



ReDREAM
change your energy

D2.7

Digital Twin of the Consumers

June 2022



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¹ PU = Public

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

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Review

Reviewers	Andres Nikoglou (NTUA), Hamed Abbasi (RIMOND)
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Issue	Date	Author	Comments
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V0.1	17/05/22	Sergio Díaz	Add structure of how the simulation is structured in section 2.
V0.2	20/05/22	Alberto Castillo	Add section 3.1 that addresses the thermal behaviour related to the heating systems of end-users. Add section 3.2, which deals with the hot water behaviour of users.
V0.3	27/05/22	Lorenzo Ramponi Carlos Álvarez	Add section 3.3, which deals with the simulation of RES. In particular, solar production.
V0.4	3/06/22	Carlos Becker	Add the explanation 3.5 of the non-manageable demand (base demand).
V0.5	13/06/22	Sergio Díaz	Add sections about the behaviour of electric charging posts, market simulations and the creation of virtual prosumers.
V1.0	29/06/22	Sergio Díaz	Include Introduction and conclusions. Check Grammar.
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V3.0	11/07/22	Sergio Díaz	Address PC comments from Alvaro and Bad'r. This is a Website, patents, filling... deliverable so the structure should be changed and detail about deployment is added.



Summary

ReDREAM Project

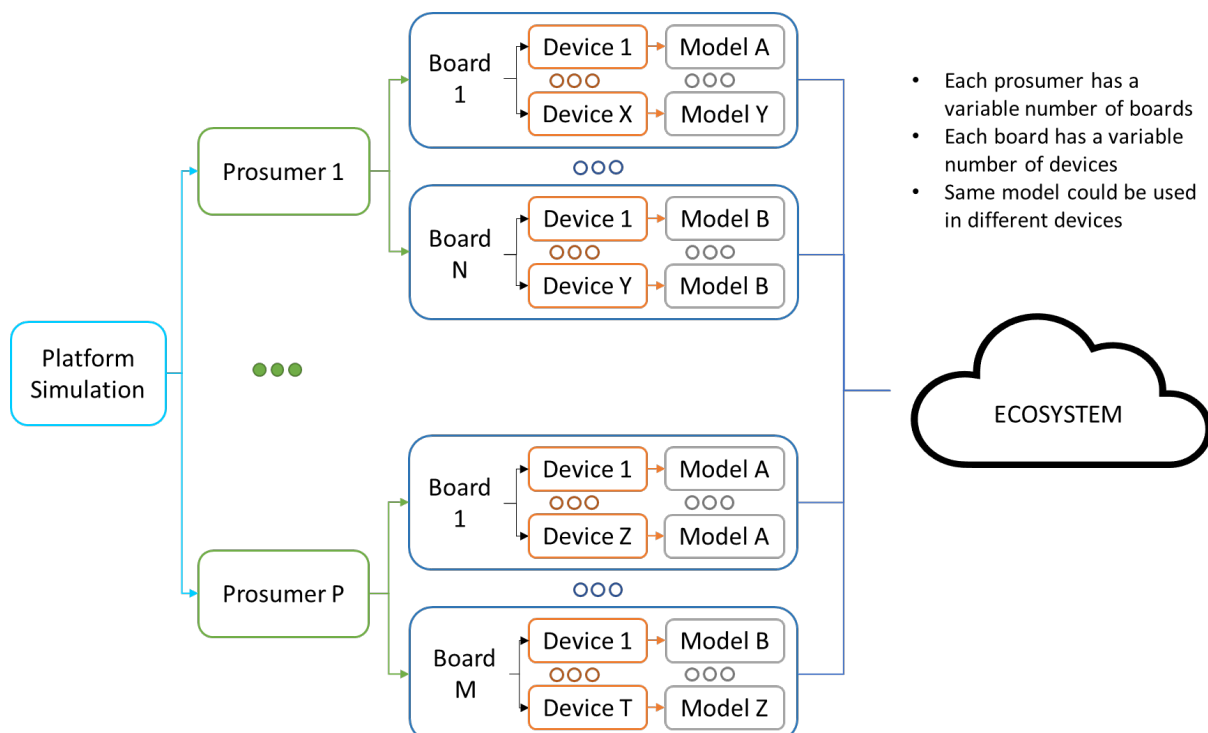
The energy market is rapidly transforming, and so is the role of the Consumer. Yesterday's passive consumers are central actors in today's energy markets. As new prosumers, energy markets can benefit from their generation, consumption and storage capabilities. The EU-funded ReDREAM project will enable the effective participation of consumers and prosumers in the energy market. The project will develop a strategy for creating a value generation chain based on a revolutionary service-dominant logic in which services are exchanged. The project will foster the demand response tools and energy/non-energy services that enable consumers to participate in the energy market. This will lead to the establishment of a new concept: a connected user-centred energy ecosystem.

Deliverable Summary

A complete software platform that creates virtual devices that use the same communication ways (It should use layer 2) that real devices should be implemented. In addition, layer 4 is helping all the REDREAM partners to develop trials of the tools developed in WP3 (layer 5) through the creation of virtualising demo users and their assets, and all the KPIs developers since allow them to develop the automation and start thinking what information is available for their calculation. In those countries where explicit demand response wanted to be tested, the appropriate tools to connect to the electricity market platforms were developed in T2.4, the mirroring of those markets is explained here.

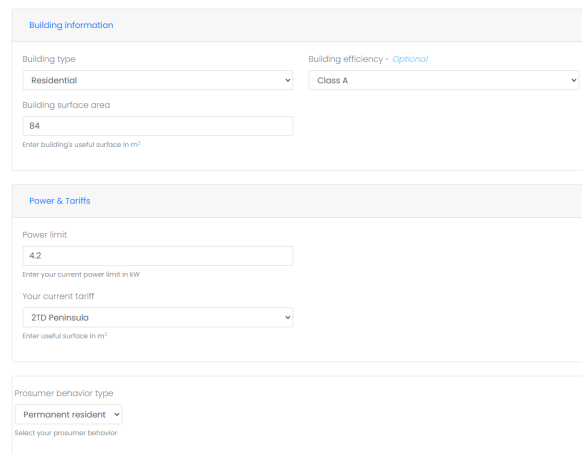
In this deliverable, the main consumption types and generations are modelled differently. Details can be found throughout the deliverable, but a short description is given here:

- a) Communication simulation: A platform is used to allocate virtual prosumers that have virtual equipment related to a specific physical model considering their consumption type. The model is fed by different forecasts and past data to obtain the next measurement for the device.



- b) Thermal consumptions (heating, fridges, refrigeration): the simulation allow us to represent the changes in inner temperatures of rooms, fridges... and determine with a hysteresis logic the consumption of these device considering their current operation mode.
- c) Hot Water: Immersion heater tanks store heated water simulating the inner temperature as SOC level considering their current operation mode and the profiles of usage of the virtual clients.
- d) RES production (Solar production): The simulation will use the available data of the hour global irradiation, the predicted data series of the global irradiation and the characteristics of the virtual PV system, such as the nominal power installed and the system losses to calculate the current production.
- e) Electric Vehicles: In this case, equivalent to the simulation of an electric battery. Instead of having just a battery model, the simulation of electric vehicle charging uses a model for the ECP itself and another model for the EV. Splitting the simulation into two models facilitates the necessary flexibility to recreate real EV charging scenarios where multiple EV's can be connected to a single ECP with multiple connectors.
- f) Non-manageable energy: The simulation of this kind of consumption is straightforward, and it is based on representative consumption curves from real clients.

An internal-only webpage to simplify the creation of simulated prosumers with the most important parameters such as the location, building information, prosumer behaviour, electric tariff or the installed technologies and number of devices has been created. This has allowed the creation of different virtual users for testing purposes of WP2, WP3 and WP5.



Building information

Building type: Residential (dropdown)
 Building efficiency - *Optional*: Class A (dropdown)

Building surface area: 84 (input field)
Enter building's useful surface in m²

Power & Tariffs

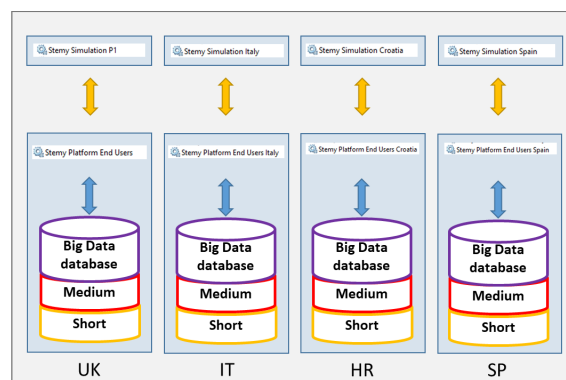
Power limit: 4.2 (input field)
Enter your current power limit in kW

Your current tariff: 2TD Peninsula (dropdown)
Enter useful surface in m²

Prosumer behavior type

Permanent resident (dropdown)
Select your prosumer behavior

Finally, four simulation services have been running from M6 to allow ReDREAM Partners to develop their tools in WP3. The execution during ReDREAM project makes possible the evolution to pre-commercial functionalities reaching TRL7 (services starting at TRL5 and 6) and TRL8 (services at TRL7) since the complete platform is being validated in a fully multi-consumer operational environment.



GOOGLE CLOUD
 Production 1



Table of Acronyms

Acronyms	Description
AP(s)	Action Point(s)
API	Application Programming Interface
CA	Consortium Agreement
DER	Distributed Energy Resource
DR	Demand Response
EC	European Commission
ECP	Electric Charging Post
ECR	European Commission Reporting
EE	Energy Efficiency
EPOV	Energy Poverty Observatory
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
PDF	Probability Density Function
PV	Photovoltaic
GA	Grant Agreement
GDPR	General Data Protection Regulation
H2020	Horizon 2020 programme
HBS	Household Budget Survey
DSO	Distribution System Operator
LTP	Linked Third Party
MP	Multilayer Perceptron
OAuth 2	Open Authorization
OCPP	Open Charge Point Protocol
PC	Project Coordinator
PMB	Project Management Board
PTC	Project Technical Committee
RES	Renewable Energy Sources
RLS	Recursive Least Square
TPR	Ten Percent Rule
TRL	Technology Readiness Level
TSO	Transmission System Operator
T&C	Terms & Conditions
UC	Use Case
UML	Unified Modelling Language
SILC	Survey on Income and Living Conditions
SOC	State of Charge
WLS	Weighted Least Squares
WP(s)	Work Package(s)



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1. Introduction

The current Deliverable D2.7 is a document that is associated with layer 4 of the ecosystem. Therefore, the content of Deliverable D2.7 is strongly related to the content of the software and how it is implemented.

The idea of this deliverable is to show how the energy behaviour of an end-user has been simulated. Since end-users can consume and produce energy if they have solar PV panels, all end-users are considered possible prosumers from the point of view of the simulation. This fact requires having a complete representation of the main consumption and production types that can be found: Thermal consumption (heating, fridges, refrigeration), Hot Water, RES production, Electric Vehicles, or Non-manageable energy. This means that different assets should be modelled to represent their electrical behaviour, but since some of them depend on the outer conditions, such as the building behaviour or the prosumer preferences, that should also be modelled.

In order to obtain a simulation that is close enough to reality, layer 4 should use the same communication channels and context that an actual consumer should face. This means that if a real consumer needs a smart meter and a device to measure a control a type of consumption, the same should be applied to the simulated Consumer. Thus, a complete software platform that creates virtual devices that use the same communication ways (It should use layer 2) that real devices should be implemented. In addition, layer 4 is helping all the REDREAM partners to develop a test of the tools developed in WP3 (layer 5) through the creation of virtualised demo users and their assets, and all the KPIs developers since allow them to develop the automation and start thinking what information is available for their calculation. In those countries where explicit demand response wanted to be tested, the appropriate tools to connect to the electricity market platforms were developed in T2.4, and the mirroring of those markets is explained here.

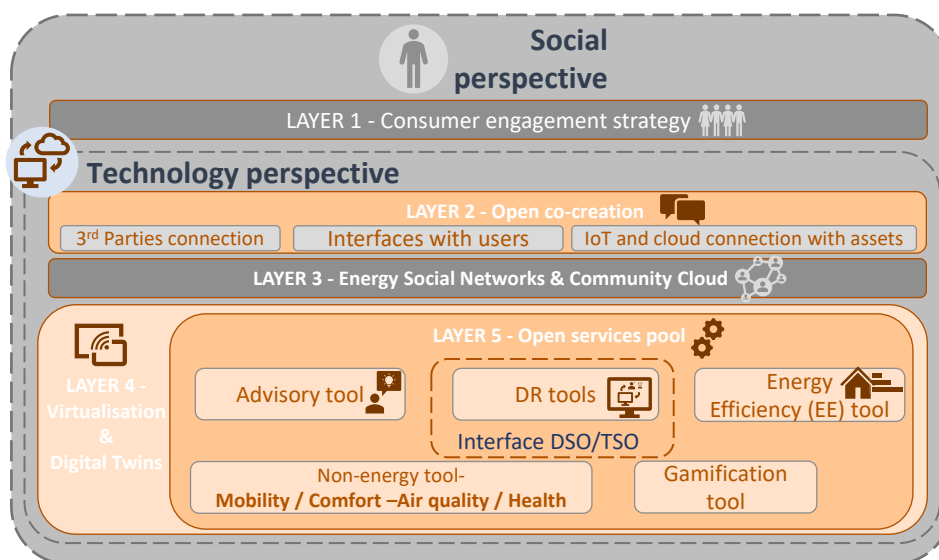


Figure 1 Main layers affected (coloured ones) in this deliverable

In this deliverable, the structure of the simulation of physical devices can be found in section 2. Afterwards, different simulations are explained in section 3. Thermal behaviours are addressed in section 3.1, and Hot Water modelling is located in section 3.2. Then, RES production, which is solar production, is explained in section 3.3. Afterwards, section 3.4 presents the modelling of the Electric Charging Posts, non-manageable demand described in section 3.5 and markets are mirroring is defined in section 3.6. Then, the internal process to create virtual users in section 4 and how the simulation is deployed is explained in section 5.



2. Prosumers simulation

The simulation of prosumers refers to the simulation of virtual simulated boards and devices of each virtual prosumer. It is done under the prosumers simulation service that is executing 24 hours as an independent service in a Google server.

The concept of a virtual board is a digital twin of a real physical board. As such, the behaviour of a virtual board is the same as the physical one, using the same procedures and communication protocols. Each board communicates with the ecosystem and runs the control for every device associated with the board.

The service is structured in three main parts that interact with each other:

1. Platform simulation
2. Prosumer simulation
3. Board simulation

Figure 2 is a diagram of how the prosumers simulation service is structured. The different parts are explained in detail in the following sections.

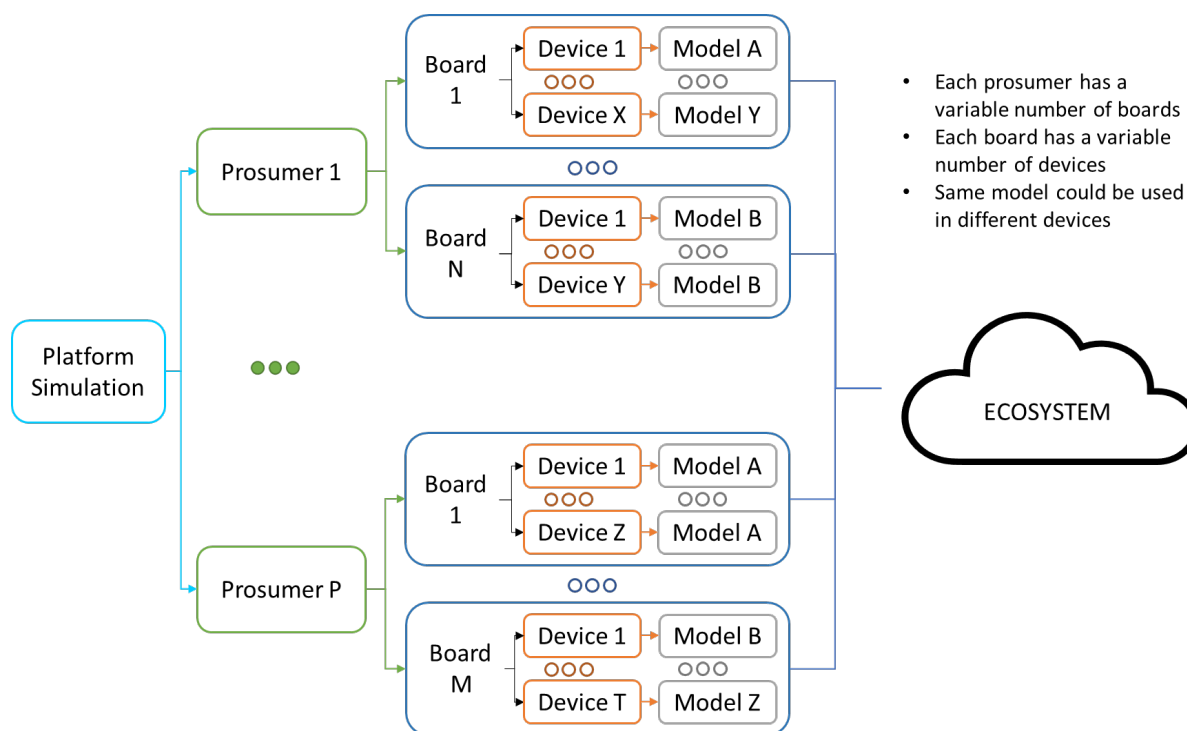


Figure 2 Prosumers simulation diagram

2.1. Platform simulation

The simulation platform represents the entry point of the program. It reads the credentials and communication parameters necessary for requesting data to the ecosystem, as well as reads specific simulation filters to customise the prosumers and board types that the service simulates.

It requests, every five minutes, all virtual simulated boards to the ecosystem. Each board is associated with a prosumer that is also requested to identify all prosumers that need to be simulated. At last, it executes the simulation of every prosumer with at least one virtual simulated board or stops the prosumer simulation if the prosumer no longer requires to be simulated.



2.2. Prosumer Simulation

The prosumer simulation receives the virtual simulated boards associated with them every five minutes from the platform simulation. Each prosumer simulation also requests to the databases the necessary prosumer data for simulation, such as the associated energy consumption behaviour profile or installation power and extra physical model parameters for each technology.

Once it has all the required data, the prosumer simulation then distributes the data among all the virtual simulated boards. Finally, it executes the simulation for each board or stops it when the board is no longer received.

2.3. Board simulation

As virtual simulated boards are digital twins of hardware boards, the board simulation recreates and models the behaviour of a physical board. There are four main structures under the execution of a board:

- a) the communication layer with the ecosystem.
- b) The device layer represents each device of a board.
- c) An interface between each device and physical model.
- d) The physical model itself.

The communication layer manages the communication between the board and the ecosystem with the same structure and protocols as the real hardware boards do. This is a full-duplex communication as boards send measurements to the ecosystem, and the ecosystem sends orders and other information coming from the App, web or from other external sources.

According to the information received by the prosumer simulation, each board knows the number of devices and their types to be executed. The board simulation runs over all its devices and executes their controls every five seconds.

Every device type has its own control, but they all need information from the physical model. Instead of requesting it directly from the physical model, there is another layer called the interface between the device and the physical model. The aim of this layer is to make the control agnostic of the physical model that is behind it, allowing multiple physical models and different ways to get the physical information required by the device control. Regardless of the difference between each control, they all follow the same structure:

- Update physical model state.
- Request control inputs to the physical model through the interface layer.
- Check for new information received through the communication layer from the ecosystem
- Execute control logic.
- Propagate control outputs accordingly.
- Update variables values so the communication layer sends them to the ecosystem according to each variable sampling time.

At last, there is the physical model for each technology. The state of the physical model is updated on every execution of the device control, which is every five seconds.



3. Simulation Types

Main consumption and production types that can be found: Thermal consumption (heating, fridges, refrigeration), Hot Water, RES production, Electric Vehicles, or Non-manageable energy. All these simulated devices have the variables indicated in D1.6. Main inputs and outputs are highlighted here where an example of the measures of a virtual device of each type is shown.

3.1. Thermal Simulation

The behaviour of the physical system of a heating space must be correctly modelled to ensure thermal comfort and optimise the available resources at the same time. It will be explained for the heating system in a building, but other thermal consumption can be represented in a similar way.

Inputs:

- Ambient temperature
- Parameters of the house: isolation level and volume of the household
- Thermal heat: heat input to the building
- Device Mode (Off, Manual, Programmed, Automatic)
- Consumption mode (Cooling, Heat)
- Orders from the cloud (from services or from users)
- References of the device

Outputs

- Indoor Temperature
- Consumption action
- Electrical Power

The objective of the thermal simulation is to test new developments and their performance with different thermal requirements and profiles. Simulation uses a thermal model for each simulation. To obtain realistic thermal behaviours, a random location is given for each simulation to obtain real outdoor temperatures for the thermal model. In addition, a logic should be implemented to represent the hysteresis behaviour of this type of consumptions.

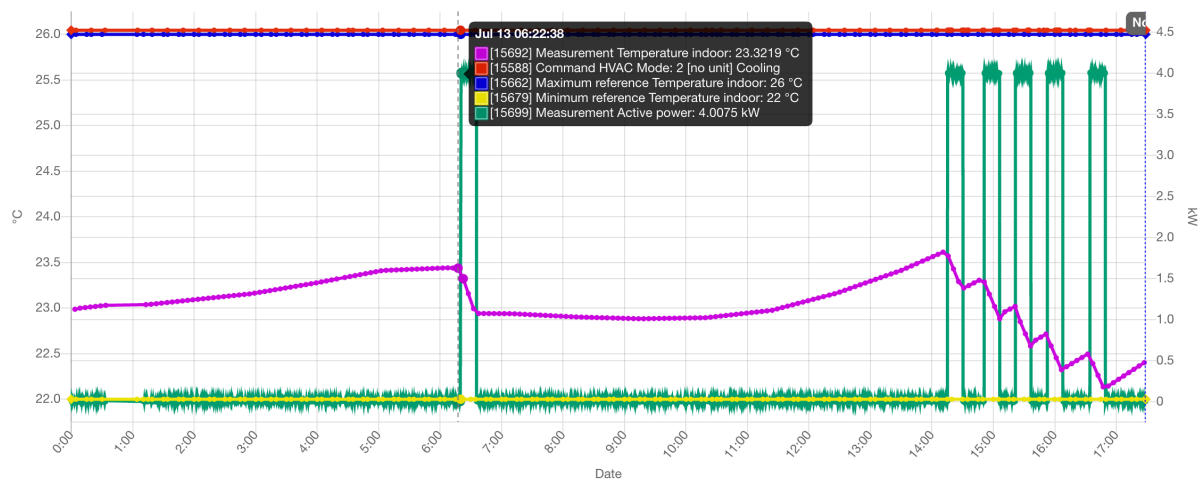


Figure 3 Measures of a virtual heat pump



3.2. Hot Water (HW) Simulation

The behaviour of the physical system of a HW system must be correctly modelled to ensure hot water availability and, at the same time, optimise the available resources. Moreover, thermal power demand must be obtained to correctly estimate the energy stored in the system. To minimize installation cost, this is done with indirect measurements where the thermal energy demand is detected and estimated.

Simulation uses a HW thermal model with different parameters for each simulation to add variability. To test different scenarios, different thermal demand profiles, tank sizes and cold input water temperatures are generated.

Inputs:

- Parameters of the tank: Volume, cold input temperature, power...
- Thermal heat demand: usage profile of hot water.
- Device Mode: Off, Manual, Programmed, Automatic
- Orders from the cloud (from services or from users)
- Schedules of the device (user preferences for consumption)

Outputs:

- Tank Temperatures
- Electrical Power
- Energy stored in the tank as SOC variable.

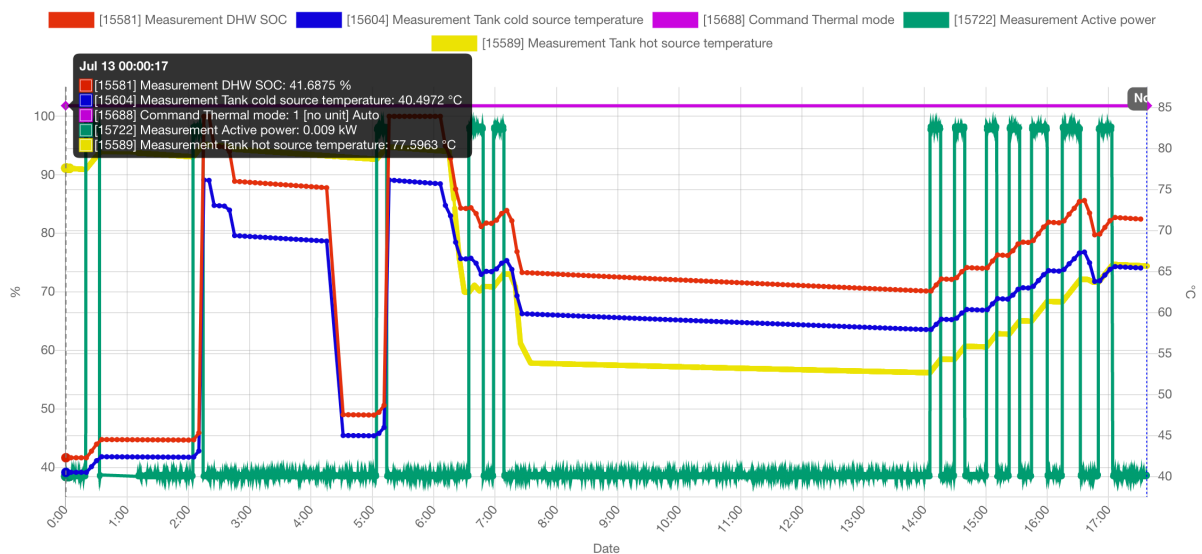


Figure 4 Measures of a virtual hot water tank

3.3. Solar Simulation

The behaviour of photovoltaic panels is simulated separately for each of the consumers with such technology installed. If a board for a virtual PV system has been assigned to a consumer, the control system of such board will launch a simulation thread on a 5-seconds basis. The aim of the simulation task is to obtain the electricity generation [kW] of the virtual device according to the global irradiation available.



The simulation thread will use the available data of:

- The hour global irradiation is calculated as a weighted sum of the interpolated hourly global irradiation and the interpolated value of the global irradiation from the predicted data series.
- The predicted data series of the global irradiation
- the characteristics of the virtual PV system, such as the nominal power installed and the system losses
- The maximum global horizontal irradiance.

The expected data of this device is:

- The electricity generation.

A random error in the range of 0-1% is applied to obtain the final value of the electricity generation.

$$err = (rand \% 2000 - 1000) / 100000$$

$$Final\ kW = kW * (1 - err)$$

rand is a pseudo-random integral value between 0 and 32767.

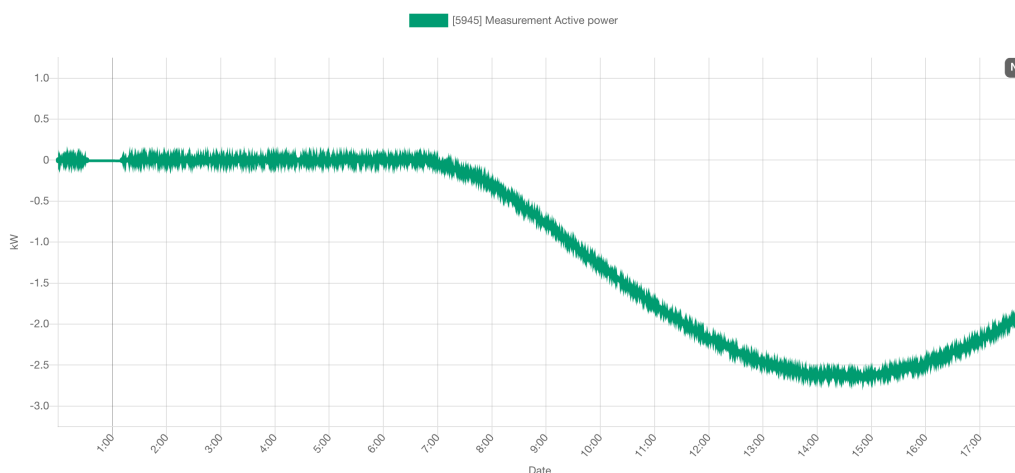


Figure 5 Measures of a virtual PV panel

3.4. Electric Charging Post (ECP) Simulation

The simulation of EV charging is essentially equivalent to the simulation of an electric battery. Instead of having just a battery model, the simulation of electric vehicle charging uses a model for the ECP itself and another model for the EV. Splitting the simulation into two models facilitates the necessary flexibility to recreate real EV charging scenarios where multiple EV's can be connected to a single ECP with multiple connectors (EVSE).

Inputs:

- EV Connection
- Parameters of the charging post: kW and EV connectors
- Device Mode: Off, Manual, Programmed, Automatic.
- Orders from the cloud (from services or from users)
- Schedules of the device



Outputs

- SOC of the EV connected
- Electrical Power
- EV Status of the OCPP protocol (Available, Charging...)

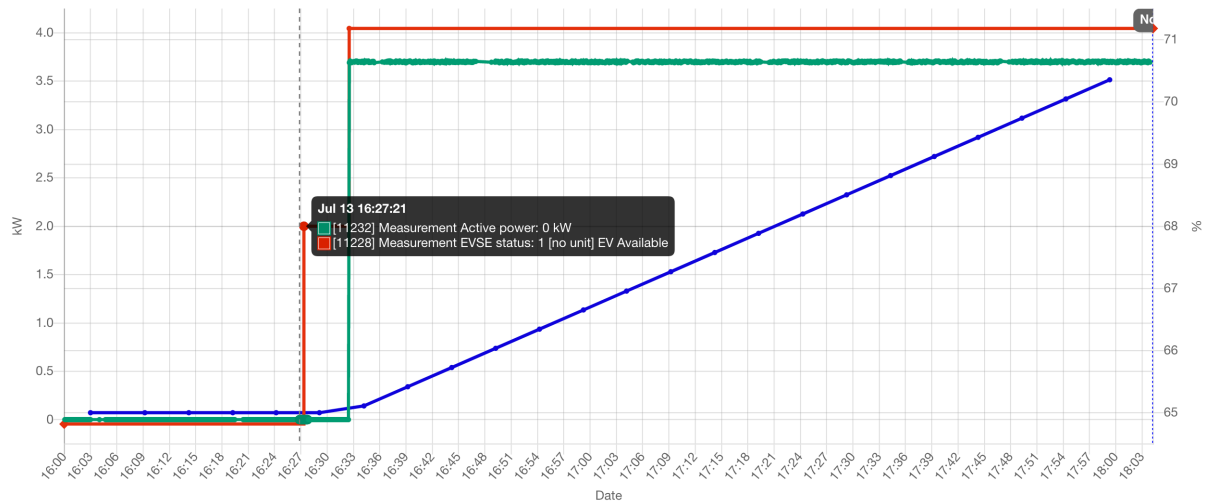


Figure 6 Measures of a virtual EV Charging Post

3.4.1.1. EV simulation

The EV is considered as a battery with maximum energy stored equal to the EV capacity and the maximum charging and discharging given by the EV specifications. The inputs for the EV simulation are:

- P_{elect} is the electric power input into the system. A positive value in the case of charging and negative when discharging.
- P_{losses} is the electric power lost into the environment as thermal energy and inefficiencies.

The output will be state of charge of the battery is defined as:

$$SOC = \frac{\text{Energy stored in kWh}}{\text{Energy Capacity in kWh}}$$

Additionally, the EV needs to simulate the distance covered in kilometres according to weekly profiles that are read from the database. These profiles vary depending on the prosumer behaviour type and the type of prosumer. The distance profile is used to reduce the state of charge of the battery when the EV is not connected to a charger. The reduction is made only when the EV connects to a charging post with the total estimated distance.

Finally, there is a connection profile to simulate when the EV is connected and for how long to a charging post. Again, the connection profile is a weekly profile read from the database and differs for each prosumer according to the prosumer behaviour type and type of prosumer. The different profiles have been defined according to different studies about the frequency of recharging by user type [1].

3.4.1.2. Charging post simulation

ECP simulation considers that the EV is plugged into a charging post. There is no direct communication between the virtual simulated board and the EV, as with the hardware boards. The communication is done with the charging post model. The charging post model detects when there is an EV connected to one of its EVSE and updates the charging post status internally. The status values are based on the OCPP 1.6 protocol [2]:



- Available
- Preparing
- Charging
- Suspended EV
- Suspended EVSE
- Finishing

It receives the charging power order from the device control and distributes it among all the connected EVs, as well as stores all intermediate calculations such as total charging session energy consumed. When the device control requests the necessary variable values, it is the charging post model that answers with the current model state values of the charging post and the EV model (SOC).

Finally, the charging post model also creates in the ecosystem the EV charging connection when it detects a new EV plugged in, equivalent to what a user has to do with the App to establish a charging session.

3.5. Base demand Simulation

The simulation of this kind of consumption is straightforward. There are representative consumption curves obtained from real users per each type of day.

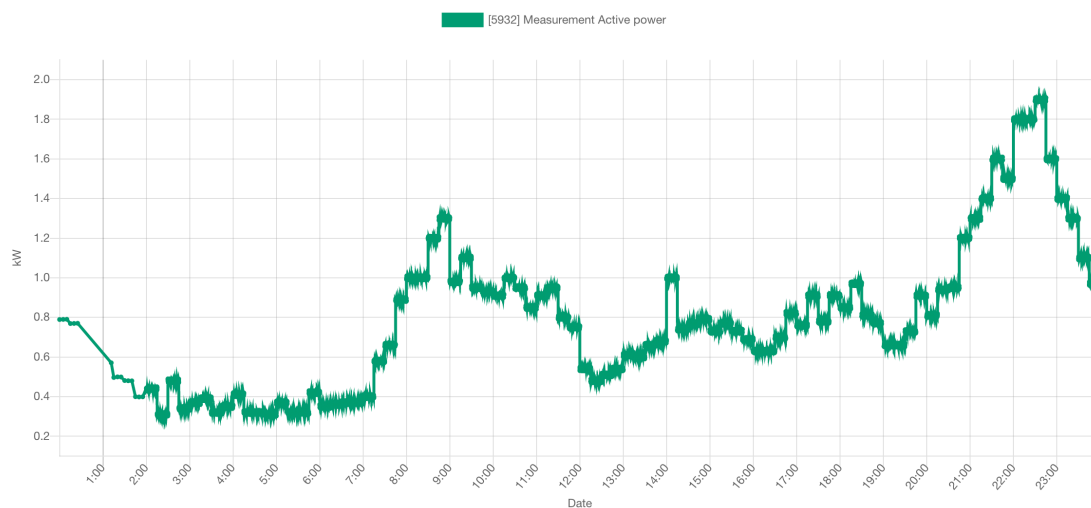


Figure 7 Measures of a virtual smart meter

3.6. Market Simulation

The different market has been reviewed in D1.3 and D2.5: a) Energy Markets and b) ancillary and local flexibility markets. Energy markets at the retail level are the ones that end-users are currently used to them. However, national and local flexibility markets have strong requirements that make the simulation of this market the only option for the project to study their behaviour. The requirements include the minimum amount of power and recognition of new actors such as aggregators that allow demand to participate in markets. These and other requirements were reviewed in D1.3).

Since not all markets are opened yet, three markets were decided to be mirrored:



- National Ancillary markets: Spanish automatic frequency restoration reserve (aFRR) or Secondary Market.
- Local congestion market: British study case from a WPD initiative to solve constraints on the electricity distribution network.
- Local Flexibility Markets: OMIE is developing this market (IREMEL), and tests could be done taking advantage of their role as partners. However, this market was still being developed at the time this deliverable was done.

3.6.1. Spanish aFRR

In general, aFRR has to be fully activated within 5 minutes and maintained for up to 15min. This service is paid through market mechanisms for two concepts: availability (regulation band) and use (energy):

- Reserve assignation price [€/kW]: the regulation band is remunerated as the result of the marginal cost. It is an availability payment for being ready to act.
- Effective net energy [€/kWh]: aFRR energy is used because of the real-time monitoring of the regulation requirements. This energy is valued at the marginal price of the manual frequency restoration reserve that would have been necessary to program each hour, both to go up and down, to replace this net use of aFRR energy.

The information on requirements, activations and prices are published in ESIOS [3] and obtained as explained in D2.5. Using this information, different forecasts can be determined:

- Availability and Usage Prices: Hourly prices can be estimated to be able to determine the available and profitable flexible demand and their location on time. This is what is used in the demand response algorithm explained in D3.3.
- Real-time simulated activations: Using the past data of activations and requirements, real-time signals can be created for this purpose. This is what is used to simulate the behaviour of this market.

Thus, Activation of the markets is sent to all participants proportionally to their commits. For this reason, the activation signal that emulates the market is calculated as commits decided/accepted by the demand response algorithm and the last week's activations.

In addition, this market simulation has the option to send several activations (one per minute) to represent noise in the activation signal.

3.6.2. Flexible Power - WPD Market

In short, Flexible power is an initiative by five British Distribution Network Operators (Western Power Distribution, Northern Powergrid, Scottish and Southern Electricity Networks, SP Energy Networks, and Electricity North West) to procure flexibility from customers in order to avoid constraints in distribution networks using assets at all voltage levels. Flexible power uses a customer-facing portal in which Flexibility Service Providers (FSPs) can declare their flexible assets' availability, receive dispatch signals, and view performance and settlement reports. This portal is based on API communications that allow its simulation. This market was extensively explained in D2.5.

FSP declares availability on the Flexible Power portal by midnight on Wednesday to offer flexibility. On Thursday morning, offers are accepted or rejected by the DNOs. The following figures show how availability and acceptance appear in the Flexible Power portal:



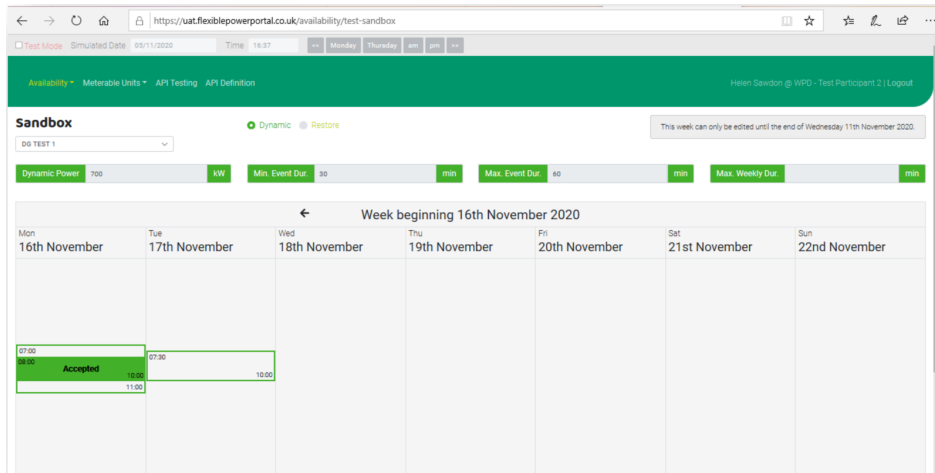


Figure 8 Definition of flexibility availability (green edge of the rectangle) and accepted flexibility in the Flexible Power portal.

3.6.2.1. Activation service

This market is based on API communications:

- *Dispatch/start*: activation requests from WPD when the client should start to change its consumption.
- *Dispatch/stop*: requests from WPD when the service should finalize.
- readings:
- stop

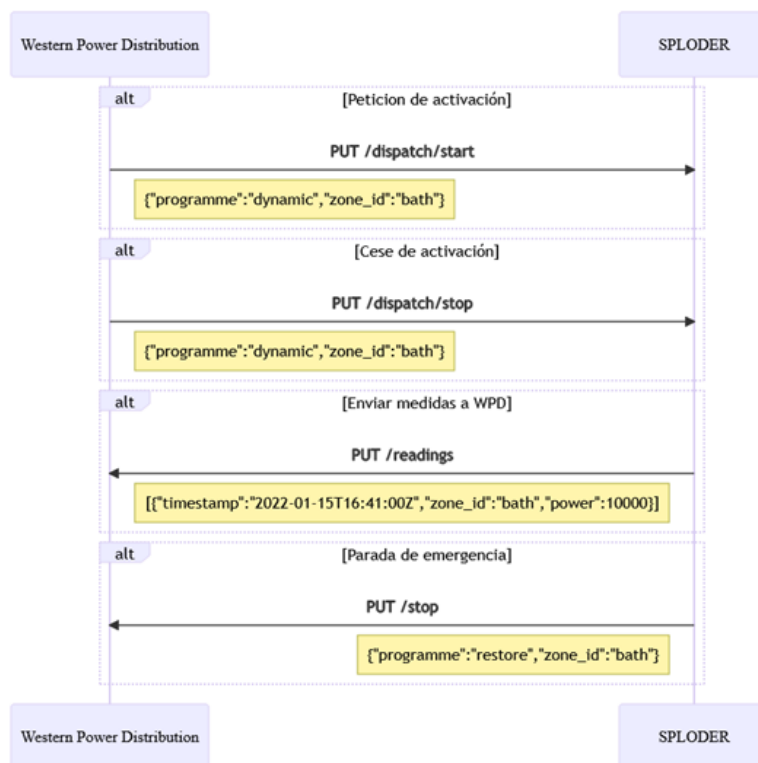


Figure 9 API of the WPD market to start and stop the service

The local constraint network is based on data (Table 1) about this market from the MADE project developed during the last years [4]



Table 1 MADE project data to study the WPD market

Scenario	DSO Service	Tender success rate	Utilization probability rate
Narrow (15h-19h)	Secure	75%	100%
Narrow (15h-19h)	Dynamic	75%	80%
Wide (8h-21h in summer and 7h-19h)	Dynamic	75%	20%



4. Create virtual prosumers

The creation of each virtual prosumer fulfils a testing purpose or scenario recreation. For this reason, each virtual prosumer is highly customizable to be as precise as possible to reality. Every virtual prosumer has the same characteristic fields and behaves the same way inside the system as a real prosumer. However, it also has some extra parameters to simulate the way the virtual prosumer is going to behave. The desired total installed power for each technology and some extra information necessary for each model. This total prosumer information is necessary to distribute the parameters among all the simulated devices.

There is an internal-only webpage to simplify the creation of simulated prosumers with the most important parameters such as the location, building information, prosumer behaviour, electric tariff or the installed technologies and number of devices (Figure 10, Figure 11 and Figure 12). It also allows creating multiple prosumers with the same characteristics in one go.

Creating virtual prosumers this way also creates all the necessary information in the system as well as subscribes to the required services according to the selected technologies and prosumer behaviours. If, for example, the created prosumer only has an electric vehicle charger, the creation process additionally creates an electric vehicle with the characteristics set at building information, assigns the required profiles considering the prosumer behaviour and subscribes to all-electric vehicle charging necessary services.

Simulated prosumers creation panel

Country


Aggregator id

Status Agent ID

Agent Sector

Number of simulated prosumers to create

Location



The map shows a geographical view of Europe and its surroundings, including parts of North Africa and the Middle East. Major cities and countries are labeled, such as London, Paris, Berlin, Rome, and Istanbul. A search bar is located in the top left corner of the map area, and there are zoom in (+) and zoom out (-) buttons.

Figure 10 Virtual prosumer creation panel. General and location information



Building information

Building type: Building efficiency - *Optional*:

Building surface area:
Enter building's useful surface in m²

Power & Tariffs

Power limit:
Enter your current power limit in kW

Your current tariff:
Enter useful surface in m²

Prosumer behavior type:
Select your prosumer behavior

Figure 11 Virtual prosumer creation panel. Building and power tariffs information

Devices

Ampere

Number of boards:

Volta

Number of boards: <input type="text"/>	Building info PV power: <input type="text"/>	Building info Battery capacity: <input type="text"/>	Building info Battery discharging power: <input type="text"/>	Building info Battery charging power: <input type="text"/>
--	--	--	---	--

Kelvin

Number of boards:

Watt

Number of boards: Building info Radiator power:

Watt DHW

Number of boards: <input type="text"/>	Building info DHW cylinder power: <input type="text"/>	Building info DHW capacity(L): <input type="text"/>
--	--	---

Carrier

Number of boards: Building info Cooling power:

Anderson

Number of boards: <input type="text"/>	Building info Total EV capacity: <input type="text"/>	Building info CP discharging power: <input type="text"/>	Building info CP charging power: <input type="text"/>
--	---	--	---

Figure 12 Virtual prosumer creation panel. Devices management.



5. Execution of the platform tool

The services of each ecosystem will be connected through Kernel to carry out the required communications in a safe way. Context Broker, Schedulers and Orchestrators allow the coordination of the services.

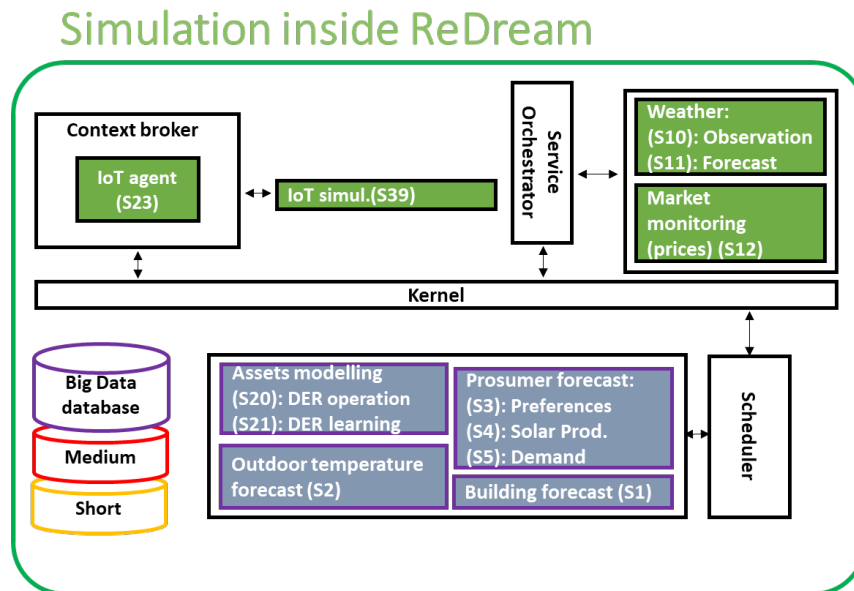


Figure 13 ReDREAM Simulation and related services

As stated in D2.1, there are four ReDREAM ecosystems (one per demo) to avoid the possibility of a full services downtime in all demos when an error or a maintenance action is taking place. They are deployed in a google server as independent services, and services have four instances using in each of them a specific database per ecosystem.





 Stemy Simulation Croatia	Board simulation for redream Cr...	Running	Automatic (D...	Local System
 Stemy Simulation Italy	Board simulation for redream Italy.	Running	Automatic (D...	Local System
 Stemy Simulation P1	Stemy Simulation P1.	Running	Automatic (D...	Local System
 Stemy Simulation Spain	Board simulation for redream Sp...	Running	Automatic (D...	Local System

Figure 14 Example of deployed services

As can be seen in the image, the services are Automatic. This has been set to guarantee that once the machine starts, the services are executed. This is very useful to avoid down states after automatic updates. In general, all the services are prepared to receive some incoherence in the input data that can produce an error, making a warning in the logs but continuing working. In this case each of the simulation service communicates through the internet with the platform located in the same machine using the same ports that physical devices.



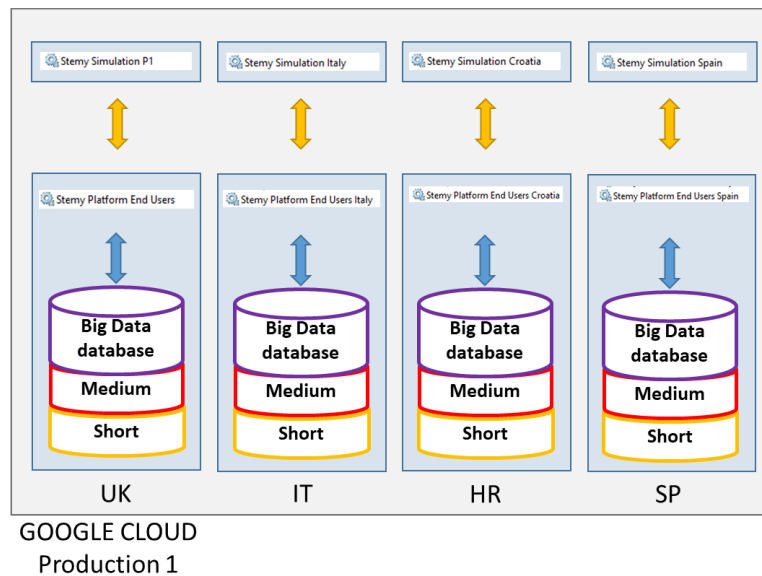


Figure 15 Clouds deployment of services

These services need to have some configuration files established in a file called config.ini with:

- Database Information: hostname, username, password, schema

```
[database]
hostname = |
username =
password =
schema =
```

- Logs preferences: security level, directory route, maximum file size, maximum directory size, the maximum number of files...

```
[[database]
security_level = info
directory = logs/database
rotation_file_size_mb = 10
directory_limit_size_mb = 100
directory_max_file_number = 10
instant_writing = false
console = false
```

- Other info: options of a service...

-

```
[simoptions]
#PROSUMER
prosumers=
prosumersOperator=

#BOARDS
boards=
boardTypesList=

[boardlogoptions]
#PROSUMERFILTERS
prosumerFilterType=
prosumersList=
```



Different virtual users have been created to test ReDREAM services. For instance, in the Italian platform.

ID	FULL NAME	TYPE	REGION ID	ADDRESS	MARKET VARIABLE ID	MAX POWER	ACTIONS
2	Filippo Moretti	Virtual	20000		264	3.5000	
3	Camilla Moretti	Virtual	10000	Via Cassia, 1286 00189 Roma RM Italy	265	3.5000	
37	Matilde Leone	Virtual	20000		265	8.0000	
38	Vincenzo Barbieri	Virtual	20000		265	8.0000	
39	Margherita Marini	Virtual	20000		265	5.0000	
40	Alessia Russo	Virtual	20000		265	5.0000	
41	Viola Mariani	Virtual	20000		265	5.0000	
42	Filippo Caruso	Virtual	20000		265	4.5000	
43	Daniel Costa	Virtual	20000		265	4.5000	
44	Francesco Ferri	Virtual	20000		265	4.5000	
First Previous 1 2 Next Last							
44	Francesco Ferri	Virtual	20000		265	4.5000	
45	Abramo Fabbri	Virtual	20000		265	4.0000	
46	Giovanni Martinelli	Virtual	20000		265	4.0000	
First Previous 1 2 Next Last							

Figure 16 Example of virtual users in the Italian platform

We have created different typologies of clients (Figure 17) in all the platforms to create different types of clients. In Figure 18 and Figure 19, the measurements created by the simulation services for a client are shown.

✓	✓	✓	✓	✓	✓
✓	✓	✗	✓	✓	✗
✓	✓	✗	✓	✗	✗
✓	✓	✗	✗	✗	✗
✓	✗	✓	✓	✓	✗
✓	✗	✓	✗	✗	✗
✓	✗	✗	✓	✗	✗
✓	✗	✗	✓	✗	✗
✗	✗	✓	✓	✓	✗
✗	✗	✓	✗	✓	✗
✗	✗	✗	✓	✗	✗
✗	✗	✗	✓	✗	✗
✗	✗	✗	✓	✓	✗
✗	✗	✗	✓	✓	✗
✗	✗	✗	✗	✗	✓
✗	✗	✗	✗	✓	✗
✗	✗	✗	✗	✗	✓

Figure 17 Typologies of virtual users



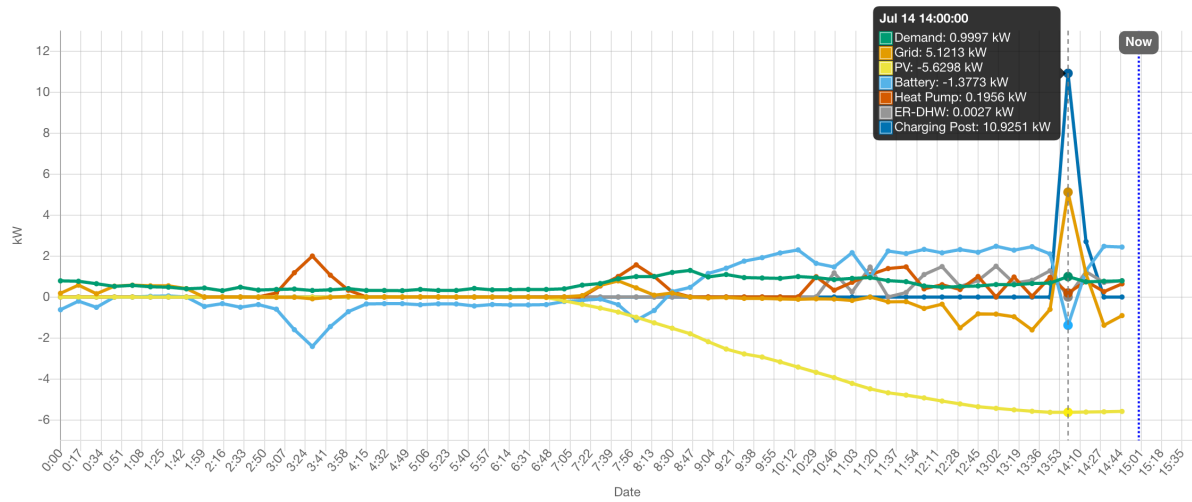


Figure 18 Example of a virtual user with PV panels, hot water, batteries, and HPs (id 3 in Spanish Ecosystem - 14 July)

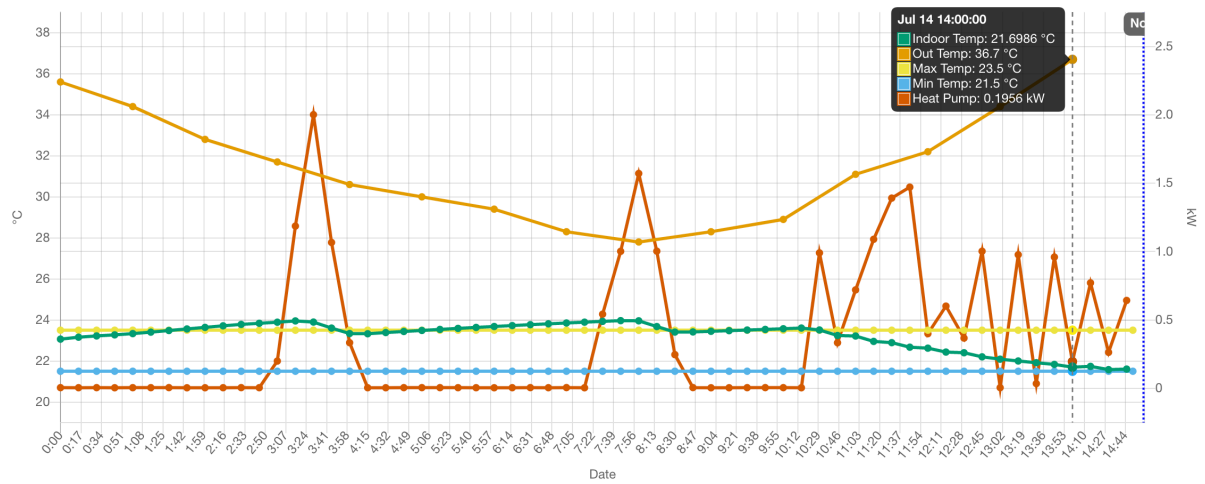
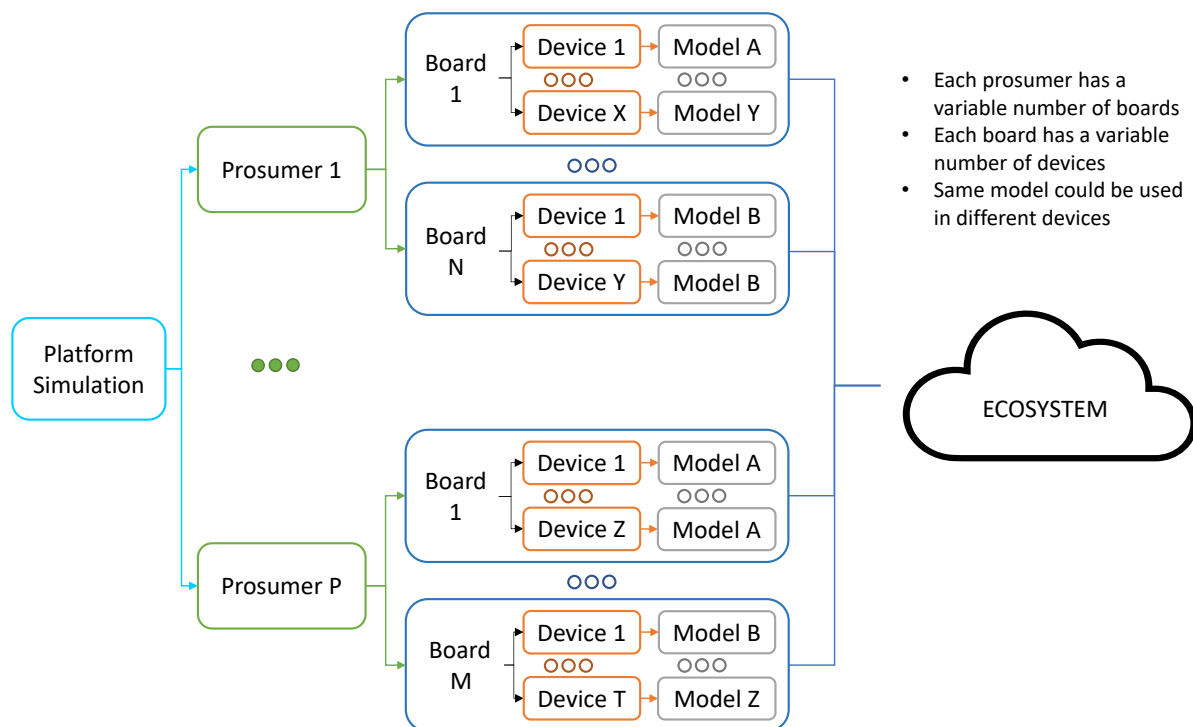


Figure 19. Example of heating performance of virtual user id3 in Spanish Ecosystem - 14 July



6. Conclusion

The capability of having twins of real users enables developers to test new algorithms and new developments with them. The simulation of prosumers considers virtual simulated boards and devices of each virtual prosumer that use the same communication channels as the real equipment. Four deployments, one per each of the platforms has been developed. Simulating different devices for different virtual users. The virtual device (asset model) uses a physical model to consider the outer conditions (building performance and prosumer preferences) and the physics related to its consumption. This simulation uses different data to obtain the next measurement for the device. In a similar way, markets could be mirrored using the communication channels that a real one would use. This was originally thought in the proposal to test the demand response in those markets where regulations have not been open to the demand during ReDREAM period.



In this deliverable, the different simulations for the main consumption types that can be found: Thermal consumption (heating, fridges, refrigeration), Hot Water, RES production, Electric Vehicles, or Non-manageable energy. How simulations are deployed is also explained. Thanks, the execution during ReDREAM project, all these services are evolving to pre-commercial functionalities reaching TRL7 (services starting at TRL5 and 6) and TRL8 (services at TRL7), since the complete platform is being validated in a fully multi-consumer operational environment.



7. References

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