consumer engagement means, as well as the specificities and differences between the pilot sites. The workshop was organised online using a virtual board system to encourage contribution from all the HESTIA partners. It was separated in 5 sessions:

1) **Stakeholders and information flows.** The objective of this session was to collaboratively build upon the initialpropositions to clarify and position the stakeholders and HESTIA services, and to shape the information and data flows between the stakeholders and services within the Use Case temporal process.

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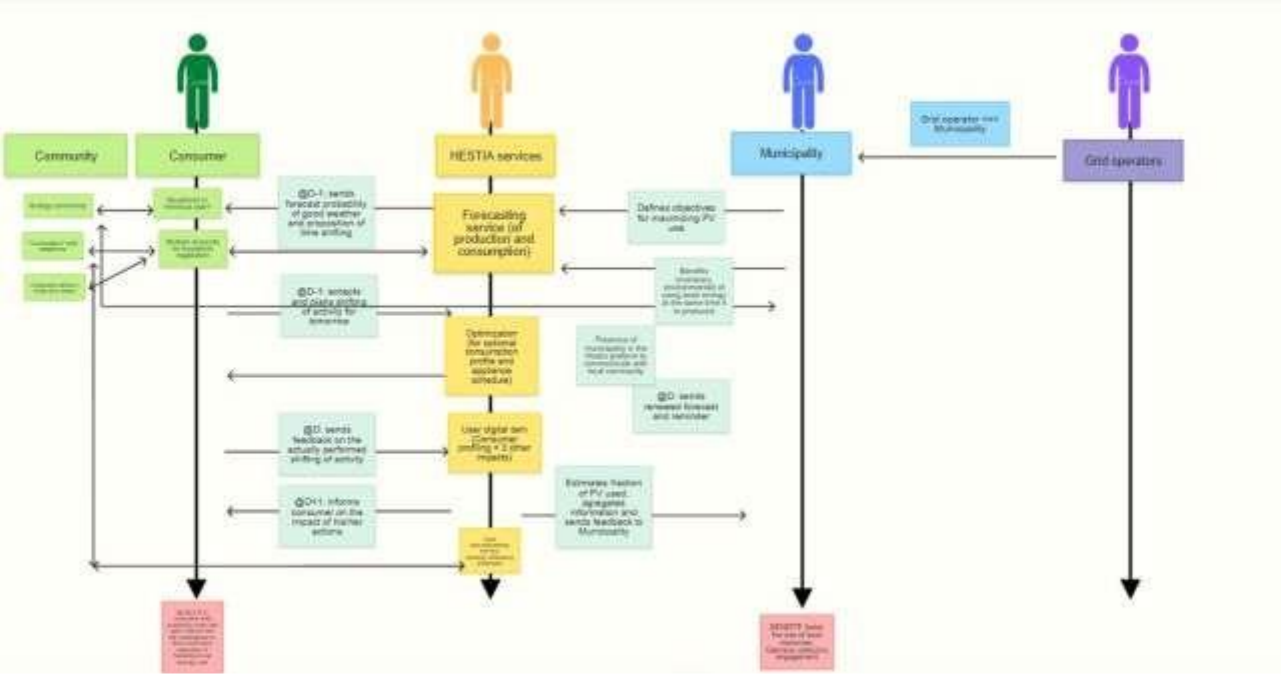

Figure 1: Illustration of the work board for defining stakeholders' relationships and information flows

2) **User engagement and user journey.** The objective of this session was to collectively discuss actions that will be necessary for 1/ creating and 2/ maintaining user engagement over time. This session served as inputs for the WP2 work on the continuous user engagement process.
3) **Technology enablers and their position in the use cases.** The objective of this session was to locate the HESTIAanalytical services and technologies on the developed diagrams, to identify at which point of the process theseservices or technologies will be activated to support the Use case
4) **Common and specific traits of the developed use cases.** The objective of this session was to identify the specificities and the common traits of all Use Cases, as an input to Task T1.4 HESTIA platform requirements for identifying required data types, required services, data processing or communication constraints.

The initial propositions were regrouped and summarized in order to facilitate their development during the workshop,as shown in Table 3.

T

Berchidda	**Shifting the use or programming of appliances** (e.g., washing machines, dryers, DHW, garden irrigation) to favourable time for consuming locally generated energy
	Optimal energy storage for flexible use and longevity of appliances (battery charging strategies, boiler always on v. on/off, etc.)
Camille Claudel	**Shifting heating and DHW use** to shave consumption peaks and collectively improve the share of wood of the heating network while maintaining comfort
	Shifting the use of other electrical appliances for reducing the electricity peak consumption at favourable moments with **simulated RE production**
Voorhout village	**Optimal individual and collective self-consumption ;** managing **energy excesses** inside or outside the district for improved collective gains
	Optimal individual and community energy storage for developing community-scale flexibility

Table 3: Synthetic Use Cases studied during the convergence workshop

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3. DESCRIPTION OF THE DEFINED HESTIA USE CASE PROPOSITIONS

This section describes the applications and Use Cases that were defined during the Use Case ideation process.

3.1 Common goals and shared applications across the pilot sites

The summary and formalisation of the initial proposition led to the identification of 8 shared goals to be applied and tested during the HESTIA project. Depending on the local constraints and goals, each pilot aims to develop a specific implementation of these applications. These common applications are described in Table 4:

Creating an energy community	The aim is to foster the creation of energy communities for promoting the exchange of information and best practices, in order to facilitate the development of sustainable habits at the community scale. The success of this application will be estimated from the effective existence of a community based around the HESTIA use cases, and its sustainability over time.
Improving the use of renewable energy by shifting energy use	The aim is to improve the use of locally produced renewable energy by adapting practices to the availability of local resources. The Berchidda and Voorhout Pilot Sites are focused on the optimal use of currently installed photovoltaic panels. The Camille Claudel Pilot Site is focused on the optimal use of wood for heating and hot water coming from the biomass-fuelled heat plants (instead of natural gas), and the anticipation of future local PV generation and the development of electricity uses. Considering the production of renewable power in a certain time frame, the success of this application is estimated by comparing the use of renewable energy before and after HESTIA implementation.
Lowering maximum energy consumption	The aim is to decrease the peak energy consumption of households, allowing to consider changes in the contracted power, or helping to stay within the boundaries of the contracted power, particularly with the development of new specific electricity uses such as electric vehicles. This will be focused on electricity consumption for the Berchidda and Voorhout Pilot Sites, and on mixed heat and electricity consumption in the Camille Claudel Pilot Site. The success of this application is estimated by comparing the peak and total energy consumptions before and after HESTIA implementation.
Fostering responsible consumption by means of energy consumption explanation and visualisation	With the introduction of intelligent measuring devices and an improved awareness on their energy consumption, consumers are more inclined to act with energy savings in mind. The aim is to provide citizens with measures of their own consumption to encourage virtuous behaviour which translates into overall energy savings. This will be supported by the use of visualisation interfaces for displaying consumptions, forecasts, and the impact of demand response actions at the individual and collective level. The success of this application is estimated by analysing the acceptance and usage of the HESTIA interfaces through surveys, feedback from the involved consumers and usage data, before and after HESTIA implementation.
Community-level optimisation	The aim is to set up community-level exchanges of information and energy between neighbours and to dispatch Demand Response suggestions or control signals that were planned at the community scale, in order to improve the local energy system (e.g., decreasing the electricity or heat amount requested from the grids) and improve community-level services such as the optimisation of EV charging on external/public charging stations. The success of this application is estimated by comparing the electricity or heat used from the grids before and after HESTIA implementation and the response rate of the targeted households.

Table 4: HESTIA common goals and applications

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Three other applications were defined as more pilot specific, depending on the availability of specific appliances and technologies at the pilot sites. These applications are described in Table 5:

Improved water management	The aim is to foster sustainable habits allowing for a reduced consumption of hot and/or cold water. Feedback from the T1.2 HESTIA surveys show that water is also identified as a precious resource for the consumers that can be studied along the reduction of energy consumption itself. The success of this application is estimated by comparing estimates of energy and water consumptions before and after HESTIA implementation.
Optimal use of energy storage	The aim is to leverage the existing (or future) storage solutions in order to improve self-consumption at the individual and community scale. The success of this application is estimated by comparing the reduction in grid energy consumed by the households and the local renewable energy consumed before and after HESTIA implementation.
Transparency and certified data	The aim is to use tools such as Blockchains for registering and certifying data and equipping the community with a solid and trustable database. This data can be further used for settlement and billing purposes, with the goal of building a Local Energy Market. This application depends strongly on the regulatory constraints of each pilot site associated with data privacy and GDPR application.

Table 5: HESTIA specific goals and applications

These common applications are adapted to the Use cases propositions for each pilot site described in the following sections. Their description includes:

- the summary of the Use Cases for each pilot sites,
- the interaction diagrams between stakeholders (e.g., consumer, community, public bodies, networkoperators…) and HESTIA services,
- the associated Demand Response actions propositions (including the targeted appliances, possible constraintsassociated with household expectations or technical constraints) and associated HESTIA analytical services.

The described Use cases are summarised in Table 6.

Berchidda	Shifting electricity uses to favourable moments to leverage PV production
	Improved management of storage systems for answering DR needs to support the grid
Camille Claudel	Reducing energy consumption from the heating network and shaving off consumptionpeaks at the community level
	Shifting electricity uses to favourable moments for anticipating the development of renewable electricity generation
Voorhout village	Leveraging energy excesses at the individual and community level
	Leveraging renewable energy storage for reduced grid consumption

Table 6: Summary of the HESTIA use cases

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3.2 Specific Demand Response Use Cases for the Berchidda pilot site

3.2.1 Summary of DR propositions in Berchidda

The Berchidda pilot site is focused on the optimal use of local photovoltaic energy within a local energy community, promoting self-consumption as well as energy exchange, buying or selling among citizens, supported by certified and transparent use of energy consumption and PV generation metering data. The two main Use Cases revolve around theshifting of appliance use at favourable moments in order to maximise the use of PV energy, and the optimal use of energy storage for creating additional flexibility and improving the operation and longevity of these appliances (e.g., with an optimised battery charging strategy or boiler on/off management). In both cases, this is applied within an energy community for encouraging community trading and collective maximisation of renewable consumption in case of energy excess from the PV production.

The expected benefits for the citizens are focused on the reduction of energy consumptions from the grid and electricity bills, and on the participation in a community objective of fostering the use of local energy resources. For the Municipality, the benefits are a long-term engagement of citizens in sustainable energy use, by encouraging virtuous behaviours that translate into overall energy savings. AEC, the municipal electricity company, aims to develop the use of renewable energy, federating households under a common Renewable Energy Community, maximising the reliance on local production, optimising the use of aggregated energy demand and providing flexibility and stability to the grid.

In addition to the general energy savings brought by a stronger citizen awareness on their consumption by an improved management of energy storage, the main practices/appliances targeted for the application of demand response actionsare:

Category	Practices or appliances
Domestic hot water	individual electric boilers
Home appliances	washing machines, dryers and dishwashers (cooking stoves and ovens are powered by gas)
Electric mobility[1]	Electric vehicles

Table 7: Targeted practices / appliances in Berchidda

3.2.2 Use cases description

3.2.2.1 Berchidda pilot Use Case 1 – Shifting electricity uses to favourable moments to leverage PV production

The first Use Case in Berchidda is focused on the flexible use of hot and cold water-consuming appliances. Following propositions of favourable consumption periods by the HESTIA analytical services, it is proposed that the user activates or programmes the washing machine, dryer or dishwasher, gardening equipment or other water-consuming electrical equipment in order to benefit from locally produced energy. The individual energy consumption of each appliance willbe monitored using smart plugs. The automatisation of this type of demand response action depends on the smart control capabilities of the currently installed appliances. However in most cases, they will require manual intervention or activation. Therefore, the consumer digital twin of the household will be used for proposing personalised demand response actions (targeted appliance, period of the day) so that they are more acceptable according to the household practices and capacity to be flexible.The proposed general process of interactions between the stakeholders and the HESTIA services is described in Figure2.

In this process, the HESTIA services send the consumers an estimation of PV availability for the next day and

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propositions for appliance shifting or programming. The consumers can acknowledge these propositions and plan modifications in their plans for the next day (e.g., preparing a dishwasher for the next day). If the consumer confirms his participation, the acknowledgment can be sent back to the HESTIA services and used to optimise and dispatch flexibility propositions. On the day of action, the HESTIA platform sends renewed forecasts and reminder of action to the consumers. After the consumer has performed a Demand Response action, the impact of this action is estimated and communicated at the individual and community scale. If energy excesses arise during the day, these can be tradedor exchanged between neighbours in order to maximize the use of renewable resources at the community scale.

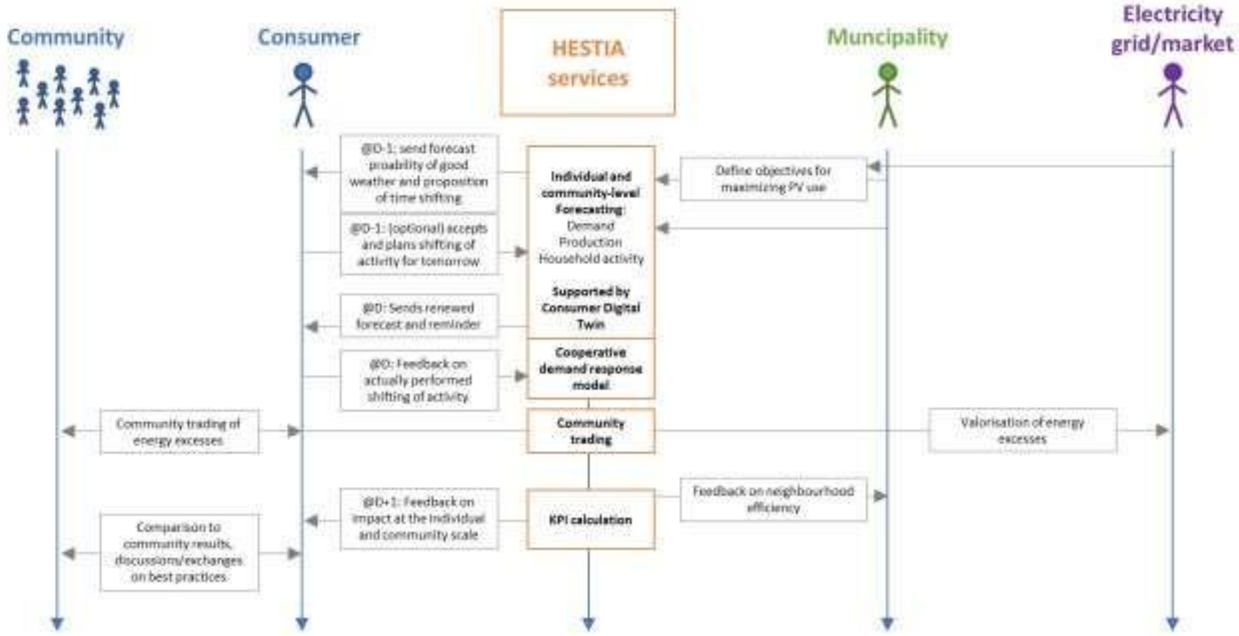

Figure 2: Information flows in the Berchidda “Shifting electricity uses to favourable moments to leverage PV production” Use Case

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Several practices and appliances can be addressed by the following Demand Response actions:

Leveraging PV and application to cold and hot water use, by:	
shifting the use of home appliances to favourable moments	
Targeted energy use	Specific electricity used for clothes- and dishwashing and other water-using electrical appliances
DR action	This actions aims at scheduling or starting appliances such as washing machines, dryers, dishwashers and other electrical appliances so that they are active during favourable periods of available PV electricity. These DR action propositions have to take the daily activities and habits of the household into account, as the household participants need to present for preparing these machines before starting or scheduling them.
Constraints	Presence of occupants needed for the preparation of machines
Associated HESTIA analytical services	RES generation forecasting, for estimating available PV electricity Consumer digital twin, user profiling and non-intrusive load monitoring, used for adapting the propositions and scheduling to the reality of the household practices Optimal energy dispatching at the community level
Associated equipment	Smart plugs for measuring equipment consumptions General energy consumption and production metering PV panels

Table 8: DR actions for the Berchidda pilot Use Case 1 – Shifting electricity uses to favourable moments to leverage PV production

3.2.2.2 Berchidda pilot Use Case 2 – improved management of storage systems for answering DR needs to support the grid

The second Use case is focused on an improved management of energy storage for answering Demand Response needs by taking into account DSO requests and considering energy prices, demand peaks and weather forecasts. The improved storage management also aims at improving the longevity of appliances (e.g., managing the charge/discharge cycles ofbatteries within acceptable ranges of state of charge), and at advising citizens on suggested consumption patterns for the following day. Another appliance that can be integrated in this approach for improving durability is the hot water boiler, managed by means of ON/OFF settings in order to benefit from local PV generation while limiting losses. This is achieved by leveraging all the HESTIA services in order to identify the optimal moments of use for these appliances.

The proposed general process of interactions between the stakeholders and the HESTIA services is described in Figure 2. In this process, the HESTIA services consider inputs and constraints from the electricity grid operator in order to plan an optimal use of energy storage for maximizing the use of renewable energy and answering constraints of the grid. The HESTIA services send to the consumers an estimation of available stored energy and propositions for ideal appliance shifting or programming for benefitting from this stored energy. The consumers can acknowledge these propositions and plan modifications in their plans for the next day (e.g., preparing the dishwasher for the next day). If the consumer confirms his participation, the acknowledgment can be sent back to the HESTIA services and used to optimise and dispatch flexibility propositions. On the day of action, the HESTIA platform sends renewed forecasts and reminder of action to the consumers, as well as updated parameters for the storage management. After the consumer has performed a Demand Response action, the impact of this action is estimated and communicated at the individual and community scale. If energy excesses arise, these can be traded or exchanged between neighbours in order to maximize the use of renewable resources at the community scale.

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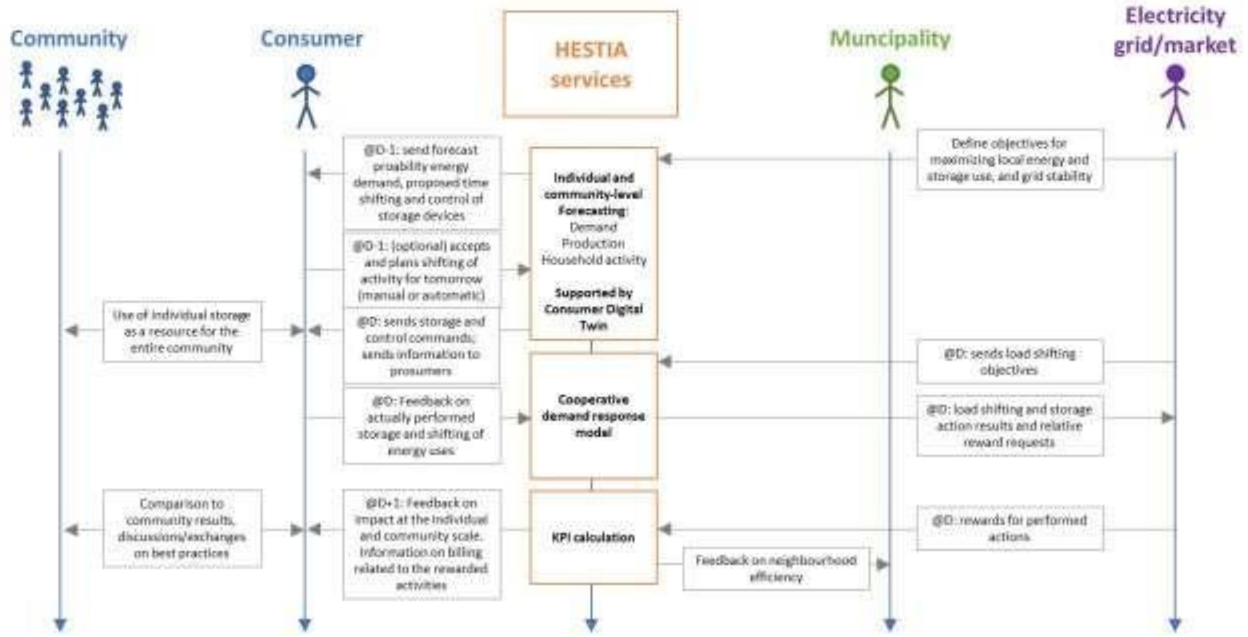

Figure 3: Information flows in the Berchidda Use Case 2: "Improved management of storage systems to support the grid"

In addition to a dedicated battery management, several practices and appliances can be addressed by the following Demand Response actions:

Improved management of storage systems for answering DR needs to support the grid, by:	
shifting the use of home appliances to favourable moments	
Targeted energy use	Shiftable specific electricity uses e.g. for clothes- and dishwashing & clothes drying
DR action	This actions aims at scheduling or starting appliances such as washing machines, dryers, dishwashers and other electricity-consuming appliances so that they use available stored energy. These DR action propositions have to take the daily activities and habits of the household into account, as the household participants need to be present for preparing these machines before starting or scheduling them.
Constraints	Presence of occupants needed for the preparation of machines
Associated HESTIA analytical services	RES generation forecasting, for estimating available PV electricity Consumer digital twin, user profiling and non-intrusive load monitoring, used for adapting the propositions and scheduling to the reality of the household practices Optimal energy dispatching at the community level
Associated equipment	Smart plugs for measuring equipment consumptions General energy consumption and production metering PV panels Batteries and associated charge/discharge manager

Table 9: DR actions for the Berchidda pilot Use Case 2 – improved management of storage systems to support the grid

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3.3 Specific Demand Response Use Cases for the Camille Claudel pilot site

3.3.1 Summary of DR propositions in Camille Claudel

The Camille Claudel pilot site use cases are focused on the joint improvement of heat and electricity consumptions. Thespecificity of this pilot site is that all consumers are connected to a heating network for space heating and DHW. This heating network is fuelled by a biomass boiler, and a back-up gas boiler. The wood used in the biomass boiler is a local resource that comes from the maintenance of the surrounding forests, parks and gardens within a radius of 50 km. Thisis wood that is not suitable for any other use. The boilers were sized for feeding hot water to the currently existing district, but also for the future buildings that will be built short- to mid-term. The future evolution of the district will putstronger constraints on the optimal use of biomass, and an increased role of individual consumptions on the network renewable/gas balance and costs. In addition, the future development of renewable electricity on the territory such asPV panels will also bring opportunities to consume locally produced electricity and to decrease the amount of electricityneeded from the grid. The Camille Claudel Use Cases propose to study the use of heat and electricity at the community level in order to anticipate and accompany these changes.

The expected benefits for the households is a reduction in heating consumption and costs, and the contribution to thecommon goals of reducing consumption and using more renewable energy, goals that are already fostered with the inhabitants by the Municipality and the Urban Community. At the same time, the benefit is to understand how their electricity consumption and costs could be changed with the installation of more renewable electricity sources such asPV, particularly with the development of new electricity uses such as electric mobility. The district developer also aims at reaching the highest Eco-District Label, which implies the active participation of citizens in energy questions. For theUrban community, it is a step towards reaching the climate and energy reduction objectives. Finally, the heating network operator aims at proposing new network management means for optimising operational costs and build new pricing propositions with the building owners.

The main practices/appliances targeted for the application of demand response actions are:

Category	Practices or appliances
Space heating	control devices for adjusting heating set point temperatures of the heaters
Domestic hot water	hot water consuming practices (e.g., showering, meal preparation)
Home appliances	washing machines, dryers, dishwashers electric cooking appliances
Electric mobility[2]	electric vehicle

Table 10: Targeted practices / appliances in Camille Claudel

3.3.2 Use cases description

3.3.2.1 Use Case 1: reducing energy consumption from the heating network and shaving off consumption peaks at thecommunity level

This first Use Case aims at decreasing the energy consumption related to the use of hot water delivered from the heating network. This mainly targets space heating, however domestic hot water is also addressed, as well as other hot-water consuming practices (that might also be concurrent with the use of electricity, such as meal preparation). In periods ofhigh demand (mainly in the colder season between November and March for heating and October and May for DHW), the consumption peaks at the community level might trigger the use of a gas boiler for feeding the heating network.

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By shaving the peak at the community level, the firing of the gas boiler could be limited or avoided, increasing the shareof renewable energy used. This is achieved with various scenarios including controlled or manual management of heating set point levels or moments of use, and shifting of hot-water consuming practises. The dispatching of Demand Response actions should be made according to the consumption profiles of the community, in order to shave the peakat a global scale.The proposed general process of interactions between the stakeholders and the HESTIA services is described in Figure2. In this process, the HESTIA services use input information from the heating network such as constraints on the wood/gas ratio as well as weather forecasts in order to send to the consumers personalised propositions for bestmoments of shifting of heating or DHW consumption. After the consumer has performed a Demand Response action,the impact of this action is estimated and communicated at the individual and community scale.

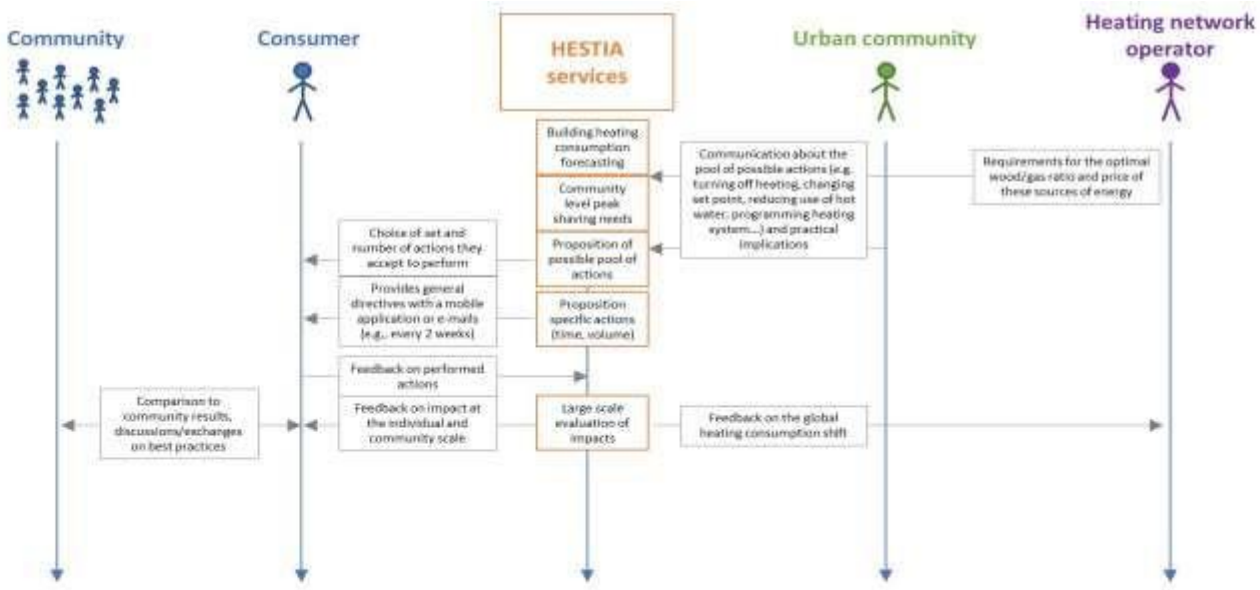

Figure 4: Information flows in the Camille Claudel "Heating Management" Use Case

Several practices and appliances can be addressed by the following Demand Response actions:

Reducing energy consumption from the heating network and shaving off consumption peaks at the community level by:	
managing heating levels	
Targeted energy use	Space heating
DR action	This actions aims at acting on heating control in order to limit the heat consumption for space heating in un-favourable moments (e.g., moments of increased use of gas for the heating network). These actions will be performed either on the thermostat of the dwelling, or directly on the heaters in each room with controlled or manual thermostatic valves.
Constraints	Maintain expected thermal comfort over time
Associated HESTIA analytical services	Weather and building-level energy demand forecasting, for estimating heating demand Consumer digital twin, used for adapting the scheduling to the reality of the household practices (presence) and for estimating the DHW needs Optimal dispatching at the community level, for community-level peak shaving Model predictive control for the automated control of appliances

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Associated equipment	Temperature sensors Thermostatic valves, thermostats
managing domestic hot water consumption	
Targeted energy use	Domestic hot water
DR action	This actions aims at proposing favourable moments for shifting hot-water consuming practices such related to hygiene (e.g., showers) or meals (e.g. meal preparation, manual dishwashing).
Constraints	Take inhabitants practices into account in order to schedule optimally
Associated HESTIA analytical services	Consumer digital twin, used for adapting the scheduling to the reality of the household practices Optimal energy dispatching at the community level
Associated equipment	Hot water consumption metering

Table 11: DR actions for the Camille Claudel pilot Use Case 1 – reducing energy consumption from the heating network and shaving off consumption peaks at the community level

3.3.2.2 Use Case 2: Shifting electricity uses to favourable moments for anticipating the development of renewable electricity generation

This second Use Case aims at studying the capacity of households to make themselves flexible in future situations of stronger development of renewable electricity generation, such as PV panels. The Camille Claudel district will see no installation of PV panels during the HESTIA project, however it is expected that these energy source develop on the territory: a first project is being developed for installing PV generation capacities on the parking lot of the public pool ofthe Camille Claudel district. This Use case aims to anticipate these new situations for proposing an improved RES development and a stronger replicability of the possible scenarios. Therefore this Use case will be a hybrid approach between real interventions with households and simulated energy generation.

This use cases aims at leveraging possible renewable electricity sources by shifting electricity consumption to more favourable moments of renewable energy generation. As the buildings have no electric heating nor DHW, the targeted appliances are focused around the appliances used for clothes- and dishwashing, meal preparation, as well as the charging of electric vehicles on the public charging stations of the district.

The proposed general process of interactions between the stakeholders and the HESTIA services is described in Figure 2. In this process, the HESTIA services send to the consumers an estimation of PV availability for the next day, and propositions for appliance shifting or programming. The consumers can acknowledge these propositions and plan modifications in their plans for the next day (e.g., preparing a dishwasher for the next day). If the consumer confirms his participation, the acknowledgment can be sent back to the HESTIA services and used for a better optimization and dispatch of flexibility propositions. On the day of action, the HESTIA platform sends renewed forecasts and reminder of action to the consumers. After the consumer has performed a Demand Response action, the impact of this action is estimated and communicated at the individual and community scale.

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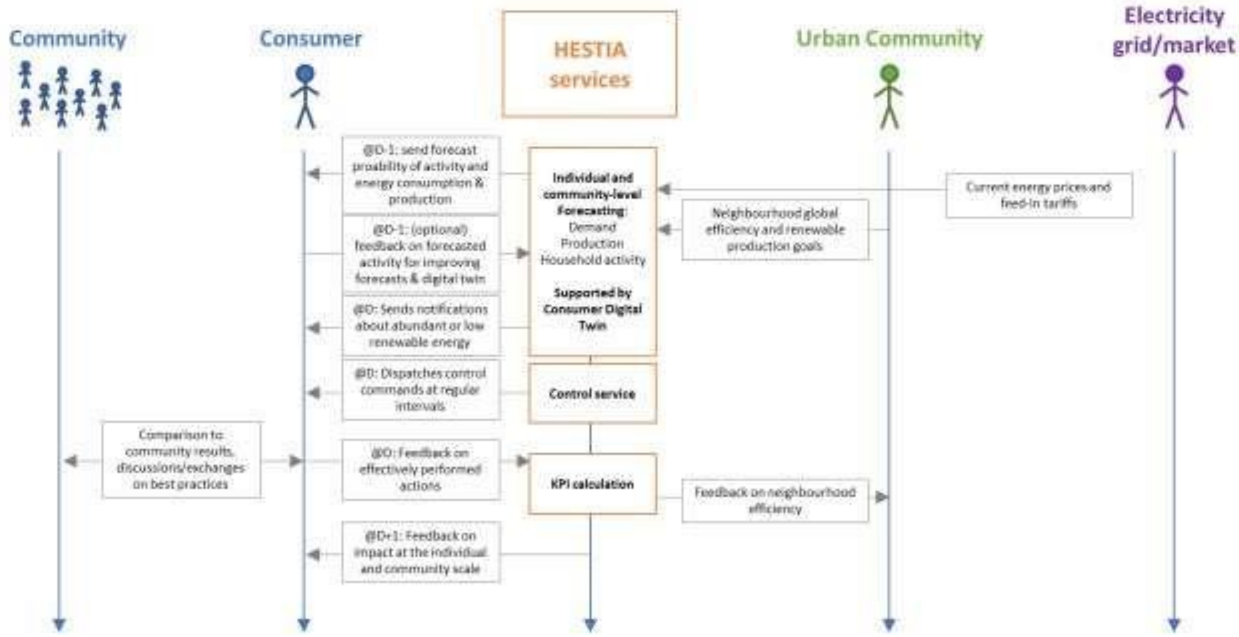

Figure 5: Information flows in the Camille Claudel "Development of renewable electricity" Use Case

Several practices and appliances can be addressed by the following Demand Response actions:

Leveraging renewable electricity by:	
shifting the use of home appliances to favourable moments	
Targeted energy use	Specific electricity used for clothes- and dishwashing or meal preparation
DR action	This actions aims at scheduling or starting appliances such as washing machines, dryers and dishwashers so that they are active during favourable periods of available PV electricity. These DR action propositions have to take the daily activities and habits of the household into account, as the household participants need to present for preparing these machines before starting or scheduling them.
Constraints	Presence of occupants needed for the preparation of machines
Associated HESTIA analytical services	RES generation forecasting, for estimating available PV electricity Consumer digital twin, user profiling and non-intrusive load monitoring, used for adapting the propositions and scheduling to the reality of the household practices Optimal energy dispatching at the community level
Associated equipment	Smart plugs for measuring equipment consumptions General energy consumption metering PV panels (models)
coordinating the charging of electric vehicles	
Targeted energy use	Electric mobility
DR action	This actions aims at proposing favourable moments for charging electric vehicles, according to the forecasted PV generation. This implies the presence of occupants for plugging the vehicle and might not be applicable to all households or days.
Constraints	Presence of occupants

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Associated HESTIA analytical services	RES generation forecasting, for estimating available PV electricity Consumer digital twin, user profiling and non-intrusive load monitoring, used for adapting the propositions and scheduling to the reality of the household practices Optimal energy dispatching at the community level
Associated equipment	Electric vehicles and public charging stations PV panels (models)

Table 12: DR actions for the Camille Claudel pilot Use Case 2 – Shifting electricity uses to favourable moments for anticipating the development of renewable electricity generation

3.4 Specific Demand Response Use Cases for the Voorhout village pilot site

3.4.1 Summary of DR propositions in Voorhout village

The specificity of the Voorhout village pilot site is that it built around new, net positive buildings and efficient systems,associated with local PV production and electricity storage capabilities. As of today, during the day most of the production of the PV panels is injected to the grid. Therefore, the Voorhout village use cases are focused on:

- the improvement of self-consumption at the individual level and within the community
- the valorisation of energy production excesses inside or outside the district, with the application of HESTIA community trading
- the possibility of offering market flexibility through the use of individual and community batteries and other shiftable or controllable loads including electric vehicles.

As such, the Voorhout village use cases are focused on the management of batteries and can reach to all types of shiftable loads in order to increase the share of renewable energy consumption in the community. Thanks to demand and production forecasts for each individual households and local battery storage with remote control capability, the households can be optimized for individual self-consumption. As all households are connected to the same IT system, the optimization objective can also take global/collective self-consumption into account.

The expected benefits for the households is to consume less electricity from the grid while participating in a communityeffort to foster the best use of local resources. The scale of valorisation of the energy excesses and their beneficiaries (e.g., households, community, property developer, neighbouring districts…) is to be studied within this Use Case.

In Voorhout village, the uses cases will therefore be focused on the management of batteries. Additionally, practices/appliances can be targeted for the application of demand response actions, such as:

Category	Practices or appliances
Space heating/cooling	Individual electric heating/cooling
Domestic hot water	Optimal scheduling of hot water production
Home appliances	Washing machines, dryers and dishwashers,
Electric mobility	Charging of electric vehicles

Table 13: Targeted practices / appliances in Voorhout village

3.4.2 Use cases description

3.4.2.1 Use Case 1: leveraging energy excesses at the individual and community level

This first Use Case aims at leveraging the renewable resources and available control and flexibility capabilities to ensure that a maximum amount of renewable energy is self-consumed. The batteries of the household are used to store the produced PV energy. However if the forecast algorithms detect that excess energy will not

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be able to be stored, the roleof the HESTIA platform is to communicate to household members the moments when PV energy excess is available. This helps households decide whether to shift the use of appliances to these identified time periods, or share the available excess at the community level. The PV production from the neighbouring households and grid electricity pricecan also be taken into account to set up a tailored Demand Response action plan for each household.

The proposed general process of interactions between the stakeholders and the HESTIA services is described in Figure 2. In this process, the HESTIA services send to the consumers an estimation of PV excess availability for the next day, and propositions for appliance shifting or programming. The consumers can acknowledge these propositions and plan modifications in their plans for the next day (e.g., preparing a dishwasher for the next day). If the consumer confirms his participation, the acknowledgment can be sent back to the HESTIA services and used for a better optimization and dispatch of flexibility propositions. On the day of action, the HESTIA platform sends control commands for the batteriesand renewed forecasts and reminder of action to the consumers. After the consumer has performed a Demand Response action, the impact of these actions and the energy excesses are estimated and communicated at the individualand community scale.

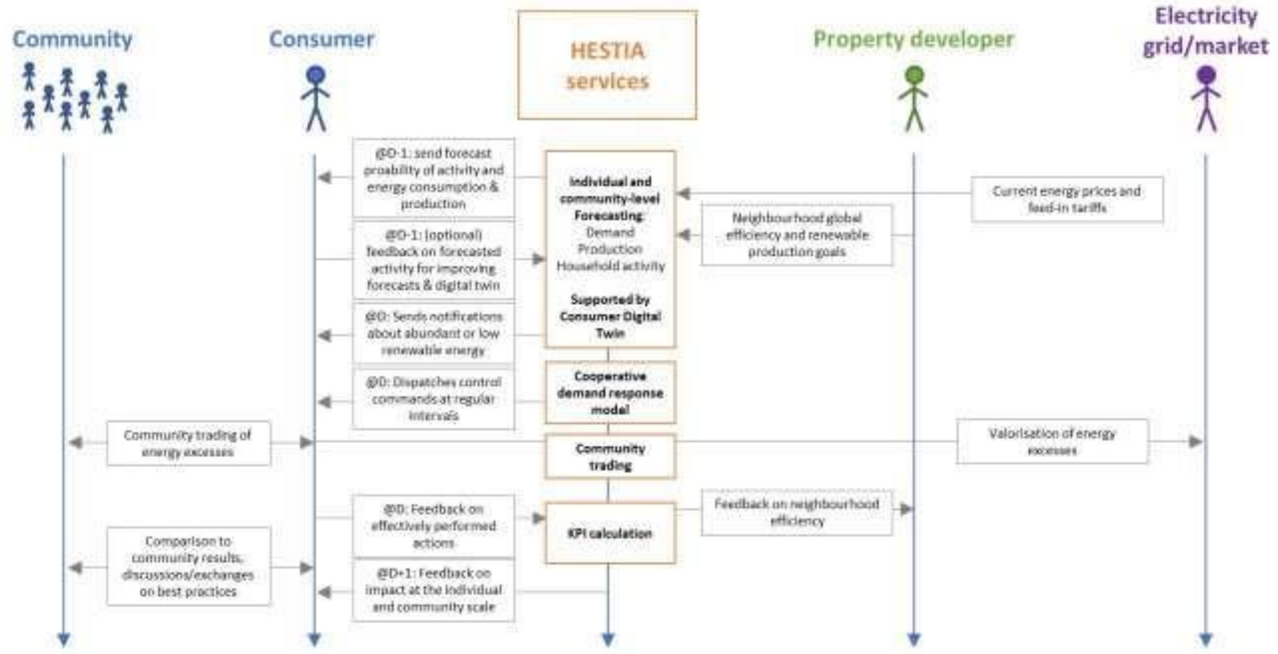

Figure 6: Information flows in the Voorhout village "Leveraging PV excesses" Use Case

In addition to the optimal management of batteries, several practices and appliances can be addressed by the following Demand Response actions:

Leveraging PV production excesses by: managing domestic hot water production	
Targeted energy use	Domestic hot water
DR action	This actions aims at scheduling/managing the individual heat pump of each household in order to produce hot water during the day, when there is an excess of PV energy.
Constraints	Take inhabitants practices into account in order to schedule optimally to make sure hot water is available when needed
Associated HESTIA analytical services	Weather and building-level energy demand forecasting, for estimating losses RES generation forecasting, for estimating available PV electricity

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	Consumer digital twin, user profiling and non-intrusive load monitoring, used for adapting the propositions and scheduling to the reality of the household practices Optimal energy dispatching at the community level Model predictive control for the automated control of appliances
Associated equipment	Temperature sensors Heat pump for DHW General energy consumption and production metering PV panels
shifting the use of home appliances	
Targeted energy use	Specific electricity used for clothes- and dishwashing
DR action	This actions aims at scheduling or starting appliances such as washing machines, dryers and dishwashers so that they are active during time periods of PV energy excess. These DR action propositions have to take the daily activities and habits of the household into account, as the household participants need to present for preparing these machines before starting or scheduling them.
Constraints	Presence of occupants needed for the preparation of machines
Associated HESTIA analytical services	RES generation forecasting, for estimating available PV electricity Consumer digital twin, user profiling and non-intrusive load monitoring, used for adapting the propositions and scheduling to the reality of the household practices Optimal energy dispatching at the community level
Associated equipment	Smart plugs for measuring equipment consumptions General energy consumption and production metering PV panels
coordinating the charging of electric vehicles	
Targeted energy use	Electric mobility
DR action	This actions aims at proposing favourable moments for charging electric vehicles, according to the forecasted energy excesses. This implies the presence of occupants for plugging the vehicle and might not be applicable to all households or days.
Constraints	Presence of occupants
Associated HESTIA analytical services	RES generation forecasting, for estimating available PV electricity Consumer digital twin, user profiling and non-intrusive load monitoring, used for adapting the propositions and scheduling to the reality of the household practices Optimal energy dispatching at the community level
Associated equipment	Electric vehicles and charging stations General energy consumption and production metering PV panels

Table 14: DR actions for the Voorhout pilot Use Case 1 – leveraging energy excesses at the individual and community level

For each of these Demand Response actions, the knowledge of the community production and consumption leads to a community-level dispatching of Demand Response request or propositions, in order to improve the general self- consumption of the neighbourhood.

3.4.2.2 Use Case 2: leveraging renewable energy storage for reduced grid consumption

This second Use Case aims at benefitting from the individual and community storage systems to consume, in the morning or after working hours, the energy produced by the PV and stored in the batteries during the day. To ensure that a maximum amount of renewable energy is self-consumed while limiting the grid consumption, the HESTIA services aim at providing information to the households on the availability of stored

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PV energy. If the stored energy is not enough for answering the forecasted energy needs, the HESTIA services aim at proposing Demand Response actions to the household for reducing consumption, if they endorse the goal of limiting grid consumption.

As the aim is to shift the use of appliances at favourable moments, the proposed general process of interactions between the stakeholders and the HESTIA platform is therefore similar to the process described in Figure 6:

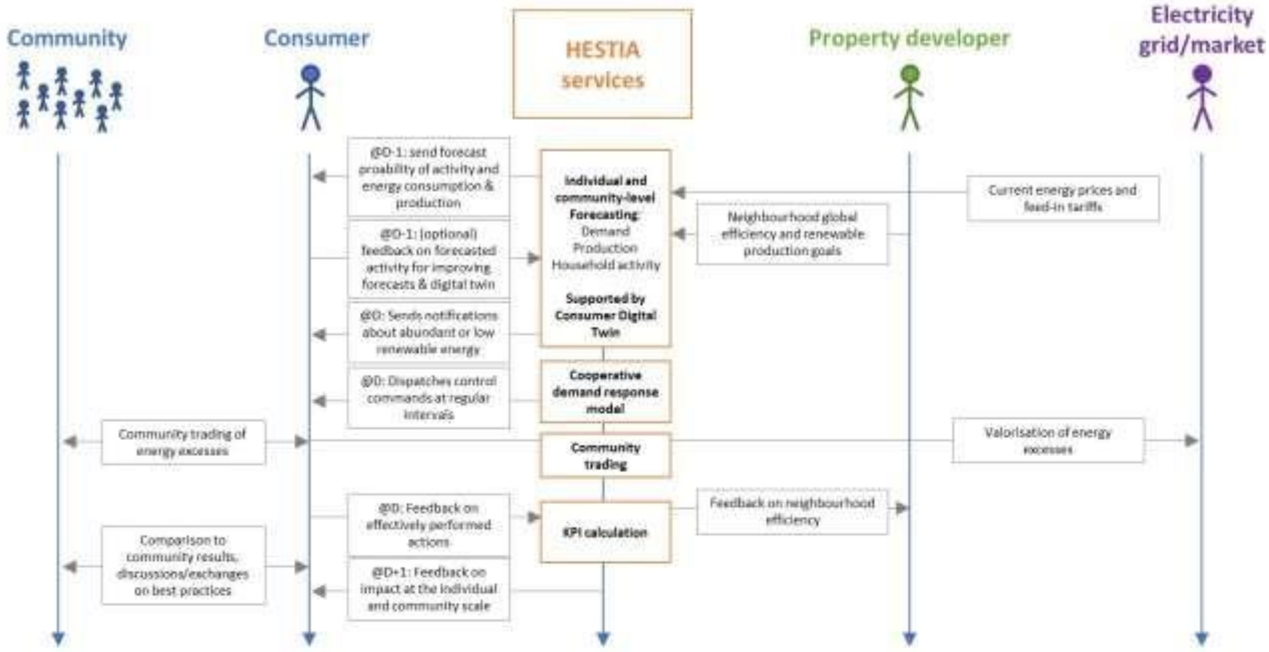

Figure 7: Information flows in the Voorhout village “leveraging renewable energy storage for reduced grid consumption” Use Case

Several practices and appliances can be addressed by the following Demand Response actions:

Leveraging renewable energy storage for reduced grid consumption by: managing domestic hot water production	
Targeted energy use	Domestic hot water
DR action	This actions aims at scheduling/managing the individual heat pump of each household in order to produce hot water when stored energy is available
Constraints	Take inhabitants practices into account in order to schedule optimally to make sure hot water is available when needed
Associated HESTIA analytical services	Weather and building-level energy demand forecasting, for estimating needs and losses RES generation forecasting Consumer digital twin, user profiling and non-intrusive load monitoring, used for adapting the propositions and scheduling to the reality of the household practices Optimal energy dispatching at the community level Model predictive control for the automated control of appliances
Associated equipment	Temperature sensors Heat pump for DHW General energy consumption metering PV panels Individual or community batteries

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shifting the use of home appliances	
Targeted energy use	Specific electricity used for clothes- and dishwashing
DR action	This actions aims at scheduling or starting appliances such as washing machines, dryers and dishwashers so that they use available stored energy consumption or, on the contrary, are shifted to more favourable time periods. These DR action propositions have to take the daily activities and habits of the household into account, as the household participants need to present for preparing these machines before starting or scheduling them.
Constraints	Presence of occupants needed for the preparation of machines
Associated HESTIA analytical services	Building-level energy consumption forecasting RES generation forecasting Consumer digital twin, user profiling and non-intrusive load monitoring, used for adapting the propositions and scheduling to the reality of the household practices Optimal energy dispatching at the community level
Associated equipment	Smart plugs for measuring equipment consumptions General energy consumption metering PV panels Individual or community batteries
coordinating the charging of electric vehicles	
Targeted energy use	Electric mobility
DR action	This action aims at proposing favourable moments for charging electric vehicles, when stored renewable energy is available, or on the contrary, shifting the charging of EVs to more favourable time periods. This implies the presence of occupants for plugging the vehicle and might not be applicable to all households or days.
Constraints	Presence of occupants
Associated HESTIA analytical services	RES generation forecasting Consumer digital twin, user profiling, used for adapting the propositions and scheduling to the reality of the household practices Optimal energy dispatching at the community level
Associated equipment	Electric vehicles and charging stations General energy consumption metering PV panels Individual or community batteries

Table 15: DR actions for the Voorhout pilot Use Case 2 – leveraging renewable energy storage for reduced grid consumption

For each of these Demand Response actions, the knowledge of the community production and consumption leads to a community-level dispatching of Demand Response request or propositions, in order to improve the general self- consumption of the neighbourhood by the use of the individual or community batteries.

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4. COMMON AND SPECIFIC TRAITS AND REQUIREMENTS OF THE USE CASES AND PILOT SITE

Table 16 describes common requirements that arose from the Use Case development, and that are valid across all the Use case propositions and pilot sites.

Explanation needs	• Provide simple and clear explanations on the constraints of today's and tomorrow's energy system and the individual collective benefits of flexibility • Evaluate digital literacy of participant households and adapt communication and propositions accordingly
Communication needs	• Establish intermediation networks (professional to amateur, households to community, households to media platforms) • Support households in the transition to the establishment of new practices or change in existing ones • Support people if difficulty in the use of smart systems arise, to help them become autonomous • Share stories of household experience in the community as a positive and challenging feedback
Household comprehension	• Understand what is considered "normal" in the local community in terms of performance and everyday practices • Understand local contexts and social dynamics, and align engagement activities with community practices already in place
Data	• Collect and analyse the data from the baseline period to formulate meaningful targetsand actions • Data storage service for personal data that must comply with local regulatory framework and companies policies
Stakeholders	• Double role of the Municipality in Berchidda (municipality + DSO) • Role of the CPS in Camille Claudel: relationship with the heating network operator and DSO. Presence of a heating network connecting the households with additional constraints/inputs from an exterior stakeholder (heating network operator)
Communication	• Type of communication with the participant households, communication channels and tools: each pilot site should adapt the Use Case to the most efficient communication means and existing practices (e.g. Facebook groups, WhatsApp groups, apps, e-mail, …)
Analytical services and technologies	• Application of blockchain-enabled secure energy exchanges will be pilot specific and applicable when local electricity or stored energy can be leveraged • Energy storage integration and management in Berchidda and Voorhout (no electricity storage installed in Camille Claudel)
Data	• Specific data models associated with local energy meters (e.g., DSO energy data points): requires data transformation towards the HESTIA data model • Time resolution of measured smart meter data will be pilot-specific • Access to individual heating consumptions in the French pilot site (presence of individual heating consumption meters is required since 2019)

Table 16: Requirements and goals associated with the developed Use Cases

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The use of the HESTIA analytical services implies the measurement of data points across all pilot sites. A first list of data points has been proposed in Table 17 below. The precise definition of the data points is performed in WP1 T1.4 “HESTIA platform design, requirements and KPI specifications”. Each pilot also presents specificities that will need to be taken into account in the further development of the experiments. This is presented in Table 18.

Instantaneous power demand for each household	Smart meter
Instantaneous power injection from renewable source for each household	Smart meter
Instantaneous power demand for each involved appliance	Smart plugs
Outdoor temperature	Temperature sensor or weather service
Energy produced by PV panels of a given household, before being self-consumed or injected	PV metering
State of charge of home batteries	Battery metering
State of charge of community batteries	Battery metering
Instantaneous power of a battery (charging or discharging)	Battery metering
Gas imported by the household (if applicable)	Gas metering
Indoor data e.g. occupancy, indoor temperature, windows opening, humidity	Smart sensors
Heat consumption from heating network (if applicable)	Heat metering
Power of heating appliances (either electric or heating network related)	Heating system metering

Table 18: Use Case specificities to consider in the following interactions with consume

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5. CONCLUSION

The developed Use cases proposed for each pilot site are based on the pilot characteristics (dwelling types, geographical location and weather, type of installed appliances) described in D1.1 "Pilot technical characterisation and regulatory framework analysis", and on the general goals of the community or property developers that have been understood from the interactions with the local stakeholders.

Across each pilot site, the proposed use cases cover common goals including the creation of an energy community, the improvement of renewable energy use, the decrease in maximum energy consumption, an improved understanding of energy consumption by inhabitants for maintaining long-term, sustainable behaviours, an optimisation of consumption and DR actions at the community-scale.

While being all centred on the common theme of flexibility of practices and use of appliances, the use cases cover a diverse set of DR-related categories of actions summarised in Table 19.

Category	Berchidda	Camille Claudel	Voorhout village
Manage space heating/cooling		X	X
Shiftable home appliances	X	X	X
Electric mobility[3]		X	X
Electricity storage	X		X
Multi-carrier energy use (heat/elec)		X	
Assisted living: maintaining comfort	X	X	X
Mixed energy and water management	X	X	

Table 19: Global coverage of the proposed Use Cases

These propositions are used as inputs for the participatory design process of DR solutions of WP2 with the participating households, to adapt the propositions to the reality of their everyday practices and to foster shared understanding of the benefits and shared community-level objectives.

The information gathered and produced within T1.3 serves as inputs for the following tasks:

- WP1 T1.4 – HESTIA platform design, requirements and KPI specification (M7-M12) – the use cases guide the definition of requirements regarding the needed data points
- WP2 T2.2 – Task 2.2: Inclusive and participatory DR solution design processes (M4-M12) and WP2 T2.3 – Proof-of-concept for user-centred DR initiatives (M12-M17) – the use case propositions are to be challenged by the involved consumers and used as the basis for the participatory design of DR solutions that will be eventually implemented at the pilot sites
- WP4 ICT enabled cooperative demand response model – the use case propositions present requirements to take into account in the optimisation processes
- WP5 T5.1 – Pilot site planning and deployment activities (M7-M18) – the use case define requirements for the needed metering equipment
- WP7 T7.6 – Products, services and supporting business model definition (M13-M36) – the use case and the analysis of benefits serves as an input for the definition of related business models

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