Nantes | Hamburg | Helsinki

my SMART Life

Deliverable due date: M36 – November 2019

D2.6 Design and implementation of RES in building

WP2, Task 2.2 (Subtask 2.2.4)

Transition of EU cities towards a new concept of Smart Life and Economy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

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Task description	Subtask 2.2.4 RES integrated in tertiary and public buildings. Design of an integration of RES in a former social restaurant that will be rebuilt to host municipal showers (Building Pierre Landais). The needs for hot water will be partly covered by a digital boiler. In this subtask, design and construction of a new building, integration digital boilers producing 22 MWh/yr each covering a large part of hot water needs; tests and analysis of performance will be implemented. In a new social housing building "Oiseau des Iles", one additional digital boiler will be installed. Two digital boilers will be installed and monitored in other buildings.	

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Abbreviations and Acronyms

Acronym	Description
mySMARTLife	Transition of EU cities towards a new concept of Smart Life and Economy
RES	Renewable Energy System

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1. Executive Summary

Today, new technologies based on digital products are becoming more and more numerous, and require the use of data centers. The latter create an increasing heat source while operating, and need to be cooled to continue to run properly.

On the other hand, the need for hot water is constant in every residential building and in some tertiary buildings.

A new equipment has been developed to merge these two issues: the digital boiler. With this new technology, domestic water is heated thanks to the heat released by computing servers.

In France, two companies, Stimergy and Qarnot, have each developed their own version of the digital boiler. The Tebios system designed by Stimergy has been installed on “Ile de Nantes”, in the “L’Oiseau des Iles” building, and in the North of Nantes, in the “Albert Londres” building. 50% of the energy needed to produce domestic hot water for respectively 30 dwellings and 40 dwellings is thus provided by the digital boilers. The QB-1 system designed by Qarnot will provide part of the heat required to heat domestic hot water to the new public baths building “Pierre Landais”.

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2. Introduction

2.1 Purpose and target group

Heating water is a major source of energy consumption in residential buildings and in some tertiary buildings such as swimming pools or public baths. The consumption of energy is mostly influenced by the need of hot water (involving user behaviours) and the performance of the boiler.

On the other hand, data flows increase every year by 25%, thus data centers cause heat and have to be cooled to operate properly. Additional energy is needed to evacuate the heat produced by the data centers. The evacuated heat is lost in the outside air and represents a loss of energy. It also may contribute to the temperature rise in the area.

In France, the company Stimergy has developed a few years ago a digital boiler that preheats water thanks to the heat waste of computer servers. The innovation named TEBIOS® can be installed in different kinds of buildings (residential building, universities, swimming pools, public baths…). Stimergy provides not only hot water but also services to store and calculate data and then supports the emergence of a smart society where economic growth and respect for the environment can coexist without compromises.

Another company, Qarnot, has also recently developed a digital boiler, named QB-1. This equipment is newer than the system TEBIOS. It will also provide hot water and computer services like data storage or calculation.

This deliverable describes how digital boilers work. It first introduces the new technologies developed by Stimergy and Qarnot and then focuses on three examples where digital boilers have been installed in Nantes.

The deliverable is targeted at project managers and prime contractors in the construction field but also at city public building planners and public policy makers. This deliverable serves as a basis to raise the awareness of these target groups to digital boilers.

2.2 Contributions of partners

The following table depicts the main contributions from participant partners in the development of this deliverable.

Table 1: Contribution of partners

Participant short name	Contributions
CER	Redaction of the deliverable
NAN	Provide the information and read back
Nantes Métropole Habitat	Provide the information and read back

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2.3 Relation to other activities in the project

The following table depicts the main relationship of this deliverable to other activities (or deliverables) developed within mySMARTLife project and that should be considered along with this document for further understanding of its contents.

Table 2: Relation to other activities in the project

Deliverable Number	Contributions
D2.1	This deliverable provides the overall description of the baseline situation of Nantes Metropole in terms of city characterization, publics policies and strategies, public procurement procedures and actions for citizen engagement
D5.3	Definition of the monitoring program: the monitoring scheme defines the actions' impact in the intervention's system and how data will be collected to ensure the calculation of the monitoring KPIs.
D2.8	Development of improved services in Nantes Urban Platform

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3. The digital boiler

With a 25 % data flow increase each year, data centers are developed all over the world to store our data and realize a lot of digital calculus. Those data centers have to be cooled all the time to operate properly. When the cooling systems are in progress, they extract the calories inside the data center to release them in the outside air. All those calories are wasted even though they could be used to heat water or buildings. Data centers and their energy consumption are major ecological challenges.

Two French companies, Stimergy and Qarnot, have developed a system in which all the calories released by the servers are spent to preheat hot water.

Both products are presented in this part of the deliverable. The system TEBIOS by Stimergy is older than QB.1 by Qarnot, which explains that there is more information on TEBIOS than QB.1

3.1 TEBIOS system, developed by Stimergy

3.1.1 Stimergy, the company

The creation of digital boilers at first is based on the statement that on one hand we have an increasing heat source produced by datacenter, so that the latter need to be cooled, and on the other hand, the need for hot water in buildings (especially residential buildings and swimming pools) is permanent. The meeting point for those two statements is to create a system which uses the calories released by the servers to preheat hot water.

In 2013, based on this idea, Christophe Perron created Stimergy, a French company based in Grenoble and Paris to develop and launch their digital boiler, TEBIOS.

The digital boiler has already been installed in a swimming pool in Paris and also in different residential buildings in Nantes, Grenoble and Lyon.

3.1.2 The digital boiler TEBIOS®

The goal of this system is to transfer the calories released by the working servers to water. Thanks to those calories, the water entering the storage tank is hotter than the running water and the consumption to heat domestic water can be reduced up to 60%. The energy is this way employed for two different purposes: to run the servers and to heat the water. The energy to cool the servers is nearly reduced to zero.

The calories produce by the servers are transferred to the water through oil. The servers are encapsulated to be waterproof and immerged in oil which is a better conductor than water. The temperature of the oil increases as the servers are running.

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Figure 1: Servers immerged in oil

The efficiency of the system measured in lab is 96 % (fatal energy recovered/ energy consumed by the system).

A heat exchanger transfers the calories from the oil to the water. The water, which is not yet domestic water, is stored into a water tank, at around 45°C. Another heat exchanger transfers the calories to the domestic water and a second system heats the water up to the set point temperature requested by the users (around 55°C).

The servers operate all day long to provide the power at any time. When hot water is not needed and the water tank is already at the set point temperature, the surplus of calories is evacuated by a water air heater to the outside of the building.

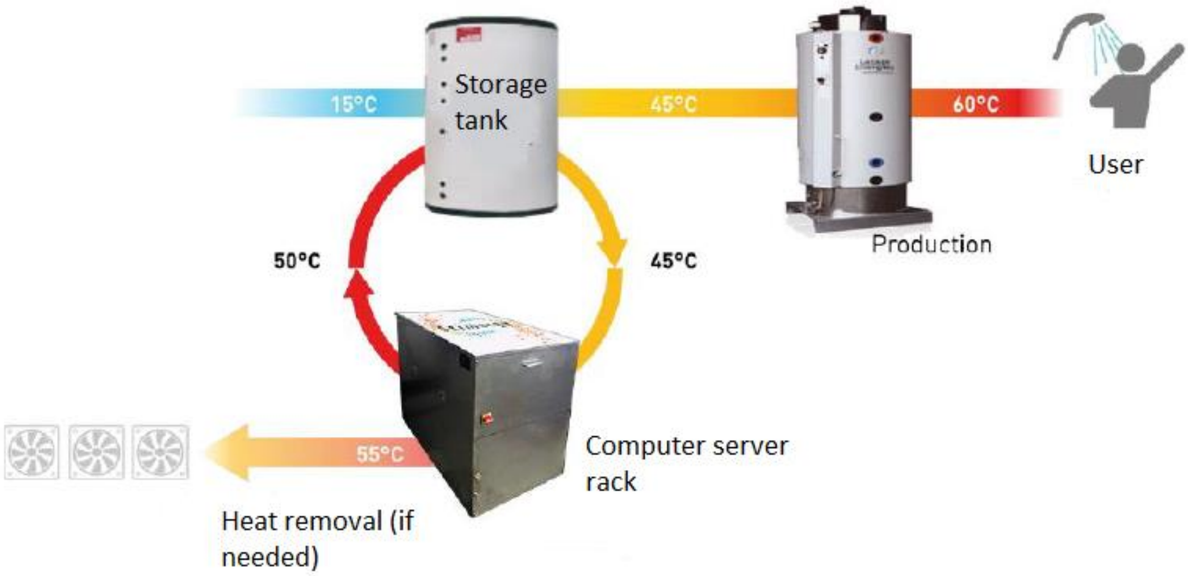

Figure 2: Schematic layout of the hot water production

As the power depends on the type and numbers of servers installed in the system, the digital boiler can adapt in any kind of residential buildings or any building where there is a consistent and important enough need of hot water. Indeed, the minimum power of a TEBIOS digital boiler implies that there should be a minimum of around 30 dwellings in the building, or an equivalent need, to install it. The power of one

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digital boiler is 8 kW maximum and it can contain up to 24 servers. However, it is possible to install up to 6 boilers for the same building in order to reach a maximum power of 48 kW.

The boiler has to be installed in a secure space of at least 7 m². The room needs to be ventilated with a system allowing to extract the thermal power of the room. The access to this room must be protected with badges or locked doors and the ground resistance must exceed 600 kg/m².

Figure 3: Secured door and connections for the optical fiber and electricity

In the room must be found a hydraulic inlet to connect the exchanger and an electrical supply from a dedicated delivery point. Finally, the building has to be eligible to the optical fiber as all the data transit through the internet.

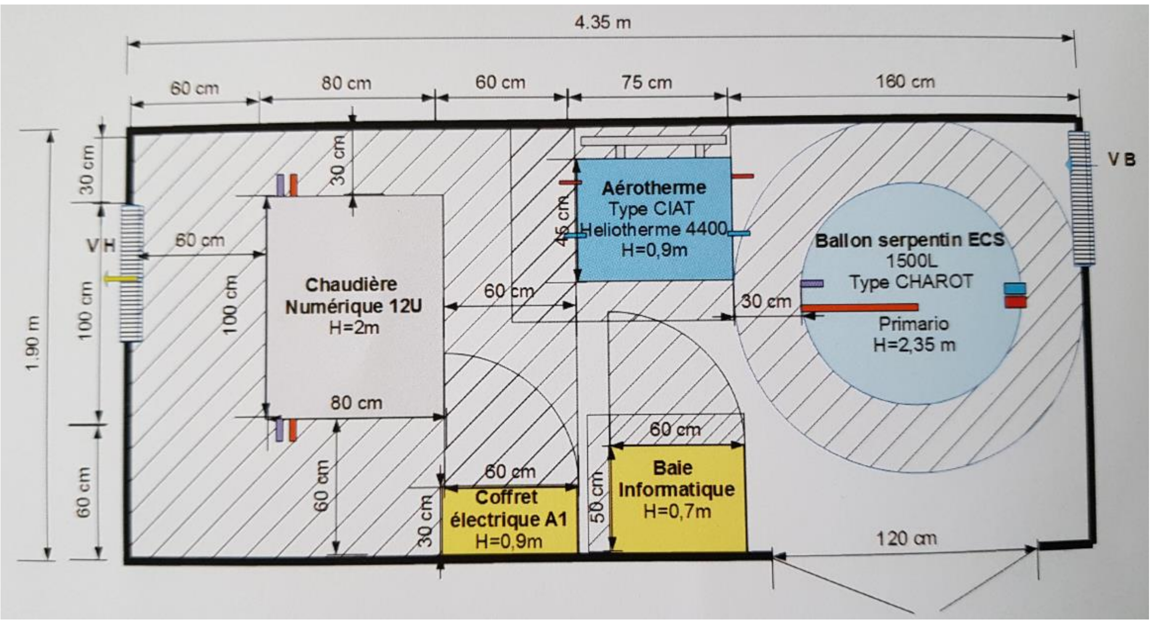

Figure 4: Schematic layout of the room where the digital boiler TEBIOS® has to be installed

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3.1.3 The contract

Stimergy **commits to provide an amount of energy** (or a percentage of the total consumption to produce hot water to the building) according to a contract signed with the building manager and for the duration of the contract. The contract is based on a **stable price of the energy** for the duration of the contract. Today, the price of 1 kWh produced with the digital boiler is a bit higher than 1 kWh of gaz. However, considering the future rise of the price of energy, this situation may reverse. Besides, the energy provided by the digital boiler is **considered as renewable** by the thermal regulation in France. Indeed, the energy used to heat the water is an energy that no longer needs to be spend to cool the servers. Depending on the contract, the boiler can be sold or rented to the building manager.

The digital boiler can be installed either in a new building or during a renovation. The building manager has to provide the room where the digital boiler will be installed, which is not always directly in the existing boiler room, as well as all the hot water connections within the building. Then Stimergy deals with the different connections: optical fiber, electricity and water connection to the main production system.

The servers are plugged on the internet with an optical fiber, which is installed and administered by Stimergy. The company also provides and pays the bills for the electricity spent for running the servers, the different pumps and heat exchangers which constitute the digital boiler. The maintenance of the complete system (digital boiler, internet furniture…) is taken over by Stimergy.

On one hand, Stimergy is engaged with the property owner to p**rovide energy all over the year to produce hot water.** On the other hand, the company also has contracts with different entities and offers them a high-performance cloud computing service for 3D rendering and visual effects aimed at animation studios, specialized schools and freelances. Stimergy also provides servers to store data.

Stimergy can offer a **2-in-1 service** of both an environment-friendly server room and a system that recycles the heat produced by the computers for domestic hot water production, thus allowing to improve the building energy efficiency.

If Stimergy does not succeed in providing the amount of energy specified in the contract, a penalty is calculated and must be paid by Stimergy to its client.

Different **sensors are installed** in the boiler room to count the energy produced by the digital boiler (see 4.4). This energy is corrected with some predefined parameters. The formula is always defined in the contract and so is the cost for 1 kWh not produced.

During the redaction of the report Stimergy filed for bankruptcy. This bankruptcy is not linked to technical problems on the digital boiler but to shareholders difficulties. A new company has been created by the former owner of Stimergy to provide the data to the servers installed in the digital boilers that have already been installed in Nantes. This new company kept the name “Stimergy”. Due to the bankruptcy, the contracts signed between Stimergy and the property owners are now null. A **new contract has been signed** between the property owners and the new company. An example of this possible new contract is described in a paragraph below dedicated to the system installed in Nantes.

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3.2 QB-1 system, developed by Qarnot

3.2.1 Qarnot, the company

Qarnot is a French IT company specialized in "edge computing". The "edge computing" is the ability to spread informatics calculation into different servers which are not installed in a regular data center.

Regarding the need to cool servers and to heat buildings, Qarnot developed different technologies to reduce the energy consumption to cool servers by using the heat created to heat buildings or water. Qarnot first developed a digital heater where the resistance is replaced by servers, named Qrad. The heat released by the servers directly heats the air in the room. The Qrad system runs like any other heater except that the heat released can be considered as renewable. Nevertheless, the Qrad system is only relevant in winter and loses its interest in summer.

Qarnot has also recently developed a digital boiler called QB-1. This equipment is described in the next paragraph.

The Q.ware platform manages the job computing distribution according to the heating needs in the building either to heat the spaces or the water.

3.2.2 The digital boiler QB-1

The aim of the device is the same as the Tebios system: to transfer the calories released by the working servers to water. Thanks to those calories, the water entering the storage tank is hotter than the running water. The energy is this way employed for two different purposes: to run the servers and to heat the water. The energy to cool the servers is nearly reduced to zero.

Each QB-1module cools the servers with purpose built cold plate retrieving more than 80% of the heat generated by IT computing in the water circuit. QB-1 also increases efficiency by retrieving waste heat generated by power supply units.

The heat needs and the set point temperature are regulated by Qarnot hardware and firmware embedded in QB-1. Thanks to this hardware, the servers only work when hot water is needed. The rest of the time, there is no heat generated, so there is no need to evacuate the surplus of heat.

QB-1 system is made of:

- Externalized energy circuits for power input and heat extraction
- IT modules embedding up to 2kW of computing nodes.

QB-1 modules are designed to provide up to 100 kW per system. The device can adapt in any kind of building where there is a consistent need of hot water.

The system needs a good and reliable connection to the Internet, therefore, the building has to be eligible to the optical fiber.

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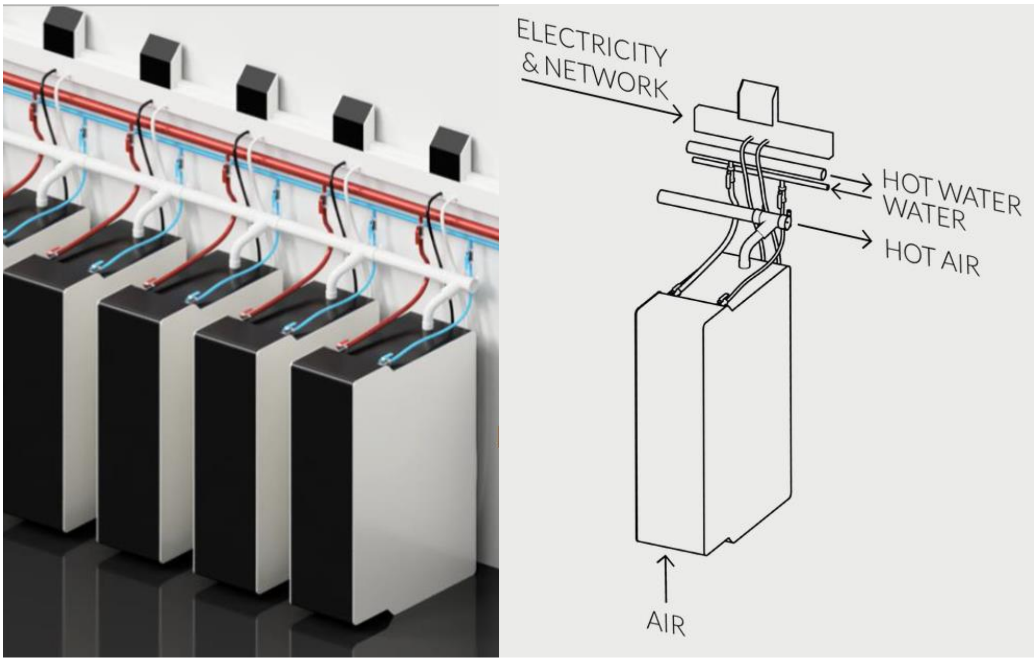

Figure 5: QB-1 system

The heat generated by each QB-1 module is converted into:

- More than 85% of hot water over 60°C
- And less than 15% of hot air over 45°C.

3.3 Summary

3.3.1 Comparison between the two systems

Table 3: Comparison between Tebios and QB-1

	Tebios	QB-1
Purposes of use	Domestic hot water in apartments or any buildings with high demand of hot water (public bath, swimming pool)	Domestic hot water in apartments or any buildings with high demand of hot water (public bath, swimming pool)
Fluid to exchange calories	Oil	Water
Power max	48 kW	100 kW
Energy saved or energy transferred	Up to 60 % of the energy to produce hot water is saved	Up to 85 % of the heat produced by the data center is transferred to hot water
Internet connection with fiber	Yes	Yes

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3.3.2 Pros and cons for digital boilers

Table 4: Pros and cons for digital boilers

Pros	Cons
Save energy to produce domestic hot water and cool the data centers and reduce CO_2 emissions	Space in the building to host the digital boiler and the water tank. The space dedicated has to be protected with a safe lock.
The energy produced is renewable (fatal energy from the data centers) and doesn't depend on meteorological parameters (wind, sun, …)	An internet connection with fiber is needed
The system is an innovation and quite simple	

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4. Three digital boilers in Nantes, France

Nantes Metropole Habitat, a social housing landlord in Nantes, has installed 2 digital boilers in its buildings, with the support of its Innovation Department. As Nantes Metropole Habitat wants to get involved in the energy transition and since the digital boiler system has already met its expectations, a study is currently being carried out to try to find a third building on the social housing landlord's assets in Nantes to install a digital boiler in it.

Nantes Metropole has also confirmed its commitment to energy transition with its roadmap for energy transition. On the latter, several commitments regarding the development of renewable energy have been taken. With this in mind, the Department managing the Metropole buildings tries to integrate RES whenever a renovation of new construction is carried out.

4.1 « Oiseau des Îles » building

4.1.1 The operation

On "Ile de Nantes", Nantes Métropole Habitat constructed a residential building named "Oiseau des îles". The project, managed by the architect Antonini-Darmon, started in 2010 and the building was delivered in June 2014. 26 apartments and 4 small houses are spread on 2800 m² and on the first floor 548 m² are available to shops or tertiary activities. In 2014, heating and hot water were produced through a district heating. The latter is working with a biomass and wood boiler and gas as a second heating system.

Figure 6: Building "Oiseau des Iles" on Ile de Nantes (picture by Nantes Métropole)

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Nantes Métropole Habitat installed a first digital boiler in another site in Nantes (see 4.2), and then decided to install another one in the building “Oiseau des Iles“ since the results were good in the first building and there was enough space to install a digital boiler in “Oiseau des Iles”. They choose the TEBIOS system, the only digital boiler available at that time.

4.1.2 The digital boiler installed

Nantes Métropole Habitat transformed an empty space into a secured room which can receive the digital boiler and all the furniture within (water tank, exchanger…). This room is not the same as the initial boiler room. The entire hot water network is insulated between the two spaces to reduce the loss of calories.

Figure 7: Tebios and water tank in the second boiler room

Figure 8: Technical description of the digital boiler in Oiseau des Iles

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An 8 kW digital boiler has been installed with 20 servers inside. It will provide 50% of the needs of hot water in the building.

The digital boiler started working in January 2019. It stopped for a few months when the company closed in March 2019 because of shareholders difficulties, but then started again in July 2019, when the new contract was signed.

4.1.3 The contract

Nantes Métropole Habitat signed a 15-year contract with Stimergy.

This contract took end when the company Stimergy closed. In this contract, the price of the energy produced is considered constant. Today one kWh produced with the digital boiler is a bit more expensive than 1 kWh of gas, but the trend is that the price of gas will increase. Moreover, the digital boiler provides renewable energy.

Nantes Métropole Habitat spent 30 000€ (excluding taxes) on this 15-year contract: 14 900€ to buy the digital boiler and the rest to install it and for the supply of heat. Thus, Nantes Métropole Habitat does not have additional bills for the energy produced by the digital boiler, this price is directly included in the contract. The maintenance of the system is also included in the contract. On the other hand, Stimergy will have to provide the amount of energy formalized in the contract i.e. 19 MWh per year (285 MWh for the next 15 years), or they will have to pay a compensation to Nantes Metropole Habitat. The compensation is calculated according to the cost for 1 MWh, set at 60€, which is not delivered by the system. The energy provided by the digital boiler is measured all over the year by a calorimeter.

A new contract, with the same conditions as mentioned above for the energy supply, has been signed between Nantes Metropole Habitat and the new Stimergy company. Both entities decided that there won't be any penalties in 2019.

4.1.4 Why did Nantes Métropole Habitat choose the digital boiler for this building?

Different reasons have influenced their choice.

Nantes Métropole Habitat has already installed a digital boiler and even if it was one of the first device installed in France, the results were good and they wanted to duplicate the installation. The project My Smart Life and the building "Oiseau des îles" was a good opportunity for them to install the system once more.

The digital boiler is an innovation and even a quite simple one. The risk that the system does not work is quite reduced compared for example to a solar water heating system. It also provides hot water with "recycled" waste energy. Nantes Métropole Habitat wants to take part in the green transition and wants to offer green and renewable energy to their tenants. It is also a way to reduce and stabilise their rental expenses thanks to the reduction of energy expenses. The way the digital boiler works adheres to environmental issues as it prevents the construction of more data centers and reduces the impact of their cooling.

On a practical point of view, Stimergy's system is quite easy to install as Stimergy does not have to operate in the dwellings. Thus, the tenants are not disturbed and the installation does not depend on their

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presence. The need of hot water is always provided to the occupants, as there is another system (the urban heating) in case of problem with the digital boiler.

Nantes Métropole Habitat is satisfied with this system and the installation was quite easy and did not fall behind. The only difficulties were related to the electrical connection of the system, since an appointment with the French electricity distributor was required as well as for the connection to the optical fiber. Both interventions were delayed and must be anticipated for this kind of project.

4.2 Social housing « Albert Londres »

4.2.1 The operation

In the North of Nantes, Nantes Métropole Habitat, a social housing landlord constructed a residential building in December 2010, named “Albert Londres”. In the latter, 40 apartments are spread on 3008 m².

Figure 9: Albert Londres building in Nantes

From 2010 to 2016, heating and hot water were produced by a gas-condensing boiler. In 2016, a digital boiler has been installed in the building with an expected production of 44 MWh to heat domestic water. The complement is still produced by the gas-condensing boiler.

4.2.2 The digital boiler installed

The digital boiler and the water tank to store the calories produced by the digital boiler were installed inside the original boiler room. Inside the latter, some works have been done in order to find enough space to install the equipment and the door was changed into a secure one to match with the security conditions.

The digital boiler is one of the first created by Stimergy. The two units of 4 kW each can produce 44 MWh per year to cover 60% of the domestic hot water need inside the building (except energy loss in the loopback).

18 servers are installed in each boiler.

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Figure 10: The two boilers

The digital boiler started working in August 2016. It stopped when the company closed in March 2019, and started again in July 2019 thanks to the new Stimergy company.

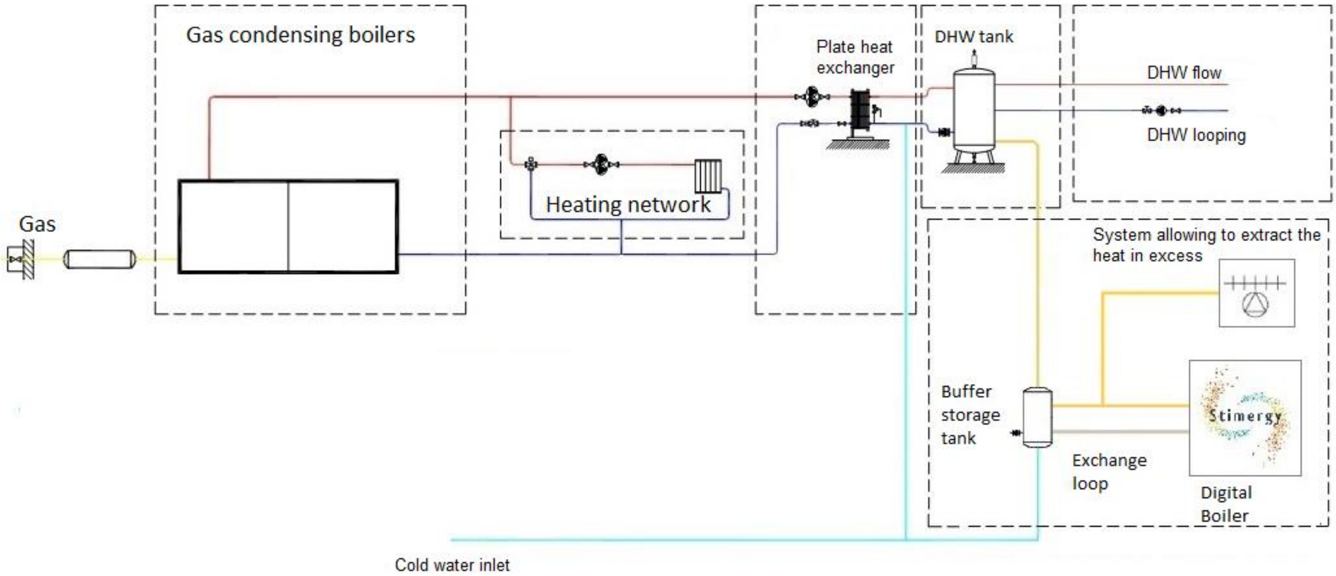

Figure 11: Technical description of the installation in Albert Londres building

4.2.3 The contract

Nantes Métropole Habitat signed a 10-year contract with Stimergy in February 2016.

For this installation, Nantes Métropole Habitat rented the installation. As Stimergy closed in summer 2019, Nantes Métropole Habitat initiates a procedure to acquire the equipment. Stimergy will sell the two digital

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boilers for 1€. This amount is just symbolic after Stimergy closes, Nantes Metropole Habitat will then become the owner of the boiler.

Stimergy have to provide the amount of energy formalized in the contract i.e. 44 MWh per year, otherwise they will have to pay a compensation: every MWh which hasn't been produced cost 60€.

The energy provided by the digital boiler is measured all over the year by a calorimeter and a protocol based on IPMVP (International Performance Measurement and Verification Protocol) standards (option B) has been created to follow the production for the first two years. Today, the instrumentation is still in place and working. The data are directly transmitted to Stimergy's platform.

For example, in 2017, Stimergy had to pay 907€ penalty as the amount of energy produced by the digital boiler did not reach 44MWh. In 2018, the penalty was 994€.

Table 5: Energy provided by the two digital boilers each month in 2017 and 2018 (in MWh)

	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Tot
2017	2,55	2,76	3,81	3,2	2,43	1,88	1,77	1,3	2,26	2,43	2,28	2,2	28,87
2018	2,15	1,38	1,77	1,65	2,07	2,65	2,17	2,07	3	3,32	2,79	2,4	27,42

The power specified in the contract has not been reached for the years 2017 and 2018. For 2017, it was about connection issue of the optical fiber; in 2018 it was due to data calculations. Indeed, there were not enough data calculations, so that the heat generated was not sufficient enough.

A new contract, with the same conditions as mentioned above for the energy supply, has been signed between Nantes Metropole Habitat and the new Stimergy. As with the "L'Oiseau des Iles" building, there won't be any penalties in 2019.

4.2.4 Why did Nantes Métropole Habitat choose the digital boiler for this building?

In 2016, Nantes Metropole Habitat was looking for a system using renewable energy to produce domestic hot water: either a solar equipment or a digital boiler. The conditions (orientation and shadows) does not complied with a solar system, so, Nantes Metropole decided to go with a digital boiler.

Regarding the technology, Nantes Métropole Habitat was looking for an innovation and a simple technology: Stimergy's system is quite easy to install and if the digital boiler does not work, the initial system will still be able to provide all the domestic hot water. So the tenants won't lack hot water.

So the digital boiler answers the environmental and economic issues as it saves energy.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

4.3 Social restaurant and public baths « Pierre Landais »

4.3.1 The operation

The old building where a social restaurant was hosted, has been demolished and a new building welcoming both a social restaurant and public baths is under construction on the demonstration district Ile de Nantes. The building will be delivered in Spring 2020.

Figure 12: The building under construction (picture by Nantes Métropole)

The consumption of hot water in this new building will be important as it will provide around 200 showers a day to the most deprived people of Nantes. The production of domestic hot water will be covered by the digital boilers for the showers and by the district heating for the restaurants.

4.3.2 The digital boiler installed

Nantes Métropole, the project owner, decided to install a digital boiler in this building to reduce the energy consumption to provide domestic hot water. The building will be connected to the district heating which will provide energy to heat the building and the remaining need of domestic hot water.

The new building includes a dedicated room to the digital boiler, with all the hydraulic and internet connections. The QB-1 system will be installed in the dedicated room and will provide part of the energy to produce domestic hot water.

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The building was under construction while the report was written, so that there was no picture available of the installation.

The boiler will heat water while cooling the servers and the energy caught will be transferred to the domestic water through a heat exchanger placed inside the water tank storage. The complement will be realized by the urban heating system.

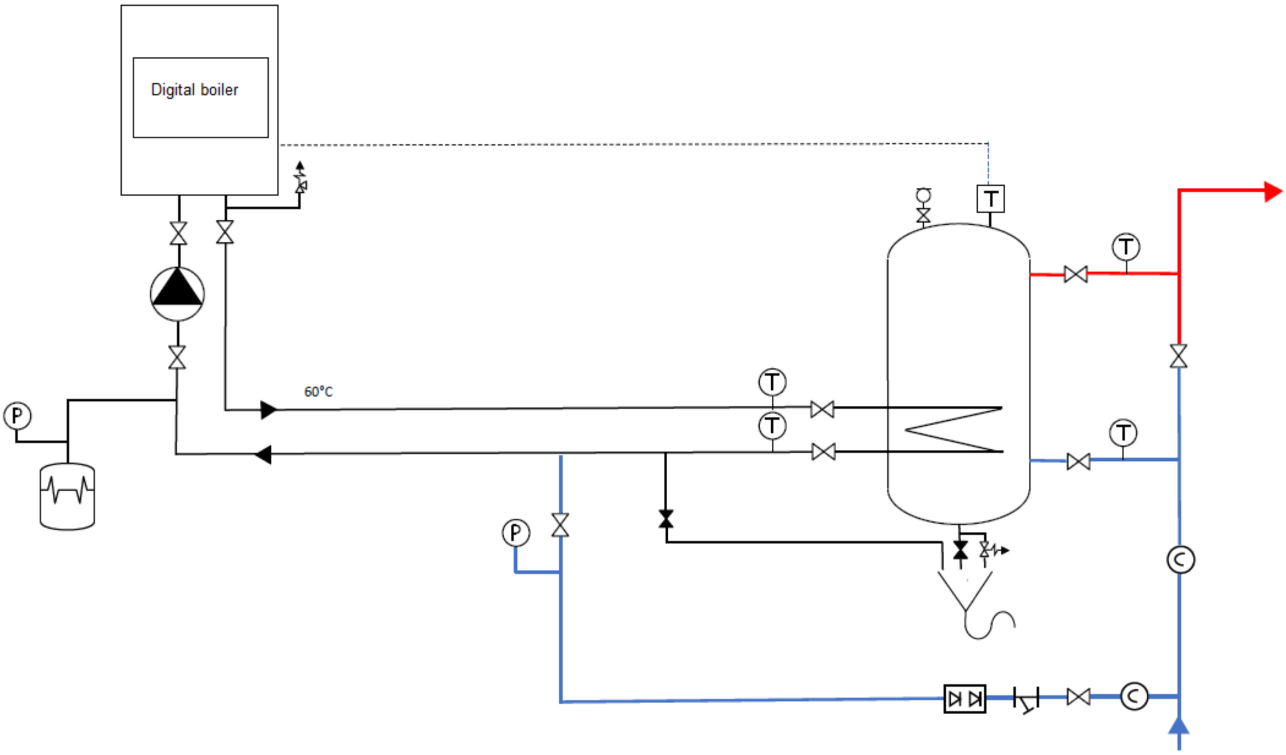

Figure 13: Schematic layout of the installation

4.3.3 The contract

Nantes Métropole signed a 10-year contract with Qarnot and spent 10 000 € (excluding taxes) for the supply and the installation of the device. Nantes Métropole will rent the digital boiler for 10 years, and the contract can be renewed once for another 10 years under the same conditions.

The contract, which is a concession contract, stipulates that Qarnot, who will occupy and manage the premises with their equipment, will pay a yearly rent of 1 200 € (excluding taxes) to Nantes Metropole.

Nantes Métropole will pay the energy provided by the digital boiler to Qarnot up to 90 € (excluding taxes) per MWh produced and consumed to heat the domestic water. This cost will be reassessed every year regarding the cost of energy. Nantes Metropole will also pay for the maintenance of the system, maintenance realized by Qarnot or one of its subcontractors. The cost for the maintenance is 2 000 € (excluding taxes) and will be reassessed every year. The following schema sums up the contract set up.

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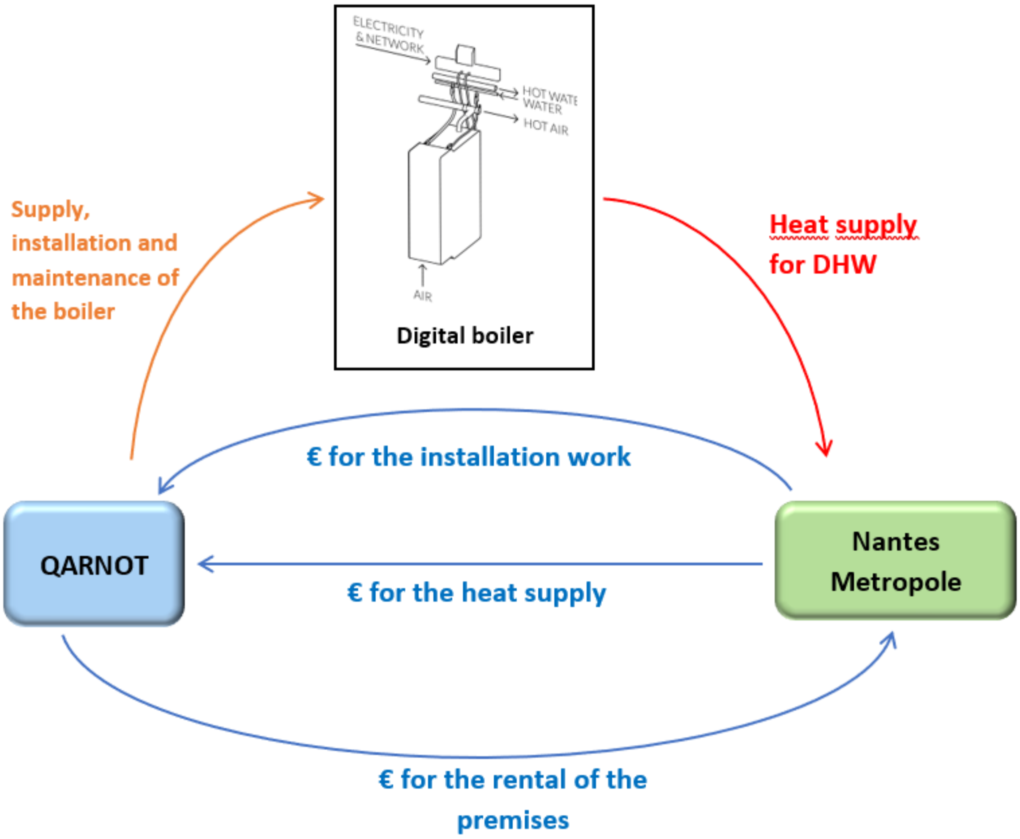

Figure 14: Schematic layout of the installation

4.3.4 Why did Nantes Métropole choose the digital boiler for this building?

Nantes Métropole also wanted to install a renewable system to produce domestic hot water, one of the major energy consumers in the building. A feasibility study was carried out. The installation of solar thermal panels for hot water was not relevant as the roof is partly shaded because of the others new surrounding buildings. The digital boiler was the second option and Nantes metropole decided then to go with it.

The digital boiler is a virtuous system and it seemed to be the best choice for this building. Moreover, the heating needs and the remaining DHW needs will be covered by Nantes Metropole main district heating, which is 84%-green. Indeed, the latter produces energy thanks to waste and biomass incineration by 84% and the 16% left are covered by gas boilers.

Another opportunity that could be studied for future digital boilers projects in institution like Nantes Metropole that have both DHW production needs on one hand and digital needs on the other hand, would be to have a digital boiler in which the computer servers deals with data from Nantes Metropole. In other words, it would mean to have a contract for the digital boiler and the heat supply and another one for the data calculation. Thus, a virtuous cycle would be established, as Nantes Métropole would heat domestic water with its own servers.

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4.4 Monitoring

The monitoring process is an essential part of the project. It provides the necessary raw material for carrying a precise evaluation of this project, keeping track of performance, further helping to understand the impacts one intervention can bring.

As part of WP5 dedicated to the monitoring, some work has already been done and preparation was undertaken to be ready for M36, and to prepare for the monitoring. The WP5 work is still ongoing, and projections are subjected to change; but first milestones have undoubtedly been reached upon the common work of WP5 T5.1, T5.2 and T5.3, such as the set of monitoring KPIs, shared between the three lighthouse cities and based upon reference sources (“SCIS” or “CITYKEYS” to name a few).

As for this deliverable and at the time of writing, a monitoring schema and a refined set of KPIs have been consolidated to prepare the monitoring implementation.

These documents are developed as part of the WP5 T5.3 for which an interim version of the deliverable D5.3 is due by M36, and the final one by M48; it is likely, therefore, they could be updated with a few changes.

An important issue of this action is to follow the part of the total domestic hot water consumption that is covered by the digital boiler. The monitoring consists more specifically in gathering the production data and the total consumption and to be able to see the evolution of the production over the months and years.

For each digital boiler, a schema has been realized to visualize all the data directly collected on site or through bills required for the monitoring.

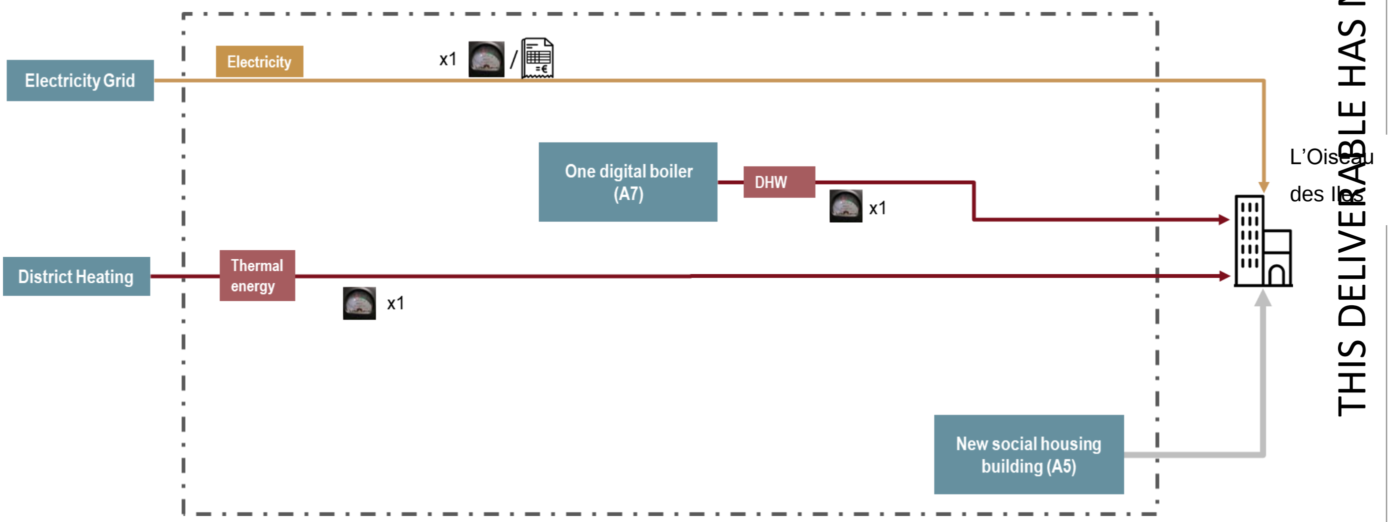

Figure 15: Instrumentation diagram for “Oiseau des Iles” building

In mySMARTLife project, a list of shared indicators has been established so that the actions and their impacts may be compared from one city to another. These indicators will be centralized in the Urban Data Platform. Below is the monitoring table which explains, for each chosen KPI, how they will be calculated, with formulas, units, KPI sources and more information on the integration with the mySMARTLife ICT

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ecosystem. As mentioned above, this table can still be updated in the coming months, as it is part of WP5 T5.3 and for which the final version of the deliverable is due by M48.

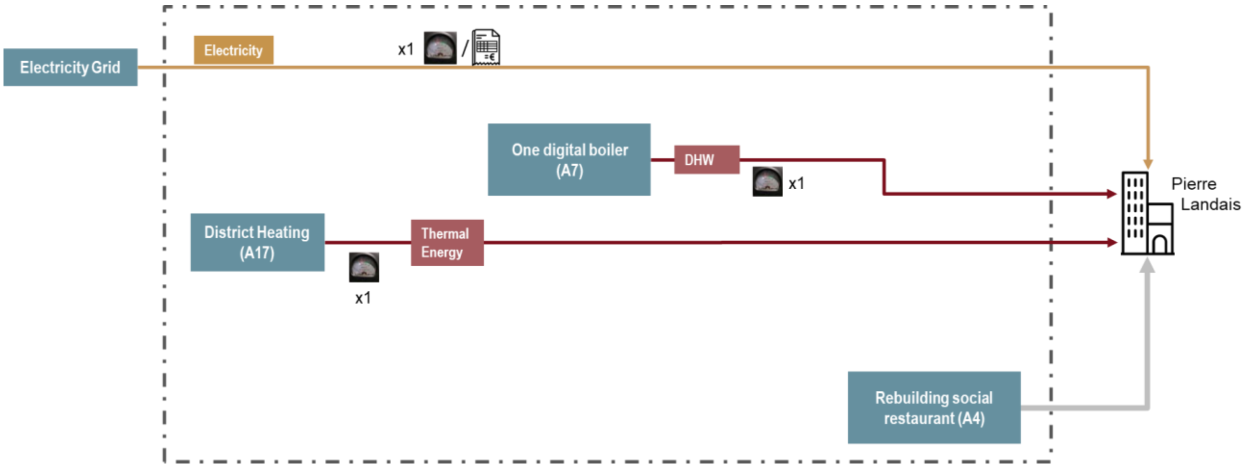

Figure 16: Instrumentation diagram for "Pierre Landais" building

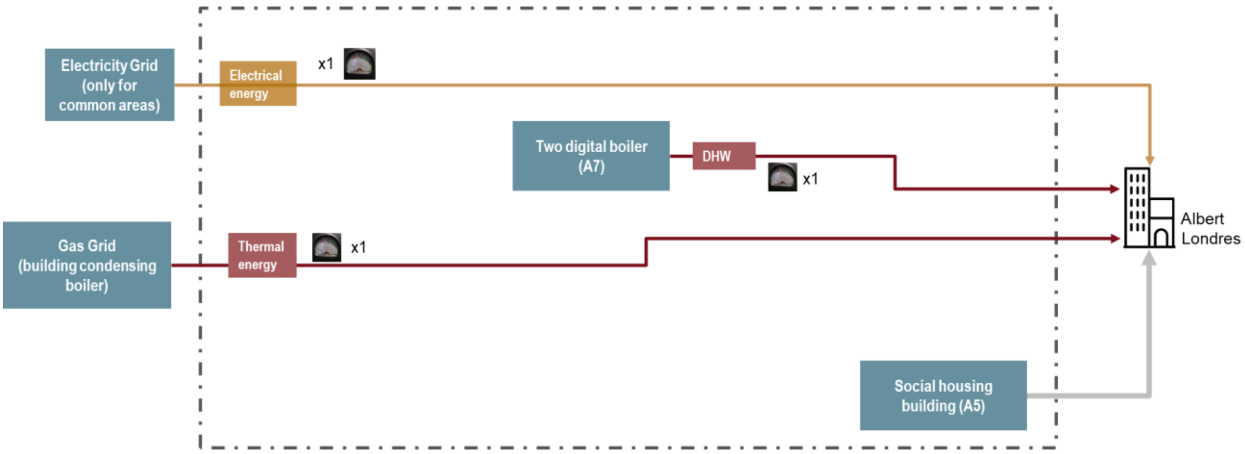

Figure 17: Instrumentation diagram for "Albert Londres" building

In this table, yellow rows highlight primary indicators, which are based on the collected data; blue rows show the secondary indicators, which can be calculated straight from the primary KPIs; and green rows color, finally, show the secondary indicators for which a human evaluation is required (e.g. evaluation of Greenhouse Gas Emissions reduction if emissions prior to the intervention need to be simulated).
Finally, from the common KPI list shared with the three cities, Nantes' stakeholders from monitoring & the Urban Platform have worked together to bring a systemic KPI integration framework into Nantes' Urban Platform. This is described more into details in the Urban Platform deliverable (D2.8) in the "ontology" chapter.

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Table 6: List of indicators monitored or calculated for "Oiseau des Iles" and "Albert Londres" buildings

KPI	Indicator	Type	Monitored?	Formula	Unit	Source	Urban Platform			Responsible
							Service	Integration	Open Data	
E1	Thermal energy consumption	Primary	Monitored	#	kWh/(m2.month); kWh/(m2.year)	Heatmeter	No	Yes	Yes	[NMH] Luc Stephan
E5	Annual energy consumption	Secondary	Monitored	E1	kWh/(m2.month); kWh/(m2.year)	Calculation	No	Yes	Yes	
E6	Energy use for heating	Primary	Monitored	#	kWh/(m2.year)		No	Yes	Yes	
E7	Energy use for DHW	Primary	Monitored	#	kWh/(m2.year)		No	Yes	Yes	
E24.A	Recovery	Primary	Monitored	Saved energy from server cooling	kWh/year	Supervision system	No	Yes	Yes	
E19	Primary thermal energy consumption	Secondary	Monitored	E1 * primary thermal energy factor	kWh/(m2.year)	Calculation	No	Yes	Yes	
E21	Total primary energy consumption	Secondary	Monitored	E19	kWh/(m2.year)	Calculation	No	Yes	Yes	
E28	Total greenhouse gas emissions (thermal)	Secondary	Monitored	E1 * thermal energy emission factor	kg CO2eq/(m2.month); kg CO2eq/(m2.year)	Calculation	No	Yes	Yes	
E31	Total greenhouse gas emissions	Secondary	Monitored	E28	kg CO2eq/(m2.month); kg CO2eq/(m2.year)	Calculation	No	Yes	Yes	
E25	Total heat supplied to the buildings connected to district heating network	Secondary	Monitored		kWh/year	Calculation	No	Yes	Yes	
E26	Degree of heating supply by district heating	Secondary	Monitored	(E25 * 100) / E4	% of kWh/year	Calculation	No	Yes	Yes	
E11	Reduction in annual DHW energy use ambitious compared to national regulation for new or retrofit building	Secondary		100 - [(E.7 * 100) / (national regulation)]	kWh/(m2.year)	Evaluation	No	Yes	Yes	
E22	Reduction of total primary energy consumption	Secondary	Monitored	100 - [(E21 after * 100) / (E21 before)]	% change in kWh/(m2.year)	Evaluation	No	Yes	Yes	
E32	Reduction of total greenhouse gas emissions	Secondary	Monitored	100 - [(E31 after * 100) / (E31 before)]	% change in kg CO2eq/(m2.year)	Evaluation	No	Yes	Yes	

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Table 7: List of indicators monitored or calculated for "Pierre Landais" building

KPI	Indicator	Type	Monitored?	Formula	Unit	Source	Urban Platform			Responsible
							Service	Integration	Open Data	
E1	Thermal energy consumption	Primary	Monitored	#	kWh/(m2.month); kWh/(m2.year)	Heatmeter	No	Yes	Yes	[NAN] Marine Buron
E2	Electrical energy consumption	Primary	Monitored	#	kWh/(m2.month); kWh/(m2.year)	Wattmeter	No	Yes	Yes	
E4	Annual energy consumption	Secondary	Monitored	E1 + E2	kWh/(m2.month); kWh/(m2.year)	Calculation	No	Yes	Yes	
E6	Energy use for heating	Primary	Monitored	#	kWh/(m2.year)		No	Yes	Yes	
E7	Energy use for DHW	Primary	Monitored	#	kWh/(m2.year)		No	Yes	Yes	
E24.A	Recovery	Primary	Monitored	Saved energy from server cooling	kWh/year	Supervision system	No	Yes	Yes	
E19	Primary thermal energy consumption	Secondary	Monitored	E1 * primary thermal energy factor	kWh/(m2.year)	Calculation	No	Yes	Yes	
E20	Primary electrical energy consumption	Secondary	Monitored	E2 * primary electrical energy factor	kWh/(m2.year)	Calculation	No	Yes	Yes	
E21	Total primary energy consumption	Secondary	Monitored	E19 + E20	kWh/(m2.year)	Calculation	No	Yes	Yes	
E28	Total greenhouse gas emissions (thermal)	Secondary	Monitored	E1 * thermal energy emission factor	kg CO2eq/(m2.month); kg CO2eq/(m2.year)	Calculation	No	Yes	Yes	
E29	Total greenhouse gas emissions (electrical)	Secondary	Monitored	E2 * electrical energy emission factor	kg CO2eq/(m2.month); kg CO2eq/(m2.year)	Calculation	No	Yes	Yes	
E31	Total greenhouse gas emissions	Secondary	Monitored	E28 + E29	kg CO2eq/(m2.month); kg CO2eq/(m2.year)	Calculation	No	Yes	Yes	
E25	Total heat supplied to the buildings connected to district heating network	Secondary	Monitored		kWh/year	Calculation	No	Yes	Yes	
E26	Degree of heating supply by district heating	Secondary	Monitored	(E25 * 100) / E4	% of kWh/year	Calculation	No	Yes	Yes	
E13	Total renewable thermal energy production	Primary	Monitored	#	kWh/year or kWh/(m2.year)	Sensors	No	Yes	Yes	
E15	Total renewable energy production	Secondary	Monitored	E13	kWh/year or kWh/(m2.year)	Calculation	No	Yes	Yes	
E27	Degree of energy self - supply by RES	Secondary	Monitored	(E15 * 100) / E4	% of kWh/year	Calculation	No	Yes	Yes	
E10	Reduction in annual heating energy use ambitious compared to national regulation for new or retrofit building	Secondary		100 - [(E6 * 100) / (national regulation)]	kWh/(m2.year)	Evaluation	No	Yes	Yes	
E11	Reduction in annual DHW energy use ambitious compared to national regulation for new or retrofit building	Secondary		100 - [(E.7 * 100) / (national regulation)]	kWh/(m2.year)	Evaluation	No	Yes	Yes	
E16	Increase in local renewable energy production	Secondary		[(E15 after * 100) / (city heating prod)]	% of kWh/year	Evaluation	No	Yes	Yes	

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In the buildings "L'Oiseau des Iles" and "Albert Londres", the information below can be followed on the monitoring device:

- Water consumption (flowmeter);
- Temperatures of the oil, the hot and cold water (temperature sensors placed inside the boiler and on the water pipes);
- The energy produced during one month (calorimeter).

The sensors and meters are connected to Stimergy's processing system.

Figure 18: Flowmeter installed in the boiler room in "Oiseau des Iles" building

Figure 19: Temperature sensors and calorimeter in "Oiseau des Iles" building

Thanks to this information, the money saved on the bill with the system is calculated. The "number of showers saved" is also calculated by using standard data (volume or energy for one shower) so that the tenants can be made aware of the energy saving and have a more meaningful information.

The energy production and temperature data are uploaded to an online platform and then aggregated.

The data are formatted in tables and graphs and are used to calculate a series of indicators on a web platform: the thermal energy consumption, the energy saved by using a digital boiler, the reduction of greenhouse gas emission…

The monitoring is also used to follow the contract and the amount of energy which is due.

From August 2019 to November 2021, around 43 MWh and 1 806 kg_{eqCO2} should be saved in the building "Oiseau des Iles" and around 99 MWh (based on 44 MWh provided every year) and 23,166 T_{eqCO2} should be saved in the building "Albert Londres".

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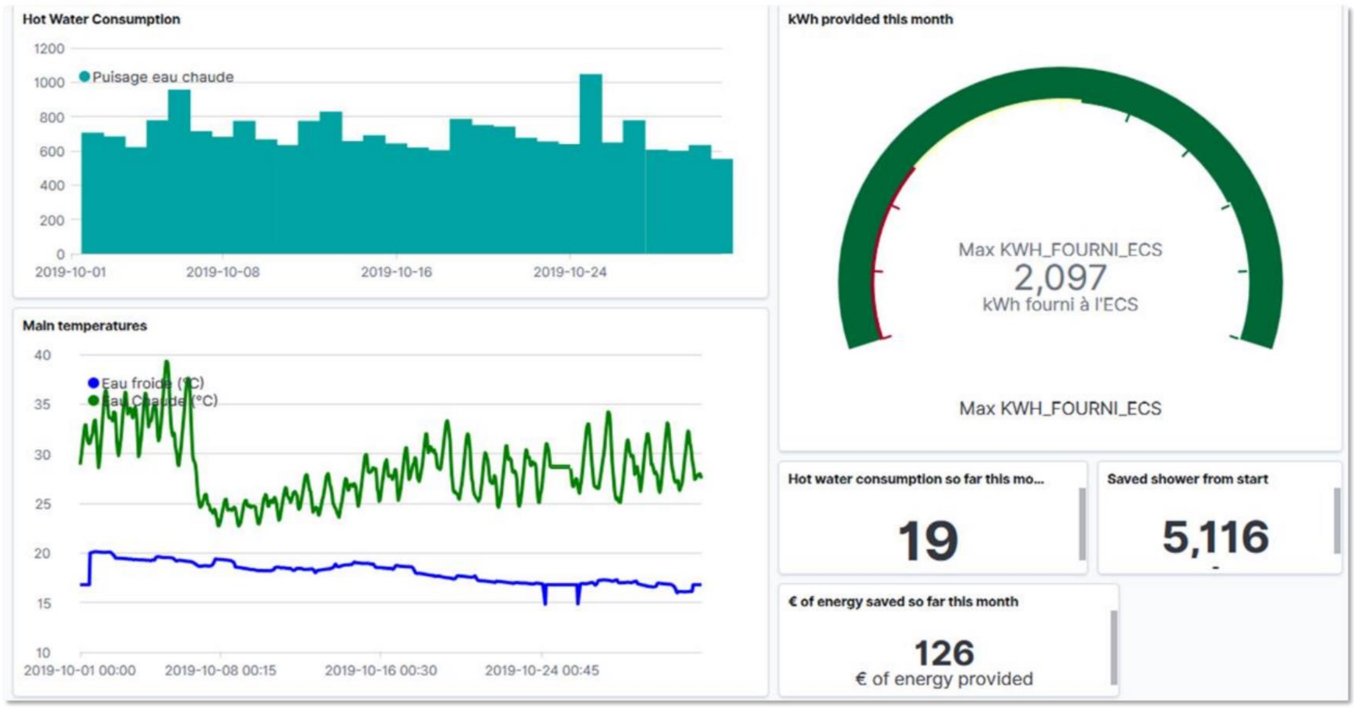

Figure 20: Onboard software to follow the functioning of the TEBIOS system in “Oiseau des Iles” building (one week in September 2019)

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5. Conclusions

Today, new technologies based on digital products create an increasing waste heat source, in particular through data centers (as they have to be cooled). On the other hand, the need for hot water in buildings is permanent in every residential buildings and in some tertiary buildings like swimming pools or public baths. A new equipment has been developed to merge these two issues: the digital boiler. In digital boilers, all the heat released by the working servers is used to heat domestic water. Digital boilers can also be considered as an adaptation of an industrial ecology concept applied to the context of cities. Last but not least by mixing different types of buildings in a reduced perimeter and installing digital boilers, a virtuous circle could be established between the tertiary buildings which need servers and dwellings where domestic hot water consumption is important.

First Stimergy and then Qarnot, two French companies, developed digital boilers, which can provide domestic hot water for dwellings or any other buildings with a consequent need of hot water. Both systems retrieve the calories released while the servers are working through a fluid that can be either oil or water. Those calories are then transmitted to the domestic hot water through a heat exchanger.

The Tebios system, developed by Stimergy, provides energy to produce hot water for two social housing buildings. The first one is fitted with one digital boiler of 8 kW, includes 30 dwellings and is located on Ile de Nantes. The second one is in the North of Nantes and has the first digital boilers that were installed in Nantes; there are 2 of them, of 4kW each. Nantes Métropole Habitat, owner of the building, signed a 15 years contract with the company. Nantes Métropole Habitat bought the two digital boilers and Stimergy has to provide a contractual amount of energy or penalties will be applied.

The QB-1 system, developed by Qarnot, will be installed in public baths on Ile de Nantes. The contract is different from the one Nantes Metropole Habitat has with Stimergy. Here, Nantes Métropole, owner of the building, will provide a room for the digital boiler to Qarnot. The latter will pay a rent for the use of this room and provide the digital boiler system. Thus, Nantes Metropole will not be the owner of the digital boiler, but Nantes Metropole will pay for the installation work and will buy the energy from Qarnot.

The digital boiler contributes to reduce the energy consumption and CO_2 emissions since it reduces both the energy needs to cool servers and the heating needs for domestic hot water. Thus, the energy produced is considered as renewable. If the servers installed in the boiler belong to the project manager and store its data or computation a virtuous circle is created and the data will be subject to French laws.

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