Orchestration of Renewable Integrated Generation in Neighbourhoods

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D5.8 Options for installing the ORIGIN intelligent energy management architecture

WP5 - Deployment and Validation of the ORIGIN Energy Control and Orchestration Algorithm

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ORIGIN	WP5 - Deployment and Validation of the ORIGIN Energy Control and Orchestration Algorithm
Deliverable	D5.8 Options for installing the ORIGIN intelligent energy management architecture

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1. Introduction

This deliverable intends to present some of the possible options for installing the Origin system with different alternative architectures. The existence of alternative options for the Origin system are intended to make the system adaptable to a set of deployment scenarios with different demands in terms of financial budget and optimization objectives. The proposed architectures present the scalability characteristics of the original Origin system and are suitable for communities of a wide range of sizes. Like the original Origin architecture, the proposed alternative architectures are also suitable for communities independent of their climate or their energy mix.

Deliverable 8.3 – Replication Pack gives a flowchart of the process a community would go through to assess which scenario might be best for them.

In summary, the main objective of this document is to demonstrate that the Origin platform can be easily tailored to the specific needs of each potential community, minimizing any burden that may influence negatively the adoption of the system by the community.

2. Architecture modules

To simplify the presentation of the distinct scenarios, the Origin architecture has been split into macro functional modules. The scenarios presented later in this document make use of the modules described in this section, using them as building blocks, with minor adjustments to fit the chosen overall deployment scenario. As building blocks, they can be physically implemented in many different final hardware configurations depending on the requirements. All these ORIGIN components are grouped into two main blocks: **Field Devices** and **ORIGIN CEMS** (*Community Energy Management System*).

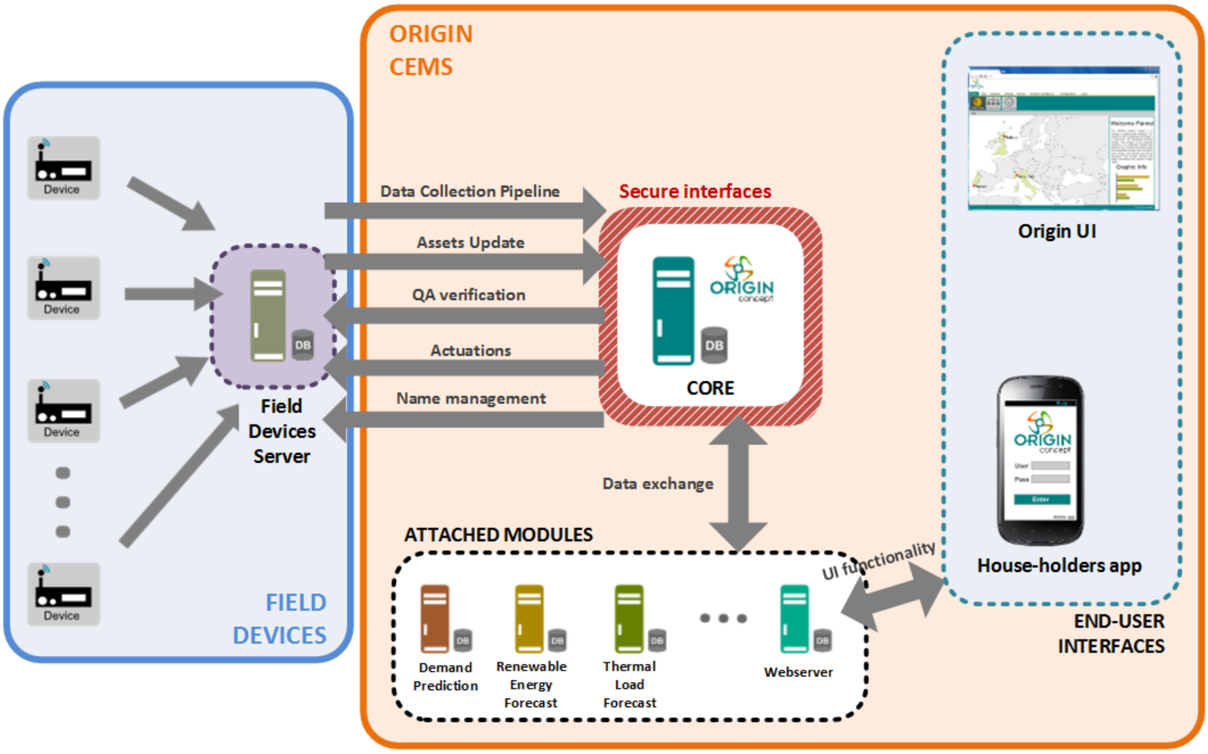

Figure 1 - ORIGIN platform high-level architecture

2.1. Field Devices block

This block includes all the devices installed in the field to monitor/control the community; the communications and integration architecture; and the Field Devices Server, which manages and reads them.

The Field Devices Server is the first step in this architecture and requires a high level of management effort. Every new device, architecture change, modification of parameters or device error is managed from here, so although it can be managed internally by the communities, it is highly recommended to outsource this server to a professional consulting office. ISA offers very competitive prices for managing this server, with a pricing plan based on the number of installed hubs.

For the field devices, there is a basic or a more advanced monitoring option

Basic monitoring module

The basic monitoring module aims to provide the most basic electrical consumption data to the system. This module should measure the global (i.e. total) consumption of each community dwelling or public building independently. It is also possible to measure two additional electrical circuit consumptions along with the global consumption with a minor cost increment (cost of two additional current transformer clamps).

In some cases, depending on the electrical installation, this basic monitoring system can also provide information about the generation of small RES systems such as PV systems or wind micro-turbines. The maximum output current that can be measured by the basic monitoring module must not exceed 50A AC.

This module can be seen as a stripped down and low cost version of the advanced monitoring system, which can be easily deployed at every dwelling or building in a community.

The basic monitoring system internal layout is shown on Figure 2. This layout is composed of the following hardware components:

- Field Devices Server (Origin data server in figure 2) – This component is installed on the cloud level (i.e. not at the community level) and acts as a data storage for the collected electrical measurements. This component presents an interface for other modules to fetch data from it.

- Cloogy Hub – For coordinating the sensor network and interfacing between the sensors and the data server of the system; this component communicates with the sensors using a Zigbee interface and with the Data Server using a wired Ethernet interface;

- Cloogy Transmitter – For collecting electrical consumption data by measuring the current on the electrical wires where clamp are placed;
    - One Cloogy transmitter clamp for monitoring of the main feed-in electrical circuit
    - Up to two optional transmitter clamps for monitoring of alternative electrical circuits

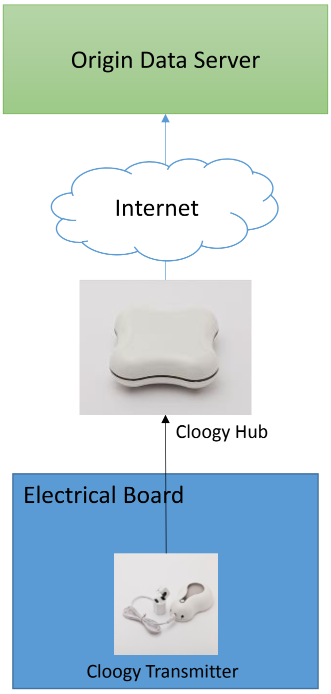

Figure 2 - Basic Monitoring Module Layout

The requirements for installing a basic monitoring module in a community are:

- Availability of a wired internet connection point (Ethernet RJ45 format plug) in every point where a Cloogy Hub is installed.
- Possibility to fit a transmitter and clamp(s) on the electrical board of each monitored dwelling or building

The basic monitoring module is capable of providing the following basic electrical consumption measurements:

- Measurement of the total consumption of each monitored dwelling or building of the community
- Possibility to measure up to two additional electrical circuits on each monitored dwelling of the community
- Possibility to measure the electrical generation of a micro-PV or micro wind turbine installed on the dwelling or community building.

Advanced monitoring module

The advanced monitoring module provides the most complete and reliable information on energy consumption, generation and status of a dwelling or building to the Origin system. By using this module, the Origin overall system has the best knowledge of the status of each individual site where the module is installed and thus gives the best optimization response possible, as not only the electrical profiles (generation and demand) but also the comfort levels presented to the dwelling/building occupants can be considered. This module also permits the Origin system to consider the real available thermal inertia on thermal accumulators and of the building itself. This module is the one used in the three Origin pilot sites.

This module makes use of not only the Cloogy solution, most suitable for dwellings, but also the iHub based solution, suitable for the larger community buildings and larger renewable generation systems such as PV systems, wind turbines, thermal-solar systems, biomass boilers or others.

Despite this module being complex and capable of collecting data from multiple sources, it can be stripped-down and tailored to the needs of each specific monitoring site of the community even some of the monitoring sites can be fitted with the same solution as presented in the simple monitoring module. The decision on which components will be installed in each site is based on the information collected during the community audit phase. The audit phase procedure is described in detail in deliverable D8.3 and D1.1.

Some of the components used in this module, such as the Cloogy plug or the I/O module, can be used not only to monitor but also to perform actuations. The actuations can be used to implement automatically the optimizations provided by the optimization module of the Origin system.

The full details of the advanced monitoring module are described in detail in deliverable D2.1 of this project. Although a large set of monitoring devices is described as components of the module, this set is not limited and can be extended if needed with new monitoring device types. The following list summarizes the hardware used in this module until now in the Origin project pilots:

- Field Devices Server (Origin data server in figure 3) – Similarly to the Field Devices Server component in the simple monitoring scenario, this component is installed on the cloud level (i.e. not at the community level) and acts as a data storage for the collected electrical measurements. This component presents an interface for other modules to fetch data from it.

- Dwelling solution
    - Cloogy Hub – Like the Cloogy hub used in the simple monitoring scenario, this component is used for coordinating the sensor network and interfacing between the sensors and the data server of the system; Unlike the hub used in the simple scenario, in the advanced monitoring module, this device contains an additional radio transceiver for communicating with devices using the 868 MHz ISM radio frequency. This component communicates with the sensors using a Zigbee interface or 868MHz radio interface and with the Data Server using a wired Ethernet interface;

    - Cloogy Transmitter – For collecting electrical consumption data by measuring the current on the electrical wires where clamp are placed (similar to the simple monitoring scenario);

    - One Cloogy transmitter clamp for monitoring of the main feed-in electrical circuit
    - Up to two optional transmitter clamps for monitoring of alternative electrical circuits

  - Cloogy Plug – For collecting electrical consumption data of an appliance. It is placed between the electrical socket and the plug. This device can also actuate and cut the electrical supply to the appliance;~

  - iPointTH – This device measures the air temperature and relative humidity. It can be used to evaluate the comfort level of a dwelling;

  - iPointCO2 – The iPoint CO2 measures the CO2 concentration in the air. It can be used to evaluate the comfort level or indirectly the occupancy of a space;

  - MBus Gateway – This device is used to read data from MBus devices such as heat meters. Heat meters can be fitted as example on thermal storages, thermal solar panels or other to measure the house thermal production and consumption;

  - RTU TriTemp – The RTU TriTemp can be used to measure temperatures on three points. Commonly, this device is used to measure temperatures at distinct levels of thermal storages or refrigerators/freezers;

- Community Building Solution
  - iHub – This component has similar functionalities to the Cloogy Hub but presents a different format, suitable to be installed inside electrical boards, and different interfaces with the monitoring devices. The iHub is capable of communicating with devices using a Modbus line (over RS485) or a 868MHz radiofrequency;

  - Electrical Meter – The electrical meter is used to measure consumptions on electrical circuits. The most common electrical meters are capable of measuring 3 phase circuits and communicate with the hub using the Modbus interface;

  - iPointTH – Similarly to the Cloogy iPointTH, this device measures the air temperature and humidity;

  - iPointCO2 – This device measures the air CO2 concentration, as the Cloogy iPointCO2;

  - ADFWeb MBus to Modbus – This device makes possible the reading of MBus devices such as the heat meters by the iHub;

- I/O Module – The I/O module can be used to read any digital or analog variable, such as the temperature provided by an analog temperature probe. If the device is fitted with output interface, it can be used to actuate on other devices.

- Other devices – The iHub solution can easily interface with other 3rd party devices such as high voltage electrical meters or district heating boilers.

In addition to the dwelling and community building monitoring, this module also includes the possibility of installation of a local weather station. The weather station represents an important asset to improve the quality of the weather prediction algorithms, resulting in a better prediction of the renewable energy generation and consumption predictions. A simple weather station capable of measuring the following variables is usually sufficient for the prediction module:

- Air Temperature
- Air Relative Humidity
- Barometric pressure
- Global solar radiance
- Diffused solar radiance
- Wind speed
- Wind direction
- Precipitation

In summary, the internal layout of the advanced monitoring module has the same base as the simple monitoring module, but fitted with additional device types.

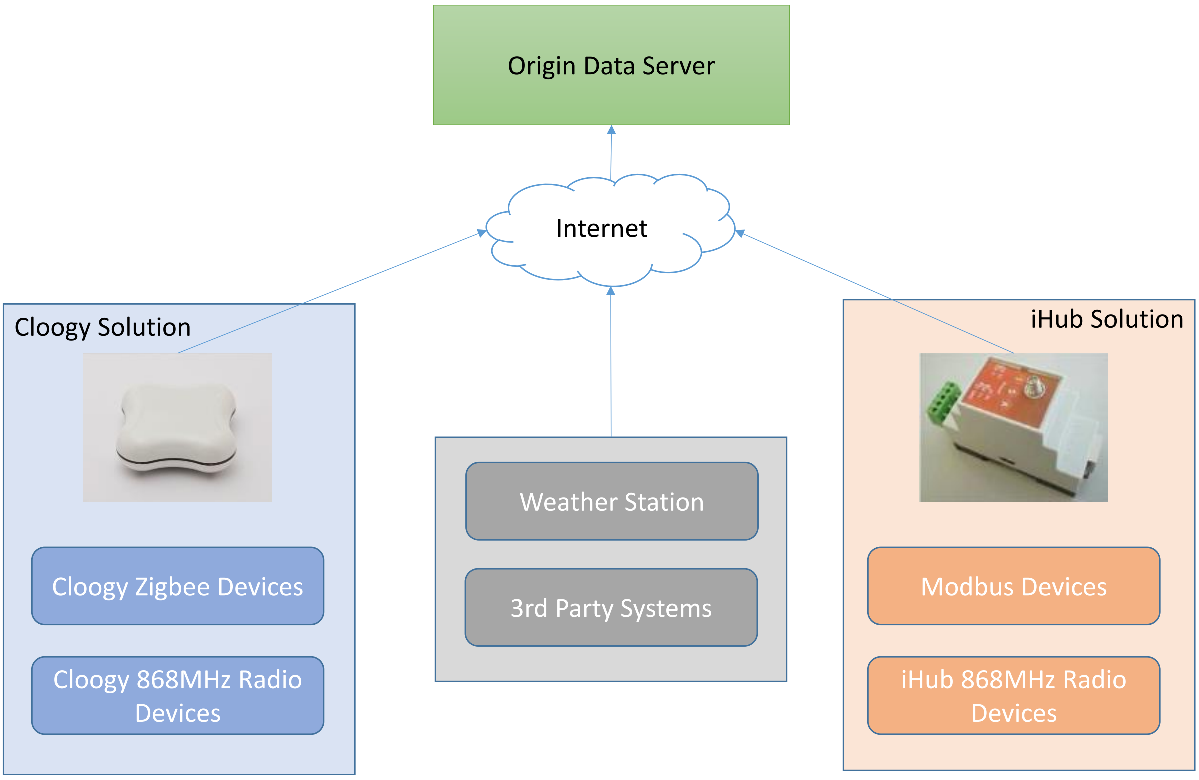

Figure 3 - Advanced Monitoring Module Layout

2.2. ORIGIN CEMS block

The ORIGIN Community Energy Management System (CEMS) processes the information coming from the Field Devices block and analyses it. This analysis generates forecasts and predictions, which are used later to orchestrate the energy in the community. It is composed of a group of functional modules that brings the full functionality, and can be summarized in two groups:

- Core: includes servers for the ORIGIN core, database, and communication and interfacing scripts.
- Attached Modules: include servers for high computing analysis (forecasting and predictions) and the User Interface webserver.

Based on the community size, requirements and interests, the ORIGIN CEMS block can be implemented in many physical configurations. The number of servers and their computation/storage requirements depend on the size of the community and the number of desired functionalities. The database can start with a medium sized disk, and add more storage capabilities as needed. The analysis modules require more powerful machines with 4-8 cores to help parallelizing the jobs, while the webserver requires a medium processor with a good amount of RAM and a guaranteed bandwidth. Small communities can mount all these modules in the same physical server, but bigger communities will need to use a second server for the analysis modules.

These servers can be installed and managed internally in the community if sufficient IT resource is available or they can be outsourced. Outsourcing these servers can be a really good solution. Prices for hosting/housing are very competitive, and the service offered includes server management, data/servers replication, and a high quality Internet access. The service provided is clearly stated in a Service-Level Agreement. The community can start by hiring a medium-sized hardware, and as space is consumed or the computing needs start to increase, more resources can be incrementally hired.

The ORIGIN platform allows different communities to share the same CEMS, so associated communities can share this housing/hosting service and its costs. Each new community increases the storage needs and analysis server requirements, but most resources can be shared, reducing costs significantly.

The Origin CEMs houses the ORIGIN algorithms. The key ORIGIN algorithms include a weather prediction algorithm (WPA), a renewable generation prediction algorithms (RPA), a demand prediction algorithms (DPA), a load shift opportunity prediction algorithm (OPA), and the orchestration control algorithm (OCA). D4.2 and D4.3 give more information on the data required for these algorithms and their operation

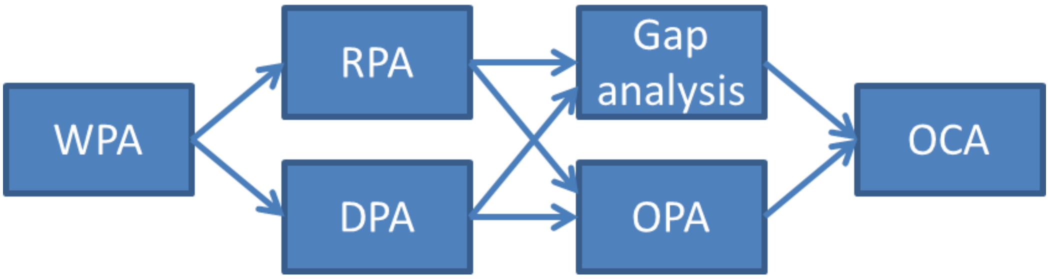

Figure 4. High Level Architecture of the ORIGIN algorithm

These are combined to provide an informational (user led) module and or an Automatic Actuation module

Informational module

The information module can give:

User Awareness information: historical energy consumption information, future energy surplus forecast information, performance information relative to other community members etc

Recommendations: users receive recommendations to enable them to schedule their energy use so that it aligns more successfully with local renewable generation but they have to decide to take action

Dynamic tariff information –a tariff system can be used to penalize energy consumption when no surplus is forecast thus encouraging users to change their behaviour and move their energy consumption to match high renewable generation where possible.

This information is presented to the community via an end user interface via a series of gadgets described in more detail in D3.5

Automatic Actuation module

The Automatic Actuation module can be used to implement, in an automatic way without the community intervention, some or all of the recommendations provided by the informational module (described in the previous section). This module requires the existence of the advanced monitoring module, which has the capability to include devices that can act as actuators. The actuation's script sends the actuation orders to the Field Devices Server, which is responsible for managing directly the actuation devices in the community. Every actuation is logged in the system, and any communication or interfacing error is registered. If an error does occur, the system will try to act it again every 5 minutes.

3. Deployment Scenarios

This section presents some possible deployment scenarios using the modules described in the previous sections. The presented scenarios can be easily converted so, even if a community chooses to adopt a specific simple scenario at a point in time, it can afterwards evolve the deployed scenario to a more complex one to increase the obtained advantages from the Origin system. This way, some of the simpler scenarios can act as entry points for new communities and, after the community evaluates the potential of the system and the limitations of the deployed scenario, the scenario can evolve to a more complex one.

The following table summarizes the proposed deployment scenarios, ordered in terms of complexity, which are described in detail in the next sub-sections.

Table 1 - Deployment scenarios table

Scenario	Simple Monitoring	Advanced Monitoring	Informational	Automatic Actuation
0			X	
1	X			
2	X		X	
3		X	X	X

The table below summarizes qualitatively the deployment difficulty, cost and effectiveness of each one of the proposed scenarios. The deployment difficulty represents the difficulty to deploy the scenario in a new community; it takes into consideration the difficulty to prepare the scenario (audit phase) and also the difficulty to install it in the community (most of the effort is on installing the monitoring module). The cost represents the monetary cost of the deployment and running of the solution; this field takes into consideration the cost of hardware, installers and maintenance for each one of the scenarios. The effectiveness is the measurement of how effective the Origin system will be with each one of the scenarios in optimizing the energy balance of the community.

Table 2 - Comparison of the proposed scenarios

Scenario	Deployment Difficulty	Cost	Effectiveness
0	Very Easy	Very Low	Limited
1	Easy	Low	Limited
2	Easy	Medium	Medium
3	Medium / Hard	Medium / High	Excellent

3.1. Scenario 0 – Standalone Optimization

Scenario	Simple Monitoring	Advanced Monitoring	Informational	Automatic Actuation
0			X	

In this scenario, only the informational module is used. In this scenario, available weather data is used to estimate both the production of the renewable power sources and the demand by the community and then provide recommendations

As there is no direct monitoring of the energy consumption, it is hard to model effectively the consumption demand of the population, thus the prediction algorithms accuracy can be quite limited. In addition, due to the lack of monitoring, it is also very difficult to observe if the delivered recommendations had any effect at all on the population behaviour. Therefore, the effectiveness of this scenario is very limited.

This scenario has the advantage of being very easy to deploy and is cheap, as no hardware is installed in the community other than possibly a set of wide screen displays installed at key points in the community to highlight recommendations from the system. This scenario can be used as a starting point and the community can increase the functionality of the system as they realize the potential benefit that the Origin platform can offer.

3.2. Scenario 1 – Basic Monitoring

Scenario	Simple Monitoring	Advanced Monitoring	Informational	Automatic Actuation
1	X			

In Scenario 1 only the basic monitoring module is installed in the community. The basic monitoring gathers data regarding electrical consumptions from each one of the community buildings and dwellings.

As no information and or automatic actuation module is installed, the effectiveness of the system is limited by the motivation of the community to monitor their own consumption and infer which measures they can perform to optimize their consumption to the renewable production or to reduce the consumption of avoidable loads/appliances.

The advantage of this scenario is that if the community decides later to install the information and or actuation module, the data collected in the previous period by the monitoring system is valuable for the calibration of the models that inform the information and actuation modules.

As with scenario 0, this scenario is also a good entry point for the Origin system and can be used for the community to evaluate the potential of a monitoring system that composes a full-fledged Origin platform.

3.3. Scenario 2 – Infomational System

Scenario	Simple Monitoring	Advanced Monitoring	Informational	Automatic Actuation
2	X		X	

Scenario 2 represents an evolution compared to scenario 0 and scenario 1 by joining the basic monitoring system (scenario 1) and the informational system.

The joining of the two scenarios, as mentioned above, yields an enormous improvement in relation to the deployment of the individual scenarios. The simple monitoring module gains an improvement on its effectiveness as it is less dependent on the motivation of the inhabitants to access the monitored data to produce effects because now it has a new way of reaching the population through the recommendations provided by the information module. Also, the information module is now being fed with real data for calibration of the models and optimization procedure processing (i.e. evaluation of feedback/acceptance of the issued advices) thus improving the accuracy of the system.

The ease of deployment for this scenario is similar to scenario 1, as the most challenging task is the deployment of the simple monitoring module.

This scenario is the typical evolution for a community that opted to install only the limited scenario 0 or scenario 1 and want to go a step further with the Origin platform functionalities with a small additional investment.

3.4. Scenario 3 – Actuated System

Scenario	Simple Monitoring	Advanced Monitoring	Informational	Automatic Actuation
3		X	X	X

This scenario is the most complete one. It is in fact the full Origin system as deployed in the project's pilots with no limitations.

The installed monitoring system is as complete as possible and enables the Origin platform to take knowledge on the status of not only the electrical energy balance but also on the thermal energy. Other parameters such as comfort levels and occupancy can be easily calculated using the data collected from the monitoring system and used to improve the decisions produced by the optimization system. In this scenario, the advanced monitoring system is also capable of including actuation devices and implement, in an automatic way, the commands issued by the information system without the need for intervention from the community's population. If an energy surplus is predicted, the system can take advantage of this and actuate specific appliances. The monitoring system can also include a local weather station to optimize weather prediction algorithms and therefore the demand and generation algorithms, thus making the Origin system as effective as it can be.

In this scenario, the informational module is also deployed and this combination is most likely to provide the best results.

The disadvantages of this scenario are the overall cost and the potential deployment difficulty. In the other scenarios the monitoring system can be deployed by a non-technical person (i.e. the responsible/owner of the dwelling), this scenario requires qualified technicians to install some of the monitoring devices on electrical boards and on the heat or water pipes. As the number and price of the monitoring equipment is also typically higher, the cost of the solution for this scenario is also higher than the cost for the other simpler scenarios.

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4. Future Replication

Deliverable 7.5 – Commercialisation plan details possible exploitation routes for scenario 2 and 3. Scenario 2 corresponds to the demand response informational model and scenario 3 corresponds to the demand response actuated model. Deliverable 8.3 highlights the possible replication routes for all the scenarios.